Published in final edited form as:

J Speech Lang Hear Res. 2007 April ; 50(2): 508–528. doi:10.1044/1092-4388(2007/035).

Longitudinal Relationships Between Lexical and Grammatical Development in Typical and Late-Talking Children

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Abstract

Purpose—This study examined the longitudinal relationships between lexical and grammatical development in typically developing (TD) and late-talking children for the purposes of testing the single-mechanism account of language acquisition and comparing the developmental trajectories of lexical and grammatical development in late-talking and TD children.

Method—Participants included 30 children identified as late talkers (LTs) at 2;0 (years; months), and 30 TD children matched on age, nonverbal cognition, socioeconomic status, and gender. Data were collected at 5 points between 2;0 and 5;6.

Results—Cross-lagged correlational analyses indicated that TD children showed evidence of bidirectional bootstrapping between lexical and grammatical development between 2;0 and 3;6. Compared with the TD group, LTs exhibited less evidence of syntactic bootstrapping. Linear mixed-effects modeling of language sample data suggested that the relationship between lexical and grammatical growth was similar for the 2 groups.

Conclusion—Lexical and grammatical development were strongly related in both groups, consistent with the single-mechanism account of language acquisition. The results were mixed in terms of finding longitudinal differences in lexical–grammatical relationships between the TD and late-talking children; however, several analyses suggested that for late-talking children, syntactic growth may be less facilitative of lexical development.

Keywords

late talkers; longitudinal language development; lexical–grammatical relationships

A long-standing debate exists in the literature concerning the relationship between lexical and grammatical development in children (for a review, see Marchman & Thal, 2005). One perspective considers these domains of language to develop autonomously, with grammatical development dependent on innate, domain-specific cognitive mechanisms that are triggered with minimal environmental input (e.g., Chomsky, 1975). These grammar-specific abilities are encapsulated within mental modules separate from the mechanisms responsible for vocabulary acquisition (e.g., Fodor, 1983; Pinker, 1999). In line with this perspective is the *dual-mechanism view* (e.g., Marcus, 1996; Pinker, 1991), which suggests

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that lexical and grammatical development are mediated by distinct mechanisms. For example, Pinker and colleagues (Marcus et al., 1992; Pinker & Ullman, 2002) have suggested that two autonomous mechanisms are responsible for acquisition of the English past tense, with a rule-based mechanism responsible for regular past-tense forms and a separate associative-memory network responsible for storing irregular forms.

Another perspective emphasizes the interdependence of the lexicon and grammar (e.g., Bates & Goodman, 1997; Marchman, Martinez-Sussman, & Dale, 2004; McGregor, Sheng, & Smith, 2005). For example, there has been a great deal of interest in investigating the continuity of lexical and grammatical development in children at the early stages of language acquisition (i.e., between 8 and 30–36 months of age; see Bates & Goodman, 2001, for a review). The continuity view proposes that grammar emerges from the lexicon once a critical mass of lexical items has been acquired (Marchman & Bates, 1994). In a landmark longitudinal study of language development, Bates, Bretherton, and Snyder (1988) reported that vocabulary development is a strong predictor of later morphological and syntactic achievements. Specifically, they found vocabulary size at 1;8 (years;months) was the best predictor of mean length of utterance (MLU) at 2;4 ($r = .83$). In fact, this across-domain correlation was stronger than the within-domain correlation between MLU at 1;8 and MLU at 2;4 ($r = .48$). In order to further test the interdependence of lexical and morphosyntactic development (i.e., the critical mass hypothesis), Marchman and Bates (1994) used data from more than 1,000 English-speaking children between 1;4 and 2;6 whose parents completed the toddler form of the MacArthur Communicative Developmental Inventory (CDI;Fenson et al., 1993), a parent report checklist of vocabulary and grammatical development. They focused on the relationship between the number of verbs in the vocabulary and the use of past-tense verb forms. In general, children progress through a characteristic sequence in the use of regular and irregular past-tense verbs. To begin, they produce both regular and irregular past-tense verb forms correctly (e.g., *kissed*, *went*). This is assumed to be due to rote, item-specific learning. Next, children pass through a stage where they overregularize past-tense irregular forms that were previously produced correctly (e.g., *goed*), showing evidence of productivity in the formation of the regular past tense. In the final phase, both irregular and regular past-tense verbs are produced correctly. Marchman and Bates (1994) hypothesized that in line with the continuity view, two morphosyntactic phenomena would be observed regarding the development of past-tense verb usage. First, the initial stage involving correct usage of both regular and irregular past-tense forms would be associated with small vocabularies. Second, the onset of overgeneralization errors would occur when verb vocabularies grew to a sufficient size (i.e., critical mass). Their findings supported these hypotheses, such that verb vocabulary size was predictive of the correct usage of irregular past-tense forms as well as the onset of overgeneralization errors. In addition, a nonlinear pattern of learning was observed, consistent with the critical mass hypothesis. According to this account, as increasing numbers of lexical items are learned, they become organized in such a fashion as to facilitate the abstraction and productive use of grammatical patterns. This nonlinear pattern of learning verb morphology was observed even though cross-sectional analyses indicated that the learning of verb types during this period of development increases in a steady, linear fashion.

Subsequent studies conducted by Bates and colleagues (e.g., Fenson et al., 1993; Fenson et al., 1994; Marchman & Bates, 1994) have provided additional evidence for the continuity between early vocabulary development and later grammatical achievements. In particular, these studies demonstrated that verb vocabulary size is highly predictive of the onset of verb morphological forms. Research by Dale, Dionne, Eley, and Plomin (2000) investigated whether a genetic overlap between lexical and grammatical development could be detected in monozygotic versus dizygotic twins at 2 years of age. Results indicated a strong genetic correlation between lexical and grammatical development, suggesting that they are mediated by common genetic factors, supporting a single-mechanism account of language development. Recent research by McGregor et al. (2005) found grammatical development to be more highly associated with lexical size than chronological age in typically developing (TD) 2-year-olds. To summarize, a substantial body of research investigating lexical–grammatical relationships has found that grammatical development appears to be highly dependent on vocabulary development in TD English-speaking children in the early stages of language acquisition (i.e., prior to 30–36 months of age).

Various characterizations of the nature of lexical–grammatical relationships have been offered in the literature. For example, research by Bates and colleagues (e.g., Bates et al., 1988; Bates & Goodman, 2001; Fenson et al., 1994; Marchman & Bates, 1994) suggested that lexical development predicts grammatical development in the early stages of language acquisition, also known as *lexical bootstrapping* (Bates & Goodman, 1997; Dale et al., 2000; Marchman & Bates, 1994). According to this perspective, the lexicon provides the basis for grammatical development. Specifically, as a sufficient number of lexical exemplars are acquired, the grammatical patterns and regularities needed for syntactic productivity are abstracted. Along these lines, the lexicalist view of language proposes that grammar does not dissociate from the lexicon at any point in the lifespan, as grammatical representations are integrated within lexical forms (Bates & Goodman, 1997). In contrast, other investigators have suggested that children utilize syntactic cues to infer word meaning, referred to as *syntactic bootstrapping* (e.g., Gleitman & Gillette, 1999). For example, Anisfeld, Rosenberg, Hoberman, and Gasparini (1998) questioned the widely accepted assumption that the vocabulary spurt observed in young children always precedes the onset of combinatorial speech. Results of their research showed that for 4 of the 5 children they studied, the period of rapid vocabulary acquisition occurred after the appearance of word combinations. Anisfeld et al. proposed that the children's emergent sensitivity to grammar facilitated the learning of new vocabulary by providing syntactic frameworks that offered new perspectives on word meanings. Other investigators have focused on the role of syntactic bootstrapping relative to the acquisition of verbs. For example, research by Naigles and colleagues (Naigles, 1990; Naigles & Hoff-Ginsberg, 1995) has supported the claim that children use information from the syntactic structures of phrases and sentences to derive verb meanings.

More recently, research suggested that lexical and syntactic bootstrapping occur simultaneously in early language acquisition, also known as *bidirectional bootstrapping*. In other words, while grammatical patterns are abstracted from a developing lexicon (i.e., lexical bootstrapping), grammatical knowledge facilitates lexical acquisition (i.e., syntactic bootstrapping). For example, Dionne, Dale, Boivin, and Plomin (2003) examined lexical and grammatical development in over 2,500 twin pairs assessed at the ages of 2;0 and 3;0. They found both genetic and phenotypic evidence of bidirectional bootstrapping between lexical and grammatical development during this period of early language development. Further investigation examining the roles of lexical and syntactic bootstrapping mechanisms beyond the earliest stages of language acquisition would help to clarify the nature of later language development in typical children.

Recent research has also explored relationships between lexical and grammatical development in children with early language delay, or *late talkers* (LTs; e.g., Ellis Weismer, Marchman, & Evans, 2001; Olswang, Long, & Fletcher, 1997), and children with specific language impairment (SLI; e.g., Conti-Ramsden & Jones, 1997; Windfuhr, Faragher, & Conti-Ramsden, 2002). LTs are characterized by delayed and protracted lexical development (Ellis Weismer, Murray-Branch, & Miller, 1994; Paul, 1991; Rescorla, 1989) and are at risk for SLI (Rescorla, Roberts, & Dahlsgaard, 1997). *SLI* is a developmental disorder characterized by delayed language in the absence of any accompanying disability, such as mental retardation, autism, hearing loss, socioemotional disorder, or frank neurological impairment (Leonard, 1998). As reviewed by Leonard (1998), English-speaking children with SLI exhibit particular deficits in morphosyntax, even when matched with children on MLU, a general index of grammatical development. Much of the research on the continuity of lexical and grammatical development in LTs and children with SLI has focused on verbs because of their instrumental role in syntactic and morphological development (e.g., Conti-Ramsden & Jones, 1997; Olswang, Long, & Fletcher, 1997; Windfuhr, Faragher, & Conti-Ramsden, 2002). Ellis Weismer, Marchman, and Evans (2001) examined a group of LTs and compared them with age-matched and vocabulary-matched peers. Specifically, they were interested in whether LTs showed deficits in their verb lexicons and grammatical development compared with vocabulary-matched younger controls. Results indicated similarities and differences between the late-talking and TD toddlers. For example, LTs had the same proportion of verbs in their lexicon as younger children matched on vocabulary size. However, they exhibited a weaker relationship between vocabulary size and MLU as compared with TD toddlers. In other words, although LTs had the same lexical foundations, they demonstrated delayed syntactic development.

In a study on lexical learning in children with SLI, Windfuhr et al. (2002) tested the *SLI critical mass hypothesis* (Conti-Ramsden & Jones, 1997), which proposes that children with SLI require more exposures in order to learn new lexical items and that they require more lexical types in order to abstract or generalize the grammatical regularities of the input. This hypothesis would explain not only the delayed lexical development in children with SLI (because more exposures are required to learn words) but also the difficulties with morphosyntax (because more types are required before grammatical rules are abstracted). This study involved 28 children with SLI, 4;4–5;10 years old, and the same number of younger TD children. The two groups were matched carefully on size of the verb lexicon and the number of overregularizations. The experimental task consisted of teaching novel verbs and novel nouns. The results indicated that children with SLI demonstrated significant difficulties in learning novel verbs as compared with the control group. In contrast, children with SLI learned more novel nouns than did the TD children. The authors concluded that these results provide further evidence that verb learning is an area of weakness in children with SLI. Specifically, the authors found that compared with TD children, the children with SLI required twice as many exposures to novel verbs (i.e., a larger critical mass) before they acquired them in their expressive language. Results of this study suggest that in addition to early delays in vocabulary acquisition, children with SLI may have differences in their pattern of lexical acquisition as compared with typical language learners. These differences may have important cumulative effects for language development (Reed, 2005).

Several researchers have investigated the language outcomes of LTs, and similar themes have emerged. Rescorla et al. (1997) assessed the language skills of 34 toddlers identified as LTs between 24 and 31 months, with follow-up assessments conducted at 3 years of age. Although originally identified on the basis of their limited expressive vocabularies, by age 3 these toddlers had moved into the normal range on a test of expressive vocabulary. However, most of the children continued to exhibit language delays on syntactic measures. Rescorla et al. concluded that these LTs appeared to make more progress in lexical skills as compared with grammatical skills. A follow-up study of these same children examined their MLU and Index of Productive Syntax scores (Scarborough, 1990) between 3 and 4 years of age (Rescorla, Dahlsgaard, & Roberts, 2000). Rescorla et al. (2000) found that although children with a history of late talking made greater gains on the syntactic measures than the comparison children, they still exhibited significantly lower MLUs and Index of Productive Syntax scores at both ages compared with the control group. In an earlier study, Paul (1993) had found similar results in her longitudinal study of LTs between 2 and 4 years. These children exhibited receptive language skills that were within normal limits by age 3. In addition, their expressive vocabularies were in the normal range. However, at age 4, nearly half (47%) of the children were still exhibiting delays in expressive syntax, as measured by Developmental Sentence Scoring (Lee, 1974). Paul concluded that expressive syntax is the area of greatest concern for children with a history of late talking. In summary, these studies suggest that children with a history of late talking are at risk for persistent language delays. The nature of their language deficit may change over time, beginning with delays in expressive vocabulary and continuing with deficits in expressive syntax.

Purpose of the Present Study

Several themes emerge from the research to date. First, lexical and grammatical development are highly interdependent, most notably for children between 8 and 30–36 months of age, the point in development when grammar typically emerges. However, the nature of lexical–grammatical relationships and bootstrapping mechanisms beyond 30–36 months is not well understood. Although vocabulary acquisition appears to be driving grammatical development initially, investigation is needed to determine whether this trend continues beyond the initial stages of language acquisition. Our conceptualization of typical language development has important theoretical and clinical implications. For example, recent research that included TD kindergartners and first graders found that vocabulary level accounted for more variance in the quality of children's narrative production (as measured by inclusion of story grammar components) than did level of syntactic development

(Heilmann & Miller, 2006). Findings from this study suggest that enhancing children's narrative ability may depend more on improving lexical skills than expressive syntax.

In addition, further investigation is necessary to discern whether children with language delay follow similar developmental trajectories as TD children in the language learning process (Olswang et al., 1997). The preliminary results of Ellis Weismer et al. (2001) suggest that although there are a number of similarities between LT and TD children, there are also differences, particularly in the relationship between vocabulary size and MLU. Of particular interest in the current study is whether LTs exhibit a grammatical deficit relative to lexical–semantic development. If differences in the patterns between lexical and grammatical development are a signature of SLI, these differences may be apparent in LTs, insofar as late talking is a precursor to persistent language impairment. It should be emphasized that differences observed in the relationship between lexical and grammatical development in LTs would not necessarily imply that these aspects of language are dissociated. Rather, it was expected that lexical and grammatical development would be related in these children but perhaps in a different manner and/or to a different degree.

The purpose of the current research is to extend the investigation into lexical–grammatical relationships for TD children beyond the age of 30–36 months. In this study, lexical and grammatical data are included for children between 24 months (i.e., 2;0 years) and 66 months (i.e., 5;6 years). In addition, this research attempts to further investigate the links between the domains of lexical–semantic and grammatical development in children with late onset of language (i.e., LTs), and compare patterns of development in LTs with those of TD children.

Research Questions

1. For TD children, does lexical development continue to predict grammatical development beyond 30–36 months of age (2;6), such that advances in lexical skills consistently predict subsequent syntactic abilities, or does grammatical growth predict lexical growth at certain points in development? It was predicted that beyond 30–36 months bidirectional bootstrapping between lexical–grammatical relationships would be observed, providing evidence for a single-mechanism account of language development.
2. Compared with TD children, do LTs show the same (or different) patterns of development with respect to the relationship between lexical and grammatical development, albeit delayed? Do LTs show evidence of grammatical deficits at this early age? It was hypothesized that similarities and differences between the TD and late-talking children would be observed. First, it was predicted that both groups would show evidence of lexical bootstrapping, lending support to the continuity and single-mechanism views of language acquisition. In addition, it was predicted that the underlying language deficit in LTs (which first presents as a delay in expressive vocabulary) would manifest in the grammatical domain as reduced syntactic bootstrapping. These findings (i.e., particular difficulty with the morphosyntactic aspects of language) would lend support to the proposed

relationship between late-talking children and children with SLI (i.e., coexisting on a language endowment spectrum; Ellis Weismer, 2007; Rescorla, 2000).

Method

Participants

The participants in this study included 30 children identified as LTs at approximately 2 years of age (i.e., 22–26 months) and 30 TD children. These children were a subset of a larger group who participated in a longitudinal study investigating linguistic processing in children with specific language delay. Children were recruited via a birth registry maintained by the Research Participation Core at the Waisman Center, flyers posted throughout the community, advertisements in local newsletters, posters at health fairs, and referrals from Birth to Three providers. All children participating in the study were screened to ensure they were developing normally in all areas (with the exception of language in the case of LTs), and all came from monolingual English-speaking homes. Parents completed background questionnaires regarding their child's developmental and medical history during the initial recruitment and the first laboratory visit. In addition, the Denver II (Frankenburg et al., 1990), a developmental screening test, was administered during the children's first visit. Also, cognition was measured using the Mental Index of the Bayley Scales of Infant Development (Bayley, 1993), and oral and speech motor abilities were screened by a pediatric assessment tool developed by Robbins and Klee (1987). Children with developmental disabilities or delays (identified by parent report or clinical testing) were excluded from the study. All children passed a hearing screening each year they came for testing. Distortion product otoacoustic emissions were measured at 2;6 and 3;6 with a Biologic otoacoustic emissions screener (2000, 3000, 4000, and 5000 Hz in at least one ear), and pure-tone screenings (20 dB HL at 500, 1000, 2000, and 4000 Hz in at least one ear; American Speech-Language-Hearing Association, 1997) were conducted at 4;6 and 5;6.

Children were initially identified as LTs if they scored at or below the 10th percentile at 2;0 on the MacArthur CDI: Words and Sentences (Fenson et al., 1993), a parent report measure of vocabulary and grammatical development. The CDI norms are gender-based, allowing for developmental differences in boys and girls. Using a cutoff of the 10th percentile to identify late-talking children is a common criterion in research (e.g., Robertson & Ellis Weismer, 1999; Thal, Bates, Goodman, & Jahn-Samilo, 1997; Thal & Tobias, 1994). Children in the TD group scored at or above the 20th percentile on the CDI. Children who scored between the 10th and 20th percentile were excluded in order to clearly differentiate between the LT and TD groups. Groups were matched on chronological age, socioeconomic status (SES; years of maternal education), nonverbal cognition, and gender. Matching on nonverbal cognition was determined by the number of nonverbal items correct at 2;6 on the Bayley Scales of Infant Development. The same set of items from the Bayley was administered to each child. Additionally, nonverbal cognition was assessed at each laboratory visit to track cognitive levels. At 3;6, nonverbal items from the Bayley Scales of Infant Development were again used. At 4;6 and 5;6, two composites from the Leiter-R (Roid & Miller, 1996) were administered (Fundamental Visual and Memory Screen). Nonverbal cognitive levels were similar between the two groups throughout the study. Each group was composed of 20 boys and 10 girls. The uneven gender distribution of the groups was expected given that late talking is more common in boys. Previous studies of LTs found gender ratios of boys to girls ranging from 3:1 or 4:1 (Ellis Weismer et al., 1994; Paul & Smith, 1993) to 19:1 (Rescorla & Goossens, 1992). A summary of participant characteristics is provided in Table 1. After initial recruitment at 24 months (2;0), children were seen in the laboratory at 2;6, 3;6, 4;6 and 5;6 years of age. Three LTs were lost as a result of attrition after their 3;6 visit, and three TD children were lost as a result of attrition after their 4;6 visit.

Language Measures

At each of the five time points of data collection (2;0, 2;6, 3;6, 4;6, and 5;6), various lexical and grammatical measures of expressive language were obtained that were used for the analyses. The specific measures are as follows (also see Table 2).

MacArthur CDI: Words and sentences—The CDI was completed by parents when their children were 2;0 and 2;6. For the present study, three measures were used from the CDI: Words Produced (an index of lexical development), Sentence Complexity (a grammatical measure), and Mean of Three Longest Utterances (a measure of the upper limit of syntactic complexity). Words Produced is derived from a checklist of 680 commonly produced words, from which parents indicate the ones their child currently says. For Sentence Complexity, parents are given 37 sentence pairs differing in grammatical complexity and are asked to indicate which sentences sound more like their child (e.g., “Where mommy go?” vs. “Where did mommy go?”). Mean of Three Longest Utterances is obtained by having parents write down the three longest utterances they remember hearing their child say. The MLU in morphemes is then calculated.

Preschool Language Scale–3 (PLS-3; Zimmerman, Steiner, & Pond, 1992)—This assessment was administered at 2;6 and 3;6. For the purposes of this study, an individual item analysis was conducted on the Expressive Communication subscale. Of the 48 items on the test, 12 were immediately excluded, as they assessed precursors to language (i.e., preverbal skills). Of the 36 verbal items, 26 were classified in the test manual as assessing either semantic or syntactic skills. The remaining 10 items were classified in an “other” category (e.g., social communication, integrative thinking skills). So that it could be ascertained whether any of these 10 items could be reliably classified as assessing semantic or syntactic skills, 10 individuals with backgrounds in language development (e.g., graduate students in communicative disorders, certified speech-language pathologists) were asked to judge whether each item assessed semantic skills, syntactic skills, or neither. Seven of the 10 items were reliably classified (90%–100% agreement) as assessing either semantics or syntax. The 3 remaining items were excluded from the analysis. Following the individual item analysis, the semantic category included 15 items, and the syntactic category contained 18 items. When administering the PLS-3, it is necessary to establish a basal and ceiling for each child. Therefore, children were given credit for items below their basal (assumed to be correct), in addition to those items answered correctly during administration.

Test of Language Development-3: Primary (TOLD-3:P; Newcomer & Hammill, 1997)—The TOLD-3:P was administered at 4;6 and 5;6. At both time points, children were given the Oral Vocabulary subtest, a semantic measure of children's ability to provide oral definitions of common words. In addition, the Grammatic Completion subtest was administered, which measures a child's ability to use common morphological forms. The Sentence Imitation subtest was included at 5;6. This subtest taps into children's familiarity with word order and syntactic markers. Raw scores were used for the current study. Every subtest on the TOLD-3:P begins with the first item (i.e., no basal needs to be established), and is discontinued after five consecutive zero scores.

Language sample analysis—At each laboratory visit (2;6, 3;6, 4;6, and 5;6), spontaneous language samples were collected from each child and analyzed with Systematic Analysis of Language Transcripts (SALT; Miller & Chapman, 2002). Samples at 2;6 and 3;6 consisted of children conversing with the examiner while playing with toys. At 4;6, children were interviewed by the examiner, following the format of Evans and Craig (1992). Samples at 5;6 consisted of a standard conversational format between the child and examiner about topics relevant to the child's life (e.g., school, recent vacations). Two measures, MLU in Morphemes (MLU; a measure of syntactic complexity) and Number of Different Words (NDW; a measure of lexical diversity), were obtained from each language sample. Both of these measures have been found to positively correlate with increasing chronological age, indicating that they are developmentally sensitive indices of language growth (Miller, 1991). Recently, NDW has become the preferred measure of lexical diversity over type–token ratio (TTR; e.g., Conti-Ramsden & Jones, 1997). *TTR* is the ratio of different word types over total number of words. As explained by Richards (1987), values for TTR tend to decrease as sample size increases. Specifically, this is because with increasing sample size, the variety of different words grows at a slower rate than the raw number of words. Richards recommended using a set number of tokens (versus number of utterances) because of the potential confound of MLU (e.g., when samples are matched on number of utterances, children with higher MLUs produce more tokens than children with lower MLUs, potentially resulting in more word types). For the current study, it was determined that matching samples based on number of tokens was not a viable option because of the low output of the LTs at 2;6. Specifically, matching transcripts on number of tokens resulted in eliminating any differences in lexical diversity between groups and across ages. Therefore, in order to control for the potential confound of MLU, total number of words (TNW) was used as a covariate in both the cross-lagged correlational and linear mixed-effects modeling analyses when a NDW variable was involved.

Utterances were segmented according to communication units, or C-units (Loban, 1976). A *C-unit* consists of an independent clause (subject + predicate) and all associated subordinating clauses. An advantage to using C-unit segmentation is that MLUs are not inflated as a result of run-on sentences that consist of simple sentences joined by coordinating conjunctions. Instead, increasing MLUs more accurately reflect true increases in syntactic complexity. The first 50 complete and intelligible utterances were used for the analyses. Because of the low verbal productivity and reduced intelligibility of some of the younger participants (4 LTs at 2;6; 4 LTs and 2 TDs at 3;6), we combined examiner–child and parent–child transcripts in order to obtain 50 complete and intelligible utterances.

Composite Lexical and Grammatical Rankings Based on Normalized Scores

In addition to examining relationships between individual measures, composite lexical and grammatical rankings at each time point were calculated for each child. (Note that the lexical ranking at 2;0 is not a composite measure, given that only one lexical assessment, CDI: Words, was administered at this time point.) We examined composite scores in order to gain more stable, robust measures of language ability than can be afforded by the individual measures alone. The various measures used in this study assess different aspects of lexical or syntactic ability (e.g., TOLD:P-3 Grammatic Completion specifically assesses grammatical morphology at the word level, whereas SALT: MLU assesses syntactic skills at the utterance level). In order to combine measures from different assessments, we first normalized data from individual measures. The formula for normalizing data was as follows: $(x_i/\max_x) \times 100$ (i.e., individual scores were divided by the maximum score observed across the two groups and multiplied by 100). The normalized scores represent a proportion of the observed maximum score. This method was appropriate for these data given that none of the maximum scores were outliers (i.e., there was no risk of obtaining skewed scores). Mean rankings based on the normalized data were calculated at each time point for lexical and grammatical measures. See Table 3 for means and standard deviations.

Scoring Agreement

Scoring agreement across raters was assessed for all measures. Graduate students in speech-language pathology conducted the independent scoring used in these calculations. To assess interrater scoring agreement for standardized measures, we chose a random sampling of 8 children (4 TD and 4 LTs, 4 boys and 4 girls, 13% of the total sample) from the pool of participants. For each of the standardized measures used in the current study, scoring agreement was calculated at each time point on the basis of total scoring agreements divided by number of total number of scoring judgments. The resulting agreement was high for each standardized measure, ranging from 96.99% to 100% accuracy. Interrater scoring agreement for measures derived from language sample analysis was verified with examiner–child and parent–child transcripts from a random sampling of 10 children (5 TD and 5 LTs, 6 boys and 4 girls) at 2;6, for a total of 20 transcripts. Morpheme-by-morpheme scoring resulted in 92% accuracy (21,178 agreements/23,047 judgments), and utterance segmentation scoring resulted in 96% accuracy (6,115 agreements/6,373 judgments).

Long-Term Outcomes for LTs

One goal of the larger longitudinal project from which these data were originally collected was to track the language status of the late-talking children, and their participation in speech-language intervention. Results of standardized language testing at 5;6 revealed that the majority of LTs had moved into the normal range; however, their average scores were significantly below those of their TD peers (see Table 2), despite being matched for SES and nonverbal cognition. A few LTs (7.5%) did exhibit deficits in expressive language (i.e., scored at least one standard deviation below the mean on the speaking quotient of the TOLD:P-3). A notable percentage of LTs were receiving speech and/or language therapy at 5;6 (37.5%), whereas none of the children in the comparison group was receiving services (see Ellis Weismer, 2007, for a detailed discussion of participant outcomes).

Results

Concurrent Correlations

Prior to analyses of cross-lagged correlations, concurrent correlations (i.e., within the same time point) between individual lexical and grammatical measures were conducted (see Table 4). This analysis involved multiple comparisons, which could increase the risk of statistically significant correlations due to chance alone. To control the Type I error rate, we used the False Discovery Rate (FDR) method (Benjamini & Hochberg, 1995). The FDR method controls the proportion of Type I errors among those tests whose null hypotheses were rejected. The FDR method has more power than the traditional Bonferroni method, which is known for missing real differences while controlling for false discoveries. Results indicated that for both the TD and LT groups, the majority of significant concurrent correlations were between standardized lexical and syntactic measures (e.g., 9 significant correlations of 12 possible for the TD group; 8 significant correlations of 12 possible for the LT group). Correlations involving a language sample measure (i.e., MLU, NDW), either in combination with a standardized measure or in relationship to another language sample variable, tended to be nonsignificant for both groups (e.g., 2 significant correlations of 16 possible for the TD group; 0 significant correlations of 16 possible for the LT group). Significant concurrent relationships were observed beginning at 2;0 for the TD group and were delayed until 2;6 for the LT group. (It should be noted that by definition, LTs produced low scores on all measures at 2;0, therefore the observed delays in relationships among measures at the earliest time points were most likely due to floor effects). See Table 5 for concurrent correlations between lexical and syntactic composite rankings. Results indicated that concurrent composite rankings were moderately to highly correlated for both groups at each time point, except for the 4;6 time point for the TD group and the 2;0 time point for the LT group.

Cross-Lagged Correlations

We performed cross-lagged correlations across adjacent time points in order to address the issue of continuity and directionality in lexical and grammatical development. We again used the FDR method used to adjust the alpha for multiple comparisons. Correlations by themselves are not evidence of causality; however, longitudinal correlational data have been used to examine the relative contribution of earlier measures on later measures (e.g., Bates et al., 1988; Crano & Mellon, 1978; Dionne et al., 2003; Gathercole, Willis, Emslie, & Baddeley, 1992). Cross-lagged correlational analysis is based on the observation that correlations across time and measures are not symmetrical. The resulting asymmetrical pattern of intercor-relations allows for assessment of the relative cross-time contributions of one measure on another (Dionne et al., 2003). For example, if earlier lexical measures are more strongly correlated with later grammatical measures than the reverse (i.e., grammatical measures correlated with later lexical measures), it could be concluded that early lexical development plays a stronger role in later grammatical development during this period (i.e., lexical bootstrapping) than early grammatical development plays in later lexical development (i.e., syntactic bootstrapping).

Cross-lagged correlations: Individual measures—We conducted correlations between individual language measures in order to examine detailed patterns of cross-lagged relationships. In the current study, an inspection of the simple zero-order cross-lagged correlations between individual measures is discussed in a descriptive manner (e.g., Bates et al., 1988). Because of the high number of correlations (84), the adjusted *p* value using the FDR method of alpha adjustment was small ($p \leq .004$), resulting in few significant correlations. Nevertheless, the results revealed differences in the correlational patterns for the TD and LT groups (see Table 6 and Figures 1 and 2). As compared with the TD group, significant correlations between lexical and syntactic measures were delayed and protracted in the LT group. For the TD group, significant relationships were observed beginning at the earliest time point (2;0). No significant cross-lagged correlations were exhibited after 3;6. The LT group did not exhibit significant relationships between measures until age 3;6 and then continued to show evidence of significant cross-lagged correlations until 5;6. Results for the TD group included evidence for both lexical and syntactic bootstrapping between 2;0 and 3;6 (see Table 6 and Figure 1). Specifically, earlier lexical measures were associated with later grammatical measures, suggestive of lexical bootstrapping (CDI Words-2;0 to CDI Complexity-2;6, $r = .649$, $p < .001$; PLS-3 Semantics-2;6 to PLS-3 Syntax- 3;6, $r = .666$, $p < .001$). In addition, earlier grammatical measures were associated with later lexical measures, suggestive of syntactic bootstrapping (CDI Complexity-2;0 to CDI Words-2;6, $r = .588$, $p = .001$; CDI Complexity-2;0 to PLS-3 Semantics-2;6, $r = .508$, $p = .004$; CDI M3L-2;0 to CDI Words-2;6, $r = .531$, $p = .003$). The five observed significant cross-lagged correlations were distributed nearly equally in terms of lexical (two correlations) and syntactic (three correlations) bootstrapping. These findings suggest that bidirectional influences between lexical and grammatical development occurred for TD children between 2;0 and 3;6. The LT group exhibited a pattern of results that was different from that of the TD group (see Table 6 and Figure 2). Specifically, the two significant cross-lagged correlations were both consistent with lexical bootstrapping (PLS-3 Semantics-3;6 to TOLD-3:P Grammatic Completion-4;6, $r = .710$, $p < .001$; TOLD-3:P Oral Vocabulary-4;6 to TOLD-3:P Grammatic Completion-5;6, $r = .570$, $p = .002$).

The significant cross-lagged correlations between lexical and grammatical measures all involved standardized assessments. Relationships involving a language sample measure (MLU or NDW) were nonsignificant (this same pattern was noted previously for concurrent correlations between measures). Although the groups differed significantly on MLU and NDW at 2;6 and 3;6 (see Table 2), their group scores were similar at 4;6 and 5;6. In contrast, the groups significantly differed on standardized tests throughout the course of this study. The lack of difference on language sample measures at the older ages may have been due to the considerable variability in performance in both groups. In addition, the standardized assessments may have taxed the children's linguistic systems to a greater degree, enabling an increased ability to differentiate between the groups' language abilities.

Cross-lagged correlations: Composite rankings of normalized scores—We also conducted cross-lagged correlation analyses on the composite lexical and grammatical rankings at each time point. The majority of individual syntactic measures were moderately correlated at each time point for both groups, indicating that although the measures were related, they were not completely overlapping. In contrast, the majority of concurrent correlations between individual lexical measures were nonsignificant. Specifically, NDW did not exhibit a significant association with the other lexical measures at any time point. One conclusion to draw from these observations is that NDW is not a valid measure of lexical ability. However, the use of NDW as a lexical measure has been a longstanding practice in language research (Miller, 1991). In addition, previous research has shown that children with language impairments exhibit deficits in lexical diversity, as measured by NDW (e.g., Watkins, Kelly, Harbers, & Hollis, 1995). Therefore, it seems likely that NDW is assessing an aspect of lexical development that is not measured by the standardized lexical measures, which would account for the lack of observed associations.

Results for the TD group were similar to the results for cross-lagged correlations of individual lexical and syntactic measures (see Table 5 and Figure 3). Specifically, results indicated bidirectional influences of lexical and grammatical development between 2;0 and 2;6 (Lexical Composite-2;0 to Grammatical Composite-2;6, $r = .630$, $p <.001$; Grammatical Composite-2;0 to Lexical Composite-2;6, $r = .562$, $p = .001$). Results differed slightly between composite scores and individual measures in that significant correlations between composite rankings were not observed after 2;6 (vs. 3;6 for individual measures). Similar to the methodology of Gathercole et al. (1992), we statistically compared the strengths of correlations associated with lexical and syntactic bootstrapping across the same adjacent time points using z transformation (Steel, Torrie, & Dickey, 1997). For example, we compared the correlation associated with Lexical Score-2;0 to Grammatical Score-2;6 with the correlation associated with Grammatical Score-2;0 to Lexical Score-2;6 (and so on for each adjacent time point where significant correlations existed) to examine whether earlier lexical skill more strongly influenced later grammatical skill or vice versa. Results for the TD group did not reveal any significant differences in the strengths of the correlations within adjacent time points, suggesting that lexical and grammatical skills influence each other at later time points more or less equally.

Results of cross-lagged correlations between composite measures for the LT group provided evidence for bidirectional bootstrapping (see Table 5 and Figure 4). Specifically, lexical bootstrapping was observed from 2;6 to 4;6 (Lexical Composite-2;6 to Grammatical Composite-3;6, $r = .445$, $p < .016$; Lexical Composite-3;6 to Grammatical Composite-4;6, $r = .717$, $p < .001$), and syntactic bootstrapping was observed between 4;6 and 5;6 (Grammatical Composite-4;6 to Lexical Composite 5;6, $r = .460$, $p = .021$). The onset of significant cross-lagged correlations was delayed in comparison with the TD group; however, it occurred earlier for the composite measures (2;6) than for the individual measures (3;6). Given that significant correlations were unidirectional across time points (i.e., the corresponding correlations across adjacent ages were insignificant), statistical comparisons of the correlation coefficients were not conducted.

An additional analysis investigating cross-lagged correlations between composite measures was conducted for groups matched on lexical level. Specifically, a subset of the TD group at 2;0 ($n = 19$) was matched with a subset of the LT group at 2;6 ($n = 19$) on the basis of CDI: Words Produced (TD group, $M = 296$, $SD = 98$; LT group, $M = 286$, $SD = 92$), $F(1, 36) = 0.110$, $p = .724$. Results for the TD group indicated relationships of moderate strength consistent with lexical bootstrapping from 2;0 to 2;6 (Lexical Composite-2;0 to Grammatical Composite-2;6, r = .425, p = .070) and syntactic bootstrapping from 2;6 to 3;6 (Grammatical-2;6 to Lexical Composite-3;6, r = .410, p = .091; see Table 7 and Figure 5). These correlations do not reach the conventional levels of statistical significance; however, the smaller number of children in each group and subsequent reduction in statistical power may have contributed to the larger p values. Results for the LT group revealed moderately strong relationships consistent with lexical bootstrapping from 2;6 to 3;6 (Lexical Composite-2;6 to Grammatical Composite-3;6, r = .579, p = .012) and from 3;6 to 4;6 (Lexical Composite-3;6 to Grammatical Composite-4;6, r = .616, p = .011; see Table 7 and Figure 6). Significance levels for these relationships remained high despite the smaller group size. No evidence of syntactic bootstrapping was observed for the LT group.

Linear Mixed-Effects Modeling

We used modeling of lexical and grammatical development over time to compare the developmental trajectories of the groups (Pinheiro & Bates, 2002). Linear mixed-effects modeling was performed only on the language sample analysis data, given that language samples were collected at a sufficient number of time points to justify the use of this analysis. Specifically, NDW was used as a measure of lexical development, and MLU was used as a measure of syntactic development at four different time points (2;6, 3;6, 4;6, and 5;6). As discussed previously, the measure of NDW is confounded by MLU unless the TNW is taken into account (e.g., Richards, 1987). In order to control for this potential confound, we entered TNW into the model as a time-varying covariate for each individual.

The model included both fixed and random effects. Fixed effects included an intercept term, a term for group (TD vs. LT), a term for measure (NDW vs. MLU), and a 3-*df* class variable for age. All interactions among these variables were also evaluated. The random effects included an intercept term and the age variable. This allowed for variability due to subject (intercept term) and for the amount of variability to change at different ages (random age variable). Random effects for group and measure were tested but found not to provide a significant improvement in the fit of the model. Prior to the analyses, MLU and NDW data were normalized using the method described earlier, $(x_i / \max_x) \times 100$, so they could be readily compared and combined within a single analysis (e.g., to examine age by measure interactions). Various models were fit to the longitudinal data, including models with random slope and intercept and those examining linearity. The model presented is the model that provided the best fit to the data. (Models that did not fit the data are not presented. The estimated parameters and p values are misleading if the assumptions of the model are not satisfied.)

Fixed effects—Within the fixed effect variables, there were two significant interaction terms. These include Measure × Age, $F(3, 381) = 11.07$, $p < 0.0001$, and Group × Age, $F(3, 381) = 13.27$, $p < 0.0001$. These interactions indicate that the pattern of increase over time was different for the two measures (NDW and MLU) and for the two groups. In addition, the main effects of measure, $F(1, 381) = 11.48$, $p = .0008$, and age, $F(3, 381) = 44.61$, $p < .0001$, were significant; however these main effects must be interpreted along with the significant interactions. Figure 7 shows group population means for each measure and illustrates the different growth patterns for these measures across time. The three-way interaction of Group × Measure × Age was nonsignificant, indicating that the relationship between NDW and MLU did not significantly differ between groups. In sum, the results for the fixed effect variables indicate that although NDW and MLU showed different developmental trajectories when the TD and LT groups were compared, the relationship between these measures was similar within each group.

Random effects—The following standard deviations summarize the variability between participants at each time point: 2;6 = 1.8%, 3;6 = 1.0%, 4;6 = 2.4%, and 5;6 = 1.3%. A chi-squared likelihood ratio test revealed that the standard deviations were significantly different, $\chi^2(9, N= XX) = 30.3793$, $p < .0001$. The TD and LT groups were combined given that a chi-squared likelihood ratio test found that the two groups were not different in their variability, $\chi^2(5, N = XX) = 8.39$, $p = .132$. These results suggest that although variability between participants changes across time points, a meaningful pattern in variability is not apparent. Figure 8 shows individual developmental trajectories of NDW and MLU by group. The residual standard deviation for within-subject observations is 2.9% (i.e., the variability within an individual which is assumed to be constant over time).

Effect sizes—For the purposes of these analyses, effect sizes were defined as the difference in the means of two groups divided by a pooled estimate of their variability (Coe, 2000). Effect sizes greater than 0.5 or less than −0.5 (i.e., the difference between the means is equal to or greater than the value of half the standard deviation) were considered to be significant. Results indicated that effect sizes for group (TD vs. LT) were significant at 2;6 for both NDW ($d = 0.986$) and MLU ($d = 1.161$), meaning that the groups significantly differed on the two measures at 2;6. Effect sizes for measure (NDW vs. MLU) were significant for the LT group at each time point (2;6, $d = 0.931$; 3;6, $d = 2.99$; 4;6, $d = -0.658$; and 5;6, $d = 1.46$) and for the TD group at each time point except 2;6 (3;6, $d = 1.46$; 4;6, $d = -0.83$; and 5;6, $d = 1.77$). Effects for the age variable (2;6–3;6, 2;6–4;6, 2;6–5;6, 3;6–4;6, 3;6–5;6, and 4;6–5;6) were calculated for each group (TD and LT) and measure (NDW and MLU). Results indicated significant effect sizes for all conditions except the differences in MLU between 4;6 and 5;6 for both the LT and TD groups.

Discussion

The first research question examined whether lexical development continues to predict grammatical development beyond 30–36 months of age for TD children and whether evidence of syntactic bootstrapping would be detected. It was predicted that bidirectional bootstrapping would be observed, and the results confirmed this hypothesis. Specifically, analyses of cross-lagged correlations using both individual and composite language measures of the larger group of TD children ($n = 30$) resulted in bidirectional bootstrapping (i.e., evidence of both lexical and grammatical bootstrapping). These results are consistent with previous work suggesting that once the grammatical system emerges, it facilitates lexical growth, which facilitates grammatical development, and so on (Anisfeld et al., 1998; Bates et al., 1994; Dionne et al., 2003).

The results of cross-lagged analyses using a smaller group formed by lexical matching on CDI: Words Produced also provided evidence of bidirectional bootstrapping. The pattern of results differed from the previous analyses in that bootstrapping mechanisms occurred sequentially rather than simultaneously. Specifically, relationships suggesting lexical bootstrapping were observed from 2;0 to 2;6, followed by syntactic bootstrapping from 2;6 to 3;6. In order to match groups on lexical level, we omitted data from 11 children in each group. The children removed from the TD group tended to be those with the highest lexical levels. Future research focusing on subgroups of children may help to more precisely determine the timing and sequence of bootstrapping mechanisms in TD children.

The results of all three cross-lagged correlational analyses were consistent with recent research showing bidirectional bootstrapping between lexical and grammatical development for TD children (Dionne et al., 2003). These results are in partial support of the continuity view of language development (e.g., Bates et al., 1988; Marchman & Bates, 1994) in that grammar appears to emerge from the lexicon, and they partially support the notion of syntactic bootstrapping, such that grammar was predictive of lexical growth. This interdependence between the grammar and the lexicon is more easily explained by a domain-general, or single-mechanism, conception of language than by a modular, dual-mechanism view. On the other hand, cross-lagged relationships between lexical and grammatical measures were not observed after 3;6. As described by Karmiloff-Smith (1992), the system for language learning may start out as a general processing mechanism. As development proceeds, however, a process of modularization may occur, in which language systems become more autonomous, also know as *emerging modularity*. Bates and Goodman (2001) also speculate that the tightly linked relationship between lexical and grammatical development may be relevant only to the earliest stages of language acquisition. Subsequently, lexical and grammatical systems may dissociate to some extent later in development.

The second research question focused on whether LTs exhibited different patterns of development with respect to the relationship between lexical and grammatical growth compared with TD children. It was predicted that LTs would show less evidence of syntactic bootstrapping than the TD group because of suspected weaknesses in grammatical development, given the proposed overlap between LTs and children with SLI. Two of the three analyses using cross-lagged correlations supported these results. Specifically, relationships between individual measures in the larger group (n = 30) of children and composite measures in the smaller group (n = 19) based on lexical matching were all consistent with lexical bootstrapping, and none were associated with syntactic bootstrapping. Results based on the composite scores for the larger group, however, showed evidence of bidirectional bootstrapping for the LT group, although two of the three significant correlations were consistent with lexical bootstrapping. The difference in results for the two analyses based on composite measures is of interest. When the smaller group was formed on the basis of lexical matching, the 11 LTs whose data were omitted tended to be those with the lowest scores on the CDI: Words Produced at 2;6. As discussed earlier, the cross-lagged analysis performed on the lexical-match group resulted in lexical bootstrapping exclusively. Perhaps the children with the lowest number of words produced tended to be late bloomers who caught up linguistically through syntactic bootstrapping, thereby contributing to the observed correlation consistent with syntactic bootstrapping at the later time point. As noted previously, further examination of subgroups of children could help discern individual differences in the timing of bootstrapping mechanisms.

Overall, cross-lagged correlational analyses showed a pattern of results for the LT group that was different from that of the TD group. To begin, the significant relationships between lexical and grammatical measures were delayed in terms of onset (the lack of observed correlations between the earliest time points were expected, and, as noted previously, were likely due to floor effects) and protracted in terms of duration, particularly in the analysis of individual measures. In addition, the LT group exhibited less evidence of syntactic bootstrapping throughout the period of development included in this study. Specifically, across the three cross-lagged analyses conducted, the LT group exhibited one correlation consistent with syntactic bootstrapping compared with six consistent with lexical bootstrapping, whereas the TD group exhibited a more equal ratio of syntactic bootstrapping (five correlations) to lexical bootstrapping (four correlations). The predominance of lexical bootstrapping for LTs during this period of development could be due to a continuation of the critical mass phenomenon, where lexical growth continues to drive language development beyond the earliest stages of language development. It could also reflect difficulty LTs may have with grammatical aspects of language relative to vocabulary. This grammatical weakness may negatively affect the ability of syntax to bootstrap lexical growth such that using syntactic structure to interpret meaning may be more difficult for late-talking children. In other words, although lexical development facilitates grammar, grammatical development is not as facilitative to lexical growth. Given that LTs are at risk for SLI, which is characterized by particular difficulty in the grammatical (especially morphosyntactic) aspects of language (e.g., Leonard, 1998), these children may be revealing grammatical deficits at this early age.

It is important to point out that the differences in lexical-grammatical relationships observed in the LT group (as compared with the TD group) are not indicative of a dissociation between lexical and grammatical development. Rather, the predominance of lexical bootstrapping observed in the LT children lends support to the continuity and critical mass hypotheses. In addition, the majority of concurrent correlations between standardized measures of lexical-semantic and syntactic skills were significant for both groups at each time point, indicating that these language domains were consistently related throughout development. Moreover, the longitudinal relationships between the language sample measures (NDW, MLU) were similar for both groups. What the current results suggest is that the underlying factors responsible for the language delays in LTs (which initially manifest as delays in productive vocabulary) affect the relationship between lexical and grammatical growth. Specifically, grammatical development does not appear to predict (or bootstrap) lexical development to the same extent in LTs, as compared with TD children.

The results of linear mixed-effects modeling in the present study, which used language sample data only, indicated that the patterns of increase over time were different for the lexical (NDW) and grammatical (MLU) measures. In addition, each group's performance on these measures increased at different rates, as would be expected. However, this analysis did not support a relative difference between lexical and grammatical growth between the two groups of children (i.e., the three-way Group × Measure × Age interaction was not statistically significant). Nonetheless, a visual inspection of the developmental trajectories of the mean values for MLU and NDW (see Figure 7) suggests patterns of growth that would be expected, given what we know about long-term outcomes for LTs. Specifically, for NDW the TD and LT group means were quite distinct at 2;6 (30 months), but by 3;6 (42 months), the trajectories are essentially overlapping. For the grammatical measure (MLU), the two groups also differed sharply at 2;6, as expected, but the LT group did not catch up to the TD group until 4;6 (54 months). These observations are consistent with the literature showing that LTs close the gap more quickly in vocabulary than in grammar. The lack of statistical significance for the three-way interaction was likely due to the high variability within groups, as demonstrated by the overlapping confidence intervals at each time point after 2;6 (see Figure 7). As mentioned earlier, language sample data may not be as sensitive to detecting differences in language ability as compared with standardized assessments, in that language samples tend to be more child centered and may not pressure children's linguistic systems to the same extent. Future research using elicited production tasks or more complex narration at the older ages may reveal consistent differences between the groups.

Conclusion

The current study suggests that TD children showed evidence of bidirectional bootstrapping between lexical and grammatical development between 2;0 and 3;6 years of age, in support of the single-mechanism view of language development. In contrast, LTs exhibited a predominance of lexical bootstrapping and less evidence of syntactic bootstrapping. In fact, when subgroups of TD and LT children matched on lexical level were compared, TD children again showed evidence of bidirectional bootstrapping, whereas the LT group exhibited lexical bootstrapping exclusively. These results are consistent with previous research showing that LTs show a particular weakness in expressive syntax (Paul, 1993; Rescorla et al., 1997, 2000). Therefore, the reduced evidence for syntactic bootstrapping in LTs may be related to their depressed grammatical abilities. As stated by Rice (1991), “The end result would be the opposite of bootstrapping. Instead of using one area of language to build another … children would be left without a solid strap to hang onto” (p. 455).

Limitations of the Current Research

A limitation of the current research was the use of different standardized assessments across the time points. For example, the PLS-3 was used at ages 2;6 and 3;6, and the TOLD-P:3 was used at 4;6 and 5;6. Although the norms of the PLS-3 extend to 6;0, the TOLD-P:3 is a better measure of the upper limits of linguistic ability at 5;6 (especially for children in the TD group and particularly with respect to grammatical complexity). Also, the current study was part of a larger study looking at the outcomes of children with specific language delay; therefore, an additional rationale for switching to the TOLD-P:3 was to match the EpiSLI criteria at kindergarten established by Tomblin et al. (1997) in their epidemiological study on SLI. When language measures change with age, it is more difficult to make direct comparisons of language growth and draw firm conclusions about the specific nature of the observed changes. In addition, statistical methods associated with longitudinal research require identical measures across time points. With an increasing emphasis on longitudinal research in the field of childhood language disorders, language measures that are appropriate across wider age ranges are needed (Cooper & McCardle, 2004). Another limitation included the global nature of the measures that were used in this study. As a result, statements regarding the developmental relationships between grammar and the lexicon can be made on a general level, but conclusions cannot be drawn regarding how specific aspects of syntactic growth (e.g., argument structure, grammatical function words, morphosyntax) affect particular aspects of vocabulary and vice versa.

In addition, the current findings do not rule out the possibility that lexical and grammatical development are associated with a third factor, such as general language ability. According to this view, lexical and grammatical growth are not directly linked but instead are indirectly related via an underlying latent language ability factor. Recent research with bilingual children tested this “third factor” hypothesis (Kohnert & Kan, 2006; Marchman et al., 2004). Bilingual children provide an opportunity to measure lexical–grammatical relationships across languages while holding other child-related factors constant. Results showed that links between lexical and grammatical development were language specific, even after controlling for numerous variables such as age and proportion of language exposure. In sum, the results provided evidence for the view that grammatical development is directly linked to lexical growth, consistent with the continuity view and critical mass hypothesis.

Implications for Future Research

The current results suggest that children with a history of late talking show less evidence of syntactic bootstrapping than TD children. As already mentioned, LTs are at risk for SLI, which is characterized by particular difficulty with syntax and especially grammatical morphology. Therefore, causal explanations for the grammatical weaknesses observed in children with SLI may be applicable to late-talking populations, who continue to exhibit poorer syntactic abilities as compared with their TD peers into the school-age period (Rescorla, 2000, 2002; Thal & Katich, 1996). Several researchers have suggested that children with SLI have particular difficulty in detecting the statistical regularities inherent in language and generalizing the grammatical patterns they do know (e.g., Evans, 2001; Jones & Conti-Ramsden, 1997). Various hypotheses have been put forward to account for this learning deficit, including limited processing capacity (e.g., Ellis Weismer, 1996; Windfuhr et al., 2002). However, more research is needed in order to more clearly define what causes these processing limitations. Further investigation may lead to the delineation of several subgroups of children with SLI who can be grouped according to very specific underlying etiologies. For example, promising new research with functional magnetic resonance imaging suggests that differences in attentional processes may factor into the language deficits observed in SLI (Ellis Weismer, Plante, Jones, & Tomblin, 2005; Plante, 2004). Other areas of future research indicated by the current study include examining lexical–grammatical relationships over a longer period of time (i.e., beyond 5;6) and identifying subgroups of children on the basis of various developmental profiles.

Acknowledgments

Funding for this research was provided by National Institute on Deafness and Other Communication Disorders Grant 5 R01 DC03731, “Linguistic Processing in Specific Language Delay” (S. Ellis Weismer, PI, J. L. Evans & R.

S. Chapman, Co-PIs) and support from the National Institute of Child Health and Human Development P30 core grant awarded to the Waisman Center. We would like to extend thanks to all the children and families who made this research possible. We would also like to thank Chris Hollar for her assistance with data collection and analysis and the graduate students in the Language Processes Laboratory at the Waisman Center who assisted with transcription and reliability.

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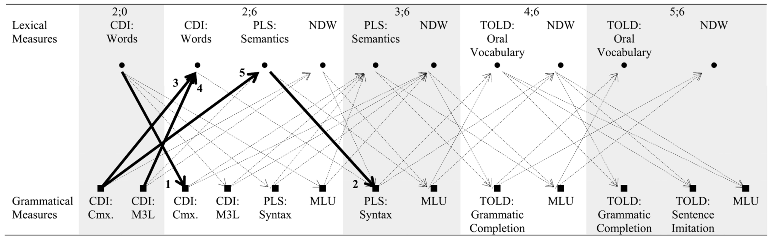

Figure 1.

Typically developing group: Cross-lagged correlations, individual measures (significant correlations are in boldface). CDI = Communicative Developmental Inventory; NDW = number of different words; PLS = Preschool Language Scale; TOLD = Test of Language Development; MLU = mean length of utterance; Cmx. = Sentence Complexity; M3L = Mean of Three Longest Utterances. 1 = CDI: Words 2;0 months to CDI: Complexity 2;6 months (r = .649, p < .001). 2 = PLS: Semantics 2;6 months to PLS: Syntax 3;6 months (r = .666, p < .001). 3 = CDI: Complexity 2;0 months to CDI: Words 2;6 months (r = .588, p = .001). 4 = CDI: M3L 2;0 months to CDI: Words 2;6 months (r = .531, p = .003). 5 = CDI: Complexity 2;0 months to PLS: Semantics 2;6 months (r = .508, p = .004).

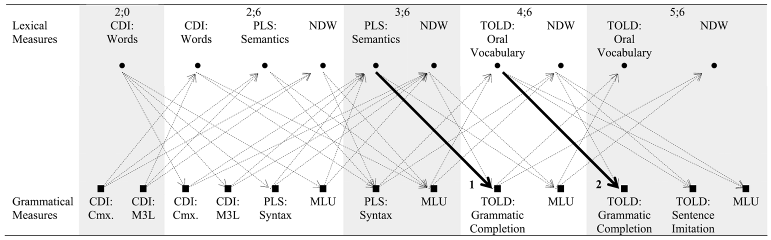

Figure 2.

Late-talking group: Cross-lagged Correlations, individual measures (significant correlations are in boldface). 1 = PLS: Semantics 3;6 months to TOLD: Grammatic Completion 4;6 months (r = .710, p < .001). 2 = TOLD: Oral Vocabulary 4;6 months to TOLD: Sentence Imitation 5;6 months (r = .570, p = .002).

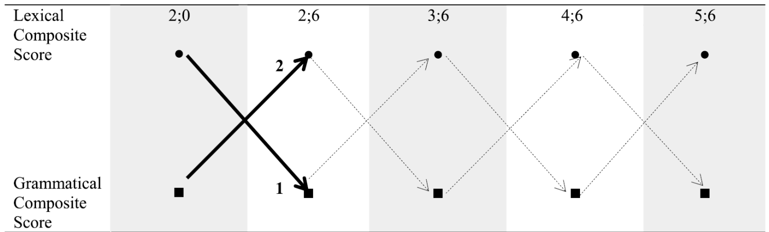

Figure 3.

Typically developing group: Cross-lagged correlations, composite measures (significant correlations are in boldface). 1 = Lexical Score 2;0 to Grammatical Score 2;6 (r = .630, p < .001). 2 = Grammatical Score 2;0 to Lexical Score 2;6 (r = .562, p = .001).

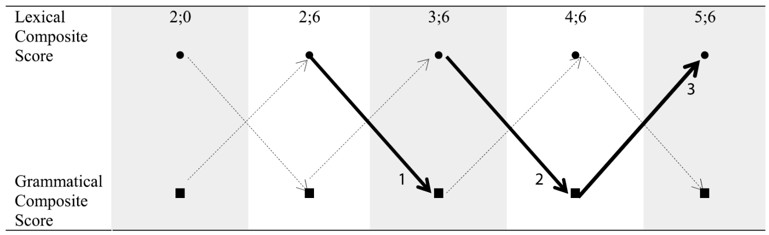

Figure 4.

Late-talking group: Cross-lagged correlations, composite measures (significant correlations are in boldface). 1 = Lexical Score 2;6 to Grammatical Score 3;6 (r = .445, p = .016). 2 = Lexical Score 3;6 to Grammatical Score 4;6 (r = .717, p < .001). 3 = Grammatical Score 4;6 to Lexical Score 5;6 (r = .460, p = .021).

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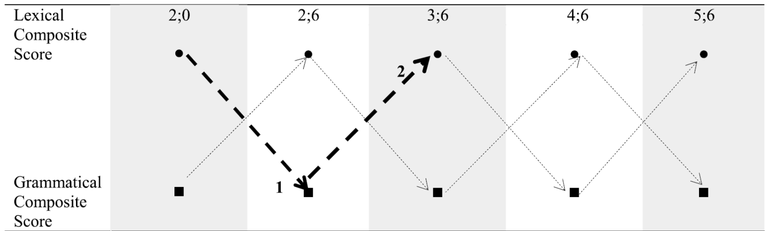

Figure 5.

Typically developing subgroup (lexical matching, n = 19): Cross-lagged correlations, composite measures (correlations that exhibit a trend toward significance are in boldface). 1 = Lexical Score 2;0 to Grammatical Score 2;6 (r = .425, p = .070). 2 = Grammatical Score 2;6 to Lexical Score 3;6 (r = .410, p = .091).

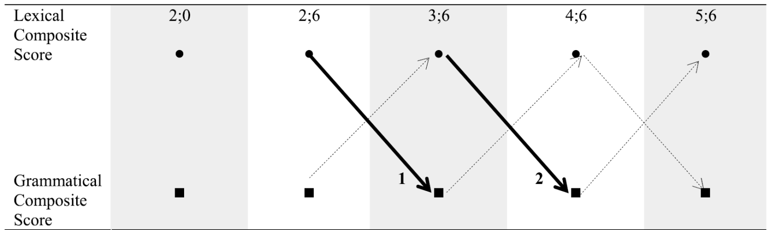

Figure 6.
Late-talking subgroup (lexical matching, *n* = 19): Cross-lagged correlations, composite measures (significant correlations are in boldface). 1 = Lexical Score 2;6 to Grammatical Score 3;6 (*r* = .579, *p* = .012). 2 = Lexical Score 3;6 to Grammatical Score 4;6 (*r* = .616, *p* = .011).

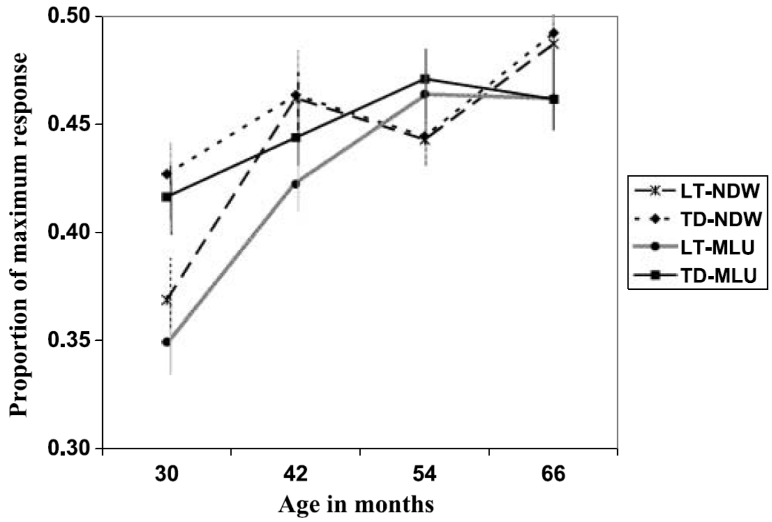

Figure 7.
Population means by measure (number of different words, mean length of utterance) and group (typically developing, late talking). Vertical lines indicate confidence intervals. LT-NDW = Late Talkers–Number of Different Words; TD-NDW = Typically Developing–Number of Different Words; LT-MLU = Late Talkers–Mean Length of Utterance; TD-MLU = Typically Developing–Mean Length of Utterance.

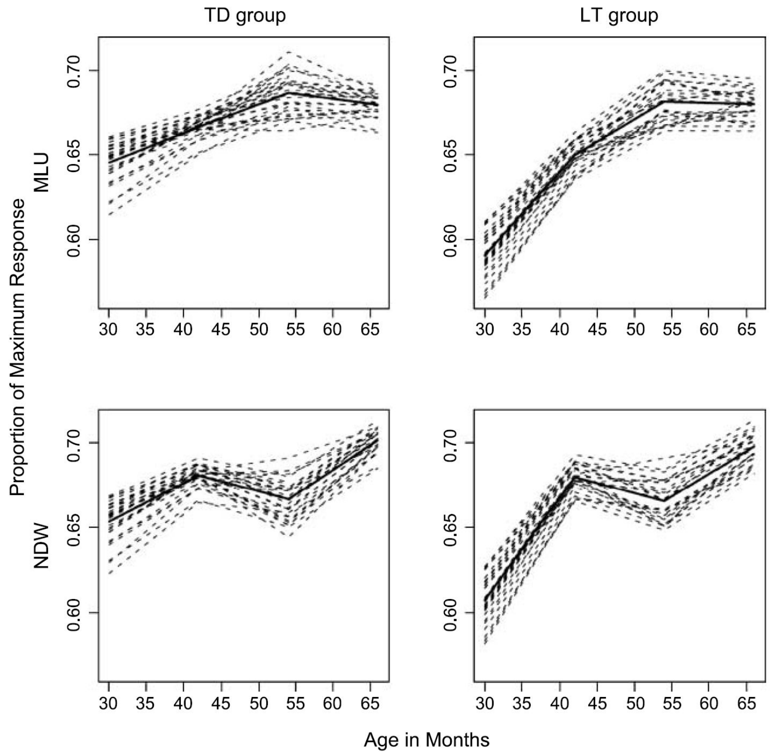

Figure 8.

Individual developmental trajectories (dashed lines) and population means of MLU and NDW for TD and LT groups.

Table 1

Means and standard deviations for background characteristics of late-talking (LT) and typically developing (TD) children.

Variable	LT (*n* = 30)	TD (*n* = 30)
Gender	20 male, 10 female	20 male, 10 female
Heritage	30 Caucasian	29 Caucasian, 1 Biracial (African American/White)
Nonverbal Cognition 2;6[a]	7.53 (1.83)	8.00 (1.26)
Nonverbal Cognition 3;6[a]	10.26 (2.10)	11.00 (1.62)
Nonverbal Cognition 4;6[b,e]		
Fundamental Visual	117.93 (11.68)	110.30 (12.70)
Memory Screen	112.50 (15.28)	107.13 (12.32)
Nonverbal Cognition 5;6[b,f]		
Fundamental Visual	116.50 (8.05)	119.90 (7.11)
Memory Screen	114.88 (16.90)	118.20 (12.01)
SES[c]	15.57 (1.91)	16.27 (1.66)
CA 2;0[d]	23.87 (1.48)	24.00 (1.05)
CA 2;6[d]	29.70 (.54)	29.80 (.66)
CA 3;6[d]	42.23 (.82)	42.20 (.71)
CA 4;6[d,e]	54.04 (.44)	54.03 (.49)
CA 5;6[d,f]	66.25 (.81)	66.00 (.68)

[a]Nonverbal items correct at 2;6 from the Bayley Scales of Infant Development (Bayley, 1993).

[b]Composite scores from the Leiter-R (Roid & Miller, 1996).

[c]Mother's years of education.

[d]Chronological age in months.

[e]Results based on LT = 27, TD = 30.

[f]Results based on LT = 27, TD = 27.

Table 2

Means (and standard deviations) for lexical and grammatical measures obtained at each time point for late-talking (LT) and typically developing (TD) children.

	2;0		2;6		3;6		4;6		5;6	
Measure	**LT**	**TD**	**LT**	**TD**	**LT**	**TD**	**LT**	**TD**	**LT**	**TD**
Lexical measures										
CDI: Words Produced	46.2* (27.2)	376.4 (142.1)	237.0* (109.5)	560.5 (88.4)						
PLS: Semantics			4.2* (.9)	5.7 (1.2)	9.0* (2.9)	11.1 (2.3)				
TOLD: Oral Vocabulary							3.5* (2.3)	7.0 (3.9)	8.9* (5.0)	13.1 (3.6)
SALT: NDW			36.2* (9.4)	55.6 (11.8)	63.5* (9.5)	76.1 (13.6)	97.7 (23.9)	111.5 (15.6)	101.6 (27.7)	114.2 (21.2)
Grammatical measures										
CDI: Complexity	0.2* (0.7)	12.2 (10.4)	5.5* (6.5)	27.5 (7.2)						
CDI: Mean 3 Longest Utterances	1.7* (.9)	5.0 (2.4)	3.6* (1.8)	8.1 (3.0)						
PLS: Syntax			5.2* (2.1)	9.1 (1.4)	11.0* (2.5)	13.4 (2.0)				
TOLD: Grammatic Completion							6.5* (4.2)	10.6 (4.8)	12.5* (5.1)	18.2 (2.7)
TOLD: Sentence Imitation									7.7* (4.9)	15.3 (6.0)
SALT: MLU			1.7* (.5)	2.8 (.6)	3.0* (.6)	3.8 (.8)	5.3 (1.5)	6.0 (.9)	5.0 (1.3)	5.6 (1.3)

Note. CDI = Communicative Developmental Inventory; PLS = Preschool Language Scale; TOLD = Test of Language Development; SALT = Systematic Analysis of Language Transcripts; NDW = Number of Different Words; MLU = Mean Length of Utterance.

* Significant group difference, $p \leq .01$.

Table 3

Mean (standard deviation) lexical and grammatical composite scores (based on normalized data) obtained at each time point for late-talking (LT) and typically developing (TD) children.

Variable and age	LT	TD
Lexical composite		
2;0[a]	6.83 (4.03)*	55.68 (21.01)
2;6[b]	45.48 (10.16)*	76.56 (11.94)
3;6[c]	61.84 (11.86)*	74.78 (10.13)
4;6[d]	45.00 (13.66)*	59.54 (13.07)
5;6[e]	50.46 (15.61)*	64.27 (11.11)
Grammatical composite		
2;0[f]	6.62 (3.92)*	35.88 (22.28)
2;6[g]	31.19 (11.73)*	67.35 (12.16)
3;6[h]	62.82 (12.29)*	77.71 (11.33)
4;6[i]	49.98 (18.05)*	64.46 (15.64)
5;6[j]	46.88 (15.57)*	67.27 (13.76)

[a]Based on CDI Words-2;0 (note that the 2;0 lexical ranking is not a composite measure, given that only one lexical assessment was administered at this time point).

[b]Based on CDI Words-2;6, PLS Semantics-2;6, NDW-2;6.

[c]Based on PLS Semantics-3;6, NDW-3;6.

[d]Based on TOLD-3:P Oral Vocabulary-4;6, NDW-4;6.

[e]Based on TOLD-3:P Oral Vocabulary-5;6, NDW-5;6.

[f]Based on CDI Complexity-2;0, CDI M3L-2;0.

[g]Based on CDI Complexity-2;6, CDI M3L-2;6, PLS Syntax-2;6, MLU-2;6.

[h]Based on PLS Syntax-3;6, MLU-3;6.

[i]Based on TOLD-3:P Grammatic Completion-4;6, MLU-4;6.

[j]Based on TOLD-3:P Grammatic Completion-5;6, TOLD-3:P Sentence Imitation-5;6, MLU-5;6.

*Significant group difference, $p \leq .01$.

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Table 4

Concurrent correlations between individual lexical and grammatical measures.

		Lexical measure									
		2;0	2;6			3;6		4;6		5;6	
Age	Syntactic measure and group	CDI Words	CDI Words	PLS Sem.	NDW[a]	PLS Sem.	NDW[b]	TOLD Oral Vocab.	NDW[c]	TOLD Oral Vocab.	NDW[d]
2;0	CDI Complx.										
	TD	.741*									
	LT	.109									
	CDI M3L										
	TD	.726*									
	LT	.387									
2;6	CDI Complx.										
	TD		.749*	.536*	.119						
	LT		.537*	.156	−.041						
	CDI M3L										
	TD		.399	.370	.122						
	LT		.629*	.464*	.141						
	PLS Syntax										
	TD		.460*	.450*	.275						
	LT		.625*	.436*	.248						
	MLU										
	TD		.309	.623*	.028						
	LT		.345	.133	−.269						
3;6	PLS Syntax										
	TD					.824*	.012				
	LT					.812*	.181				
	MLU										
	TD					.036	−.111				
	LT					.364	−.031				

		Lexical measure									
		2;0	2;6			3;6		4;6		5;6	
Age	Syntactic measure and group	CDI Words	CDI Words	PLS Sem.	NDW[a]	PLS Sem.	NDW[b]	TOLD Oral Vocab.	NDW[c]	TOLD Oral Vocab.	NDW[d]
4;6	TOLD Gram. Comp.										
	TD							.447*	−.054		
	LT							.520*	.240		
	MLU										
	TD							.272	.517*		
	LT							.336	−.240		
5;6	TOLD Gram. Comp.										
	TD									.109	.051
	LT									.500*	.250
	TOLD Sent. Imit.										
	TD									.706*	.101
	LT									.386	.069
	MLU										
	TD									.146	.348
	LT									.215	.138

Note. Sem. = Semantics; Oral Vocab. = Oral Vocabulary; Complx. = Complexity; Gram. Comp. = Grammatic Completion; Sent. Imit. = Sentence Imitation.

[a]TNW at 2;6 was included as a covariate.

[b]TNW at 3;6 was included as a covariate.

[c]TNW at 4;6 was included as a covariate.

[d]TNW at 5;6 was included as a covariate.

* $p \leq .016$, the False Discovery Rate (FDR) adjusted alpha level for the 56 *p* values associated with these correlations.

Table 5

Concurrent correlations (bold squares) and cross-lagged correlations between lexical and grammatical composite scores.

	Age		Lexical composite scores				
			2,0	**2;6[a]**	**3;6[b]**	**4;6[c]**	**5;6[d]**
Grammatical composite scores	2;0	TD	.766*	.562*			
		LT	.372	−.034			
	2;6	TD	.630*	.602*	.366		
		LT	.103	.644*	.088		
	3;6	TD		.308	.724*	.105	
		LT		.445*	.716*	.398	
	4;6	TD			.055	.355	.218
		LT			.717*	.516*	.460*
	5;6	TD				.237	.620*
		LT				.327	.464*

[a]TNW at 2;6 was included as a covariate.

[b]TNW at 3;6 was included as a covariate.

[c]TNW at 4;6 was included as a covariate.

[d]TNW at 5;6 was included as a covariate.

*$p \leq .021$, the FDR adjusted alpha level for the 26 *p* values associated with these correlations.

Table 6

Cross-lagged correlations between individual lexical and grammatical measures.

		Lexical measure									
		2;0	2;6			3;6		4;6		5;6	
Age	Syntactic measure and group	CDI Words	CDI Words	PLS Sem.	NDW[a]	PLS Sem.	NDW[b]	TOLD Oral Vocab.	NDW[c]	TOLD Oral Vocab.	NDW[d]
2;0	CDI Complx.										
	TD		.588*	.508*	.082						
	LT		.143	.200	.127						
	CDI M3L										
	TD		.531*	.423	.148						
	LT		−.107	−.086	.043						
2;6	CDI Complx.										
	TD	.649*				.298	.211				
	LT	.061				.198	.182				
	CDI M3L										
	TD	.500				−.042	−.066				
	LT	.158				.332	.075				
	PLS Syntax										
	TD	.475				.407	−.009				
	LT	.145				.166	.354				
	MLU										
	TD	.279				.338	.223				
	LT	−.009				.317	.123				
3;6	PLS Syntax										
	TD		.314	.666*	.242			.235	.150		
	LT		.470	.366	.101			.512	.058		
	MLU										
	TD		.160	.343	−.143			.107	.565		
	LT		.444	.195	.128			.038	−.029		
4;6	TOLD Gram. Comp.										

		Lexical measure									
		2;0	2;6			3;6		4;6		5;6	
Age	Syntactic measure and group	CDI Words	CDI Words	PLS Sem.	NDW[a]	PLS Sem.	NDW[b]	TOLD Oral Vocab.	NDW[c]	TOLD Oral Vocab.	NDW[d]
	TD					.173	−.276			.231	.084
	LT					.710*	.347			.509	.385
	MLU										
	TD					.159	−.039			.244	−.172
	LT					.454	.413			.393	.059
5;6	TOLD Gram. Comp.										
	TD							.061	−.277		
	LT							.570*	.178		
	TOLD Sent. Imit.										
	TD							.296	−.375		
	LT							.378	−.025		
	MLU										
	TD							−.103	.043		
	LT							.136	.176		

[a] TNW at 2;6 was included as a covariate.

[b] TNW at 3;6 was included as a covariate.

[c] TNW at 4;6 was included as a covariate.

[d] TNW at 5;6 was included as a covariate.

* $p \leq .004$, the FDR adjusted alpha level for the 84 *p* values associated with these correlations.

Table 7

Cross-lagged correlations between lexical and grammatical composite scores based on lexical matching.

	Age		Lexical composite scores				
			2;0	**2;6[a]**	**3;6[b]**	**4;6[c]**	**5;6[d]**
Grammatical composite scores	2;0	TD		.333 (.177)			
		LT					
	2;6	TD			.410 (.091)		
		LT	.425 (.070)		−.058 (.818)		
	3;6	TD		.208 (.407)		.089 (.725)	
		LT		.579* (.012)		.321 (.225)	
	4;6	TD			−.276 (.267)		.437 (.103)
		LT			.616* (.011)		.367 (.178)
	5;6	TD				−.153 (.572)	
		LT				.255 (.340)	

Note. TD $n = 19$, LT $n = 19$. Data are r values (and p values).

[a] TNW at 2;6 was included as a covariate.

[b] TNW at 3;6 was included as a covariate.

[c] TNW at 4;6 was included as a covariate.

[d] TNW at 5;6 was included as a covariate.

* $p \leq .049$, the FDR adjusted alpha level for the 16 p values associated with these correlations.