Modeling the Nature of Grammar and Vocabulary Trajectories from Pre-Kindergarten to Third Grade

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Abstract

Purpose. This study investigated the longitudinal development of two important contributors to reading comprehension, grammar and vocabulary skills. The primary interest was to examine the trajectories of the two skill areas from preschool to third grade.

Methods. The study involved a longitudinal sample of 420 children from four sites. Language skills including grammar and vocabulary were assessed annually with multiple measures. Multivariate latent growth curve modeling was used to examine the developmental trajectories of grammar and vocabulary, to test the correlation between the two domains, and to investigate the effects of demographic predictors on language growth.

Results. Results showed that both grammar and vocabulary exhibited decelerating growth from preschool to grade 2. In grade 3 grammar growth further flattened while vocabulary continued to grow stably. Growth of vocabulary and grammar were positively correlated. Demographic characteristics such as child gender and family socioeconomic status were found to predict the intercept but not the slope of the growth trajectories.

Conclusions. Children's growth in grammar skills is differentiated in a number of important ways from their growth in vocabulary skills. Results of this study suggest the need to differentiate these dimensions of language when seeking to closely examine growth from preschool to primary grades.

Modeling the Nature of Grammar and Vocabulary Trajectories from Pre-Kindergarten to Third Grade

Language development is one of the most renowned and well-documented accomplishments of the early childhood years. From the time of the first birthday into the early primary grades, children's language growth exhibits a very steep trajectory, influenced by both genetic and environmental factors (Hayiou‐Thomas, Dale, & Plomin, 2012). The relatively slow developments in language skill observed during the first year of life, such as the emergence of canonical babbling and referential gestures (Eilers et al., 1993), are followed in the second year of life by what is often described as a language 'spurt' (Ganger & Brent, 2004): children begin to acquire numerous new words per day and to combine these words into two- and three-word combinations to express increasingly complex needs and interests. Over the forthcoming years, from two to about nine years of age, children will achieve a near-mature adult-like language system (Gleitman, Gleitman, & Shipley, 1972), with neurobiological correlates (e.g., syntactic density in the language-processing areas of the brain) approximating the adult range (Huttenlocher, 2009). The rapid advances in language skill, based on behavioral indices, as well as corresponding changes in the functional anatomy of the language processing systems of the brain, contribute to the perspective that the first eight or nine years of life are a 'sensitive period' for language acquisition (Fox, Levitt, & Nelson, 2010).

Two domains of language skill often of interest to researchers as well as other constituents, including preschool and primary-grade teachers, are grammar and vocabulary, especially given their strong contribution to reading achievement. Recent work shows that children's grammar and vocabulary skills at third grade are among the strongest correlates of skilled reading comprehension, even as compared to other prominent predictors including word

recognition, working memory, and higher-level language processing (e.g., comprehension monitoring, inferencing) (Language and Reading Research Consortium & Logan, in press). Further, the contribution of grammar and vocabulary to reading comprehension spans the entire continuum of reading-comprehension skill, explaining significant amounts of variance in comprehension for poor, average, and above-average readers (Language and Reading Research Consortium & Logan, in press). The importance of these domains of language skill to children's performance in a particularly important area of formal schooling, namely reading achievement, has contributed to a growing interest in advancing our understanding of the nature of children's growth in vocabulary and grammar skills from early into middle childhood.

In the present study, we examined children's growth in grammar and vocabulary skill from an average of five to ten years of age, spanning pre-kindergarten to third grade. Of special interest was examining the shape of growth trajectories in these two linguistic domains over these grades and the relations among the domains developmentally. This study therefore employed multivariate latent growth modeling to advancing our understanding of children's language development as they transition from preschool into the primary grades.

With respect to examining the shape of growth trajectories, there is considerable evidence showing that children's grammar and vocabulary skills incrementally and continuously grow over time, such that children who comprehend very few words and have very primitive grammars at age one have thousands of words and complex grammatical systems by adolescence. Experts contend that continuous growth in language skill across early childhood represents an ongoing restructuring of grammatical rules and lexical representations reflective of ongoing exposure to linguistic stimuli within the environment (Pinker, 2015; Verhoeven, van Leeuwe, & Vermeer, 2011). However, we do not have a full understanding of the shape of the

trajectories in each of these linguistic domains, beyond recognizing that there is a general upward trend in both grammar and vocabulary skills over time. Some researchers have suggested that the rate of learning new words and grammatical rules increases over time, based on patterns observed during very early childhood (Ganger & Brent, 2004), characteristic of an accelerating trajectory. However, it is unclear whether acceleration describes language trajectories only among the very young, or whether this pattern lasts into adolescence or even adulthood. To the latter point, others have asserted that linguistic growth will naturally plateau when children's skills achieve maturation, suggesting that linguistic trajectories will eventually decelerate to a point of plateau (McKean et al., 2015). To date, understanding of the shape of grammar and vocabulary trajectories is largely piecemeal, given a lack of longitudinal research that transcends the early childhood period and includes measures of both vocabulary and grammar development.

Some evidence focused specifically on the shape of trajectories for vocabulary growth has suggested that early acceleration in this domain of development may eventually give way to deceleration. Rowe and colleagues noted this trend in a sample of very young children, whose vocabulary trajectories were examined from one to nearly four years of age (Rowe, Raudenbush, & Goldin‐Meadow, 2012). With nine measurement occasions over this period of time, these researchers were able to carefully examine the shape of early vocabulary trajectories, finding that an initial period of acceleration, such that the yearly rate of growth increased initially, was followed by deceleration at the later observations. This result articulates well with findings presented by Farkas and Beron, which involves analysis of vocabulary trajectories for children from 3 to 12 years of age (Farkas & Beron, 2004). Using longitudinal data from the Children of the NLSY79 (n = 10,366), which included receptive vocabulary scores for children at irregular

intervals from age three forward, these researchers were able to plot vocabulary trajectories by children's age in months from 3 to 12 years of age; the shape of the trajectories over this time was examined using three-month moving averages. Consistent with perspectives that linguistic skills continuously develop, Farkas and Beron found that vocabulary scores increased about 1.4 points of the standardized measure for every month of age. Further, this study also showed a pattern of deceleration, with a flattening of the vocabulary trajectory occurring at around 7 years of age. Study findings were interpreted to show that the greatest gains in vocabulary occurred between 3 to 6 years of age, followed by declining rates of growth. This finding converges with work using an alternative approach to estimating children's growth in vocabulary skill, which examined standardized gains in vocabulary based on age-based norms presented in commercially available norm-referenced assessments involving thousands of children (Schmitt, Logan, Tambyraja, Farquharson, & Justice, 2017). Analysis of standardized gains annually for children from 3 to 9 years also suggested a pattern of deceleration in gains over time. From 3 to 4 years of age, children's vocabulary scores increased nearly one standard deviation unit (d = .95) whereas from 8 to 9 years children's scores improved one-half of a standard deviation unit (d = 0.46).

We have far less understanding of trajectories specific to grammar development than we do for vocabulary. While longitudinal studies of children's language development have included measures of grammar (Catts, Fey, Zhang, & Tomblin, 1999; Storch & Whitehurst, 2002), these data have not been used to examine the shape of grammatical trajectories over time, with two noteworthy exceptions. First was a study that explored grammatical trajectories during the toddler and preschool years, with collection of six measures of complex syntax between 22 and 42 months of age (Vasilyeva, Waterfall, & Huttenlocher, 2008). Longitudinal analysis showed an incremental linear increase in grammar skills over these ages, although the shape of the

trajectories was not statistically analyzed. Relying on analysis of variance procedures and visual inspection of the trajectories, the authors noted that one subgroup of children, namely children from low-income homes, showed a "divergent" pattern in their grammatical trajectories characteristic of deceleration over time and a possible plateau in their growth. This pattern was contrasted to that of advantaged children, who showed a positive, linear trajectory of grammar growth to the final time-point. Second, researchers explored growth in grammar skills from 7 to 11 years in a sample comprising only children with specific language impairment (SLI) (Law, Tomblin, & Zhang, 2008). The authors suggested that the pattern of grammar trajectories over these years was consistent with deceleration/declining growth rates. Although intriguing, these data do not necessarily help us to understand the shape of grammar trajectories as children matriculate into the primary grades and for children who are typically developing. To address this limitation in the literature, the present study specifically examines the shape of children's trajectories in grammar development from pre-kindergarten to third grade; further, by doing this concurrently with analysis of vocabulary trajectories, we can determine whether children's development in grammar and vocabulary follow a similar or distinct trajectory.

Improving our understanding of developmental trajectories in language skill may be useful for understanding the nature of language disabilities and differences. For instance, some have suggested that a divergence in linguistic trajectories over time may serve as an important diagnostic indicator of underlying language disability and/or risk for reading-comprehension difficulties (Justice, Mashburn, & Petscher, 2013; Rice, Wexler, & Cleave, 1995). Justice and colleagues demonstrated how children who would go on to have reading comprehension difficulties at grade five showed a pattern of linguistic divergence from other children from approximately two to five years of age, with their skills declining relative to children who would

go on to be good readers. To this end, Hoff (2013) has argued the importance of identifying groups of children for whom their language trajectories may signal the potential for negative consequences; for instance, children whose grammar development decelerates significantly over time when other children's are accelerating require prompt remediation efforts.

However, a recent study raises questions as to whether trajectories over time serve to differentiate groups of children as a function of their language skill. Specifically, Klem and colleagues examined trajectories of language skill, based on a latent variable, for profiles of children whose classification was based on language skills at age 4 (Klem, Hagtvet, Hulme, & Gustafsson, 2016). The profiles essentially conveyed children's language skills in terms of being high-performing, average-performing, and low-performing. While the groups differed significantly at age 4, with the low-performing children showing a large initial gap in skills compared to the other two groups, their trajectories from age four to age six did not vary significantly. Given such findings, it raises questions as to whether the shape of children's trajectories over time does, in fact, serve to differentiate groups of children. A limitation of the Klem et al study is that the authors used a latent-variable approach to represent children's language skills over time, which may then mask even subtle differences in trajectories across different linguistic dimensions represented in the latent variable, including vocabulary and grammar. Further, this study only examined trajectories over a two-year timeframe; to fully understand children's linguistic trajectories, it may be necessary to examine them over a broader developmental period.

The present study seeks to improve our understanding of the nature of typical language-development trajectories over the early primary grades, examining vocabulary and grammar simultaneously and over a lengthy period of time as children transition from preschool learning

environments to formal schooling. This study provides an in-depth investigation of the growth curves of vocabulary and grammar, examines their interplay, and tests the effects of potential predictors on the trajectories, namely child gender and socioeconomic status (SES). These predictors were selected for inclusion given prior evidence in the literature that both are associated with the nature of child language development during the years of early childhood (Hoff, 2003, 2013; Simonsen, Kristoffersen, Bleses, Wehberg, & Jørgensen, 2014). We are particularly interested in determining whether there is linear growth in these trajectories or whether, as some have theorized, there is deceleration in growth as children get older. While in the present study our goal is not to investigate whether there are certain subgroups of children whose trajectories diverse from what is typical, the present work is foundational for such efforts as it is designed to identify what is normative in grammar and vocabulary trajectories during early childhood.

Methods

Participants

Children were participants in a larger longitudinal study conducted by the Language and Reading Research Consortium (LARRC) on the development of language skills and reading comprehension, in which children were followed from pre-kindergarten for five consecutive years, with the majority of children in grade 3 at the final testing point. Recruiting and sampling activities were conducted in parallel at four university-based research sites in four states, three in the mid-west and one in the south-west. Recruitment activities were largely concentrated in public and private preschool programs serving as partners to the research sites. The sampling approach is thoroughly discussed elsewhere (see LARRC, Farquharson, & Murphy, 2016).

The total sample consisted of 420 pre-kindergartners (245 boys, 175 girls) enrolled when they were, on average, 60.5 months of age (range 44 to 73 months, *SD* = 4.35). The children came from 44 different preschools and were nested within 87 preschool classrooms (average number of classrooms per school: *M* = 1.98; range: 1 – 5). The mean number of children per classroom was *M* = 4.83 (*SD* = 3.86), with a range of 1 to 22 children. As shown in Table 1, a majority of the participating children were white (94.6%), with a similar percentage speaking English as their primary language at home (97.6%). Primary caregivers provided information regarding maternal education and status of free/reduced lunch, to serve as indices of the children's socioeconomic status. Overall, 15% of the children received free or reduced price lunch. For maternal education, indexed as highest credential earned, 14% of mothers had a high-school diploma or some high-school education; 21% had some college but no degree; 42% had a two- or four-year college degree; and 23% had an advanced degree.

Procedures

Preschool programs were recruited to partner for this longitudinal study in the fall of the 2010 academic year. Partnering programs' roles included assistance with recruiting and consenting children, providing locations for assessing children, allowing teachers to complete questionnaires about children enrolled in the study, and permitting researchers to conduct classroom observations (not used in this study).

Children were typically enrolled in the study in the fall of the year, and then subsequently tested in multiple sessions over an approximately five-month timeframe between January and May of each academic year through grade three. Children completed numerous assessments in order to span the constructs of relevance in the larger study, namely language and reading skill; the entire battery of measures is presented under separate cover (Language and Reading

Research Consortium, Farquharson, & Murphy, 2016). The assessments were administered in blocks, with no block lasting more than 60 minutes. The measures were administered in a quiet room within the child's school, local university site, community center, or home by trained research staff. Prior to working in the field, staff completed a multi-pronged training program for each measure, consisting of tutorials for each measure, practice with test administration, and observations by a senior assessor.

For the purposes of the present research study, three measures were used to represent children's grammar skills and two measures to represent vocabulary. The use of multiple indicators can reduce measurement error represented in individual tests and provide a more comprehensive representation of the constructs. For each of the five measures, the same test was administered every year from preschool to third grade. The selected measures are widely relied upon by researchers to measure the constructs of grammar and vocabulary developmentally (e.g., Frijters, Barron, & Brunello, 2000; Van der Lely, Rosen, & McClelland, 1998; Vargha-Khadem, Watkins, Alcock, Fletcher, & Passingham, 1995), thus our results can be directly applicable to future research on grammar and vocabulary development.

Grammar. Two standardized measures were used to assess children's language skills in the domains of grammar: the *Clinical Evaluation of Language Fundamentals-4* (CELF-4; Semel et al., 2003), and the *Test for Reception of Grammar–2* (TROG; Bishop, 2005). Specifically, we selected two subtests of the CELF-4 to measure grammar, namely Word Structure (CELF-WS) and Recalling Sentences (CELF-RS). For Word Structure, the examiner used a cloze procedure to elicit target morphemes from children (e.g., the plural marker); the subtest is designed to assess children's knowledge of inflectional and derivational morphology. For Recalling Sentences, children listened to spoken sentences of increasing length and complexity, and

repeated the sentences without changing word meaning and content, word structure (morphology), or sentence structure (syntax); this subtest evaluates children's semantic, morphological, and syntactic competence. TROG was used to assess children's comprehension of English grammatical contrasts marked by inflections, function words, and word order. Test items are arranged in 20 blocks of four, each block assessing knowledge of the same grammatical contrast. For each item, the child was shown four pictures and the assessor read the accompanying sentence and asked the child to point to the picture for that sentence.

Vocabulary. The *Peabody Picture Vocabulary Test- 4* (PPVT; Dunn & Dunn, 2007) Form A, and the *Expressive Vocabulary Test-2* (EVT-2; Williams, 1997) were used to assess children's vocabulary. For the PPVT, children were presented test plates that provided four possible responses to a spoken single-word stimuli (e.g., crawling). The child selected the response to the spoken stimuli, and test plates were continually presented until the test's ceiling rules were reached. For the EVT-2, children are presented with pictures and need to provide labels or synonyms that fits the pictured context. Items were administered in order of increasing difficulty until test ceiling is reached.

Analytic Strategy

Children's raw scores on the measures of grammar and vocabulary at up to five time-points per child were used to analyze growth in these skills. Since grammar and vocabulary were treated as latent constructs, longitudinal measurement invariance was first established to ensure that the same constructs were being measured across time (Little, 2013). Subsequently, the trajectories of grammar and vocabulary development were estimated using multivariate latent growth curve modeling (MLGM; Figure 1). Once the shapes of the trajectories were identified, we further compared the growth of grammar against that of vocabulary, and examined the

correlation between the growth parameters. Reciprocal relations between the two constructs were also tested. Finally, we explored the roles of children's gender and SES in predicting the intercept and slope of language growth. Mplus Software Version 7.11 (Muthén & Muthén, 1998-2012) was used for model estimation in all analyses. Model fit was assessed by chi-square ($\chi 2$) test, root mean square error of approximation (RMSEA; values of .08 or less are desirable), comparative fit index (CFI; values of .95 or above are desirable), and root mean square residual (SRMR; values of .08 or less are desirable). See guidelines by Browne and Cudeck (1993), Hu and Bentler (1995, 1999).

As is typically the case in longitudinal investigations, there was missing data at each time-point. Data were missing due to inability to collect a given measure from a given child as well as attrition of children from the overall study. Overall, the percentage of missing data ranged from 0.5% to 23.3% for the grammar measures, and from 0% to 22.6% for vocabulary, with increasing missingness for the latter time points. Instead of listwise deleting missing data, which leads to reduced sample size and potentially biased results (Graham, 2012), we used full information maximum likelihood (FIML; Arbuckle et al., 1996) to treat missing data. When our hypothesized latent growth models are correctly specified, and the missing-at-random (MAR) assumption is plausible, the estimates derived from FIML should be unbiased (Little, Jorgensen, Lang, & Moore, 2014).

Results

Preliminary Assessment of Grammar and Vocabulary Measures

Descriptive information among the primary study variables is displayed in Table 2. On average, children's observed grammar and vocabulary scores increased substantially over the five-year period. As compared to the baseline (preschool year), scores on the grammar measures

increased by 2.3 (CELF-WS and RS) and 2.8 (TROG) standard deviations (*SD*) on average, while scores on the vocabulary measures increased by 3.2 (PPVT) and 3.0 (EVT) *SD*s. On average, scores of grammar assessments collected at preschool and at grade 3 were correlated at 0.506 (R^2 = 25.6%), and scores of vocabulary were correlated at 0.708 (R^2 = 50.1%).

Across the five time points, the correlations between the grammar measures ranged from 0.39 to 0.91 (Mean = .60), and the correlations between the vocabulary measures ranged from 0.64 to 0.86 (Mean = 0.74). The concurrent correlations between vocabulary and grammar were also high, ranging from 0.46 to 0.70 (Mean = 0.61). These correlational patterns provided basis for the latent variable model, and suggested that children's vocabulary and grammar development was intricately related.

Longitudinal Measurement Invariance of Grammar and Vocabulary

Before employing latent growth modeling to investigate developmental trajectories, we first established construct validity as well as longitudinal measurement invariance for grammar and vocabulary. A good fit of the measurement model provides evidence for our hypothetical factor structures, that is, that grammar skills underlie scores on the CELF-WS, CELF-RS and TROG, while vocabulary skills underlie scores on the PPVT and EVT. Moreover, measurement invariance indicates that the factor structures are robust across time, and thus the latent construct is psychometrically equivalent and longitudinally comparable. Based on the guidelines of Little (2013), we tested configural invariance, metric invariance, and scalar invariance consecutively using structural equation modeling (SEM). As shown in Table 3, there was evidence of longitudinal invariance for vocabulary, and evidence of partial invariance for grammar. As argued by Little (2013, pp.159), partial invariance still provides reasonable ground for discussing

changes in the underlying constructs as long as the majority of the loadings and intercepts do not change meanings over time.

Overall, the final longitudinal measurement models had satisfactory fit (Grammar: χ^2 = 142.03, df = 60, $p < 0.001$, CFI = 0.983, RMSEA = 0.057, SRMR = 0.072; Vocabulary: χ^2 = 25.71, df = 13, $p = 0.019$, CFI = 0.997, RMSEA = 0.048, SRMR = 0.031). High factor loadings were observed in all indicators, ranging from 0.666 to 0.809 for grammar, and from 0.818 to 0.913 for vocabulary.

Shape of Growth Trajectories for Grammar and Vocabulary

The primary aim of this study was to determine the shape of children's growth trajectories in language skills from preschool to third grade. Multivariate latent growth curve modeling was used to analyze the five-year development of the two latent outcomes, grammar and vocabulary, simultaneously. Since the shapes of the trajectories were yet unknown, we freed the growth curve by setting the factor loadings from latent slope to year 3-5 outcomes as unconstrained parameters (Figure 1). This approach allows us to capture any potential non-linearity in the estimated growth trajectories. The LGM fits the data well (χ^2 = 432.970, df = 234, $p < 0.001$, CFI = 0.979, RMSEA = 0.045, SRMR = 0.061), and results of the model are listed in Table 4.

Given that baseline grammar and vocabulary were represented by latent variables with means of 0 and *SD*s of 1, grammar increased by 1.054, 0.877, 0.684, and 0.464 *SD* units over the course of five years, while vocabulary increased by 1.200, 0.930, 0.812, and 0.774 *SD* units. To statistically investigate the shape of the growth curves, we compared the free-form model against a series of alternative latent growth models, where growth rates are constrained to be equal across the entire trajectory or a segment of that. First, assuming constant growth for either

grammar or vocabulary led to a substantial drop in model fit ($p < 0.001$), suggesting non-linear growth patterns. Second, significant deceleration of growth was detected for both grammar and vocabulary from year 2 to year 3 ($p = 0.002$ for grammar, $p < 0.001$ for vocabulary) and from year 3 to year 4 ($p < 0.001$ for grammar, $p = 0.010$ for vocabulary). From year 4 to year 5 however, only grammar experienced a decrease in growth rate ($p < 0.001$).

Seeing that the growth patterns of vocabulary and grammar were potentially different, we further juxtaposed their trajectories by comparing the model fit of free-form model and a series of constrained models. The hypothesis that the growth curves of grammar and vocabulary shared the same shape was rejected ($p < 0.001$), and vocabulary had generally faster growth than grammar, as indicated by a steeper latent slope ($p = 0.032$). Closer examination revealed that the two trajectories diverged significantly in year 5 (third grade), where grammar growth flattened while vocabulary maintained momentum. Figure 2 provides a visual representation of the estimated growth curves. As shown on the plot, by the end of year 5 vocabulary skills increased by 3.71 *SD* units as compared to the baseline, while grammar gained 3.08 *SD* units.

While the growth trajectories thus far discussed represent the average trends of grammar and vocabulary development, substantial individual differences existed in our sample, as evidenced by the significant variance of latent slopes. The LGM also revealed a negative correlation between intercept and slope (r = -0.575 for grammar, -0.249 for vocabulary), implying that children with lower language skills at baseline tended to have more rapid growth.

Correlation between Grammar and Vocabulary Trajectories

To investigate the relation between grammar and vocabulary developmental trajectories, we examined the correlation between latent growth parameters in LGM (Table 4). These analyses showed that baseline grammar skill was positively and highly related to baseline

vocabulary level (r = 0.935), as was the slope of the grammar trajectory to the slope of the vocabulary trajectory (r = 0.912). This implies that preschool children who are advanced in vocabulary are also likely to be advanced in grammar, and that children making rapid gains in vocabulary subsequently are likely to make commensurate level of gains in grammar as well.

Predicting Grammar and Vocabulary Growth from Child Gender and SES

Lastly, we examined the roles of child gender and SES in the prediction of language growth. We again employed the free-form latent growth model, now including child gender, maternal education, and free/reduced lunch status as predictors of latent growth parameters. The latter two variables were both included as estimates of child SES. The highest level of mother's education was coded into three categories (high school or less, associate or bachelor's degree, and advanced degree), which were in turn converted into two dummy variables, with high school or less as the reference category. As shown in Table 5, the model has satisfactory fit (χ^2 = 538.302, df = 318, p < 0.001, CFI = 0.977, RMSEA = 0.041, SRMR = 0.060), and estimation of growth parameters and trajectories remained stable. The predictors accounted for 15.9% of the variation in grammar intercept, 5.2% in grammar slope, 13.4% in vocabulary intercept, and 0.4% in vocabulary slope.

While child gender did not appear to predict the growth parameters, maternal education significantly predicted the initial level of grammar and vocabulary (grammar: b = 0.323, p = .022; vocabulary: b = 0.334, p = 0.026). In other words, children whose mother had an advanced degree were expected to have approximately 0.3 *SD* of an advantage over the reference group in grammar and vocabulary skills at baseline. On the other hand, free or reduced lunch status negatively predicted the latent intercepts (grammar: b = -1.034, p < .00; vocabulary: b = -0.940, p < .001), implying that children who received free or reduced lunch had approximately

one *SD* disadvantage in initial language skills compared to their counterparts. None of the demographic characteristics examined predicted latent slopes, indicating that the developmental trajectories of grammar and vocabulary were not conditional on child gender or SES, only the starting point (i.e., intercept).

Discussion

Children's grammar and vocabulary skills during early and middle childhood have long been of interest to theorists, researchers, and practitioners (Farkas & Beron, 2004; Ganger & Brent, 2004; Rowe et al., 2012); however, our understanding of the nature of change in these skills as children move from preschool into formal schooling is far from complete. Important questions remain, including whether these different dimensions adhere to similarly shaped growth trajectories and whether language growth continuously grows across these years or whether trajectories plateau and/or decelerate at a given point. Pragmatically, understanding the nature of linguistic growth across this period of time may be especially useful for identifying children whose growth is distinguishable from what is typical, including children with language impairment, and providing them enrichment and potentially therapeutic opportunities (Klem et al., 2016). This study addressed key gaps in the literature by examining children's trajectories in grammar and vocabulary over a five-year span transcending pre-kindergarten to third grade, using multivariate latent growth curve modeling.

Our first contribution to the literature is showing that there are several salient ways in which children's pre-kindergarten skills and growth trajectories in grammar and vocabulary are distinguishable. First, children showed greater stability in their vocabulary skills over time as compared to grammar; preschool grammar indicators explained on average 25% of the variance in third-grade grammar, whereas preschool vocabulary indicators explained 50% of variance in

third-grade vocabulary. This suggests that grammatical skills may be more malleable than vocabulary skills over this period of time, which may help to explain why interventions focused on vocabulary development delivered to children across the early primary grades tend to have only very modest effects on general vocabulary knowledge (Coyne, McCoach, & Kapp, 2007). There are relatively few examples of grammar interventions delivered to children outside of those designed for clinical populations, but one recent study showed relatively robust effects of a grammar-focused intervention delivered to pre-kindergarten through first graders, suggesting that grammar skills can be positively influenced by targeted interventions (Phillips, 2014).

Some experts have suggested that five years of age represents a time-point in which children's vocabulary skills become stable, following a period of great instability during the toddler and preschool years (Duff, Reen, Plunkett, & Nation, 2015). Duff and colleagues' examination of growth in vocabulary skills from toddlerhood (18 to 24 months) to around eight years of age showed that early vocabulary skills explained about 16% of the variance in vocabulary at eight years, whereas our study showed that vocabulary at about five years explained 50% of the variance in vocabulary at grade three. A comparison of these results do suggest that vocabulary skills become increasingly stabilized over time, and more so than grammar skills. Such work presents an interesting complement to recent cross-sectional research showing that children's language skills become increasingly dimensional from pre-kindergarten to third grade; while language skills at pre-kindergarten are best represented as a unitary construct, over time there is a divergence among vocabulary, grammar, and discourse skills (Language and Reading Research Consortium, 2015). The distinguishing trajectories of grammar and vocabulary as reported in this longitudinal study may contribute to this emergent dimensionality.

Second, evaluation of growth trajectories for grammar and vocabulary showed that these are distinguishable: while both grammar and vocabulary development showed a pattern of deceleration from preschool to second grade, grammar development continued to decelerate through third grade, whereas vocabulary development showed stability after second grade to third grade (no ongoing deceleration). With respect to the decelerating pattern of growth in children's grammar trajectories, this was not entirely unanticipated, given a long-standing perspective in the developmental literature that children's grammatical skills will plateau as they near adolescence; such perspectives view grammatical development as constrained by a critical, or sensitive period, corresponding to maturational constraints (Fromkin, Krashen, Curtiss, Rigler, & Rigler, 1974; Long, 1990). Neurobiologically, the plasticity of the syntactic-processing regions of the human brain appear to mature much earlier in time than the semantic-lexical processing regions of the brain (Hofman et al., 2002). A lengthy neural window for grammar is not theoretically necessary, as grammatical development largely involved acquiring a finite set of rules (Chomsky, 2002). In other words, the developmental set to be acquired is finite/closed.

The pattern of deceleration of vocabulary observed in this study has been suggested previously in some research. Specifically, Farkas and Beron (2004) studied vocabulary growth for children from three to twelve years of age, and showed a point of deceleration when children were about seven years of age. However, the present study showed a slightly different pattern: vocabulary generally and slightly decelerated from five to about eight years of age, but then a positive linear trajectory from eight to nine years of age. This suggests the need to explore differences between our study and that of Farkas and Beron, especially given that both studies utilized the PPVT and growth modeling. One salient difference between the two studies is the time-frame of the study, with the Farkas and Beron sample tested between the years 1996 and

2000, and ours tested between the years 2010 and 2015. In 2010, three of the four states serving as sites for the present study adopted the Common Core State Standards, which places a heavy emphasis on vocabulary development and instruction from kindergarten to twelfth grade. It is possible that these policy changes modified the schooling environments of children in such a way that vocabulary growth shifted from a decelerating trend in 1996-2000 to a growing trend in 2010-2015. Yet another salient difference between the two studies involves the sample size, with Farkas and Beron using the NLSY79 sample involving more than 10,000 children. It may be that the heightened power and measurement approach was able to discern a deceleration in vocabulary growth that was too small in size to detect using our relatively smaller size at the later time-point. It is important for our result to be replicated using other samples, given the discrepancy between these studies.

A third contribution of note is the close alignment of children's developmental trajectories in grammar and vocabulary. The analysis of the relations between trajectories showed that baseline skills were very highly correlated, meaning that children with high levels of grammar at age 5 also tended to have high levels of vocabulary. These relations were stronger than often reported in the literature (r = .94 in the present study); for instance, Cabell and colleagues reported concurrent correlations of .64 between measures of receptive vocabulary and grammar, and .71 between measures of expressive vocabulary and grammar for 4-year-old children (Cabell, Justice, Konold, & McGinty, 2011). A major difference between such prior work and the present findings is the use of a latent-variable approach in the current study, which allows for more precise representation of the constructs being investigated. As the study shows, there is an extremely high level of congruence between both initial status of grammar and

vocabulary skill, and children's trajectories over time, with grammar and vocabulary trajectories also related to a high degree ($r = 0.912$).

This finding shows that preschool children who are advanced in vocabulary are also likely to be advanced in grammar, and that children making rapid gains in vocabulary are also likely to be making rapid gains in grammar. The converse is also true: children who are deficient in vocabulary are also likely to be deficient in grammar, and children making poor progress in vocabulary will likely to do so in grammar. Theoretically, these linkages likely represent the near uni-dimensionality of language skill when children are young (Language and Reading Research Consortium, 2015). It is important to learn, in future experimental work, whether children's grammar and/or language skills can be improved relative to other children in the early years of development, and whether this contributes to elevated trajectories over time, as might be suggested by the present normative study. Further, it is also crucial to understand whether improvement in one component language skill, such as grammar, would lend improvement to another component language skill, such as vocabulary, given the high level of inter-connectedness between the two sets of skills.

Limitations of this study warranting consideration are threefold. First, our sample was not very diverse with respect to race, ethnicity, and linguistic background. It is unknown whether our results would have varied substantially if a more diverse sample was utilized, and research seeking to replicate our findings should be undertaken with other, more diverse samples. Second, our examination of children's linguistic trajectories involved only one measurement occasion per year per child for a total of five time-points. Other studies examining trajectories have featured more frequent observations of children (Farkas & Beron, 2004; Rowe et al, 2012), and it may be that more precise assessment of linguistic change is necessary to represent

trajectories during early and middle childhood. This is an important methodological consideration for research on children's language development, given that even at very young ages, children's language skills show significant change in even relatively small increments of time (Duff et al., 2015). Finally, we did not represent the nested data-structure of this study into our modeling, although children were nested in classrooms at the initial observation and then longitudinally. Our investigation of multilevel latent growth models based only on the nested data structure at the preschool time-point led to convergence problems and estimation errors. Due to these practical concerns we used single-level analyses instead. Future research might explore how to use latent-variable growth modeling in the context of nested data-structures with extensive cross-classification as children go through schooling. This would be useful for understanding how classroom contexts may alter developmental trajectories.

Despite these limitations, the finding we present help to improve our understanding of language development among children as they transition from the pre-kindergarten milieu into the space of formal schooling. Children's grammar and vocabulary skills are continuing to incrementally improve across these years, on a magnitude that is quite profound: grammar skills increased 3.08 standard deviation units (Cohen's *d*) over the five-year period, whereas their vocabulary skills increased 3.71 units. Interestingly, our growth models suggest that educational interventions should be explored to determine their effects on children's trajectories of grammar skill, as children show a deceleration in skills in this linguistic domain starting around kindergarten.

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Table 1

Background Characteristics of Participating Children and Families

Demographic variable	Scale	*N (%)*
Maternal education	High school or less	51 (13.6%)
	Some college but no degree	81 (21.5%)
	Associates or bachelor's degree	157 (41.8%)
	Advanced degree	87 (23.1%)
Free or reduced lunch	Yes	57 (15.3%)
	No	316 (84.7%)
Child gender	Male	245 (58.3%)
	Female	175 (41.7%)
Home language	English	369 (97.6%)
	Non-English	9 (2.4%)
Race	American White/Caucasian	351 (94.6%)
	Non-White	20 (5.4%)

Table 2

Descriptive statistics of grammar and vocabulary measures

Domain	Measure	*N*	Min	Max	Mean	*SD*	Skewness	Kurtosis
Grammar	CELF-WS Y1	408	0	29	15.59	5.56	-0.45	0.17
	CELF-WS Y2	388	4	31	20.17	4.67	-0.45	0.50
	CELF-WS Y3	362	9	32	23.72	4.16	-0.49	0.08
	CELF-WS Y4	344	14	32	26.67	3.30	-0.88	0.79
	CELF-WS Y5	329	13	32	28.14	2.91	-1.57	3.87
	CELF-RS Y1	394	0	74	32.13	14.00	0.10	-0.30
	CELF-RS Y2	385	0	85	42.31	15.03	-0.15	0.14
	CELF-RS Y3	354	15	92	52.16	13.95	0.11	-0.04
	CELF-RS Y4	333	22	97	60.10	14.00	-0.09	-0.23
	CELF-RS Y5	322	24	99	64.80	13.91	-0.06	-0.27
	TROG Y1	418	0	18	6.25	3.76	0.48	-0.15
	TROG Y2	384	0	18	10.88	3.88	-0.46	-0.28
	TROG Y3	366	2	20	13.45	3.61	-0.68	0.05
	TROG Y4	345	4	20	15.28	3.16	-1.00	0.71
	TROG Y5	324	6	20	16.69	2.64	-1.42	2.06
Vocabulary	PPVT Y1	420	24	107	70.06	13.78	0.00	-0.15
	PPVT Y2	383	45	115	84.37	13.27	-0.29	-0.19
	PPVT Y3	366	55	134	95.04	13.89	-0.12	-0.16
	PPVT Y4	344	62	144	105.44	13.54	-0.24	0.27
	PPVT Y5	325	69	150	114.79	14.53	0.01	-0.09
	EVT Y1	418	33	150	94.04	18.98	-0.39	0.15
	EVT Y2	384	26	162	112.59	18.14	-0.76	1.55
	EVT Y3	368	69	180	127.09	16.15	-0.37	0.85
	EVT Y4	346	86	180	138.82	16.12	-0.39	0.48
	EVT Y5	327	93	192	150.59	15.95	-0.39	0.80

CELF, Clinical Evaluation of Language Fundamentals – Fourth Edition (CELF-4, Semel et al., 2003); WS, CELF-4 Word Structure; CFRS, CELF-4 Recalling Sentences; TROG, Test for Reception of Grammar–2 (Bishop, 2005); PPVT, Peabody Picture Vocabulary Test (Dunn & Dunn, 2007); EVT, Expressive Vocabulary Test – Second Edition (Williams, 1997).
Y1, all children in prekindergarten; Y2, 95.0% children in kindergarten, 4.8% in prekindergarten,.3% in frist grade; Y3, 91.9% children in first grade, 7.5% in kindergarten, .5% in second grade; Y4, 90.9% children in second grade, 8.9% in first grade, .3% in third grade; Y5, 88.9% children in third grade, 10.5% in second grade, .6% in first grade.

Table 3

Longitudinal measurement invariance of grammar and vocabulary, preschool to grade 3

	χ^2 (df)	*p*	$\Delta\chi^2$	*p*	CFI	ΔCFI	RMSEA	SRMR	Modification
Grammar									
1. Configural invariance	73.97 (50)	.015			.995		.034	.018	
2.1 Metric invariance	167.51 (58)	<.001	vs. 1: 93.54	<.001	.977	vs. 1: -.018	.067	.134	
2.2 Partial metric invariance	99.08 (55)	<.001	vs. 1: 25.11	<.001	.991	vs. 1: -.004	.044	.037	Free loadings CFWS1, CFWS4, CFWS5
3.1 Scalar invariance	239.63 (63)	<.001	vs. 2.2: 140.55	<.001	.963	vs. 2.2: -.028	.082	.119	
3.2 Partial scalar invariance	142.03 (60)	<.001	vs. 2.2: 42.95	<.001	.983	vs. 2.2: -.008	.057	.072	Free intercepts CFWS4, CFWS5, TRG1
Vocabulary									
1. Configural invariance	7.503 (5)	.277			1.000		.024	.004	
2. Metric invariance	20.120 (9)	.017	vs. 1: 12.517	.014	.997	vs. 1: -.003	.054	.030	
3. Scalar invariance	25.711 (13)	.019	vs. 2: 5.591	.232	.997	vs. 2.2: -.000	.048	.031	

Table 4

Parameter estimates of multivariate latent growth model for grammar and vocabulary, preschool to grade 3

		Grammar			Vocab		
		Coeff	SE.	*p*	Coeff	SE	*p*
Parameter estimates							
Growth Parameters	Mean of intercept	0	--	--	0	--	--
	Variance of intercept	1	--	--	1	--	--
	Mean of slope	1.054	.060	<.001	1.200	.060	<.001
	Variance of slope	.012	.005	.011	.025	.006	<.001
Trajectory	Y1 to Y2	1.000	/	/	1.000	/	/
	Y2 to Y3	1.832	.049	<.001	1.775	.039	<.001
	Y3 to Y4	2.481	.076	<.001	2.452	.055	<.001
	Y4 to Y5	2.921	.094	<.001	3.097	.072	<.001
Correlations of growth parameters							
		1	2		3	4	
	1. Grammar intercept	--					
	2. Grammar slope	-.575***	--				
	3. Vocabulary intercept	.935***	-.715***		--		
	4. Vocabulary slope	-.105	.912***		-.249**	--	
Model fit							
	χ^2 test	χ^2=432.970 (234), *p*<.001					
	RMSEA (90% CI)	.045 (.038, .052)					
	CFI	.979					
	SRMR	.061					

* *p* < .05, ** *p* < .01, *** p < .001.

Table 5

Predicting intercepts and slops of latent growth curves of grammar and vocabulary

		Grammar			Vocab		
		Coeff	SE.	*p*	Coeff	SE	*p*
Parameter estimates							
Growth	Mean of intercept	0	--	--	0	--	--
Parameters	Variance of intercept	1	--	--	1	--	--
	Mean of slope	1.151	.072	<.001	1.275	.073	<.001
	Variance of slope	.013	.006	.017	.028	.006	<.001
Trajectory	Y1 to Y2	1.000	/	/	1.000	/	/
	Y2 to Y3	1.830	.055	<.001	1.775	.039	<.001
	Y3 to Y4	2.477	.088	<.001	2.451	.055	<.001
	Y4 to Y5	2.916	.111	<.001	3.096	.072	<.001
Predictors	Gender (1=female)	.111	.105	.289	-.066	.107	.537
on intercept	Mother having AA or BA	.048	.114	.422	.127	.124	.304
	Mother having advanced degree	.323	.141	.022	.334	.150	.026
	Free or reduced lunch	-1.034	.159	<.001	-.940	.163	<.001
Predictors	Gender (1=female)	.003	.024	.889	-.006	.028	.824
on slope	Mother having AA or BA	-.036	.033	.277	.029	.039	.450
	Mother having advanced degree	-.006	.029	.842	.014	.034	.686
	Free or reduced lunch	.055	.039	.157	.015	.044	.738
Model fit							
	χ^2 test	χ^2=538.302 (318), *p*<.001					
	RMSEA (90% CI)	.041 (.035, .046)					
	CFI	.977					
	SRMR	.060					

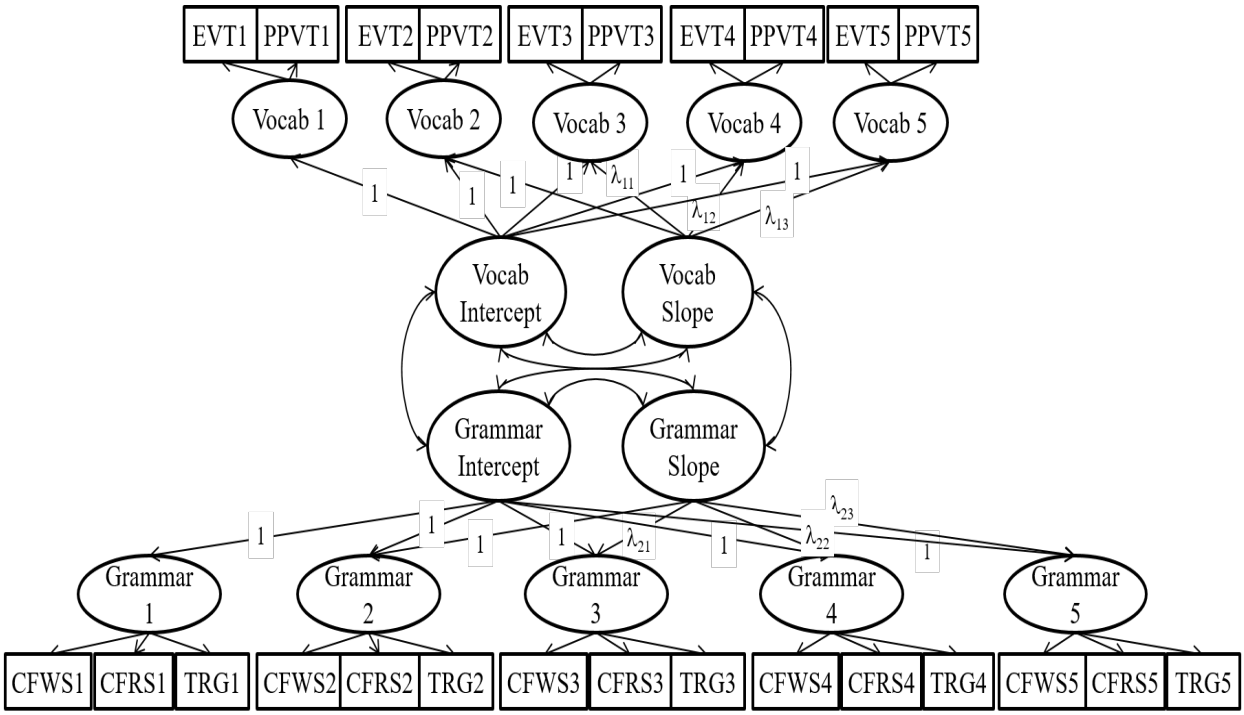

Figure 1 Multivariate latent growth model (MLGM) depicting growth of grammar and vocabulary from preschool to grade 3

Note. Covariance between the same measure across different time points are included in the model, but not depicted on the diagram.

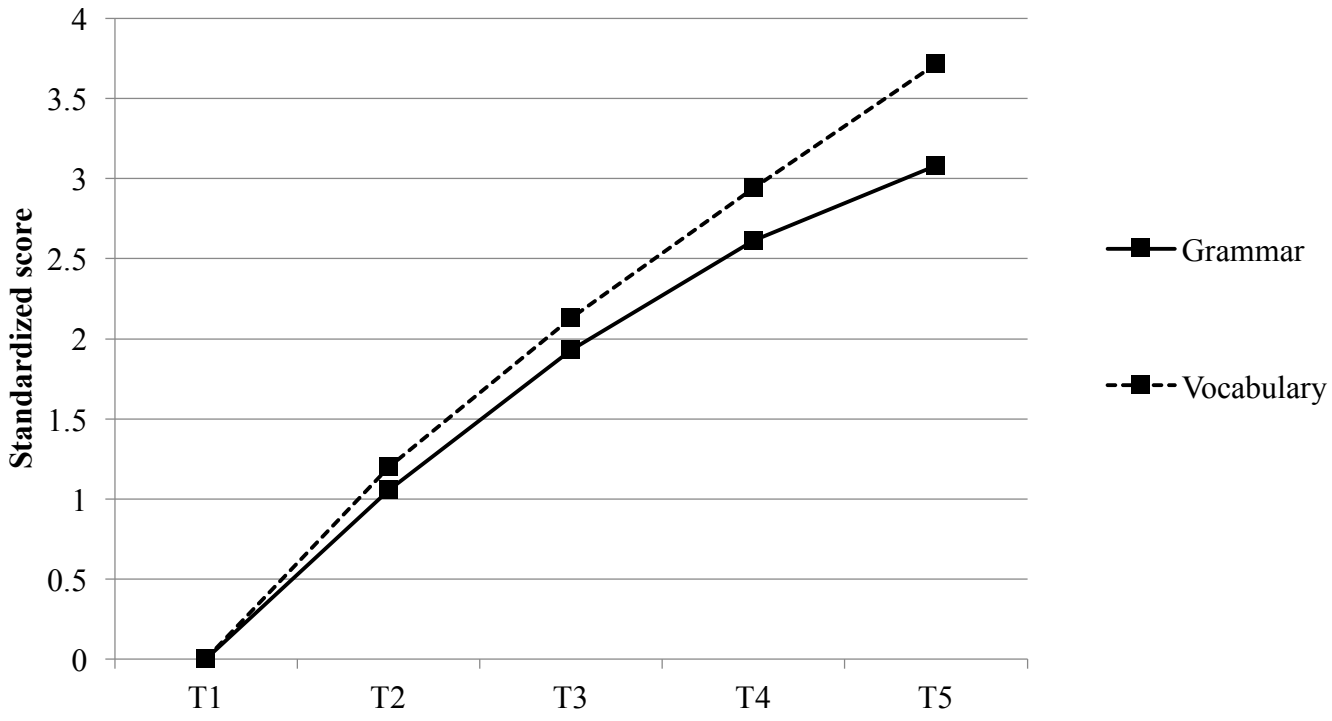

Figure 2 Estimated growth curves of grammar and vocabulary from preschool to grade 3