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Diversity matters: parent input predicts toddler verb production*

NING HSU, PAMELA A. HADLEY AND MATTHEW RISPOLI

University of Illinois at Urbana-Champaign, USA

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ABSTRACT

The contribution of parent input to children's subsequent expressive verb diversity was explored in twenty typically developing toddlers with small verb lexicons. Child developmental factors and parent input measures (i.e. verb quantity, verb diversity, and verb-related structural cues) at age 1;9 were examined as potential predictors of children's verb production in spontaneous language samples at age 2;3. Parent verb input diversity, rather than input quantity, was the primary input factor contributing to children's subsequent verb diversity. Regression analysis showed that verb diversity in parent input at age 1;9 accounted for 30% of the variance in children's verb production six months later, with children's total vocabulary size at age 1;9 accounting for an additional 16% of the variance. These findings demonstrate the relative contributions of developmental and input factors to individual differences in toddlers' language development and establish the importance of input diversity to verb acquisition.

INTRODUCTION

Children's acquisition of a verb lexicon forms a crucial interface between lexical and grammatical development (Pinker, 1989; Tomasello, 2005).

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Verbs emerge later than nouns and occupy a smaller percentage of the initial lexicon (Bates *et al*., 1994; Nelson, 1973). Theoretically, verb acquisition may be more difficult than noun acquisition. First, verbs involve conceptually more complicated notions (cf. Gleitman, Cassidy, Nappa, Papafragou & Trueswell, 2005). Whereas early common nouns denote entities, verbs denote event structures. The meaning of verbs must encode relationships between the event and one or more noun phrases, also known as arguments. Second, information in the input may provide more support for the acquisition of nouns relative to verbs. Nouns in the input tend to be aligned with the physical objects they refer to, but verbs in the input may not be 'time locked' to the events they describe (Gleitman *et al*., 2005). Finally, "verb acquisition entails the learning of sentence frames" (Hadley, 2006, p. 175). To learn a verb meaning is to learn what noun phrase arguments are involved and how to arrange the verb and the arguments in the correct sequence (Pinker, 1989; Rice, 1991). In this sense, the expansion of the verb lexicon provides a foundation for the development of simple, diverse sentences (Hadley, 2006).

Despite the importance of the verb lexicon to children's language development, few studies have investigated how input affects children's verb acquisition, and different research traditions have approached this question from distinct perspectives. One research tradition in developmental and educational psychology has focused on understanding relationships between language input and individual differences in children's rate of vocabulary development. These input studies have established the associations between lexical quantity and lexical diversity in parent input and children's general vocabulary development (Hoff & Naigles, 2002; Huttenlocher, Haight, Bryk, Seltzer & Lyons, 1991; Huttenlocher, Waterfall, Vasilyeva, Vevea & Hedges, 2010; Rowe, 2012). By the third year of life, lexical diversity in parent input has been shown to be a stronger predictor of children's later vocabulary abilities than the sheer quantity of words in parent input (Rowe, 2012). However, it is not clear whether such relationships hold specifically for the verb lexicon. An alternative approach, influenced by psycholinguistic theories of language acquisition, has focused on the problem of how children learn verb meanings. Theories of SYNTACTIC BOOTSTRAPPING have proposed that children are sensitive to verb-related syntactic and morphological cues, as these cues may serve to restrict verb meanings (Behrend, Harris & Cartwright, 1995; Fisher, Hall, Rakowitz & Gleitman, 1994; Naigles & Swensen, 2007; Yuan, Fisher & Snedeker, 2012). However, little is known about the nature of these structural cues in naturalistic parent input and how parents vary in providing verb-related structural cues to their children. The current study integrated these two research traditions by investigating the contribution of lexical quantity, lexical diversity, and

verb-related structural cues in parent input to children's subsequent expressive verb diversity.

The methods used in early input studies were primarily observational, with studies documenting correlations between features of naturalistic parent speech at Time 1 and children's progress in language development between Time 1 and Time 2 (see Richards, 1994, and Valian, 1999, for comprehensive reviews). More recent studies have associated parent input quantity and diversity with children's language development (Hoff & Naigles, 2002; Huttenlocher *et al*., 1991, 2010; Rowe, 2012). For example, Hoff and Naigles (2002) studied sixty-three children who ranged in age from 1;6 to 2;5. Time 1 parent input measures, specifically the number of total words, the number of different words, and mean length of utterance (MLU) in morphemes, were positively associated with children's Time 2 vocabulary size obtained 10 weeks later. Huttenlocher *et al*. (1991) reported converging results using a more sophisticated measure of children's vocabulary GROWTH for twenty-two children from 1;2 to 2;2. After controlling for child gender, Huttenlocher and colleagues found that approximately 20% of the variance in children's rate of vocabulary acceleration was accounted for by the number of total words in the parent input. Huttenlocher *et al*. (2010) adopted a similar longitudinal design, following the children from 2;2 to 3;10. They found that both lexical and grammatical development were predicted by parent input quantity and diversity. Additionally, Huttenlocher and colleagues revealed bi-directional influences with children's language abilities accounting for later lexical measures of parent input. This means that parents were not only exerting an influence on children's later language development, but they were also adjusting their vocabulary input to their children's levels of lexical development. However, bi-directional influences were not apparent for the grammatical measures. Most recently, Rowe (2012) examined the contribution of parent input quantity and diversity to children's vocabulary abilities one year later on a standardized measure of receptive vocabulary knowledge. Different input properties emerged as better predictors of children's vocabulary scores at different time points. Parent input quantity at 1;6 was most strongly related to children's vocabulary scores at 2;6, whereas input richness in both vocabulary diversity and sophistication at 2;6 were stronger predictors of the subsequent vocabulary scores at 3;6. These findings underscore the importance of children's exposure to diverse words in parent input during the third year of life.

Other input studies have been inspired by the SYNTACTIC BOOTSTRAPPING HYPOTHESIS, focusing on verb-related structural cues such as syntactic frames or morphological contexts that may support children's verb acquisition (de Villiers, 1985; Naigles & Hoff-Ginsberg, 1995, 1998). SYNTACTIC BOOTSTRAPPING refers to a process by which children restrict

verb meanings according to the structural environments in which verbs occur (Gleitman, 1990; Landau & Gleitman, 1985; Naigles & Swensen, 2007). Structural cues tend to correspond with verb semantics (Naigles & Hoff-Ginsberg, 1995, 1998). For example, verbs involving agent-and-patient relations such as *take* and *push* usually occur in the transitive frame (Naigles & Hoff-Ginsberg, 1998). In experimental studies, children show sensitivity to structural cues such as the number of arguments attached to verbs or the morphological contexts of verbs (Behrend *et al.*, 1995; Fisher *et al.*, 1994; Yuan *et al.*, 2012). The hypothesis is that the more different structural cues a verb co-occurs with, the earlier the verb will emerge in the lexicon. Children may also use the verb in more different ways.

Guided by the syntactic bootstrapping hypothesis, Naigles and Hoff-Ginsberg (1995, 1998) investigated fifty-seven parent–child dyads and collected naturalistic conversations at home. The relationship between Time 1 parents' verb use and Time 2 children's verb production was examined, with a 10-week interval between Time 1 and Time 2. The input sample at Time 1 was constructed by combining the fifty-seven parent speech samples into a single input corpus, with each parent providing the same number of utterances (i.e. 393). The child speech sample at Time 2 was constructed by combining the fifty-seven child speech samples into a single child corpus, with each child contributing ninety utterances. Naigles and Hoff-Ginsberg examined the emergence of twenty-five commonly used verbs in parent input and child speech, analyzing the verb frequency and the verb-related syntactic frames in the pooled input sample. They coded two types of syntactic frames, the 'broad syntactic frames' and the 'narrow syntactic frames'. The broad frames identified verbs for transitivity, postverbal sentences, postverbal prepositional phrases, and adverbs. Naigles and Hoff-Ginsberg showed that the broad frames in parent input were reliable cues to the verb semantics. For example, 85% of all input sentences containing the transitivity frame had main verbs that indicated agent-and-patient relations. Likewise, 67% of input sentences with a post-verbal sentence frame had main verbs that referred to internal states such as *think* and *know*. Finally, 85% of input sentences with postverbal prepositional phrases had main verbs that denoted physical motions such as *come* and *go*. In a second analysis, Naigles and Hoff-Ginsberg used the narrow frames to identify the SEQUENCE of non-head materials of the target verb phrases. This was hypothesized to reflect the potential parsing strategies children with rudimentary syntax might adopt when listening to input. Using the narrow syntactic frame coding, Naigles and Hoff-Ginsberg showed that the frequency of individual verbs in the Time 2 child speech was significantly correlated with Time 1 input verb frequency and the narrow syntactic frame diversity. The regression analysis suggested that

Time 1 input verb frequency explained 24% of the variance in Time 2 verb frequency in child production, and the narrow syntactic frame diversity accounted for an additional 2% of the variance beyond the input verb frequency. Naigles and Hoff-Ginsberg interpreted this finding as evidence that using multiple syntactic frames with verbs facilitates verb learning. Of interest to the current study was whether syntactic frame diversity would also support children's verb acquisition when applied to individual parent–child dyads, a question that Naigles and Hoff-Ginsberg did not ask.

In another study of structural cues, de Villiers (1985) investigated the relationship between parent input and children's production of verb morphology with two parent–child dyads. Language samples were collected through bi-weekly 2-hour sessions at home in a series of ten sessions. The input sample was constructed for each child by combining the mother's speech in the first five sessions. Both parents' and children's verb use were coded for their immediately adjacent morphemes, with thirteen morphological contexts identified. Examples are third person singular present tense *-s*, present progressive tense *V-ing*, or regular past tense *-ed*. Only verbs that were shared between the parent input and the child output were analyzed. Children's morphological variety of verb use was regressed on children's verb frequency, input verb frequency, and input morphological variety of verb use. Separate regression analyses for the two children revealed similar results. Morphological variety of verb use in the parent input was the only significant predictor for both parent–child dyads. Furthermore, de Villiers found that each child's production was predicted by their own mother's verb use, but not by that of the other mother. De Villiers suggested that the input and the output of individual parent–child dyads were unique to the dyad, and not to more general properties of parent input to children.

Though Naigles and Hoff-Ginsberg (1998) and de Villiers (1985) demonstrated that verb-related syntactic frames and morphological contexts in parent input are helpful for children to learn verbs, these studies have several limitations. First, methodological choices in study design temper the strength of the generalizations that can be drawn. Recall that Naigles and Hoff-Ginsberg used pooled speech samples of maternal input and child output to study how input properties influenced the acquisition of DIFFERENT VERBS. Their study was not designed to examine the contribution of differences in parent input to between-child differences in verb diversity. The findings therefore cannot be generalized to the verb acquisition of individual children. In contrast, de Villiers examined individual parent–child dyads, but the sample size (two dyads) was very small. Second, Naigles and Hoff-Ginsberg did not provide a clear rationale for assessing narrow syntactic frame diversity as a parent input property.

Given that they stated "it is not obvious how these narrow frame differences might translate into meaning differences for the children" (Naigles & Hoff-Ginsberg, 1995, p. 833), the measure of narrow frame diversity seems to lack a solid theoretical basis. Third, these studies examined only a subset of common verbs. And finally, the relationship between the children's verb use and parents' verb use was not controlled. Based on findings of Huttenlocher *et al.* (2010), it is important to consider the possibility of bi-directional influences from child to parent, as well as parent to child.

In summary, two gaps are apparent in our understanding of how naturalistic input contributes to children's verb acquisition. First, it is not clear whether the relationships that exist between input quantity, input diversity, and children's lexical development hold specifically for verbs. Second, much less is known about how verb-related structural cues are used in naturalistic parent input, such as syntactic frame diversity and morphological context diversity. Whether these cues provide additional benefit to increase children's verb lexicon remains uncertain. The current study addressed these issues by investigating the contribution of parent input to children's subsequent verb diversity. Conventional measures of verb input quantity and diversity were included, as well as theoretically motivated measures of syntactic and morphological context diversity (de Villiers, 1985; Naigles & Hoff-Ginsberg, 1995, 1998). In addition, we expected children's prior developmental abilities to influence subsequent verb acquisition. Children who used more different words early in development were anticipated to produce more different verbs six months later. Controlling for initial vocabulary abilities was also important in light of Huttenlocher *et al.*'s (2010) evidence of bi-directional influences between children's vocabulary abilities and lexical properties of parent input. Children's intelligibility and talkativity during conversations were also considered, because these factors might influence parent input. Finally, child gender was considered, because Huttenlocher *et al.* (1991) reported that gender influenced the rate of lexical development, with girls accelerating more quickly than boys before 1;8.

The following four research questions were explored:

1. Are measures of children's 1;9 developmental abilities associated with their 2;3 verb diversity? This question explored the evidence for general continuity in early language development.
2. Are measures of children's 1;9 developmental abilities associated with 1;9 parent input measures? This question addressed whether parent input is related to concurrent children's abilities.
3. Are the 1;9 parent input verb quantity, verb diversity, and verb-related structural cues associated with children's 2;3 verb diversity? This

question explored different dimensions of parent verb input that may influence children's subsequent verb production.

4. Do parent input verb measures at age 1;9 predict children's verb diversity at age 2;3 when children's 1;9 developmental abilities are controlled? This question addressed the contribution of parent input to children's subsequent verb acquisition above and beyond the contribution of the children's developmental abilities.

METHODS

Participants

Participants for the current study were selected from an existing longitudinal database funded by the Natural Science Foundation (NSF; Rispoli & Hadley, 2013). Fifty-eight families were originally recruited for a study of the acquisition of tense and agreement in toddlers between 1;9 and 3;0 in English monolingual homes. Children with congenital or acquired neurological or sensory impairments, insertion of pressure equalization tubes as a result of repeated bouts of otitis media, or delayed onset of walking or talking (i.e. after 1;3) were not eligible to participate. Spontaneous language samples were collected in the lab playroom at ages 1;9, 2;0, 2;3, 2;6, 2;9, and 3;0. The 1-hr data collection involved two contexts. Parents were instructed to "play as they would at home" with their children for the first 30 min with age-appropriate toys. In the second 30-min context, an examiner joined the parent–child dyads to create more opportunities for the children to produce tense and agreement morphemes with different lexical subjects and verbs. Information regarding children's general development and language production was also available from two parent report checklists, the *Ages and Stages Questionnaire* (ASQ; Bricker & Squires, 1999) and the *MacArthur-Bates Communicative Development Inventories: Words and Sentences* (CDI; Fenson, Marchman, Thal, Dale, Reznick & Bates, 2007). For a parent–child dyad to be included in the current study, the children were required to: (a) demonstrate a passing score on the communication section of ASQ at 1;9 and 2;0; (b) demonstrate an expressive vocabulary at or above the 10th percentile on the CDI at 2;0; and (c) have no history of early intervention (EI) services prior to 3;0. The above criteria excluded twelve children and identified forty-six children as typically developing in regards to communication and vocabulary development. From this pool, twenty-one children with ten or fewer action words on the CDI (i.e. *Part I section 14: Action Words*) at 1;9 were selected. Based on cross-sectional CDI norms, these children could be characterized as low-average typically developing toddlers (i.e. 50th percentile at 21 months = 14 action words; Dale & Fenson, 1996; Jørgensen, Dale, Bleses & Fenson, 2010). We then combined the verbs

parents reported on the CDI with the different verbs children produced in the 1;9 language sample. The number of different verbs combined for one girl was 2 *SD* above the mean for the participants selected; therefore, she was excluded due to her outlier status. Together, the combination of inclusionary and exclusionary criteria created a homogeneous group of typically developing children. Selecting a homogeneous sample was an important design feature for revealing the contribution of input to verb acquisition for two reasons. First, it minimized the extent to which prior verb lexicon size would influence subsequent outcomes. Second, it reduced the possibility that differences observed in parents' use of verbs in their child-directed speech could be attributed to differences in children's initial status.

The twenty children (15 boys) selected for this study had one to thirteen verbs ($M = 5{\cdot}30$, $SD = 3{\cdot}85$) in their expressive vocabulary at 1;9, as determined by the combination of CDI action words reported and the verbs children produced in the language sample. Most children were in the single-word stage, with their MLUs in morphemes ranging from 1·00 to 1·75 ($M = 1{\cdot}17$, $SD = 0{\cdot}19$). Boys were over-represented in this sample because of differences in CDI action words reported at 1;9. Approximately two-thirds of the typically developing boys in the database had ten or fewer CDI action words reported, whereas only one-fourth of the girls met this inclusionary criteria.

Twenty parents (1 father) participated in the study, ranging in age from twenty-three to forty years ($M = 30{\cdot}50$, $SD = 5{\cdot}14$). Parents' highest educational levels included completion of high school ($n = 3$), associate's degree or some college ($n = 3$), bachelor's degree ($n = 10$), and advanced degree ($n = 4$). Participating parents and children were primarily White, non-Hispanic ($n = 16$). One parent self-identified as White Hispanic and three parents self-identified as Black ($n = 3$).

Language samples

The input speech samples came from the 30-min of parent–child free play at 1;9. Each sample was transcribed according to the standard conventions of the Systematic Analysis of Language Transcripts (SALT; Miller & Iglesias, 2012). The transcription of adult and child utterances was completed separately by trained graduate or undergraduate research assistants based on audio- and video-recordings. Transcribers listened to each utterance a maximum of three times and used video-recordings to provide information about the physical context, if necessary. Following the initial transcription pass, a second transcriber completed a consensus pass (cf. Shriberg, Kwiatkowski & Hoffmann, 1984), re-listening to the recording and marking as unintelligible or removing any morphemes that

could not be confirmed. The consensus transcriber was allowed to add content words, but was not allowed to add tense/agreement morphemes without confirmation by a third transcriber, since the original study focused on the acquisition of tense and agreement.

Measures and the coding procedures

Parent input measures at 1;9. Measures of parent input from the 1;9 measurement point were computed to characterize the total amount of parent input, the quantity and diversity of verb input, and the verb-related structural cues provided by the parents. These parent input variables were examined as potential predictors of children's 2;3 verb diversity.

1. Descriptive measures. Several descriptive measures were computed from parents' spontaneous, complete, and fully intelligible utterances, including the number of total utterances addressed to the children, the number of total words, and the number of different words produced by the parents. Utterances produced during singing, book reading, or daily and game-playing routines (e.g. 'peekaboo') were excluded. When computing the number of total words and the number of different words, we followed the general procedures of Huttenlocher and colleagues (Huttenlocher *et al*., 1991; Huttenlocher, Vasilyeva, Waterfall, Vevea & Hedges, 2007). Specific classes of words such as animal noises (e.g. *baaa, moo, quack*, etc.), letter names, and parental imitations of babbling were excluded. Interjections such as *ooh, oops*, or *ohno*, and words used as interjections such *cool, great*, or *darn* were also excluded. Words derived from derivational affixes were considered different types (e.g. *bake* and *baker*). Regular inflectional variants of one word were considered the same type (e.g. *cook, cooks, cooking*, and *cooked*), whereas irregular inflectional variants were considered distinct types (e.g. *run* and *ran; goose* and *geese; go* and *went; see* and *saw*). Frequently used irregular forms in English tend to be phonologically distinct from their base forms, and children might treat the early irregular forms and the base forms as separate words. A proper name and its nickname were considered one word type (e.g. *Cynthia* and *Cindy*). Diminutives and commonly occurring motherese words were also standardized and counted as examples of the same word type (e.g. *doggy* and *dog; ma, mama, mommy*, and *mom*).

2. Measures of verbs. The quantity and diversity of verbs were measured by the number of total verbs and the number of different verbs produced by the parents. Verbs that could be used as main verbs or as auxiliaries (i.e. *have* and *do*) were counted only when parents used them as main verbs.

3. Measures of input verb-related structural cues of frequently used verbs. To investigate whether parents provided structurally different environments when using verbs, the syntactic frame diversity and the morphological

context diversity proposed by Naigles and Hoff-Ginsberg (1995, 1998) and de Villiers (1985) were examined. To control the effect of verb frequency upon the diversity of structural cues, only the ten most frequently used verbs in each language sample were analyzed. Verbs used less than five times were excluded because they provided insufficient opportunities for parents to demonstrate diversity. Five verbs (i.e. *eat, go, help, sit*, and *stop*) that were already produced by more than 25% of the children ($n = 5$) were also excluded in order to reduce the influence of children's verb use on parents' verb use. These procedures were adopted to focus on verbs that were: (a) not initially part of children's lexicon; and (b) frequent enough to demonstrate the diversity of structural cues if present. Note that the number of frequent verbs that met these criteria varied among parents. A parent might have less than ten verbs in this analysis because fewer verbs were produced at least five times. Other parents might have more than ten verbs in the analysis if two or more verbs were produced with an identical frequency.

3.1. Syntactic frame diversity. Recall that Naigles and Hoff-Ginsberg (1995, 1998) used the broad frame coding to demonstrate the frame cue validity in restricting verb meanings, and the narrow frame coding to assess input syntactic frame diversity and its relationship to children's use of corresponding verbs. Because their narrow frame coding was not theoretically motivated, we integrated their two types of frame coding to form the current coding scheme. This approach retained the spirit of Naigles and Hoff-Ginsberg's narrow frame coding in that it provided more opportunities to capture input variation for each verb type than would be possible with the broad frame coding alone. At the same time, it preserved the cue validity to verb semantics that was revealed by the broad frame coding.

The broad frame coding was adopted with two modifications. First, phrasal verb construction (e.g. *put away the toys*) was added as a valid frame because many English verbs co-occur with verb particles to form distinct semantic units. Second, the adverb frame was excluded. Unlike the noun phrase direct objects or the prepositional phrases, adverbs as a syntactic category do not provide clues to the verb semantics. Naigles and Hoff-Ginsberg (1995) stated that the adverb frame "has not been hypothesized to correlate with verb meaning" (Naigles & Hoff-Ginsberg, 1995, p. 829). The broad frame coding therefore included: (a) transitivity (i.e. followed immediately by a noun phrase direct object); (b) postverbal sentence; (c) postverbal prepositional phrase; and (d) verb–particle construction. Each target verb was then coded for its COMBINATION of broad frames. For example, the verb *put* in the sentence *put the box under the chair* would be coded as combining the transitivity frame and the postverbal prepositional phrase frame. The target verb *blow* in the sentence

are you blowing? would be coded as combining no broad frames, which is itself a unique frame combination. The coding scheme thus allowed sixteen possible broad frame combinations (see 'Appendix'). Finally, for each verb analyzed, we calculated the number of unique frame combinations and computed the ratio of different combinations to total verb tokens. Each parent received an average ratio for his/her ten most frequently used verbs. This represented the extent to which the parent used diverse syntactic frames. See Hsu (2014) for a detailed example of computing the syntactic frame diversity.

3.2. Morphological context diversity. Verbs that were analyzed for syntactic frame diversity were also analyzed for morphological context diversity. The coding followed de Villiers (1985) with some modifications. Twelve morphological contexts for verbs were coded, with negative constructions being categorized with their corresponding forms. The twelve morphological contexts were:

(a) Unmarked V
(b) Infinitive *to* V
(c) Modal + V (e.g. *can, must, should* + V)
(d) Future *will* + V and the contracted *'ll* + V
(e) Catenatives + V and the full forms of catenatives + V (e.g. *gonna, wanna, gotta* + V and *going to, want to, got to* + V)
(f) Do support + V
(g) Progressive *be* + V-*ing*
(h) Third person present tense V-*s*
(i) Regular past tense V-*ed*
(j) Perfect *have* + V participle
(k) Irregular past tense (e.g. *blew, said, ran*, etc.)
(l) Irregular third person present tense (e.g. *says, has*, etc.)

Similar to the analysis of syntactic frame diversity, the ratio of different morphological contexts to total verb tokens was computed for each target verb. Each parent received an average ratio that reflected the diversity of his/her ten most frequently used verbs with different morphological contexts. See Hsu (2014) for a detailed illustration for computing the morphological context diversity.

Child developmental measures at 1;9. Several measures of children's 1;9 developmental abilities were computed as potential predictors of the 2;3 verb diversity and to determine whether children's language production influenced concurrent properties of parent input in the 1;9 language samples.

1. Measures of vocabulary size. Two measures of children's vocabulary size, CDI total words and the number of different words produced by children in the language samples, were used. CDI total words reflected children's overall lexicon size as reported by their parents. The number of different words

denoted the expressive lexicon size observed during the naturalistic conversations during free play. The number of different words was used to investigate continuity in lexical development and the potential influence of children's vocabulary use on parent language input.

2. The measure of talkativity and intelligibility. Children's talkativity and intelligibility was measured using the number of complete and intelligible utterances produced in the 30-min language sample. Only spontaneous utterances were included. Children's imitations of the adult utterances were not included. Utterances such as singing, number counting, or daily and game-playing routines (e.g. *amen*) were also excluded. We hypothesized that children's talkativity and intelligibility would be related to the number of different words they produced. In addition, it seemed possible that parents might respond differently to children with limited intelligibility, so we examined the influence of children's number of complete and intelligible utterances on parent input.

Child expressive verb diversity at 2;3. Children's 2;3 verb diversity was measured by the number of different verbs produced in the 30-min language sample. For a word to be counted as a verb, it had to either belong only to the verb category or be used in a context that granted the word verb status. For example, the word *put* would be counted as a verb because it can only be used as a verb. On the other hand, an appropriate verb context was required for the word *open* to be counted as a verb in the child's lexicon (cf. *I open the door* [verb] vs. *the door is open* [adjective]). The first author examined all words that had the possibility to be used as other word classes. All words counted as verbs were used in appropriate verb contexts.

Reliability

Transcribers completed approximately 20 hours of training. They were required to complete three consecutive training transcripts at 80% reliability overall before transcribing child data used in the analyses. Transcription reliability was obtained through consensus procedures designed to reduce measurement error and to err on the side of conservative transcription whenever possible (Shriberg *et al*., 1984). The consensus transcription procedures, previously described, provided the transcription reliability for this study. These procedures were adopted given the inherent difficulty in transcribing very young children's speech, consistent with the procedures of other investigators transcribing toddlers' speech (e.g. Eisenberg, Guo & Germezia, 2014; Rescorla, Roberts & Dahlsgaard, 1997; Theakston & Rowland, 2009).

The first author was the primary coder for all parent verb measures at 1;9 and the children's verb diversity at 2;3. To ensure high levels of coding reliability, a graduate student research assistant with prior experience

coding verbs was trained on the study-specific procedures. Since the coding schemes for verb-related structural cues were unique to this study, the reliability coder completed three practice trials and received feedback on any coding disagreements. The three practice trials were all above 90% accuracy in both syntactic frame coding and morphological context coding. When computing the agreement rate for syntactic frame coding, the original coding and the reliability coding had to have the same frame combinations to be counted as agreement. That is, for each parent utterance, the absence/presence of the four syntactic frames (i.e. transitivity, postverbal sentence, postverbal prepositional phrase, and verb–particle construction) had to be coded identically.

Three additional language samples were then coded independently (15% of the data). For all three samples, coding agreement on all measures exceeded acceptable levels of reliability (i.e. 90% agreement). Agreement rates for each measure follow: parent verb identification ($M = 97{\cdot}68$, $SD = 0{\cdot}89$); syntactic frame coding ($M = 94{\cdot}86$, $SD = 4{\cdot}15$); morphological context coding ($M = 98{\cdot}38$, $SD = 1{\cdot}68$); child verb diversity ($M = 98{\cdot}55$, $SD = 2{\cdot}51$).

Analysis plan

First, Pearson correlation coefficients were computed to explore the relationships between children's 1;9 developmental abilities, parent 1;9 verb input measures, and children's 2;3 verb diversity. Results of the correlational analyses served to answer the first three research questions and to identify developmental factors and verb input measures that were potential predictors of children's subsequent verb diversity.

A hierarchical regression analysis was conducted to address the fourth research question. This analysis investigated the unique contribution of parent input to children's verb diversity after controlling for children's developmental abilities. Children's 2;3 verb diversity was the outcome variable. The predictor variables were entered in three blocks. Block 1 included all measures of children's 1;9 developmental abilities to control for children's developmental differences at 1;9. Block 2 included measures of 1;9 parent verb input. Only input measures that were significantly correlated with children's 2;3 verb diversity were used as predictor variables in the regression analysis. Gender was entered in Block 3 to remove any spurious relations between predictors and the outcome variable that were influenced by gender.

RESULTS

A total of 8,404 input utterances were examined, containing 4,675 verbs. Descriptive statistics for the parent input measures and child developmental measures at 1;9 and the child verb diversity at 2;3 are

TABLE 1. *Developmental and input measures at 1;9 and 2;3 by child gender*

Variable	Boys ($n = 15$)	Girls ($n = 5$)	Total ($n = 20$)	Boys vs. Girls	
Age 1;9	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*t*	*p*
Child CDI-total	81·13 (42·61)	71·00 (28·13)	78·60 (39·05)	0·492	·63
Child NDW	16·60 (8·97)	21·60 (9·86)	17·85 (9·20)	−1·055	·31
Child C&I Utts	73·47 (54·07)	74·00 (43·23)	73·60 (50·47)	−0·020	·98
Parent C&I Utts	442·20 (93·29)	354·20 (135·97)	420·20 (108·78)	1·634	·12
Parent NTW	1476·53 (314·63)	1301·80 (611·17)	1432·85 (397·00)	0·846	·41
Parent NDW	245·20 (46·20)	217·60 (51·32)	238·30 (47·73)	1·128	·27
Parent NTV	240·07 (48·73)	215·20 (83·95)	233·85 (57·92)	0·824	·42
Parent NDV	53·87 (11·35)	54·00 (11·75)	53·90 (11·14)	−0·023	·98
Parent syntactic diversity	0·25 (0·06)	0·30 (0·05)	0·26 (0·06)	−1·795	·09
Parent morphological diversity	0·32 (0·08)	0·37 (0·06)	0·33 (0·08)	−1·472	·16
Age 2;3	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*t*	*p*
Child verb diversity	17·47 (7·96)	17·20 (6·98)	17·40 (7·55)	0·067	·95

NOTES: NDW = the number of different words; C&I utt = the number of complete and intelligible utterances; NTW = the number of total words; NTV = the number of total verbs; NDV = the number of different verbs. Child verb diversity = the number of different verbs children produced.

presented in Table 1. Because boys were over-represented in this sample (i.e. 75%), independent sample *t*-tests were conducted. There were no significant gender differences in the developmental measures at 1;9 or for children's verb diversity at 2;3 (see Table 1). Boys and girls appeared to receive similar verb input at 1;9. No differences were observed between boys and girls in the number of total verbs and the number of different verbs produced by parents in the 30-min free play.

We first explored the relationships among the 1;9 developmental measures. Pearson correlation coefficients for CDI total words, the number of different words, and the number of complete and intelligible utterances are presented in Table 2. The number of different words produced by the children and the number of complete and intelligible utterances were significantly correlated with each other ($r(18) = 0{\cdot}62$, $p = {\cdot}003$), indicating that children

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TABLE 2. *Pearson correlations among developmental measures at 1;9, parent verb input measures at 1;9, and child verb diversity at 2;3*

	Age 1;9						Age 2;3
	Developmental measures		Parent verb input measures				Child verb diversity
Measures	2.	3.	4.	5.	6.	7.	8.
1. Child CDI-total	0·40	0·14	−0·42	−0·09	0·43	0·15	0·49*
2. Child NDW	–	0·62**	−0·26	0·06	0·27	0·23	0·47*
3. Child C&I Utts		–	0·07	0·15	0·12	0·06	0·44
4. Parent NTV			–	0·65**	−0·50*	−0·41	0·15
5. Parent NDV				–	0·06	0·20	0·56*
6. Parent syntactic diversity					–	0·77**	0·32
7. Parent morphological diversity						–	0·26

NOTES: NDW = the number of different words; C&I utt = the number of complete and intelligible utterances; NTV = the number of total verbs; NDV = the number of different verbs; * $p < .05$, ** $p < .01$ (two-tailed).

who produced more intelligible utterances also used more different words in the conversational language samples. In contrast, correlations were not statistically significant between the language sample measures and children's total lexicon size estimated by the parent report; however, the correlation between the number of different words and CDI total words was in the predicted direction ($r(18) = 0.40$, $p = .08$).

To address the first research question, we explored the continuity between children's 1;9 measures with the measure of 2;3 verb diversity. Both 1;9 vocabulary measures were significantly correlated with the 2;3 verb diversity, CDI total words ($r(18) = 0.49$, $p = .028$), number of different words produced ($r(18) = 0.47$, $p = .037$). In addition, the correlation between the number of complete and intelligible utterances at 1;9 and the 2;3 verb diversity approached significance ($r(18) = 0.44$, $p = .052$). In light of these significant correlations, children's developmental abilities at 1;9 were associated with their verb diversity at 2;3. Therefore, it was necessary to control for children's prior development in the primary analysis to identify the relative contribution of developmental and input factors to children's subsequent verb diversity.

The second research question explored if children's developmental abilities influenced parents' verb use. Correlations between the 1;9 measures of child vocabulary and talkativity and the measures of parent verb input were examined. None of the correlations were statistically

significant (see Table 2), indicating that parents' verb use was not directly influenced by their children's expressive vocabulary abilities or by their talkativity during the parent–child interactions.

We then examined the relationships between the 1;9 parent verb input and children's 2;3 verb diversity. Pearson correlation coefficients were computed for the number of total verbs and the number of different verbs produced by parents in the 30-min free play, syntactic frame diversity and morphological context diversity of the frequently used verbs, and children's verb diversity (see Table 2). The number of total verbs and the number of different verbs in parent input correlated with each other ($r(18) = 0{\cdot}65$, $p = {\cdot}002$), indicating that parents who produced more verbs also used more different verbs. However, only parents' number of different verbs in the input was correlated with children's 2;3 verb diversity ($r(18) = 0{\cdot}56$, $p = {\cdot}011$); parents' total verbs was unrelated ($r(18) = 0{\cdot}15$, $p = {\cdot}524$). Input syntactic frame diversity of the frequently used verbs correlated with the morphological context diversity ($r(18) = 0{\cdot}77$, $p < {\cdot}001$). Parents who used the frequent verbs in more unique syntactic frames also employed more different morphological contexts. Interestingly, the number of total verbs produced was negatively correlated with the syntactic frame diversity of the frequently used verbs ($r(18) = -0{\cdot}50$, $p = {\cdot}025$). Parents who produced more verbs appeared to be more repetitive in their use of the frequent verbs, repeating this set of verbs in similar syntactic patterns.

A hierarchical regression analysis was conducted to determine if parent verb input explained additional variance in children's 2;3 verb diversity, after controlling for children's prior developmental abilities. Children's 2;3 verb diversity was the outcome variable. Three developmental factors were entered in Block 1: CDI total words, the number of different words, and the number of complete and intelligible utterances produced. Together, the three 1;9 developmental factors explained approximately 39% of the variance in the 2;3 verb diversity ($R^2 = {\cdot}388$, $F(3,16) = 3{\cdot}380$, $p = {\cdot}044$). Next, the number of different verbs produced by parents was entered in Block 2, since it was the only input measure that had a significant correlation with children's 2;3 verb diversity. The addition of parent verb input diversity resulted in a significantly improved model (R^2 change $= {\cdot}304$, $F(1,15) = 14{\cdot}797$, $p = {\cdot}002$; $R^2 = {\cdot}692$, $F(4,15) = 8{\cdot}420$, $p = {\cdot}001$). In this model, the four predictor variables together explained 69% of the variance; only the number of different verbs produced by parents and children's CDI total words were significant predictors. Finally, gender was entered in Block 3 to control for potential spurious effects influenced by gender. The addition of gender did not improve the model (R^2 change $< {\cdot}001$, $F(1,14) = 0{\cdot}002$, $p = {\cdot}965$), nor did it alter the significant predictor variables. In addition, semi-partial correlations were used to identify which predictor variables explained unique variance in children's 2;3 verb diversity, that is, variance

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explained that was not shared with any other variables in the model. In the final model, the number of different verbs produced by parents at 1;9 accounted for 30% of the variance in children's 2;3 diversity ($t(14) = 3{\cdot}717$, $p = {\cdot}002$), and children's CDI total words at 1;9 accounted for an additional 16% of the variance ($t(14) = 2{\cdot}721$, $p = {\cdot}017$). Note that the degree of overlap between verbs that parents used at 1;9 and those that children used at 2;3 differed among the dyads, ranging from 23% to 94% ($M = 69\%$, $SD = 0{\cdot}16$). In contrast, children's number of different words from the language samples, the number of complete and intelligible utterances produced by children, and gender, were not significant predictors ($t(14) = 0{\cdot}494$, $p = {\cdot}629$; $t(14) = 1{\cdot}126$, $p = {\cdot}279$; $t(14) = -0{\cdot}044$, $p = {\cdot}965$, respectively) (see Table 3).

DISCUSSION

The field of language development has long recognized that language learning is influenced by factors internal to the child as well as factors external to the child, such as his or her linguistic environment. The current study revisited this topic, presenting new empirical findings about the unique contribution of these two influences on children's verb acquisition. Parents' 1;9 verb input diversity predicted children's 2;3 verb diversity, uniquely accounting for 30% of the variance. Evidence for developmental continuity in children's lexical development was also apparent, as children's 1;9 lexicon size predicted their verb diversity six months later, explaining an additional 16% of the variance.

The current study builds upon the findings of prior research in children's lexical development (Hoff & Naigles, 2002; Huttenlocher *et al*., 1991, 2010; Rowe, 2012) by uncovering evidence for input effects specific to verb lexicon development. As verb acquisition is a vital component in language development, it is important to know how parent input facilitates children's verb learning. The previous literature documents that both input quantity and input diversity are important to lexical development at different ages (Huttenlocher *et al*., 1991, 2010; Rowe, 2012), with input diversity becoming more important than quantity by 2;6. Our findings provide converging evidence for the importance of input diversity to verb acquisition at an earlier point in development before the second birthday.

To better understand the kinds of verbs that parents with more diverse verb lexicons were using, we examined which verbs were used by most parents and which verbs were used by only a few. A total of 216 different verbs was produced collapsed across the twenty parents in the study, with thirty-two verbs (15%) used by more than half of the parents. Nine verbs were produced by all parents: *do, get, go, have, look, play, put, see*, and *want*, with most of them falling into the categories of the 'light verbs'

TABLE 3. *Predicting children's 2;3 verb diversity using 1;9 child developmental measures, 1;9 input verb measure, and child gender*

			Coefficients						
		Predictors	*beta*	*t*	*p*	*semi-partial r*	*F*	*p*	R^2
Model 1	Child developmental measures	CDI-total	0·402	1·861	·081	0·364	$F(3,16) = 3·380$	·044*	·388
		C-NDW	0·114	0·417	·682	0·082			
		C-C&I utt	0·312	1·236	·234	0·242			
Model 2	Child developmental measures	CDI-total	0·464	2·916	·011*	0·418	$F(4,15) = 8·420$	·001**	·692
		C-NDW	0·115	0·574	·575	0·082			
		C-C&I utt	0·221	1·187	·254	0·170			
	Input verb measure	P-NDV	0·561	3·847	·002**	0·551			
Model 3	Child developmental measures	CDI-total	0·466	2·721	·017*	0·404	$F(5,14) = 6·289$	·003**	·692
		C-NDW	0·111	0·494	·629	0·073			
		C-C&I utt	0·223	1·126	·279	0·167			
	Input verb measure	P-NDV	0·561	3·717	·002**	0·551			
	Child gender	C-Gender	−0·007	−0·044	·965	−0·007			

NOTES: C-NDW = children's number of different words; C-C&I utt = children's number of complete and intelligible utterances; P-NDV = parents' number of different verbs; C-Gender = child gender. * $p < ·05$, ** $p < ·01$.

proposed by Pinker (1989) or the general all-purpose (GAP) verbs proposed by Rice and Bode (1993). These verbs are frequent in input and are less specific in meanings as they do not map to specific actions (Pinker, 1989; Rice & Bode, 1993). The nine most frequently used verbs in the CHILDES database (Li & Shirai, 2000; MacWhinney, 2000) completely overlapped with our parents' most frequently used verbs. Only *do* and *have* were not included in the CHILDES list of verbs. More than half of our parents used common mental state verbs such as *know, think*, and *like*. They also used verbs that were commonly associated with the specific activities and materials in the playroom, including *eat, feed, cook* (kitchen area), *fit* (puzzles), *blow* (bubbles), and *open* (cabinets, toys in boxes with lids).

Among the total of 216 verbs, 184 verbs (85%) were used by ten or fewer parents, and 82 verbs (38%) were produced by only a single parent. Thus, the input verb lexicon collapsed across parents consisted of a small number of frequent verbs shared by most parents, with the vast majority of verbs rarely produced, often by only a single parent. Although the verbs produced by the majority of parents were mostly meaning-general, the remaining 85% included verbs that were more specific in the manner or the instrument encoded in the designated actions. Fewer parents used verbs with more specific meanings. For example, the general movement verb *go* was used 283 times by all twenty parents, whereas its manner-specific counterparts such as *walk, run*, and *step* were produced by fewer than six parents. Another example is the verb *play*. *Play* could be used as a general action label for many different activities and was used 175 times by all twenty parents, yet verbs denoting more precise play actions such as *bounce, lift*, and *toss* were used by fewer than three parents. Similarly, the activity verb *cook* was more likely to be used in the kitchen area of the playroom. It was produced 58 times by thirteen of the twenty parents. In contrast, the more specific verbs such as *stir, fry*, and *bake* were used by fewer than four parents. In summary, parents with more diverse verb lexicons tended to expose their children to more meaning-specific verbs, even though the children encountered these verbs infrequently in the input. Nevertheless, exposure to more meaning-specific verbs provided critical opportunities for children to increase their verb lexicon size.

Of the developmental factors considered, children's 1;9 vocabulary size as measured by parent report was a significant predictor of 2;3 verb diversity. This finding provides additional evidence for developmental continuity in early language development (Bates, Bretherton & Snyder, 1988; Marchman & Thal, 2005), as the expansion of the verb lexicon starts later compared to the rapid expansion of common nouns (Bates *et al*., 1994). On the other hand, children's talkativity and intelligibility at 1;9

did not predict their subsequent verb diversity. Children who were more intelligible or more talkative were not necessarily more advanced in verb development. Additionally, children's 1;9 developmental abilities did not influence the concurrent parent input they received. No significant relationships were observed between measures of children's vocabulary size and talkativity with the parents' verb input quantity, input diversity, or verb-related structural diversity. Although the finding differs from Huttenlocher *et al.*'s (2010), it should be noted that we restricted our sample to children with a limited initial verb lexicon size. Thus, the difference in findings may be attributable to a narrower range of children's vocabulary abilities in our sample as compared to Huttenlocher *et al.*'s sample.

The study further tested the hypothesis that syntactic and morphological diversity facilitate verb acquisition (de Villiers, 1985; Naigles & Hoff-Ginsberg, 1995, 1998). Our coding scheme, adapted from Naigles and Hoff-Ginsberg (1995, 1998), better captured the notion of the syntactic bootstrapping hypothesis. We counted the unique combinations of 'broad syntactic frames', the frames considered to be cues to verb meanings, whereas Naigles and Hoff-Ginsberg used the 'narrow syntactic frames', which do not translate into cues to verb meanings in an obvious manner (Naigles & Hoff-Ginsberg, 1998, p. 101). However, our input syntactic frame diversity variable was not significantly correlated with children's subsequent verb diversity, and hence was not included in the regression analysis. Recall that Naigles and Hoff-Ginsberg used pooled speech samples to examine the contribution of input structural cues to children's verb production. In contrast, we concentrated on the variation among parents in their input structural diversity. The fact that there were no significant relations between input structural diversity and children's subsequent verb diversity suggested that either parents did not differ sufficiently in their use of structural cues with frequent verbs, or the variability that was apparent did not contribute to children's verb diversity. It should also be noted that Naigles and Hoff-Ginsberg's measure of input structural diversity explained only 2% of the additional variance in child verb frequency, after controlling for the parent input verb frequency. Insofar as the current study examined variability in a small sample of individual parent–child dyads ($n = 20$) and not variability in the use of verbs within a language for a large pooled sample of many more dyads ($n = 57$), the absence of a significant effect for the structural cues may not be particularly surprising. Future research is needed to reconcile the difference between these two approaches to characterize structural cue diversity in input and its effect on verb acquisition.

This study also made use of a valuable methodological technique for exploring the impact of parent input on individual differences in toddlers'

language development. Following the design of Huttenlocher *et al*. (1991) and Rowe (2012) for initial vocabulary development, and Hadley, Rispoli, Fitzgerald, and Bahnsen (2011) for initial morphosyntactic development, we selected children to be homogeneous in age and developmental status. Developmental differences in verb lexicon size at the initial measurement point were also controlled, selecting children with ten or fewer verbs on the CDI. If developmental differences had been too extensive at the initial measurement point, the effects of developmental continuity could have overpowered the contribution of parent input. In addition, since parents may adjust their input to their children's level of lexical development (Huttenlocher *et al*., 2010), homogeneity in the target variable across the child participants also minimized differences in parent input that could be influenced by children's vocabulary abilities. Despite the homogeneity in children's initial verb lexicons, the parent input remained variable. As a result, we were able to isolate the contribution of input diversity to subsequent between-child differences in verb diversity. In contrast, the child participants in Hoff and Naigles' (2002) study were more heterogeneous. Hoff and Naigles investigated input effects on lexical development using children who were approximately 2;0. They selected children who "were just beginning to combine words", and examined the relationship between Time 1 input and Time 2 children's lexicon size ten weeks later. However, the child participants varied both in age and lexicon size at Time 1. Hoff and Naigles did not find input lexical diversity to be a significant predictor of children's subsequent lexicon size. Given the developmental differences between children at Time 1, it is possible that the developmental differences overrode the input effect. On the other hand, the current study was limited by the use of an archival database. Ideally, we would have initiated this study at 1;6, when nearly all children might be expected to have small expressive verb vocabularies. Because the initial measurement point in the archival database was at 1;9, we had to restrict our child participants to those with small expressive verb vocabularies to reduce initial developmental differences. This decision resulted in a sample of children drawn from the low to average range of verb acquisition (Dale & Fenson, 1996; Hadley, Rispoli & Hsu, in press) and a gender imbalance of fifteen boys and five girls. Replication of this study, beginning at an earlier point in development, will be important to determine the extent to which characteristics of the child participants may have influenced our findings.

In light of Rowe's (2012) findings, future studies should also be designed to determine whether different input characteristics contribute to children's verb diversity in different developmental periods. Given our observation that parents who had a more diverse verb lexicon tended to expose their children to more semantically specific verbs, future studies are needed to understand

factors that may influence the diversity and sophistication of the parent input verb lexicon. Potential factors such as parents' general education level, verbal ability, and joint engagement in play activities are worth exploring.

In closing, the current study showed that parent verb input diversity at 1;9 had a significant impact on children's subsequent verb diversity six months later, even after accounting for developmental continuity in early lexical development. Although a sufficient amount of parent input is essential early in children's lexical development (Huttenlocher *et al*., 1991, 2010), a diverse parent input verb lexicon with more semantically specific verbs appears to be a crucial factor for enhancing toddler's verb acquisition between 1;9 and 2;3.

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Appendix

The sixteen potential unique syntactic frame combinations with examples from the input corpus

Examples	Target Vs	Trans	Post-V Sen	Post-V PP	Verb-P
Are you blowing?	blow	o	o	o	o
You want to blow bubbles?	blow	✓	o	o	o
I thought you said byebye bubbles.	think	o	✓	o	o
Do you wanna play with the farm?	play	o	o	✓	x
Were you cleaning up?	clean	o	o	o	✓
I'll go get you some more to drink if you finish that.	get	✓	✓	o	o
Can you bring them to the table?	bring	✓	o	✓	o
Mommy has shoes on.	have	✓	o	o	✓
Go to the store and then we'll eat lunch.	go	o	✓	✓	o
Sit down this way until I tell you.	sit	o	✓	o	✓
Do you want me to hold on to them?	hold	o	o	✓	✓
You knocked so much stuff on the floor that you can't even walk.	knock	✓	✓	✓	o
Wipe it up because you got a little on the table.	wipe	✓	✓	o	✓
Can you put the bubbles back on the table?	put	✓	o	✓	✓
No example		o	✓	✓	✓
No example		✓	✓	✓	✓

NOTES: Target Vs = target verbs; Trans = transitivity; Post-V Sen = post-verbal sentence; Post-V PP = post-verbal prepositional phrase; Verb-P = verb-particle construction.

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