HHS Public Access

Author manuscript

Lang Learn Dev. Author manuscript; available in PMC 2023 January 01.

Published in final edited form as:

Lang Learn Dev. 2022 ; 18(3): 352–376. doi:10.1080/15475441.2021.1977645.

Difference or delay? Syntax, semantics, and verb vocabulary development in typically developing and late-talking toddlers

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Abstract

While semantic and syntactic properties of verb meaning can impact the success of verb learning at a single age, developmental changes in how these factors influence acquisition are largely unexplored. We ask whether the impact of syntactic and semantic properties on verb vocabulary development varies with age and language ability for toddlers aged 16 to 30 months in a large sample (N = 5520, $N_{\text{Late Talkers}}$ = 821; $N_{\text{Typically Developing}}$ = 4699, cutoff = 15th percentile) of vocabulary checklist data from the MacArthur- Bates Communicative Development Inventory (MBCDI). Verbs from the MBCDI were coded for their syntactic and semantic properties, including manner/result meanings, durative/punctual events, and syntactic complexity. Both late talkers and typically developing children were less likely to produce syntactically complex verbs at younger ages as compared to older ages. Group differences emerged for manner/result: Typically developing children were more likely to produce manner verbs at all ages, but late talkers were more likely to produce result verbs. Regardless of group, children who produced more manner versus result verbs also had larger verb vocabulary sizes overall. These results suggest that late talkers and typically developing toddlers differ in how they build their verb vocabularies.

Keywords

vocabulary; verbs; syntax; semantics; late talkers

Introduction

Verbs hold a unique place in language acquisition, providing the building blocks for mature sentence structure and supporting children's transition into multi-word utterances. Indeed, the number of verbs that children produce at age two is a better predictor of later grammatical skills than is the number of nouns they produce (Hadley et al., 2016). At the same time, verb learning poses unique challenges in vocabulary development, relying on different mechanisms than noun learning (Gentner, 1978; Gleitman, 1990). Children's first 50 words are predominantly nouns (Nelson, 1973), and this "noun advantage" continues through toddlerhood (Gentner, 1982; Gentner & Boroditsky, 2001). These differences in acquisition may be driven by how nouns and verbs encode meaning. Nouns frequently refer to physical, tangible objects. By contrast, verbs frequently refer to actions, which are ephemeral and often involve coordination among multiple participants in events and

arguments in syntactic structure. In this study, we focus on how several semantic and syntactic features of verbs related to event structure explain patterns in verb learning and expressive language skills in general across toddlerhood, from 16 to 30 months of age.

Verb learning is likely to be particularly difficult for children with early expressive vocabulary delays, known as late talkers (LTs: Rescorla, 1989). While the term “late talker” is not a clinical diagnosis, it has been used extensively in literature to identify toddlers who present with expressive vocabulary deficits absent any known developmental disorder, hearing loss, or cognitive impairment (e.g., Beckage et al., 2011; Fernald & Marchman, 2012; Horvath et al., 2019; Rescorla, 1989, 2002, 2005, 2009; for review, see: Desmarais et al., 2008). In turn, status as an LT is a risk factor for a later diagnosis of language disorder (Rescorla & Dale, 2013); although estimates vary, perhaps one third or more LTs will qualify for such a diagnosis by the age of five (Dale et al., 2003; Hammer et al., 2017). Further, LTs who do not develop a language disorder still have poorer language and academic outcomes as compared to their typically developing peers (TDs) throughout childhood and adolescence (Rescorla, 2002, 2005, 2009).

Beyond the differences in the raw number of words that LTs and TDs produce – which define LTs – there appear to be differences in the types of words that LTs and TDs’ acquire, including in their verb vocabularies (Beckage et al., 2011; Colunga & Sims, 2017; Horvath et al., 2019; MacRoy-Higgins et al., 2016; Rescorla et al., 2001). Differences in verb learning are particularly concerning because of their possible cascading effect on language outcomes, as the number and type of verbs that children learn predicts later language abilities (Hadley et al., 2016; Olswang et al., 1997). These observed differences in verb vocabulary development between LTs and TDs may also in part explain LTs’ poorer long-term outcomes (Rescorla, 2002, 2005, 2009).

Several aspects of lexical semantics and linguistic context are likely to influence early verb learning. In noun learning, for example, children are more likely to acquire nouns that denote basic level taxonomic distinctions (e.g., they are more likely to learn the word “dog” than the superordinate category “mammal”; Markman, 1989), and nouns that are higher in iconicity and those are associated with more perceptual features tend to be earlier acquired (Perry et al., 2015; Peters & Borovsky, 2019). While verbs do not share the same kind of semantic structures as nouns, they can be classified according to how they highlight aspects about the temporal structure and manner of events (e.g., Levin, 1993). Not only do the syntactic and semantic features of verbs predict individual verb acquisition at age two, but there are notable differences in the composition of early verb vocabularies in children who are LTs as compared to those who are TDs (Horvath et al., 2019).

Horvath et al. (2019, hereafter HRA) compared several syntactic and semantic features in the composition of LTs’ and TDs’ expressive verb vocabularies at age two with the Language Development Survey (LDS: Rescorla, 1989), a checklist of parent-reported expressive vocabulary. Verbs on the LDS were coded for their semantic properties, such as whether they denote manner or result meanings or whether they reference durative or punctual events, and also for the syntactic frames in which the verbs could appear, such as intransitive, transitive, or ditransitive frames. This work revealed that both syntactic and

semantic properties of verbs predicted the likelihood with which a child would produce them, and that LTs and TDs differed in the types of verbs they produced at age two.

A notable limitation of this prior study is that HRA were able to measure these verb learning phenomena only in two-year-olds' vocabularies. Toddlers, though, begin to acquire verbs well before their second birthdays. The average toddler has two verbs in their expressive vocabulary at 19 months of age and more than 40 verbs just six months later (Frank et al., 2016). These developmental differences may be driven by a range of factors, including increased linguistic experience and overall cognitive development. Properties of the verb, then, may differentially impact toddlers' verb learning over the course of development.

By focusing on the development of verb vocabulary across toddlerhood, we will also be able to identify fundamental mechanisms that contribute to variability in early verb learning and determine whether children with early delays show fundamentally different or simply delayed patterns in verb learning. Specifically, by exploring developmental trajectories from the start of the growth in expressive verb vocabulary, we can ask whether LTs demonstrate the same patterns of verb vocabulary development as TDs but are on a delayed trajectory or whether LTs demonstrate differences in which verbs they tend to learn – that is, whether LTs build up their verb vocabularies in different ways compared to TDs.

To implement this developmental approach, we extracted data from Wordbank (Frank et al., 2016), a large, open-access dataset of administrations of the MacArthur-Bates Communicative Development Inventories: Words and Sentences (MBCDI: Fenson et al., 2007), a checklist for parent-reported expressive vocabulary for children ages 16 to 30 months. Not only does this dataset include a larger number of administrations than was available to HRA using the LDS, but the MBCDI also captures a larger, more comprehensive set of early productive vocabulary (680 words vs. 310 words). This difference in scale is also true of verb vocabulary items (103 verbs to 50 verbs), with just 41% of the verbs on the MBCDI also appearing on the LDS. Therefore, this project will replicate and expand on prior work by identifying factors that support early verb learning using a larger dataset, across a wider age range, and a wider set of verbs. The following sections consider the semantic and syntactic verb properties that we measure in this project.

We note here that, as in the original HRA paper, we compare LTs to TDs matched by age rather than vocabulary size. While some LT studies include a control group matched for vocabulary size (e.g., Beckage et al., 2011), we argue that age-matching is inappropriate for this project's research questions. First, the second year of life is marked by significant cognitive and linguistic maturation, with implications for verb learning. Second, although LTs have delays in expressive vocabulary, at least some LTs have age-appropriate receptive language skills (e.g., Paul, 1991). Finally, children's vocabulary development is driven at least in part by exposure to vocabulary items (Goodman et al., 2008; Ma et al., 2009), which is unlikely to be equivalent between younger TDs and older LTs. Taken together, these factors suggest that older LTs are unlikely to demonstrate similar patterns of verb vocabulary development as younger TDs with similar vocabulary sizes, and that age-matched TDs are a better comparison point for understanding LT verb vocabulary development.

Manner and result meanings

Verb acquisition can be influenced by properties of the event the verb encodes, including manner/result distinctions (Behrend, 1990; Clark, 1995; Clark et al., 1995; Gopnik & Meltzoff, 1986; de Lemos, 1981; Horvath et al., 2019; Huttenlocher et al., 1983; Genter, 1978; Gropen et al., 1991; Penner et al., 2003). Manner verbs (e.g., “run,” “sing”) denote the mode of action of an event, and result verbs (e.g., “break,” “close”) denote the end state of the event. There is conflict in the literature as to which young children more easily acquire. Some studies suggest that resultive states are particularly salient and promote acquisition in toddlerhood (Clark, 1995; Clark et al., 1995; Gopnik & Meltzoff, 1986; de Lemos, 1981; Huttenlocher et al., 1983). Other studies find that toddlers demonstrate a bias toward interpreting and labeling events using manner verbs (Gentner, 1978; Gropen et al., 1991), suggesting that manner meanings might be easier for children to learn. Still other research has produced mixed findings depending on the task at hand (Behrend, 1990).

HRA provided a unifying explanation for these conflicting accounts based on a study of two-year-olds. In that study, TDs’ verb vocabularies included proportionally more manner verbs than result verbs, but LTs showed the opposite pattern. HRA posited that biases for manner or result verbs vary with age or language experience. Toddlers may initially acquire result verbs due to the saliency of end states, but then develop a later bias toward manner meanings. We test this hypothesis directly in our study.

Durative and punctual meanings

Children’s verb acquisition may also be affected by the temporal duration of the referent event. Durative verbs (e.g., “walk,” “play”) denote events which can be protracted over time, whereas punctual verbs (e.g., “clap,” “hit”) denote instantaneous events. Durative verbs may facilitate verb acquisition as compared to punctual verbs (Abbot-Smith et al., 2017; Horvath et al., 2018, 2019): Children have longer to identify and attend to the referent action with durative events, making a mapping between the event and verb more likely. With punctual events, a child may miss the opportunity to learn a verb if they do not attend at the appropriate moment.

Although less studied than the effect of manner and result, this hypothesis is supported by some research, both in tasks of novel-verb learning (Abbot-Smith et al., 2017) and in studies of toddlers’ verb vocabularies (Horvath et al., 2018, 2019). In a cross-linguistic study of English, Greek, Korean, Portuguese, and Italian, Horvath et al. (2018) found that children know proportionally more durative verbs than punctual verbs in all languages, although this difference was only significant for English and Korean. HRA also observed this pattern for both LTs and TDs, although the difference was not significant after controlling for word frequency.

Given these findings, we expect children to be more likely to have durative verbs than punctual verbs in their vocabularies but that this bias decreases across development. If indeed children struggle to acquire punctual meanings because of the challenges of attention allocation, then this should be less challenging for the child as attention allocation skills mature.

The syntactic environment of verbs

Verbs vary in their usage, appearing in more or less syntactically complex frames. For example, a verb may appear in a relatively simple intransitive frame (e.g., “The girl slept”) or in a more complex ditransitive frame (e.g., The girl gave the boy a present”). Longer utterances require more efficient linguistic processing abilities, which develop throughout toddlerhood (Fernald & Marchman, 2012; Fernald et al., 2006, 1998). Children who are more efficient at processing are better equipped to learn words (e.g., Peter et al., 2019). For example, Lany (2018) found that processing abilities predicted toddlers’ concurrent abilities to learn novel nouns. Unsurprisingly, toddlers’ processing abilities also predict later vocabulary size, and can even distinguish between LTs who are more likley to catch up and those who will remain delayed between 18 and 24 months of age (Fernald & Marchman, 2012).

Although no published studies have directly examined the relationship between processing and verb learning, findings from several studies indicate that children struggle to acquire verbs from complex lingusitic environments. For example, He et al. (2020) found in an experimental verb-learning task that two- and three- year-olds are more likely to acquire verbs that appear in simpler rather than more complex syntactic frames. HRA found that both LT and TD two-year-olds had proportionally fewer verbs that appear in complex ditransitive frames as compared to verbs that appear in intransitive or transitive frames.

We hypothesize that the difficulties associated with complex syntactic environments will be even greater for children at younger ages because of their slower processing abilities (Fernald et al., 2006). Although HRA did not find any differences between LTs and TDs at age two, we also tentatively predict there may be between-group differences in younger toddlers, with LTs having even greater difficulty with complex syntax as compared to TDs.

Methods

Participants

We use a freely available data sample of MBCDI vocabulary assessments from Wordbank, an open- source repository (Frank et al., 2016). We include all the data collected using the American English MBDCI Words and Sentences form, which includes 5520 children between 16 and 30 months of age (M = 22 months, SD = 4.7 months). For one-quarter of the data (N = 1426, 26%) we have no additional demographic data beyond age. Of the remaining, there was an approximately equal distribution of females (N = 1989, 49%) and males (N = 2105, 51%).

Participants’ overall productive vocabulary percentile rankings were calculated based on norms established by Fenson et al. (2007). Participants were classified as LT or TD based on overall vocabulary size, with LTs being those whose total vocabulary scores were below the 15th percentile for their age. (We note here that the percentile for classifying LTs has varied across the literature. While many studies have used the 15th percentile as a cutoff measure (e.g., Ellis et al., 2015; Horvath & Arunachalam, in press), others have used more stringent (10th percentile: Thal et al., 1997) or relaxed (30th percentile: Jones, 2003) cutoff points.

We use the 15th percentile because it is the closest cutoff to the estimated population rate of 13 to 15% (Desmarais et al., 2008; Zubrick et al., 2007).

In total, 15% of the sample were LTs (N_{LT} = 821, N_{TD} = 4699). LTs were, on average, slightly younger than TDs (M_{LT} = 21.2, SD_{LT} = 4.6; M_{TD} = 22.6, SD_{TD} = 4.7; t = 7.8, p < .001).

Verb Coding

All 103 vocabulary items in the "Actions" category of the MBCDI were included in our analysis. Verb features were coded by two trained undergraduate research assistants and then checked by SH and JK. Disagreements were rare (<5%) and resolved through discussion.

Manner and Result: We identified manner and result verbs via established diagnostics from Rappaport-Hovav and Levin (e.g., Levin & Rappaport-Hovav, 2013; Rappaport-Hovav & Levin, 2010). We excluded stative verbs (n = 8) – which are not associated with manner or result meanings – based on whether they can take the present progressive (e.g., #"I am wanting a shoe": Jackendoff, 1983). The remaining verbs were then rated on their acceptability in a sentence with the phrase "but nothing changed." Result verbs were identified as inacceptable in this frame (e.g., #"I broke the cup, but nothing changed"), while manner verbs were rated as acceptable (e.g. "I danced, but nothing changed"). In total, there were 50 manner verbs and 45 result verbs.

Durative and Punctual—Verbs were coded as durative or punctual based on whether the referent action could be protracted over time (e.g., Abbot-Smith et al., 2017; Horvath et al., 2018, 2019). Stative verbs do not encode durative or punctual meanings and were excluded from further diagnostics. The remaining verbs were placed in sentences with the phrase "three times in one minute" to identify whether the referent events could happen in rapid succession. If the sentence was felicitous, the verb was coded as a punctual verb (e.g., "I knocked on the door three times in one minute"); if the sentence was infelicitous, the verb was coded as durative (e.g., #"I cooked the pasta three times in one minute"). Additionally, coders were asked to judge whether the referent action could be stopped halfway through (durative) or not (punctual).

Some verbs, like "sit," vary in the temporal properties of the event (e.g., "The boy sat down on the ground" versus "The toy sat on the shelf all week"). In total, fifteen verbs in the data set were identified as able to denote both durative and punctual actions; these were not coded as belonging to either category but were instead excluded from this analysis. Of the remaining verbs, 47 were coded as durative and 33 were coded as punctual.

Linguistic complexity—Our linguistic complexity measure sought to estimate complexity according to verb usage in naturalistic, child-directed speech. Using the morphologically tagged North American transcripts from the CHILDES corpus (MacWhinney, 2000), we randomly sampled 100 utterances including each verb spoken to children at or under 30 months of age. Seven verbs ("chase," "hate," "paint," "skate," "smile," "splash," and "sweep") occurred fewer than 100 times and for these we included all instances of the verb. For each utterance, we quantified the complexity of the argument

structure with which a verb appeared by awarding one point for each of the following: subject, direct object, indirect object, and adjunct (e.g., prepositional phrase). Scores were averaged over the 100 utterances for an "average complexity score" for each verb (M = 1.4, SD = 0.4, range = 0.13 ("hurry") – 2.11 ("give")). Higher average complexity scores indicate that the verb regularly appears in more complex syntactic environments. Syntactic complexity scores did not differ between manner (M = 1.37, SD = 0.38) and result verbs (M = 1.45, SD = 0.32, $t(93) = 1.24$, $p = .22$, *n.s.*), nor were there differences between durative (M = 1.37, SD = 0.41) and punctual verbs (M = 1.53, SD = 0.28, $t(78) = 1.94$, $p = .056$, *n.s.*).

Covariates

Frequency—Children are more likely to produce words, including verbs, they hear more often (Goodman et al., 2008; Horvath et al., 2019; Ma et al., 2009; Naigles & Hoff-Ginsberg, 1998; Snedeker et al., 2013; Stokes, 2010; Theakston et al., 2004). We measured the log-frequency of verb usage using the CHILDES corpus (MacWhinney, 2000), again limiting our analyses to transcripts from morphologically tagged North American corpora for children at or younger than 30 months of age. To account for polysemous pairings (e.g., "play" or "skate"), we counted only those instances in which the word was coded as a verb.

Although our verb list is different from that of HRA, we found the same patterns in frequency of exposure based on verb properties. Result verbs (M = 2.99, SD = 0.6) averaged a higher frequency than manner verbs (M = 2.64, SD = 0.6, $t(93) = 2.72$, $p = .008$). There were no differences in frequency between durative (M = 2.79, SD = 0.6) and punctual verbs (M = 2.84, SD = 0.6, $t(78) = 036$, $p = .71$, *n. s.*). Verb complexity and frequency was not correlated ($t(204) = 0.04$, $p = .69$, *n.s.*).

Imageability—Imageability is a word's ability to evoke a mental image (Paivio et al., 1968). Several studies using vocabulary checklist data have found that higher imageability words, including verbs, are produced earlier than lower imageability words (Hansen, 2017; Ma et al., 2009; McDonough et al., 2011; Smolík, 2019; Snedeker et al., 2013).

Although normative imageability ratings exist for many English words (e.g., Masterson & Druks, 1998), these do not include the full list of MBCDI verbs. We therefore collected imageability norms for using Prolific, an online participant recruitment service. All participants were above 18 years of age and were recruited in accordance with IRB protocols at Purdue University. All 120 participants (Mage = 32.83 years, SDage = 10.56 years, 58 female, 61 male, 1 other) were native speakers of American English and were born and resided in the United States. Participants were asked to rate each verb on a scale from 1 ("extremely difficult or impossible to bring up a mental image") to 7 ("extremely easy to bring up a mental image"). Instructions were modeled on previous imageability surveys (e.g., Paivio et al., 1968; see Appendix A for full instructions).

Participants were randomly assigned to one of four blocks, each containing 25 or 26 verbs presented in a random order. In total, 30 ratings were collected for each verb. These were averaged for each verb's imageability rating (M = 5.6, SD = 1.0, range = 2.63 ("have") – 6.83 ("clap")). Manner verbs (M = 6.03, SD = 0.7) averaged a higher imageability rating than result verbs (M = 5.48, SD = 0.9, $t(93) = 3.4$, $p = .001$). There were no differences

between durative (M = 5.87, SD = 0.8) and punctual verbs (M = 5.63, SD = 0.9, $t(78)$ = 1.23, p = .22, *n.s.*). Syntactic complexity and imageability were not correlated (r = 0.06, t = 0.62, p = .53, *n.s.*).

Planned analyses

We planned two series of analyses: Opportunity scores, which were used to create visual representations of the data, and logistic regressions, which were used to explore patterns in the data. Our research questions and the logistic regressions were preregistered on Open Science Framework (OSF: https://osf.io/jwg26/?view_only=a40a7dbd0f844610b2d20a6b5adf3750).

Opportunity scores—As with HRA, we calculated opportunity scores to create visual representations of the data. Opportunity scores are calculated by-child by-feature as the proportion of verbs a child produced divided by the total number of verbs that have that feature. Because of the uneven number of verbs with each feature, children have more opportunities to demonstrate knowledge of certain features than others. Opportunity scores control for this variation. For example, a child who produces 40 manner verbs and 40 result verbs would have an opportunity score of 0.80 for manner verbs and 0.89 for result verbs; this is because there are more manner verbs (N = 50) than result verbs (N = 45) in our data set. For each child, we calculated opportunity scores for total verb vocabulary (out of 103), manner verbs (out of 50), result verbs (out of 45), durative verbs (out of 47), and punctual verbs (out of 33).

Logistic regressions—We planned a series of mixed-effect logistic regressions to test whether a verb's features significantly predicted the likelihood that a child would produce that verb, controlling for verb frequency and imageability. Regressions were run in R 3.5.0 (R Core Team, 2016) using the lme4 package version 1.1– 17 (Bates et al., 2015). For all regression models, each verb for each participant was included as a separate data point. The outcome variable for all regressions was whether the child produced (1) or did not produce (0) the target verb. We planned to run separate regressions to examine the effect of manner versus result meanings (contrast coded as: manner = 1, result = −1), durative versus punctual meanings (contrast coded as: durative = 1, punctual = −1), and average syntactic complexity. For the regressions exploring manner/result and durative/punctual features, those verbs coded as having neither meaning were removed.

We ran two separate regression models for each feature (manner/result, durative/punctual, and syntactic complexity). The first regression (Age/Percentile) explored whether verb features impacted children differently across age and percentile. The model additionally included fixed effects for age, percentile, the feature of interest, and their interactions. The second regression (Group) explored whether verb features impacted LTs and TDs differently. The model included fixed effects for age, group (LT/TD), the feature of interest, and their interactions. Age was included in this model to control for the fact that older children tend to produce more verbs, regardless of group. All regressions included verb frequency and imageability as covariates. Random intercepts for child and word were included in all mixed-effects models. All continuous variables were scaled and centered.

Hypothesized statistical outcomes

Our hypothesized statistical outcomes were also outlined as part of our OSF preregistration (https://osf.io/jwg26/?view_only=a40a7dbd0f844610b2d20a6b5adf3750).

Manner and result—We hypothesized that all children would demonstrate an early preference for result verbs, but by 24 months TDs would shift and demonstrate a preference for manner verbs instead. LTs would demonstrate a result preference through at least 24 months. We therefore expected to see an interaction between age and manner/result in the Age/Percentile model. In the Group model, we expected to see an interaction between group and manner/result, indicating that the properties of manner and result mattered differently to LTs and TDs.

Durative and punctual—We hypothesized that children would produce more durative verbs than punctual verbs throughout toddlerhood and that the magnitude of this difference would lessen as children aged. We therefore expected in the Age/Percentile regression to see a main effect of durative/punctual and a significant interaction between age and durative/punctual. In the Group model, we did not expect to see group differences between LTs and TDs, which would be demonstrated by a non-significant interaction between group and durative/punctual.

Syntactic complexity—We hypothesized that 1) children would be more likely to know verbs with smaller syntactic complexity scores than those with larger scores, 2) TDs would be more likely to know verbs with larger syntactic complexity scores than LTs, and 3) and that this difference would be greater at younger ages than at older ages. We therefore expected to find 1) a main effect of syntactic complexity in both models, 2) a significant group and syntactic complexity interaction in the Group model, and 3) a significant interaction between age and syntactic complexity in the Age/Percentile model.

Results

We first explored changes in overall verb vocabulary size across toddlerhood (Figure 1). Here, children's average proportion of verbs produced out of all possible verbs on the MBCDI is graphed as a factor of age and group. We observe that not only did TDs produce more verbs than LTs across all ages but that the gap between TDs and LTs widened across development, with TDs demonstrating faster growth in their verb vocabularies than LTs.

We also examined the most common verb vocabulary items in our data set, comparing 1) "young" (16 to 18-month-old) and "old" (28 to 30 month-old) toddlers, and 2) LTs and TDs. See Table 1a–b. We found that six of the ten most common verbs for young toddlers were also among the most common verbs for older toddlers. Additionally, LTs and TDs shared eight of their ten most common verbs. This latter finding is consistent with HRA, who noted that LTs and TDs shared 7 of the 10 most common verbs on the LDS.

To consider the effects of verb features on children's developing vocabulary, we will discuss the results of analyses examining manner and result meanings, durative and punctual meanings, and average syntactic complexity in turn. We note that all regressions found that

toddlers were more likely to produce verbs that average higher imageability ratings and higher frequency (Tables 2–4). Slope estimates and *p*-values are included in each regression table. Our discussion hereafter will focus on the impact of our variables of interest (manner/result, durative/punctual, syntactic complexity) on verb vocabulary development.

Manner and result verbs

Figure 2 displays the impact of manner and result meanings on children's developing verb vocabulary. For each child, we calculated the difference in the proportion of manner and result verbs produced (as, arbitrarily, proportion manner minus proportion result). This difference was averaged, by age and by group, to produce Figure 2. A visual inspection of the data indicates that, contrary to our prediction, TDs demonstrated a preference for manner verbs over result verbs across development. By contrast, LTs showed a preference for result verbs over manner verbs through 25 months of age. (Note that this difference was significant for all ages in that range other than 21 months). It is not until 30 months of age that LTs demonstrated the same preference as TDs for manner verbs over result verbs.

As expected, there were significant effects of age and percentile and an interaction between the two, (Table 2a), indicating that older children were more likely to produce verbs than younger children (consistent with the fact that verb vocabulary size increases with age), and children with higher percentile rankings were more likely to produce verbs than children with lower percentile rankings. The interaction between age and percentile indicated that children with higher percentile rankings had a steeper growth in the likelihood of verb production across age than children with lower percentile rankings. The main effects of age, percentile, and the interaction between them were observed in all subsequent Age/Percentile models and will not be further described.

As predicted, there was not a main effect of manner/result classification, indicating that there was no overall advantage for manner or result verbs across toddlerhood. A significant interaction between age and manner/result classification indicated that younger and older children varied in their acquisition of manner/result verbs. The direction of the slope indicated that children were more likely to acquire result verbs at older ages. We also saw a significant interaction between percentile ranking and manner/result classification, such that children with larger vocabularies were more likely to produce manner verbs than children with smaller vocabularies. Finally, a three-way interaction between manner/result classification, age, and percentile indicated that the impact of age on manner/result acquisition mattered differently to children based on their percentiles.

To analyze the three-way interaction, we compared the interaction of manner/result with percentile at the upper and lower bounds of age (16 and 30 months) where the effect of the interaction would be most pronounced. Note that we selected ages at the developmental boundaries of the dataset simply to facilitate describing the interaction rather than to make claims that these effects existed only in the youngest or oldest children. This analysis indicated that the effect of manner/result differed for younger and older children as a function of percentile. For the youngest children, the difference in the likelihood of production for manner compared to result verbs was larger at the highest percentiles (OR = 1.97, 95% CI = 1.21–3.19) than at lowest percentiles (OR = 1.14, 95% CI = 0.69–1.88, z

= 5.59, $p < .001$). For the oldest children, the difference in likelihood between manner and result verbs was larger at the lowest percentiles (*OR* = 1.39, 95% CI = 0.85–2.25) than at the highest percentiles (*OR* = 1.05, 95% CI = 0.64–1.72, $z = -3.00$, $p = .001$). The magnitude of the test statistics indicated that the interaction between percentile and manner/ result was more pronounced for the youngest children than the oldest children. This suggested that the three-way interaction between age, percentile, and manner/result was driven by a response to manner/result for younger children across vocabulary development that was stronger than for older children.

The Group model (2B) identified main effects of age and group but not of manner/result classification, meaning that older children and TDs were more likely to have verbs than younger children and LTs, respectively. There was a significant interaction between group and verb type and the direction of the slope indicated that TDs were more likely to produce manner verbs than were LTs. There was also a significant interaction of age and verb type, with older children more likely to produce manner verbs than younger children. We saw significant interaction of age and group, which indicates that TDs acquired verbs at a faster rate across development than LTs did. (This is consistent with a visual inspection of Figure 1. The same pattern of results for age, group, and their interaction emerged for all subsequent Group regressions and will not be further described.) Finally, there was a significant three-way interaction between verb type, age, and group, which indicated that the effect of age on producing manner/result verbs differed between LTs and TDs.

To characterize this interaction, we compared the how effect of manner/result varied across age for each group. The two groups demonstrated differences in their response to manner/ result across age. For TDs, manner verbs were more likely than result verbs to be produced at both the youngest ages (*OR* = 1.68, 95% CI = 1.04–2.72) and the oldest ages (*OR* = 1.18, 95% CI = 0.73–1.90) but the advantage for manner verbs diminished with age ($z = -9.20$, $p < .001$). In contrast, for LTs, result verbs were more likely than manner verbs to be produced at the youngest ages (*OR* = 1.48, 95% CI = 0.82–2.67) while manner verbs were more likely than result verbs to be produced at the oldest ages (*OR* = 1.45, 95% CI = 0.88–2.38), a significant change ($z = 3.50$, $p < .001$). Taken together, these analyses indicate that whether a verb is a manner or result verb matters to the developing toddler, with its impact varying as a product of the child's age and language abilities. Notably, LTs demonstrated different patterns in their acquisition of manner and result verbs than did TDs. We explore these findings further in a series of post-hoc analyses.

Durative and punctual verbs

We calculated, for each child, the difference in the proportion of durative and punctual verbs produced, and then took the difference between them (as, arbitrarily, proportion durative minus proportion punctual). Results are depicted in Figure 3, averaged by age and by group. As predicted, TDs demonstrated a preference for durative verbs over punctual verbs throughout development. LTs also showed a preference for durative verbs over punctual verbs beginning at 24 months of age. Prior to this, LTs did not show a consistent pattern of development, variously preferring durative over punctual verbs (16 and 20 months), punctual

over durative verbs (at 21 months), or demonstrating no significant preference for either (at 17–19 and 22–23 months).

Contrary to prediction, the Age/Percentile model (Table 3A) revealed no main effect for durative/punctual classification, indicating that there was not an overall preference to produce either verb type collapsed across development. However, a significant interaction between durative/punctual and age indicated that production of durative/punctual verbs varied across age. We examined the effect of durative/punctual classification at 16 and 30 months where the interaction should be most apparent. This post-hoc testing indicated that the youngest children were more likely to produce punctual (vs. durative) verbs (*OR* = 1.03, 95% *CI* = 0.63–1.69) while the oldest children demonstrated the opposite pattern (*OR* = 0.90, 95% *CI* = 0.55–1.47). However, the difference between these odds ratios is quite small, corresponding an advantage for punctual verbs for the 16-month-olds of less than one percentage point (0.01%) and an advantage for durative verbs for the oldest children of around one percentage point (1.07%). This suggests that although there was a change in the effect of durative/punctual across age, the effect was small.

There was also a significant interaction between durative/punctual classification and percentile. The odds that a child with a vocabulary size at the lowest percentiles would produce a punctual verb were 1.02 times larger than the odds for a durative verb (95% CI = 0.62–1.67), while the odds that a child with a vocabulary size at the highest percentiles would produce a durative verb were 1.09 times larger than the odds for a punctual verb (95% CI = 0.67–1.79). As with the interaction between age and durative/punctual classification, however, these odds ratios reflected small differences in absolute percent advantage for durative or punctual verbs (0.01% and 0.77% for the youngest and oldest children, respectively), indicating that the effect of this interaction was also small. We did not see a significant three-way interaction between age, verb type, and percentile.

The Group model also indicated that LTs and TDs did not differ in the likelihood of production of durative/punctual verbs (Table 3b). There was no significant main effect of durative/punctual classification, nor was there a significant interaction between classification and age or classification and group. The three-way interaction variable of age, group, and durative/punctual was also not significant. Taken together, our models indicated that durative/punctual classification had a limited effect on the verbs that toddlers learn to produce.

Syntactic complexity

We first visualized developmental changes in syntactic complexity by averaging the syntactic complexity scores of verbs that children were reported to produce by group and age (Figure 4). We hypothesized that if verb syntactic complexity did not impact vocabulary development, then average syntactic complexity of verbs produced should be no different from the average syntactic complexity across all of the verbs on the MBCDI. This instrument-average complexity (*M* = 1.41) is represented by a dashed line in Figure 4. Early in verb vocabulary development, both LTs and TDs averaged a smaller syntactic complexity score than the mean MBCDI score. We also note that this gap disappeared for TDs at 21 months, but it did not disappear for LTs until 28 months.

As with the previous models, the Age/Percentile model (Table 4a) revealed significant main effects of age and percentile and a significant interaction between them. The main effect of syntactic complexity was not significant, but there was a significant interaction between age and syntactic complexity. Post-hoc testing revealed that the interaction between syntactic complexity and age was driven by a larger response to syntactic complexity for younger children compared to older children, with younger children showing a greater likelihood to produce verbs in simpler syntactic frames. The odds that a 16-month-old child would produce a verb with the lowest syntactic complexity score were 4.48 times larger than the odds for a verb with the largest syntactic complexity score (95% CI = 1.26– 16.00, z = 2.32, p = .041, Holm adjustment applied). In contrast, while the odds that a 30-month-old would produce a verb with the smallest syntactic complexity score were also larger than the odds for a verb with the largest syntactic complexity score, this ratio was not significantly different from 1 (OR = 2.35, 95% CI = 0.67–8.30, z = 1.51, p = .19, *n.s.*).

There was also a significant interaction between percentile and syntactic complexity. Post-hoc testing showed that the interaction between syntactic complexity and percentile was due to a larger response to syntactic complexity for children with lower vocabulary size percentiles compared to those with higher vocabulary size percentiles. The odds that a child with a vocabulary size at the 1st percentile would produce a verb with the smallest syntactic complexity score were 5.13 times larger than the odds for a verb with the largest syntactic complexity score (95% CI = 1.44–18.25, z = 2.52, p = .023, Holm adjustment applied). Just as with the interaction with age, however, the odds ratio for a child with a vocabulary size at the 99th percentile was not significantly different from 1 (OR = 2.06, 95% CI = 0.58– 7.28, z = 1.12, p = .26). The three-way interaction of age, percentile, and syntactic complexity was not significant.

These findings indicate that verb knowledge is influenced by a verb's syntactic complexity, such that younger children are more likely to learn verbs that appear in syntactically simpler frames. We also conclude that, contrary to our predictions, LTs do not incur greater deficits from syntactic complexity than do TDs.

Post-hoc analyses

Our planned analyses identified one notable difference between LTs and TDs: LTs produced more result than manner verbs during toddlerhood, while TDs produced more manner than result verbs. To further characterize these group differences, we began by asking what proportion of LTs' and TDs' verb vocabularies were "manner dominant" or "result dominant." As with our initial analyses, we calculated the proportion of manner and result verbs produced by each child and the difference between them (as manner minus result). If this value was positive, the child was considered to be "manner dominant," indicating that the child produced a greater proportion of the manner verbs on the MBCDI than result verbs. If the value was negative, the child was considered "result dominant." If the value was equal to 0, the child was considered to have "no dominance."

Figure 5a – b illustrates the proportion of manner- and result-dominant LTs and TDs, by age ($N_{\text{LT-manner dominant}}$ = 135; $N_{\text{LT-result dominant}}$ = 250; $N_{\text{TD-manner dominant}}$ = 2486; $N_{\text{TD-result dominant}}$ = 1563). We note that a greater proportion of LTs are result dominant

than manner dominant at all ages other than 30 months (overall, 30% of LTs are result dominant and 16% manner dominant). By contrast, a greater proportion of TDs are manner dominant than result dominant at all ages other than 16 months (overall, 53% of TDs are manner dominant and 33% result dominant). To confirm that dominance differed between groups, we ran a logistic model using the lme4 1.1–17 software (Bates et al., 2015) in R 3.5.0 (R Core Team), predicting children's verb dominance based on group (LT/TD), age, and their interaction. This model demonstrated that both age and group were significantly associated with dominance classification. Specifically, result dominance was less likely for older children than for younger children ($\beta = -0.39$, SE = 0.07, $z = -5.91$, $p < .001$), and more likely for LTs than TDs ($\beta = 0.64$, SE = 0.07, $z = 10.08$, $p < .001$).

We also explored whether manner or result dominance had an impact on verb vocabulary growth in Figure 6. Note that children who had no dominance ($N = 1086$, $P = .20$ of sample) were excluded from this figure for clarity, but they were included in our subsequent regression analysis. We observed a benefit for manner dominance for both LTs and TDs, wherein children who were manner dominant produced more verbs overall compared to children who were result dominant. For TDs, this benefit was observable between 16 and 25 months, and for LTs, this benefit emerged around 26 months (with significant differences at 26 and 28–30 months).

We then carried out a linear regression to explore how age (in months, centered), group (LT or TD) and dominance (manner, result) predicted number of verbs produced by each child (Table 5). This dominance variable was a continuous variable representing the difference between the proportion of manner verbs and result verbs for each child. Positive values indicated a manner dominance whereas negative values indicated a result dominance. The regression yielded main effects of age and group and a significant interaction between them, showing the same patterns as the other models. There was a significant three-way interaction between age, group, and manner/result difference.[1] This interaction was characterized by a changing effect of manner dominance compared to result dominance across age and groups. (In the following, ΔDom refers to the change in verb vocabulary size from no dominance to a 10% manner dominance. Please note, however, that this 10% value was not chosen to represent a "cutoff" or a dichotomous change. We describe how verb vocabulary size changed across this range of manner dominance only to illustrate the continuous interactions between age, group, and manner dominance from the model in our post-hoc tests.) Specifically, for TDs, having a higher manner dominance was associated with higher verb vocabulary sizes for younger children ($EMM_{\Delta Dom} = 13.91$) and lower verb vocabulary sizes for older children ($EMM_{\Delta Dom} = -7.73$, $t(5512) = 15.31$, $p < .001$). For LTs, these patterns reversed, though they did not reach significance ($t(5512) = -1.69$, $p = 0.090$, *n.s.*); a higher manner dominance was associated with lower verb vocabulary sizes for younger children ($EMM_{\Delta Dom} = -6.67$) and higher verb vocabulary sizes for older children

[1] In conducting our post-hoc analyses, we observed that children—both LT and TD—with a manner dominance also had larger overall MBCDI vocabulary sizes as compared to those with a result dominance (manner dominance: $M = 330$, $SD = 181$, $N = 2621$; result dominance: $M = 231$, $SD = 199$, $N = 1813$; $t(4432) = 17.4$, $p < .001$). A linear regression predicting the total vocabulary size from a three-way interaction of age (centered), group (LT or TD) and dominance yielded an identical pattern of results to our regression predicting verb vocabulary size. Age ($b = 13$, $p < 0.001$), group ($b = 55$, $p < .001$) and their interaction ($b = 30$, $p < .001$) were all significant, as was the three-way interaction between age, group, and dominance ($b = -4.4$, $p < .001$). Children with manner dominance have not only larger verb vocabularies but larger vocabularies overall.

($EMM_{\Delta Dom}$ = 7.35). These results suggest that the effect of manner/result dominance changed across age, particularly for TDs.

Discussion

The main goal of this study was to explore how semantic and syntactic properties of verbs impacted early verb vocabularies across toddlerhood, and whether patterns of verb vocabulary development differed between LTs and TDs. Prior studies have indicated that semantic and syntactic properties of verbs influence early verb acquisition after the age of 2, but there has been little work exploring verb acquisition patterns earlier in development. Our findings contribute to the literature by examining developmental patterns at play between 16 and 30 months.

To summarize our findings, the only property in which LTs and TDs differ in development is that of manner/result meanings: TDs are more likely to produce manner verbs, whereas LTs are more likely to produce result verbs. A post-hoc analysis revealed that, regardless of group, children who are manner dominant produce more verbs overall than those who are result dominant. Syntactic complexity also impacted toddlers' verb vocabulary development, such that toddlers were more likely to produce verbs that averaged lower syntactic complexity scores; however, contrary to prediction, we did not see any group differences. Finally, the distinction of durative/punctual verb meanings did not impact toddlers' verb vocabularies.

To begin with our null finding – that durative/punctual classification does not impact verb vocabulary development – we note that prior research has indicated a bias for durative verbs over punctual verbs (Abbot-Smith et al., 2017; Horvath et al., 2018, 2019), but findings have not always been significant across ages and languages. A visual inspection of our data suggested that children have more durative than punctual verbs in their vocabularies; however, regression results yielded no main effect of durative/punctual classification. There were significant interactions between durative/punctual and age and between durative/punctual and percentile, with older children and children with larger vocabularies producing more durative verbs than younger children and children with smaller vocabularies, respectively. Post-hoc analyses indicated that these effect sizes were very small. Still, that durative/punctual classification interacts with age may explain the varied findings in prior literature. Horvath et al.'s research (Horvath et al., 2018, 2019) included toddlers between 1.5 and 3 years of age, but Abbot-Smith et al. studied 3- to 5-year-olds. We propose further research on durative versus punctual verbs, looking at age effects throughout the preschool years.

By contrast, a verb's syntactic complexity did significantly impact verb vocabulary development. We hypothesized that LTs and younger children would be less likely to produce complex verbs as compared to TDs and older children, respectively. Only our age hypothesis was confirmed, indicating developmental differences across 16–30 months. These findings build on substantial literature that suggests that verb acquisition may be supported by simpler syntactic complexity (He et al., 2020; Hoff & Naigles, 2002; Horvath

et al., 2019) and that vocabulary acquisition is perhaps tied to toddlers maturing processing abilities (Lany, 2018).

Most interestingly, we observed that manner/result classification impacted toddlers' vocabularies, and that whether a verb was manner or result mattered differently to LTs and TDs. This was the only between-group difference in our analysis. Specifically, LTs produced proportionally more result verbs than manner verbs, while TDs showed the reverse pattern. Our results both replicate and extend HRA's findings by illustrating that between-group differences exist even at the earliest stages of verb production. In this respect, at least, LTs are not simply delayed in early patterns of verb acquisition but instead may adopt different strategies than their TD peers in building their verb vocabularies.

Irrespective of LT status, individual differences in manner and result dominance had important implications for overall vocabulary size. Toddlers in both groups (LT and TD) who produced proportionally more manner than result verbs averaged overall a larger verb vocabulary size as compared to those who produced proportionally more result than manner verbs. We put forth two explanations, not incompatible, for this manner advantage. First, manner verbs might better support the building of semantic network structure. In developing a semantic network, children are better able to acquire words that connect to vocabulary items they already know over words that have no shared connections to the network (Borovsky, 2020; Borovsky et al., 2016; Steyvers & Tenenbaum, 2005; Wojcik & Saffran, 2013). We hypothesize that manner verbs share a greater number of connections to other words as compared to result verbs. If true, learning a manner verb would then be advantageous because it opens up a greater number of connections to build from than learning a result verb does. (See Kueser et al. (in prep) for research on the semantic structure of verb vocabularies.)

It is also possible that acquiring manner and result verbs differentially challenges children's attention allocation (or inhibition) or event processing abilities. Specifically, we posit that children with better attention allocation skills are better prepared to learn manner meanings than those with poor attention allocation skills. Result verbs encode the end states of events, including often change-of -state events, and for this reason they are considered more salient to young learners (Clark et al., 1995; Gopnik & Meltzoff, 1986; De Lemos, 1981). In a verb-learning event, then, result dominant children might be more interested in the individual participants of the event rather than their interaction, with verb learning happening most often when salient changes of state draw their attention. By contrast, manner dominant children might be more attuned to the interactions among event participants, making them better poised to acquire both manner and result meanings. In support for this attention hypothesis, Yu and Smith (2011) described differences in gaze between "strong" and "weak" word learners, aged 14 months, although their task was for novel noun learning. Similarly, MacRoy-Higgins and Montemarano (2016) found broad attentional differences between LTs and TDs in learning novel nouns, which predicted their word-learning outcomes. (Although, see Kautto et al. (2021) who observe no relationship between inhibitory control and language outcomes for LTs.)

The finding that LTs and TDs differ in verb vocabulary development also has implications for assessment and intervention. We propose future research that tracks LTs' longitudinal vocabulary growth, contrasting LTs who demonstrate result dominance to those with manner dominance. We hypothesize that manner-dominant LTs would be more likely to catch up to their TD peers while result-dominant LTs may be at increased risk for developmental language disorder. Similarly, future research should explore whether interventions that specifically teach manner verbs accelerate LTs' rate of verb vocabulary growth as compared to interventions that teach both manner and result verbs.

Limitations

We note three primary limitations in this study. The first is perhaps the most obvious: We lack rich participant demographic information for a large portion of our sample. Although the cause of late talking is unknown, having demographic information would help us better characterize and compare LTs and TDs. We would also be able to remove from the LT group toddlers whose late talking has a clear antecedent (such as premature birth); at present, we acknowledge that some LTs likely have more complex profiles than just delays in language.

Second, we measured children's verb knowledge based on productive verb vocabulary between 16 and 30 months. Although this choice allowed us to use a large data repository (Wordbank: Frank et al., 2016), and although receptive verb knowledge is notoriously difficult to measure in this age range (Fenson et al., 1994; Horvath & Arunachalam under review, in press; Houston-Price et al., 2007; Valleau et al., 2018), children's productive vocabularies are not an exact match for their receptive knowledge. This relationship is likely particularly complex for LTs, some of whom have receptive deficits and some of whom do not (Desmarais et al., 2008).

Finally, we assumed that all children had accurate representations of the verbs they produce. Although errors in word learning appear to be rare, at least in considering expressive vocabulary, lack of errorful production does not equate to adult-like representation of words. Children are notoriously hesitant to extend verbs, and whether this is a reflection of impoverished representation (Tomasello & Abbott-Smith, 2002; Tomasello & Akhtar, 2003) or a conservative strategy (Naigles, 2002; 2003) is still debated. Accuracy in representation may also be a reflection of the type of meaning encoded. For example, Arunachalam and He (2018) recently found that two- to three-year-olds are more likely to have errors in representation for nouns that encode events rather than objects, such as "party." They hypothesized that this is because eventive nouns violate the assumption children make in word-learning that nouns denote objects, evidenced by the fact that most children's incorrect representations were of proto-typical objects associated with the event (such as a cake). The accuracy and robustness of verb representations remains an open area of research for the field.

Conclusion

We conclude that the syntactic and semantic properties of verbs impact verb vocabulary development, and that this impact varies with age and language ability. Importantly, LTs show marked differences in their patterns of verb vocabulary development as compared

to TDs. This finding has potential clinical implications for both early diagnosis and early intervention. Further research should explore these differences with particular attention to improving LTs' outcomes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgements:

This work was partially supported by HD052120 to AB, T32 DC000030 to SH, and F31 DC018435 to JBK.

References

Abbot-Smith K, Imai M, Durrant S, & Nurmsoo E (2017). The role of timing and prototypical causality on how preschoolers fast-map novel verb meanings. First Language, 37(2), 186–204.

Arunachalam S, & He AX (2018). Children's acquisition of nouns that denote events. In Bertolini AB & Kaplan MJ (Eds.), Proceedings of the 42nd annual boston university conference on language development (pp. 29–44). Cascadilla Press.

Bates D, Mächler M, Bolker B, & Walker S (2015). Fitting linear mixed-effects models using lme4. Journal of Statistical Software, 67(1), 1–48.

Beckage N, Smith L, Hills T, & Perc M (2011). Small worlds and semantic network growth in typical and late talkers. PLoS ONE, 6(5), e19348. [PubMed: 21589924]

Behrend DA (1990). The development of verb concepts: Children's use of verbs to label familiar and novel events. Child Development, 61(3), 681–696. [PubMed: 2364743]

Borovsky A (2020). When slowing down processing helps learning: Lexico-semantic structure supports retention, but interferes with disambiguation of novel object-label mappings. Developmental Science, 23(6), e12963. [PubMed: 32160363]

Borovsky A, Ellis EM, Evans JL, & Elman JL (2016). Lexical leverage: Category knowledge boosts real-time novel word recognition in 2-year-olds. Developmental Science, 19(6), 918–932. [PubMed: 26452444]

Clark E (1995). The lexicon in acquisition. Cambridge University Press.

Clark E, Carpenter K, & Deutsch W (1995). Reference states and reversals: Undoing actions with verbs. Journal of Child Language, 22(3), 633–652. [PubMed: 8789517]

Colunga E, & Sims CE (2017). Not only size matters: Early-talker and late-talker vocabularies support different word-learning biases in babies and networks. Cognitive Science, 41(S1), 73–95. [PubMed: 27873349]

Dale PS, Price TS, Bishop DV, & Plomin R (2003). Outcomes of early language delay. Journal of Speech, Language, and Hearing Research, 46(3), 544–560.

de Lemos C (1981). Interactional processes in the child's construction of languages. In Deutsch W (Ed.), The child's construction of language (pp. 57–76). Academic Press.

Desmarais C, Sylvestre A, Meyer F, Bairati I, & Rouleau N (2008). Systematic review of the literature on characteristics of late-talking toddlers. International Journal of Language & Communication Disorders, 43(4), 361–389. [PubMed: 17885825]

Ellis EM, Borovsky A, Elman JL, & Evans JL (2015). Novel word learning: An eye-tracking study. Are 18-month-old late talkers really different from their typical peers?. Journal of communication disorders, 58, 143–157. [PubMed: 26188415]

Fenson L, Dale PS, Reznick JS, Bates E, Thal DJ, Pethick SJ, Tomasello M, Mervis CB, & Stiles J (1994). Variability in early communicative development. Monographs of the Society for Research in Child Development, 59(5), i–185. [PubMed: 8047076]

Fenson L, Marchman VA, Thal DJ, Dale P, & Reznick JS (2007). MacArthur-bates communicative development inventories: User's guide and technical manual (2nd ed.). Singular.

Fernald A, & Marchman VA (2012). Individual differences in lexical processing at 18 months predict vocabulary growth in typically developing and late-talking toddlers. Child Development, 83(1), 203–222. [PubMed: 22172209]

Fernald A, Perfors A, & Marchman VA (2006). Picking up speed in understanding: Speech processing efficiency and vocabulary growth across the 2nd year. Developmental Psychology, 42(1), 98. [PubMed: 16420121]

Fernald A, Pinto JP, Swingley D, Weinbergy A, & McRoberts GW (1998). Rapid gains in speed of verbal processing by infants in the 2nd year. Psychological Science, 9(3), 228–231.

Frank MC, Braginsky M, Yurovsky D, & Marchman VA (2016). Wordbank: An open repository for developmental vocabulary data. Journal of Child Language.

Gentner D (1978). On relational meaning: The acquisition of verb meaning. Child Development, 49(4), 988–998.

Gentner D (1982). Why nouns are learned before verbs: Linguistic relativity versus natural partitioning. In Kuczaj S (Ed.), Language development: Language, thought, and culture (Vol. 2, pp. 301–334). Lawrence Erlbaum Associates.

Gentner D, & Boroditsky L (2001). Individuation, relativity, and early word learning. In Bowerman M & Levinson S (Eds.), Language Acquisition and Conceptual Development (Language Culture and Cognition, pp. 215–256). Cambridge: Cambridge University Press.

Gleitman LR (1990). The structural sources of verb meanings. Language Acquisition, 1(1), 3–55.

Goodman JC, Dale PS, & Li P (2008). Does frequency count? Parental input and the acquisition of vocabulary. Journal of Child Language, 35(3), 515. [PubMed: 18588713]

Gopnik A, & Meltzoff AN (1986). Relations between semantic and cognitive development in the one-word stage: The specificity hypothesis. Child Development, 57(4), 1040–1053.

Gropen J, Pinker S, Hollander M, & Goldberg R (1991). Affectedness and direct objects: The role of lexical semantics in the acquisition of verb argument structure. Cognition, 41(1/3), 153–195. [PubMed: 1790653]

Hadley PA, Rispoli M, & Hsu N (2016). Toddlers' verb lexicon diversity and grammatical outcomes. Language, Speech, and Hearing Services in Schools, 47(1), 44–58. [PubMed: 26803292]

Hammer CS, Morgan P, Farkas G, Hillemeier M, Bitetti D, & Maczuga S (2017). Late talkers: A population-based study of risk factors and school readiness consequences. Journal of Speech, Language, and Hearing Research, 60(3), 607–626.

Hansen P (2017). What makes a word easy to acquire? The effects of word class, frequency, imageability and phonological neighbourhood density on lexical development. First Language, 37(2), 205–225.

He AX, Kon M, & Arunachalam S (2020). Linguistic context in verb learning: Less is sometimes more. Language Learning and Development, 16(1), 22–42. [PubMed: 33013240]

Hoff E, & Naigles L (2002). How children use input to acquire a lexicon. Child Development, 73(2), 418–433. [PubMed: 11949900]

Horvath S, Rescorla L, & Arunachalam S (2018). Acquiring a verb lexicon: Semantic features of toddlers' early vocabularies. In Syrett K & Arunachalam S Eds., Semantics in acquisition (Trends in Language Acquisition Research) (pp. 68–92). John Benjamins Publishing Company.

Horvath S, & Arunachalam S (in press). Repetition vs. variability in verb learning: Sometimes less is more. Journal of Speech, Language, and Hearing Research.

Horvath S, & Arunachalam S (under review). Assessing receptive verb vocabulary in children with language delays and disorders.

Horvath S, Rescorla L, & Arunachalam S (2019). The syntactic and semantic features of two-year-olds' verb vocabularies: A comparison of typically developing children and late talkers. Journal of Child Language, 46(3), 409–432. [PubMed: 30632475]

Houston-Price C, Mather E, & Sakkalou E (2007). Discrepancy between parental reports of infants' receptive vocabulary and infants' behaviour in a preferential looking task. Journal of Child Language, 34(4), 701–724. [PubMed: 18062356]

Huttenlocher J, Smiley P, & Charney R (1983). Emergence of action categories in the child: Evidence from verb meanings. Psychological Review, 90(1), 72–93.

Jackendoff R (1983). Semantics and cognition. MIT Press.

Jones SS (2003). Late talkers show no shape bias in a novel name extension task. Developmental Science, 6(5), 477–483.

Kautto A, Jansson-Verkasalo E, & Mainela-Arnold E (2021). Generalized slowing rather than inhibition is associated with language outcomes in both late talkers and children with typical early development. Journal of Speech, Language, and Hearing Research, 64(4), 1222–1234.

Kueser JB, Horvath S, & Borovsky A (in prep). Semantic feature norms for early-learned English verbs.

Lany J (2018). Lexical-processing efficiency leverages novel word learning in infants and toddlers. Developmental Science, 21(3), e12569. [PubMed: 28597549]

Levin B (1993). English verb classes and alternations: A preliminary investigation. University of Chicago press.

Levin B, & Rappaport Hovav MR (2013). Lexicalized meaning and manner/result complementarity. In Arsenijević B, Gehrke B, & Marín R (Eds.), Subatomic semantics of event predicates (pp. 49–70). Springer.

Ma W, Golinkoff RM, Hirsh-Pasek K, McDonough C, & Tardif T (2009). Imageability predicts the age of acquisition of verbs in Chinese children. Journal of Child Language, 36(2), 405. [PubMed: 18937878]

MacRoy-Higgins M, & Montemarano EA (2016). Attention and word learning in toddlers who are late talkers. Journal of Child Language, 43(5), 1020. [PubMed: 27464621]

MacRoy-Higgins M, Shafer VL, Fahey KJ, & Kaden ER (2016). Vocabulary of toddlers who are late talkers. Journal of Early Intervention, 38(2), 118–129.

MacWhinney B (2000). The CHILDES project, 3rd ed. Lawrence Erlbaum.

Markman EM (1989). Categorization and naming in children: Problems of induction. MIT Press, Bradford Books.

Masterson J, & Druks J (1998). Description of a set of 164 nouns and 102 verbs matched for printed word frequency, familiarity and age-of-acquisition. Journal of Neurolinguistics, 11(4), 331–354.

McDonough C, Song L, Hirsh-Pasek K, Golinkoff RM, & Lannon R (2011). An image is worth a thousand words: Why nouns tend to dominate verbs in early word learning. Developmental Science, 14(2), 181–189. [PubMed: 21359165]

Naigles LR (2002). Form is easy, meaning is hard: Resolving a paradox in early child language. Cognition, 86(2), 157–199. [PubMed: 12435535]

Naigles LR (2003). Paradox lost? No, paradox found! Reply to Tomasello and Akhtar (2003). Cognition, 88(3), 325–329.

Naigles LR, & Hoff-Ginsberg E (1998). Why are some verbs learned before other verbs? Effects of input frequency and structure on children's early verb use. Journal of Child Language, 25(1), 95–120. [PubMed: 9604570]

Nelson K (1973). Structure and strategy in learning to talk. Monographs of the Society for Research in Child Development, 38(1/2), 1–135.

Olswang L, Long S, & Fletcher P (1997). Verbs in the emergence of word combinations in young children with specific expressive language impairment. European Journal of Disorders of Communication, 32(2s), 15–33. [PubMed: 9279425]

Paivio A, Yuille JC, & Madigan SA (1968). Concreteness, imagery, and meaningfulness values for 925 nouns. Journal of Experimental Psychology, 76(1p2), 1.

Paul R (1991). Profiles of toddlers with slow expressive language development. Topics in Language Disorders, 11(4), 1–13.

Penner ZVI, Schulz P, & Wymann K (2003). Learning the meaning of verbs: What distinguishes language-impaired from normally developing children? Linguistics, 41(2), 289–319.

Perry LK, Perlman M, Lupyan G, & Bolhuis JJ (2015). Iconicity in English and Spanish and its relation to lexical category and age of acquisition. PLOS One, 10(9), e0137147. [PubMed: 26340349]

Peter MS, Durrant S, Jessop A, Bidgood A, Pine JM, & Rowland CF (2019). Does speed of processing or vocabulary size predict later language growth in toddlers? Cognitive Psychology, 115, 101238. [PubMed: 31539813]

Peters R, & Borovsky A (2019). Modeling early lexico-semantic network development: Perceptual features matter most. Journal of Experimental Psychology. General, 148(4), 763. [PubMed: 30973265]

R Core Team. (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing. https://www.R-project.org/

Rappaport Hovav M, & Levin B (2010). Reflections on manner/result complementarity. In Rappaport Hovav M, Doron E, & Sichel I (Eds.), Lexical semantics, syntax, and event structure (pp. 21–37). Oxford University Press.

Rescorla L (1989). The language development survey: A screening tool for delayed language in toddlers. Journal of Speech, Language, and Hearing Research, 54(4), 587–599.

Rescorla L (2002). Language and reading outcomes to age 9 in late-talking toddlers. Journal of Speech, Language, and Hearing Research, 45(2), 360–371.

Rescorla L (2005). Age 13 language and reading outcomes in late-talking toddlers. Journal of Speech, Language, and Hearing Research, 48(2), 459–472.

Rescorla L (2009). Age 17 language and reading outcomes in late-talking toddlers: Support for a dimensional perspective on language delay. Journal of Speech, Language, and Hearing Research, 52(1), 16–30.

Rescorla L, Alley A, & Christine JB (2001). Word frequencies in toddlers' lexicons. Journal of Speech, Language, and Hearing Research, 44(3), 598–609.

Rescorla LA, & Dale PS (Eds.). (2013). Late talkers: Language development, interventions, and outcomes. Paul Brookes Publishing.

Smolík F (2019). Imageability and neighborhood density facilitate the age of word acquisition in czech. Journal of Speech, Language, and Hearing Research, 62(5), 1403–1415.

Snedeker J, Zeitlin M, Crawford J (2013, November 2). Why are some words learned before others? Predictors of lexical production in infants and children learning English. Talk presented at the 38th Annual Boston University Conference on Language Development, Boston, MA.

Steyvers M, & Tenenbaum JB (2005). The large-scale structure of semantic networks: Statistical analyses and a model of semantic growth. Cognitive Science, 29(1), 41–78. [PubMed: 21702767]

Stokes SF (2010). Neighborhood density and word frequency predict vocabulary size in toddlers. Journal of Speech, Language, and Hearing Research, 53(3), 670–683.

Thal DJ, Bates E, Goodman J, & Jahn-Samilo J (1997). Continuity of language abilities: An exploratory study of late-and early-talking toddlers. Developmental Neuropsychology, 13(3), 239–273.

Theakston AL, Lieven EV, Pine JM, & Rowland CF (2004). Semantic generality, input frequency and the acquisition of syntax. Journal of Child Language, 31(1), 61–99. [PubMed: 15053085]

Tomasello M, & Abbot-Smith K (2002). A tale of two theories: Response to fisher. Cognition, 83(2), 207–214. [PubMed: 11869724]

Tomasello M, & Akhtar N (2003). What paradox? A response to Naigles (2002). Cognition, 88(3), 317–323. [PubMed: 12804815]

Valleau MJ, Konishi H, Golinkoff RM, Hirsh-Pasek K, & Arunachalam S (2018). An eye-tracking study of receptive verb knowledge in toddlers. Journal of Speech, Language, and Hearing Research, 61(12), 2917–2933.

Wojcik EH, & Saffran JR (2013). The ontogeny of lexical networks: Toddlers encode the relationships among referents when learning novel words. Psychological Science, 24(10), 1898–1905. [PubMed: 23938274]

Yu C, & Smith LB (2011). What you learn is what you see: Using eye movements to study infant cross-situational word learning. Developmental Science, 14(2), 165–180. [PubMed: 22213894]

Zubrick SR, Taylor CL, Rice ML, & Slegers DW (2007). Late language emergence at 24 months: An epidemiological study of prevalence, predictors, and covariates. Journal of Speech, Language, and Hearing Research, 50(6), 1562–1592.

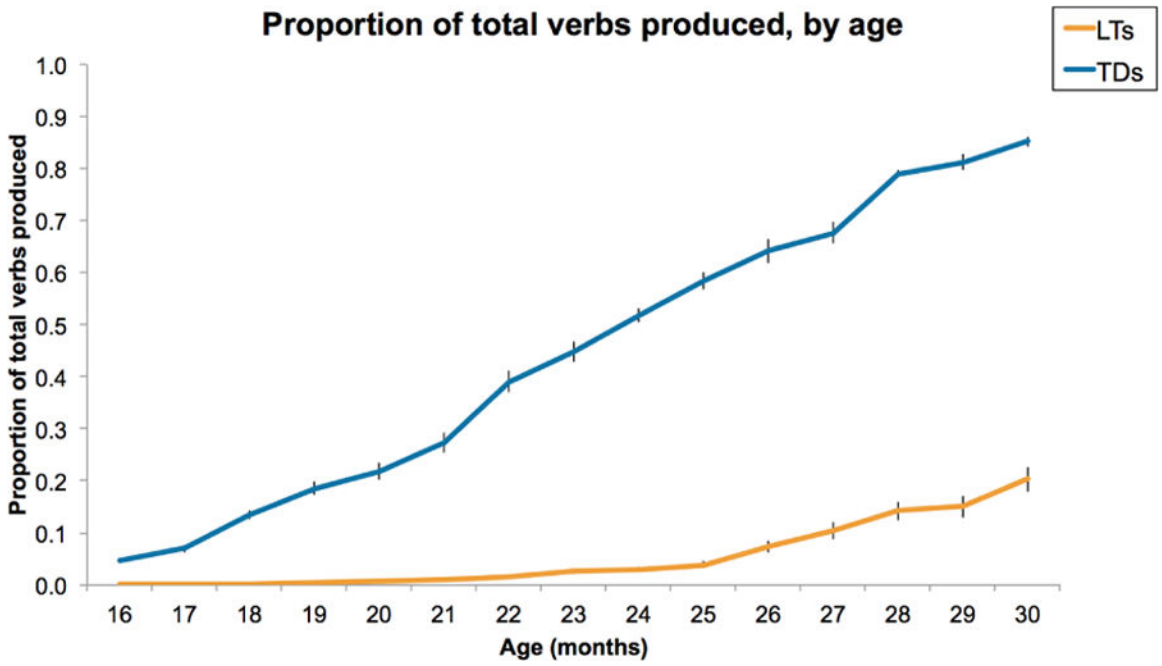

Figure 1.

Proportion of verbs produced across toddlerhood out of all possible MBCDI verbs (N = 103). Error bars indicate standard error of participant averages.

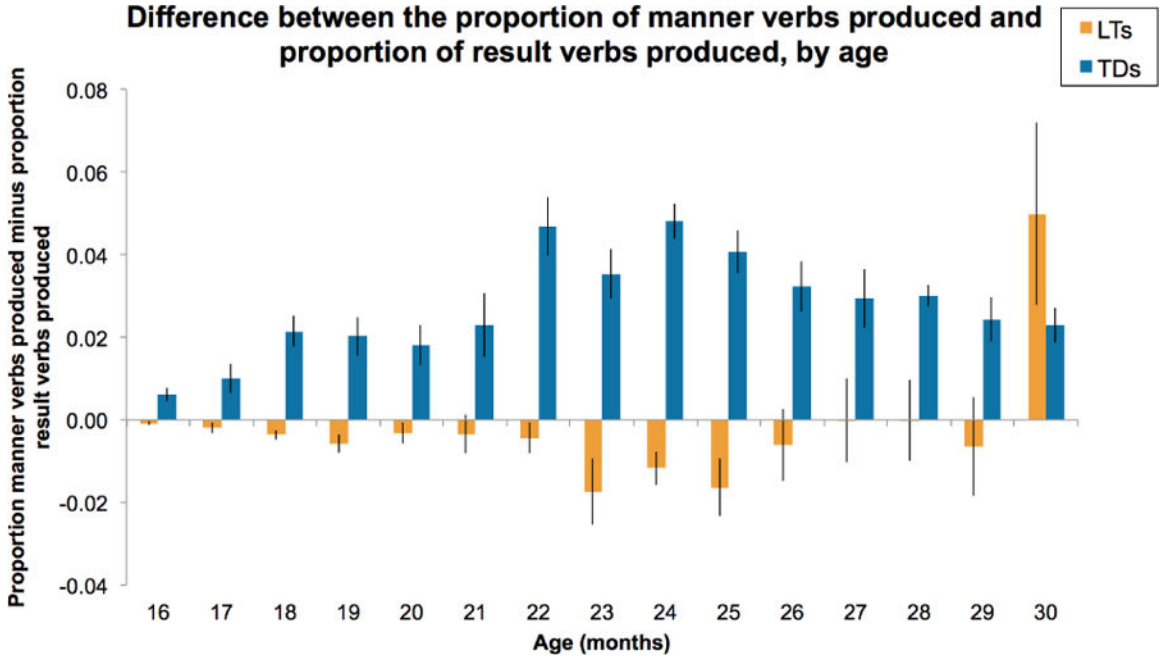

Figure 2.

Differences in proportion of manner verbs produced and proportion of result verbs produced, by age and by group. Values greater than 0 indicate that children produce proportionally more manner verbs than result verbs, and values less than 0 indicate that children produce proportionally more result verbs than manner verbs. Error bars indicate standard error of participant averages.

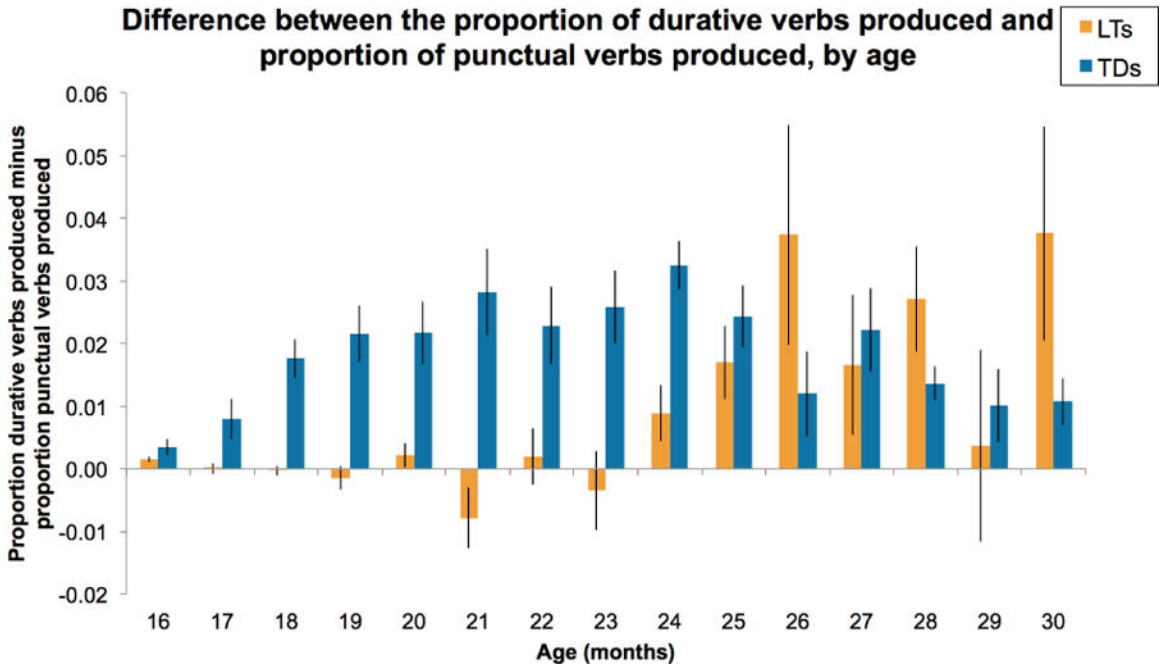

Figure 3.

The difference in children's proportion of durative verbs produced and proportion of punctual verbs produced, by age and by group. Values greater than 0 indicate that children produce proportionally more durative verbs than punctual verbs, and values less than 0 indicate that children produce proportionally more punctual verbs than durative verbs. Error bars indicate standard error of participant averages.

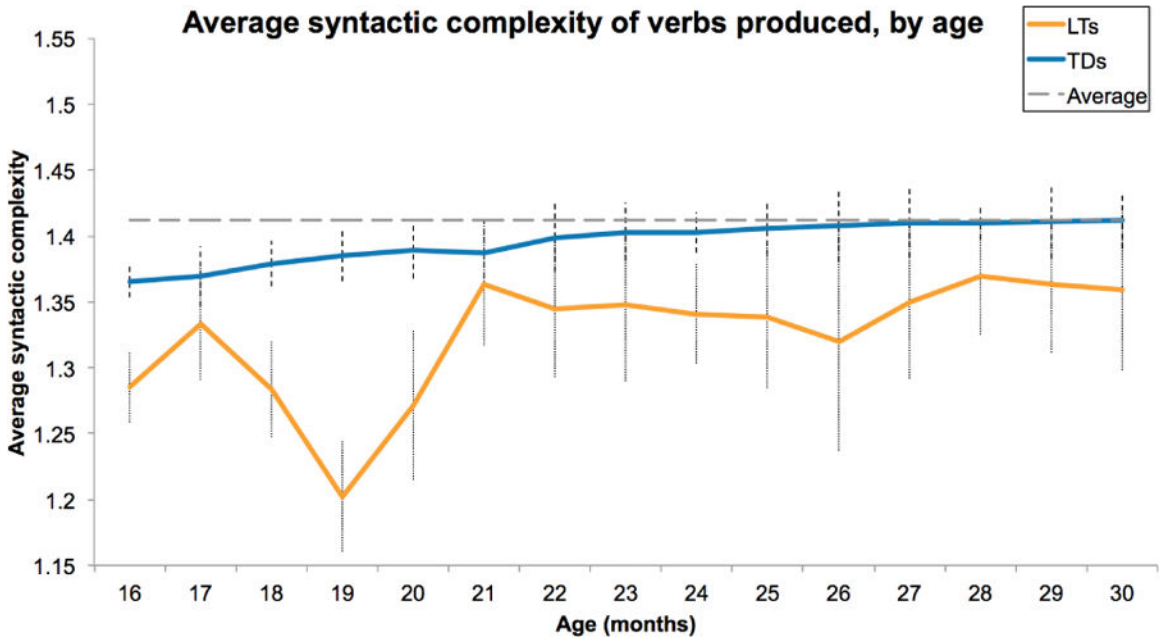

Figure 4.

The average syntactic complexity of verbs produced by TDs and LTs. The dashed line indicates the average syntactic complexity score of all verbs on the MBCDI. Error bars indicate standard error.

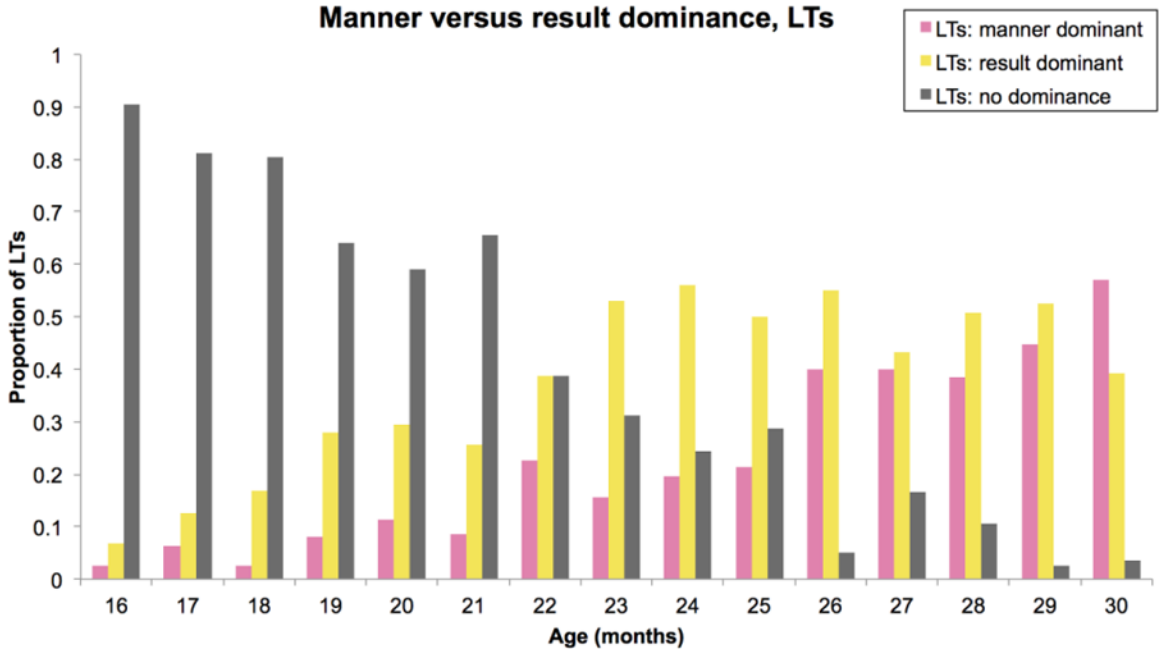

Figure 5A.
The proportion of LTs who are manner and result dominant, by age.

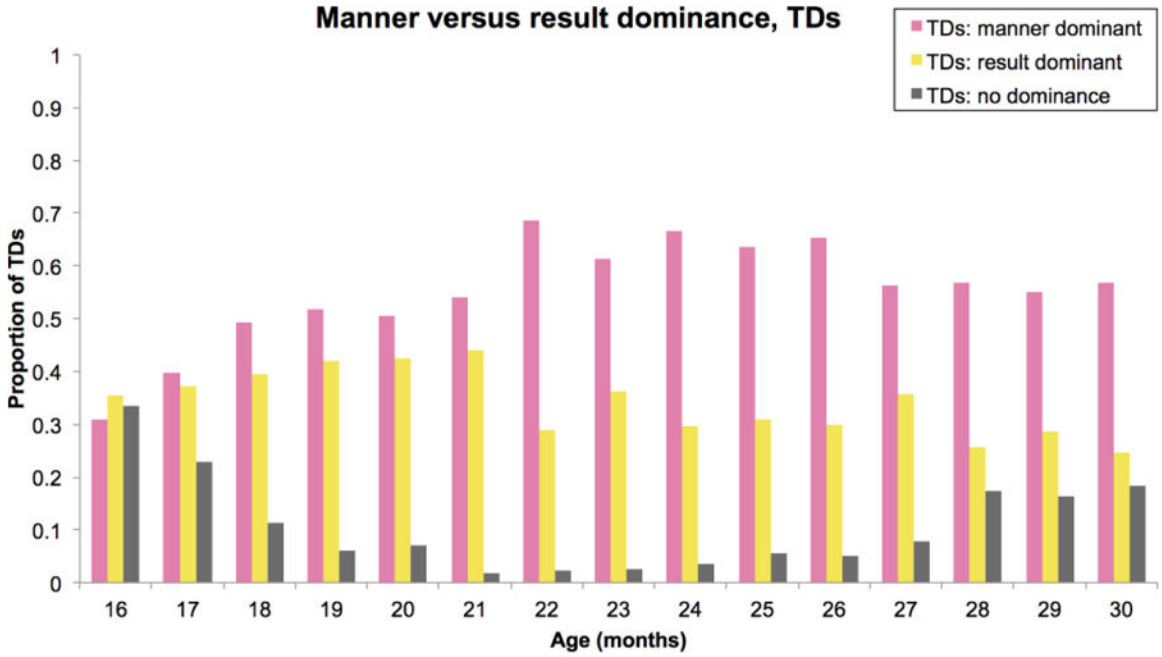

Figure 5B.
The proportion of TDs who are manner and result dominant, by age.

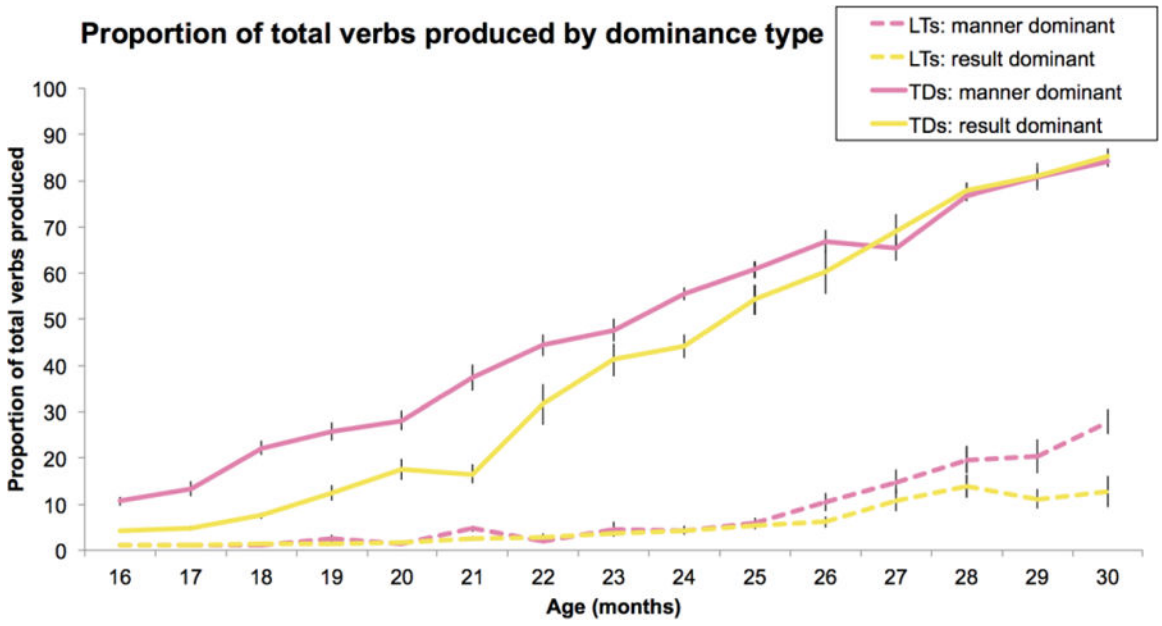

Figure 6.

Children's proportion of total verbs produced across age, by group and by dominance type. Children who did not have a manner or result dominance ($N = 1086$) are excluded. Error bars indicate standard error.

Tables 1A and 1B.

The ten most common verbs for (A) young and old toddlers and for (B) LTs and TDs.

1A.

Rank	Young toddlers (16–18 months)	Old toddlers (28–30 months)
1	Go	Eat
2	Eat	Go
3	Drink	Kiss
4	Kiss	Hug
5	Bite	Open
6	Tickle	Drink
7	Sit	Play
8	Open	Read
9	Hug	Cry
10	See	Sleep

1B.

Rank	LTs	TDs
1	Go	Go
2	Eat	Eat
3	Kiss	Drink
4	Drink	Kiss
5	Stop	Hug
6	Hug	Open
7	Sit	Sit
8	Open	Bite
9	Bite	Read
10	Help	Walk

Tables 2A and 2B.

Parameter estimates for logistic regressions examining the effect of manner/result classification on verb knowledge. Table 2A (Model 1) examines the relationship between age and manner/result classification. Table 2B (Model 2) examines the relationship between group and manner/result classification, with beta estimates calculated using the TD group as a baseline.

2A.

Variable	Estimate	*SE*	*p*
Intercept	− 1.42	0.12	< .001*
Imageability	0.64	0.13	< .001*
Frequency	0.81	0.13	< .001*
Age	2.54	0.016	< .001*
Percentile	2.35	0.016	< .001*
Manner/Result	0.15	0.12	.22, *n.s.*
Age*Percentile	0.21	0.017	< .001*
Age*Manner/Result	−0.03	0.008	< .001*
Percentile*Manner/Result	0.03	0.008	.001*
Age*Percentile*Manner/Result	−0.04	0.007	< .001*

2B.

Variable	Estimate	*SE*	*p*
Intercept	− 5.47	0.15	< .001*
Imageability	0.64	0.13	< .001*
Frequency	0.81	0.13	< .001*
Age	2.10	0.11	< .001*
Group (TD)	4.70	0.11	< .001*
Manner/Result	−0.02	0.13	.86, *n.s.*
Age*Group (TD)	0.71	0.11	< .001*
Age*Manner/Result	0.13	0.04	< .001*
Group (TD)*Manner/Result	0.20	0.04	.001*
Age*Percentile*Manner/Result	−0.19	0.04	< .001*

Tables 3A and 3B.

Parameter estimates for logistic regressions examining the effect of durative/punctual classification on verb knowledge. Table 3A (Model 1) examines the relationship between age and durative/punctual classification. Table 3B (Model 2) examines the relationship between group and durative/punctual classification, with beta estimates calculated using the TD group as a baseline.

3A.

Variable	Estimate	*SE*	*p*
Intercept	− 1.45	0.12	< .001*
Imageability	0.73	0.14	< .001*
Frequency	0.71	0.14	< .001*
Age	2.54	0.02	< .001*
Percentile	2.36	0.02	< .001*
Durative/Punctual	0.01	0.12	.92, *n.s.*
Age*Percentile	0.17	0.018	< .001*
Age*Durative/Punctual	0.02	0.009	.009*
Percentile*Durative/Punctual	0.01	0.009	.045*
Age*Percentile*Durative/Punctual	−0.01	0.008	.20, *n.s.*

3B.

Variable	Estimate	*SE*	*p*
Intercept	− 5.57	0.17	< .001*
Imageability	0.72	0.14	< .001*
Frequency	0.71	0.14	< .001*
Age	2.17	0.12	< .001*
Group (TD)	4.78	0.12	< .001*
Durative/Punctual	−0.007	0.13	.96, *n.s.*
Age*Group (TD)	0.62	0.12	< .001*
Age*Durative/Punctual	0.03	0.04	.54, *n.s.*
Group (TD)*Durative/Punctual	0.03	0.05	.53, *n.s.*
Age*Percentile*Durative/Punctual	−0.01	0.04	.76, *n.s.*

Tables 4A and 4B.

Parameter estimates for logistic regressions examining the effect of syntactic complexity on verb knowledge. Table 4A (Model 1) examines the relationship between age and syntactic complexity. Table 4B (Model 2) examines the relationship between group and syntactic complexity, with beta estimates calculated using the TD group as a baseline.

4A.

Variable	Estimate	*SE*	*p*
Intercept	− 1.57	0.11	< .001*
Imageability	0.95	0.12	< .001*
Frequency	0.89	0.12	< .001*
Age	2.53	0.02	< .001*
Percentile	2.35	0.02	< .001*
Syntactic complexity	−0.62	0.32	.057, *n.s.*
Age*Percentile	0.20	0.02	< .001*
Age*Syntactic complexity	0.11	0.02	< .001*
Percentile*Syntactic complexity	0.14	0.02	< .001*
Age*Percentile*Syntactic complexity	−0.002	0.02	.94, *n.s.*

4B

Variable	Estimate	*SE*	*p*
Intercept	− 5.57	0.15	< .001*
Imageability	0.95	0.12	< .001*
Frequency	0.89	0.12	< .001*
Age	2.07	0.11	< .001*
Group (TD)	4.66	0.11	< .001*
Syntactic complexity	−0.78	0.35	.025*
Age*Group (TD)	0.75	0.11	< .001*
Age*Syntactic complexity	0.06	0.11	.60, *n.s.*
Group (TD)*Syntactic complexity	0.23	0.12	.062, *n.s.*
Age*Percentile*Syntactic complexity	−0.03	0.11	.78, *n.s.*

Table 5.

Parameter estimates for a linear regression to examine whether manner or result dominance predicts verb vocabulary size.

Variable	Estimate	*p*
Intercept	5.52	< .001*
Age	1.08	< .001*
Group (TD)	40.57	< .001*
Dominance	3.41	.91, *n.s.*
Age*Group (TD)	5.50	< .001*
Age*Dominance	10.01	.09, *n.s.*
Group (TD)*Dominance	27.48	.38, *n.s.*
Age*Group*Dominance	−25.46	< .001*

Note. Dominance refers to the difference between the proportion of manner and result verbs produced.