HHS Public Access

Author manuscript

Lang Learn Dev. Author manuscript; available in PMC 2016 October 01.

Published in final edited form as:

Lang Learn Dev. 2015 October 1; 11(4): 356–368. doi:10.1080/15475441.2014.978331.

Learning verb syntax via listening: New evidence from 22-month-olds

Katherine Messenger[a],
University of Warwick

Sylvia Yuan, and
University of Illinois

Cynthia Fisher
University of Illinois

Abstract

Children recruit verb syntax to guide verb interpretation. We asked whether 22-month-olds spontaneously encode information about a particular novel verb's syntactic properties through listening to sentences, retain this information in long-term memory over a filled delay, and retrieve it to guide interpretation upon hearing the same novel verb again. Children watched dialogues in which interlocutors discussed unseen events using a novel verb in transitive (e.g., "Anna blicked the baby") or intransitive sentences ("Anna blicked"). Children later heard the verb in isolation ("Find blicking!") while viewing a two-participant causal action and a one-participant action event. Children who had heard transitive dialogues looked longer at the two-participant event than did those who heard intransitive dialogues. This effect disappeared if children heard a different novel verb at test ("Find kradding!"). These findings implicate a role for distributional learning in early verb learning: Syntactic-combinatorial information about otherwise unknown words may pervade the toddler's lexicon, guiding later word interpretation.

Children learn the meanings of words in part by linking them with world events. Learning to interpret *apple* and *eat* requires hearing these words in contexts that inspire thoughts of apples and eating. However, some aspects of verb meanings challenge views of word learning based only on observing events (Gleitman et al., 2005; Landau & Gleitman, 1985). Verbs do not simply label events; instead, they lexicalize particular perspectives on events, often focusing on the roles of different subsets of participants in the same events (e.g., Clark, 1990; Levin & Rappaport Hovav, 2005). The abstract perspective-dependent meanings of verbs are difficult to determine from world observations alone (e.g., Gillette, Gleitman, Gleitman, & Lederer, 1999).

Syntactic bootstrapping theory proposes that verbs are learned efficiently even so, because learners integrate syntactic evidence with world observations (Gleitman et al., 2005; Landau & Gleitman, 1985). To illustrate, verbs entailing two argument-roles license transitive

[a]Corresponding author: Katherine Messenger, Department of Psychology, University of Warwick, Coventry, CV4 7AL, UK. K.Messenger@warwick.ac.uk.

structures, with two noun-phrases (NPs) (“She pushed her”); verbs focusing on one role license intransitive structures, with one NP (“She fell”). Such syntax-semantics links are strikingly similar across languages (e.g., Levin & Rappaport-Hovav, 2005), and toddlers use these links, assigning different meanings to verbs encountered in different sentence structures (e.g., Arunachalam & Waxman, 2010; Lidz, Gleitman, & Gleitman, 2003; Naigles, 1990; Naigles & Kako, 1993; Yuan, Fisher, & Snedeker, 2012). For example, 19-month-olds who heard a novel verb in transitive sentences (“He's blicking him”) looked longer at a two-participant causal event (as opposed to a one-participant action) than did children who heard the verb in intransitive sentences (“He's blicking”; Yuan et al., 2012).

This view raises central questions about how syntactic bootstrapping begins, and about how young children—linguistic novices—gather evidence about verb syntax. We have proposed a structure-mapping account of the origins of syntactic bootstrapping, on which even partial sentence representations guide early sentence interpretation (e.g., Fisher, Hall, Rakowitz & Gleitman, 1994; Fisher, Gertner, Scott, & Yuan, 2010). On this account, syntactic bootstrapping begins with an innate bias toward one-to-one mapping between NPs in sentences and semantic arguments of predicate terms. Given this bias, children gain some syntactic guidance for verb interpretation as soon as they can identify some nouns in sentences. Centrally for present purposes, this account also assumes that children gather and retain distributional facts about verbs from listening experience, independent of other sources of information about verb meaning. This distributional learning, via the proposed one-to-one mapping bias, guides later verb interpretation.

To illustrate, imagine a toddler who hears her parents talking about past events during a car ride. Their utterances do not refer to the here and now, and thus the car-ride setting provides little guidance for interpreting them. On hearing “Anne called Betty” in this unhelpful context, our toddler might still observe that *call* is a transitive verb, one that licenses two NPs, and thus that its meaning involves two participant-roles. On hearing “Betty laughed,” the child might observe that *laugh* is an intransitive verb, one that licenses one NP, and thus that its meaning highlights one participant-role. Implicit learning of these linguistic-distributional facts could permit children to establish an initial lexical entry for a verb, including its syntactic properties and aspects of its semantic structure (two participant-roles vs. one), but leaving unspecified its semantic content. If children create such entries, and retain them over time, then these linguistic observations could guide later inferences about each verb's event-derived semantic content.

Recent findings show that 2-year-olds can encode syntactic-structure information and use it to interpret new verbs, independent of other cues to verb meaning (Arunachalam & Waxman, 2010; Scott & Fisher, 2009; Yuan & Fisher, 2009). For example, Yuan and Fisher showed 29-month-olds dialogue videos in which two women discussed unseen events using a novel verb. The verb appeared in transitive (“Anna blicked the baby!”) or intransitive sentences (“Anna blicked!”). In test trials, children heard the same verb in isolation (“Find blicking!”) while viewing two side-by-side events. Because the verb was heard in isolation at test, the only source of syntactic guidance for its interpretation was the child's memory of the dialogue sentences. Children who had heard the verb in transitive sentences in the dialogues looked longer at a two-participant (as opposed to a one-participant) event than did

those who had heard it in intransitive sentences. Two-year-olds succeeded in a similar task even when the dialogues included more complex sentences (“The boy mooped the girl” vs. “The boy and the girl mooped”; Arunachalam & Waxman, 2010). Arunachalam, Escovar, Hansen, and Waxman (2013) extended this investigation to younger children: They tested 21-month-olds with the materials used by Arunachalam and Waxman (2010), and found that those who heard transitive dialogues looked longer at a two-participant causal event (as opposed to a non-causal event) than did those who heard intransitive dialogues.

Success in this dialogue-and-test procedure shows that children find syntactic evidence informative without the support of a simultaneously-presented referent event; this is one prerequisite of the distributional learning procedure sketched above. Could this learning via listening support the establishment of lasting (although skeletal) lexical entries for verbs?

Some additional requirements must be met before we can conclude that it can. To benefit from the distributional information about verbs in our car-ride example, children must (a) link their observations about sentence-structure to a particular verb-form (e.g., *call* vs. *laugh*), (b) store this information in long-term memory, permitting retrieval after attention is diverted elsewhere, and (c) use the reappearance of the same verb as a cue to retrieve this information. Such *long-term lexical encoding* would permit learners to benefit from vast distributional data about new words, independent of whether those data arrive in supportive referential contexts.

Most of the dialogue-and-test experiments cited above did not address these memory requirements, because they did not assess whether combinatorial information learned via listening was linked to a particular verb, and also tested interpretation of each verb immediately after the corresponding dialogue (we will describe one exception below). An immediate test might primarily reflect information maintained in working memory to support comprehension of subsequent events, rather than long-term memory.

To illustrate, if an experimenter announces “I'm gonna plunk Big Bird”, then demonstrates an action on Big Bird without further comment, 2-year-olds link the verb *plunk* with that action (Tomasello & Barton, 1994; Tomasello & Kruger, 1992). Such results suggest that young children, like adults, readily treat language as relevant to impending events, and thus maintain information about recent utterances in working memory for immediate use. The maintenance of information in working memory need not result in encoding that information into long-term memory: Later recall also depends on the fit of each event element within a larger goal structure, both for toddlers and adults (e.g., Bauer & Mandler, 1989; Kurby & Zacks, 2008; Travis, 1997).

Moreover, most of the dialogue-and-test experiments cited above provided cues encouraging children to treat the dialogues as relevant to upcoming test events. Children received several trials in sequence, each with its own dialogue and test phase (Arunachalam et al., 2013; Arunachalam & Waxman, 2010; Scott & Fisher, 2009; Yuan & Fisher, 2009, Experiment 1). This alternation of dialogue and test minimizes memory demands, and also creates a higher-level structure linking each dialogue with subsequent test events. In some cases, the final sentences of each dialogue referred directly to upcoming test events (e.g., “The boy's gonna

fez the girl," preceding events depicting a boy and girl; Arunachalam & Waxman, 2010). These situational and linguistic cues to impending reference might prompt children to maintain information about the dialogue sentences in working memory for anticipated immediate use.

In contrast, to support the distributional learning procedure described above, children must encode combinatorial facts about new verbs into long-term memory, permitting retrieval even after their attention is diverted to different events and sentences.

One existing result suggests that the dialogue effects reviewed above can reflect long-term lexical learning. Yuan and Fisher (2009, Experiment 2), presented 29-month-olds with a single new verb in dialogues presented at the start of the experiment. The dialogue and novel-verb test phases were separated by a filled delay of either 1-2 minutes or 1-2 days. In both delay conditions, children showed robust effects of dialogue exposure on verb interpretation; this effect disappeared in a control condition in which children heard neutral audio at test ("What's happening?"). Relatedly, Scott and Fisher (2009) found that their dialogue effect disappeared in control conditions in which, at test, children heard a different novel verb from the one presented in the dialogues ("Find pimming" rather than "blicking")[1].

This finding suggests that, by 29 months, children's learning via listening has the right properties to support the establishment of lexical entries for verbs. During the dialogues, children created a lasting representation of the combinatorial properties of a new verb, and did so spontaneously, as a simple result of attending to the dialogues, without situational cues to impending reference. The present study built on this evidence, and had two goals: We aimed (a) to replicate this evidence for long-term lexical learning from listening, and (b) to extend this investigation to younger, 22-month-old children. The ability of these younger children to succeed in this task will have important consequences for the role of syntactic evidence in early vocabulary learning.

In the current experiment, 22-month-olds viewed materials similar to those of Yuan and Fisher (2009, Experiment 2). One novel verb was presented and tested in a two-phase procedure, with the syntactic and referential contexts for the new verb widely separated in time and unrelated in content. At the start of the experiment, children watched videos in which two women conversed, using the invented verb *blick* in either transitive or intransitive sentences. These dialogues provided only linguistic information about the verb: As in our car-ride example, children heard sentences describing absent events, with no accompanying scenes to specify the verb's semantic content. At the end of the experiment, in the novel-verb test item, children heard a novel verb in isolation while viewing two events: a two-participant causal event in which one woman swung another woman's leg back and forth, and a one-participant action event in which two women each wheeled an arm through the air.

[1]Scott and Fisher (2009) tested the verb immediately after the relevant dialogues, in a sequence of dialogue-and-test trials; thus this is evidence for lexical encoding in an immediate test, but not for long-term lexical learning.

This design allowed us to test long-term memory for combinatorial knowledge about a new verb. The dialogues at the start of the experiment, and the novel-verb test item at the end, were separated by several filler items including two familiar-verb practice items (with no dialogues of their own), resulting in a filled delay of about 1.4 minutes. In adulthood, information in a short-term memory store is quickly lost when attention is diverted elsewhere (e.g., in 20 seconds or fewer; Muter, 1980; Peterson & Peterson, 1959); thus a filled delay of more than a minute should be ample to ensure that the task measures long-term memory.

To test lexical encoding, we compared a same-verb and a different-verb condition. Children in the same-verb condition heard the new verb from the dialogue phase at test ("Find blicking"), whereas those in the different-verb condition heard another verb ("Find kradding"). If 22-month-olds link what they learn via listening to a representation of a particular novel verb, then we should see effects of dialogue exposure only in the same-verb condition. Children who had heard the verb in transitive dialogues should look longer at a two-participant event than those who heard it in intransitive dialogues. In contrast, we should see no effect of dialogue exposure in the different-verb condition, because children in this condition had not encountered their test verb in the dialogues.

Method

Participants

Thirty-two toddlers (mean age 22.5 months, range 21.1–23.9; 16 girls) participated; all were born full-term, and were from monolingual English-speaking homes. Two additional children were tested but eliminated due to crying (1) or inattentiveness (1). Children's productive vocabularies, measured by the short form of the MacArthur-Bates CDI, Level II (Fenson et al., 2000), ranged from 6 to 92 (median = 38). Four parents reported that their children did 'not yet' combine words, 13 that they did so 'sometimes', and 15 'often'. Children were randomly assigned to one of the four conditions created by our two (dialogue: transitive, intransitive) × two (test condition: same-verb, different-verb) design. Children's vocabularies did not differ across conditions.

Apparatus

Children sat on a parent's lap about four feet from a 50″ television. Soundtracks played from the television's internal speakers. A central camera beneath the television screen recorded children's faces while they watched. Parents wore opaque glasses.

Materials and Procedure

The experiment began with a dialogue phase, in which the novel verb *blick* was presented in 16 sentences distributed across four dialogue video-clips each showing two women conversing (Figure 1a; Appendix). Two pairs of talkers were shown in the dialogue videos, one in the first two clips and another in the last two clips. Dialogue video-clips were 26.6-29s long, separated by 3s blank-screen intervals. Each dialogue-clip was presented as a video image 13.5″ high and 20.5″ wide centered on the television screen. Children in the transitive condition heard the novel verb in transitive sentences (e.g., "Jane blicked the

baby"); those in the intransitive condition heard it in intransitive sentences ("Jane blicked"). All nouns in the dialogues referred to animates; these included proper names (*Jane*, *Grandpa*), pronouns, and common nouns (e.g., *baby*, *duck*, *boy*). The final sentences of each dialogue-clip described past rather than future events, to avoid cueing children to treat dialogue sentences as references to impending action. The dialogue interlocutors did not gesture as they spoke, to avoid providing verb-referential information through gesture (Goodrich & Hudson Kam, 2009; Mumford & Kita, 2013).

A 'laughing baby' filler item followed the dialogue phase. During a 6.5s blank-screen interval, children heard "Hey watch! Look!"; next, they saw two brief (6-6.8s) video-clips of a baby laughing (from a video retrieved from the internet), separated by a 2s blank-screen interval. Finally, during a 4s blank-screen interval, children heard "That was fun."

Next, two familiar-verb practice items were presented, with a trial structure identical to that of the novel-verb test item (Figure 1b). Children saw synchronized pairs of videos showing people performing actions, with soundtracks recorded by a female native English speaker. Each event-pair appeared as two 10.5″ by 16″ images shown side by side, vertically centered on the television screen and 9" apart. The first familiar verb was *eat*; the target event showed a man eating, and the distracter event showed a woman drawing. First, during an 8s blank-screen interval, children heard "Hey watch, eating. Find eating." Next, two 8s videos played simultaneously; while children heard the familiar verb three times (e.g., "Find eating!"). Children heard the verb again during a 6s blank-screen interval ("Did you find it? Where's eating?"), then saw a second presentation of the 8s event-pair, again with three repetitions of the verb. This procedure was repeated with the second familiar verb ("Find drinking!"); the target event showed a man drinking, and the distracter event showed a man reading. These items familiarized children with the task, informing them that one video matched the soundtrack on each trial, and also familiarized them with the wording of the isolated-verb prompts ("Find *verb*-ing!"). Most importantly, they also increased the delay (to about 1.4 minutes) between the dialogues and the novel-verb test item.

Finally, one novel-verb test item was presented, following the procedure described for the practice items. Children saw two presentations of an 8s event-pair, accompanied by novel-verb prompts (Figure 1c); children in the same-verb condition heard the novel verb from the dialogues ("Find blicking!"), whereas those in the different-verb condition heard another novel verb ("Find kradding!"). The 8s event-pair included a two-participant causal event (one woman swung a seated woman's leg) and a one-participant action performed by two actors (two women circled their arms in synchrony). We included two people in the one-participant action event to ensure that effects of dialogue exposure reflected children's learning about the combinatorial properties of the new verb, rather than a match between the number of people in the test videos and the number of referents mentioned in the dialogues. Both test videos depicted two people but only the two-participant causal event depicted a coherent event involving two participant-roles, and thus only this event provided a suitable referent for a transitive verb.

The left/right position of the test events was counterbalanced with dialogue (transitive vs. intransitive) and test condition (same-verb vs. different-verb).

Coding and analysis

We coded where children looked during each 8s trial (left, right, away), frame by frame from silent video. A second coder re-coded 25% of the data (8 children); the two coders agreed on 98.9% of video frames.

The time spent looking away from either video-clip during the novel-verb test item was analyzed by means of a 2×2 ANOVA with dialogue (transitive, intransitive) and test conditions (same-verb, different-verb) as between-subjects factors. No effect was significant (F's < 1), suggesting that children in all four cells of the design looked away about equally during the test item (same-verb: transitive M = 0.36 s, SD = 0.22; intransitive M = 0.37 s, SD = 0.20; different-verb: transitive M = 0.53 s, SD = 0.60; intransitive M = 0.41 s, SD = 0.28). Given the uniformity of time spent looking away, we conducted our main analyses on a single measure, looking-time to the causal event as a proportion of time spent looking at either event, averaged across the two 8s presentations of the novel-verb test item.

Results

Preliminary analyses of test-item performance revealed no significant interactions of dialogue and test condition with sex or with whether the child's vocabulary or performance in the practice trials was above or below the median. These factors were not examined further.

As shown in Figure 2, children who had heard transitive dialogues looked longer at the two-participant as opposed to the one-participant event, than did children who heard intransitive dialogues. This difference appeared only in the same-verb condition, in which children heard at test the same verb presented in the dialogue phase. For children in the different-verb condition, looking-time to the two-participant event did not depend on whether they had heard transitive or intransitive dialogues. This pattern was tested by a 2×2 ANOVA with the between-subjects factors dialogue (transitive, intransitive) and test condition (same-verb, different-verb). This analysis showed no significant main effect of dialogue ($F(1,31) = 3.43$, $p = .075$) or test condition ($F < 1$), but a significant interaction of these two factors, ($F(1,31) = 6.50$, $p = .017$).

Planned comparisons revealed a significant effect of dialogue on looking-times in the same-verb ($t(14) = 4.35$, $p = .001$) but not the different-verb condition ($t(14) < 1$). Thus, as predicted, children in the same-verb condition who heard transitive dialogues looked longer at the two-participant event upon hearing the same verb again (“Find blicking!”) than did children who heard the intransitive dialogues; this dialogue effect disappeared in the different-verb condition.

Children in the same-verb condition who heard transitive dialogues also looked significantly longer at the two-participant event than did their counterparts in the different-verb condition ($t(14) = 2.35$, $p = .034$). Children in the same-verb condition who heard intransitive dialogues, in contrast, did not differ significantly from their counterparts in the different-verb condition ($t(14) = 1.41$, $p = .180$). This suggests that the transitive dialogues more strongly constrained interpretation than did the intransitive dialogues, given the referential

options. This asymmetry makes sense, and has been observed before (Arunachalam & Waxman, 2010; Naigles & Kako, 1993; Yuan et al., 2012): A transitive verb implies two participant-roles, and therefore directs attention to a coherent two-participant event. An intransitive verb, in contrast, could refer either to the action in the one-participant event, or to the role of one of the actors in the two-participant event.

Discussion

Twenty-two-month-olds learned combinatorial facts about an unknown verb by listening to sentences, without a concurrent referent event providing information about the verb's semantic content. During the dialogues, upon hearing sentences such as “Bill was blicking the duck” or “Bill was blicking”, children could not have known in any concrete sense what it meant to *blick*. Despite this uncertainty, children learned what they could about the verb—its transitivity, and thus aspects of its semantic structure. As a result, later interpretations of the verb were guided by dialogue experience: Children who had heard the test verb in transitive dialogues looked longer at the two-participant causal event, as opposed to a one-participant action event, than did those who had heard it in intransitive dialogues.

These results add to a small set of experimental reports showing that children under two years old use verb syntax to guide sentence comprehension and verb learning, assigning appropriately different interpretations to new transitive versus intransitive verbs as in the present study (Arunachalam et al., 2013; Yuan et al., 2012), and using knowledge of English word order to link a new transitive verb with an appropriate event (Gertner, Fisher, & Eisengart, 2006). This precocious use of syntax suggests that syntactic bootstrapping plays a role in early acquisition, rather than being a late addition to the child's set of information-sources.

Most centrally, these results show that children under two, like older children in a previous experiment (Yuan & Fisher, 2009), can create a stable lexical representation for a verb encountered in a non-referential context. We argue that this learning meets the requirements of the distributional learning proposal outlined in the introduction, for several reasons. First, the dialogue effect disappeared when children heard a different verb at test; thus children linked combinatorial information acquired from the dialogue to a tentative lexical entry for a particular verb, rather than to any novel verb, or to the task context. Second, the dialogue effect held across a delay of more than a minute, filled with other sentences and events; thus children's success reflected information stored in long-term memory, rather than in an actively-maintained working-memory representation. Third, the dialogue effect emerged despite the absence of task features, as described in the Introduction, that might have encouraged children to link the dialogues referentially with upcoming events; this suggests that toddlers spontaneously learned about the combinatorial properties of a new verb, as a simple result of attending to the dialogues.

Toddlers' ability to retain combinatorial facts about a new verb over a filled delay seems particularly impressive to us given reports of early failures to retain newly-learned words in other tasks. For example, toddlers tend to interpret a new noun as referring to a novel rather than a familiar (already-named) object (e.g., Halberda, 2003; Liitschwager & Markman,

1994); 30-month-olds retain these new mappings over a filled delay (Spiegel & Halberda, 2011). However, in two recent experiments, 24-month-olds succeeded in initial referent-selection trials, but failed to retain the new word-object links across a brief filled delay (Bion, Borovsky, & Fernald, 2013; Horst & Samuelson, 2008); both experiments showed better retention following unambiguous ostensive labeling trials.

Given the apparent frailty of 24-month-olds' new word representations, it might seem surprising that 22-month-olds retained verb knowledge acquired in our dialogues, under conditions of great referential ambiguity. A number of factors could account for these differing outcomes. First, we presented children with only one new word, and multiple dialogue sentences; factors such as the number of words to be learned, and the number of repetitions, naturally affect retention (e.g., Munro et al., 2012; Wojcik, 2013). Second, however, we tested children's retention of a different dimension of lexical knowledge—a new verb's syntactic properties, rather than a new object-label link. Word learning requires encoding multiple types of information (phonological, syntactic, referential), and may recruit more than one memory system (e.g., Chang, Janciauskas & Fitz, 2012; Gupta & Dell, 1999); these memory systems, in turn, may differ in their development or vulnerability to interference (e.g., Nelson, 1995; Rovee-Collier, 1997). The link between word-form and referent is typically thought to depend on a declarative memory system that supports rapid binding of arbitrarily-related elements (Cohen & Eichenbaum, 1993; Duff & Brown-Schmidt, 2012; Friedrich & Friederici, 2011). Learning verb syntax via listening, in contrast, may owe more to procedural memory systems that support probabilistic categorization and skill learning (Chang et al., 2012; Gupta & Cohen, 2002; Poldrack & Foerde, 2008; Ullman, 2004), including syntactic priming (Ferreira, Bock, Wilson & Cohen, 2008). Future investigations of toddlers' memory for multiple dimensions of new lexical entries, including verbs' syntactic properties as well as their event-referents, will shed light on how infants integrate linguistic and non-linguistic information-sources across exposures to the same word.

How might the learning assessed in our task contribute to verb learning ‘in the wild’? We imposed a brief delay between dialogue and test; thus our results cannot tell us whether 22-month-olds would succeed if tested a day later, as did 29-month-olds in an earlier experiment (Yuan & Fisher, 2009). Several considerations suggest that future experiments might reveal such long-lasting retention even in children under 2. First, 1- to 2-year-olds remember new object-labels when tested the next day, given highly informative initial exposures (e.g., Goodman, McDonough, & Brown, 1998; Woodward, Markman, & Fitzsimmons, 1994; see also Markson & Bloom, 1997; Carey & Bartlett, 1978). Thus, once encoded into long-term memory, new lexical entries can withstand substantial delays. Second, 1- to 2-year-olds remember distinctive events over intervals of weeks or months in deferred-imitation tasks (e.g., Bauer et al., 2000; Meltzoff, 1995), and retain new operant responses over multi-week delays (e.g., pressing a lever to activate a toy; Rovee-Collier, 1999). Maximum delays increase with development in both kinds of tasks (e.g., Bauer, 2006; Rovee-Collier, 1999). Such findings suggest that long-lasting retention of multiple dimensions of word knowledge should be possible before age 2, but also that older children should withstand longer delays.

In conclusion, the present results implicate a powerful role for distributional learning in early sentence interpretation and verb learning. Before their second birthday, children spontaneously create lasting lexical entries for new verbs through listening experience. These lexical entries can be highly abstract, reflecting information about how the verb combined with other constituents in sentences, not its semantic content. Combinatorial information about otherwise unknown words may pervade the toddler's lexicon, providing useful constraints on sentence comprehension and word learning.

Acknowledgments

This research was supported by the National Institute of Child Health and Human Development (HD054448) and the National Science Foundation (BCS-0620257).

Appendix. Complete dialogues by condition. The first two dialogues depicted one pair of women conversing (A & B), and the last two dialogues depicted two different women conversing (C & D)

Transitive condition:	**Intransitive condition:**
Dialogue 1	*Dialogue 1*
A Hey! You know what?	A Hey! You know what?
B What?	B What?
A Jim is gonna blick the cat!	A Jim is gonna blick!
B Really? He's gonna blick the cat?	B Really? He's gonna blick?
A And Mary was blicking the man!	A And Mary was blicking!
B Wow! She was blicking the man!	B Wow! She was blicking!
Dialogue 2	*Dialogue 2*
A Guess what!	A Guess what!
B What?	B What?
A Jane blicked the baby!	A Jane blicked!
B Hmmm. She blicked the baby?	B Hmmm. She blicked?
A And Bill was blicking the duck!	A And Bill was blicking!
B Yeah. He was blicking the duck!	B Yeah. He was blicking!
Dialogue 3	*Dialogue 3*
C Hey! How are you?	C Hey! How are you?
D I'm pretty good!	D I'm pretty good!
C You know what?	C You know what?
D What?	D What?
C Abby is gonna blick the lady!	C Abby is gonna blick!
D Great! She's gonna blick the lady?	D Great! She's gonna blick?
C And Jack blicked the bird!	C And Jack blicked!
D Yeah. He blicked the bird.	D Yeah. He blicked.
Dialogue 4	*Dialogue 4*
C Hello there!	C Hello there!
D Hello!	D Hello!

Transitive condition:		Intransitive condition:	
C	Guess what!	C	Guess what!
D	What?	D	What?
C	John is gonna blick the dog!	C	John is gonna blick!
D	Great! He's gonna blick the dog?	D	Great! He's gonna blick?
C	And Dave was blicking the boy!	C	And Dave was blicking!
D	Right! He was blicking the boy!	D	Right! He was blicking!

References

Arunachalam S, Escovar E, Hansen MA, Waxman SR. Out of sight, but not out of mind: 21-month-olds use syntactic information to learn verbs even in the absence of a corresponding event. Language and Cognitive Processes. 2013; 28:417–425. [PubMed: 24163490]

Arunachalam S, Waxman SR. Meaning from syntax: Evidence from 2-year-olds. Cognition. 2010; 114:442–446. [PubMed: 19945696]

Bauer, PJ. Event memory. In: Kuhn, D.; Siegler, RS.; Damon, W.; Lerner, RM., editors. Handbook of Child Psychology, 6th Edition Vol 2: Cognition, Perception, and Language. Hoboken, NJ: Wiley; 2006. p. 373-425.

Bauer PJ, Mandler JM. One thing follows another: Effects of temporal structure on 1-to 2-year-olds' recall of events. Developmental Psychology. 1989; 25:197–206.

Bauer PJ, Wenner JA, Dropik PL, Wewerka SS. Parameters of remembering and forgetting in the transition from infancy to early childhood. Monographs of the Society for Research in Child Development. 2000; 65

Bion RA, Borovsky A, Fernald A. Fast mapping, slow learning: Disambiguation of novel word–object mappings in relation to vocabulary learning at 18, 24, and 30 months. Cognition. 2013; 126:39–53. [PubMed: 23063233]

Carey S, Bartlett E. Acquiring a single new word. Papers and Reports on Child Language Eevelopment. 1978; 15:17–29.

Chang F, Janciauskas M, Fitz H. Language adaptation and learning: Getting explicit about implicit learning. Language and Linguistics Compass. 2012; 6:259–278.

Clark EV. Speaker perspective in language acquisition. Linguistics. 1990; 28:1201–1220.

Cohen, NJ.; Eichenbaum, H. Memory, amnesia, and the hippocampal system. Cambridge, MA: MIT Press; 1993.

Duff MC, Brown-Schmidt S. The hippocampus and the flexible use and processing of language. Frontiers in Cognitive Science. 2012; 6:1–9.

Fenson L, Pethic S, Renda C, Cox JL, Dale PS, Reznick JS. Short-form versions of the MacArthur Communicative Development Inventories. Applied Psycholinguistics. 2000; 21:95–115.

Ferreira VS, Bock K, Wilson M, Cohen NJ. Memory for syntax despite amnesia. Psychological Science. 2008; 19:940–946. [PubMed: 18947361]

Fisher C, Gertner Y, Scott RM, Yuan S. Syntactic bootstrapping. Wiley Interdisciplinary Reviews: Cognitive Science. 2010; 1(2):143–149. [PubMed: 26271229]

Fisher C, Hall DG, Rakowitz S, Gleitman LR. When it is better to receive than to give: Syntactic and conceptual constraints on vocabulary growth. Lingua. 1994; 92:333–375.

Friedrich M, Friederici AD. Word learning in 6-month-olds: fast encoding–weak retention. Journal of Cognitive Neuroscience. 2011; 23:3228–3240. [PubMed: 21391764]

Gertner Y, Fisher C, Eisengart J. Learning words and rules: Abstract knowledge of word order in early sentence comprehension. Psychological Science. 2006; 17:684–691. [PubMed: 16913951]

Gillette J, Gleitman LR, Gleitman H, Lederer A. Human simulations of vocabulary learning. Cognition. 1999; 73:135–176. [PubMed: 10580161]

Gleitman LR, Cassidy K, Nappa R, Papafragou A, Trueswell JC. Hard Words. Language Learning and Development. 2005; 1(1):23–64.

Goodman J, McDonough L, Brown N. The role of semantic context and memory in the acquisition of novel nouns. Child Development. 1998; 69:1330–1344. [PubMed: 9839419]

Goodrich W, Hudsom Kam CL. Co-speech gesture as input in verb learning. Developmental Science. 2009; 12:81–87. [PubMed: 19120415]

Gupta P, Cohen NJ. Theoretical and computational analysis of skill learning, repetition priming, and procedural memory. Psychological review. 2002; 109:401–448. [PubMed: 11990324]

Gupta, P.; Dell, GS. The emergence of language from serial order and procedural memory. In: MacWhinney, B., editor. The emergence of language. Mahwah, NJ: Erlbaum; 1999. p. 447-480.

Halberda J. The development of a word-learning strategy. Cognition. 2003; 87:B23–B34. [PubMed: 12499109]

Horst JS, Samuelson LK. Fast mapping but poor retention by 24-month-old infants. Infancy. 2008; 13:128–157.

Kurby CA, Zacks JM. Segmentation in the perception and memory of events. Trends in cognitive sciences. 2008; 12:72–79. [PubMed: 18178125]

Landau, B.; Gleitman, LR. Language and experience: Evidence from the blind child. Cambridge, MA: Harvard University Press; 1985.

Levin, B.; Rappaport Hovav, M. Argument realization. New York, NY: Cambridge University Press; 2005.

Lidz J, Gleitman H, Gleitman LR. Understanding how input matters: Verb learning and the footprint of universal grammar. Cognition. 2003; 87:151–178. [PubMed: 12684198]

Liittschwager JC, Markman EM. Sixteen-and 24-month-olds' use of mutual exclusivity as a default assumption in second-label learning. Developmental Psychology. 1994; 30:955–968.

Markson L, Bloom P. Evidence against a dedicated system for word learning in children. Nature. 1997; 385:813–815. [PubMed: 9039912]

Masson MEJ, Loftus GR. Using confidence intervals for graphically based data interpretation. Canadian Journal of Experimental Psychology. 2003; 57:203–220. [PubMed: 14596478]

Meltzoff AN. What infant memory tells us about infantile amnesia: Long-term recall and deferred imitation. Journal of Experimental Child Psychology. 1995; 59:497–515. [PubMed: 7622990]

Mumford K, Kita S. Children use gesture to interpret novel verb meanings. Child Development. 2013; 85:1181–1189. [PubMed: 24266553]

Munro N, Baker E, McGregor K, Docking K, Arciuli J. Why word learning is not fast. Frontiers in Psychology. 2012; 3:41. [PubMed: 22393326]

Muter P. Very rapid forgetting. Memory & Cognition. 1980; 8:174–179. [PubMed: 7382818]

Naigles L. Children use syntax to learn verb meanings. Journal of Child Language. 1990; 17:357–374. [PubMed: 2380274]

Naigles LG, Kako ET. First contact in verb acquisition: Defining a role for syntax. Child Development. 1993; 64:1665–1687. [PubMed: 8112112]

Nelson CA. The Ontogeny of human memory: A Cognitive neuroscience perspective. Developmental Psychology. 1995; 311:723–738.

Peterson LR, Peterson MJ. Short-term retention of individual verbal items. Journal of Experimental Psychology. 1959; 58:193–198. [PubMed: 14432252]

Poldrack RA, Foerde K. Category learning and the memory systems debate. Neuroscience & Biobehavioral Reviews. 2008; 32:197–205. [PubMed: 17869339]

Rovee-Collier C. Dissociations in infant memory: Rethinking the development of implicit and explicit memory. Psychological Review. 1997; 104:467–498. [PubMed: 9243961]

Rovee-Collier C. The development of infant memory. Current Directions in Psychological Science. 1999; 8:80–85.

Scott RM, Fisher C. 2-year-olds use distributional cues to interpret transitivity alternating verbs. Language and Cognitive Processes. 2009; 24:777–803. [PubMed: 20046985]

Spiegel C, Halberda J. Rapid fast-mapping abilities in 2-year-olds. Journal of Experimental Child Psychology. 2011; 109:132–140. [PubMed: 21145067]

Tomasello M, Barton ME. Learning words in non-ostensive contexts. Developmental Psychology. 1994; 30:639–650.

Tomasello M, Kruger A. Joint attention on actions: Acquiring verbs in ostensive and non-ostensive contexts. Journal of Child Language. 1992; 19:311–333. [PubMed: 1527205]

Travis, LL. Goal-based organization of event memory in toddlers. In: van den Broek, PW.; Bauer, PJ.; Bourg, T., editors. Developmental spans in event comprehension and representation: Bridging fictional and actual events. NY, NY: Erlbaum; 1997. p. 111-138.

Ullman MT. Contributions of memory circuits to language: The declarative-procedural model. Cognition. 2004; 92:231–270. [PubMed: 15037131]

Wojcik EH. Remembering new words: integrating early memory development into word learning. Frontiers in Psychology. 2013; 4:151. [PubMed: 23554599]

Woodward AL, Markman EM, Fitzsimmons CM. Rapid word learning in 13-and 18-month-olds. Developmental Psychology. 1994; 30:553.

Yuan S, Fisher C. “Really? She blicked the baby?” Two-year-olds learn combinatorial facts about verbs by listening. Psychological Science. 2009; 20(5):619–626. [PubMed: 19476591]

Yuan S, Fisher C, Snedeker J. Counting the nouns: Simple structural cues to verb meaning. Child Development. 2012; 83(4):1382–1399. [PubMed: 22616898]

(a) Dialogue Phase:

Transitive dialogue
A: Guess what? Jane blicked the baby!
B: Hmm. She blicked the baby?
A: And Bill was blicking the duck.
B: Yeah, he was blicking the duck.

Intransitive dialogue
A: Guess what? Jane blicked!
B: Hmm. She blicked?
A: And Bill was blicking.
B: Yeah, he was blicking.

(4 4-sentence dialogue clips)

(b) Familiar-verb practice items:


"Find eating! Where's eating? …"
(2 8s presentations)


"Find drinking! Where's drinking? …"
(2 8s presentations)

(c) Novel-verb test item:


2-participant event


1-participant event

Same-verb condition:
"Find blicking! Where's blicking? …"

Different-verb condition:
"Find kradding! Where's kradding? …"
(2 8s presentations)

Figure 1. Sample dialogue sentences (a), familiar-verb practice items (b) and test item (c)

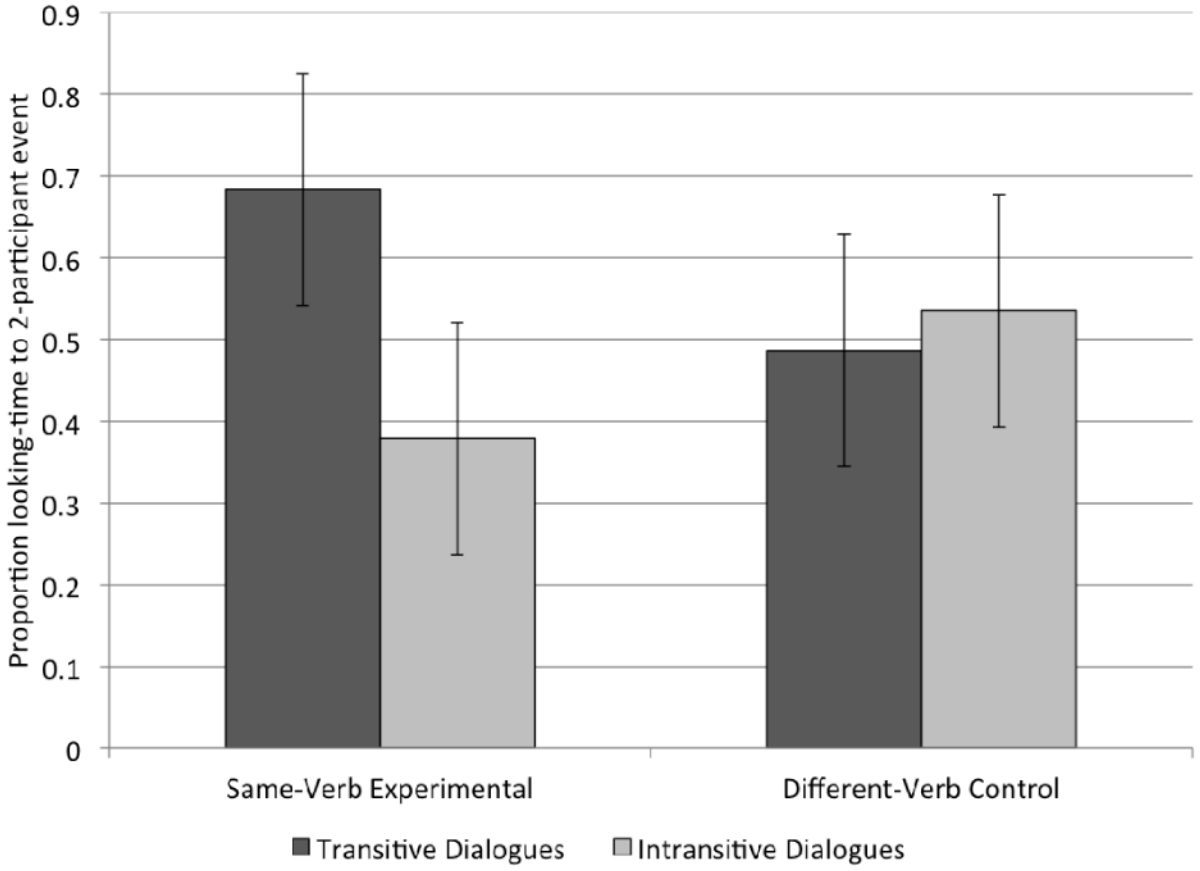

Figure 2. Mean proportion looking-time to the two-participant causal event, by dialogue type and test sentence condition. Error bars show 95% confidence intervals[2]

[2]Confidence intervals were calculated using a pooled estimate of variability and represented as a single interval plotted on each mean, as recommended for a between-subjects design by Masson and Loftus (2003).