"*Really? He Blicked the Cat?*": Two-Year-Olds Learn Distributional Facts About Verbs in the Absence of a Referential Context

Sylvia Yuan and Cynthia Fisher
University of Illinois

A fundamental task of sentence comprehension involves assigning semantic roles to various sentence constituents—determining *who did what to whom*. Verb knowledge plays a central role in this task. A verb is the syntactic and semantic heart of a sentence, determining both what other phrases can appear in the sentence and what semantic relation among the referents of these phrases the sentence will convey. For example, in *Eva fed the baby*, the verb *feed* both licenses the transitive sentence structure (cf. **Eva slept the baby*), and tells the hearer what specific event roles Eva and the baby play. When encountering an unknown verb, the learner must work out what particular relationship among event participants is intended by the speaker, without the set of syntactic-semantic instructions provided by the verb.

It is clear this requires observing events that co-occur with the verb. However, some aspects of verb meaning challenge views of verb learning based solely on observation of events (e.g., Fisher, Hall, Rakowitz, & Gleitman, 1994; Gleitman et al., 2005): Verb meanings do not simply label events; instead they represent a perspective on an event. For example, pairs of verbs such as *feed* and *eat*, or *give* and *receive*, denote not different world events, but different aspects of the same class of events.

An additional source of information may fill this gap: The syntactic bootstrapping theory proposes that children use precursors of the adult's knowledge of linkages between syntax and semantics to understand sentences, and therefore to learn verbs (e.g., Gleitman, 1990). This view is supported by considerable evidence that young children assign different meanings to verbs presented in different sentence structures (Fisher et al., 1994; Naigles, 1990, 1996; Naigles & Kako, 1993).

For example, Yuan, Fisher, and Snedeker (in prep.) showed 21-month-olds two events: a one-participant event (a boy making arm motions as in jumping-jacks) and a two-participant causal event (one boy causing another to bend). Children heard a new verb presented in transitive ("He's gorping him!") or intransitive sentences ("He's gorping"). Children who heard a transitive verb looked longer at the two-participant event than did those who heard an intransitive verb, or who heard neutral, control audio ("What's going on?"). Thus young children use sentence structure to interpret new verbs.

The sentence structure provides only very abstract information about verb meaning. In the preceding example, the transitive and intransitive structures

could tell the child only whether the meaning of the verb in the input sentence centrally involves two participant-roles or one. The verb's semantic content (whether the relevant two-participant event involves *bending*) must be derived from the scene (see Fisher, 2000, for a review). Thus the sentence acts as a linguistic 'zoom lens', helping the child to identify which perspective on a scene the speaker has in mind (Gleitman, 1990; Fisher, 1996; Gillette et al., 1999).

This zoom-lens metaphor implies referential links between an input sentence and a concurrent scene. In the present paper we ask to what degree syntactic bootstrapping depends on these referential links. Is it essential that children be invited to treat an input sentence as referring to a concurrent scene, in order to use the syntactic structure of that sentence to guide verb interpretation? Or can children learn syntactic facts about verbs simply by hearing them used in sentences, and bring this knowledge to bear on later verb interpretation?

One possibility is that the referential links between components of the sentence and the scene are necessary: Children need simultaneous access to syntactic and referential context for syntactic bootstrapping to take place. Without a concurrent referential scene, no candidate scene interpretations are generated, thus there is nothing for linguistic cues to 'zoom in' on. Such a proposal has been made by Grimshaw (1994) and by Chang, Dell, and Bock (in press): Both propose that children use syntax to guide verb interpretation by generating a sentence structure appropriate for a candidate interpretation derived from the scene, and comparing that predicted structure with an input sentence.

Another possibility is that children might learn useful combinatorial information about a new verb from its syntactic contexts alone. Suppose a child hears the word *blick* in sentences such as *The girl is blicking the cat* and *Jane blicked her*. Even if these utterances are not presented in a helpful referential context, the child could learn from them that *blick* is a transitive verb. In principle, she could infer from this syntactic fact that the new verb can refer to a two-participant relation. Finally, when the verb is invoked in a useful referential setting, the child could retrieve this syntactic-semantic combinatorial information, and use it to guide the assignment of semantic content to the verb.

Prior experimental studies of syntactic bootstrapping provide no way to decide between these alternatives, since all involved providing children with simultaneous access to syntactic and referential contexts (e.g., Fisher & Gleitman, 2002; Naigles, 1990; Yuan et al., in prep.). The present study asked whether children can (a) learn distributional facts about a novel verb simply by overhearing its use in sentences in a non-referential context, and (b) later retrieve this information to guide their interpretation of the verb in a referential context.

Several considerations predict success in this task. First, infants readily detect distributional patterns over novel linguistic items—those that have not yet been assigned a meaning (Gómez & Gerken, 1999; Marcus, Vijayan, Bandi Rao, & Vishton, 1999; Saffran, Aslin, & Newport, 1996). For example, 12-month-olds heard nonce words in sentence frames characteristic of English verbs (e.g., *She wants you to deeg it*) or nouns (e.g., *I see the bist in the room*); infants later listened longer to new combinations of words and frames that were 'ungram-

matical' given the categories established in training (Mintz, in press). Such evidence of early prowess in distributional learning suggests that toddlers are well equipped to identify the sequential patterns distinguishing transitive and intransitive verbs—some verbs are reliably followed by nouns, for example, while others are not. Second, there is ample evidence that preschoolers, like adults, encode detailed combinatorial information in their lexical entries for familiar verbs. This information guides parsing under ambiguity (Gordon & Chafetz, 1990; Snedeker & Trueswell, 2004), permits the prediction of the semantics of upcoming argument roles (e.g., Chang & Fernald, 2003), and guides the construction of sentences in language production (Tomasello, 2000).

1. Experiment 1

In Experiment 1, we asked whether 2-year-olds could learn distributional facts about an unknown verb from listening to sentences containing the verb, and later retrieve this information to guide their attention to candidate scenes upon hearing the verb in isolation. To do so, we adopted a two-phase procedure, depicted in Figure 1. In the *training phase* for the novel verb, children watched a videotaped dialogue in which two women used a novel verb in 8 sentences. In the Transitive condition, children always heard the novel verb in transitive sentences (e.g., "Jim is gonna blick the cat!"); in the Intransitive condition, children always heard the novel verb in intransitive sentences (e.g., "Jim is gonna blick!"). Next, in the *test phase*, all children saw and heard the same visual and auditory stimuli. A pair of novel events was presented side by side: one was a one-participant action by one woman (making arm circles); the other was a two-participant causal event in which one woman acted on another (swinging the other's leg back and forth). During the test phase children were exhorted to "Find blicking!".

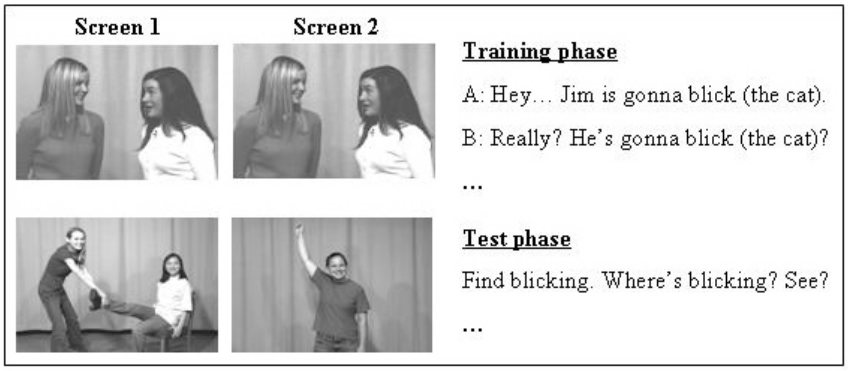

Figure 1: Training and test phases for the novel verb (Experiment 1)

The key feature of this design is that the syntactic and referential contexts were separated in time, and unrelated in content: When the novel verb was presented in its syntactic context during the training phase, no referential scene was provided; when the candidate events were presented in the test phase, the verb

appeared as an isolated gerund, without local evidence as to its transitivity ("Find blicking!"). If 2-year-olds can learn distributional facts about verbs in a non-referential context, and later retrieve this information when hearing the verb presented in isolation, then children in the transitive condition should look longer at the two-participant event in the test phase than do those in the intransitive condition.

1.1 Method

Participants. Sixteen 2-year-olds (Mean 28.6 months; range 27-30; 8 girls, 8 boys), all native speakers of English, participated. One additional child was tested but not included due to fussiness. Children's productive vocabularies, measured by the short form of the MacArthur CDI (Level II; Fenson et al., 2000), ranged from 29 to 100, with a median of 78.5. These scores are roughly consistent with norms for this measure: Fenson et al. reported fiftieth percentile scores at 28 months of 85 for girls and 74 for boys.

Apparatus. Children sat on a parent's lap, facing two 20" color monitors about 30" away. The screens were laterally separated by 12". The audio stimuli were presented from a speaker concealed between the monitors. A hidden central camera recorded the child's eye-movements. Parents wore opaque glasses.

Materials. The stimulus materials were color videos of two young women holding a dialogue (the training dialogues), and color videos of people performing simple actions, accompanied by a soundtrack recorded by a female native speaker of English. Events were videotaped and combined into synchronized pairs, to be played side by side on the two video screens. The structure and timing of the events will be described below.

Procedure. We presented two familiar verbs as practice items (*clap*, *tickle*), and one novel verb (*blick*), each in a two-phase procedure: training and test. The structure and timing of these phases was the same for the familiar and novel verbs. The purpose of the familiar-verb practice sequences was to familiarize children with the task, and to teach them that one of the two videos presented in the test phase matched the verb on each trial.

The procedure began with the first familiar verb: In the *training phase*, children watched a dialogue in which the verb *clap* was presented in 8 sentences. The dialogue consisted of two clips (25s to 30s long), each comprising four sentences, and separated by a 3s blank-screen interval. The dialogues for *clap* and *blick* are shown in Table 1. Note that Speaker B partly repeated each of Speaker A's sentences; this was done to help children understand the sentences. The same video dialogue was shown on both video screens simultaneously.

The *test phase* was preceded by a 7s blank-screen interval. Near the end of this interval, children heard "Look! Clapping!". Next, a pair of 8s videotaped test events played, one on each screen, and the child heard "Find clapping. Where's clapping? See? Where's clapping?". The target video showed a male participant clapping, while the distracter video showed a different male participant pretending to sleep. The distracter video included much less movement than the target video; this tactic was adopted to increase the probability that children would be looking at the target video when they heard the target verb,

making it easier for them to detect the relationship between the audio and the video stimuli. Following a 3s blank-screen interval, the 8s test events played again, again accompanied by an exhortation to "Find clapping!...".

After a 4s interval, the second practice verb (*tickle*) was introduced and tested in the same manner. In this case the target video showed one female participant tickling another; the distracter showed two different female participants, one feeding the other.

Finally, after another 4s interval, the novel verb was trained and tested in the same manner (see Figure 1). In the transitive condition, the novel verb was presented in transitive sentences, while in the intransitive condition, the novel verb was presented in intransitive sentences. Note in Table 1 that the transitive and intransitive sentences were identical, except that the intransitive sentences omitted the nouns in direct object position.

Table 1: Example dialogues for the training phases, Experiments 1-3

Verb	***Clip***	***Dialogue***	
Familiar (*clap*)	1	A: Hey, you know what? A: Tom is gonna clap. A: And Bob was clapping.	B: What? B: Really? He's gonna clap? B: Wow, he was clapping.
	2	A: Guess what? A: Anna clapped. A: And Emma was clapping.	B: What? B: Hm, she clapped. B: Yeah, she was clapping.
Novel (*blick*)	1	A: Hey, you know what? A: Jim is gonna blick (the cat). A: And Mary was blicking (the man).	B: What? B: Really? He's gonna blick (the cat)? B: Wow, she was blicking (the man).
	2	A: Guess what? A: Jane blicked (the baby). A: And Bill was blicking (the duck).	B: What? B: Hmm, she blicked (the baby)? B: Yeah, he was blicking (the duck).

Training dialogues and test videos were combined so that the nouns in the training dialogue did not obviously label the actors in either test event. In addition, we made sure that the gender of the nouns in the last sentence in each dialogue differed from the gender of the actors in the test events. All noun phrases in the training sentences named animate referents; subject noun phrases were proper nouns or pronouns, direct objects were proper nouns or definite noun phrases. The same two female speakers were videotaped for all three training dialogues, but each actor in a test video appeared in only one event. Side of presentation of the test events was counterbalanced with sentence condition.

Coding and analysis. We coded where children looked (left, right, or away) during the two 8s trials of the novel-verb test phase, frame by frame from silent

video. Reliability was assessed for 3 randomly selected children; primary and reliability coders agreed on 98% of video frames. We calculated the proportion of time spent looking at the two-participant event, out of the total time spent looking at either event. The average of this proportion across the two 8s trials was our dependent measure.

1.2 Results

The 2-year-olds' looking patterns were affected by the sentence condition. Those in the transitive condition looked significantly longer at the two-participant event (M = .63, se = .061) than did those in the intransitive condition (M = .44, se = .036; $F(1,14) = 6.958$, $p = .019$).

The effect of sentence condition did not depend on whether children's productive vocabulary was above or below the median for this group: A 2 (sentence condition) by 2 (high vs. low vocabulary) between-subjects ANOVA revealed a significant effect of sentence condition ($F(1,12) = 5.530$, $p = .037$), but no interaction of sentence and vocabulary level ($F(1,12) = 1.635$, $p = .225$).

1.3 Discussion

As predicted, 2-year-olds who had heard the novel verb in transitive sentences in the training phase looked longer at the two-participant event during the subsequent test phase than did those who had heard the novel verb in intransitive sentences. Despite the temporal separation between the syntactic and referential contexts, a novel verb's syntactic properties influenced children's later attention to candidate scenes labeled by that verb. This suggests that 2-year-olds can learn distributional information about a novel verb in a non-referential context, and later retrieve this information to guide interpretation of the same verb presented in isolation.

2. Experiment 2

The findings of Experiment 1 provide clear evidence that children learned distributional facts about the novel verb from the training phase and were influenced by these facts during the test phase. In Experiments 2 and 3 we asked whether children's looking patterns during the test phase were due to their retrieval of that distributional information in response to hearing the verb at test.

An alternative explanation is possible. Given the structure of the task, children could have responded as they did, not because they retrieved the verb's distributional properties in response to hearing the verb at test, but simply because they had learned from the practice sequences about the relationship between successive pairs of training dialogues and video event pairs. Having been exhorted twice to find during the test phase an event that matched the verb used in the preceding dialogue (*clap* and *tickle*), children could have learned to expect to be asked to look for a particular kind of event (e.g., a two-participant event in the transitive condition) following the novel-verb dialogue.

The goal of Experiment 2 was to rule out this alternative interpretation. To do so, we tested another group of 2-year-olds in a modified version of Experiment 1: During the test phase for the novel verb, instead of hearing the verb in isolation ("Find blicking!"), children heard neutral audio containing no novel

verb (e.g., “What’s happening?”). If children simply learned to expect what they heard in each dialogue to be related to the following test events, we should see the same looking patterns during the test phase for the novel verb found in Experiment 1, even though the novel verb was not presented during the test phase.

2.1 Method

Participants. Sixteen 2-year-olds (Mean 28.0 months; range 27-30; 8 girls, 8 boys), native speakers of English, participated. Three additional children were tested but not included due to side bias (1) or inattentiveness (2). Productive vocabulary scores ranged from 17 to 100, with a median of 79.5.

Procedure. The apparatus, materials, and procedure were as described for Experiment 1, with one modification. Only the test phase following the training dialogue for *blick* was modified: instead of sentences containing the novel verb (“Find blicking”), we presented neutral sentences containing no novel verb (e.g., “What’s happening? What do you see?”). Coding and reliability assessment were as described for Experiment 1; primary and reliability coders agreed on 99% of video frames.

2.2 Results

In this case, children's looking patterns were unaffected by sentence condition: those in the transitive condition did not look reliably longer at the two-participant event (M = .60, se = .069) than did those in the intransitive condition (M = .69, se = .058; $F(1,14) < 1$). As before, the effect of sentence condition did not vary with whether children's vocabulary was above or below the median: A 2 (sentence condition) by 2 (high vs. low vocabulary) ANOVA revealed no effect of sentence and no interaction of sentence and vocabulary (F's < 1).

2.3 Discussion

In Experiment 2, we replaced the test phase audio from Experiment 1 with neutral sentences (e.g., “What’s happening?”) instead of exhortations to “Find blicking!”. During this neutral test phase, children showed no effect of sentence condition. This suggests that the children in Experiment 1 used the presence of the novel verb at test as a cue to retrieve recently-learned distributional knowledge about the verb.

3. Experiment 3

In Experiment 1 and 2, 2-year-olds had a chance to learn the transitivity of a novel verb simply by hearing it used in sentences in a non-referential context. The results suggested that they attached this information to the verb; upon hearing the same novel verb in a subsequent test phase (Experiment 1), children retrieved the verb’s distributional information to guide their attention to the candidate scenes provided. When they did not hear the novel verb at test (Experiment 2), children showed no effect of sentence condition.

Next we ask whether children encoded the phonological form with reasonable accuracy: Did it matter that children heard the *same* novel verb in the test phase, or could they easily be fooled into retrieving the distributional information upon hearing a different unfamiliar verb? To address this question, we made a different modification to the materials of Experiment 1: during the test phase,

children heard a novel verb that was different from the one presented in the training dialogue ("Find daxing!"). If children are easily fooled into retrieving earlier-learned distributional information in response to hearing the wrong novel verb, we should expect those in the transitive condition to look longer at the two-participant event during the test phase than would those in the intransitive condition, just as in Experiment 1.

3.1 Method

Participants. Sixteen 2-year-olds (Mean 28.4 months; range 27-30; 8 girls, 8 boys), all native speakers of English, participated. Five additional children were tested but not included due to fussiness (1), side bias (1), a bathroom break (1), or equipment problems (2). Vocabulary scores ranged from 18 to 95, with a median of 65.5.

Procedure. The apparatus, materials and procedure were identical to that of Experiment 1, with one exception: In the novel-verb test trials, instead of presenting children with the verb they had just heard in the training dialogue ("Find blicking!"), we presented a different novel verb ("Find daxing!").

Coding and reliability assessment were as described for Experiment 1; the primary and reliability coders agreed on 97% of video frames.

3.2 Results

As in Experiment 2, the children's looking patterns were not affected by sentence condition: those in the transitive condition did not look reliably longer at the two-participant event (M = .64, se = .078) than did those in the intransitive condition (M = .61, se = .069; $F(1,14) < 1$). Also as before, the effect of sentence condition did not vary with whether children's vocabulary was above or below the median: A 2 (sentence condition) by 2 (high vs. low vocabulary) between-subjects ANOVA revealed no effect of sentence or interaction of sentence and vocabulary (F's < 1).

3.3 Discussion

Just as did children who heard no novel verb at all in the test phase (Experiment 2), children who heard the wrong novel verb (*dax* rather than *blick*) showed no effect of the preceding training dialogue on their attention to the one- and two-participant test events. This suggests that children needed to hear the same verb (or at least a closer approximation of it) in order to retrieve recently-learned distributional facts about that verb.

The results of Experiments 2 and 3 could be considered estimates of children's baseline preference for the two test events. The means show a strong bias towards the two-participant event (M = .65, M = .62 for Experiments 2 and 3, respectively). This baseline is close to the mean preference for the two-participant event in the transitive condition of Experiment 1 (M = .63), but quite different from the mean in the intransitive condition (M = .44). The pattern of data across experiments shows that intransitive training affected children's preferences for the test events, but provides less clear evidence that transitive training increased children's preference for the two-participant event above baseline. Other evidence makes clear that children at this age and younger understand transitive sentences containing novel verbs (Yuan et al., in prep.). The transitive

training dialogues in the present experiments may have been harder to understand, for a variety of reasons including the lack of referential support for sentence interpretation. However, the baseline preference for the two-participant event in the present data was quite high, leaving little opportunity to observe an increase due to hearing a transitive verb. Ongoing studies with a pair of events that is better matched in visual salience will allow a better opportunity to assess the effect of transitive training in this task.

4. General Discussion

These findings show that 2-year-olds learned something about the combinatorial behavior of a new verb in a conversation, even without a concurrent referential context that would allow them to assign semantic content to the verb. Children who had heard the novel verb in transitive sentences looked longer at a two-participant event than did those who had heard the novel verb in intransitive sentences (Experiment 1). The crucial difference between the transitive and intransitive training groups disappeared when no novel verb was presented at test (Experiment 2: "What do you see?"), or when the wrong novel verb was presented (Experiment 3: "Find daxing!"). Thus if (and only if) they encountered the same novel verb during the test phase, children retrieved the previously-learned combinatorial information and used it to guide their attention to candidate referential scenes.

These findings are consistent with many other reports of toddlers' ability to learn distributional facts about new words. In tasks including word segmentation (Saffran et al., 1996), the generalization of distributional rules to new syllables (Gómez & Gerken, 1999; Marcus et al., 1999), and the formation of word categories based on shared distributional properties (Gómez & Lakusta, 2004; Mintz, in press), infants and toddlers show formidable abilities to detect and remember patterns in linguistic data. Our findings add to this literature by showing that 2-year-olds can recruit such distributional information in interpreting a new verb in a referential setting.

The child's ability to gather useful combinatorial facts about unknown verbs simply by listening has important consequences for syntactic bootstrapping: In principle, it should allow children to interpret sentences, and learn verbs, using not only the syntactic evidence available in the current sentence, but also the syntactic history of the verb in the sentence.

This could help to solve a problem for syntactic bootstrapping, and syntax acquisition more generally: Phrases in a sentence and arguments of the verb are not the same thing. First, sentences can contain phrases that are adjuncts rather than arguments of the main verb. In (1a) *on the table* is an argument of *put*, expressing the destination of the putting action; in (1b) the same phrase is not an argument of *see*, but an adjunct specifying which book was seen. Second, in many languages, including Chinese, subjects and direct objects can be omitted if recoverable in the discourse context (e.g., Clancy, 1985; Lee & Naigles, 2005; Rispoli, 1989). In (2), the Mandarin transitive verb *na2*, meaning *get*, is presented with neither a subject nor a direct object. Both of these well-known phe-

nomena ensure that individual sentences in casual speech are not reliable indicators of verbs' argument structures.

(1) a. John put the book on the table.
b. John saw the book on the table.

(2) Man4 dianr3 na2.
Slow bit get.
Slowly get [it].

For the older child or the adult, prior knowledge of the combinatorial behavior of verbs aids listeners in computing the correct syntactic and semantic structure for such sentences (e.g., Snedeker & Trueswell, 2004). Upon hearing (1b), the experienced English listener knows that *see* is very unlikely to take *on the table* as an argument; similarly, the Chinese listener knows that *na2* is a transitive verb, thus this sentence contains an implicit object argument. Discussions of syntactic bootstrapping have proposed that young learners escape from this difficulty in just the same way—by gathering syntactic information across many sentences to estimate the argument-structure biases of each verb (e.g., Fisher & Gleitman, 2002). Analyses of child-directed speech both in English (Brent, 1994; Naigles & Hoff-Ginsberg, 1995) and Mandarin Chinese (Li, 1994; Lee & Naigles, 2005) show that collections of ordinary sentences provide strong probabilistic information about verbs' argument structures. The present findings constitute a hint that children can make use of the voluminous data in the input speech to estimate the argument-taking behavior of verbs.

In order to make good on this hint, of course, we will have to explore children's collection of syntactic evidence over longer time periods than examined in our brief experiments, and under more variable conditions. In our experiments, there were no potentially confusing adjunct phrases or discourse-based omissions. Recent studies provide promising evidence that infants can detect simple distributional patterns despite some noise in the data (Gómez & Lakusta, 2004; Thiessen & Saffran, 2004).

What is the nature of the combinatorial information that 2-year-olds learned about the new verb, and retrieved during the test phase? There are two classes of possibilities, which are difficult to distinguish both in our task and in principle. First, children could have encoded strictly syntactic combinatorial information: for example, those in the intransitive condition could have learned that *blick* is an intransitive verb. Second, children could have also encoded combinatorial information that is semantic in nature: children in the intransitive condition could have inferred that *blick* can encode a conceptual-semantic predicate involving one core participant. These possibilities are difficult to disentangle because of the intimate relationship between verb syntax and semantics on which any form of syntactic bootstrapping depends. Verbs vary in their syntactic privileges (i.e., the number, type, and position of their complements), and these variations are systematically related to the verbs' semantic argument structure (e.g., Bloom, 1970; Fillmore, 1968; Fisher, Gleitman, & Gleitman, 1991; Gleit-

man, 1990; Goldberg, 1995; Grimshaw, 1994; Levin & Rappaport Hovav, 1995; Pinker, 1989).

However, this method does provide a way to investigate whether and how children encode semantic combinatorial information: For example, note in Table 1 that all the noun phrases in the training dialogues named animate referents. Since the test events involved only animate participants, it may be that this coarse semantic similarity between training sentences and test scenes helped children to apply their recently-acquired combinatorial knowledge to choose among the scenes. New studies using this technique could manipulate animacy in sentences and scenes to determine whether children encode semantic restrictions on argument positions based on listening experience. Information about the semantic type of participants in various argument positions could further contribute to the acquisition of verb meanings (Gleitman et al., 2005), and to the individuation of different word senses associated with the same word form (Grimshaw, 1994; Resnik, 1996).

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