



# Preschoolers' Acquisition of Novel Verbs in the Double Object Dative

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## Abstract

Children have difficulty comprehending novel verbs in the double object dative (e.g., *Fred blicked the dog a stick*) as compared to the prepositional dative (e.g., *Fred blicked a stick to the dog*). We explored this pattern with 3 and 4 year olds ( $N = 60$ ). In Experiment 1, we replicated the documented difficulty with the double object frame, even though we provided more contextual support. In Experiment 2, we tested a novel hypothesis that children would comprehend novel verbs in, and generalize them to, the double object frame if they were first familiarized to the verbs in the prepositional frame. They did, suggesting that part of their difficulty with the double object frame is due to uncertainty about a new verb's semantic/syntactic properties, information that the easy-to-comprehend prepositional frame provides. The benefits of training were short-lived, however; children again struggled after a 2-h delay. The results are discussed in the context of mechanisms underlying verb acquisition.

**Keywords:** Language acquisition; Dative alternation; Syntactic bootstrapping; Verb learning; Syntactic generalization; Double object dative; Cross-structure training

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## 1. Introduction

One important task of language acquisition is discovering the set of syntactic frames in which a verb can appear. This is a challenge for the learner, as in some ways this set is relatively unconstrained, as illustrated in the examples in (1) from Ramchand (2008, p. 21):

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- (1) (a) John ate the apple
- (b) John ate at the apple
- (c) The sea ate into the coastline
- (d) John ate me out of house and home
- (e) John ate
- (f) John ate his way into history

Nevertheless, there are both restrictions (e.g., \*John put the apple), and generalizations (e.g., verbs that describe a change of state caused by one event participant on another can appear in transitive sentences) that can help the learner acquire these sets without having to hear each verb in all of its permitted frames. Crucially, the relationships between a verb's meaning and the set of syntactic frames in which it appears can both limit the hypothesis space for the learner seeking to discover verb meaning and help the learner generalize a new verb to a range of frames (e.g., Gleitman, 1990; Landau & Gleitman, 1985; Lederer, Gleitman, & Gleitman, 1995; Naigles, 1996; Naigles & Hoff-Ginsberg, 1995).

In principle, given these syntax-semantics correspondences, if learners have correctly identified the meaning of a verb, and know the syntactic frames available in their language, they should be able to infer which frames the verb can appear in on the basis of its semantics, or generalize it from one modeled frame to other permissible frames. Yet young children often struggle to generalize new verbs to unmodeled frames. Instead, several studies have found that young children produce verbs almost exclusively in the frames in which they had heard them, as if they were unaware of or unwilling to use syntax-semantics correspondences to infer what other frames the verb could appear in (e.g., Akhtar & Tomasello, 1997; Conwell & Demuth, 2007; Olguin & Tomasello, 1993; Tomasello & Brooks, 1998).

While some scholars have taken this as evidence that young children's early verb representations are concretely tied to the particular frame in which the verb was heard (e.g., Akhtar & Tomasello, 1997; Olguin & Tomasello, 1993; Tomasello, 2003), others claim that children are able to represent verb meanings independently of the particular frame in which the verb was first heard, but that for various reasons they do not always exhibit this knowledge (e.g., Bencini & Valian, 2008; Fernandes, Marcus, DiNubila, & Vouloumanos, 2006; Fisher, 2002a; Naigles, 2002, 2003; Naigles, Bavin, & Smith, 2005). The latter scholars take as evidence findings in which learners do, in some comprehension tasks, reveal knowledge of abstract syntax-semantics correspondences. For example, several studies have found that by 2 years of age, children hearing a novel verb in a transitive sentence preferentially match it to a causative event over a non-causative event (e.g., Arunachalam, 2013; Arunachalam, Escovar, Hansen, & Waxman, 2013; Fisher, 1996, 2002b; Naigles, 1990; Naigles & Kako, 1993; Noble, Rowland, & Pine, 2011; Yuan & Fisher, 2009; Yuan, Fisher, & Snedeker, 2012).

In these studies, the child was not required to generalize from one syntactic frame to another, but rather to use the syntactic frame in which the verb appeared to infer aspects of its meaning—an ability known as syntactic bootstrapping (Landau & Gleitman, 1985).

These studies provide evidence that young learners possess verb-general knowledge that, for example, transitive verbs—and not just specific transitive verbs they already know—can describe causative events.<sup>1</sup>

If children do have syntax-semantics knowledge that abstracts beyond particular lexical items, then why do studies testing generalization of a novel verb to new frames fail to find evidence of it? Fisher (2002a) and Naigles (2002) have argued that children's apparent failures to generalize novel verbs syntactically may be due to their sparse semantic representations for these newly learned lexical items in the first place. After all, knowing which frames a verb can appear in depends on its meaning (e.g., Levin, 1993), and the acquisition of a verb's meaning and its syntactic affordances are undoubtedly linked (e.g., Bloom, 1991; Braine, 1992; Gentner & Boroditsky, 2001; Gleitman, 1990; Grimshaw, 1981; Maratsos, 1990; Pinker, 1989). Young learners may thus be reluctant to generalize verbs to new frames unless and until their understanding of the verb's meaning licenses that new frame.

If this is the case, then providing children with more evidence that appropriately constrains their hypothesis about the verb's meaning should help them extend the verb to permissible frames. One obvious source of evidence could be multiple visual exemplars of events that can be described by the verb. But another source of information about a verb's meaning could be *more* syntactic information—that is, knowledge about what other syntactic frames the verb can appear in. Given the relationships between verb meaning and syntax, knowledge about one or more of the frames in which a verb appears can lead to inferences about the kinds of events the verb describes, and it can in turn help the learner to determine what other unattested frames the verb can also appear in. This line of reasoning turns the generalization problem on its head: The claim is that if the syntactic evidence provided is sufficiently helpful in allowing children to form an appropriate lexical representation for the new verb, they will succeed in interpreting the verb in other permissible frames; in effect, they will succeed in generalizing the verb to a new frame.

In the current study, we test this hypothesis, that providing evidence about a novel verb's meaning by providing an informative syntactic context will improve comprehension of the verb in a new, unmodeled frame. We call this *cross-structure training* to highlight the fact that although it is the verb's meaning whose representation we aim to boost, we do so by providing syntactic evidence about what structures the verb can appear in, knowing that children are quite competent at making use of syntax-semantics relationships in verb learning.

This investigation focuses on preschoolers' acquisition of novel dative verbs. Dative verbs appear in either double object (DO) frames, for example, "Bill gave the dog the bone," or prepositional dative (PP) frames, for example, "Bill gave the bone to the dog." While there are semantic and pragmatic differences in when these two frames are used, there is much overlap in their permitted contexts: Both can describe situations in which a theme participant is transferred to a recipient. The dative alternation is ideal to study relative to the question of abstract syntactic knowledge precisely because of the strong semantic similarities between the two frames as well as the fact that both frames overtly

realize theme and recipient event participants, but with different phrase types and in a different order. The two frames are not completely synonymous, however, and not all verbs that appear in one appear in the other; for example, the DO frame entails that the recipient gains possession of the theme participant while the PP frame does not, and verbs of Latinate origin do not typically appear in the DO frame (e.g., Gropen, Pinker, Hollander, Goldberg, & Wilson, 1989).

Studies probing children's competence with dative verbs have had mixed results. With known verbs, production and comprehension in both DO and PP frames are robustly demonstrated in early childhood, even by 3 years of age (Bürkle, 2015; Campbell & Tomasello, 2001; Gropen et al., 1989; Stephens, 2015). Corpus studies have found that DO frames are more frequent than PP frames in speech directed to children as well as in children's own speech (Campbell & Tomasello, 2001; Snyder & Stromswold, 1997; Viau, 2007). By age 3, children also show verb-general priming of both dative frames, indicating that they have abstract knowledge of these frames (Rowland, Chang, Ambridge, Pine, & Lieven, 2012; Shimpi, Gámez, Huttenlocher, & Vasilyeva, 2007; Thothathiri & Snedeker, 2008).

Novel verb learning studies, on the other hand, document a strikingly different pattern: Preschool-aged children struggle with novel verbs in the DO frame in both comprehension and production, even though at the same ages they succeed with novel verbs in the PP frame (Conwell & Demuth, 2007; Rowland & Noble, 2010; Rowland, Noble, & Chan, 2014). For example, Rowland and Noble (2010) presented 3- and 4-year-old children with novel verbs in PP frames (e.g., "I'm *bilking* the frog to the teddy") or DO frames (e.g., "I'm *bilking* the teddy the frog") in the context of two events from which the child had to choose the appropriate referent: An agent transferred a theme participant to a recipient, and the agent acted on both event participants simultaneously (i.e., both played the theme role). Children successfully chose the transfer event in the PP condition, but performed at chance with DO frames unless the recipient argument was realized as a proper noun rather than a definite description (e.g., "I'm *bilking* Teddy the frog"). This is a more canonical marking than having two definite descriptions in a row, and even adults have difficulty parsing stacked definite descriptions (e.g., Frazier & Fodor, 1978; Gropen et al., 1989). Nevertheless, Rowland and Noble's finding is surprising and warrants explanation given that Thothathiri and Snedeker (2008) found that with *familiar* verbs, children correctly comprehended and carried out instructions with two definite descriptions, such as "Give the bird the dog bone" as often as they did with PP frames. (But see earlier work by Cook, 1976; Osgood & Zehler, 1981; and Roeper, Lapointe, Bing, & Tavakolian, 1981.) It is worth noting, too, that children do hear instances of DO frames with two determiner phrases. Examples of child-directed speech from the CHILDES database (MacWhinney, 2000) include the following: "You're going to give the baby the bottle?" "You'll give the duck your hands and then you'll be a duck?" (Adam corpus; Brown, 1973), "I think we should give the froggie this banana," "Would you give your mommy a snake for her birthday?" "The mommy birds give all their babies worms to eat" (Clark, 1978), and "Give the animals some coffee, honey" (Sachs, 1983).

In a recent chapter, Rowland et al. (2014) report that 4 year olds (mean age 4;9) do successfully comprehend novel verbs in the DO frame, but 3 year olds still do not. This

study presented two transfer scenes to choose from at test (e.g., a rabbit catapults a frog to a duck, a rabbit uses a conveyer belt to transfer a duck to a frog), but otherwise the design was similar to Rowland and Noble (2010).

A notable difference between Rowland and Noble and Rowland et al.'s task and Thothathiri and Snedeker's task is animacy: Rowland and Noble and Rowland et al., in using animate characters for both the theme and recipient, provided less frequent examples of dative events, as animate event participants are not typically "received" by other animate event participants.<sup>2</sup> It may be that acquiring the novel verb given such events is too challenging for the younger learners. Thus, in the current study, children were familiarized to the verb, given events with inanimate themes and animate recipients (although their knowledge is tested with two animate characters so that the test taps into syntactic knowledge alone).

In production, Conwell and Demuth (2007) also found that children struggled with novel verbs in the DO frame. They tested generalization of a newly learned dative verb from one frame to the other, finding that 3 year olds were generally conservative in their production of newly learned dative verbs, though they were able to generalize them to the unmodeled frame if they had recently heard a familiar verb in that other frame. However, they showed an asymmetry in their mastery of the two frames: Those for whom the novel verb was modeled in the DO frame were more likely to produce it in a PP frame than were those for whom it was modeled in the PP frame to produce it in a DO frame. By 7 years of age, children can successfully generalize novel verbs in either frame (Gropen et al., 1989).

The evidence thus far suggests, then, that with novel verbs, but not familiar verbs, 3 year olds and possibly young 4 year olds struggle with the DO frame in both production (Conwell & Demuth, 2007) and comprehension (Rowland & Noble, 2010; Rowland et al., 2014). However, given that these are the only studies on this issue, we aimed to contribute further evidence on children's acquisition of novel dative verbs in this frame.

Specifically, in the present study, we speculated that part of children's difficulties in using novel verbs, but not familiar verbs, in DO frames is due to uncertainty about the novel verb's precise meaning. This speculation is grounded in Fisher (2002a) and Naigles's (2002) suggestion that children's conservative behavior in previous studies can be explained by the fact that no single learning situation provides sufficient information to determine exactly what a new verb means, and so children are conservative because they are not confident about the set of frames with which a new verb is compatible. Indeed, with respect to the two dative frames, the DO frame is very semantically restricted, and so children may require a robust semantic representation for the verb before applying the DO frame to it.

The DO frame is, then, difficult in at least two ways. First, it has particular semantic properties such that not all verbs can occur in it; the verb's semantics must be compatible with transfer semantics to be felicitous in this frame. Second, it is difficult to parse; it invokes a non-canonical thematic role assignment, in which the first object following the verb is a recipient and not a theme, and it involves two noun or determiner phrases stacked after the verb, which is unusual in English. These issues may especially compli-

cate understanding of novel verbs; Dautriche et al. (2013) find that 2 year olds struggle to comprehend novel, but not familiar, verbs in difficult frames. Hearing a novel verb in the DO frame alone may be too challenging because children have not yet figured out the relevant properties of the verb and have to simultaneously identify both its meaning and its syntactic properties even as they attempt to parse the difficult DO frame.

Providing useful exposure to the novel verb may alleviate these issues. Comprehension in a DO frame may be *easier* if children are given informative and easy-to-parse evidence about it—specifically, evidence that it can appear in a PP frame. The PP frame may help the learner engage in syntactic bootstrapping and zoom in on the aspect of the visual scene being described by the verb; the learner may infer, for example, that the theme participant's motion, and not simply the agent's manner of motion, is an important component of the event described by the verb. And evidence from younger learners indeed suggests that acquisition of a novel verb's meaning is aided if the verb is presented in a linguistic context with low processing demands (e.g., Arunachalam, Escovar, Hansen, & Waxman, 2013; Arunachalam, Leddon, Song, Lee, & Waxman, 2013; Kon, Göksun, Bağci, & Arunachalam, 2015; Lidz, Bungler, Leddon, Baier, & Waxman, unpublished data).

Thus, we asked whether children can better understand a novel verb in the difficult DO frame if they have first been presented with it in the PP frame, along with a canonical transfer event. To do so, we introduced 3- and 4-year-old children to novel verbs in either PP or DO dative frames while they watched a transfer event. Then, they were tested on their abilities to identify the correct referent of a sentence containing the same novel verbs, again in either PP or DO dative frames. As in previous research, the current study focused on 3- and 4 year olds, who understand and produce both frames with familiar verbs, but struggle with novel or newly learned verbs in the DO frame. The critical test was whether children could correctly identify the referent of a sentence containing a novel verb in this difficult frame.

To maximize the likelihood of success, we incorporated several design features. Like Rowland and Noble (2010) and Rowland et al. (2014), we tested comprehension instead of production, as it generally precedes production and poses fewer task demands. We also aimed to provide evidence that the verb's meaning was an appropriate fit for the DO frame, from two perspectives. First, children were initially familiarized to the novel verb in the context of a canonical transfer event, in which a human agent moved an inanimate object toward an animate (toy) recipient (e.g., a block to a stuffed turtle). We also strove to make the recipient's possession of the object transparent, at least during the familiarization event, as an event in which one object moves to another, but cannot be said to be "possessed" by the latter, may *not* be felicitously described by the DO frame (e.g., We sent the package to Rome / #We sent Rome the package) (e.g., Green, 1974; Oehrle, 1976; Pinker, 1989). (Rowland and Noble and Rowland et al. used differently sized animals to achieve this possession cue.) At the conclusion of the familiarization event, the inanimate object was in the arms of the recipient. Second, Experiment 2 also incorporated cross-structure training—specifically, we provided syntactic evidence that the verb could describe an event in which a theme participant moves toward a recipient by familiarizing children to the novel verb in the PP frame. This frame poses no difficulty even for newly



learned verbs (Conwell & Demuth, 2007; Rowland & Noble, 2010). We hypothesized that given exposure in this easy frame, children would be able to generalize the novel verb to the more difficult DO frame.

To preview our results, the hypothesis that exposure to the novel verb in the PP frame aided children's comprehension of it in the DO frame was supported. In Experiment 1, we replicated prior evidence that children could successfully identify the referent of novel verbs in the PP frame, but struggled in the DO frame, despite provision of a canonical transfer and change-of-possession event during training. However, in Experiment 2, children did succeed in the DO frame with cross-structure training in which DO testing was preceded by PP training, supporting our hypothesis that the DO frame can be made easier if strong and useable evidence is provided. This success may be fragile, however; a subset of the children in this condition returned for a follow-up test 2 h later, and they performed significantly worse than they had at the first test. Thus, in Experiment 2, we found evidence of comprehension of novel verbs in the DO frame and of generalization of novel verbs from the PP frame to the DO frame in comprehension, but the representations the children formed were apparently not robust enough to persist over a delay.

## 2. Experiment 1

The goal of this experiment was to see if we would replicate previous results on 3 and 4 year olds' comprehension of novel verbs in PP and DO frames using different stimuli and procedures. Children were randomly assigned to either the PP condition, in which they were trained on the novel verb in a PP frame and tested on it in a PP frame, or the DO condition, in which both training and test involved only the DO frame. Although prior research has found that children succeed in the PP frame but not the DO frame, here we asked whether the addition of a separate familiarization phase with a canonical transfer and possession event (animate recipient, inanimate theme), and a comprehension task with low task demands, would also allow children in the DO condition to succeed.

### 2.1. Methods

#### 2.1.1. Participants

Forty typically developing children (20 girls) aged 3;0 to 4;11 (mean age 4;2) were included in the final sample. We focused on 3 and 4 year olds based on prior research (Conwell & Demuth, 2007; Rowland & Noble, 2010; Rowland et al., 2014; Shimpi et al., 2007; Thothathiri & Snedeker, 2008). Note that even among just our 4 year olds, our mean age was slightly younger than Rowland et al. (2014) who did find successful comprehension of novel verbs in the DO dative: 4;5 as opposed to their 4;9. An additional 13 children were excluded from analysis and replaced in the design because of failure to point during the pointing warm-up game (see below) ( $N = 6$ ), failure to provide a clear codable pointing response on at least two experimental trials ( $N = 3$ ), experimenter error ( $N = 1$ ), or parental interference ( $N = 3$ ). Participants were recruited from the Greater

Boston area and were tested either in a quiet room in their preschool or at the Child Language Lab at Boston University.

2.1.2. Materials

Children participated in four trials, each introducing a different novel verb and different visual scenes, and each consisting of an Introduction, Familiarization, and Test phase. See Fig. 1.

2.1.2.1. Visual stimuli: We recorded video clips of actors performing actions with objects. During the Introduction, an actor simply smiled and waved. Two toys were in front of her, one inanimate (e.g., a block), and the other animate (e.g., a stuffed turtle). During Familiarization, the clips depicted the actor moving the inanimate toy to the animate toy in a particular manner (e.g., bouncing).

During Test, two new clips appeared simultaneously, side-by-side. Both depicted the same actor as before but with two new animate toys (e.g., a sheep and a pig). In one, she moved the sheep to the pig, and in the other, the pig to the sheep. Two animate toys were used for the Test phase to make it possible to have each of the toys play either a theme or a recipient role. The animals were the same size and so it was more difficult to make the possession aspect perfectly clear during Test than it had been during Familiarization, but the actor moved the animal so that it ended up against the body of the other.

2.1.2. 2. Auditory stimuli: The auditory stimuli consisted of sentences recorded by a female native speaker of American English in a sound booth. The sentences were edited


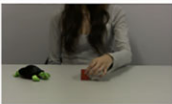

	Visual Stimuli	Auditory Stimuli	
		PP Condition	DO Condition
Introduction		Here's Bridget. Hi, Bridget! Here's a block, and a turtle. See? A turtle and a block!	
Familiarization		She's gonna meek the block to the turtle. ...	She's gonna meek the turtle the block. ...
Test		Let's see more meeking! Here's a sheep, and a pig. See? A pig, and a sheep.	
		Where is she meeking the sheep to the pig? ...	Where is she meeking the sheep the pig? ...

Fig. 1. Sample stimuli from one (of four) trials. Note that the target syntactic frames were repeated multiple times as indicated by the ellipses and as described in the Procedure.



in Praat software (Boersma & Weenink, 2013) and synchronized with the visual stimuli. The sentences included novel verbs (/gɔɹp/, /mik/, /pɪlk/, /stɑɹp/) in PP frames (e.g., “She’s gonna *meek* the block to the turtle”) or DO frames (e.g., “She’s gonna *meek* the turtle the block”).

### 2.1.3. Apparatus

Children watched the videos on a 15” MacBook Pro laptop. Their pointing responses were recorded with the laptop’s webcam.

### 2.1.4. Procedure

Participants first played a warm-up game with the experimenter to familiarize them with the experimental setup and encourage them to point to the screen when asked. They viewed two warm-up trials, each depicting two pictures side-by-side, for example, a truck and a bird, and were asked to “Point to the bird.” Children were gently encouraged to point if they were reluctant, and children who failed to point during the warm-up game or pointed incorrectly were replaced in the design.

Next, they participated in the four experimental trials presented in one of two orders, counterbalanced across participants. Children were randomly assigned to either the PP or DO condition, which applied to all four trials. Each trial began with an introduction to an actor (e.g., “Here’s Bridget. Hi, Bridget!”) who waved and smiled at the camera, and to two toys that lay side-by-side on a table (e.g., “Here’s a block, and a turtle. See? A turtle and a block!”). This introduction was identical across conditions and served to make all of the event participants discourse “given”; this was critical because the DO frame is generally infelicitous if new information rather than given information occupies the first object position (e.g., Bresnan, Cueni, Nikitina, & Baayen, 2007). The order in which the toys were introduced was counterbalanced across trials. Then children viewed the Familiarization Phase. During Familiarization, they first heard a sentence incorporating the novel verb in either the PP frame (e.g., “She’s gonna meek the block to the turtle”) or the DO frame (e.g., “She’s gonna meek the turtle the block”). Then, the actor moved the inanimate toy toward the animate toy in a particular manner (e.g., bouncing), an action lasting approximately 8 sec. The description was repeated (e.g., “Did you see? She meeked the block to the turtle” or “Did you see? She meeked the turtle the block”). Then the action scene played a second time (“Let’s see it again!”), and the description repeated (e.g., “She meeked the block to the turtle!” or “She meeked the turtle the block!”). The left-right placement of the two toys was counterbalanced across trials.

Finally, children viewed the Test Phase. Two new video clips appeared side-by-side, on a black background. Both scenes depicted the same actor as seen during Familiarization and two new toys (e.g., a sheep and a pig). Children first heard, “Let’s see more meeking! Here’s a sheep, and a pig. See? A pig, and a sheep.” Once again, this introduction served to ensure that children heard the target labels for the animals, but also that the referents were now given in the discourse.

Then, they heard the target test sentence, which repeated twice. In the PP condition, this was, “She’s gonna meek the sheep to the pig,” and in the DO condition, “She’s

gonna meek the sheep the pig.” The referent of the argument immediately following the verb was the same across conditions, but in the PP condition, children had to assign this argument a theme role, and in the DO condition, a recipient role. In both scenes, the actor then performed an action, in one, moving the pig toward the sheep and in the other, moving the sheep toward the pig. No audio played during this time to allow children to view each event. The action repeated a second time, and children heard, “Can you find it? Where is she meeking the sheep to the pig?” or “Where is she meeking the sheep the pig?” The action scenes repeated two additional times, and the question repeated one more time, to allow children time to point and to rehear the question if need be. The test syntactic frame was thus heard four times, either in statement or query form. The position of the toys and the scenes was counterbalanced across trials. Within a trial, both test scenes depicted motion in the same direction.

Children’s pointing responses were recorded. Their first point was used as the dependent measure, with the exception of one child on one trial who explicitly and verbally corrected himself as he pointed to the other scene (“No, I think it’s that one”).

## 2.2. *Predictions*

Because both test scenes depicted exactly the same action, simply with different role assignment of the toys, children could only succeed if they comprehended the syntax presented in the test query. If children understood the test query, they should have pointed to the scene depicting the labeled action at above chance levels. Therefore, our analyses tested whether children pointed to the target scene reliably more often than chance—here, chance is a 50% baseline, given that there are two test scenes to choose from, and these are essentially identical in salience because they use the same two characters and depict the same actor performing the same action.

Following previous work, we predicted that children will succeed in the PP condition, pointing to the target scene (i.e., the one in which the sheep moves to the pig) at above chance levels. Given the difficulty of the DO frame, we asked whether we would replicate Rowland and Noble (2010) and the younger group in Rowland et al. (2014)—showing failure of DO comprehension, or whether our inclusion of an initial familiarization phase depicting a canonical transfer event with inanimate theme and animate recipient might help children acquire the verb’s meaning and successfully choose the correct scene (in this condition, the one in which the pig moves to the sheep).

## 2.3. *Results*

See Fig. 2. Children in the PP condition, as predicted, correctly preferred the scene in which the first mentioned object was assigned a theme role in the event, on 69% of trials. To assess this statistically, we fitted the data to a mixed-effects logistic regression model with logit link (binomial family), coding points to the target as 1 and points to the distractor as 0, and including subject and verb as random intercepts and children’s sex (effect coded as  $-0.5$  for males and  $0.5$  for females) and age (with the mean centered

around 0 to ensure that the intercept was interpretable) as fixed effects. The model’s parameter estimate for the intercept was 0.84 ( $p < .01$ ), indicating that performance was significantly better than chance. There were no effects of age ( $p = 0.14$ ) or sex ( $p = 0.34$ ). Analyses were conducted using the `glmer()` function (version 1.1-9) in R (v. 3.2.2) (Bates & Bolker, 2012; R Development Core Team, 2012). To test significance, we used the  $z$ -test and  $p$ -values output by `glmer()`. Parameter estimates and  $z$  scores for Experiments 1 and 2 are listed in Table 1.

Children in the DO condition did not perform as well. They selected the scene in which the first mentioned object was assigned a recipient role, the correct choice in this condition, just 53% of the time. We fitted the data to a model as with the PP condition; here the estimate for the intercept was 0.10 ( $p = .74$ ), indicating that performance was no different from chance. Again there were no effects of age ( $p = .55$ ) or sex ( $p = .20$ ). This indicated that, contrary to our hypothesis, merely providing a familiarization phase depicting a canonical transfer was insufficient to support children’s comprehension of the novel verb in the DO frame.

Although our primary interest was whether children would perform differently from chance in each condition, as a secondary analysis we asked whether performance in the two conditions differed from each other. We fitted the data from both the PP and DO conditions to a mixed-effects logistic regression model as above, including Condition as a fixed effect. We found a significant effect of condition ( $p < .01$ ) and no other significant effects.

Recall that both test scenes depicted the same motion in the same direction, but which toy was moved and which was the recipient differed, with the position of the toys coun-

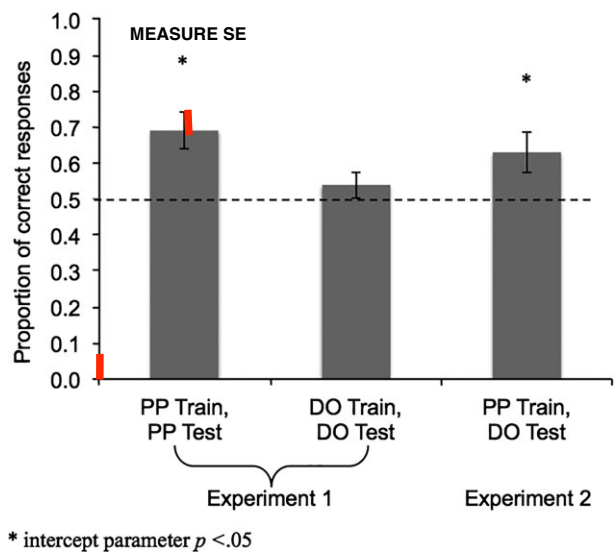


Fig. 2. Results from Experiments 1 and 2. The dashed line indicates chance performance. Error bars indicate the standard error of subject means.

Table 1  
Parameter estimates for all models, Experiments 1 and 2

Experiment	Condition	Parameter	Estimate	Standard Error	z value	p value
1	PP	Intercept	0.84*	0.26	3.24	0.0012
		Age	0.065	0.043	1.49	0.14
		Sex	0.53	0.56	0.95	0.34
1	DO	Intercept	0.10	0.29	0.34	0.74
		Age	0.025	0.043	0.59	0.55
		Sex	−0.67	0.53	−1.28	0.20
1	PP and DO	Intercept	0.11	0.24	0.43	0.66
		Age	−0.023	0.029	−0.80	0.42
		Sex	−0.41	0.35	−1.18	0.24
		Condition	−.92*	.35	−2.64	0.0084
2	PP-DO	Intercept	0.59*	0.30	1.97	0.049
		Age	0.0098	0.061	0.16	0.87
		Sex	0.84	0.51	1.65	0.10
2	PP-DO (only those children who participated before and after a delay)	Intercept	0.72	0.57	1.26	0.21
		Age	−0.062	0.081	−0.77	0.44
		Sex	0.91	0.52	1.74	0.081
		Visit (1 or 2)	−0.96*	0.48	−2.014	0.044

Note. \*Indicates  $p < .05$ .

terbalanced across trials. This means that for two of the four trials, the left-right position within the target scene of the toys that were named first versus second was the same from Familiarization to Test and different for the other two. One possibility is that if children were unsure of the test sentence’s meaning and unable to identify the appropriate test scene based on syntactic structure, they may have simply chosen the scene in which the toy that was first named in the sentence was in the same position as it had been during Familiarization. To explore this possibility, we repeated the analyses reported above, but including as a fixed factor whether the trial was one in which the positions of the toys named first versus second were aligned or misaligned to the first versus second named toys during Familiarization. The trial depicted in Fig. 1 was an “aligned” trial, because in both syntactic conditions, the target test scene for each condition depicted the first-named toy in the same scene as it appeared during Familiarization (i.e., in the PP condition, the block, which appears on the right, is the first-named toy during Familiarization, and the correct test scene depicts the first-named toy, the sheep, also on the right). On misaligned trials, by contrast, the position of the first-named toy differed from Familiarization to the target test scenes—to respond correctly on this trial, children would have to inhibit any preference to match the toys to their positioning with respect to the sentence. We interpret these results cautiously, because there were only four trials, and we counterbalanced toy position across trials rather than across children, but these analyses did reveal that for the DO condition, but not the PP condition, this alignment mattered: In the DO condition there was a main effect of trial type ( $p < .05$ ), with children performing better on aligned trials (67%) than misaligned trials (41%); in the PP condition there was no such effect

( $p = .25$ ). This result suggests that while performance in the PP condition was relatively robust, in the DO condition children were baffled by the syntax and used a strategy of aligning the first toy they heard named at Test to its position during Familiarization to inform their guesses. This in fact led them to choose the *incorrect* scene on misaligned trials more than half the time.

## 2.4. Discussion

We replicated prior work demonstrating that 3 and 4 year olds can understand even novel verbs in the PP dative frame, but that they struggle with DO datives. This was so, even though our stimuli differed considerably from Rowland and Noble (2010) and Rowland et al. (2014), and included a familiarization phase with a canonical transfer event. It is thus unlikely that children in previous work who struggled with acquiring a novel verb in a DO frame did so because they received insufficient visual evidence about the verb's meaning.

The challenge then remains to explain why children struggle with the DO frame. One reason that has been proposed, and is almost certainly at least part of the explanation, is that the DO frame is more difficult when the two objects are realized as definite descriptions. Thus, Rowland and Noble (2010) found that children succeeded when the first object was realized as a proper name instead. However, during pilot testing, we included conditions with the first object as a pronoun after establishing it as the topic (e.g., during Familiarization, "See the turtle? She's gonna *meek* him the block," and during Test, "See the sheep? She's meeking him the pig."). Though we expected this to be easier to process, the patterns were the same as those we reported above—good performance in the PP condition and poor performance in the DO condition—and so we did not pursue these conditions further.

In Experiment 2, we investigated a different (partial) explanation for children's difficulty with this frame. We asked whether children's underspecified knowledge about the novel verb could also play a role, and whether, if children are given easy to process *syntactic* evidence that can help them identify the novel verb's meaning, in the form of what we call *cross-structure training*, they would have greater success at understanding the novel verb in the DO frame.

## 3. Experiment 2

The goal of Experiment 2 was to test whether introducing children to a novel verb in the PP frame *first* would provide them with the evidence they need to facilitate their subsequent comprehension of the verb in the DO frame. Therefore, in Experiment 2, we used the same experimental paradigm as in Experiment 1, except that we took the Familiarization phase from the PP condition and the Test phase from the DO condition.

In addition, for a subset of the children in Experiment 2, we added a second test after a delay of about 2 h, with two possible motivations in mind. If children did successfully comprehend the verb in a DO frame after PP familiarization, the second test would reveal

how robust the effects of this training were. Would children still be able to comprehend the novel verb in the DO frame after a delay? If children did not succeed in the first test, however, the second test might serve a different purpose. Specifically, even if familiarization with the PP frame did facilitate acquisition, children might still have difficulty with the DO frame because the PP structure had been primed. If so, a delay might present an opportunity to forget the details of their first encounter with the novel verb, but remember only its general semantic features (Werchan & Gómez, 2014), such as that it involved a change of location of a theme participant. The delay might then facilitate performance in the second test.

### 3.1. Methods

#### 3.1.1. Participants

A different sample of 20 typically developing children aged 3;4 to 4;9 (mean age 4;4) were included. An additional 5 children were excluded from analysis and replaced in the design because of failure to point during the pointing warm-up game ( $N = 2$ ), failure to provide a clear codable pointing response on at least two experimental trials ( $N = 2$ ), or experimenter error ( $N = 1$ ). Participants were recruited from the Greater Boston area and were tested either in their preschool or at the Child Language Lab at Boston University. Of these 20 children, 12 participated in the second test session after a delay; this subset was a convenience sample consisting of those parents who lived close by and were willing to bring their children back to the lab for the second session.

#### 3.1.2. Materials

The materials were identical to Experiment 1, except that on each trial children viewed the Familiarization phase from the PP condition (e.g., actor bounced a block into the arms of a stuffed turtle, with the audio, “She’s gonna meek the block to the turtle / She meeked the block to the turtle”) and the Test phase from the DO condition (e.g., “Where is she meeking the sheep the pig?”).

We refer to this as the PP-DO condition. For those children who also participated in the second test after a delay, the DO condition’s Test phase was repeated.

#### 3.1.3. Apparatus

Identical to Experiment 1.

#### 3.1.4. Procedure

The procedure was as in Experiment 1 during the first test session. For the 12 children who participated in the second test session, parents were asked to return home and engage in normal activities for approximately 2 h, and then return for the second test. They were also asked not to use the novel words with their child or to discuss the videos during the delay. On their return, parents were asked whether their child slept during the delay, as sleep is known to affect memory consolidation (e.g., Stickgold, 2005); no children did. During the second test, children completed the test phase of each trial again.



### 3.2. Predictions

As in Experiment 1, because both test scenes depicted exactly the same action, simply with different role assignment of the toys, children could only succeed if they comprehended the syntax presented in the test query. Thus, an overall preference for the correct scene indicates that children were able to understand the novel verb in the DO frame.

Taking as background the finding in Experiment 1 that familiarization in a DO frame does not permit subsequent comprehension in the DO frame, this experimental condition permitted us to ask whether familiarization children on a novel dative verb in a PP frame would facilitate their comprehension of it in a DO frame. It could be that hearing the novel verb in the PP frame makes it *difficult* for children to then comprehend the verb in a different frame—after all, if children are conservative verb learners and have difficulty generalizing to new frames, they should fail to comprehend the verb in a different frame. Alternatively, if previous attempts to demonstrate DO comprehension in children failed in part because children had insufficient confidence about the novel verb's meaning or an insufficiently robust representation for the verb, then familiarization in the easy PP frame should facilitate DO comprehension.

After a brief delay, two outcomes are again possible. It could be that children's representations for the novel verb decay over the delay, and that they once again have difficulty interpreting novel verbs in the DO frame at the second test. Alternatively, some decay could be helpful, allowing children to forget the details of their encounter with the novel verb and preserve only that it was a transfer event (and therefore likely to be permissible in the DO frame).

### 3.3. Results

In this condition, with PP familiarization and DO test, at the first test session children chose the correct scene, in which the first object corresponded to the recipient role, 63% of the time. A mixed-effects logistic regression model as in Experiment 1 revealed a significant intercept estimate (0.59,  $p < .05$ ). There were no effects of age ( $p = .87$ ) or sex ( $p = .097$ ). Results from this condition are folded into Fig. 2 with the results from Experiment 1.

We also assessed a model including position of the toys as in Experiment 1, again interpreting them cautiously because of the small number of trials. In Experiment 2, because of the switch in syntactic condition from Familiarization to Test, the two trials that were "aligned" in Experiment 1 were misaligned in Experiment 2, and vice versa for the other two trials. Here, too, we found a significant effect of alignment ( $p < .05$ ). But here, while children performed quite well on aligned trials (76%), they were at chance on misaligned trials (51%), indicating that the PP familiarization boosted their performance above a preference for the incorrect scene that we would expect if they were *only* matching the toy position. Note too that the effect of alignment held despite that the syntactic frame, and thus, which event participant moved during the event differed from Familiarization to Test in this condition; children were not displaying a preference for the scene

in which the first-named toy held the same thematic relationship to the verb (e.g., theme participant) as it did during Familiarization. Perhaps, then, despite their above-chance performance and greater success overall, interpreting the DO frame was still difficult even in this condition and children were supported by a low-level strategy of visual alignment.

The 12 children who participated in the second test session showed markedly different performance from their first session. While on the first visit this subset of 12 participants preferred the correct scene 66% of the time, on the second visit they were at chance, choosing the correct scene just 44% of the time. We included data from just these 12 participants from both their first and second visits in a single model as before, but including Visit (first vs. second) as a fixed effect. The only significant effect was of Visit (parameter estimate of  $-0.96$ ,  $p < .05$ ), indicating that participants performed reliably better on the first visit compared to the second. See Fig. 3.

### 3.4. Discussion

The results of Experiment 2 revealed that familiarizing children to a novel verb in a PP frame helped them understand that same verb in a DO frame immediately afterward. Our interpretation of this result is that children derived some useful information from the verb's appearance in the PP frame that they could not derive in the DO condition of Experiment 1, when the visual information was the same, but the verb appeared in a DO frame during familiarization. The PP training, we hypothesize, helped them anchor a lexical representation for the novel verb that contained sufficient lexico-semantic and -syntactic information for them to extend this verb to the DO frame. Although the DO frame is

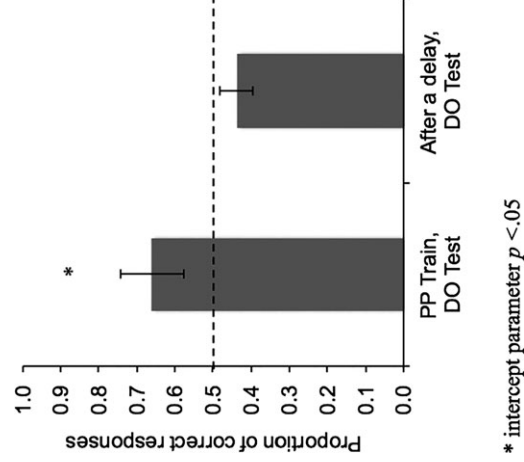


Fig. 3. Results from the subset of children in Experiment 2 who participated in the PP Train, DO Test condition, and repeated the DO Test after a delay. The dashed line indicates chance performance. Error bars indicate the standard error of subject means.

difficult for them to comprehend, this boost from the semantic representation nevertheless provided some benefit, at least during the test they completed at the first visit.

However, there is another possible interpretation of our results. It could be that children did not “process” the DO frame at all at the test, but rather simply noticed that it was somehow different from the frame they had just heard the novel verb during Familiarization (in addition to having different event participants), and, 63% of the time, they chose an interpretation different from the one they would have chosen had it been the same frame. We think this is unlikely, because children had never heard the novel verb in a PP frame with the event participants shown at test, nor had they been tested or asked to point during the Familiarization phase when they did hear a PP frame. For children to have heard the sentence, imagined what that sentence would have been had the “sheep” and “pig” entered into the frame they had previously heard the novel verb in, and then explicitly chosen the scene that did not correspond, seems like a great feat. Indeed, their greater success on trials on which toy position was aligned from Familiarization to Test in the DO condition in both experiments, regardless of whether the structure was the same or different, suggests that they were not doing this. We consider it more likely that the familiarization we provided permitted children to establish a more robust lexical representation for the verb with the correct semantic properties, as gleaned from the PP frame, and to use this representation subsequently to comprehend the verb in the DO frame.

After a delay of a couple of hours, however, any advantage conveyed by this training was lost; children were back to chance performance levels. Naturally we interpret these results cautiously, as there were fewer participants in the post-delay test. We speculate, however, that children’s chance performance after the delay is due to some decay in their representation for the novel verb. Without the boost provided by recent PP familiarization, children were again interpreting the DO frame “from scratch” as it were, and failing just as they have in other tasks and in the DO train, DO test condition in Experiment 1. We suspect that the benefits of cross-structure training may only be long-lasting if more exposure is provided.

#### **4. General discussion**

The goal of this study was to explore children’s abilities to extend novel dative verbs to an unmodeled frame. We built on prior literature documenting that the double object (DO) frame is more difficult to comprehend and produce novel verbs in than the prepositional object (PP) frame. This difficulty in itself is not surprising given the non-canonical thematic assignment in the DO frame, and we too found evidence of this difficulty in Experiment 1, with children succeeding when trained and tested in the PP frame, but not when trained and tested in the DO frame. However, Experiment 2 showed that children can succeed with the DO frame if they are originally introduced to the novel verb in the PP frame. This suggests that providing a good exemplar of the verb’s use that provides insight into its syntactic and semantic properties, in a frame that children can easily pro-

cess, makes it subsequently easier to extend to the challenging DO frame. We call this cross-structure training to emphasize that it is syntactic information that is being provided, despite that its crucial benefit may in fact be that it helps learners zoom in on the verb's meaning, via syntactic bootstrapping.

This work makes three contributions. First, we provide a replication of Rowland and Noble (2010) and the younger children's data from Rowland et al. (2014), the only prior studies testing preschoolers' comprehension of novel verbs in dative frames. Like them, we found that DO datives containing novel verbs are extremely challenging for young learners, despite the addition of a familiarization phase. Given the differences between our paradigm and Rowland and Noble (2010), this finding also allows us to narrow down the explanation for the chance performance in their study: Recall that Rowland and Noble presented children with one event that depicted a transfer event (the target) and one that did not. Chance performance in their study could have occurred because children were choosing between a canonical first-object-as-theme mapping (as would be the correct mapping with the highly frequent simple transitive) and a transfer-event mapping; that is, that they were conflicted between a thematic role mapping preference and an event category match. If this were the case, then in our study, because both scenes depicted transfer events, we might have expected the first-object-as-theme preference to win out and cause significantly more points to the *incorrect* scene. That this did not occur, and that children were at chance, suggests that a first-object-as-theme preference did not determine performance in Rowland and Noble's study either. Rather, this chance pattern in both studies suggests that children are not able to use the DO frame to acquire a novel verb.

Rowland et al. (2014), however, did find successful comprehension of novel verbs in the DO frame with 4 year olds, who were on average older than the 4 year olds in our study. This suggests that the ability to comprehend the DO frame is developing rapidly over this period; one intriguing hypothesis for future work is that their increasing exposure to and processing experience with the PP frame is a factor in this development.

Second, we found that children chose the correct scene significantly more often than chance when familiarized to the novel verb in the PP frame before being tested in the DO frame. That is, children comprehended novel verbs in the difficult DO frame despite never having heard it in this frame before, but only when we provided cross-structure training. This finding provides a partial resolution to the question of why children struggle with novel verbs in the DO frame. As we have noted, the frame itself poses some challenges, and our particular realization of the frame with two definite descriptions labeling the theme and recipient event participants may be particularly challenging. But we add another factor to consider. By providing easy to process linguistic evidence about the novel verb—which includes not only syntactic evidence that it can occur in a PP frame but also, given syntax/semantics correspondences, semantic evidence that it is likely to be compatible with a transfer event—we increased children's success at understanding the novel verb in the DO frame. This suggests that children simply needed more information, and easily processed information, about the verb's meaning and syntactic affordances to succeed.

It is interesting that we did not find evidence of syntactic priming instead, under which we might have predicted poorer processing in a different frame from the one previously presented. Syntactic priming effects are well established in children (e.g., Huttenlocher, Vasilyeva, & Shimpi, 2004; Savage, Lieven, Theakston, & Tomasello, 2003, 2006; Shimpi et al., 2007; Thothathiri & Snedeker, 2008), but it could be the case that the more robust semantic representation formed on the basis of PP familiarization outweighed any priming effects. Alternatively, it could be that we did not observe priming because we used an offline measure—had we measured children's eye gaze, we may have seen that children first looked to the scene depicting the first object as the theme in the PP-DO condition (e.g., Thothathiri & Snedeker, 2008), but managed to revise their parse. We leave investigations of the relative effects of cross-structure training and priming for future research. Note that two other attested learning mechanisms that would have predicted poor comprehension in a different frame, preemption (Goldberg, 1995) and entrenchment (Braine & Brooks, 1995), are not expected to play a role here because they are relevant to verbs to which the child has had significant exposure (whether novel or familiar) (e.g., Theakston, 2004; Ambridge, Pine, Rowland, & Young, 2008; Ambridge, Pine, Rowland, & Chang, 2012; Ambridge, Pine, Rowland, Freudenthal, & Chang, 2014).

This work thus sheds light on the learning mechanisms underlying successful verb acquisition. Once syntactic/semantic links are in place (by the age of three for dative verbs, as established in prior work), children need to know that any particular new verb possesses the appropriate semantics in order to comprehend it in the DO frame. Following Naigles (2002), we suggest that lack of certainty or evidence about a new verb limits children's abilities to generalize the verb to a new frame. As the syntactic bootstrapping literature argues, hearing the verb in other syntactic frames can be particularly strong evidence about verb meaning (e.g., Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005; Lederer et al., 1995; Naigles, 1996), and potentially so above and beyond a visual event that provides a canonical exemplar (Gillette, Gleitman, Gleitman, & Lederer, 1999). In fact, although we endeavored to present a visual scene of a canonical transfer event during familiarization, given that children only succeeded with the DO frame in Experiment 2 with cross-structure training, we have no evidence that the presence or properties of the visual scene were relevant at all for children's success. Syntactic information thus provides learners with information that they can use to identify other syntactic frames that are compatible with this meaning. Interestingly, this means that having a supportive syntactic context not only permits children to comprehend a novel verb in a difficult frame, but also to extend the novel verb from one frame (the PP frame) to another (the DO frame), thus alleviating both the comprehension and generalization problems. Future research should investigate whether the benefit of cross-structure training is primarily in its semantic contribution—that is, that it helps learners identify the verb's meaning, or in its processability—that is, training in an easy-to-process frame helps children grapple with the novel verb and establish a lexical representation for it, or, as we have suggested here, whether both semantics and processing are at play.

Our third finding was that for those children who were trained on the novel verb in the PP frame and then tested in the DO frame, after a delay of about 2 h any advantage of

the PP training was gone. Children performed significantly worse with the DO frame at their second visit than they did at their first. On one hand, this is not particularly surprising; some studies involving novel word acquisition have shown decay of memories for the novel words after even brief 5-min delays (e.g., Horst & Samuelson, 2008). Yuan and Fisher (2009), however, found that children provided only with a dialog incorporating a novel verb in either transitive or intransitive sentences were able, after a delay of 1 or 2 days, to identify an appropriate referent for that novel verb. The current study is similar to theirs, in that children need not have retained the mapping of the novel verb to any particular semantics or referent event; both of the scenes they chose between at test depicted the same transfer event, so the semantics was essentially given them for free. Instead, what was required of participants was the ability to parse the DO frame and assign the event participants to appropriate thematic roles as indicated by the structure. Nevertheless, children's representations decayed rapidly. Little is currently known about what aspects of a newly formed lexical representation are likely to decay over a delay and what aspects are likely to remain (see Wojcik, 2013, for discussion). A few studies have addressed this issue, but specifically focusing on the question of how sleep during a delay may affect performance; while grammatical representations seem to become more abstract and consolidated over delays including sleep (Gómez, Bootzin, & Nadel, 2006; Hupbach, Gómez, Bootzin, & Nadel, 2009), generalization of novel words to new category members appears to benefit from delays without sleep rather than delays including sleep (Werchan & Gómez, 2014). Thus, the evidence does not yet point to a single set of predictions about how linguistic representations will fare over delays, and we need much more careful research to determine which elements (e.g., phonological form, semantics, syntax, event/visual representations) are expected to be retained and which lost and what kind of training is necessary to yield robust enough representations to support the retention of any particular one of these elements. The acquisition of novel words in syntactic frames is an interesting issue because it invokes both semantic and syntactic representations.

In sum, given a difficult learning situation, such as a novel verb in the DO dative frame, really knowing what the verb means and what its properties are can support children's comprehension of difficult syntactic frames. Cross-structure training is one way to provide sufficient support for learning. The current findings indicate that children can make use of abstract syntax-semantics correspondences when generalizing novel verbs to unmodeled frames. However, our findings also suggest that the representations they form on this basis may be fragile; future work will hopefully shed light on the robustness of the verb representations children form given various kinds of syntactic and observational exposure.

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## Notes

1. Of course, evidence that children's early representations contain abstract semantic and structural information does not entail that children are not nevertheless tracking usage-based information, such as the frequency with which verbs appear in particular frames, or co-occur with particular lexical items. The claim is simply that this is not *all* that children know. See, for example, Arunachalam (2015) for discussion.
2. Some apparent counterexamples from CHILDES are given above, although they still largely obey a "hierarchy" of sorts even if both are animate; for example, "mommy" is more agentive than "a snake," perhaps explaining the felicity of "give your mommy a snake." Thanks to an anonymous reviewer for pointing this out.

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