CHAPTER 7

Not all subjects are agents

Transitivity and meaning in early language comprehension

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Children use syntax to guide sentence comprehension and verb learning. We explored the nature of the meanings children infer from syntactic evidence by examining the types of event-roles they can link with the subjects and objects of transitive verbs. In two experiments, 23-month-olds heard a novel verb in a transitive sentence while viewing pairs of events in which one participant acted on another without producing a clear effect (Experiment 1) or one participant moved relative to another without contacting it (Experiment 2). In both cases, children looked longer at the event in which the subject referent played a more prominent role. These findings suggest that children map a highly abstract conceptual-semantic asymmetry onto the syntactic difference between subjects and objects.

Keywords: syntactic bootstrapping, verb learning, language acquisition, thematic roles, transitivity, word order

1. Introduction

Children use syntax to guide sentence comprehension and verb learning (e.g., Arunachalam, 2013; Arunachalam & Waxman, 2010; Naigles, 1990; Yuan, Fisher, & Snedeker, 2012). This syntactic bootstrapping procedure has been proposed to solve otherwise intractable problems of ambiguity that face attempts to infer verb meanings from world events alone (e.g., Fisher, Hall, Rakowitz, & Gleitman, 1994; Gleitman, Cassidy, Nappa, Papafragou, & Trueswell, 2005). The structure-mapping account of the origins of syntactic bootstrapping (Fisher, Gertner, Scott, & Yuan, 2010; Gertner & Fisher, 2012; Yuan et al., 2012) further proposes that some syntactic guidance for verb interpretation is available from the start of multi-word sentence comprehension. On this account, syntactic bootstrapping begins with an innate bias towards one-to-one mapping between the number of nouns in a sentence and the

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number of core participant-roles in a conceptualization of an event. Equipped with this bias, even toddlers assign appropriately different meanings to unknown verbs essentially by *counting the nouns* in simple sentences (Jin, 2015; Yuan et al., 2012). As a result, a new verb that appears in two-noun transitive sentences is interpreted as describing a two-participant relation, whereas a verb that appears in one-noun intransitive sentences is assumed to describe one participant's role[1].

But learners go beyond counting the nouns, to determine how their language links semantic roles with syntax – thus specifying who does what to whom. For example, on hearing *The zum mecked the zard*, adults infer not only that *mecking* describes a two-participant relation, but also that *the zum* plays a more agentive role in that relation than *the zard* (Kako, 2006). Children make strikingly similar inferences, using word order to interpret novel verbs (e.g., Dittmar, Abbot-Smith, Lieven, & Tomasello, 2008; Fernandes et al., 2006; Gertner & Fisher, 2012; Gertner, Fisher, & Eisengart, 2006). For instance, Gertner et al. (2006) presented 21-month-olds with a pair of caused-motion events. In one event, a girl bent a boy forward and back by pushing and pulling on his shoulders; in the other, the boy turned the girl in a swivel chair. While viewing these events, children heard "The girl is gorping the boy" or "The boy is gorping the girl." Children looked longer at the event in which the subject of their test sentence played the agent's role. Thus toddlers possess some general knowledge of how their language links semantic roles to syntax: Like adults, when children encounter an unknown verb in a transitive sentence, they infer both that the verb's meaning involves two participant-roles and that the subject referent plays a privileged role, such as an agent's role, in the event.

The experiments just cited presented children with causal events as referents for transitive sentences. These studies therefore establish that children, like adults, readily link transitive subjects and objects with causal agents and patients. However, as we shall see, the meanings of transitive verbs extend far beyond causal action. In this paper we explore the meanings children infer from syntax, by asking what types of event-roles children can link with the subjects and objects of transitive verbs.

The answers to this question will shed light on toddlers' representations of sentence form and meaning, and their expectations about links between the two. Theoretical accounts of language acquisition differ in their assumptions on both these points. A core controversy concerns whether abstractions such as 'subject' or 'agent' are available to guide early acquisition (e.g., Gleitman et al., 2005; Pinker,

1. Note that this single-participant semantic structure could be a component of an event involving other participants (Arunachalam & Waxman, 2010; Fernandes, Marcus, Di Nubila, & Vouloumanos, 2006; Yuan et al., 2012). This follows from a rock-bottom fact about language, that verbs describe construals of events, not the events themselves (e.g., Gleitman et al., 2005; Levin & Rappaport Hovav, 2005; Pinker, 1989).

1989), or whether they emerge from initially concrete representations of language experience (e.g., Abbot-Smith, Lieven, & Tomasello, 2008; Ambridge & Lieven, 2015). Accounts that posit early abstract representations further vary in their assumptions about whether children begin with detailed innate links between syntax and semantics (e.g., Pinker, 1989), or whether many such links are learned from experience (e.g., Chang, Dell, & Bock, 2006).

1.1 Abstract vs. concrete representations of language experience

The structure-mapping account proposes both early abstract representations of syntax and semantics, and simple innate links between the two – namely, the bias to align nouns one-to-one with participant-roles. Early abstract representations play two roles in this account. First, they give children access to the proposed one-to-one mapping bias: To align nouns with participant-roles, children must represent diverse sentences in terms of their number of nouns, and diverse events in terms of their number of core participants. Second, these representations provide an abstract format for new learning, permitting the quick detection and generalization of syntactic–semantic patterns in the native language. For example, we assume children must learn the subject-verb-object word order of English, along with its role in signaling agent-patient roles. Equipped with appropriately abstract representations of form and meaning, children should detect such patterns readily, and promptly extend them to new verbs.

This early-abstraction assumption is at odds with constructivist accounts of language acquisition, which hold that early linguistic representations are word-specific (e.g., Abbot-Smith, et al., 2008; Ambridge & Lieven, 2015). According to these accounts, a child who heard (1) would at first represent this sentence in terms specific to the words it contains and the referent situation, perhaps noting that the "breaker" is named before, and the "thing-broken" after, the word *break*. This representation could not guide the child's interpretation of word order in a sentence containing a different verb, as in (2), with different event-roles ("spinners" and "spinnees") and different representations of sentence positions (before and after *spin*). On the constructivist view, children accumulate and compare word-specific representations, gradually constructing the abstract semantic and syntactic representations that allow them to detect abstract patterns including that, in English, agents are specified before, and patients after, transitive verbs. This abstraction process is predicted to be slow because it requires children to generalize across a host of irrelevant features. In contrast, if young children are biased to represent sentence form and meaning in usefully abstract terms, then the word-order pattern shared by (1) and (2) should readily be detected and extended to other verbs.

(1) The girl broke the window.

(2) The girl is spinning the top.

Strong support for early abstraction comes from the experimental evidence cited above, showing that before age two, children use word order to interpret novel verbs (e.g., Dittmar et al., 2008; Fernandes et al., 2006; Gertner & Fisher, 2012; Gertner et al., 2006). Those findings imply that young children are not limited to word-specific sentence representations. Instead, they represent linguistic experience in abstract terms, allowing them to quickly detect abstract syntactic-semantic patterns in their native language.

1.2 The semantics of subjects and objects

Deep questions remain regarding what kinds of similarities children readily detect across words and sentences, and therefore what generalizations they can apply to the interpretations of new verbs. The answers to these questions depend on the nature of early representations of sentence form and meaning, and children's expectations about links between the two. The structure-mapping account assumes no built-in links between syntax and semantics beyond the one-to-one mapping bias itself; but this is in part because the account focuses on structural cues that become available as soon as the child can identify some nouns. Once children can identify the grammatical subject of the sentence, they may gain access to more refined built-in links between syntax and semantics (e.g., Fisher et al., 1994; Fisher & Song, 2006; Hartshorne et al., 2016; Lidz, Gleitman, & Gleitman, 2003).

For instance, one proposal is that children initially and preferentially link transitivity with *causation* (Hartshorne, Pogue, & Snedeker, 2015; Kline, Snedeker, & Schulz, 2017), assuming that the subjects and objects of transitive verbs are linked with the agents and patients of causal meanings. This proposal stems in part from cross-linguistic evidence that causal meanings make good transitive verbs. Although far from all transitive verbs describe causal events, verbs that describe events in which an agent causes a change in a patient, such as change-of-state (1) or caused-motion verbs (2), are prototypical transitive verbs that are uniformly transitive across languages (e.g., Hopper & Thompson, 1980). In contrast, verbs that describe other types of two-participant events, such as verbs denoting contact actions without a specified effect (e.g., *hit, tap, hug*), or verbs of perception (e.g., *see, hear*), exhibit greater variability in how they are realized syntactically (e.g., Levin & Rappaport Hovav, 2005; Tsunoda, 1985). Hartshorne et al. (2015) and Kline et al. (2017) propose that the strong cross-linguistic tie between transitivity and causality results from learners' built-in biases: If children are biased to interpret transitive

sentences as describing causal events, then they should have more trouble learning the meanings, and semantic-syntactic linking properties, of transitive verbs that do not have causal meanings.

An alternative possibility, proposed by Fisher and Song (2006; see also Landau & Gleitman, 2015), is that young children approach language ready to map a more abstract conceptual-semantic asymmetry onto the syntactic difference between subjects and non-subjects. The impetus for this proposal stems from two considerations. First, despite the variety of transitive meanings, diverse linguistic analyses suggest that the semantic roles linked to subject and object positions share an abstract semantic similarity (e.g., Dowty, 1991; Grimshaw, 1990). For example, languages link a broad class of prominent event-roles (including causal agents as noted above, but also other roles entailing sentience, volitional involvement, or motion) with the subjects of transitive verbs. Second, there is evidence that the syntactic distinction between subject and non-subject or complement phrases conveys a broad asymmetry in semantic prominence that is not limited to the subject and direct object of transitive verbs (e.g., Gleitman, Gleitman, Miller, & Ostrin, 1996; Landau & Gleitman, 2015). We next discuss each of these considerations in turn.

1.2.1 *Proto-agents and proto-patients*

Dowty (1991) laid out a contrast between two broad prototype role categories, *proto-agent* and *proto-patient*, each associated with a set of semantic entailments. Proto-agent role entailments include volition, sentience, causing a change in another participant, and movement relative to another participant; proto-patient entailments include undergoing a change of state, being causally affected by another participant, and being stationary relative to another participant's movement. For each transitive verb, the argument with the most proto-agent entailments is realized as the subject, and the argument with the most proto-patient entailments as the object. Causal action verbs exhibit a stark asymmetry in these entailments. For example, the subjects of transitive *break* and *spin* in (1) and (2) have many proto-agent entailments and few or no proto-patient entailments, while the reverse is true of the objects. A related asymmetry applies to the non-causal verbs in (3) and (4). The subject of *hug* is not a causal agent, but still has more proto-agent entailments than does the object (volition, movement relative to another participant); similarly, the subject of *see* must be sentient, whereas the object need not be.

(3) The girl hugged the boy.

(4) The girl saw the boy.

Dowty (1991) argued that these proto-roles result from conceptual categories that emerge early in cognitive development. That is, languages link to subject position

the broad class of roles that can be characterized as proto-agents because children view them as similar. Subsequent research in infant cognition has yielded powerful evidence for (at least the building blocks of) suitably broad role categories. For example, pre-linguistic infants identify entities as psychological agents, thus suitable targets for psychological reasoning, if those entities appear to perceive and respond volitionally to changes in their environment (see Baillargeon, Scott, & Bian, 2016, for a review). On this view, the link between transitivity and causality may not be specific to true causality after all, but may instead be a special case of a more general propensity to link transitive subjects with agentive (causal, mobile, or volitional) roles in events.

1.2.2 *Beyond transitives: The asymmetry of syntax*

Dowty's (1991) proto-role proposal was formulated to explain the argument-linking patterns of transitive verbs, but a related semantic asymmetry characterizes the subjects and non-subjects of sentences that do not contain transitive verbs. For example, Talmy (1983) argued that the syntactic asymmetry between subject and non-subject arguments (not just transitive objects) maps onto a perspective-dependent semantic asymmetry that is somewhat independent of the event roles played by each participant. To illustrate, both sentences in (5) describe the same state of affairs; but the predicates *above* and *below* permit different choices as to which participant is construed as the conceptual figure, whose position relative to a ground or reference object is the point of the sentence. The choice of figure vs. ground depends not only on the state of affairs, but also on the focus of the speaker's attention, and what is viewed as changeable vs. stable in the referential context (e.g., Nappa, January, Gleitman, & Trueswell, 2004; Osgood & Bock, 1977). On this view, the choice of subject vs. non-subject serves as an abstract semantic framing device, highlighting one participant as a potentially changeable figure relative to a stable ground object.

(5) a. The star is above the circle.
b. The circle is below the star.

1.2.3 *The semantic prominence of subjects: Prior evidence from adults and children*

Thus, the subjects and objects of transitive verbs can be described as linked with roles bearing more of the semantic entailments of proto-agents (such as causation, motion, or volitional involvement; Dowty, 1991), or roles played by entities that are more readily viewed as the conceptual figure in a figure-ground relation (Talmy, 1983). These theoretical descriptions differ in important ways, but share the assumption that grammatical subjects are linked to arguments that are prominent in a ranking of conceptual-semantic roles. These proposals raise the

intriguing possibility that children might have access to a highly abstract default interpretation for transitive verbs. For example, even when the referential scene makes a true causal interpretation unlikely, children might link transitive word order with an asymmetry in movement, volitional involvement, or suitability as a conceptual figure.

Considerable evidence suggests adults can access this abstract default interpretation. First, when given the example with which we began, *The zum mecked the zard*, adults rated *the zum* as more likely to act intentionally, or to cause a change, and rated *the zard* as more likely to undergo a change of state, or to be stationary relative to another participant (Kako, 2006). These patterns could indicate a preference for causal interpretations in particular, or the unfettered attribution of independent proto-agent entailments to the subjects of novel transitive verbs, and proto-patient entailments to their objects, just as Dowty (1991) would predict. Second, adults assign asymmetrical roles to subject and non-subject referents even when the verbs (or other predicates) in those sentences have inherently symmetrical meanings (Gleitman et al., 1996). For example, *meet* describes a symmetrical relationship (two people meet to the same degree), yet adults rated sentence (6a) as more sensible than (6b). Similarly, two objects are equally *near* each other, yet adults found (7a) more sensible than (7b). When interpreting symmetrical predicates combined with nonsense nouns (*The dax met the zum*), adults rated the referents of nouns in object position as bigger, more important, and less mobile than those in subject position. This asymmetrical interpretation must result from the syntax of the sentence, not from the symmetrical predicates themselves. Just as Talmy (1983) would predict, the subject can be interpreted as a potentially moveable figure relative to a stable ground object.

(6) a. My sister met Meryl Streep.
    b. Meryl Streep met my sister.

(7) a. The bicycle is near the building.
    b. The building is near the bicycle.

Experimental studies of children's interpretations of novel verbs have typically presented children with causal events as target referents for transitive sentences (e.g., Arunachalam, Escovar, Hansen, & Waxman, 2013; Fisher, 2002; Gertner et al., 2006; Gertner & Fisher, 2012; Lidz et al., 2003; Naigles, 1990; Naigles, Fowler, & Helm, 1992; Naigles, Gleitman, & Gleitman, 1993; Yuan & Fisher, 2009; Yuan et al., 2012). The results of these studies establish that even toddlers under two years old, like adults, readily map transitive sentences onto causal events, and readily interpret transitive word order relative to such events, linking transitive subjects and objects with causal agents and patients.

Given these early successes, we might suppose that children prefer causal interpretations of transitive syntax, and have trouble accessing a more abstract default interpretation. Two findings have been offered as support for this hypothesis. First, Kline et al. (2017) found that 4-year-olds mapped novel verbs in transitive (but not intransitive) sentences onto events that could be construed as causal (e.g., an actor claps, then a toy spins), as opposed to similar events in which the perception of causality was disrupted by a spatio-temporal gap between action and effect or by reordering the events so that the effect came first (the toy spins, then the actor claps). Thus, children prefer to link transitive sentences with causal events, at least over certain kinds of non-causal events. Second, Hartshorne et al. (2015) found that 4-year-olds more reliably used word order to determine who did what to whom in sentences containing causal emotion verbs: After hearing a story, children more accurately evaluated the truth of sentences containing emotion verbs denoting the causation of emotion (*Tiger frightened Lion* vs. *Lion frightened Tiger*) than those denoting non-causal emotional states (*Tiger loves Lion* vs. *Lion loves Tiger*). Hartshorne et al. argued that 4-year-olds did not yet understand the argument-role linkings of non-causal emotion verbs such as *love*, because they expect transitive verbs to have causal meanings. Another possibility, however, is that children had trouble with non-causal emotion verbs in this task partly because these verbs denote states rather than actions; the actions in 'frighten' stories may have suggested stronger causal links between propositions than did the states in 'love' stories, facilitating story comprehension and recall (Bransford & Johnson, 1972).

Other data suggest that children can also map transitive verbs onto non-causal meanings. For example, invented verbs in transitive frames (*The duck is kradding the bunny!*) prompted 29-month-olds to look longer at non-causal contact events (e.g., a duck touched a bunny's head) as opposed to synchronous events (both duck and bunny wheeled their arms), relative to their peers who heard the verbs in intransitive frames or in isolation (Naigles & Kako, 1993). This suggests that toddlers viewed non-causal contact events as coherent two-participant events, thus plausible referents for a novel verb in a transitive frame (see also Naigles, 1996; Scott & Fisher, 2009). However, these studies did not test whether children systematically mapped transitive subjects and objects onto participant-roles in non-causal contact events.

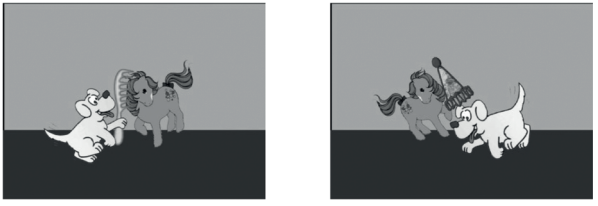
Other evidence suggests older preschoolers can use word-order to map the arguments of novel verbs onto roles in non-causal events. Fisher and Song (2006) showed 3-year-olds non-causal motion or location scenes (e.g., a toy car rolling up to a flashlight) accompanied by transitive sentences containing ambiguous pronouns and nonsense verbs (e.g., *It's pilking it.*); scene participants varied in animacy.

When asked, "Which one is pilking the other one?", children tended to select moving rather than immobile objects and animate rather than inanimate objects. These choices are just what we should expect if children preferred to map subjects onto event roles with more proto-agent properties (e.g., volition, movement relative to another participant), and direct objects onto roles with more proto-patient properties. Perhaps most strikingly, 4-year-olds assign asymmetrical interpretations to the subject versus non-subject arguments of symmetrical predicates (Chestnut & Markman, 2016): Children heard sentences with nonsense nouns and symmetrical predicates (*A blicket is like a toma; The plig is next to the fem.*), and were asked to choose the referents of the novel nouns in a picture. Children's choices revealed that, like adults, they aligned subjects and non-subjects with an abstract figure-ground asymmetry, and thus inferred that subject referents were less typical (a zebra is like a horse, rather than the reverse) or smaller and more movable (the bicycle is next to the building) than non-subject referents. Taken together, these data show that 3- and 4-year-olds can interpret the syntactic distinction between subject and non-subject in terms of highly abstract categories of semantic roles – perhaps proto-agent vs. proto-patient, or figure vs. ground.

1.3 The present research

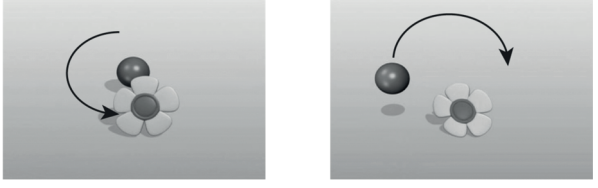
Building on this evidence, we asked whether much younger children, just under two years old, could also use word order to map novel transitive verbs onto two-participant relationships beyond prototypical causality. In two verb-learning experiments, we tested toddlers in a preferential-looking task in which they heard a single novel verb in a transitive sentence, while viewing a pair of candidate referent events. In Experiment 1, we took a modest step away from the prototypical caused-motion events examined in previous studies of early sensitivity to word order (e.g., Gertner et al., 2006): children saw events in which one participant acted on another but produced no clear change of position or posture in the recipient of this action (see Figure 1). In Experiment 2, children saw events in which one participant simply moved relative to another without contacting it. If toddlers, like older children and adults, can align broad semantic categories such as proto-agent vs. proto-patient with transitive subjects and objects, then they should look longer at the target event – the event in which the subject of the test sentence plays a role with more of the features of proto-agency, such as volitional action and motion relative to another participant.

Test events shown in Experiment 1



Horse-subject: The horse is meeking the dog!
Dog-subject: The dog is meeking the horse!

Test events shown in Experiment 2



Flower-subject: The flower is snedding the ball!
Ball-subject: The ball is snedding the flower!

Figure 1. Event-pairs and sentences for the novel-verb test trials in Experiments 1 and 2. Arrows superimposed on the event-pair for Experiment 2 sketch the path of motion in these events

2. Experiment 1

In Experiment 1, we tested 23-month-olds' comprehension of English word-order in reference to two novel 'grooming' events. In one event, a horse placed a hat on a dog's head; in the other, the dog passed a comb over the horse's mane (Figure 1). These events were accompanied by a transitive sentence containing an invented verb. For half the children, the horse was the subject of the sentence ("The horse is meeking the dog!"); for the other half, the dog was the subject ("The dog is meeking the horse!").

These events involved the action of one participant on another, but differed from the caused-motion events examined in previous work in that they involved no change in the position or posture of the recipient of action. English has transitive verbs that describe dressing (*dress, garb*) or grooming (*groom, curry*). But such verbs are few, and many transitive verbs describing acts of bodily care specify a body part rather than the whole body as direct object (*brush his hair*; Levin, 1993). The events labeled by such verbs could be construed as causal; after all, the goal

is typically to bring about a dressed or groomed state. But unlike causal transitive verbs such as *break* or *spin*, many such verbs do not entail the achievement of any particular intended outcome. For example, consider the fictional character Harry Potter, who is known for his notoriously messy hair. One could comb his hair in vain, never achieving a well-groomed state.

These are contact-action events, like those that Naigles and Kako (1993) contrasted with synchronous-action events. Their data, discussed above, showed that 2-year-olds readily viewed non-causal contact events as coherent two-participant events, and thus plausible referents for a novel verb in a transitive as opposed to an intransitive frame. However, Naigles and Kako did not test whether children systematically mapped transitive subjects and objects onto participant-roles in such events. Although these contact-action events lacked the clear causal effects shown in most previous work, their participants' roles still suggest a strong asymmetry in proto-agent vs. proto-patient entailments, and in likely construal as figure vs. ground. For example, the proto-agent entailments of the actor's role in these events are volitional involvement, and motion relative to another participant. If 23-month-olds' interpretation of transitive word-order extends beyond the prototypical caused-motion events examined thus far, then they should be able to use word order in a transitive sentence to identify the target event, and thus look longer at the event in which the subject of their test sentence performs the action.

2.1 Method

2.1.1 *Participants*

Twenty-four 23-month-olds participated (mean 23.1, range 22.0–24.0, 13 male, 11 female). All were native speakers of English. Five additional children were excluded due to inattentiveness (1), failure to complete the experiment (1), or because their average match proportion (see *Coding* below) was more than 2.5 SD from the mean of their condition (3). Children's productive vocabulary was measured using the short form of the Bates-Macarthur CDI, Level 2 (Fenson, Pethick, Renda, Cox, Dale, & Reznick, 2000). Vocabulary scores ranged from 17 to 80 with a median of 52.

2.1.2 *Apparatus*

Children sat on a parent's lap facing two 20-inch television screens placed about 30 inches away. The screens were 12 inches apart and at child's-eye level. Soundtracks played from a central speaker. A camera hidden between the two monitors recorded children's eye movements during the experiment. Parents wore opaque sunglasses, preventing them from biasing their children's responses.

2.1.3 *Materials and procedure*

Stimulus materials were simple animated videos involving a cartoon horse and dog. Events were shown in synchronized pairs and accompanied by a soundtrack recorded by a native English speaker. The procedure had three phases: character-familiarization, practice, and test.

In the character-familiarization phase, the horse was shown moving across the screen (6s) and was labeled twice ("There's a horse! Look at the horsie!") while the other screen remained blank. Following a 2-s interval, the dog was introduced on the other screen in the same manner ("There's a dog! Look at the doggie!"). This was followed by two 6-s trials, separated by 2-s blank-screen intervals. In each trial, the horse and dog appeared on their respective screens simultaneously. In the first trial, children were asked to "Find the dog!"; in the second trial they were instructed to "Find the horse!"

In the practice phase, two familiar transitive verbs were presented accompanied by familiar events. The first familiar verb, *feed*, was accompanied by a feed event in which the horse fed the dog with a bottle, and an approach event, in which the horse approached the dog and stopped a short distance away. Children were introduced to these events in two previews. In the first preview, children saw the feed event on one screen (6s) accompanied by neutral audio (e.g., "Look here! Watch this!") while the other screen remained blank. Following a 2-s blank-screen interval, the approach event was previewed in the same manner on the other screen. Next, during a 6-s blank-screen interval, children heard, "Now watch! The horse is gonna feed the dog!" Children then saw the feed and approach events simultaneously (6s) and heard the sentence, "The horse is feeding the dog" repeated twice. This was followed by a 6-s blank-screen interval in which children heard, "The horse fed the dog. Find feeding." Children then saw both videos again (6s) and heard, "The horse is feeding the dog. Find feeding." Following a 3-s blank-screen interval this procedure was repeated with a second familiar verb, *lick*; one event showed the dog licking the horse and the other showed the dog moving away from the horse.

The character-familiarization and practice phases were designed to familiarize the children with the two characters, the wording of the test trials, and the fact that one of the two events matched the soundtrack on each trial. *Horse, dog, feed*, and *lick* were used because these words are likely to be familiar to 2-year-olds (Dale & Fenson, 1996). Practice events were paired so that the same character was the actor on both screens; thus, children had to use knowledge of the verb, rather than word order, to identify the matching screen in the practice trials.

Finally, in the test phase, children were presented with the novel verb *meek* accompanied by a pair of test events. In the hat event, the horse placed a hat on the dog's head. In the comb event, the dog passed a comb once over the horse's mane. The left/right position of the actor in the test events was counterbalanced within sentence condition using a "flip" operation in the video-editing software.

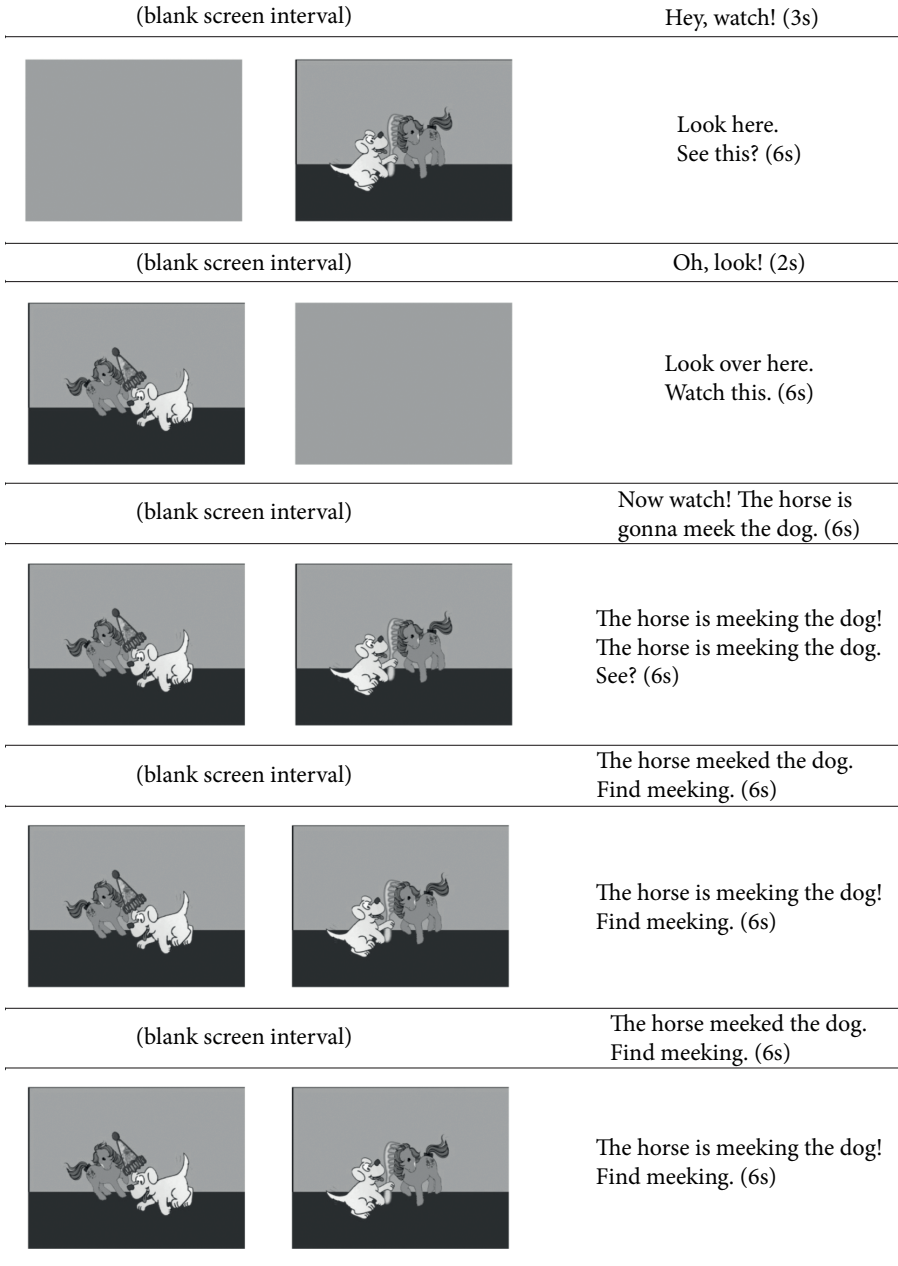


Figure 2. The sequence of events during the test phase in Experiment 1

The sequence of events within the test phase is shown in Figure 2. The test events were first previewed separately, as described above for the practice phase. Next, during a 6-s blank-screen interval, children heard the novel verb *meek* in a transitive sentence. Half of the children heard, "The horse is gonna meek the dog" and half heard "The dog is gonna meek the horse." This was followed by three 6-s test trials in which children saw the two test events and heard the novel verb used in sentences with the appropriate subject (*horse* or *dog*). Test trials were separated by 6-s blank-screen intervals in which children heard additional novel-verb sentences. In total, children heard the novel verb presented 7 times, before, during and after 3 presentations of the test events. Multiple verb forms (*gonna meek, meeking, meeked*) were included to provide ample evidence that the new word was a verb, and to suit the timing of stimulus sentences relative to presentation of the events.

The left-right positioning of events in the character-familiarization, practice, and test phases was counter-balanced with test-sentence subject and with the left-right side of the actor in the test events.

2.1.4 *Coding*

We coded where children looked (left-screen, right-screen, away) frame by frame from silent video. To assess reliability, 6 children's data were independently coded by a second coder. The two coders agreed on the children's direction of gaze for 95% of video frames. Trials in which children looked away from the two screens for more than 67% of the trial were eliminated from analyses (1/96 practice trials, 5/72 test trials). We analyzed the proportion of looking time to the event that matched the audio out of the total time spent looking at either test event, averaged across the three test trials. Analyses based on mean looking times to the matching and non-matching events rather than proportions revealed the same pattern of significant effects as the main analyses reported below.

Preliminary analyses of children's looking-time performance in the test trials revealed no effects of sex, sentence subject, or whether the child's vocabulary or performance in the practice trials was above or below the median, all Fs < 2.07, all ps > .16[2]. We therefore collapsed across these factors in subsequent analyses.

2. Preliminary analyses revealed a marginal effect of actor side, $F(1, 22) = 3.30$, $p = .08$. Children looked marginally longer at the matching event if the actor was on the right side of the event ($M = .68$, $SD = .19$) than if the actor was on the left side of the event ($M = .54$, $SD = .20$).

2.2 Results and discussion

Averaged across the three 8s test trials, children looked significantly longer at the matching video, the one in which the subject of the sentence performed the contact action, than expected by chance ($M = .61$, $SD = .20$), $t(23) = 2.58$, $p = .017$, $d = .54$. Children's preference for the matching event was not significantly correlated with their vocabulary score, $r(24) = -.22$, $p = .30$. Examination of individual children's performance indicated that 7/11 of the children with vocabulary scores above the median and 8/13 children with vocabulary scores at or below the median looked longer at the matching event.

Even though our two test events did not depict a clear causal effect, 23-month-olds used their knowledge of English word order to arrive at a sensible interpretation of a novel transitive verb. They might have done so by inferring that the subject of the sentence referred to an event participant whose role had more proto-agent properties (volition, movement relative to another participant), while the object of the sentence referred to the participant whose role had more proto-patient properties (stationary relative to another participant).

3. Experiment 2

In Experiment 1 we showed for the first time that 23-month-olds could use their understanding of English word order to interpret transitive sentences that depart from the prototypical caused-motion events examined in earlier work. However, the contact-action events of Experiment 1 constituted only a modest step away from the clear caused-motion events examined in previous studies. In Experiment 2, we sought to confirm and extend our finding by asking whether 23-month-olds could systematically map a transitive sentence onto non-causal events that involved *no contact* between event participants, but simply the motion of one participant relative to the other. As in Experiment 1, children watched pairs of animated events (Figure 1). In one event, a ball jumped back and forth over a flower while the flower tilted gently in place; in the other event, the flower moved around the ball in a circle as the ball bounced gently in place. While viewing these events, half of the children heard "The ball is snedding the flower", and half heard "The flower is snedding the ball".

The roles of the ball and flower in these events lacked most of the features of prototypical causality. Neither participant acted on or touched the other, and neither appeared to cause a change in the other's motion. Nonetheless, one participant in each event still exhibited more proto-agent properties than the other because it underwent a salient motion relative to the other participant.

English has transitive verbs that could describe similar actions (*hurdle* and *circle*, though children are unlikely to know these verbs), as well as other transitive motion verbs that express the path of motion relative to a ground object (*enter the room, cross the street*). Such verbs are atypical transitive verbs (i.e., they have few proto-agent and proto-patient entailments), and transitive verbs of this sort are atypical motion descriptions in English. English motion verbs tend to express manner of motion, with path of motion expressed via prepositional phrases (*jumping over the flower, going around the ball*; Naigles & Terrazas, 1998; Papafragou, Massey, & Gleitman, 2006; Talmy, 1985). However, prior evidence suggests that both preschoolers and adults can interpret transitive verbs as referring to motion relative to a reference object (Hohenstein, Naigles, & Eisenberg, 2004; Naigles & Terrazas, 1998; Wagner, 2010). For example, Hohenstein et al. (2004) presented 3.5-year-olds with directed motion events (e.g., a woman skipping toward a tree) accompanied by transitive verbs ("She's kradding the tree") or intransitive verbs with a prepositional phrase ("She's kradding toward the tree"). Syntactic structure guided children's extensions of these verbs to new events. Children who heard transitive sentences looked longer at new test events that preserved the path (tree-ward) but not the manner (skipping) of the original event, relative to those who heard intransitive sentences. This suggests that older children and adults readily interpreted directed-motion events as two-participant events and thus suitable referents for a transitive verb; but these studies did not test whether children systematically mapped transitive subjects and objects onto the moving participants and reference objects in such events.

If 23-month-olds, like older children and adults, map subjects and objects onto broad semantic role classes such as proto-agent vs. proto-patient, or conceptual figure vs. ground, then they should look longer at the target event in this task – the event in which the subject of their test sentence is the more active, mobile participant.

Experiment 2 was also designed to address an alternative interpretation of the word-order findings of Experiment 1. In Experiment 1, the test phase was preceded by a practice phase in which children heard two familiar transitive verbs with the test characters (the horse and dog) named in subject and object position. Dittmar et al. (2008) argued that previous results showing early sensitivity to syntax (Gertner et al., 2006) could be attributed to within-experiment learning from practice items that were similar to the novel-verb test items. To rule out this possibility, in Experiment 2 we removed the familiar-verb practice trials altogether.

3.1 Method

3.1.1 *Participants*

Twenty-four 23-month-olds participated (mean 22.8, range 21.8–23.9, 13 male, 11 female). All were native speakers of English. Three additional children were excluded due to inattentiveness (1), because their productive vocabulary was below the fifth percentile for their age (1), or because their average match proportion was more than 2.5 SD from the mean of their condition (1). Children's productive vocabulary scores, measured as in Experiment 1, ranged from 16 to 91 with a median of 55.

3.1.2 *Apparatus*

The apparatus was identical to that used in Experiment 1.

3.1.3 *Materials and procedure*

Stimulus materials were animated videos involving a ball and a flower, created using the 3D animation software Maya®. Events were shown in synchronized pairs and accompanied by a soundtrack recorded by a native English speaker.

The procedure had two phases: character-familiarization and test. In the character-familiarization phase, a ball was shown in the center of one screen (7s) and was labeled twice ("There's a ball! Look at the ball!") while the other screen remained blank. Following a 2-s interval, a flower was introduced on the other screen in the same manner ("There's a flower! Look at the flower!"). This was followed by two 7-s trials, separated by 2-s blank-screen intervals. In each trial, the ball and flower appeared simultaneously on their respective screens. In the first trial, children were asked to "Find the flower!"; in the second trial they were instructed to "Find the ball!"

Next, in the test phase, children were presented with the novel verb *sned* accompanied by a pair of test events. In the hurdle event, the ball jumped back and forth over the flower while the flower tilted gently in place; in the circle event, the flower circled the ball while the ball bounced gently in place.

The sequence of events within the test phase is shown in Figure 3. The test events were first introduced separately in two previews. In the first preview, children saw the hurdle event on one screen (7s) accompanied by neutral audio (e.g., "Look here! See this?"); the other screen remained blank. Following a 2-s blank-screen interval, the circle event was previewed in the same manner on the other screen. Next, during a 6-s blank-screen interval, children heard the novel verb *sned* in a transitive sentence. Half of the children heard "The ball is gonna sned the flower," and half heard "The flower is gonna sned the ball." This was followed by three 7-s test trials in which children saw the two test events and heard the novel verb used in

sentences with the appropriate subject (ball or flower). Test trials were separated by 6-s blank-screen intervals in which children heard additional novel-verb sentences in the past tense. As in Experiment 1, children heard the novel verb presented 7 times and in three different tenses.

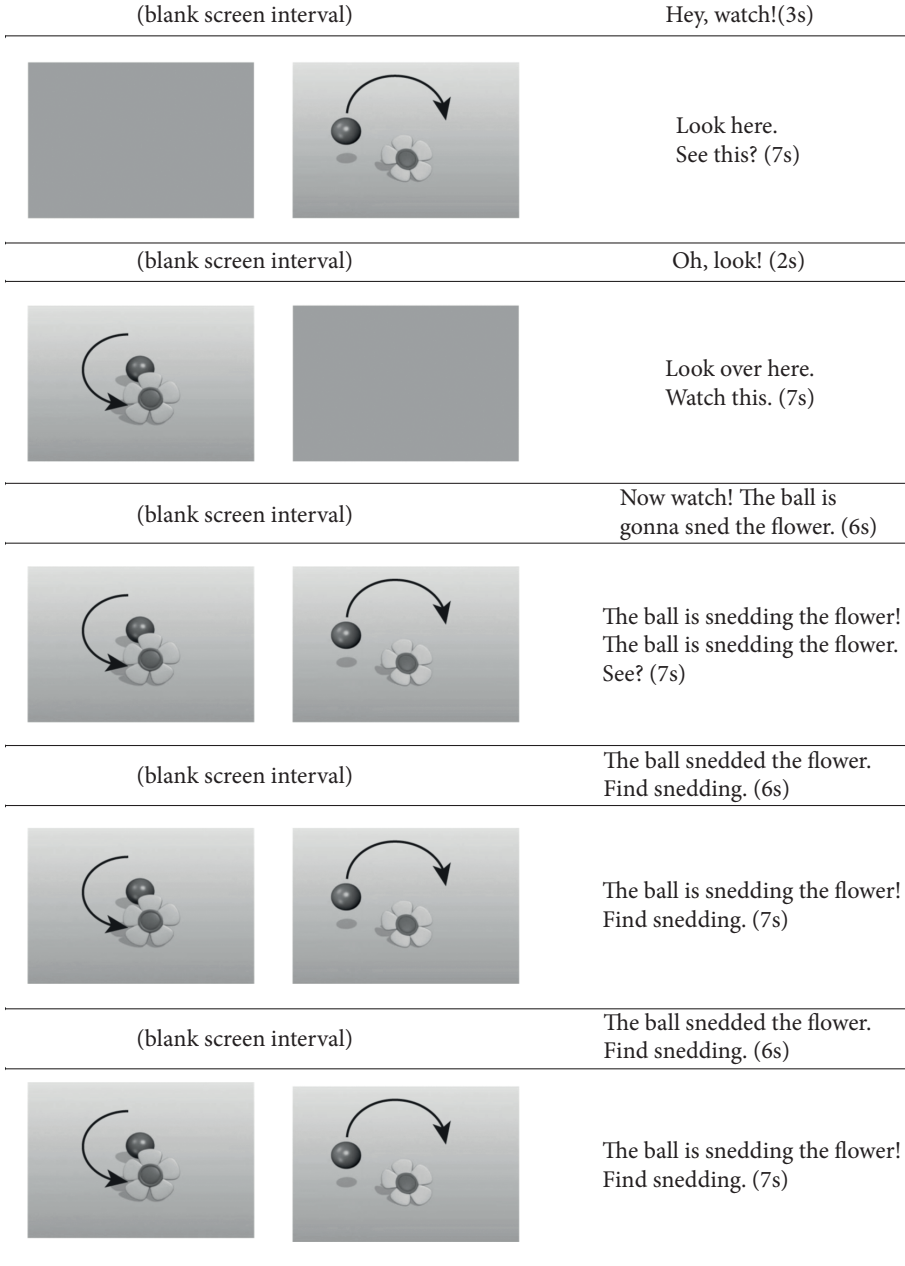


Figure 3. The sequence of events during the test phase in Experiment 2

The left-right positioning of the sequence of events in the character-familiarization and test phase was counter-balanced with test-sentence subject.

3.1.4 *Coding*

As in Experiment 1, we coded where children looked (left-screen, right-screen, away), frame by frame from silent video. To assess reliability, 4 children's data were independently coded by a second coder. The two coders agreed on the children's direction of gaze for 97% of coded video frames. We analyzed the proportion of looking time to the event that matched the audio out of the total time spent looking at either test event, averaged across the three test trials. Analyses based on mean looking times to the matching and non-matching events rather than proportions revealed the same pattern of significant effects as the main analyses reported below.

Preliminary analyses of children's looking time performance in the test trials revealed no effects of sex, sentence subject, or whether the child's vocabulary or performance in the practice trials was above or below the median, all Fs < 1. We therefore collapsed across these factors in subsequent analyses.

3.2 Results and discussion

Averaged across the three test trials, children looked significantly longer at the matching video, the one in which the subject of the sentence moved more relative to the other participant, (M = .57, SD = .14) than expected by chance, $t(23) = 2.56$, $p = .018$, $d = .50$. Children's proportion of looking time to the matching video was not significantly correlated with their vocabulary scores, $r(24) = .09$, $p = .67$. Examination of individual children's performance indicated that 6/11 of the children with vocabulary scores above the median and 10/13 children with vocabulary scores at or below the median looked longer at the matching event.

Even though our two test events depicted non-causal motion events, 23-month-olds again used their knowledge of English word-order to arrive at a sensible interpretation of a transitive sentence containing a novel verb.

4. General discussion

In two verb-learning experiments, we probed what kinds of asymmetries in event roles children map onto word order in transitive sentences. To do so, we created stimulus events lacking key features of the prototypical caused-motion events examined in previous studies. In our events, although there was no causal agent, one participant's role entailed more of the semantic entailments of proto-agency than the other (motion or volitional involvement; Dowty, 1991). In both experiments, despite the absence of 'real' causal agents, 23-month-olds interpreted word order

systematically: they looked longer at the event in which the subject of the sentence was the more mobile participant. This suggests that 23-month-olds readily link transitive word order with broad event-role categories that extend beyond the prototypical agent-patient case to include cases in which one character contacts another, or simply moves relative to another. Our findings add to what we know about early interpretation of transitive word order in three ways.

First, children's success in our word-order tasks confirms and extends prior evidence that 2-year-olds can link transitive sentences with contact-action events (Naigles & Kako, 1993), and that older preschoolers and adults can link transitive sentences with directed-motion events (e.g., "She's kradding the tree!"; Hohenstein et al., 2004; Naigles & Terrazas, 1998; Wagner, 2010). The systematic responses in our task suggest that by 23 months, children can view contact-action and directed-motion events as *two-participant events*, thus appropriate referents for a transitive verb.

Second, the present studies were the first to show that toddlers mapped transitive subjects and objects systematically onto participant-roles in non-causal events. In both experiments, children linked the subject of their test sentence with the participant in the event that initiated the contact (Experiment 1), or that moved more saliently relative to the other participant (Experiment 2). This suggests that they linked a highly abstract semantic-role asymmetry with the subject and object of the transitive test sentences.

Third, in Experiment 2 children interpreted word-order systematically despite the absence of familiar-verb practice trials. The test phase was preceded only by a character-familiarization phase; thus, children had no opportunity to learn shallow sentence-interpretation strategies within the experiment that could have supported test-item performance. This tells us that the 23-month-olds brought to the task some knowledge of the semantic significance of English word order; this knowledge was robust enough to influence interpretation of a novel verb, and abstract enough to guide children's attention toward an event in which the subject of the sentence was not a causal agent, but merely mobile.

The early recruitment of this abstract grouping of semantic roles constrains theories of early syntax acquisition. Constructivist accounts propose that abstract semantic-role categories emerge through language experience: children learn to see diverse event-roles as similar because their language expresses them similarly (e.g., Abbot-Smith et al., 2008). Early-abstraction accounts propose that language learning builds on the child's own tendency to view broad classes of semantic roles as similar, and to assume any language will treat them similarly (e.g., Chang et al., 2006; Gleitman et al., 2005; Pinker, 1989). Toddlers' willingness to link abstract role categories with transitive word order challenges the constructivist account, but is easily handled by an early-abstraction account.

Similarly, the abstract nature of the semantic roles children infer from syntax has consequences for early syntactic bootstrapping. Via structure-mapping, once

children can identify some nouns, they infer that sentences containing two nouns refer to two-participant construals of events. Given abstract representations of form and meaning, children generalize what they learn about how one verb arranges its arguments in the syntax to other verbs. The present results suggest that 2-year-olds readily link broad classes of semantic roles with word order in transitive sentences, and thus that early extensions of syntactic knowledge across verbs may be correspondingly broad. For example, if proto-agent and -patient roles form part of the starting point for language acquisition, then any learning about *hitting* and *breaking* should promptly guide learning about *hugging* and *seeing*.

Dowty's (1991) proto-role proposal could easily explain our results. At the core of this proposal is a claim that proto-agent and proto-patient role categories emerge from non-linguistic cognitive development, and thus are available to guide the inferences of young learners. Causal verbs exhibit the strongest asymmetry in proto-agent vs. proto-patient entailments, but our stimulus events were designed to strip away some of these entailments. Nonetheless, one participant in each event still made a better proto-agent than the other because it appeared to volitionally contact the other (in Experiment 1), or underwent a salient motion relative to the other participant (in Experiment 2).

However, given the arguments and evidence reviewed in the Introduction, we suspect this is unlikely to be the whole story, and that children might have access to a default interpretation of the subject-object asymmetry that extends beyond the semantic-role entailments of proto-agents and proto-patients. Recall that 4-year-olds and adults preferred interpretations such as 'the zebra is like the horse' over 'the horse is like the zebra' (Chestnut & Markman, 2016; Gleitman et al., 1996). Because *is like* has a symmetrical meaning (and thus its two arguments play the same roles), the perceived semantic asymmetry in these sentences must come from the syntax, not from the semantic role entailments of the predicate. As Talmy (1983) noted, the choice of subject vs. non-subject depends not only on the event-dependent participant-roles associated with the verb, but also on which of the participants filling those roles makes a better conceptual figure in a figure-ground relation. Because more mobile event-participants make better conceptual figures as well as proto-agents, Talmy's figure-ground asymmetry could also explain our results. Disentangling these two explanations will require investigating the early learning of a wide range of predicate meanings, including spatial terms and symmetrical predicates (e.g., Landau & Gleitman, 2015). Whatever the result of these investigations, the current findings suggest that young children have access to a flexible range of default interpretations for transitive verbs. Even when the referential scene makes a causal construal unlikely, toddlers systematically map transitive word order onto a broad asymmetry in semantic roles.

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