Research Article

Learning Words and Rules

Abstract Knowledge of Word Order in Early Sentence Comprehension

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ABSTRACT—*Children quickly acquire basic grammatical facts about their native language. Does this early syntactic knowledge involve knowledge of words or rules? According to lexical accounts of acquisition, abstract syntactic and semantic categories are not primitive to the language-acquisition system; thus, early language comprehension and production are based on verb-specific knowledge. The present experiments challenge this account: We probed the abstractness of young children's knowledge of syntax by testing whether 25- and 21-month-olds extend their knowledge of English word order to new verbs. In four experiments, children used word order appropriately to interpret transitive sentences containing novel verbs. These findings demonstrate that although toddlers have much to learn about their native languages, they represent language experience in terms of an abstract mental vocabulary. These abstract representations allow children to rapidly detect general patterns in their native language, and thus to learn rules as well as words from the start.*

Languages are composed of words and rules by which words are meaningfully combined. Although languages vary greatly, their combinatory rules have striking similarities. For example, languages differentiate the subjects and objects of transitive sentences (e.g., Croft, 1990). This differentiation has semantic consequences: In sentences (1) and (2), the placement of *Mary* and *Bill* specifies who did the kissing or kicking, and who was kissed or kicked.

(1) Mary kissed Bill.

(2) Mary kicked Bill.

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The formal marking of grammatical roles differs cross-linguistically; thus, children must learn how to identify subjects and objects in their native language.

Children appear to quickly acquire these fundamental links between sentence form and meaning. Even 17.5-month-old English learners use word order to understand transitive sentences containing familiar words (Hirsh-Pasek & Golinkoff, 1996). Appropriate markings of grammatical relations also emerge early in children's speech (e.g., Brown, 1973; Clancy, 1985).

What kind of knowledge underlies these achievements? Should early sensitivity to English word order be considered knowledge about words or rules? For our purposes, a rule is a generalization that applies freely to new cases, independently of their similarity to previously experienced cases. For example, the rule for transitive word order in English could be roughly stated as "transitive subjects precede the verb and refer to agents; transitive objects follow the verb and refer to patients (or undergoers of action)" (see Dowty, 1991). This generalization applies to any transitive verb.

It is generally agreed that the English word-order pattern counts as a rule in its mature form. The developmental antecedents of such rules, however, have long been debated. Two broad classes of theories have been proposed: *lexical* and *early-abstraction* accounts. These accounts make different assumptions about the mental vocabulary children initially use to represent linguistic experience, and therefore differ in their claims for how and when abstract linguistic rules emerge.

According to lexical accounts of language acquisition, children first learn to interpret sentences by acquiring verb-specific knowledge (e.g., Braine, 1963; Lieven, Pine, & Baldwin, 1997; Tomasello, 2003). The lexical-account child might represent the positions of *Mary* and *Bill* relative to *kiss* in (1) and to *kick* in (2); the semantic roles of Mary and Bill might be represented as something like "kisser" and "kissee" in (1) and "kicker" and "kickee" in (2). Verb-specific representations obscure the similarity across the two sentences: Kissers and kickers differ in many features (the involvement of lips vs. feet, etc.) that are

irrelevant to the abstract significance of word order. The ability of any lexical or instance-based system to generalize depends on how items are represented and how similarity is computed (e.g., Nosofsky & Johansen, 2000). A key assumption of lexical accounts of syntax acquisition is that children approach language without a priori constraints on possible relationships between sentence form and meaning. Rule formation is therefore predicted to be slow, because the features of sentence form and meaning necessary to identify general patterns must be disentangled from a host of irrelevant features. According to this view, abstractions such as *subject*, *object*, *agent*, and *patient* are not primitive to the language-acquisition system, but are gradually constructed via comparison (perhaps via structural analogy; Tomasello, 2003) across verbs that appear in similar sentential contexts and have similar meanings.

According to early-abstraction accounts, children acquire facts about particular words, but are also constrained to represent knowledge of sentence structure in terms of a more abstract mental vocabulary (e.g., Chang, Dell, & Bock, 2006; Fisher & Gleitman, 2002; Pinker, 1989; Wexler, 1999). Some proponents of early-abstraction accounts describe these constraints as an innate universal grammar that includes elements such as *subject*, *object*, *agent*, and *patient* as primitives (e.g., Pinker, 1989; Wexler, 1999); others view some elements of universal grammar as constructed from other primitives, given a suitably constrained learning architecture (e.g., Chang et al., 2006; Newport, 2000; Saffran, 2002). In either case, it is assumed that early in the course of lexical learning, the child has some abstract format in which to represent sequences of words and their possible meanings. For example, the early-abstraction child might represent the positions of Mary and Bill in (1) and (2) relative to a category such as *transitive verb*; the associated semantic representations would indicate that kissers and kickers are *agents*, and kissees and kickees are *patients*. Such representations would transparently display the similarity across the two sentences. A key assumption of early-abstraction accounts is that a priori constraints on possible relationships between sentence form and meaning prevent irrelevant features of individual verbs from interfering with the detection of general patterns. Thus, children learn from the start where agents, rather than just kissers and kickers, belong in sentences. Rule formation is therefore predicted to be rapid relative to lexical learning.

Both accounts can explain early sensitivity to language-specific grammatical patterns in sentences containing familiar verbs. The toddler who understands sentences like (1) and (2) could do so based on either word-specific or more abstract knowledge of linguistic structure. Where these accounts differ is in their predictions regarding the timing of extensions of syntactic knowledge to novel verbs.

Two kinds of evidence, from experiments on novel-verb comprehension and production, have been offered in support of the lexical account. Akhtar and Tomasello (1997) reported that children under age 3 failed to use word order to comprehend who acted on whom in sentences containing novel verbs, thus showing no evidence of a transitive word-order rule. However, this experiment assessed comprehension using an act-out task ("Make Mickey dack Ernie!"). Such tasks are difficult and may underestimate young children's knowledge (e.g., Golinkoff, Hirsh-Pasek, Cauley, & Gordon, 1987).

Findings from experiments on novel-verb production have also been taken as evidence for lexical accounts: Young children are conservative in language production, tending to use each verb in the structures in which they have heard it used. For example, if an experimenter models a new verb in a transitive sentence ("Ernie is tamming Bert!"—describing an event in which Ernie acts on Bert), 2-year-olds readily produce new transitive uses of the verb. However, if the experimenter models the verb in a different structure (e.g., "Bert is tamming!"—describing the same event), children younger than 3 rarely use the new verb transitively (e.g., Tomasello & Brooks, 1998). Early conservatism in verb use has been documented in spontaneous and elicited speech (Bowerman, 1978; Maratsos, Gudeman, Gerard-Ngo, & DeHart, 1987; Pinker, Lebeaux, & Frost, 1987) and has been taken to suggest that children under about age 3 represent linguistic knowledge in concrete lexical terms (Lieven et al., 1997; Tomasello, 2000).

Innovative uses of verbs in new structures provide compelling evidence that children possess an abstract representation of those structures. However, such extensions also require the inference that a verb can occur in a new sentence structure (Fisher, 2002; Pinker, 1989). Verbs are choosy about the sentence structures they can occur in: Some verbs can be both intransitive and transitive (e.g., *The ball rolled* and *He rolled the ball*), whereas others cannot (e.g., *The ball fell* but **He fell the ball*). A child who encounters a new verb in one structure should not assume that it can be extended to another; thus, conservatism in verb use need not indicate the absence of abstract structural knowledge.

Because of the difficulties in interpreting negative results in both the act-out comprehension task and the extension task, we adopted a different tactic. We used a looking-preference comprehension task, relying on the well-established tendency of children and adults to look at scenes related to sentences they hear (e.g., Tanenhaus, Spivey, Eberhard, & Sedivy, 1995). If 2-year-olds represent language experience entirely in verb-specific terms, they should have no idea how to interpret word order relative to a novel verb. In contrast, if 2-year-olds represent language experience in suitably abstract terms, and have already learned where agents and patients belong in sentences, they should readily apply this knowledge to sentences containing novel verbs.

EXPERIMENT 1

Two-year-olds watched side-by-side videos showing two novel caused-motion events (Fig. 1). In one, a duck acted on a bunny;

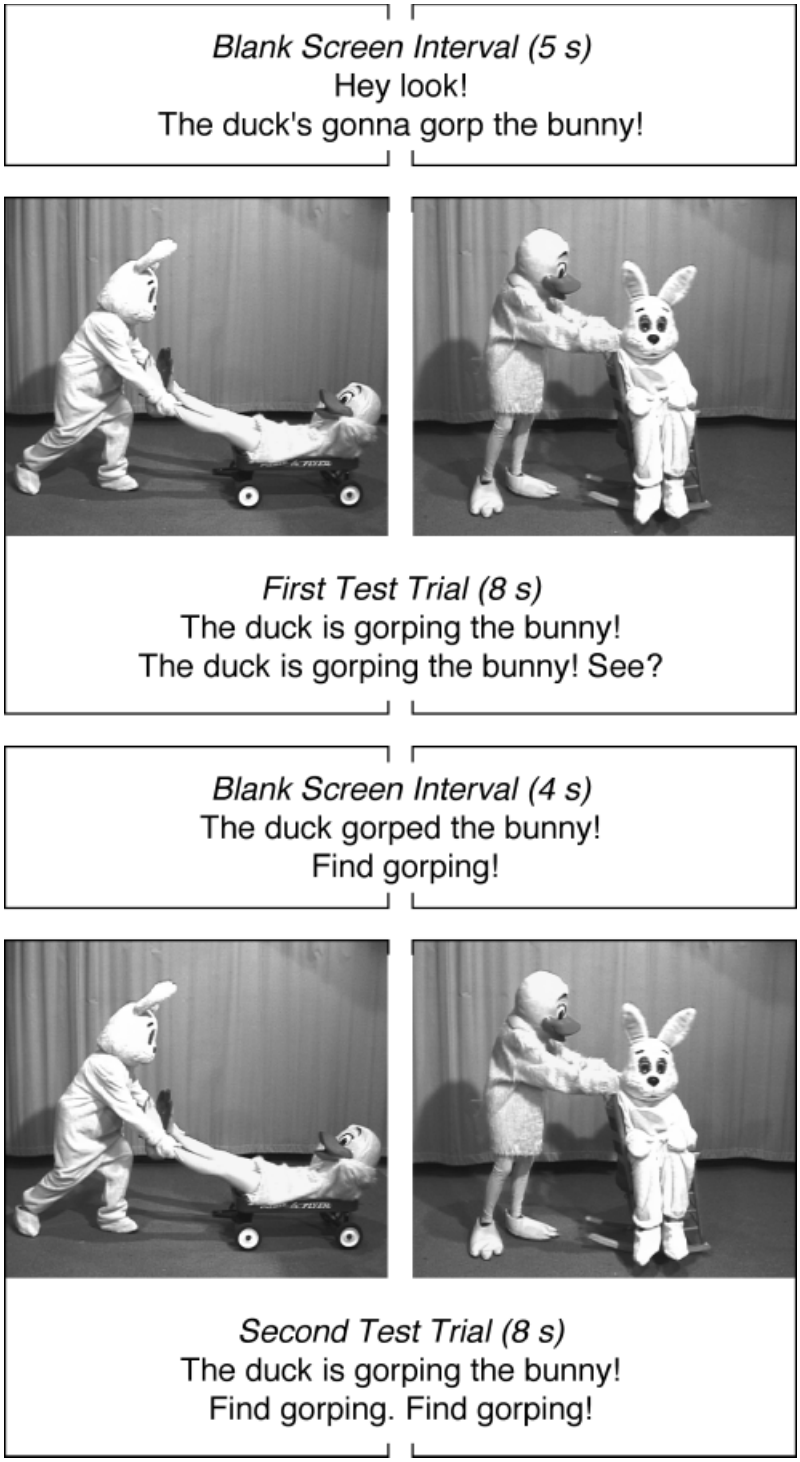

Fig. 1. Sequence of events in the novel-verb test phase of Experiment 1. The test phase was preceded by a character-identification phase and by two familiar-verb practice items with the same structure shown here for the novel-verb test phase. Half the children heard the sentences shown here, and half heard sentences with the opposite assignment of characters to roles.

in the other, the bunny performed a different action on the duck. This event pair was accompanied by a transitive sentence with a novel verb. For half the children, the duck was the subject of the test sentence ("The duck is gorping the bunny!"); for the other half, the bunny was the subject ("The bunny is gorping the duck!"). We predicted that if the children had detected the abstract word-order pattern of English transitive sentences, then they would look longer at the event that matched the sentence—

the one in which the agent of the action was the subject of the sentence.

Method

Participants

Twenty-four 2-year-olds (M = 25.45 months, range: 24.28–27.17; 11 girls) who were native learners of English participated. Another child was eliminated because of a side bias. The children's productive vocabularies, measured using the short form of the MacArthur Communicative Development Inventory (Fenson et al., 2000), ranged from 27 to 99 (Mdn = 55).

Apparatus

Children sat on a parent's lap facing two 20-in. monitors 30 in. away. The screens were at eye level, 12 in. apart. Sound tracks were presented centrally; a hidden camera recorded the children's eye movements. Parents wore opaque glasses.

Materials

The children watched a synchronized pair of videos depicting people costumed as a duck and bunny. The sound track was recorded by a female native English speaker.

Procedure

The videos were presented in three phases: character identification, practice, and test. In the first trial of the character-identification phase, the duck appeared on one screen, waving, and was labeled three times ("There's a duck!"), while the other screen remained blank (4 s). After a 2-s interval, the bunny was introduced in the same manner on the other screen ("There's a bunny!"). In the next two trials, the duck and bunny appeared simultaneously, and the sound track instructed the child to look at the bunny ("Find the bunny!") or the duck ("Find the duck!").

In the practice phase, two familiar transitive verbs were presented, accompanied by familiar events. Each practice verb was heard five times in transitive sentences before and during two presentations of a pair of 8-s videos. One practice sentence was presented during a 5-s blank-screen interval ("The bunny's gonna hug the duck!"). The videos then appeared while the stimulus sentence, with tense changed appropriately, played twice more ("The bunny's hugging the duck"); in one video, the bunny hugged the duck; in the other, the bunny washed the duck. The sentence, again with tense varying appropriately, played once more during a 4-s blank-screen interval ("The bunny hugged the duck!"), then again during a second presentation of the videos ("The bunny's hugging the duck! Find hugging!"). This procedure was repeated with a second practice verb ("The duck's gonna feed the bunny!"); in this case, one video showed the duck feeding the bunny, and the other showed the duck tickling the bunny. Practice events were paired so that the same character was the agent of action on both screens; thus, the children had to use knowledge of the verb to identify the matching screen in the practice trials.

The character-identification and practice phases were designed to familiarize the children with the characters and wording of the test trials, and to teach them that one of the two screens matched the sound track on each trial. *Duck*, *bunny*, *hug*, and *feed* were selected to be used in the experiment because these words are likely to be familiar to 2-year-olds (Dale & Fenson, 1996).

In the test phase, the children saw a pair of caused-motion events (Fig. 1). In one, the bunny wheeled the duck back and forth in a wagon; in the other, the duck tipped the bunny in a rocking chair. The timing of the videos and sentences was as described for the practice phase; thus, the children saw the 8-s event pair twice and heard the test sentence five times. Half of the children heard, "The bunny is gorping the duck," and half heard, "The duck is gorping the bunny." Sentence subject was counterbalanced with match side (left vs. right).

Coding

We coded the children's visual fixations to each screen during the two 8-s test trials, frame by frame from silent video. A second coder judged visual fixations for 5 children; the coders agreed on 94% of video frames. We calculated the proportion of time spent looking at the screen matching the audio, out of total looking time to the two screens, for each trial. An individual trial was treated as missing if the child looked away for more than half of the trial.

Preliminary analyses of novel-verb test performance revealed no significant effects of sex, stimulus sentence, or whether the match proportion in the character-identification or practice trials was above or below the median. The data were collapsed across these factors in subsequent analyses.

Results and Discussion

The children looked longer than expected by chance at the matching video, the one in which the agent of the novel action was the subject of the sentence they heard, with match proportions averaged across the two test trials (mean proportion = .56, SEM = .03), $t(23) = 2.37$, $p_{rep} = .95$, $d = 0.48$. This preference suggests that the children used knowledge of English word order to infer that, whatever *gorping* meant, it involved the actions of the subject referent on the object referent, rather than the reverse.

To investigate how quickly the children used word order, we divided the first test trial into four 2-s segments. The children heard the test sentence once before the trial began, and heard the subject and verb of a second rendition of the sentence during the first 2 s of the trial. Table 1 shows the mean proportion of looking time to the matching screen in each 2-s segment of the first test trial. The children showed a strong preference for the matching screen during the first 2-s segment. A planned,

TABLE 1

Mean Proportion of Looking Time to the Matching Screen Within the Four 2-s Intervals of the First Test Trial in Experiments 1 Through 4

Experiment	Interval			
	0–2 s	2–4 s	4–6 s	6–8 s
Experiment 1: 25-month-olds (e.g., "The bunny is gorping the duck!")	.67 (.08)	.61 (.09)	.57 (.09)	.58 (.09)
Experiment 2: 25-month-olds (e.g., "He is gorping the duck!")	.66 (.09)	.63 (.09)	.48 (.10)	.51 (.09)
Experiment 3: 21-month-olds (e.g., "The girl is gorping the boy!")	.74 (.10)	.73 (.10)	.68 (.11)	.59 (.12)
Experiment 4: 21-month-olds (e.g., "Who's gorping the boy?")	.71 (.11)	.66 (.12)	.72 (.11)	.72 (.10)

Note. Standard errors of the mean are shown in parentheses.

directional t test revealed that children's match preference during the first 2 s of the first trial was greater than expected by chance, $t(23) = 2.07$, $p_{rep} = .92$, $d = 0.42$. Thus, 2-year-olds made rapid use of word order: The match preference emerged after they had heard the entire test sentence once, as they began watching the novel events.

EXPERIMENT 2

Do 2-year-olds know not only that the subject of a transitive verb names the agent, but also that the object names the patient? Or might they simply expect the first noun they hear to name an agent? Another group of 2-year-olds watched the videos created for Experiment 1, but heard sentences in which the subject was a pronoun ("He is gorping the bunny" or "He is gorping the duck"). We predicted that if the children had already abstracted a word-order rule for English transitive sentences, they would look longer at the event that matched the sentence—the one in which the patient was the direct object of the sentence.

Method

Twenty-four 2-year-olds (mean = 25.29 months, range: 23.69–26.94; 12 girls) participated. Another 5 children were eliminated because of side bias (3) or fussiness (2). The median productive vocabulary score was 62 (range: 4–91).

Experiment 2 was identical to Experiment 1, with two exceptions: First, all sentences in the practice and test trials had pronoun subjects (*He* or *Who*). Second, we counterbalanced the order of practice sentences with test-sentence condition. This ensured that any tendency to interpret the pronoun in the test sentence as coreferential with the subject of the preceding practice sentence would not interfere with our test of word-order comprehension.

Coding reliability was assessed as in Experiment 1; the coders agreed on 98% of video frames. Preliminary analyses of novel-verb test performance revealed no significant effects of sex, stimulus sentence, or whether the match proportion in the character-identification or practice trials was above or below the median. The data were collapsed across these factors in subsequent analyses.

Results and Discussion

The children looked longer than expected by chance at the video in which the patient was the direct object of the test sentence, with match proportions averaged across the two test trials (mean proportion = .56, *SEM* = .02), $t(23) = 2.61$, $p_{rep} = .96$, $d = 0.53$. As Table 1 shows, children again showed a robust preference for the matching event during the first 2 s of the first test trial, $t(23) = 1.88$, $p_{rep} = .90$, $d = 0.38$.

Thus, 2-year-olds used word order to comprehend transitive sentences with novel verbs, even when the only full noun phrase was the object: They inferred that the novel word *gorp* had to refer to an event in which the direct-object referent played a patient's role. Given that the children heard only one character named explicitly in the test sentences of Experiment 2, it could not be that they simply interpreted the first character name they heard as referring to the more causally potent participant in the event. Had they done so, they would have tended to look longer at the wrong event, the one in which the object referent (the only character named in the sentence) was the agent, than at the matching event.

EXPERIMENT 3

In Experiment 3, we asked whether younger children, 21-month-olds, use word order to understand transitive sentences containing novel verbs. Children of this age are typically just beginning to combine words and have small vocabularies in which verbs are underrepresented (e.g., Caselli, Casadio, & Bates, 1999). A vocabulary containing few verbs provides little basis for abstraction; a lexical account would strongly predict that children this age would fail our comprehension task.

Method

Sixteen 21-month-olds (mean = 21.29 months, range: 20.11–22.05; 8 girls) participated. Another 3 children were eliminated because of inattentiveness (2) or side bias (1). The median productive vocabulary score was 34 (range: 12–86).

Experiment 3 was similar to Experiment 1, with several changes. First, the characters in the videos were people in ordinary clothing, referred to as a boy and a girl. Second, the test trials involved different events. In one video, the girl bent the

boy forward and back by pushing and pulling on his shoulder; in the other, the boy rotated the girl on a chair by pulling on a band around her waist. Third, children saw a preview of each practice and test event before the 8-s videos began: A 5-s clip of one event appeared on one screen; following a 2-s blank-screen interval, a 5-s clip of the other event appeared on the other screen. Previews were accompanied by neutral language ("Watch!"). We also increased the blank-screen interval between the two presentations of each 8-s event pair from 4 s to 5 s. Finally, the left/right position of the agent in the test events was varied (using a "flip" operation in the video-editing software) and counterbalanced with test-sentence condition and match side.

Coding reliability was assessed as before; the coders agreed on 97% of video frames. Preliminary analyses of novel-verb test performance revealed no significant effects of sex, stimulus sentence, whether the match proportion in the character-identification or practice trials was above or below the median, or whether the agent was on the left or right. The data were collapsed across these factors in subsequent analyses.

Results and Discussion

The children looked reliably longer than expected by chance at the video in which the agent was the subject of the test sentence, with match proportions averaged across the two test trials (mean proportion = .70, *SEM* = .05), $t(15) = 3.99$, $p_{rep} = .99$, $d = 1.00$. We again found a robust preference for the matching event during the first 2-s segment of the first test trial (Table 1), $t(14)$[1] $= 2.54$, $p_{rep} = .95$, $d = 0.66$. Thus, 21-month-olds used word order to comprehend transitive sentences with novel verbs. This effect emerged rapidly, as they watched the two events together for the first time.

EXPERIMENT 4

Do 21-month-olds know not only that the subject of a transitive verb names the agent, but also that the object names the patient? Another group of children saw the videos created for Experiment 3, but heard sentences with pronoun subjects ("Who's gorping the boy?" or "Who's gorping the girl?").

Method

Sixteen 21-month-olds (mean = 20.68 months, range: 20.01–22.24; 7 girls) participated. Another 8 children were eliminated because of fussiness (4), inattentiveness (2), or side bias (2). The median productive vocabulary score was 29 (range: 4–53).

Experiment 4 was similar to Experiment 3 except for the critical change in the test trials' sound track. We also introduced the *who* wording in the practice trials: Children heard each practice sentence four times with two full noun phrases and once with a pronoun subject. The blank-screen intervals in the practice and test phases were increased from 5 s to 6 s.

Coding reliability was assessed as before; the coders agreed on 99% of video frames. Preliminary analyses of novel-verb test performance revealed no significant effects of sex, stimulus sentence, whether the match proportion in the character-identification or practice trials was above or below the median, or whether the agent was on the left or right. The data were collapsed across these factors in subsequent analyses.

Results and Discussion

The children looked longer than expected by chance at the video in which the patient was the direct object of the test sentence, with match proportions averaged across the two test trials (mean proportion = .64, *SEM* = .06), $t(15) = 2.18$, $p_{rep} = .92$, $d = 0.54$. Children showed a preference for the matching event in the first 2 s of the first test trial (Table 1), $t(15) = 2.01$, $p_{rep} = .91$, $d = 0.50$. Thus, 21-month-olds knew that the direct object named a participant undergoing an action rather than causing one.

GENERAL DISCUSSION

In four experiments, young children (25- and 21-month-olds) used word order to interpret transitive sentences containing novel verbs: They looked longer at a scene in which the character named in subject position was the agent rather than the patient, or the character named in object position was the patient rather than the agent. The time course of the word-order effect suggests that the children found it easy to use word order in this way. In all cases, the preference for the matching video appeared as soon as the children had heard the entire test sentence once, and as they watched the events together for the first time.

This pattern was predicted by the early-abstraction account, but directly contradicts the main empirical claim of the lexical account. Even before children reach their second birthday, their representations of sentence meaning and form are not strictly tied to particular words. To detect the English transitive word-order pattern in the input and apply it to sentences with novel verbs, the children must have represented their linguistic experience in terms abstract enough to isolate the similarity in the participant roles of diverse events and in the sentence formats of different transitive verbs (see Fernandes, Marcus, DiNubila, & Vouloumanos, 2005, for converging results with 2.5-year-olds).

In principle, a lexical account could handle our data by proposing that enough verb-specific learning has taken place by 21 months to permit the abstraction of a transitive word-order rule from verb-specific representations. We consider this unlikely, in part because of the tiny verb vocabularies of 21-month-olds (e.g., Caselli et al., 1999). Moreover, the children's success in the present experiments did not depend on their vocabulary: Children above versus below the median vocabulary within each

[1]One child looked away for the entire 2-s interval.

experiment did not differ in their preference for the matching video (ts < 1.5), and in no case was there a significant correlation between vocabulary score and the proportion of time spent looking at the matching event (rs $= -.32$ to $.14$).

The present findings are consistent with evidence that young children use early-developing syntactic knowledge to learn the meanings of verbs, a procedure known as syntactic bootstrapping (Gleitman, 1990). Children as young as 2 assign different interpretations to novel verbs presented in transitive and intransitive structures (Fisher, 2002; Naigles, 1990). This ability requires representations of these structures that are abstract enough to be applied to new verbs, but it does not require that these representations incorporate knowledge of English word order. Our findings add to this literature by providing the first evidence that children younger than 2 can use syntactic cues to interpret sentences containing novel verbs, and, most important, that their representations of transitive sentences include language-specific information about the significance of word order.

Where do these abstract semantic and structural representations come from? Infants readily detect distributional patterns in linguistic experience (Gómez & Gerken, 1999; Marcus, Vijayan, Bandi Rao, & Vishton, 1999; Mintz, 2006). Such findings suggest that toddlers are well equipped to identify the abstract sequential patterns identifying transitive sentences—that certain verbs are reliably followed by nouns, for example. Moreover, there is compelling evidence that conceptual-semantic abstractions such as *agent* and *patient* appear in infancy (Golinkoff & Kerr, 1978; Luo & Baillargeon, 2005; Mandler, 2004), and in the absence of linguistic exposure: Deaf children not exposed to a conventional language invent gestural communication systems that share core properties of conventional languages, including formal devices for marking agent and patient roles (Goldin-Meadow, 2003). Evidently, children need not learn from exposure to an established language to detect the similarity between the agents and patients of *kissing* and *kicking*, or to link these abstract categories with fundamental aspects of sentence structure. Armed with these predispositions to link semantic and structural abstractions, children who are exposed to a conventional language easily learn how their language marks who does what to whom.

Although 25- and 21-month-olds have much to learn about their native languages, the present findings establish that they are constrained to represent language experience in an abstract mental vocabulary. These representations allow children to rapidly detect general patterns in their native-language grammar—and thus to learn rules as well as words from the start.

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