Linguistic and Conceptual Constraints on Verb Learning

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Abstract

We investigated the mapping between linguistic and conceptual event representations and the implications for the acquisition of verbs labeling causative events. Experiments 1 and 2 demonstrate that 2-year-old children have access to complex causative representations and that they can use syntactic subcategorization information to identify and label event subparts. Infants mapped novel unaccusative verbs onto Result subevents, novel unergative verbs onto Means subevents, and novel transitive verbs onto complete causative events. Experiments 3 and 4 reveal that when structural constraints are satisfied, 2-year-olds can be flexible in the specificity of the semantic content they assign to a causative representation. We discuss the implications of these findings for word-learning strategies and the nature of early verb representations.
Linguistic and Conceptual Constraints on Verb Learning

To learn the meaning of a word, a language learner must map a linguistic unit onto a representation of the world provided by her conceptual system. We can view the process of determining which conceptual bits are associated with which bits of language as a two-part process including (1) the generation of a set of hypotheses about the mapping between form and meaning and (2) a gradual rejection of the hypotheses that are incompatible with new information. A classic puzzle in the study of language acquisition concerns what constraints determine the set of hypotheses that a learner generates for the meaning of a novel word and what kinds of information help her to narrow down that set. It is certainly the case that a learner’s own experience, e.g., with the world or with the language she is learning, can help her to distinguish between probable and improbable hypotheses about word meaning. Infants are not blank slates, however, and they may come pre-equipped with default assumptions about language and the world that guide word learning. The goal of the studies reported here was to investigate the nature of some of these constraints and how they make themselves evident in children learning the meanings of verbs labeling causative events.

It is well-documented that children learn labels for events, i.e., verbs, later than they learn labels for objects, i.e., nouns. Traditionally, it was assumed that children learned what words meant by pairing word-sized units that they had managed to pull out of the speech (or gesture) stream with objects and events that they observed in the extralinguistic context—mapping words onto things in the world (Locke 1690/1964). On this account, the delay in verb acquisition has been attributed to differences in the complexity of the concepts labeled by the two grammatical
classes. Nouns, because they typically describe objects in the world that are concrete and observable, are taken to be simpler and therefore easier to learn, whereas verbs, which label relations between objects rather than objects themselves, are more difficult to acquire (e.g., Gentner 1982, Gentner & Boroditsky 2001).

There are two kinds of problems with this account of word learning, however. First, the concepts denoted by nouns are not really concrete: although the referent of a noun phrase might be a concrete object, the meaning of the noun itself is still an abstract category (Waxman & Markow 1995). Second, and more germane to the current paper, there is rarely a clear one-to-one mapping between the linguistic signal and the extralinguistic context (Gillette et al. 1999, Gleitman 1990). The action going on in the world is complex and continuous. Even in a single spatially and temporally bounded unit of the world, there are often many events going on at once, overlapping with each other in time, space, and participants. It is unclear in this sort of situation how a language learner would be able to pick out exactly which single event (or set of related events) to associate with a novel verb on the basis of nothing more than a single-word label. What language learners need in this kind of situation is some additional source of information to constrain their hypotheses about what novel verbs can mean. Such an information source would highlight the event features that they should be attending to in the world that link up to the words and sentences they are hearing used to describe that world.

**Event Representations**

Since concepts are so closely tied to the meanings of words, we might expect that verb learners are guided by conceptual constraints on event representations. According to this theory, the hypotheses that language learners make about the mapping between words and the world
would be limited by the way that we organize disordered happenings in the world as coherent, temporally bounded events, and by the way that those events are related to each other in conceptual hierarchies.

There is a growing body of research demonstrating that, from infancy, we encode the ongoing activity of the world as events with internal structure. The set of multiple events that correspond to one temporally bounded happening are hierarchically related, with complex events comprised of many (potentially complex) subevents. These complex structures affect our on-line perception of events and have implications for higher-level cognitive processes, including the comprehension and recall of events and event narratives and the association of event representations with linguistic forms (Zacks & Tversky 2001). And indeed, infants are sensitive to just those features of events that are relevant for semantic representation, including the number of relevant participants in an event (Gordon 2004), their path and manner of motion (Lakusta & Landau 2005, Pruden & Hirsh-Pasek 2006, Pulverman & Golinkoff 2004), and the causal relations between them (Leslie 1982, Leslie & Keeble 1987).

In the current paper, we examine causative events, which can be characterized conceptually as complex events in which one entity, the agent, performs some action that gives rise to a change of state (e.g., motion or location) in another entity, the patient (e.g., Kim 1971/1993, Mackie 1965/1993, Pietroski 2000, Thomson 1977). Imagine, for example, an event in which a girl makes a ball bounce up and down by hitting it repeatedly with her hand—she dribbles the ball. Previous work on the conceptual (e.g., Leslie 1984a, Leslie & Keeble 1987, Michotte 1946/1963, Wolff 2003) and linguistic (e.g., Carter 1976, Dowty 1979, Jackendoff 1990, Levin & Rappaport Hovav 1995, Talmy 1985) representation of events has shown that we
represent causative events as consisting of three distinct subparts, which we will refer to as the Means, the Cause, and the Result.

(1) causative event

X acts Cause Y becomes state

The subevent *X acts* in (1) specifies the Means or causing subevent—the action of agent X, and the subevent *Y becomes state* specifies the Result subevent—the change of state in entity Y. In the case of our dribbling girl, the means action is the girl’s hitting of the ball, and the result is the ball’s bouncing. The intervening subpart Cause represents the nature of the relation that links the other two subevents to each other: i.e., that agent X’s activity is responsible for inducing the change of state in entity Y. In the case of the dribbling girl, this represents our understanding that the girl’s hitting of the ball directly results in the ball’s change of state. For the event under consideration, then, the schematic diagram in (1) may be rewritten as in (2a) or equivalently as in (2b):

(2) a. [[[girl hits ball] CAUSE [ball bounces]]

   b. CAUSE(girl hits ball),(ball bounces)

   Early studies in the perception of simple mechanical causality have led many researchers to the hypothesis that our representation of this kind of event is rooted in the perceptual system (Michotte 1946/1963, see Blakemore et al. 2001 for evidence from neuroimaging). Indeed, there is a growing body of literature demonstrating that at as young as 2.5 months of age, children are
sensitive to various components of causality, including spatiotemporal continuity of motion and contact between event participants (Leslie 1982, 1984b; Leslie & Keeble 1987; Spelke et al. 1992). Our own work has shown, moreover, that by 2 years of age, children have access to the same kinds of complex representations for causative events that adults do (Bunger & Lidz 2004).

**Linguistic Representations**

It is widely accepted that the meanings that we assign to expressions in any given language are linked inextricably with our conceptual representations (Carter 1976, Jackendoff 1990, Levin & Rappaport Hovav 1995, Talmy 1985). Numerous researchers have uncovered regular mappings between event representations and aspects of sentence structure (Baker 1988, 1997; Carter 1976; Gruber 1965; Jackendoff 1972, 1983, 1990; Levin 1993; Pinker 1989), and have revealed that languages reflect the complex internal structure of the causative in the grammar.

One example of the fixed relation between a verb’s meaning and its syntactic behavior can be seen in the set of verbs that can participate in the so-called Causative/Inchoative alternation (Hall 1965, Levin 1993, etc.), illustrated in (3). Note that the verb *bounce* can be used both in a transitive frame, as in (3a), and in an unaccusative intransitive frame, as in (3b), in which the object of the transitive sentence appears as the subject of the intransitive. In this alternation, the object of the transitive verb and the subject of the intransitive verb share the same semantic role: in both cases it is the ball that is affected in the event—it bounces—and in (3a) it is the girl who somehow causes that bouncing.

(3)  

a. The girl is bouncing the ball.  

b. The ball is bouncing.
Verbs that can participate in this alternation share certain elements of meaning. First, these verbs must describe events that are internally complex: here, the girl performs some action, and this action causes a change of state in the ball. Crucially, furthermore, verbs that can occur in this alternation must label the object’s change of state. Other verbs that can participate in this alternation include *spin* and *roll*.

The verb *hit*, however, cannot participate in this alternation:

(4)  
   a. The boy hit the ball.  
   b. * The ball hit.

Although *hit* can be used in a transitive sentence, as in (4a), the corresponding unaccusative intransitive sentence is ungrammatical (4b). Note that an event of hitting does not entail that the thing hit undergoes a change of state: this is why we can make observations like that in (5):

(5) Jon hit the tree trunk, but it wasn’t affected.

Thus, the ungrammaticality of (4b) is due to the fact that the verb *hit* labels only an activity and not the result of that activity.

When we encounter an event in the world like a causative that corresponds to a complex conceptual structure, we need not specify all of the (sub)parts of that event in our descriptions of it. Indeed, one kind of linguistic support for the internal complexity of the causative comes from the fact that we can use single verbs to refer to the different specific subparts of a causative event
as well as to various combinations of the subparts, as in (6). Consider again the event in which the girl makes the ball bounce by hitting it. The verb *hit* used in a transitive frame labels only the Means subevent of this causative event (6a), and the verb *bounce* used in an unaccusative intransitive frame labels only the Result subevent (6b). However, the verb *dribble* used in a transitive frame encodes the entire causative event, both the Result and the idea that that result has been caused by the girl hitting the ball in a characteristic way (6c).

(6)  
   a. The girl hit the ball. Means  
   b. The ball bounced. Result  
   c. The girl dribbled the ball. Causative event

It is not the case, however, that any spatiotemporally related happenings in the world may be lexicalized as a single verb. Constraints on lexicalizations seem to arise both from the way that events may be related in hierarchical structures and from the way that those event structures may be mapped onto language. Cross-linguistically, verbs labeling causative events never encode some specific Means that leads to an unspecified Result. Likewise, verbs never encode subparts of the causative that are not constituents in a conceptual event representation (e.g., Rappaport Hovav & Levin 1998). So, verbs can label any of the individual subevents of the causative, or the entire event; but, no verb encodes, for example, a Means subevent and a Result subevent that are not causally related.

Cross-linguistically, then, adult speakers exhibit systematic gaps in the way that they can associate verb labels with events. These gaps correspond directly with constraints on linguistic and conceptual event representations. The question remains, however, whether children and
adults are subject to the same sets of constraints. For example, a given lexical gap could arise independently in each speaker and/or language as the result of some lexicalization bias that is learned on the basis of language-specific distributional information. Alternatively, such a gap could derive from inherent structural constraints on lexicalized meaning. In other words, do we have to learn not to postulate a noncausative verb that encodes [Means + Result] or a causative verb that encodes [Means + Cause] to the exclusion of a specified Result as possible meanings for new verbs, or do these constraints come for free as part of the architecture of the language acquisition device?

Traditionally, questions about the principles restricting lexicalization have been investigated through cross-linguistic lexicalization patterns (e.g., Embick 2004, Hale & Keyser 1993, Harley 1996, Haspelmath 1993, Jackendoff 1990, Kratzer 1996, Levin & Rappaport Hovav 1995, Lidz 1998, Marantz 1997, Rappaport Hovav & Levin 1998, Talmy 1985) or, more recently, through psycholinguistic experiments on the mapping between conceptual structures and language in adults (e.g., Lakusta & Landau 2005, Wolff 2003). Another way of approaching this issue, however, would be to ask whether children’s acquisition of novel verbs is guided by the same principles that restrict adult lexicalization. To the extent that it is, we are led to the conclusion that these principles derive from properties inherent in the learner.

**Verb Learning**

Given that there exist reliable mappings between verb meaning and verb syntax, it seems logical to postulate that a language learner would be able to use these kinds of regularities to break into the linguistic system (Landau & Gleitman 1985). In principle, the facilitation provided by this kind of mapping could work in both directions: if a language learner knows the meaning
of a verb, she should be able to use that information to infer something about the syntax of constructions in which it may occur; and on the flip side, if she knows something about the syntactic frame in which a novel verb occurs, she should be able to use that information to infer something about the verb’s meaning. And in fact, there exists an ever-growing body of experimental literature demonstrating that both adults and children make use of just this kind of mapping as a tool to aid verb learning. Experimental studies carried out by proponents of the so-called Semantic Bootstrapping Hypothesis (Pinker 1984, 1989) have demonstrated that knowledge of a verb’s meaning (i.e., of the conceptual primitives encoded by a given verb that are relevant to linguistic machinery) informs hypotheses about how that verb may be extended to new syntactic frames (e.g., Brandone et al. 2006, Gropen et al. 1991; cp. Snedeker 2000). And there is complementary evidence from the literature on the so-called Syntactic Bootstrapping Hypothesis (Landau & Gleitman 1985) that children as young as 14 months of age can use cues from the syntactic structures in which they encounter novel verbs to constrain their hypotheses about what those verbs mean (Bunger & Lidz 2004, 2006; Fisher et al. 1994; Gillette et al. 1999; Gleitman 1990; Lidz 2006; Lidz et al. 2003; Naigles 1990, inter alia).

Studies (cited in Gleitman 1990 and Hirsh-Pasek & Golinkoff 1996) have shown that even children in the one-word stage of language production possess knowledge of the ways that entities in a sentence map onto semantic arguments. Hirsh-Pasek et al. (1985) argue, for example, that the fact that children can distinguish between the event descriptions “Big Bird is tickling Cookie Monster” and “Cookie Monster is tickling Big Bird” provides evidence that children recognize not only the order of phrases or entities in a given sentence, but also the semantic significance of this ordering. Studies carried out by Naigles and associates on the acquisition of verbs denoting contact and/or causation (Naigles 1990, 1996; Naigles & Kako
1993) have demonstrated, moreover, that the use of syntax in verb learning begins very early: by the age of 24 months at least, children use information from the syntactic frame in which a novel verb is presented to determine which of two simultaneous events that verb labels (cf. Fisher 1996, 2002).

Such data, then, provide support for Landau & Gleitman's (1985) proposal that children, like adults, are influenced by their knowledge of syntax when postulating interpretations for a novel verb. Very little work, however, has examined the precise nature of the meanings that children assign to verbs when they learn them in this way. It is well established, for example, that children as young as 14 months of age can associate novel verbs with causative events (e.g., Behrend 1990; Casasola & Cohen 2000; Fisher 1996, 2002; Gentner 1978; Naigles 1990; Wolff 2003). What has yet to be satisfactorily determined is exactly what children think these verbs mean. How flexible are the linguistic representations infants associate with novel verbs? How do children’s linguistic representations map onto event representations?

Our goal, then, was to use children’s sensitivity to the systematic relations between argument structure and event representations to investigate the meanings that they assign to novel verbs associated with causative events (Bunger & Lidz 2004). In addition, we wanted to test the robustness of syntax as an information source by investigating its utility in helping children to identify and label the subparts of internally complex events. Given the evidence that children can use cues from syntax to figure out the meanings of novel verbs, we might wonder whether they are limited to using this ability to distinguish between distinct but simultaneous events (as in Naigles 1990), or whether they can also use it to parse and label single events that are internally complex.
The set of studies reported here investigate the range of meanings that learners encode in single causative verbs and how those options are guided by the mapping between conceptual and linguistic event representations. To accomplish this, we asked three specific questions: (1) Which combinations of the subparts of a causative event can learners encode in a single verb? (2) How specific are the event features encoded in novel verb meanings? (3) How do learners deal with conflicts between hypothesized verb meanings and new information from the extralinguistic context? Our results demonstrate that the meanings that 2-year-old word learners postulate for novel verbs are influenced both by cues to meaning provided by verb syntax and by more general constraints on the way that verb meanings can be related to event representations.

The period of development around 2 years of age, which corresponds approximately to the two-word stage of production, is crucial for studies of language acquisition because the child still has many words to learn and yet is just beginning to use syntax in her own production. Logically, then, it is at this time that a mechanism like syntactic bootstrapping would be most useful for the child, and, interestingly, it is exactly during this stage that the child experiences a rapid increase in the acquisition of new vocabulary, and especially of verbs. We chose to investigate causative events not only because different combinations of the subparts of a causative can be lexicalized in a single verb, but also because there are syntactic frames and frame alternations that provide robust linguistic cues to the event subparts encoded by verbs labeling causative events. Previous studies have demonstrated that children of this age have access to the same complex representations for causative events that adults do (e.g., Bunger & Lidz 2004; Leslie 1982, 1984b). We might ask, then, whether children’s lexicalizations are subject to the same constraints as are evident in adult languages. Phrasing the issue in terms of acquisition allows us to investigate the roots of constraints on possible verb meanings.
Encoding Subevents

The experiments described in this section investigate the range of meanings that 2-year-old children encode as single verbs labeling complex causative events, and what conceptual and linguistic constraints guide their hypotheses about those meanings. Specifically, we wanted to confirm that, given the proper combination of linguistic and extralinguistic circumstances, children would be willing to encode just the Result subevent as the meaning of a novel verb labeling a complex causative. Complementarily, we wanted to confirm that, given a different combination of linguistic and extralinguistic circumstances, they would be willing to encode just the Means subevent as the meaning of a novel verb. Both of these meanings correspond to possible linguistic representations, and there are syntactic frames that regularly signal each of them: unaccusative and unergative intransitive frames, respectively. In order to present the proper contexts for inferring these meanings, we manipulated both the syntactic frames in which novel verbs were presented and the subparts of the familiarized causative event that were repeated in test events.

Experiment 1: Result

The goal of Experiment 1 was to determine whether 2-year-old children are willing to interpret a novel verb associated with a causative event as a label for just the result of that event. This experiment is, in part, an attempt to replicate the findings of Bunger & Lidz 2004. There, we demonstrated not only that 2-year-old children represent complex causative events as having internal structure, but also that when the linguistic input focused children's attention on the result of a given causative event, they interpreted a novel verb as describing that subevent.

Method
Participants. Twenty-four children ranging in age from 22;1 to 25;27 \(M = 23;29\) were included in the final sample for this study. Participants were recruited from the communities surrounding Evanston, IL and College Park, MD and were acquiring English as their native language (with \(\leq 10\%\) input in a language other than English). Caregivers completed the MacArthur Communicative Development Inventory: Words and Sentences questionnaire (MCDI), which is designed to provide a measure of productive vocabulary for children between the ages of 16 and 30 months (Fenson et al. 1993). Mean productive vocabulary for children in this study was 336 words (range 16–562, out of a possible 680). An additional 10 children were excluded due to age \((n = 2)\), caregiver-reported speech or hearing problems \((n = 1)\), inattention for more than 30\% of the test phase on more than two trials \((n = 2)\), and experimenter error or equipment malfunction \((n = 5)\).

Materials. This experiment employs the preferential-looking paradigm developed by Spelke (1979) and Golinkoff et al. (1987) to study intermodal perception in infants. In our version of this paradigm, participants are presented with two dynamic event scenes displayed simultaneously on opposite sides of the screen of a large video monitor accompanied by some speech stimulus.

Visual stimuli consisted of digital videos of events that involved live actors and familiar real-world objects. Events were videotaped against a neutral background. Auditory stimuli consisted of recordings of a female native speaker of American English producing sentences from a script using child-directed speech intonation. Digital speech recordings were made in a sound-attenuated booth and were live-monitored for gross misarticulation, hesitation, and inconsistency of speaking rate. These recordings were edited by hand for duration and timing and were then synchronized with the visual stimuli. Visual and auditory stimuli were digitized to
a single source to ensure consistent presentation of stimuli across participants and experimenters and were edited to create the sequence of events described in Table 1. Each participant was presented with four 55-s trials that followed this sequence.

Each trial consisted of two phases: familiarization and test. During the familiarization phase, participants saw a video of some causative event and heard it described by a sentence that included a novel verb (see (7) below). The causative events all involved human agents causing some observable, instrument-mediated change of state in an inanimate object. For example, in one causative event a boy causes a garden flower to spin by pumping a bicycle pump that is attached to the flower. A complete list of the causative events used as familiarization stimuli is given in Table 2. 

During the familiarization phase, a given causative event was shown four times (6 s each presentation, each separated by 1 s of black screen) and on both sides of the screen, first once on each of the left and right sides in sequence, and then twice on both sides simultaneously.

Each of the four causative events was paired with a different novel verb. The frames in which novel verbs were presented varied across subjects: participants in the Unaccusative condition were exposed to novel verbs presented in unaccusative syntactic frames (7a), and participants in the Transitive condition were exposed to novel verbs presented in transitive syntactic frames (7b).

(7)  
a. Look! The flower is blicking.  
Do you see the flower blicking?

b. Look! The boy is blicking the flower.  
Do you see the boy blicking the flower?
Table 1
*Schematic of Trial Design, Experiment 1, Unaccusative Condition*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time</th>
<th>Left side of screen</th>
<th>Right side of screen</th>
<th>Audio track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recentering</td>
<td>5 s</td>
<td>baby</td>
<td></td>
<td>giggle</td>
</tr>
<tr>
<td>Familiarization</td>
<td>6 s</td>
<td>boy makes a flower spin by pumping a bicycle pump</td>
<td>black screen</td>
<td>Look! The flower is blicking. Do you see the flower blicking?</td>
</tr>
<tr>
<td></td>
<td>6 s</td>
<td>Black screen</td>
<td>boy makes a flower spin by pumping a bicycle pump</td>
<td>Wow! The flower is blicking. Do you see the flower blicking?</td>
</tr>
<tr>
<td></td>
<td>6 s</td>
<td>boy makes a flower spin by pumping a bicycle pump</td>
<td>boy makes a flower spin by pumping a bicycle pump</td>
<td>Yay! The flower is blicking. Do you see the flower blicking?</td>
</tr>
<tr>
<td>Contrast</td>
<td>6 s</td>
<td>(centered) boy waves flower from side to side</td>
<td></td>
<td>Oh no! Now the flower is not blicking. The flower is not blicking.</td>
</tr>
<tr>
<td>Familiarization</td>
<td>6 s</td>
<td>boy makes a flower spin by pumping a bicycle pump</td>
<td>boy makes a flower spin by pumping a bicycle pump</td>
<td>Yay! Now the flower is blicking. Do you see the flower blicking?</td>
</tr>
<tr>
<td>Test</td>
<td>12 s</td>
<td>Same Result</td>
<td>Same Means</td>
<td>Oh look, they’re different. Do you see blicking? Do you see blicking? Where’s blicking now?</td>
</tr>
</tbody>
</table>
Incorporating an experimental modification introduced in the literature on noun and adjective acquisition (Booth, in press; Waxman & Booth 2001; Waxman & Klibanoff 2000), during the familiarization phase, we presented participants with a noncausative contrast event involving the same person and objects involved in the causative familiarization events. Between the third and fourth presentations of our causative familiarization events, participants saw a 6-s contrast event in which the agent of the causative event was engaged in a different (noncausative) activity involving the inanimate object (Table 2). Accompanying this contrast event, they heard an event description that repeated the novel verb presented during familiarization, but that made it clear that the referent of that verb was not depicted (e.g., “Oh no! Now the flower is not blicking.”). Previous studies of verb learning have suggested that in an experimental context, young children tend to include an event’s patient in the meaning of a novel verb labeling the action performed on it, such that they have trouble extending the novel verb to label the same action performed on a new object (e.g., Imai 2002; Imai et al. 2002, 2004, 2006). The goal of our contrast phase was, in part, to constrain the hypotheses postulated for our novel verbs by pointing out the event features that were not included in the meaning of the novel verb (viz., the entities involved in the event). In addition, the contrast phase helps the infant participants recognize that some events do not fall under the novel label, thus helping them overcome task demands. Novel verbs were presented a total of 10 times during each familiarization phase (Table 1).
Table 2

Familiarization and Contrast Events

<table>
<thead>
<tr>
<th>Novel verb</th>
<th>Causative event</th>
<th>Contrast event</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>pim</em></td>
<td>girl hits ball with tennis racquet, ball bounces</td>
<td>girl swings ball back and forth</td>
</tr>
<tr>
<td><em>lorp</em></td>
<td>boy hits ring tower with stick, tower rocks back and forth</td>
<td>boy turns tower over and over</td>
</tr>
<tr>
<td><em>blick</em></td>
<td>boy pumps bike pump attached to garden flower, flower spins</td>
<td>boy waves flower back and forth</td>
</tr>
<tr>
<td><em>grek</em></td>
<td>girl turns crank attached to light, light bulb turns on</td>
<td>girl puts light on her head</td>
</tr>
</tbody>
</table>

On each trial, the familiarization phase was immediately followed by a test phase in which participants saw two new events presented simultaneously on opposite sides of the screen and were directed by the auditory stimulus to find the action represented by the novel verb introduced during familiarization. Both test events involved the same event participants (agent, instrument, patient) presented during familiarization, but each depicted a different subevent of the familiarized causative event (Table 1). In one of the test events, the object underwent the same change of state that it had during familiarization, but without any assistance from the causative agent (Same Result test event). For the familiarization event involving the boy and the flower, e.g., in the Same Result test event the flower spins on its own while the boy stands idly by. The other test event depicted the agent of the causative event performing the same activity that he had during familiarization, but with that activity not causing a change of state in the familiarized object (Same Means test event). So, in the Same Means test event, the boy pumps
the bicycle pump, but the flower does not spin. The auditory stimulus accompanying these test
events directed participants to find the action represented by the novel verb introduced during
familiarization. Note that separating the Means and Result subevents presented during
familiarization across test events ensured that neither test event would be more familiar to
participants than the other. In addition, this separation has the effect of excluding causation as a
possible part of the extended meaning of the novel verb, making it possible to confirm that
participants are interpreting the novel verb as a label for the Result subevent, and not as a label
for Result and Causation together. Each pair of 6-s test events was presented twice, separated by
0.5 s of black screen, resulting in a 12-s test phase.

Participant attention was centered before each trial by the presentation of a 5-s
(re)centering stimulus (a picture of a baby accompanied by a giggle), and the side of the
projection screen on which the causative event was first presented during familiarization was
counterbalanced, as was the location (right vs. left side) of the new events shown during the test
phase.

Procedure. Children and caregivers were greeted and given a brief description of the
experimental procedure. While the child played freely in the laboratory play area, caregivers
signed a consent form and filled out language questionnaires, including the MCDI. When both
the child and the caregiver appeared to be at ease, the experimenter led them to the adjoining
testing room. Children were tested individually, seated in a booster chair facing and situated
approximately 6 ft in front of a 4.5 by 4.5 ft white projection screen. Caregivers either stood
behind the children or sat out of the child’s line of vision. To avoid fuss-out, four children were
seated on their caregiver’s lap. Caregivers were asked to refrain from talking or offering
nonverbal encouragement while in the testing room.
Visual stimuli were projected to a 3.9 by 2.6 ft area of the projection screen. Audio stimuli were presented at 65 dB, +/- 5 dB. Presentation of the stimuli and recording of participant responses were controlled by the experimenter from behind a black curtain that extended across the entire height and width of the room behind the projection screen, completely blocking the apparatus from view of the participants. Attention to the stimuli was recorded using a digital video camera situated just below the projection screen.

Data from MCDIs were tallied and taken as a measure of caregiver-reported productive vocabulary for each child. Videos of child participants were coded for direction of visual fixation (left vs. right vs. neither side of the screen) during each frame of the test phases (360 frames per trial, four trials per participant) by research assistants who were not aware of the predicted responses. To confirm accuracy, 23% of the videos were coded by a second research assistant (n = 27, reliability: Cohen’s kappa > .8, percent agreement > 88%). For cases in which we found disagreement between coders (n = 2), a third research assistant provided a tiebreaking code of the data. Data collected in this manner were used to determine overall patterns of looking during the test phase of each trial and mean duration of attention during windows of time linked to the test audio, as well as to monitor for excessive inattentiveness or biases in looking toward a single side of the projection screen. Trials in which participants attended to the test events for less than 70% of the test period were excluded from analysis. Participants with more than two excluded trials were replaced in the design, as were those who exhibited a fixation bias of more than 75% to a single side of the projection screen. Our analyses of looking time data have been based on the prediction that participants will look longer at test events that match their interpretation of the novel verb presented during familiarization than at those that do not.
Results and Discussion

The purpose of this experiment was to find out whether participants would be willing to extend the meaning of a novel verb associated with a complex causative event to refer to just the Result subevent of the causative. If participants assigned a meaning to novel verbs during the training phase, their choices of test event should reflect that interpretation. The relevant question to ask when examining these data, then, is which test event participants are willing to accept as an extension of the meaning of the novel verb presented during familiarization. Because the unaccusative intransitive frame unambiguously labels the result of a causative event, we predicted that participants in the Unaccusative condition of this study would be more likely than those in the Transitive condition to extend novel verbs to label the Same Result test events, in which the object underwent the same change of state that it did in the familiarized causative event.

The preferential looking task presupposes that children look longer at scenes that match what they hear. Here, then, we expected our 2-year-old participants to look longer at the test event that they were willing to label with the novel verb presented during familiarization. If children are able to use the syntactic frame as a cue to the meaning of the novel verb, we expect to find differences in patterns of looking across conditions that reflect the mapping between verb meaning and verb syntax.

Proportion of looking to the Same Result test event across trials was calculated for each subject on the basis of the total time spent looking during the 12-s test phase, excluding time spent not looking at either test event. Trials in which participants attended to the test events for less than 70% of the test period were excluded from analysis. Participants with more than two excluded trials were replaced in the design. During the entire 12 s of the test period, participants
in both conditions spent just over half of their time looking at the Same Result test event (proportion of looking to Same Result = 0.52 for Unaccusative, 0.53 for Transitive).

To determine which of the test events these 2-year-olds were willing to associate with the novel verb presented during familiarization, we compared looking patterns from two 2-s windows of the test phase: a 2-s baseline window and a 2-s test window immediately after the first mention of the novel verb in the test audio. During the baseline period, participants had not yet heard the novel verb repeated, and their pattern of looking provides some information about baseline preferences for the two test events. Looking patterns after the novel verb, on the other hand, provide information about participants’ preferences for extension of the novel verb presented during familiarization. Critically, a significant shift in attention upon hearing the novel verb repeated in the test audio should serve as an indicator of the meaning that participants have associated with that verb. Figure 1 provides a graphical depiction of the mean proportion of visual fixation toward the Same Result test event for each experimental condition during the 2-s Baseline and Test windows, averaged across participant and trial (error bars represent standard error).
When asked to find the test event that could be labeled by the novel verb presented during the familiarization phase, participants in the Unaccusative condition showed a significant increase from Baseline to Test in their preference for the Same Result test event ($t(11) = 2.54, p = .04$). Recall that the verb in an unaccusative intransitive frame unambiguously labels the result of a causative event: compare the novel verb input in (8a) with the English verbs in (8b), each of which labels just what happens to the patient entity in a given causative event without making reference at all to the means by which that entity’s change of state was brought about.
The preference for the Same Result test event observed in this condition provides evidence that 2-year-olds are aware of this regular mapping between verb use and verb meaning. Because they heard novel verbs only in the unaccusative intransitive frame during familiarization, they interpreted them as labels for the Result subevents of the complex causatives. At test, then, the Same Result test event offers the only option for extension of the novel verb because it is the only test event in which the Result subevent is repeated.

Participants in the Transitive condition, on the other hand, showed no significant increase from Baseline to Test in their preference for either test event when asked to find the referent of the novel verb ($\tau(11) = .35, p = .73$). This result is not surprising when we consider that, unlike the unaccusative intransitive frame, the transitive frame is an ambiguous information source. The verb in the transitive frame may label either just the means of a causative event (hit), or the result of a causative event (bounce), or an entire causative event (dribble).

In this condition, then, because the input did not provide participants with unambiguous information about the meaning of the novel verb, it is possible that their lack of preference for either test event reflects their uncertainty about the verb’s meaning. Note, however, that we would also expect this pattern of results if these participants interpreted novel verbs in transitive frames as labels for the entire causative event: because neither test event was causative, neither provided a possible option for extension of the novel verb.
Experiment 2: Means

The goal of Experiment 2 was to determine whether children are willing to interpret a novel verb associated with a causative event as a label for just the activity of the causal agent. We designed this study with the expectation that the unergative intransitive frame would trigger this interpretation. Note, however, that unlike verbs in unaccusative intransitive frames, which invariably label the result of a causative event, verbs in unergative intransitive frames do not always label the means. An unergative verb labels an activity: this activity may happen to be the means of a causative event, but this is not always the case. For example, when describing our causative event involving the boy and the garden flower with an unergative intransitive sentence, we might use a verb like *pumping* in (9a), which specifies just what the agent is doing without revealing that that activity causes any change of state. However, we also have the option to use a verb like *playing* in (9b), which seems to describe the entire event with no regard for its internal structure.

(9)   a. The boy is pumping.
      b. The boy is playing.

In light of the compatibility of this sentence frame with so broad a range of meanings, we presented only very limited options for extension of the novel verb to test events in order to make the task as simple as possible for our word learners.
Method

Participants. Two-year-old participants were recruited from the same pools used in Experiment 1. Twenty-four children ranging in age from 22;8 to 25;27 (\(M = 24;16\)) were included in the final sample for this study. Their mean productive vocabulary (based on the MCDI questionnaire) was 378 words (range 81–660). An additional 10 children were excluded due to age \((n = 1)\), language background \((n = 1)\), unwillingness to complete the experiment \((n = 2)\), inattention during the test phase for more than 30% on more than two trials \((n = 3)\), interference from accompanying caregiver \((n = 1)\), and experimenter error or equipment malfunction \((n = 2)\). Trials in which participants attended to the test events for less than 70% of the test period were excluded from analysis.

Materials and Procedure. The task, familiarization stimuli, and procedure for running participants were identical to those described for Experiment 1, with participants familiarized to causative events labeled by novel verbs. It is important to note at this point that we designed the causative familiarization events to differ in how closely the causing activity and the change of state were associated: two of the events, including the one involving the girl and the ball, involved direct mechanical causation (pimming and lOrping); and the other two, including the one involving the boy pumping a garden flower, involved causal chains that were more indirect (greking and blicking).

Two conditions were run in a between-subjects design: Unergative and Transitive. During the familiarization phase, participants in the Unergative condition heard novel verbs in unergative intransitive frames (10a), and participants in the Transitive condition heard novel verbs in transitive frames (10b).
(10)  a. Look! The boy is blicking.
     Do you see the boy blicking?

b. Look! The boy is blicking the flower.
     Do you see the boy blicking the flower?

In this experiment, both test events depicted the agent of the familiarized causative engaged in some noncausative activity (Table 3). In one of the test events, only the means subevent of the familiarized causative was repeated (Same Means test event). For the familiarization event involving the boy and the flower, for example, in the Same Means test event the boy pumps a bicycle pump that is attached to the flower, but the flower does not spin. The other test event depicted the agent making some new kind of direct contact with the patient that could serve as a potential cause of the change of state seen in the familiarization event (New Means test event). In the New Means test event involving the boy and the flower, the boy has set aside the bicycle pump, and instead he hits the flower petals with his hand as though to set them spinning, but the flower does not spin. Note that in neither of the test events does the object affected in the causative event undergo a change of state: controlling this event feature in this way has the effect of excluding the Cause and Result subparts as possible parts of the meaning of the novel verb. As in Experiment 1, the auditory stimulus accompanying these test events directed participants to find the action represented by the novel verb introduced during familiarization.
Table 3
*Test Events for Experiment 2*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Left side of screen</th>
<th>Right side of screen</th>
<th>Audio track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>Same Means boy pumps (flower does nothing)</td>
<td>New Means boy hits flower with his hand (flower does nothing)</td>
<td>Oh look! They’re different. Do you see blicking? Do you see blicking? Where’s blicking now?</td>
</tr>
</tbody>
</table>

*Results and Discussion*

The purpose of this experiment was to find out whether participants would be willing to interpret a novel verb associated with a causative event as a label for just the activity of the causative agent. As in Experiment 1, the relevant question to ask when examining these data is which test event participants were willing to accept as an extension of the meaning of the novel verb presented during familiarization. Because the unergative intransitive frame generally labels agent activities (that are unspecified for causation), we predicted that participants in the Unergative condition of this study would be more likely than those in the Transitive condition to extend novel verbs to label the Same Means test events, in which the causative agent engages in the same activity that he performed during familiarization.

As in the previous experiment, we expected 2-year-olds to look longer at the test event that they were willing to label with the novel verb presented during familiarization when the test audio directed them to find that event. To determine which of the test events these 2-year-olds would associate with the novel verb presented during familiarization, we compared looking times during a 2-s Baseline window and a 2-s Test window immediately after the utterance of the
novel word in each condition. Figure 2 provides a graphical depiction of the mean proportion of visual fixation toward the Same Means test event for each experimental condition during the 2-s Baseline and Test windows, averaged across participant and trial (error bars represent standard error).

Figure 2. Mean visual fixation at test, Experiment 2
* In the Unergative condition, mean looking during the Test window is significantly different from looking during the Baseline window for familiarization events involving indirect causation.

Comparisons across conditions revealed differences in looking during the Baseline window that approached significance, with participants in the Unergative condition looking longer at the New Means test event than participants in the Transitive condition (Unergative: 0.39, Transitive: 0.53, $t(21) = 1.94, p = .06$). We would expect this pattern of looking if our
participants entered the test phase of each trial primed by their input during the familiarization phase to attend to certain event features. In the Unergative condition, if 2-year-olds interpreted the novel verb as a label for the activity the boy was engaged in, their initial preference for the New Means test event would reflect a novelty preference for the test event in which the boy was doing something different. In the Transitive condition, if participants were led by the transitive input frame to attend to the causal relation between the boy and the flower, both noncausative test events would have been novel.

When asked to find the test event that could be labeled by the novel verb presented during the familiarization phase, participants in the Unergative condition showed a shift from Baseline to Test in their preference for the Same Means test event. This preference was consistent across three of the four trials (for the trials involving the ball, flower, and light, looking at the Same Means test event was at least 10% greater during the Test window than during the Baseline window; for the trial involving the tower, looking at the two test events was roughly equal in the two windows). However, the trend reached significance only for trials in which the familiarization events involved indirect causation (indirect (light, flower): $t(11) = -2.54, p = .028$; direct (ball, tower): $t(11) = .256, p = .8$).

To make sense of this split, it is useful to consider what the differences between the two test events actually were for each type of causative event. Recall that in all of the New Means test events, the agents abandoned the instruments they had been using in the familiarization events and made direct contact with the objects that had been affected in the causative event. For both kinds of causative events, then, the differences between the two test events involved a difference in the configurations of the participants of the causative event and their relations to each other. For the trial involving the boy and the flower (one of the more indirect causatives),
for example, in the Same Means test event, the boy moves a bicycle pump up and down, and in the New Means test event he hits a flower. For causative events involving direct causation, however, the perceptual differences between the two test events were rather subtle. For the trial involving the girl and the ball, for example, in the Same Means test event, the girl moves her arm up and down to hit the ball with a tennis racquet, and in the New Means test event she moves her arm up and down to hit the ball with her hand. In both of these test events, then, the girl is moving in a similar manner and along an almost identical path, and in both events she makes relatively direct contact with the ball. Given these similarities, it is likely that the 2-year-olds who participated in this study did not perceive a difference between the two test events provided for the more direct causative events, making it impossible for them to choose between them.

Putting aside differences in types of causation, recall that the verb in an unergative intransitive frame labels some activity that an agent is involved in: compare the novel verb input in (11a) with the English verb in (11b), which we know labels just what the boy is doing without making explicit reference to any change of state that might be caused by that activity.

(11)  a. The boy is blicking.
     b. The boy is pumping.

The preference for the Same Means test event observed in this condition provides evidence that 2-year-olds are willing to interpret verbs in this frame as a label for the activity of the agent of a complex causative event.

This preference for the Same Means test event also sheds some light on the nature of the syntactic cues 2-year-olds use to inform their hypotheses about verb meaning. Specifically, it
demonstrates that by this age, children use specific information about the semantic role of the participants in an event to determine which subpart of a complex event is labeled by a novel verb. If our 2-year-olds had been using nothing more than the number of arguments in the input frame to drive their interpretation of novel verbs in this study, we would have expected participants in the Unergative condition, like those presented with novel unaccusative intransitive verbs in Experiment 1, to map these one-argument verbs onto the Result subevent. In this case, because the Result subevent was not repeated in either test event, neither should have provided a suitable match, and participants in this condition should have performed at chance. Instead, our participants mapped unergative intransitive verbs onto the Means subevent of the complex causative, demonstrating that they were aware of the mapping between the subjects of the input sentences and the agents of the causative events.

As in Experiment 1, participants in the Transitive condition showed no significant increase from Baseline to Test in their preference for either test event when asked to find the referent of the novel verb \( t(11) = -0.85, p = .41 \). Again, this result is expected if these 2-year-olds are biased to map novel verbs in transitive frames onto causative events. In this case, because neither of the test events was causative, neither provided a suitable match for the verb. A bias to interpret transitive verbs as causative may also explain why participants in this condition did not demonstrate a novelty preference during the Baseline window: because the input biased them to look for a causative event, both noncausative test events were equally novel.

An ANOVA including age, sex, productive vocabulary, and proportion looking during Test – Baseline windows reveals that in this experiment, participant age \( (F(1, 21) = 5.69, p = .58) \) and productive vocabulary \( (F(1, 21) = .43, p = .52) \) were not significantly correlated with performance. Participant sex was significantly correlated with performance, however, such that
across conditions male participants were more likely, on average, than female participants to demonstrate a preference for the Same Means test event during the Test window ($F(1, 21) = .31, p = .03$).

**Discussion**

The results of Experiments 1 and 2 show that 2-year-old children have access to the same complex representations for causative events that adults do. Moreover, 2-year-olds can use verb-specific subcategorization information to identify and label the subparts of these events. Specifically, participants in both experiments were willing to map intransitive verbs, but not transitive verbs, onto individual subevents of the complex causative familiarization events: mapping novel verbs in unaccusative intransitive syntactic frames (“The flower blinked.”) onto the result of a causative event, and mapping novel verbs in unergative intransitive frames (“The boy blicked.”) onto the agent’s activity. Our results were also consistent with the claim that 2-year-olds interpret novel verbs in transitive frames as labels for causative events: in both experiments, 2-year-olds who learned novel verbs in transitive frames (“The boy blicked the flower.”) were not willing to extend them to either individual subevent of the causative.

These results also demonstrate that children are using more than just the subcategorization information cued by a given input frame (e.g., number of arguments) to inform verb learning. For cases in which the input frame included only one argument, our 2-year-old participants used information about the semantic role played by the event participant picked out by the intransitive subject to map that novel verb into an event. Causers were mapped to the single argument of unergative verbs, and undergoers to the single argument of unaccusative verbs. It has been argued that adults use some kind of linking rules to map semantic roles like causer and undergoer (or agent and patient/theme) to their grammatical roles (e.g., Baker 1997,
Jackendoff 1990, Levin & Rappaport Hovav 1995, Pinker 1989, Snedeker & Gleitman 2004). It remains to be determined exactly how learners first accomplish this mapping, but recent evidence from corpus studies suggests that it may be cued by surface features like subject animacy (Merlo & Stevenson 2001, Scott & Fisher 2006).

In the experiments reported in this section, we asked 2-year-old children to interpret novel verbs as labels for just one subevent of a complex causative. In the two experiments we describe next, we wanted to find out what would happen if we led them to interpret novel verbs as labels for entire causative events and then asked them to accept changes to one of the causative subparts. Our goal in these experiments was to investigate how young word learners would resolve conflicts between hypothesized verb meanings and new information provided by the extralinguistic context. The degree of flexibility that learners permit in encoding the subparts of the causative representation sheds some light on the precision demanded in mapping conceptual event representations to linguistic structures.

Encoding Causatives

Our goal in the experiments described in this section was to probe the nature and degree of flexibility that 2-year-old word learners will allow in the semantic identity of the subevents of labeled causative events. Experiment 3 investigates whether these learners will accept changes to the Means subevent of a causative representation labeled with a single verb, and Experiment 4 investigates whether the same populations will accept changes to the Result subevent.

Again, to establish the proper set of constraints for learning each meaning, we controlled the syntactic frames in which novel verbs were presented and the options presented to participants at test for extension of the novel verb in each experiment. To draw attention to
causative events during familiarization, we presented novel verbs in transitive frames, and to
draw attention away from causative events, we presented novel verbs in unaccusative (Expt. 3)
and unergative (Expt. 4) intransitive frames, which we know, on the basis of Experiments 1 and
2, both populations of language learners will interpret as labels for subevents of complex
causatives. The changes we made to test events were designed to pit the allure of matches in
perceptual event features against matches in conceptual features of event representations. This
choice of alternatives allows us to determine which kind of event feature provides the most
important kind of information for event categorization and labeling. If we find that word learners
are willing to accept changes in conceptual event features (i.e., the kind of event category or
number of events associated with a given verb), but not in the specific identity of causative
subevents, this will suggest that it is perceptual features that guide the categorization and
labeling of events. If, however, our word learners accept changes in the specific identity of
causative subevents that still correspond to possible mappings between conceptual and linguistic
event representations, this will provide strong evidence in support of the claim that verb
representations are abstract in nature, and not tied to the specific events with which they were
first associated.

Experiment 3: Changes to the Means subevent

The goal of Experiment 3 was to explore children’s flexibility in encoding the semantic content
of the Means subpart of a complex causative. Participants were first familiarized to a causative
event labeled with a novel verb, and then at test, they were asked to extend the novel verb to one
of two events in which subparts of the familiarized causative (either the Means subevent or the
causal connection between subevents) had been modified.
Method

Participants. Participants were recruited from the same pools used in Experiments 1 and 2. The final sample for this study included 36 children ranging in age from 22;1 to 26;1 ($M = 23;28$). Mean productive vocabulary (MCDI) was 280 words (range 3–578). An additional 13 children were excluded due to age ($n = 3$), language background ($n = 1$), inattention during the test phase for more than 35% on more than two trials ($n = 1$), experimenter error/equipment malfunction ($n = 1$), or study design ($n = 7$). Trials in which participants attended to the test events for less than 70% of the test period were excluded from analysis.

Materials and Procedure. The task, familiarization stimuli, and procedure for running participants were identical to those described for Experiments 1 and 2, with participants familiarized to causative events labeled by novel verbs. Three conditions were run in a between-subjects design: Unaccusative, Transitive, and No Word. In the Unaccusative and Transitive conditions, participants heard familiarization events described with novel verbs in unaccusative intransitive and transitive sentences, respectively. In the No Word condition, participants heard event descriptions that did not include a novel verb, but instead invited them to attend generally to the familiarization (“Look at that! Do you see what’s happening?”) and test (“Oh look! They’re different. What do you see?”) events. The goal of this condition was to establish baseline preferences dictated by extralinguistic perceptual or conceptual biases for each pair of test events in the absence of a novel verb label.

Again in this experiment, both of the test events involved the person and objects presented during familiarization, but this time they differed in which of the subparts of the familiarized causative event were repeated (Table 4). One of the test events was a causative version of the New Means test events presented in Experiment 2. In these test events,
participants saw a causative event that differed from the familiarization event just in the means of causation (New Means test event). For example, after the familiarization event in which the boy makes the garden flower spin by pumping it with a bicycle pump, in the New Means test event, the boy makes the flower spin by hitting it with his hand. The other test event was one in which no causation occurred, but the activity of the causative agent and the result undergone by the causative patient were both repeated (No Cause test event). In the No Cause test event involving the boy and the flower, the boy pumps the bicycle pump and the flower spins, but the pump is not connected to the flower: the boy’s activity is not causally linked to the change of state in the flower. As in the previous experiments, the auditory stimulus accompanying these test events directed participants to find the action represented by the novel verb introduced during familiarization.

Table 4

<table>
<thead>
<tr>
<th>Test Events for Experiment 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase</strong></td>
</tr>
<tr>
<td>Test</td>
</tr>
</tbody>
</table>

Note that in both of these test events, the causative patient undergoes the same change of state that it did during familiarization, e.g., the flower is spinning. Indeed, both test events repeat exactly two of the three subparts of the familiarized causative: the New Means test event is a
causative event with the same result, and the No Cause test event repeats both the Means and Result subevents, but with no causal link between them. This particular pattern of repeated subparts has the effect of including causation as part of the possible extended meaning of the novel verb. Excluding exactly one subpart of the familiarized causative from each of the test events ensured that neither test event would be more familiar to participants than the other. The nature of the subparts excluded from each test event differed, however, allowing us to determine the relative linguistic significance of abstract conceptual elements like CAUSE versus the observable Means and Result subevents.

Results and Discussion

Both of the test videos presented in Experiment 3 depict an event with the same outcome as the causative presented during familiarization. They differ in whether there is a clear causal link between that outcome and the activity of the agent. The goal of the test phase in this experiment was to identify the limits on participants’ extension of a novel verb to new events, comparing two options: One of the test events shares the Result subevent and overall event type (i.e., causative), but not the Means subevent, with the familiarization event. The other test event shares both the Means and Result subevents with the familiarization event, but with no causal connection between them. A language learner who is willing to accept changes to the Means subevent of a complex causative should choose to extend novel verbs associated with that causative to include the test event in which the object’s change of state is actually caused by the agent, regardless of what that agent is doing to effect the change. On the other hand, a language learner who is basing her decision on perceptual similarity between familiarization and test events should choose to extend novel verbs to the test event in which more observable properties of the event are repeated, regardless of their conceptual relation.
There were no significant differences between conditions in looking preferences during the Baseline or Test windows, nor were there significant differences across conditions in differences between looking during Baseline and Test (all $\sqrt{2q^*} = 3.47, p > .05$). Participant age, sex, and productive vocabulary were not significantly correlated with performance.

To determine which of the test events these 2-year-olds were willing to associate with the novel verb presented during familiarization, we compared looking times during the Baseline and Test windows in each condition. Figure 3 provides a graphical depiction of the mean proportion of visual fixation toward the New Means test event for each experimental condition during the 2-s Baseline and Test windows, averaged across participant and trial (error bars represent standard error).

There were no significant differences between the Baseline and Test windows in the No Word condition ($t(11) = 1.74, p = .11$). This suggests that participants did not find either of the two test events more salient on the basis of extralinguistic perceptual or conceptual cues.

When asked to find the test event that could be labeled by the novel verb presented during the familiarization phase, participants in the Unaccusative condition also demonstrated no significant preference for either test event during the Test window that differed from their looking preference during the Baseline window ($t(11) = .73, p = .48$). This result is not surprising, considering that the verb in an unaccusative intransitive frame unambiguously labels the result of a causative event. In this experiment, both of the test events included the subevent that participants in the Unaccusative condition would have identified as the meaning of the novel verb presented during familiarization, and their lack of preference for a single test event simply reflects this dual compatibility.
Participants in the Transitive condition, on the other hand, showed a significant increase in their preference for the causative New Means test event from Baseline to Test when asked to find the referent of the novel verb ($t(11) = 2.20, p = .05$). Recall that unlike the unaccusative frame, the transitive frame provides ambiguous information about the meaning of the verb it carries: the verb in a transitive frame can label either just the Means of a causative event, as in (12b), or it can label a causative event, as in (12c).

(12)  
   a. The boy is blickin the flower.  
   b. The boy is pumping the flower.  
   c. The boy is spinning the flower.
The preference for the causative New Means test event demonstrated in this condition, then, provides further evidence that children of this age are biased to interpret verbs in transitive frames as causatives (e.g., Lidz et al. 2003, Slobin 1985).³

Note, moreover, that participants made this choice regardless of the fact that the means activity depicted in the test event was different from that presented in the familiarization event. This flexibility reveals that the semantic content that these participants assigned to the novel causative could not have included a highly specified Means subevent. This, then, is evidence that 2-year-olds are willing to accept changes to the Means subevent of a causative event labeled with a novel verb. Indeed, this kind of representation is what underlies the meanings of causative verbs like *spin* in (12c), which label both the change of state that an object undergoes and the idea that that change of state has been caused by some external agent without providing any information about what the agent did to bring about that change.

Interestingly, in this experiment we do not see the split observed in Experiment 2 between familiarization events involving direct and indirect causation, although the changes to the New Means test events are the same as those presented in that experiment. This suggests that children allow more flexibility in the semantic identity of an agent-driven activity when it is perceived to be the Means subevent driving a causative event than they will when the activity is represented as a complete event in its own right.

Finally, it is important to note that none of these groups of 2-year-olds showed a preference for the No Cause test events, the event that repeated the Means and Result subevents of the familiarized causative but not their causal connection. This suggests that children of this age are sensitive to the fact that events that overlap in time and space are not necessarily related
to each other, and, moreover, that they are aware that the (sub)events encoded in a single verb must be related in a partonomic hierarchy. Even though the two events depicted in the No Cause test events were perceptually identical to the means and result of a familiar causative event, because participants did not perceive any linguistically relevant connection between them, they were unwilling to extend a single novel verb to label them.

Experiment 4: Changes to the Result subevent

In Experiment 3, we observed that 2-year-olds would group two of the subparts of the causative together (Cause and Result) when extending the meaning of a novel transitive verb and would allow for flexibility in the identity of the Means subevent. Experiment 4 was undertaken to investigate whether this was the only possibility for grouping the subparts, or whether, if they were given the opportunity, children of this age would also be willing to group the Means and Cause subparts together without identifying a specific Result. As in Experiment 3, participants were first familiarized to a causative event labeled with a novel verb. At test they were asked to extend the novel verb to one of two new events in which subparts of the familiarized causative (either the Result subevent or the causal connection between subevents) had been modified.

Method

Participants. Participants were recruited from the same pools used in the previous experiments. The final sample for this study consisted of 36 children ranging in age from 22;8 to 25;25 ($M = 23;29$). Mean productive vocabulary (MCDI) was 348 words (range 5–622). An additional 19 children were excluded due to unwillingness to complete the experiment ($n = 1$), inattention during the test phase for more than 30% on two or more trials ($n = 4$), interference from accompanying caregiver ($n = 4$), experimenter error/equipment malfunction ($n = 4$), or
study design \((n = 6)\). Trials in which participants attended to the test events for less than 70% of the test period were excluded from analysis. In addition, preliminary analysis of the data suggested that the New Result test event for the causative event involving the girl and the ball (in which the girl uses the tennis racquet to make the ball deflate) was overwhelmingly more interesting than the corresponding No Cause test event, and so it was excluded from the final analysis for all participants.

*Materials and Procedure.* The task, familiarization stimuli, and procedure for running participants were identical to those described for the previous experiments, with participants familiarized to causative events labeled by novel verbs. Three conditions were run in a between-subjects design: Unergative, Transitive, and No Word. As in Experiment 3, both of the test events involved the person and objects presented during familiarization, but they differed in which of the subparts of the familiarized causative event were repeated (Table 5). One of the test events was a causative event that differed from the familiarization event in the change of state undergone by the patient (New Result test event). For the trial involving the boy and the flower, in the New Result test event the boy continues to pump the bicycle pump attached to the garden flower, but now the flower moves up and down instead of spinning. The other test events were the same No Cause events presented in the test phase of Experiment 3, in which the Means and Result subevents presented during familiarization were repeated but were no longer causally related. Again, the auditory stimulus accompanying these test events directed participants to find the action represented by the novel verb introduced during familiarization.
Table 5  
*Test Events for Experiment 4*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Left side of screen</th>
<th>Right side of screen</th>
<th>Audio track</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>New Result&lt;br&gt;boy makes flower move up and down by pumping</td>
<td>No Cause&lt;br&gt;boy pumps; flower spins (pump is not connected to flower)</td>
<td>Oh look! They're different.&lt;br&gt;Do you see blicking?&lt;br&gt;Do you see blicking?&lt;br&gt;Where's blicking now?</td>
</tr>
</tbody>
</table>

Note that in both test events, the causative agent is involved in the same activity that he was during familiarization, e.g., the boy is pumping. Indeed, as in Experiment 3, both test events repeat exactly two of the three subparts of the familiarized causative: the New Result test event is a causative event with the same causing activity, and the No Cause test event repeats both of the Means and Result subevents, but without a causal link between them. This particular pattern of repeated subparts has the effect of including causation as part of the possible extended meaning of the novel verb. Crucially, this experiment investigates whether participants will permit the same flexibility in the semantic identity of the Result subevent of a causative event labeled with a novel verb that we observed in Experiment 3 for the semantic identity of the Means subevent.

*Results and Discussion*

Both of the test videos presented in Experiment 4 depict an event in which the agent is engaged in the same activity as in the causative presented during familiarization. They differ in whether there is a clear causal link between that activity and a change of state in the patient. The goal of the test phase in this experiment was complementary to that of Experiment 3: i.e., to find out whether participants showed the same flexibility in the content assigned to the Result subevent.
that they did for the Means subevent. In this experiment, a language learner who is willing to accept changes to the Result subevent of a complex causative should choose to extend novel verbs associated with that causative to include the test event in which the agent’s activity is the cause of the object’s change of state.

There were no significant differences between conditions in looking preferences during the Baseline or Test windows, nor were there significant differences across conditions in differences between looking during Baseline and Test (all $\sqrt{2}q^* = 3.47, p > .05$). Participant age, sex, and productive vocabulary were not significantly correlated with performance. Figure 4 provides a graphical depiction of the mean proportion of visual fixation toward the New Result test event for each experimental condition during the 2-s Baseline and Test windows, averaged across participant and trial (error bars represent standard error).

There were no significant differences between the Baseline and Test windows in the No Word condition ($t(11) = .31, p = .55$). This suggests that participants did not find either of the two test events more salient on the basis of extralinguistic perceptual or conceptual cues.

Participants in both the Unergative ($t(11) = 2.19, p = .05$) and the Transitive ($t(11) = 2.24, p = .05$) conditions, on the other hand, exhibited a significant increase in their preference for the causative New Result test event from Baseline to Test. In these conditions, the Test window corresponds to the period in the test phase in which participants were asked to find the event that could be labeled by the novel verb presented during the familiarization phase. Their choice of the causative New Result test event, then, indicates that participants in both of these conditions interpreted the novel verb as a label not for a specific subevent, but rather as a label for the entire causative event.
Figure 4. Mean visual fixation at test, Experiment 4

* In the Unergative and Transitive conditions, mean looking during the Test window is significantly different from looking during the Baseline window.

Note, moreover, that this preference is exactly what we would expect if participants were willing to allow for flexibility in the semantic identity of the Result subevent of a complex causative labeled by a novel verb. Recall that what we attempted to do in this study was to teach 2-year-olds a single verb label for a causative event and then ask them to extend the meaning of that verb to include an event that differed from the familiarization event in one of the causative subparts. At test, they had the option of extending the novel verb to refer to a causative event that differed from the familiarization event in the change of state undergone by the patient entity (New Result) or to a pair of unrelated events that were identical to the Means and Result subevents of the familiarized causative (No Cause). As in Experiment 3, neither group of 2-year-olds showed a preference for the No Cause test events. This provides further support to the claim that children of this age are unwilling to extend a novel single verb label to refer to two events
that are not related in a conceptual event hierarchy, even if they are identical to the Means and Result subevents of some causative event. Instead, participants in both the Unergative and Transitive conditions demonstrated a preference for the New Result test event.

One possible interpretation of this preference is that participants were indeed willing to extend the meaning of the novel verb to include the causative New Result test event. The interpretation of novel verbs in transitive frames as causative, at least, is fully consistent with the results reported in Experiments 1–3, as well as with observations found in the verb acquisition literature. Recall, however, that the causative event that participants would be choosing in this case differs from the familiarization event in the identity of the Result subevent. This pattern of results suggests that 2-year-olds can encode a causative verb with a specific Means subevent but an unspecified Result subevent.

Note, however, that this verb meaning, viz., Means + cause, is never found in the wild: cross-linguistically there are no causative verbs that encode a specific means but not a specific result, because the meaning in question corresponds to an impossible linguistic representation. Because the semantic primitive cause (represented in the phrase structure as a light verb) always selects for a phrase that specifies some change of state in a patient, specified Means and cause subparts of a given causative event can never form a constituent to the exclusion of the Result, and so can never be encoded in a single verb (see Harley 1996, McCawley 1968, inter alia). An interpretation of the looking patterns observed in this experiment as a willingness to accept a verb that encodes just the Means and cause subparts of the causative is implausible, then: if a learner’s hypotheses about the meanings of novel verbs are guided by linguistic constraints on possible structures, then this is a meaning that she should never hypothesize at all. Acceptance of verbs with this meaning poses a problem for learnability, moreover, because the cross-linguistic
gap in verbs encoding this meaning entails that learners are not going to get any direct evidence that verbs cannot mean this.

Even if we accept that 2-year-olds in this experiment are exhibiting a real preference for the New Result test events, however, this does not entail that their linguistic representations of these novel causative verbs do not include a Result subcomponent, just that that the semantic content of that subcomponent has not been specified. Indeed, the fact that the 2-year-olds who participated in Experiments 3 and 4 were willing to accept changes to either the means or the result of a causative event labeled by a novel verb suggests that what they have learned about these novel verbs is that they encode causative events of some type, with no commitment to either the Means or the Result subevents.

Another possible interpretation of the preference for the New Result test event observed in this experiment comes from the observation that events, like objects, are related in taxonomic hierarchies that reflect varying levels of abstraction in representation and categorization. In light of this organizational structure, it may be the case that 2-year-olds in this study associated the novel verb label not with the basic-level events like spinning and bouncing depicted in these videos, but rather with a higher-level taxonomic category, perhaps something like causation (of an unspecified nature). This jump to a higher taxonomic level might be driven by something like the mutual exclusivity constraint that guides the acquisition of object labels (Markman 1993; see also Woodward 2000).

According to the mutual exclusivity constraint, children expect each entity in the world to be associated with a single label that denotes a basic-level object category. The constraint is argued to facilitate word learning by encouraging the acquisition of labels for object properties and for superordinate and subordinate object categories: when the learner is confronted with a
situation in which the one-to-one mapping between entities and labels is violated, as in the case of a single entity associated with more than one label or the case of two entities associated with a single label, they may interpret the labels as names for object properties or for object categories that are either more specific or less specific than the basic level. Several researchers have suggested, moreover, that mutual exclusivity plays a role in the acquisition of verbs and spatial terms (e.g., Merriman et al. 1996, Regier 1997, Woodward 2000).

In this experiment, if participants interpreted novel verbs in transitive and unergative intransitive frames as labels for the causative event presented during familiarization, it is possible that neither of the test events provided an option that could be construed as the same as the familiarized causative: the No Cause test events depicted two events that were not causally related, and the New Result test events depicted a causative test event that differed from the familiarization event in ways that forced learners to associated it with a different basic-level event category. On this analysis, then, during the test phase, we were effectively asking participants to interpret a single verb as a label for two different events. If something like mutual exclusivity was guiding their hypotheses about verb meaning, they would be led to interpret the novel verbs as labels for events that were either more specific or less specific than the basic level. In this case, the mapping of novel verbs to more specific events was discouraged by changes in the event features presented at test, and so participants interpreted novel verbs as labels for a superordinate event category. Their choice of the New Result test event rather than the No Cause test event suggests that the events that are included in this superordinate category share the conceptual feature of causation.

Further investigation will be required before we can decide between these possibilities.
Discussion

Our goal in the experiments described in this section was to explore the flexibility that 2-year-olds allow in causative verb representations. Specifically, we wanted to investigate how this group of word learners would resolve conflicts between hypothesized verb meanings and new information from the extralinguistic context. The results of Experiments 3 and 4 reveal that as long as structural constraints on the mapping between verb syntax and semantics are satisfied, 2-year-olds can be flexible in the specificity of the semantic content they assign to their representation of a causative. That is, when they represent a novel verb as causative, they are willing to extend it to refer to other causative events that differ in the identity of either the Means or the Result subevents, but not to events that differ in their basic event structure—i.e., to events that are not causative. This pattern of results provides insight into the nature of young children’s early verb representations.

Note first that if 2-year-olds’ verb representations were strictly tied to the events that they first associated with a given verb, then they should always have chosen the test event that was perceptually most similar to the familiarization event, i.e., the No Cause test event. On the contrary, however, across the two experiments our 2-year-old participants preferred to accept changes to causative subevents rather than to the nature of the event being labeled by a novel verb: they never chose to extend the meaning of novel verbs to label the No Cause test events. Instead, they appear to have been limited in the way that they mapped verb meanings onto event representations such that single verbs could only encode events that were related in a conceptual hierarchy. This suggests that the representations that 2-year-olds associated with these verbs encoded abstract information about the relation between event participants, and not specific information about the semantic identity of the subevents.
In addition, the results of these studies reveal facts about the kinds of flexibility that language learners allow when encoding the semantic content of causative representations. Consistent with the results of Experiments 1, 2-year-olds in Experiment 3 interpreted novel verbs in unaccusative intransitive frames as labels for just the Result subevent of a complex causative. In this experiment, both test events repeated the Result subevent presented during familiarization, and so both provided equally good extensions of the novel verb (indeed, participants demonstrated no significant preference for either test event). This experiment also reveals that 2-year-olds who learn a novel verb label for a causative event in a transitive frame will willingly extend that verb to label another causative event that differs in its Means subevent. This result could only be possible if the representations that children associate with these novel transitive verbs do not include a highly specified Means subevent. The results of Experiment 4 suggest, moreover, that this group of word learners permit a corresponding flexibility in the identity of Result subevents.

If it is indeed the case that 2-year-olds are also willing to accept changes in the Result subevent associated with a novel transitive verb (or to both of the Means and Result subevents at the same time), then we would be left with a puzzle concerning how they decide which parts of a given causative event are specified by a given transitive verb: i.e., whether the verb encodes a causative event with a specified Result subevent or a causative event with a specified Means subevent. Results from previous studies using this paradigm, as well as from reactions to test stimuli during the Baseline windows of the experiments reported here, strongly suggest that word learners come to the test phase with preferences that have been shaped by their interpretation of the novel verb presented during familiarization. If it is the case, however, that children of this age are willing to interpret novel verbs in transitive frames as labels for a causative event with
just one subevent specified (either Means or Result), then we need to determine whether they map novel verbs onto test events in these experiments by maintaining several hypotheses about the meaning of the novel verb and then choosing the one that best matches the options presented at test, or whether they associate these novel transitive verbs with underspecified representations, perhaps hypothesizing just that they label causative events of some type, with no commitment to the specific semantic content of either subevent.

General Discussion

The studies reported here investigate the range of meanings that language learners are willing to encode in single verbs associated with causative events, and the conceptual and linguistic constraints on postulated meanings of novel verbs. Our investigation was guided by several specific questions. We wanted to find out which combinations of the subparts of a complex causative 2-year-old children would be willing to encode as the meaning of a single novel verb. And we wanted to probe the degree of specificity these learners encoded in representations of verb meaning: i.e., how closely early verb meanings are tied to representations of the specific events with which they were first associated.

Consistent with previous studies demonstrating the effects of linguistic cues on the acquisition of novel words, our results show that 2-year-old children use information from the syntactic frame in which a novel verb appears to guide their hypotheses about its meaning. Indeed, we found that even when learners are presented with a novel verb that is associated with a single complex causative event, syntactic information serves to spotlight the various causative subparts, making them more or less likely candidates for the meaning of the novel verb. When learners were provided with novel verbs in syntactic frames that provided unambiguous
information about the subevents of the causative being highlighted, they interpreted the verbs as labels for those subevents. Two-year-old children interpreted novel verbs presented in unaccusative intransitive frames as labels for just the Result subevents of complex causatives, and they interpreted novel verbs in unergative intransitive frames as labels for just the Means subevent.

In many cases, however, syntactic cues do not provide enough information to eliminate all of the candidate hypotheses for the meaning of a novel verb. In these situations, learners must make use of multiple sources of information to arrive at the final meaning (Gillette et al. 1999, Hollich et al. 2000, Snedeker & Gleitman 2004). When presented with novel verbs in transitive frames, our 2-year-olds interpreted them as labels for causative events, despite the fact that it is also possible to interpret them as labels for agent-driven activities (here, for the Means subevents of causatives).

Both of these are possible meanings for a verb in a transitive frame, as illustrated by the sentences in (13): *dribbled* in (13a) labels an event in which the girl makes a ball bounce by hitting it with her hand, and *hit* in (13b) labels just what the girl does to the ball.

(13)  

(a) The girl dribbled the ball.  
(b) The girl hit the ball.

The choices made by 2-year-olds in these studies reflect an initial bias for causative events in children of this age that has been reported previously in the literature and that likely extends beyond word learning situations (e.g., Bowerman 1989, Lidz et al. 2003, Slobin 1985).
Our results also reveal that the meanings that 2-year-old word learners postulate for novel verbs are highly constrained by the mapping between conceptual and linguistic event representations. In Experiments 3 and 4, our 2-year-old participants never chose to extend the meanings of novel verbs to include the No Cause test events, in which the Means and Result subevents of the familiarized causative were repeated but were not causally related. This pattern of results suggests that this group of language learners is limited in the way that they can map verb meanings onto structural representations of events. Single verbs can only encode (sub)events that are related in a conceptual hierarchy. In the Unergative condition of Experiment 2, moreover, we found a split in our 2-year-old participants’ awareness of changes to an agent’s activity that corresponds directly with previously reported differences in the conceptualizations of direct and indirect causal chains in adults (e.g., Wolff 2003). Here, the degree of closeness between agent and patient in causative familiarization events affected whether 2-year-olds encoding the agent’s activity in a novel verb noticed a change in that activity. When the change brought the agent and the patient into closer contact, 2-year-olds only accepted the original activity as the meaning of the novel verb. As long as the degree of contact between the two event participants stayed the same, however, 2-year-olds appeared to be flexible in how precisely the means activity had to match the familiarization event: i.e., they showed no preference for extension of the novel verb between a test event depicting the agent’s original activity and one in which the agent’s activity changed, suggesting that this change was not linguistically relevant.

When 2-year-old word learners interpreted novel verbs as labels for causative events, they demonstrated a disinclination to revise their interpretation of the kind of event representation labeled by a given novel verb. Instead, they were willing to loosen their commitment to the semantic identity of the causative subevents in order to respect their initial
interpretation. Although they still represented the meaning of novel verbs in transitive frames as causative, they were willing to be flexible in what they would permit as the Means (and perhaps also the Result) subevent. Thus, although the verb meanings posited by young word learners in Experiments 3 and 4 were limited to including combinations of the subparts of a causative event that corresponded to possible structural representations, as long as that structural constraint was satisfied, the semantic content of the causative subevents was flexible. In Experiment 3, they accepted a change in the Means subevent encoded by a causative verb, and in Experiment 4, they may also have accepted a change in the Result subevent.

Our results also speak to a debate over whether children’s earliest verb meanings are as abstract as those accessed by adults (e.g., Lucariello & Rifkin 1986, Poulin-Dubois & Forbes 2006, Tomasello 2000). One side of the debate postulates that children start out with representations of individual verbs and gradually merge them to form more abstract categories (Tomasello 2000). This hypothesis derives largely from production evidence suggesting that children are unwilling to extend novel verbs learned in a specific linguistic context to new syntactic frames. Poulin-Dubois & Forbes (2006) present complementary evidence from an experimental study of the changes that children will accept in the events associated with novel verbs. Their study demonstrates that at 21 months of age, children use perceptual similarity between events rather than categorization on the basis of “unobvious commonalities” (p. 278) to extend word meanings. This result suggests that young children’s representations of verb meaning are highly context-specific, such that the events that they are willing to associate with a given verb must be maximally like the ones they first associate with the verb. The other side of the debate holds that children make use of abstract representations throughout development. For example, experimental evidence demonstrating that children can use either purely structural
information from the syntactic frame (or frames) in which a novel verb is presented (e.g., Fisher 1996, 2002) or syntactic information highlighted by structural priming (Thothathiri & Snedeker 2006) to make inferences about verb meanings suggests that their representations are, indeed, tied to abstract information about event categories rather than to specific events.

Our data provide two kinds of evidence in favor of the view that children’s representations of novel verbs are abstract from the start. Our 2-year-old word learners were sensitive to structural cues to verb meaning, pointing to a principled link between syntactic structure and semantic content. In addition, the flexibility in encoding the semantic identity of causative subevents exhibited by our 2-year-old word learners provides clear evidence that the representations available to children of this age are not comprised of fixed snapshots of the particular event that they first associated with a given word (e.g., *pim* would mean: girl makes ball bounce by hitting it with a racquet). If their interpretations of novel verbs in these studies had been tied to representations with highly specific semantic content, 2-year-olds should always have extended novel verbs to refer to the test events that were perceptually more similar to the familiarization events. On the contrary, their willingness to accept changes to the identity of either the causing subevent or the resulting change of state demonstrates that these learners were tied to the structural representations of these events rather than to their specific content. This pattern of results provides strong support, then, in favor of the argument that children’s early representations are abstract in nature, with even early verbs mapping to structures that specify semantic details that mirror conceptual features relevant for event classification (including abstract relations like CAUSE). This kind of representation provides the learner with an extremely powerful tool for word learning, allowing them to refine their hypotheses about the meanings of
words they are acquiring as they encounter new information about them from cross-situational observation of their linguistic and extralinguistic contexts of use.
References


Endnotes

1 Such cross-linguistic biases include the lexicalization of path and manner (Havasi & Malik 2004, Havasi & Snedeker 2004, Naigles & Terrazas 1998, Talmy 1985).
2 Example videos for each experiment in this paper can be found at: http://ling.umd.edu/labs/acquisition/?page=stimuli
3 Several audiences have wondered whether the preference that 2-year-olds in the Transitive condition of Experiment 3 exhibit for the New Means test event might be based on the contact between participants in this event, and not necessarily on their causal relation. Indeed, contact between event participants is a crucial factor in the perception of direct causation (e.g., Leslie 1982, 1984b). Contact, however, is not enough on its own to account for the pattern of results reported in the four experiments reported here. Note, for example, that if contact were the only (or even the most important) event feature driving participant responses to the verbs in transitive sentences, then 2-year-olds in the Transitive condition of Experiment 1 should also have exhibited a preference for the Same Means test event over the Same Result test event, because that is the only one of the two test events in which the causative agent and patient make contact. This is not what we found. Thus, we can infer that contact is not the event feature responsible for the preference in Experiment 3.