

## Constrained Flexibility in the Extension of Novel Causative Verbs

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### 0. Introduction

Whenever we learn a novel word, whatever its grammatical category, what we are learning is a label for a whole category of things in the world. The word *dog*, for example, refers not to an individual dog, but to the whole set of dog-like things in the world. Likewise, the word *jump* refers not to a single instance of jumping, but to an entire category of jumping events. A large literature has grown up around the kinds of categories that children assign to novel nouns, asking, for example, whether a novel count noun refers to a particular individual, to a basic level category, or to a superordinate category (e.g. Markman 1993, Waxman 1990). The corresponding questions have not been asked, however, about novel verbs, i.e. what categories of events a novel verb can be extended to include.

It is well established that there are systematic regularities in the mapping between verb meaning and verb syntax, such that verbs that refer to similar event types, i.e. verbs that have similar meanings, can occur in similar sentence structures (e.g. Carter 1976, Gruber 1965, Jackendoff 1990, Levin 1993). We know, for example, that only verbs that label a change of state can occur in the so-called causative-inchoative alternation, illustrated by the sentences in (1). Note that the verb *bounce* can be used both in a transitive frame (1a) and in an unaccusative intransitive frame (1b), but that *hit* cannot (2). The discrepancy between these two patterns of use is due to the fact that only *bounce* labels some change of state undergone by the ball; on the contrary, in (2a) it's Sammy that does the hitting, not the ball.

- (1) a. Michael Jordon bounced the ball.  
b. The ball bounced.
- (2) a. Sammy Sosa hit the ball.  
b. \*The ball hit.

Theorists and researchers in a range of disciplines have suggested that very early event representations may encode features that map directly onto linguistic



that aren't constituents (e.g. Rappaport Hovav and Levin 1998). So, for example, single verbs can label any of these individual subevents of the causative, or they can label the entire event, but languages don't have verbs that encode, for example, something like a means subevent and a result subevent that aren't causally related.

The broad goal of the research described here was to examine the constraints that guide language learners in their acquisition of novel verbs. To address this issue, we sought to gain a more precise idea of the different ways that two-year-olds are willing to use single verbs to encode the subparts of a causative event by investigating two more specific questions. First, we wanted to find out how children of this age are willing to package information about causative events into verbs, i.e. whether they would be willing to accept any combinations of the subparts of a complex causative as the meaning of a single verb, or whether they, like adults, would be constrained by something like the constituency constraint.

Second, we wanted to find out how flexible the world-to-word mapping is for verbs labeling causative events, i.e. how specific children are about the event features they're encoding when they're acquiring a novel verb. So, for example, when they see a girl dribbling a ball and hear it described with a novel verb like *pimming*, we want to know whether *pimming* has to mean something very specific like 'cause to bounce by hitting', or whether the semantic identity of the means and result subevents might be underspecified, with alternate meanings like 'cause to bounce by performing some unspecified action' or even 'cause to move in some unspecified way by performing some unspecified action'.

To investigate these questions, we designed two experiments using the preferential looking paradigm (e.g. Golinkoff et al. 1987, Spelke 1979). Experiment 1 explores children's flexibility in encoding the semantic content of the means subpart of a causative, and Experiment 2 explores their flexibility in encoding the semantic content of the result subpart.

## **1. Experiment 1: Means Subevent**

### **1.1. Design**

The participants in Experiment 1 consisted of 24 two-year-olds (six boys and six girls in each experimental condition) ranging in age from 22;7 (months;days) to 26;1 (mean 23;29). All were being raised in English-speaking homes.

The stimuli consisted of short live-action videos depicting human actors interacting with inanimate objects. Each trial consisted of two phases: familiarization and test. During the familiarization phase, participants saw a video of some causative event in which an actor caused a change of state in an inanimate object, e.g. a girl making a ball bounce by hitting it repeatedly with a tennis racquet. Each showing of the event was accompanied by a digitally synchronized auditory event description that included a novel verb. This event-description pairing was shown four times (for six seconds each time) and on both sides of a large projection screen: first once on each of the left and right sides of the screen, and then twice on both sides simultaneously.

There were two experimental conditions differing between subjects, which were distinguished by the syntactic frame in which the novel word was presented during familiarization. Participants in the unaccusative condition heard the novel verb used in an unaccusative intransitive sentence like *The ball is pimming*, and participants in the transitive condition heard the novel verb used in a transitive sentence like *The girl is pimming the ball*.

Between the third and fourth presentations of the causative event, participants saw a six-second contrast event in which the actor was engaged in a noncausative activity involving the inanimate object. In the case of the causative event involving the girl and the ball, for example, the contrast event consisted of the girl holding the ball in her hands and moving it back and forth in an arc across the screen. The contrast event was accompanied by an auditory event description that also incorporated the novel verb, but that made it clear that the event encoded by the novel verb was not happening.

Each participant saw four different familiarization sequences, each with a different causative event described using a different novel verb. A complete list of the causative events and their accompanying contrast events is given in (5). Novel verbs were repeated twice during each familiarization sequence, for a total of ten presentations each.

(5) Familiarization and contrast events

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

In the test phase of each trial, participants were shown two new events, presented simultaneously on opposite sides of the screen, and the auditory stimulus directed them to find the action labeled by the novel verb presented during familiarization. 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. One of the test events was a causative

*Flexible Extension of Novel Causative Verbs*

event that differed from the familiarization event in the means of causation (New Means test event) and the other was an event in which no causation occurred, but both the means and the result presented during familiarization were repeated (No Cause test event). In both test events, then, the result subevent was the same as that presented during familiarization, but in the New Means test event, the means by which that result was brought about was changed and in the No Cause test event, the means and the result subevents were both repeated, but they were no longer causally related. A schematic depiction of a representative trial, including specific examples of test events, is given in (6).

(6) Representative trial: Experiment 1, unaccusative condition

Phase	Left side of screen	Right side of screen	Audio track
Familiarization	girl bounces ball by hitting it with a racquet	black screen	Look! The ball is pimming. Do you see the ball pimming?
	black screen	girl bounces ball by hitting it with a racquet	Wow! The ball is pimming. Do you see the ball pimming?
	girl bounces ball by hitting it with a racquet	girl bounces ball by hitting it with a racquet	Yay! The ball is pimming. Do you see the ball pimming?
Contrast	(centered) girl waves ball from side to side		Oh no! Now the ball is not pimming. The ball is not pimming.
Familiarization	girl bounces ball by hitting it with a racquet	girl bounces ball by hitting it with a racquet	Yay! Now the ball is pimming. Do you see the ball pimming?
Test	<u>New Means</u> girl bounces ball by hitting it with her hand	<u>No Cause</u> girl waves racquet but does not hit ball; ball bounces	Oh look, they're different. Do you see pimming? Do you see pimming? Where's pimming now?

Stimulus videos were presented on a projection screen suspended from the ceiling of a dark room. Participants were tested individually, seated approximately six feet from the screen, and were free during the experiment to sample the contents of the entire screen. Attention to the stimuli was recorded using a digital video camera situated just below the screen, and these recordings were coded for direction of the participant's visual fixation during the test phase. An ANOVA was performed to test for differences in mean visual fixation to the New Means and No Cause test events across experimental conditions.

## **1.2. Results and Discussion**

In essence, the goal of this experiment is to find out whether two-year-old children would be more willing to extend the meaning of the novel verb presented during familiarization to refer to an event that is of the same event type as the familiarization event (i.e. a causative event), but that differs in the semantic content of the means subevent, or to an event that is of a completely different event type than the familiarization event (i.e. not a causative event), but that matches the familiarization event in perceptually salient ways. The relevant question to ask when examining these data, then, is which of the test events participants were willing to accept as an extension of the meaning of the novel verb presented during familiarization. Previous studies using the preferential looking paradigm have shown that children tend to look longer at a scene that matches the speech stimulus. In this experiment, then, we expect participants to look longer at the test event that they were willing to label with the novel verb presented during familiarization.

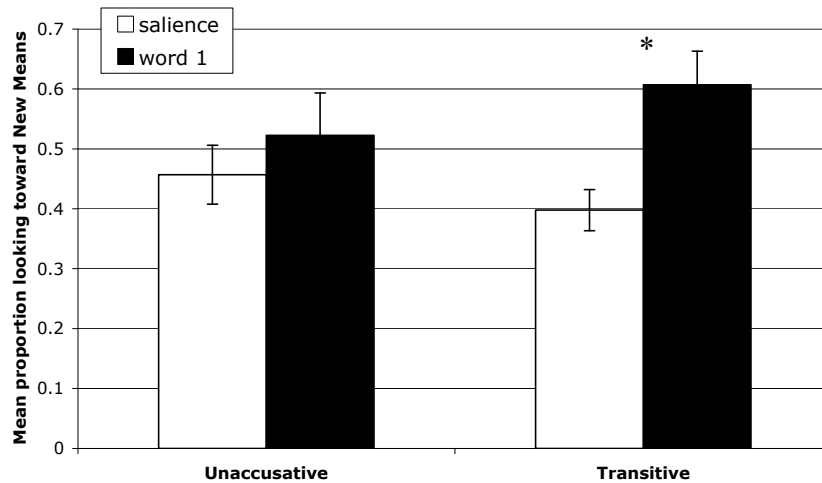
Previous work in syntactic bootstrapping has demonstrated, furthermore, that the meaning that two-year-old children assign to a novel verb is heavily influenced by the syntactic frame in which that novel verb is presented. Given this effect, we expect to find differences in patterns of looking across conditions that reflect the mapping between verb meaning and verb syntax.

The figure in (7) depicts the mean proportion of looks by participants in each condition toward the causative New Means test event. Data are presented from a two-second salience period at the beginning of the test phase and from a two-second window around the first mention of the novel verb in the test audio. During the salience period, participants have not yet heard the novel verb repeated, and so looking patterns during this time just reflect baseline preferences for the two test events. Looking patterns around the first mention of the novel verb, on the other hand, should reflect the interpretation that participants have assigned to it.

## Flexible Extension of Novel Causative Verbs

### (7) Mean visual fixation at test: Experiment 1

\*In the transitive condition, attention to test events was significantly different during salience vs. at the first mention of the novel word in the test audio.



When asked to find the test event that could be labeled by the novel verb presented during familiarization, participants in the unaccusative condition showed no significant preference for either test event ( $p=0.45$ ). This result is not surprising if we consider that in English, the verb in an unaccusative intransitive frame invariably labels the result of a causative event: compare the novel verb *pimming* (8a) to the verbs in (8b), each of which we understand as a description of some change of state being undergone by the ball.

- (8) a. The ball is pimming.  
b. The ball is bouncing/spinning/rolling.

In this experiment, the result subevent presented during familiarization was present in both of the test events, and so both of the test events should have provided an adequate match for the novel unaccusative verb. We can take the lack of preference in this condition, then, as a sign that these participants interpreted the novel verb presented in an unaccusative intransitive frame as a label for just the result of a causative event.

Participants in the transitive condition, on the other hand, showed a significant increase in their preference for the causative New Means test event when asked to find the referent of the novel verb ( $p=0.004$ ). Note that unlike the unaccusative frame, a transitive frame does not provide an unambiguous cue for the meaning of a novel verb (9a): the verb in a transitive frame can label either just the means subevent of a causative, like *hit* (9b), or it can label an entire causative event, like *dribble* (9c).

- (9) a. The girl is pimming the ball.  
b. The girl is hitting the ball.  
c. The girl is dribbling the ball.

The preference that participants in this experiment show for the New Means test event, then, can be taken as further evidence that children of this age are biased to interpret verbs in a transitive frame as causatives (Lidz et al. 2003). Note, however, that participants chose to extend the meaning of the novel verb to include causative test events that differed from the familiarization events in the means by which that causation was brought about. This suggests that children of this age permit some flexibility in the semantic content they assign to the means subevent of a causative representation.

## 2. Experiment 2: Result Subevent

In Experiment 1, we observed that two-year-olds grouped two of the subparts of a causative representation together, i.e. the cause and result subparts, when extending the meaning of a novel transitive verb, and that they allowed for flexibility in the identity of the means subevent. What we didn't know was 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. If so, this might suggest that what they've learned about these verbs is that they label causative events of some type, with no commitment to the identity of the means or the result subevents. The goal of our second experiment was to explore this possibility by investigating two-year-olds' flexibility in encoding the semantic content of the result subpart of a complex causative.

### 2.1. Design

A total of 24 two-year-olds (six boys and six girls in each experimental condition) ranging in age from 22;12 to 25;25 (mean 23;28) participated in Experiment 2. All were being raised in English-speaking homes, and none had participated in Experiment 1.

This experiment also employed the preferential looking paradigm. Participants were presented with exactly the same causative familiarization events accompanied by novel verbs that were used in Experiment 1, and at test they were asked to determine which of two new events could also be labeled by the novel verb. Experiment 2 differed from Experiment 1 in two ways: first, in the syntactic frames used to present novel verbs during familiarization, and second, in the combinations of subparts of the familiarized causative event that were repeated in the test events.

In this experiment, participants were assigned either to an unergative condition in which they heard the novel verb used in an unergative intransitive sentence like *The girl is pimming* or to a transitive condition in which they heard the novel verb used in a transitive sentence like *The girl is pimming the ball*.

*Flexible Extension of Novel Causative Verbs*

Recall that in Experiment 1, both test events included the same result subevent presented in the familiarized causative, but they varied in whether that change of state was caused or not. In Experiment 2, both test events include the familiarized means activity, but they vary in whether that activity is still a means of causation. Participants were given the option of extending the novel verb to refer either to a causative event that differed from the familiarization event only in the change of state undergone by the object (New Result test event) or to the same No Cause test events that were presented in Experiment 1. Specific examples of the test events that would follow the causative *pimming* event detailed in (6) are presented in (10).

(10) Test events: Experiment 2

Phase	Left side of screen	Right side of screen	Audio track
Test	<u>New Result</u> girl deflates ball by hitting it with the racquet	<u>No Cause</u> girl waves racquet but does not hit ball; ball bounces	Oh look, they're different. Do you see pimming? Do you see pimming? Where's pimming now?

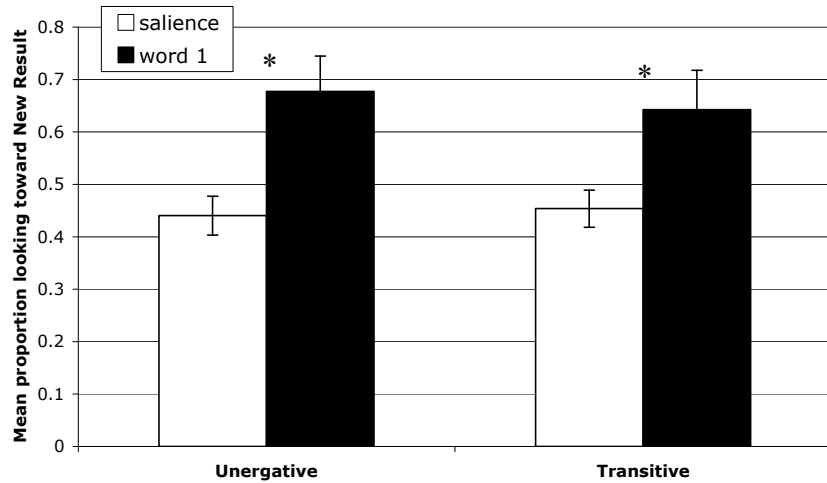
As in Experiment 1, attention to the stimuli was recorded using a digital video camera, and these recordings were coded for direction of the participant's visual fixation during the test phase. An ANOVA was performed to test for differences in mean visual fixation to the New Result and No Cause test events across experimental conditions.

**2.2. Results and Discussion**

Complementary to that of Experiment 1, the goal of Experiment 2 was to find out whether two-year-old children would be more willing to extend the novel verb presented during familiarization to refer to an event that is of the same (causative) event type as the familiarization event, but that differs in the semantic content of the result subevent, or to an event that is of a completely different event type than the familiarization event (i.e. it's not a causative event), but that matches it in easily observable ways. Again, our general prediction is that participants will look longer at the test event that they are willing to label with the novel verb presented during familiarization.

(11) Mean visual fixation at test: Experiment 2

\*In both conditions, attention to test events was significantly different during salience vs. at the first mention of the novel word in the test audio.



The graph in (11) depicts the mean proportion of looks toward the causative New Result test event during a two-second salience period and in the two seconds around the first mention of the novel word in the test audio. The results show that when asked to find the test event that could be labeled by the novel verb presented during familiarization, participants in both the unergative ( $p=0.005$ ) and the transitive ( $p=0.03$ ) conditions showed a significant preference for the causative test event. This suggests 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. Recall, moreover, that these two-year-olds chose to extend the meaning of the novel verb to include causative test events that differ from the familiarization events in the change of state induced by the causative agent. This suggests that children of this age permit some flexibility in the semantic content they assign to the result subevent of a causative representation.

**3. Conclusions**

Taken together, the results of these two experiments give us some initial insight into the categories of events that a novel verb can be extended to include. This study confirms, first, that two-year-olds can use cues from syntax to identify and label the subparts of an internally complex causative event. In Experiment 1, for example, when participants heard the novel verb in an unaccusative frame, they understood it to refer to just the result subevent of the complex causative, but when they heard it in a transitive frame, they understood it to refer to the entire causative event.

Our results suggest, furthermore, that two-year-old children are limited in the way that they can map verb meanings onto structural representations of events,

such that verbs can only encode subparts of the representation that correspond to possible structural representations. Recall that across both experiments we never saw an overall preference for the No Cause test events, in which the means and result subevents were repeated but were not causally related. This demonstrates that these participants were unwilling to extend the novel verb to refer to an event that includes subparts of the familiarization event that are not constituents.

Interestingly, however, we find that as long as that structural constraint is satisfied, two-year-olds can be flexible in the specificity of the semantic content they assign to their representation of the causative. What we've done in these experiments essentially is to ask these two-year-olds to extend a novel verb to refer to an event that conflicts with the familiarized causative in one of two ways. They have the choice of extending the verb to refer either (i) to an event that is still of the same conceptual type as the one presented during familiarization, i.e. one that is still a causative, but that differs in the identity of the means or result subevents, or (ii) to an event that is perceptually similar to the familiarized event, i.e. one that includes the same subevents, but that is of a different event type. What we have found is that they are willing to loosen their commitment to the semantics of an event, i.e. in what they will permit as the means or the result subevent of a causative, but not to the kind of event representation they have assigned to the verb, i.e. they still represent the meaning as causative. This kind of flexibility would be an extremely powerful tool for word learning, allowing children to refine their hypotheses about the meanings of words they are acquiring as they encounter new information about them in the world.

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Ann Bunger and Jeffrey Lidz

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