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Abstract

An important question in verb learning is how children extend new verbs to new situational contexts. In Study 1, 2 1/2-year-old children were shown a complex event followed by new events that preserved only the action from the initial event, only the result, or no new events. Children seeing events that preserved either the action or the result produced appropriate verb extensions at test while children without this information did not. In a follow-up study, children hearing new verbs produced more extensions than did children hearing nonlabeling speech. These studies suggest that attention to related events is helpful to young verb learners, perhaps because they structurally align these events (e.g., Gentner, 1983; 1989) during verb learning.

Attention to Multiple Events Helps Two 1/2-Year-Olds Extend New Verbs

A hallmark of language acquisition is the ability to be productive in one's native language, including the ability to appropriately use words in situations other than those in which they were learned. Previous research examining children's ability to extend words to new referents has focused mainly on their extensions of nouns (e.g., Booth & Waxman, 2002; Graham, Williams & Huber, 1999; Landau, Smith & Jones, 1988; 1998) with relatively few experimental studies examining young children's extensions of new verbs (e.g., Behrend, 1990; Forbes & Farrar, 1993; Forbes & Poulin-Dubois, 1997; Huttenlocher, Smiley & Charney, 1983; Maguire, Hirsh-Pasek, Golinkoff & Brandone, 2008). In addition, a common finding in studies of early verb learning is that children are fairly conservative in the extent to which they extend verbs (e.g., Forbes & Poulin-Dubois, 1997; Huttenlocher et al., 1983; Tomasello & Brooks, 1998). Thus, an important question is how children learn how to extend new verbs to new situational contexts. The present paper examines how attention to information available across situations that are linked to a particular new verb helps children deduce how to extend that verb to new situational contexts in the future.

For example, consider an event in which an object is moving up and down. This event can be referred to by several different verbs in English including *jump* and *bounce* (for humans, the agent needs to be on a flexible surface). The verb *jump* should not be applied to a similar action performed by a human agent using only one foot (*hop*). On the other hand, *hop* can be used to describe an action performed with two "feet" if the agent of the action is a rabbit or kangaroo. A child learning English must be able to extend verbs (e.g., *jump*) to include other objects or similar actions (e.g., extend *jump* to the action of a four legged animal jumping through a hoop or over a bar), while excluding an extension of the verb to similar actions referred to by a different verb (i.e., *hop*).

Given the difficulty faced by new language learners in determining how to extend a new verb, it is perhaps not surprising that children are often fairly conservative in their verb extensions. Two older studies suggest that two-year-old children initially use a new verb to refer to their own actions (Huttenlocher et al., 1983; Roberts, 1983) and only later extend it to include the actions of other agents. Forbes and Farrar (1993) found that three-year-olds were more conservative in their extension of newly learned verbs than were older children and adults, particularly in terms of extending verbs to events with different instruments. More recent evidence using a preferential looking paradigm shows some ability to extend verbs in 20- and 26-month-old toddlers, but the extensions by the youngest toddlers were only to changes in agent (Forbes & Poulin-Dubois, 1997). Interestingly, the 26-month-olds extended verbs to changes in manner as well (the way the action is unfolding) but not to changes in outcome (result). This pattern fits with those in Behrend (1990). In that study, three-year-olds who were asked to extend a new novel verb to events with changes in instrument, action or result exhibited a 'result verb bias'. That is, they responded as if the result of the event was more important to a new verb's meaning than were other aspects of the event. Overall, these studies suggest that young verb learners are conservative verb extenders. Children in these studies show some ability to extend new verbs but the basis for these extensions is still relatively unclear.

One way children could approach the problem of verb extensions would be to use the information that is available to them if they attend to a range of events in which a single new verb is heard. The view that children use cross-situational information in verb learning is not new (e.g., Fisher, Hall, Rakowitz & Gleitman, 1994; Pinker, 1989). For example, Behrend (1995) states that "It should be obvious that despite children's awesome fast-mapping capabilities, true verb learning probably takes place in most cases across a number of verb-event pairings" (p. 258). Pinker (1989) suggested that children use "semantic structure hypothesis testing." In this view,

while seeing an event and hearing a verb for the first time, children entertain as many hypotheses as possible, eliminating or adding meaning based on their experience with that verb across situations. Although this in an interesting idea, this view is not a theory that describes how situations are compared to each other cognitively. In fact, although it is widely believed that children use cross-situational information in verb learning, no current theory of verb learning explains exactly how they may do so.

The few studies of verb extensions that have been completed have proceeded largely without a clear theoretical basis, with a focus on exploring children's ability to extend verbs and the potential role cross-situational information may have. These studies have relied on children who are at least three years old and have used videotaped events with pointing or yes/no responses at test. Specifically, in Forbes and Farrar (1995), 3-year-olds, 10-year-olds and adults were shown videotaped novel events that had agent, instrument, manner and outcome components. Participants then saw the same event repeated three times (*same condition*), they saw three different versions of the event (*different condition*) with a change in a single component (e.g., agent change), or they saw three versions of the event in which every component was changed (*mixed condition*) except a single component (e.g., only the agent held constant). At test, participants were asked whether the new verb could be generalized (e.g., "Was that *verb*ing or was that something else?") to an event with a particular change (e.g., agent change).

In this study, 3-year-olds in the *same* and *different* conditions were more influenced by the training conditions than were children in the other age groups. Specifically, 3-year-olds who were given little cross-situational information (*same* condition) mostly resisted extending a new verb to new events (extending only to changes in manner) while 3-year-olds who had access to cross-situational information (*different* condition) were more willing to extend new verbs to new events (extending to changes in agent, instrument, and outcome).

A second study (Behrend, 1989 in Behrend, 1995) included 3-, 5-year-olds and adults. Participants saw multiple examples of new verbs that were constructed such that either the action, instrument or result varied. Thus, as in the Forbes and Farrar study, children in this study who attended to multiple events could learn that variation of one component was acceptable. In this study, even the youngest children could learn to accept variation in actions and results (but were not as attentive to instruments), and the ability to make this inference (i.e., changing components are not essential to that verb's meaning) increased with age. In addition, there appeared to be a trade-off between results and actions with children initially assuming that results were important to verb meaning unless the result varied; in this case, they assumed that that action was crucial to verb meaning. In general, Behrend's results mirrors the results from the *different* condition in Forbes and Farrar (1995) and can be predicted by an account in which children compare events to each other.

Although Forbes and Farrar (1995) and Behrend (1995) provide important information about the role of variation in children's construction of verb meaning, because both relied on responses to videotaped events this meant that the experimenter had to decide in advance which possible verb representations were appropriate and depict those for the child. In addition, because both included 3-year-olds as their youngest age group, it is unclear whether children younger than three can make use of cross-situational information in verb learning. Furthermore, neither includes an account of how the child might be locating the changing component across events (an issue explored further in the General Discussion).

In a third set of verb studies, children (4-, 5-, 7.5-year-olds) and adults were taught novel verbs that referred to either a manner or an end state (Gropen, Pinker, Hollander & Goldberg, 1991). Specifically, following an initial event accompanied by a neutral sentence (e.g., "Let me show you what keating is"), participants were given contrastive information ("Now let me show

you something that's not keating") and then were then asked to enact both events before test (the one labeled as 'keating' and the one labeled as 'not keating'). At test, they were given the original objects and asked to act out the verb again while the experimenter used prompts to elicit names for the objects in the event. Thus, the dependent measure concerned the verbal productions participants made. A main finding was that the type of verb (manner or end state) and the test question both influenced the objects participants chose to name in their productive sentences. A limitation of these studies is that the specific verb meanings children may have entertained are only hinted at by the nouns they highlighted in their productions. In addition, the way these meanings were shaped by the experience with the contrastive event could be clarified.

Gentner's structural-alignment hypothesis (e.g., Gentner, 1983; 1989; Gentner & Markman, 1994; 1997) provides a testable account of how information across contexts could be compared. In this view, an observer compares two contexts to each other by analyzing objects and their relations in one scene and then by seeking out objects in the second scene that participate in the same relations. For example, given a scene in which a truck is towing a car, an observer comparing that scene to a new scene in which a car is towing a boat would seek out objects in that second scene in terms of the relations and roles those objects play. Thus they would relate the initial object doing the towing (truck) with the object in the second scene that is fulfilling the same relation (the car in the second scene) (Gentner & Namy, 2006; Markman & Gentner, 1993). The result of this alignment process is a highlighting of the common relational structure between the two events (Gentner & Markman, 1997). Given the importance of attending to relational structure for understanding events, a process that highlights this information seems especially well suited to the problem of learning new verbs.

Gentner's view provides clear predictions that the child should attend to objects and relations, that they should align events based on their common relational structure, and that their

understanding of verb meaning should become more refined as they have more events to compare. However, this specific cognitive view of how children could compare events has not been applied to verb learning to date.

The goal of the main study was to examine whether children younger than three use information that is available from sets of related events, and whether this information helps them extend verbs in appropriate ways. In addition, we examine whether the pattern of results seen in this new set of studies is consistent with predictions one could make using Gentner's structural alignment account. To do so, we created initial complex events that were followed by simpler events that preserved only the action component or the result component of the initial event. The action component of the event included "the physical movement of an agent without … the result of that movement" (Behrend, 1990); successive events were designed to show only the action seen in the target event without accomplishing the same result as the target event (see Figure 1). Thus, after an initial complex event, 3 new events showed either only the action of that initial event or only its result. At test, children were given new objects that they could use to imitate us, to extend the action using a new object or to extend the result (see Appendix for a complete list of stimuli). In this study, we predict that children who are able to compare events, perhaps using structural alignment, will preserve those elements that are consistent across the events in their enactments at test while children who are not given the opportunity to compare events will be more imitative, extending the new verb less often. Study 2 is a follow-up study that examines the role the verb itself plays in the processing of multiple events. In this study we predicted that children's responses would differ in a verb condition compared to a no verb condition because the verb serves as a signal to compare events and because the process of extension is specific to extending new verbs and not merely related to processing the events themselves.

It would be possible to investigate these questions using children's looking or pointing behavior as the dependent measure. However, these procedures would require us to create examples of events at test that could correspond to children's event understanding. Instead, we presented children with a fairly difficult task knowing that if they creatively produced enactments using new objects these responses would provide particularly compelling evidence of the nature of their underlying verb representations.

Study 1

Method

Participants. Thirty-six 2 1/2 year old children participated in this study (range: 2;4-2;10, mean age = 2;7) with 18 girls and 18 boys. Twenty-six participants were Caucasian, nine were Hispanic or Latino, one participant was African American and another participant was Asian. Four additional children did not complete the study and four were excluded due to experimenter error. Using a list provided by a direct mail marketing company, most potential participants were first contacted by mail and then by telephone. Families contacted by telephone who expressed an interest in participating in the study were scheduled in an on-campus developmental laboratory. A few children were recruited through nearby day care centers.

Children in these studies lived in a south central region of the United States, and were mostly from middle-class or upper-middle-class families. Across studies, parents reported that their children's language exposure was predominately English. They were asked to complete selected portions of the MacArthur-Bates Communicative Development Inventory: Words and Sentences (Fenson, Dale, Reznick, Bates, Thal, & Pethick, 1994) to provide an estimate of the child's language development. In Study 1, the mean number of action words children produced was 69 words (of 103; range: 3- 103; n= 23). The mean length of longest sentence (MLS) was seven words (range: 2-13 words; n= 20). To examine whether children who were reported to

produce fewer verbs differed from children who were producing many verbs, we divided our sample into 'low vocabulary' or 'high vocabulary' groups based on a median split. In both studies, preliminary analyses with Vocabulary (high, low) as a between-subjects factor revealed no significant difference between these groups.

Materials. Four novel complex events were constructed and a novel verb (*tam, pilk, meek, gorp*) was randomly assigned to each event before the study began. Each novel complex event was created to include both an action component and a result component. A separate set of objects was used to show a series of related events depicting either consistent actions (with variations in results) or consistent results (with varying movements). A third set of stimuli including objects that could be used to preserve the action component, preserve the result component, or imitate the adult, was given to the child for his/her own enactment of the event at test (see Appendix). All of the events were designed as prototypical events (e.g., Slobin, 1981) in that they all had an animate agent (the experimenter or child) who acted on an inanimate patient (e.g., an egg).

For example, in one event, a watermelon was rolled through a flap on top of an opaque box and disappeared into the box (see Figure 1). The action component of this complex action was the melon's rolling, the result was that the melon disappeared from view. In the three action events the melon was shown rolling down a wooden incline, rolling down a curved pipe, and rolling down a foil tube; in all of these events the melon was visibly present at the end of the event and thus the result of disappearance was not present. The three result events consisted of covering the melon with a pom-pom, putting the melon into a small drawer in a miniature dresser and putting the melon into a cloth bag. Each of these resulted in the disappearance of the melon without the rolling action. At test children were given the opaque box and melon which could be used to imitate the initial complex event, a new ramp which could be used to enact the rolling

action, and a piece of cloth which could be used to make the melon disappear from view (see Figure 2 and Appendix).

Insert Figures 1 and 2 about here

Design and Procedure. Each child was randomly assigned to either a Control group, an Action group or a Result group, with 12 participants per group. In each group, each participant learned four new verbs. The order of the verbs was randomized by allowing the child to choose one of four identical boxes for each verb with no verb repeated a second time.

Each new verb was presented in a block of trials that included a teaching phase and a test phase. In the teaching phase, the experimenter began by enacting the target action while producing a novel verb in an impending action frame, an on-going action frame and a completed action frame (e.g., "Look! I'm going to <verb> it. I'm <verbing> it. I <verbed> it."). These frames were chosen to attract children's attention to the event, to comment on the action during the event, and to comment on the result or completed action. The set of three sentences with the enactment of the target event was repeated a second time. After this initial phase, children were given a chance to enact the event and say the new verb (e.g., "Now it's your turn to play. Can you say <verb>?").

Following the child's enactment, the experimenter either repeated the target action six more times (Control group) or enacted three new events that were related to the target action. These new events either maintained the movement component of the target event (Action group) or the result (Result group). When demonstrating each new event, the experimenter produced a set of three sentences (e.g., "Look! I'm going to <verb> it. I'm <verbing> it. I <verbed> it.") while performing the event once and then repeated these three sentences while she demonstrated

that event a second time. All children heard each novel verb a total of 24 times before the test phase.

In the test phase, the experimenter put new objects in front of the child and asked the child to enact the event (e.g., "It's your turn to play. Can you <verb> it?"). Each test set of objects included the apparatus used in the target event, a new object that could be used to enact the action, and a new object that could be used to produce the result (see Appendix). The length of response time at this point was child controlled and children could perform multiple enactments. During these enactments, the experimenter asked the child to produce the verb (e.g., "What are you doing?"). Once they signaled that they were finished, which they did by stopping their enactments, the experimenter retrieved the test objects and then imitated the final enactment performed by the child while asking the child to produce the verb again (e.g., "Now look. What am I doing?"). These two elicited production questions were used because it may be easier to produce a verb if children are not having to enact the event simultaneously (Childers & Tomasello, 2002; 2006). Once a child had acted on the objects in some way, and had been asked to produce the verb, we gave the child one more chance to perform a new action, which was also child controlled and could include multiple enactments (e.g., "You get one more turn. Can you <verb> again? How else can you <verb> it?").

The teaching and test phase formed a single block of trials. The process was repeated until children had completed a block of trials for each of the four novel events.

Coding. Children's enactments were coded into one of four main categories of response. Responses in which children used the target apparatus and performed the target action were coded as Target responses. Action responses were responses in which the child used new objects and performed the same movement as seen in the Target event (and comparison events). Result responses included any response in which children used a new object to accomplish the same

result that was produced in the initial complex event (and comparison events). There were specific new objects provided at test that were designed to facilitate Action and Result responses. However, we did not exclude responses that demonstrated the action or result but did not include test objects in the way that we had envisioned. Children had to demonstrate the same action or result as they were shown in the training phase, and had to make use of new objects they had not seen the experimenter act upon, but could make use of the "wrong" objects to do so. At the same time, there were innumerable actions children could make with these objects that did not imitate, preserve the action or preserve the result. Any irrelevant responses (e.g., throwing an object across the room) were coded as Other.

In Study 1, following one or both test questions, children produced a single response one or more times 66% of the time and produced two different responses 34% of the time. As children varied in the total number of responses they made, we converted their responses into proportions before performing statistical analyses. For each event and each child, we divided the total number of each type of response (e.g., total Action responses) by the total number of responses of all types (e.g., Target + Action + Result + Other). For example, if a child performed two Target responses and two Other responses, their proportion of Target responses would = 0.50 (2 Target/ 4 total responses).

A live observer created a written record of children's responses during the experimental session. A second independent observer who had not served as the experimenter or observer in the original experimental session, and did not have access to the original coding sheets, coded each participant's responses from videotape. The responses from the second coder were used in the analyses, unless the experimental session could not be coded from tape (e.g., the camera failed to record some or all of a child's actions; n = 3 participants in this study). To assess interrater reliability, a third independent coder, who had not seen the experimental session or other coding

sheets, coded a randomly selected sample of 25% of the participants from videotape. Interrater agreement in Study 1 was found to be 91% with a Cohen's Kappa =0.81.

Results

Preliminary analyses revealed that our 2 1/2-year-old children had difficulty learning four new verbs in a single experimental session (perhaps because multiple events were seen in the initial learning phase for each verb, making each learning phase somewhat lengthy). However, they did appear to perform well when we considered the first three verbs that were presented. Thus, in Study 1 and in the subsequent study, we examined their responses to the first three verbs they heard in the experiment, with different children learning different combinations of the four new verbs.

Three one-way ANOVAs with Condition (3: Control, Action, Result) as a between-subjects factor and the mean proportion of Target, Action or Result responses as the dependent measure were computed to examine whether each dependent measure varied by condition. The one-way ANOVA analysis with Target responses as the dependent measure revealed no significant differences for this response type between conditions. The one-way ANOVA with the mean proportion of Action responses as the dependent measure showed a significant difference between conditions, $F(2, 35) = 10.87$, $p<0.001$. Post-hoc tests with Bonferroni corrections for multiple tests revealed significantly more Action responses in the Action condition than in the Control or Result conditions (ps= 0.001). A similar one-way ANOVA with the mean proportion of Result responses as the dependent measure also was significant $F(2, 35) = 6.90$, $p=0.003$. Post-hoc tests with Bonferroni corrections revealed significantly more Result responses in the Result condition than in the Action or Control conditions, ps< 0.05 (see Figure 3).

Insert Figure 3 about here

We also examined children's responses as individuals by classifying each participant as a 'consistent action' or 'consistent result' responder (producing Action or Result responses for at least 2 of the 3 novel verbs), or as a 'consistent target' (producing at least 2 Target responses for at least 2 of the verbs) or 'inconsistent' responder (producing fewer than 2 of any type of response consistently across trials) (see Table 1). All of the children could be classified into one of these two categories. A Pearson chi-square analysis showed that across conditions these patterns differed significantly from chance, $\chi 2$ (df = 2, n= 36) = 7.25, $p< 0.03$.

Insert Table 1 about here

In addition to analyzing children's enactments, we also examined our participants' verbal productions. Only children's spontaneous utterances were considered; all direct imitations of the experimenter were excluded. This examination showed that a similar number of children in each condition produced at least two of the three novel verbs in some form (8/12 in the Control condition, 7/12 in the Action condition and 7/12 in the Result condition). Much of the time these utterances were produced during the learning phase of the experiment. The number of responses including the novel verb following the self question ("What are you doing?") and the experimenter question ("What am I doing?") were similar in each condition.

Table 2 shows the number of children in each condition who produced either no utterances with any of the novel verbs, productions that included only the verb by itself (e.g., "tamming"), and productions that included at least one of the novel verbs with one or more additional words (e.g., "Meek it." "I tam it!"). All children who produced no utterances that included a novel verb had other verbal productions during the experimental session. This table shows that 26 of our 36

participants produced at least one of the novel verbs in combination with other words and shows that the patterns of production were similar across conditions.

Insert Table 2 about here

Discussion

The parametric analyses show that, as predicted, the types of events children were shown influenced whether they could extend the verb in their enactments using new objects, and influenced the way in which the verb was extended. Children who were shown multiple events that preserved the action produced more Action responses than did children in any other condition, while children shown events that preserved result produced more Result responses than did children in any other condition. Children in all three conditions also produced imitative (Target) responses, which is not surprising. Many previous studies suggest that normally developing children (e.g., Huttenlocher et al., 1983; Tomasello & Brooks, 1998) as well as children with Specific Language Impairment (Jones & Conti-Ramsden, 1997) have difficulty extending verbs to new contexts. Given that we initially labeled the target event with the novel verb, demonstrating the target event in response to the novel verb is a completely appropriate (but conservative) response. In the Control and Action conditions, children also produced some Result responses, but did not produce as many of these as was seen in the Result condition.

Furthermore, children's responses as a group were reflected in the patterning of individual children's responses at test. Children who saw only the Target event either produced an inconsistent pattern of responding or imitated the Target event. Children who were shown multiple events that preserved either the action or result present in the initial event were able to extend the verb to include new objects, and were able to do so for two of three novel verbs. This

rate of extension is important given the young age of these children, the presence of new objects at test that had not been manipulated by the experimenter, and the requirement that children perform extensions for more than a single new verb in the same experimental session.

Even though enactments varied between the experimental and control conditions, verbal productions in these conditions were similar. Across condition, almost 3/4ths of the sample produced these novel verbs in combination with other words. Many of these utterances were produced during the learning phase of the study and there were no clear differences between questions focused on the child's actions as opposed to the experimenter's actions at test.

Given the clear differences in children's extensions of actions or results to new objects across conditions, the results in Study 1 begin to provide empirical evidence to suggest that children as young as 2 1/2 can use information available in successive events to guide their verb extensions. However, children who see events that follow each other and are similar to each other may spontaneously compare them. Thus, Study 2 is a follow-up study that examines whether the presence of a verb influences children's processing of events. In verb learning, it would be most useful for children to wait for events that a speaker refers to using the same new verb because that verb should signal that the new event would add information about the new verb's meaning. If hearing a repeated verb serves as a signal (or 'hint') that comparison is appropriate, children hearing verbs should produce fewer imitative responses and more responses that preserve the repeated element than do children who are not hearing the new verb. Studies of categorization (Gentner & Namy, 2000; Namy & Gentner, 2002) and adjective learning (Waxman & Klibanoff, 2000) have shown that labels influence children's comparisons of multiple (static) stimuli.

Study 2

Method

Participants. 24 2 1/2-year-old children participated in the study (mean age = 2;8; range: 2;4-2;10) with 11 girls and 13 boys. Seventeen of the participants were Caucasian, six were Hispanic or Latino, and one participant was African-American. Six additional children were excluded because they were extremely distracted, two were excluded due to experimenter error and one did not complete the experiment. Parents reported that their children were predominately exposed to English. The mean number of action words children produced was 82 (of 103; range: 21-103 words; n = 21); the mean length of longest sentence was 6.3 words (range: 2-12 words, n = 21).

Materials. The materials used in Study 2 were similar to those that had been shown in Study 1 (see Appendix).

Design and Procedure. Children were assigned either to a Verb or No Verb condition, with 12 participants per group. In this study, all of the children saw result events.

The Verb condition in Study 2 followed exactly the same procedure as used in the Result condition in Study 1. In the No Verb condition, during the presentation of the target event, the experimenter presented general language phrases (e.g., “See?” (impeding) “Look” (during the action) and (following the action) “Wow”). At test, in the No Verb condition children heard similar test questions as did children in the Verb condition (“It’s your turn to play. Can you do it? Can you play the game?” and “Can you do it again? How else can you do it?”).

The learning and test phase formed a single block of trials. The process was repeated until children had completed a block of trials for each of the four events.

Coding. Children’s enactments were coded in the same way as in Study 1. A live observer initially coded children’s responses during the experimental session, and the data were used only if the videotape could not be coded (n = 2 in this study). Interrater agreement, coded as for Studies 1 and 2, was 95% with a Cohen’s kappa = 0.90.

Results

As there were only two conditions in this study, three independent samples t-tests could be used to ask whether the mean proportion of Target, Result or Action responses varied by condition (Verb, No Verb). These revealed a significant difference in Target responses across the two conditions, $t(22) = 2.64$, $p < 0.02$ (2 tailed), a significant difference in Result responses across the conditions, $t(22) = 2.57$, $p < 0.02$ (2 tailed), and no difference in Action responses across conditions (these were rare in both conditions) (see Figure 4).

Insert Figure 4 about here

As shown for Study 1, the consistency of children's responses was examined and is shown in Table 3. We classified each participant as a 'consistent result' responder (producing Result responses for at least 2 of the 3 novel verbs), or as a 'consistent target' (producing at least 2 Target responses for at least 2 of the verbs) or 'inconsistent' responder (producing fewer than 2 of any type of response consistently across trials). All of the children could be classified into one of these categories. A Pearson chi-square analysis demonstrated that the proportion of children classified as 'consistent result' responders (as opposed to 'consistent target' or 'inconsistent' responders) was significantly greater in the Verb condition (83% of children) than in the No Verb condition (33% of children), $\chi 2$ ($df = 1$, $n = 24$) = 6.17, $p < 0.02$.

Insert Table 3 about here

Discussion

Children in the Verb condition produced more Result responses than did children in the No

Verb condition, and children in the No Verb condition produced more Target responses than did children in the Verb condition. In addition, children who heard verbs consistently produced responses that extended the result to new objects while children in a nonlabeling speech condition did not. Thus, these results suggest that hearing a verb does serve as cue to compare events.

General Discussion

The problem of verb learning is particularly difficult because verbs often refer to transient, dynamic events that unfold over time (e.g., Gentner, 1982; Gleitman & Gleitman, 1992; Tomasello, 1992). Moreover, children need to be able to extend new verbs to new situations to be productive speakers of a language. Attention to information available across multiple events could help children discern how to appropriately extend a new verb.

Gentner's theory of structural alignment (e.g., Gentner, 1983; 1989; Gentner & Markman, 1994; 1997) provides a theoretical explanation for how children make use of information across events. Specifically, in this view, observers compare events by aligning objects and relations across contexts based on the structure of the events. This search for alignments, taking into account the structure of the events, would help children learning verbs focus their attention both on those elements of events that are similar between situational contexts and on those that are free to vary. For example, children could align an object acting as an agent in one context with the agent in another context (or patient/recipient, instrument, etc.). Once one agent is aligned with another, properties of each agent could be compared to help the individual deduce whether the verb refers to the actions of particular types of agents (e.g., animate). Thus, as a particular verb is experienced in multiple contexts, additional alignments would reveal more and more information about the contexts to which that verb can be applied. Further studies that test whether children are structurally aligning successive events are needed, however the results in the present studies are consistent with this view.

In the present study, we investigated whether children younger than three-years-old could make use of multiple event information by asking them to extend a newly learned verb to include objects the experimenter had not manipulated. These studies show that children's verb extensions are influenced by the types of comparisons they are shown (actions or results), and show that children respond differently when hearing a verb than they do when hearing non-labeling speech. This new evidence adds to a small set of studies (e.g., Behrend, 1995; Forbes & Farrar, 1995; Gropen et al., 1991) that show that children can recruit information across related events during verb learning. The present studies are the first to show that children younger than three can compare successive events and that these comparisons can inform their extensions of new verbs.

The main finding that emerged in Study 1 was that the types of events that were available for comparison influenced children's subsequent enactments. This pattern is especially compelling because children had to use new objects in their enactments at test, and because similar patterns were found in both the action and result conditions. In addition, most children in all of the conditions verbally produced at least one of the novel verbs either by itself or in combination with other words. Thus children in the Control condition learned the novel verbs as well as did the children in the other conditions, but they did not spontaneously extend their meanings to include new objects at test.

Study 1 is similar to previous studies by Forbes and Farrar (1995) and Behrend (1995). In Forbes and Farrar, three-year-olds participated in a *same* condition, *different* condition or *mixed* condition. The *same* condition in their study is similar to the control study in Study 1; in both cases children saw no variation in the subsequent successive events. In Forbes and Farrar, children in the *same* condition showed more hesitation in extending verbs to new events. In our study, children in the control condition also were conservative in their responding, often

reproducing the event with the original objects. Thus, both studies support the view that children are conservative extenders in the absence of cross-situational information.

However, other conditions in Forbes and Farrar (1995) and Behrend (1995) were designed to demonstrate a single variation to the child and to discover whether three-year-olds could use that variation to assume that the varying component was not important to the verb's meaning. We approached our design of the successive events by asking whether children could attend to components that were consistent (see Akhtar & Montague, 1999, and Echols & Marti, 2004, for similar studies of consistency in adjective and noun learning respectively). Thus, the events in the action condition were designed to preserve the action of the initial event while allowing the result to vary (or at least producing a result that was different from that shown in the initial event). We predicted that children would make the same deduction as in the previous verb studies, that the component that varied was not important. At the same time, our dependent measure was whether children would reproduce those components that were consistent. Thus, the way we depicted related events differed from previous studies in important ways.

An account of verb learning in which children make use of information across multiple events, perhaps because they are structurally aligning and comparing events to each other, provides a good explanation for these findings. At the same time, the results in Study 1 do not reveal whether a similar attention to multiple related events would occur even without the presence of a new verb. One previous study (Forbes & Farrar, 1993) found little difference between a verb and no verb group. Thus, the results of Study 2 are important because they show that the ability to demonstrate extension responses at test is strongest when new verbs are heard. Even though children in the no verb condition were not responding randomly, there were two significant differences between children in this condition and children who heard new verbs: they produced more Target (imitative) responses and they produced fewer Result (extension)

responses. In some ways, it is remarkable that a difference emerged between these conditions given that both groups saw an experimenter perform related events, one after the other, from a single box of stimuli, and thus both groups had some powerful context cues that could promote comparison. That children hearing verbs benefited, above and beyond these context cues, testifies to the importance of hearing a repeated verb. At the same time, further studies are need to explore whether it was the repeated verb or whether any repeated word or other 'hint' would yield the same result.

There are several possible reasons why hearing a verb would promote the comparison of events. One is that a repeated verb could signal that it would be useful to compare the events. Children should be attending to this type of information because comparison requires a child to store some representation of an event, bring a remembered event to mind when seeing a current event, and note similarities and differences between these events. This process is somewhat costly and thus it would not be fruitful to perform if there was not some 'hint' that it is appropriate to compare two instances and draw conclusions based on that comparison. Moreover, previous studies of comparison in adults and children (e.g., Brown, Kane & Long, 1989; Gick & Holyoak, 1983) show that individuals are more successful in comparing across examples, and using the information derived from that comparison, when given explicit hints to compare. A repeated verb should be an especially useful cue to induce comparison in these studies because they concern the comparison of events.

Although these results are important, there are several issues to pursue in future research. One concerns the events themselves. Obviously some action had to be produced to create a result and some result followed each action. Thus, the action and result comparison events contain both action and result components and it is unclear exactly how children parsed these events (future studies are needed to explore this question). In addition, in these sets, the action comparison

events are very similar in their action components (as designed, see Figure 1) and also achieve similar results (although these results are different from the result in the initial event). In the result comparison events, children saw more variation in the actions along with their consistent results. For this reason, we might predict that the Action condition would produce the strongest results because the comparison events seem more similar in both the action and result components in this condition. However, it could be argued that children's result responses in the Result condition are the strongest result here (perhaps because children have a 'result verb bias', Behrend, 1990). Thus, in the Result condition, children overlooked this variation in actions and focused on the consistent result that they could reproduce using one of the new objects.

Another way of thinking about children's event processing is in terms of the experimenter's intentions. Children in these studies likely attended to cues to intentionality that were available as the experimenter intentionally produced the events. For some reason, for example in the Control condition in Study 1 and in the No Verb condition in Study 2, these cues to intentionality were not sufficient to help children produce creative responses at test in all conditions.

In addition, it is possible that children picked up on a single event presented in the comparison event set and only extended the verb to new objects using information from that event. However, in this case it is unclear why one would predict that hearing a repeated verb would matter (as seen in the results of Study 2). Furthermore, a pilot study comparing children's responses to seeing only a single comparison event to those seeing two or three comparison events provides suggestive evidence showing that children are less likely to extend the verb following a single event than they are in other conditions, though given the preliminary nature of these findings further studies of this type are needed.

Future studies also could examine how even younger children could use cross-situational information for informing verb extensions. However, the developmental period between two and three years is a time when many verbs are acquired (e.g., Bloom, 1993; Tomasello, 1992) and a period in which children appear to be extending verbs, at least in a limited way (e.g., Forbes & Poulin-Dubois, 1997). In addition, studies that include languages other than English are needed to show that this process is used by children learning other languages (see Childers & Paik, in press).

Finally, the experimenter is providing some consistency across events or objects that may be at a higher level of consistency than is found in everyday life. However, studies like these provide evidence to show that toddlers can use consistency across situations when it is available. Most studies of early word learning present the child with only a single object or sentence type from which to learn a word, and thus multiple contexts are not available. If children can take advantage of information gleaned across multiple situations, these consistencies could serve as an additional type of information children may use to solve the difficult problem of learning and extending a new verb. These studies show that children younger than three can take advantage of this information and that this information assists them in overcoming their conservative tendencies in verb learning.

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Table 1

Study 1: Patterns of Consistency for Individual Children by Condition

Condition	Inconsistent or Consistent Target	Consistent Action or Consistent Result
Control	11	1
Action	6	6
Result	5	7

Note: N = 12 per condition. Participants had to produce at least two consistent responses across two different novel verbs to be categorized as 'consistent action' or 'consistent result' responders. Two children were 'consistent action' and 'consistent target' responders. These were categorized as 'consistent action' responders as this was the more difficult pattern of responses to produce.

Table 2

Study 1: Children's Verb Productions by Condition

Condition	No Novel Verb Productions	Novel Verb Alone	Novel Verb + at least one other word
Control	1	0	11
Action	2	4	6
Result	0	3	9

Note: N = 12 per condition.

Table 3

Study 2: Patterns of Consistency for Individual Children by Condition

Condition	Inconsistent or Consistent Target	Consistent Result
No Verb	8	4
Verb	2	10

Note: N = 12 per condition. Participants had to produce at least two consistent responses across two different novel verbs to be categorized as 'consistent target' or 'consistent result' responders. Three children could be categorized as both 'consistent target' and 'consistent result' responders. These were categorized as 'consistent result' responders as this was the more difficult pattern to produce.

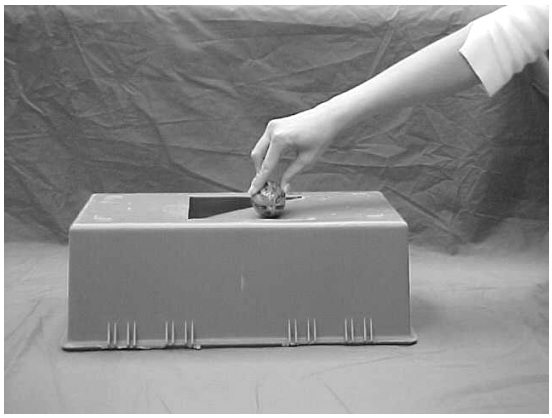
Figure Captions

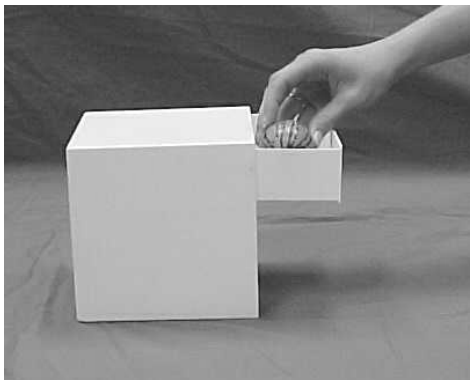
Figure 1. Example stimuli showing a Target event (top), Action comparison events (left column) and Result comparison events (right column).

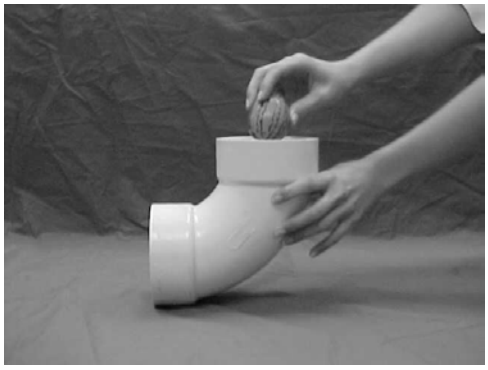
Figure 2. Example test objects.

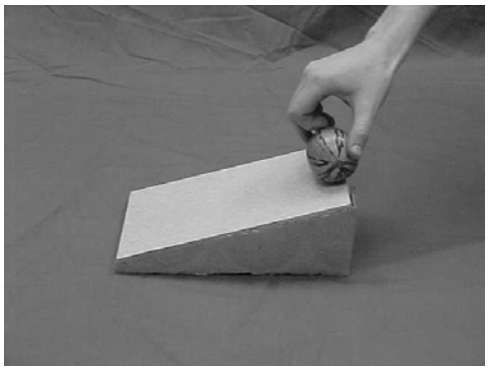
Figure 3. Study 1 Results.

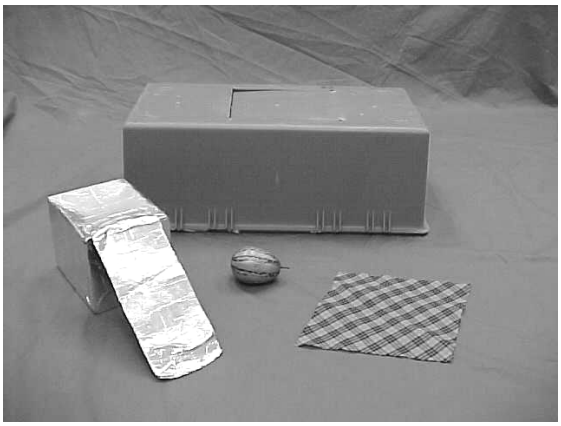
Figure 4. Study 2 Results.

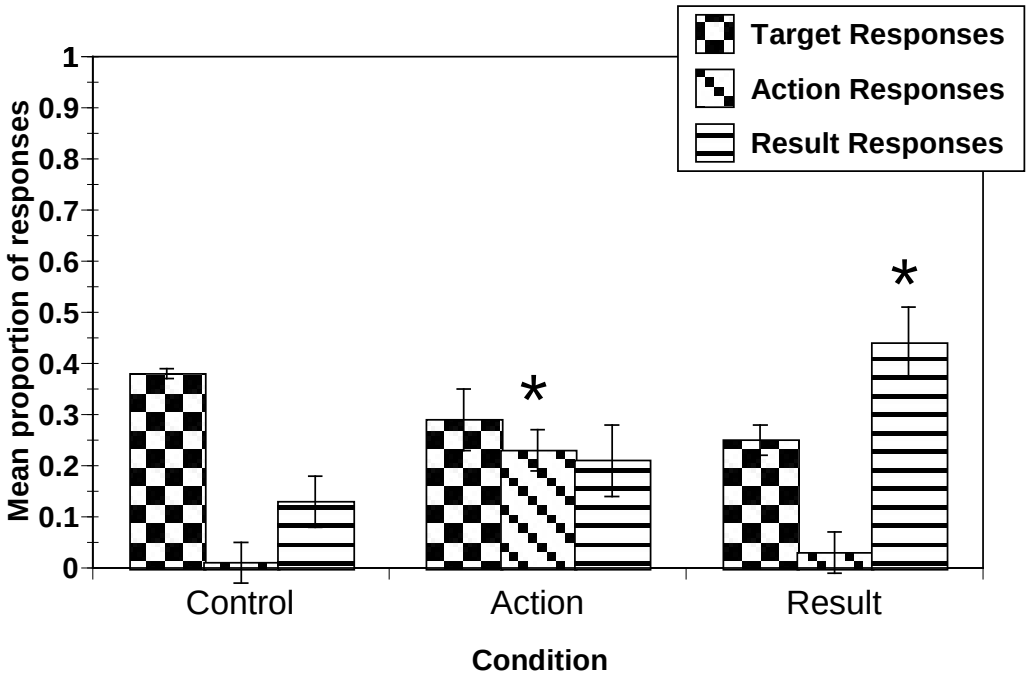


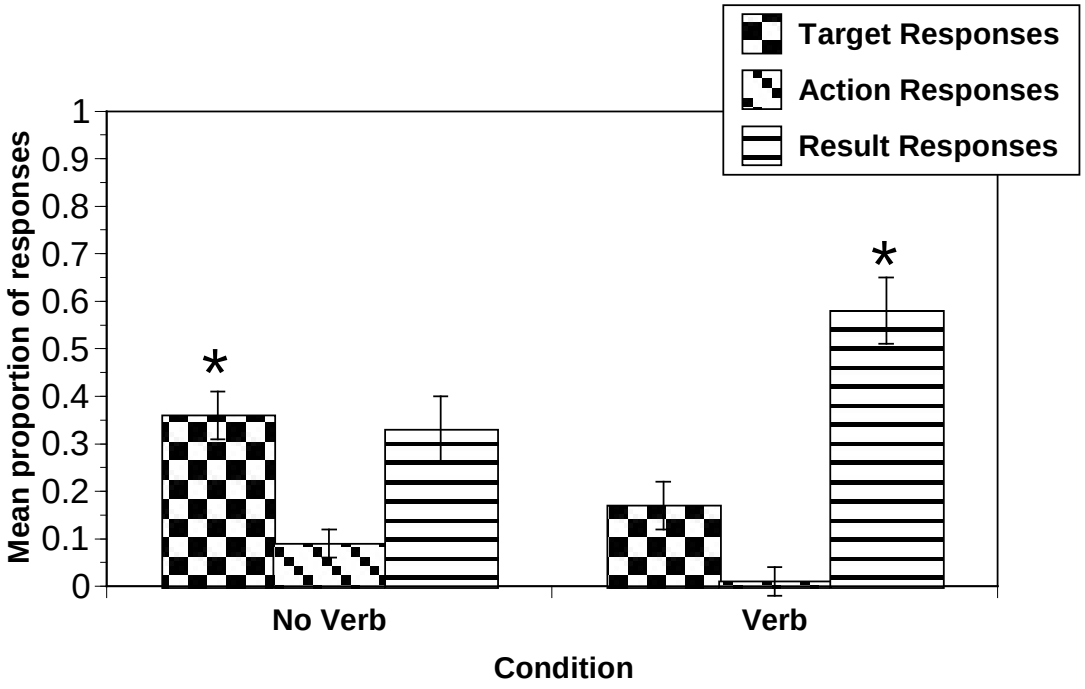









Target Responses
Action Responses
Result Responses
Mean proportion of responses
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
*
*
Control
Action
Result
Condition


Target Responses
Action Responses
Result Responses
Mean proportion of responses
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
*
*
No Verb
Verb
Condition

Appendix

Target Event: *tam*

fingers in a claw shape rake confetti (S2: spongy pieces) on ground

Action Events (shown in S1 only)	**Test Objects**	**Child actions, Coding**
clawed hand rakes a wall	confetti (pieces)	*raking of confetti*, T
clawed hand rakes a leg	S1 only: stuffed bunny	*perform raking motion (w/o bits)*, A
clawed hand rakes a stuffed tiger	S2 only: square of felt	*perform raking motion (w/o bits)*, A
Result Events	S1 only: round brush	*moving/displacing (without raking)*, R
confetti (pieces) moved using a paintbrush	S2 only: spatula	*moving/displacing (without raking)*, R
confetti (pieces) moved by scraping with shovel		
S1 only: confetti moved by pressing obj. that blows		
S2 only: confetti (pieces) moved by blowing with mouth		

Target Event: *pilk*

egg (S2: ladybug) is picked up out of plastic bucket and set on ground

Action Events (shown in S1 only)	**Test Objects**	**Child actions, Coding**
egg is picked up off of floor	plastic bucket, egg (bug)	*picking up and removing*, T
egg is picked up off top of plastic tower	inverted bowl	*picking up (without removing)*, A

egg is picked up off bottom of toy silo	S1 only: novel spoon	*removing (without picking up)*, R
Result Events	S2 only: toy wrench	*removing (without picking up)*, R
egg (bug) is removed by dumping it out		
egg (bug) is removed with salad tongs		
S1 only: egg is removed using a toy rake		
S2 only: egg (bug) is removed using sponge paintbrush		

Target Event: *meek*

S1: watermelon is rolled through a flap on opaque box and disappears inside the box

S2: ping pong ball is rolled down a tube and into a box

Action Events (shown in S1 only)	**Test Objects**	**Child actions, Coding**
melon is released at top of a wooden incline, rolls down	S1 only: orange box, melon	*rolling & hiding*, T
melon released at top opaque pipe, rolls down and out bottom	S2 only: tube with box, ball	*rolling & hiding*, T
melon released at top of foil tube, rolls out bottom	S1 only: ramp	*rolling*, A
Result Events	S2 only: binder	*rolling*, A
melon (ball) hidden under a pom-pom	piece of cloth	*hiding*, R
melon (ball) hidden in cloth bag		
melon (ball) is hidden in a drawer		

Target Event: *gorp*

top of a plastic hinged soda can crusher is opened (right to left) and then closed (left to right) to crush nerf ball

Action Events (shown in S1 only)	**Test Objects**	**Child actions, Coding**
top of a hinged binder swung open using hinge then closed	can crusher, ball	*opening & squishing*, T
lid of cardboard box is lifted off then put back on (no hinge)	S1 only: new hinged heartshaped box	*opening*, A
lid of hinged card file box is opened/closed	S2 only: rectangular cosmetic compact	*opening*, A
Result Events	large tinker toy	*squishing*, R
ball is squished with palm of hand		
ball is squished with bottom of foot		
S1 only: ball is squished by sitting on it		
S2 only: ball is squished with plastic lid		

Note. T = Target; A = Action response; R = Result response; S1 = Study 1, S2 = Study 2.