Default Values in Verb Frames: Cognitive Biases for Learning Verb Meanings

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ABSTRACT

Two experiments investigated children's and adults' initial mapping of verb meanings. In Experiment 1, subjects were asked to use a newly learned verb to label events in which the instrument, action, or result was different from the events used to teach the verbs. All subjects showed a bias to interpret the result as the most important component of the novel verbs' meanings, and this bias increased with age. In Experiment 2, either the instrument, action, or result of events was varied during training to test subjects' ability to override their default biases. When results were varied in training, 5-year-olds and adults, but not 3-year-olds, were more likely to use the novel verb to label an event in which the result was changed again. When results were varied in training, all subjects were less likely to use the novel verb to label an event in which the action was changed. These findings suggest that there is a default rule hierarchy for learning novel verbs, and that both default rules and the ability to override these rules when presented with conflicting information about the meaning of a verb are still developing during preschool.

INTRODUCTION

Children's learning of word meanings is best characterized as a rapid, "fast-mapping" (e.g. Heibeck & Markman, 1987) process that is directed at least in part by children's constrained hypotheses about what novel words mean. When learning nouns, for example, children assume that a novel noun is a label for an entire object (Markman & Hutchinson, 1984), rather than any of the many other logical interpretations that could be given to that word (e.g. Quine, 1960). Little, however, is known about children's initial mapping of verb meanings. Verbs differ substantially from nouns in their semantic structure and organization (e.g. Graesser, Hopkinson, & Schmid, 1987; Huttenlocher & Lui, 1979), and given that the learning of verb meanings has been strongly implicated in the acquisition of grammar (e.g. Pinker, 1984), understanding how children acquire verb meanings is an important empirical question with major theoretical implications. This paper examines what children assume a novel verb means upon their first exposures to that verb.

The theoretical framework used in this paper assumes that verb meanings are represented in an event schema such as a script (Schank & Abelson, 1976), or verb frame (Minsky, 1981). A verb frame has a number of placeholders, or "slots", which contain information that is carried in the verb's meaning. An important property of these slots is that they can be filled by a number of values, one or more of which may be more likely to occur or weighted most strongly in the representation. The slots in verb frames correspond to the components of

events which can be represented in a verb's meaning. Though there are many different types of information about events that can be represented in verb frames, only three types of information expressed in verb meanings are examined in this paper: 1) the physical action performed by an agent in an event, 2) the result of the event, and 3) an instrument used by an agent in an event. These three components were selected because many of the active verbs in natural language explicitly label one of these aspects of events: there are action verbs ("pound", "squeeze"), result verbs ("break", "clean"), and instrument verbs ("hammer", "mop"). Naturalistic studies have shown that these three kinds of active, transitive verbs account for over 70% of the verbs in preschooler's lexicons (Behrend, 1986). When studying the fast-mapping of verb meanings, we are interested in the *default values* for the slots in verb frames. Default values represent the learner's expectations about what component(s) of an event is most likely to be important in the meaning of a novel verb before anything is learned about the meaning of that verb. Thus, default values guide verb learning by directing the learner to those aspects of events that are most likely to be represented in verb meanings. Two questions are addressed in the current research. What are children's default assumptions about the meanings of novel verbs? Are children able to override these assumptions when presented with information that conflicts with their default values?

These questions are addressed using an original experimental paradigm in which subjects are taught novel verbs and then are asked if they are willing to use those verbs to label events in which the instrument, action, or result is different from the events on which the verbs were trained. It was reasoned that subjects should be less willing to use the newly learned verb to label events in which the component that was changed was one that the subject assumed was an important part of the new verb's meaning.

EXPERIMENT 1

Method

Ten 3-year-olds, 5-year-olds, and adults were subjects. There was an equal number of males and females in each group.

The stimuli were six sets of videotaped events each matched with a novel verb (rem, stipe, pint, chiff, bock, tizz). Each event depicted a person performing a novel action with an unfamiliar instrument to produce a clear and novel result. For each verb, there were three identical training events followed by four test events. One of the test events was identical to the training events. In the other three test events, either the instrument, action, or result was different from the training events (the test change). These events followed the training events for each verb in a random order. Before the first training event, the subject was told, "Watch this person, she is *remming*." Before the other two training events, the experimenter said, "Let's watch her do that again. Look, she's *remming* again." After the last training event, the subject was told, "O.K. Now I want you to tell me if she is *remming* this time or is she is doing something else." The test event was shown, and the experimenter asked, "Was she *remming* that time or was she doing something else?" After the last test event for a verb was shown, the training for the next verb began.

TABLE 1: NUMBER OF TIMES NOVEL VERB IS ACCEPTED AS A LABEL FOR TEST EVENTS IN EXPERIMENT 1 (maximum value = 6)

	Age			
Test Change	Three	Five	Adult	Overall
Instrument	3.6	3.5	5.2	4.1
Action	2.8	2.3	2.9	2.7
Result	1.9	0.3	0.6	0.9
Mean	2.8	2.0	2.9	2.6

Results and Discussion

The key dependent variable was the number of times subjects accepted the novel verb as a label for the test events. Subjects always used the novel verb for the test event identical to the training events, so those data were eliminated from the analysis. The remaining data were analyzed with a 3 (Age) x 3 (Test Change) ANOVA, with the latter factor treated as a within-subject factor. Table 1 summarizes the data. Note that lower values in the table represent stronger effects (i.e. subjects were less willing to accept the novel verb). A significant main effect for test change, $F(2,54) = 61.1$, $p<.001$, showed that result test changes had the strongest negative effect on subjects' acceptance of the novel verb, followed by action, and then instrument changes (all pairwise differences significant by Newman-Keuls test, $p<.05$). There was also an age x test change interaction, $F(4,54) = 2.75$, $p<.05$, which showed that 1) instrument changes were less important to adults than to children and 2) result changes were less important to 3-year-olds than to the older subjects. Still, the 3-year-olds, like older subjects, were most strongly affected by result changes and least strongly affected by instrument changes.

The findings from this experiment suggest that when learning a novel verb that labels a transitive event, children and adults have a default assumption that the result of an event is the most important component in that verb's meaning. It also appears, however, that this default assumption is still developing during the preschool years: 3-year-olds were more willing than 5-year-olds or adults to accept the novel verb as a label for the result change test event. As this assumption will frequently be wrong, it is important to know how easily subjects can change their default mappings when information about a verb's meaning conflicts with their default assumptions. In Experiment 1, all of the training events used to teach a given verb were identical, and thus no conflicting information about a verb's meaning was presented. Experiment 2 examines how children and adults deal with variable information about the meaning of a novel verb by introducing systematic variations into the training events.

EXPERIMENT 2

Method

Twelve 3-year-olds, 5-year-olds, and adults were subjects. There were eight boys and four girls in each group of preschoolers, and an equal number of adult males and females.

The stimuli were again six sets of videotaped events similar to those used in Experiment 1, each matched with a novel verb. The stimuli and procedure were identical to those used in Experiment 1, with the following exceptions. In each set of training events for this study, two of the three components (instrument, action, result) of the events remained constant while the other component was varied in each event (the training variation). Thus, for two verbs, the instrument varied in training; for two, the action varied; and for two, the result varied. These training events were followed by four test events, in random order. One test event was identical to the first training event for that verb, and there was one each in which the instrument, action, or result was different from any training event.

Results and Discussion

The data were analyzed with a 3 (Age) x 3 (Training Variation) x 3 (Test Change) ANOVA with the last two factors treated as within-subject factors. Table 2 summarizes the data. Again, lower values in this table represent stronger effects. The significant main effect for test change, $F(2,66) = 54.3$, $p<.001$, showed, as in Experiment 1, that result changes had the strongest negative effect on subjects' acceptance of the novel verb, followed by action, and instrument changes (all pairwise differences significant by Newman-Keuls test, $p<.05$). One clear effect of the variations in training was that the subjects accepted the novel verb as a label for the test events more frequently than subjects in Experiment 1 (M=3.5 vs. M=2.6, $p<.01$).

It was expected that if subjects were sensitive to the variations in the training events, then they would be more willing to accept the novel verb for a test event in which the component that was changed was also the component that was varied in the training for that verb. For example, subjects should be more willing to accept the novel verb as a label for the action change test events when the action was varied in the training events than when the action was not varied. This prediction, and analagous predictions for the instrument and result test changes, were tested with a set of orthogonal planned comparisons based on the overall ANOVA.

Figure 1 displays both a set of idealized predictions (Figures 1A, 1B, and 1C) and the actual data (Figures 1D, 1E, and 1F) from the study. As expected, there was a significant interaction between training variation and test change, $F(4,132) = 24.7$, $p<.001$. Figure 1D shows that the predicted effect was not observed for instrument test changes, primarily because

TABLE 2: NUMBER OF TIMES NOVEL VERB IS ACCEPTED AS A LABEL FOR TEST EVENTS IN EXPERIMENT 2 (maximum value = 6)

	Age			
Test Change	Three	Five	Adult	Overall
Instrument	4.6	5.3	5.3	5.1
Action	3.3	2.6	3.3	3.1
Result	2.8	2.1	2.3	2.4
Mean	3.5	3.3	3.6	3.5

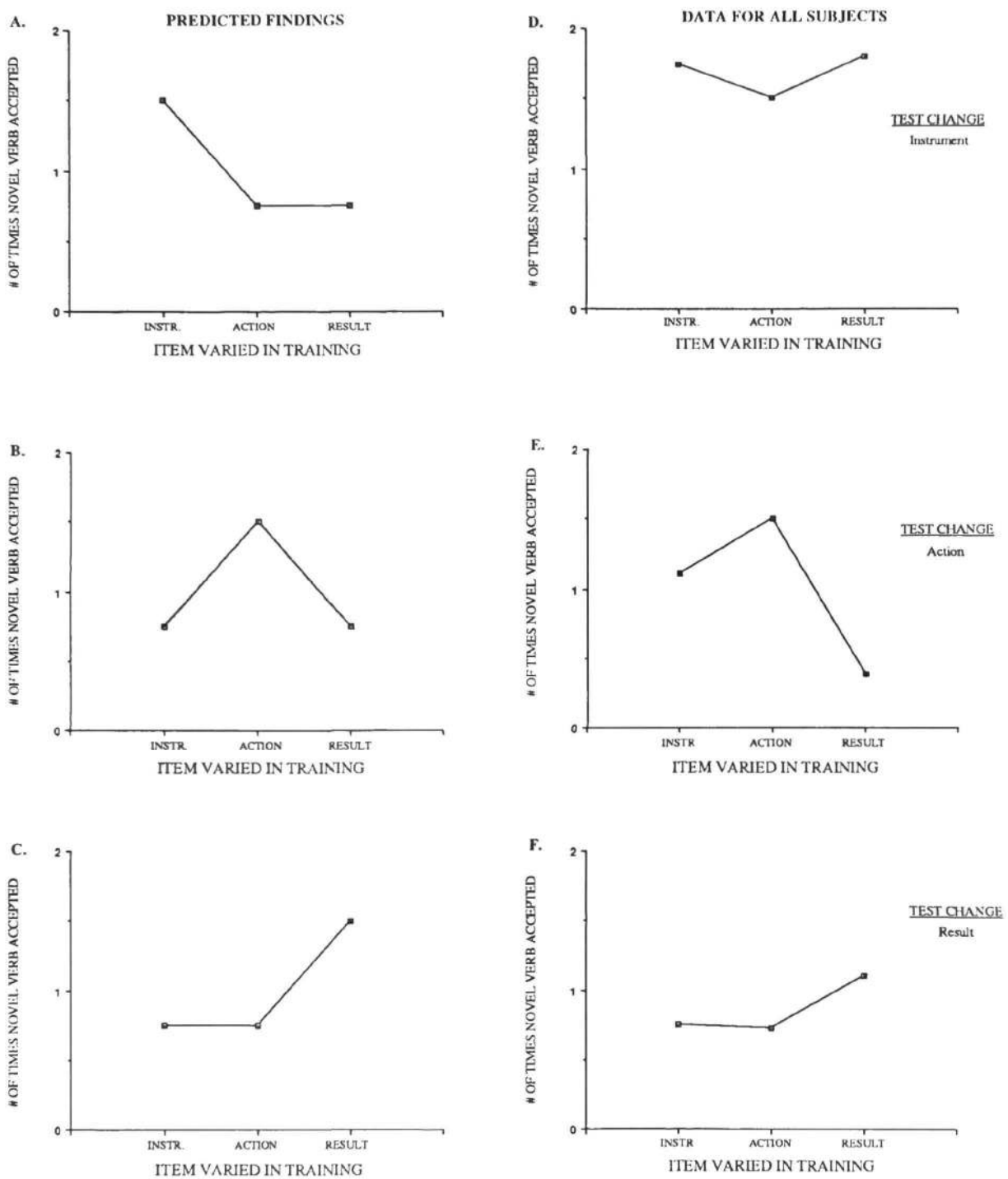

FIGURE 1: Predicted and actual data for all subjects in Experiment 2.

instrument changes did not affect use of the novel verb in the first place. However, the predicted effects for the action and result test changes were observed. Figure 1E shows that the novel verb was more likely to be accepted for action change test events when actions varied in the training events, $F(1,35) = 61.2, p<.01$, and Figure 1F shows that the novel verb was more likely to be accepted for the result change test events when results varied in the training events, $F(1,35) = 7.17, p<.01$.

There was also a 3-way interaction between age, training variation, and test change $F(8,132) = 2.78, p<.01$. This interaction reflects the finding that while the groups did not differ in how they were affected by the instrument and action training variations, varying the result in training had differential effects on the three age groups. While both the 5-year-olds, $F(1,11) = 4.96, p<.05$, and the adults, $F(1,11) = 8.43, p<.05$, were more likely to accept the novel verb for a result change test event when the result was varied in training, there was no such effect for the 3-year-olds.

One other finding is worthy of attention. Returning to Figure 1E, it can be seen that when results were manipulated in training, *action* changes had a profound negative effect across age groups on subjects' willingness to use the novel verb. This finding suggests that when the results of events were varied and, thus, were reduced in importance in a verb's meaning, subjects abandoned the default assumption that results are most important, and switched to action as the component most likely to be central to the novel verb's meaning.

GENERAL DISCUSSION

The findings from these studies suggest that there is a default assumption that the result is the most important component of a novel verb's meaning (i.e., the novel verb is a result verb). This bias also appears to become stronger during preschool. Actions are assumed to be less important than results, and instruments are rarely assumed to be important to novel verb meanings. In addition, Experiment 2 demonstrated what occurs when default assumptions are in conflict with the input that is received about a verb's meaning. When the result of an event was varied in training, adults and 5-year-olds, as predicted, more frequently accepted the novel verb as a label for an event in which the result was changed again. 3-year-olds, though, were apparently unable to override their default assumption. Also, when results were varied in training, subjects rarely accepted the novel verb for the *action* change test event. This finding suggests that there may be a hierarchy among the slots in verb concepts. When results are decreased in importance in a verb's meaning, learners next hypothesize that action, instead, is the key to the meaning of a novel verb. This account invokes a mechanism similar to a default rule hierarchy that has been proposed to account for various types of animal, human, and machine learning (e.g. Holland, Holyoak, Nisbett, & Thagard, 1986; Jackendoff, 1983) and which demands consideration as the mechanism responsible for this finding of the present research.

The interpretations of the findings of the current studies must be made with some caution. Clearly, more information than just that pertaining to instruments, actions, and results is incorporated in verb frames. For example, causal, temporal, and syntactic information, as well as information dealing with the intentionality of an action must also be represented. Indeed, the strong and increasing bias towards results in the present studies may reflect an increase in children's understanding of intentions and the planfulness of actions, and not a specific verb learning bias. However, given that the verbs studied here account for over two-thirds of the verbs in preschoolers' lexicons, some basis for generalizing these findings is warranted.

To conclude, it appears that the default assumptions that guide the fast-mapping of verb meanings are still changing in the preschool years, and that there may be important, hierarchical relationships between default values in different slots in verb concepts. Additional research with younger children and a wider range of verbs will help to clarify the exact nature of the sources of these changes and the mechanisms involved in the initial mapping of verb meanings.

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