Foundations of Verb Learning: Labels Promote Action Category Formation

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1. Introduction

Verbs are generally harder to learn than nouns (Gentner, 1982; but see Tardif, 1996). Some suggest that one of the reasons for this finding is that terms like verbs tend to label ephemeral actions and events rather than the relatively more concrete objects labeled by nouns (Gentner & Boroditsky, 2001). Others suggest that relational terms are harder to learn because children must figure out how to package actions and events in ways that are consistent with language-specific usage (Gentner & Boroditsky, 2001; Tomasello, 1995). Both of these explanations require that, at a minimum, infants dissect the flow of actions and events into the units that will be represented in language. The conceptualization of actions and events can be divided into two specific abilities: (1) the parsing and individuation of actions and events and (2) the categorization of actions and events (Golinkoff et al., 2002). We know very little about whether infants can "decompose scenes into constituent parts relevant to linguistic expressions in language?" (Clark, 2003, p.168; also see Pruden, Hirsh-Pasek, & Golinkoff, in press). The studies presented in this paper ask whether infants discriminate and categorize actions that are encoded in motion verbs and spatial expressions.

Relational terms, like spatial expressions and motion verbs, do not label whole events. Rather, they label a subset of actions or semantic components. Spatial expressions typically encode semantic components like, *containment*, *support*, and *tight-fit* relations, while motion verbs can encode a number of semantic components including, *path*, *manner*, and *result*. We focus only on *path* and *manner* in motion events. Path is defined as the trajectory of an agent or object with reference to a ground object (Talmy, 1985). Manner is how the agent or object moves relative to itself (Talmy, 1985). Path and manner are the

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focus of this paper for four specific reasons. First, path and manner are the two semantic components most widely studied in psychology and linguistics. Second, path and manner are universally codified across languages (Jackendoff, 1983; Langacker, 1987; Talmy, 1985). Third, path and manner are of interest because they are packaged in relational terms in different ways across languages (Slobin, 2001; Talmy, 1985). In English, manner is often encoded in the verb (e.g., walk, dance, swagger, stroll), while path is usually encoded outside the verb, often in the preposition (e.g., in, on, around). Spanish, on the other hand, usually encodes the path within the verb, while manner is optionally encoded in the adverb. Finally, some speculate that the semantic component, path, is a conceptual primitive needed to learn relational terms (Mandler, 2004). This path primacy is seen in the production of relational terms in both hearing and deaf populations (Naigles, Eisenberg & Kako, 1992; Zheng & Goldin-Meadow, 2002). Naigles and colleagues discovered that 2-year-olds produce more path expressions than manner expressions, while Zheng and Goldin-Meadow (2002) showed that path verbs were produced more often than manner verbs in both Chinese and American deaf children. While we focus only on VIA paths (e.g., a path where the ground object lies somewhere along the path; encoded by spatial prepositions like around, past, and over) in our current research, we recognize that perceiving and representing all types of paths, including TO (GOAL) and FROM (SOURCE) paths, is a necessary precursor to linguistically encoding a motion event (Landau & Zukowski, 2003).

When do infants discriminate and categorize path and manner? Pulverman and our colleagues at the University of Delaware were among the first to study infants' ability to pay attention to changes in both path and manner in non-linguistic motion events (Pulverman & Golinkoff, 2004; Pulverman, Sootsman, Golinkoff, & Hirsh-Pasek, 2003). Using an animated starfish, the same one used in the present studies, they demonstrated that English-speaking 14- to 17-month-olds notice changes in both path and manner. These results suggest that infants as young as 14 months of age notice components of actions typically encoded in their language. Moreover, language appears to play a role in the ability to notice and attend to these components. Infants with a higher comprehensive vocabulary, as assessed by maternal report, were more attentive to manner changes than to path changes (Pulverman et al., 2003). More recently, Pulverman and Golinkoff (2004) showed that 7-month-olds notice changes in both path and manner, using the same stimuli and methods. In similar work, Casasola and her colleagues (2003) found that 10-month-old infants discriminated changes in both path and manner in events involving human actors and natural scenes (e.g., a child crawling away from a bush vs. a child skipping away from a bush). These studies begin to shed light on when infants attend to and discriminate components like path and manner.

Discriminating spatial events is however only the first step in learning relational terms. As Oakes and Rakison note, "words refer to categories of objects and events" (2003, p.4) and not just single actions. Despite the apparent perceptual dissimilarities of a cat "running" and a human "running," both

actions are categorized as "running" and both actions receive the label "running." Infants must look for similarities across actions and form categories of actions before they can then attach a label to an action.

We began our investigation of action categorization by asking whether infants can abstract an invariant action from an ongoing event. Extracting an invariant action is a precursor to forming more abstract categories of actions. In the first studies of this kind we asked whether infants abstract the invariant path across multiple exemplars of manner and whether they abstract the invariant manner across multiple exemplars of path? In both studies, three age groups were tested, 7- to 9-month-olds, 10- to 12-month-olds and 13- to 15-month-olds. We found that infants as young as 10 months find the invariant path across multiple exemplars of manner. Further, infants as young as 13 months can abstract the invariant manner across multiple exemplars of path (Pruden, Hirsh-Pasek, & Golinkoff, in preparation; Pruden, Hirsh-Pasek, Maguire, & Meyer, 2004). These studies provide support for the speculation that the conceptual prerequisites needed to learn relational terms might be in place early in life.

The results further suggest that the categorization of semantic components, like path and manner, might not come online at the same time. For example, infants abstract the invariant path across varying manners before they abstract the invariant manner across varying paths. Thus, the ability to categorize dynamic spatial relations develops on a different time scale for different semantic components. This is similar to what Casasola and Cohen (2002) found with the semantic constructs containment and support, where the category of containment seems to be formed before category of support.

Some suggest that adding language input to a categorization task might help infants focus attention to the kind of semantic components that are language relevant. To our knowledge, only one study added language to an event categorization task. Casasola (Casasola & Cohen, 2002) found that 18-month-old English-speaking infants were unable to form an abstract spatial category of support. In more recent research, she asks whether language heightens infants' attention to the common spatial relation, support, and facilitates the formation of an abstract spatial category of support (Casasola, 2005). Her research indicates that a word **does** aid infants in forming abstract spatial categories. In this particular case, language heightens attention to the spatial relation allowing for the formation of the spatial category of support.

But, what exactly does language do for the infant? Results arising out of the object categorization literature suggest two possibilities. The addition of language could potentially disrupt or hinder performance in categorization tasks. That is, the introduction of language may further increase the processing demands needed to succeed in these tasks. By way of example, Stager and Werker (1997) showed that the introduction of language in a word-learning task disrupts 14-month-olds discrimination of fine phonetic details. The addition of language to a categorization task could, however, heighten attention to the object or spatial relation of interest. As Baldwin and Markman (1989) find labeling increases attention to objects. Further, this label could potentially

facilitate the abstraction of the invariant spatial relation. This possibility receives support from Waxman's research on object categorization where words serve as invitations to forming categories (Balaban & Waxman, 1997; Waxman & Markow, 1995).

In the present studies we expand on Casasola's (2005) work in two ways. First, we explore the categorization of two different semantic components encoded in spatial expressions and motion verbs, *path* and *manner*. Second, we study pre-verbal infants (7- to 9-month-olds) in an effort to provide further support for the claim that the conceptual prerequisites needed for learning relational terms are in place early in life. In our previous categorization studies no linguistic stimuli accompanied the motion events (Pruden et al., 2004). To address the question of whether a common label would help infants abstract the invariant motion we added a novel verb label to the motion events presented during familiarization. In the first experiment we asked whether a common label would help infants abstract the invariant *path* across multiple exemplars of *manner*. In our second experiment we asked whether a common label would help infants abstract an invariant *manner* across multiple exemplars of *path*. Two predictions follow. First, the mere addition of a novel verb label will heighten attention to the motion events presented during the familiarization phase. Second, the addition of the novel verb label during the familiarization phase will facilitate the abstraction of the invariant *path* (Experiment 1) and the invariant *manner* (Experiment 2) and hence will aid in the beginning of category formation for dynamic spatial relations.

2. Experiment 1: Do labels help infants' abstract *path* across multiple *manners*?

2.1. Participants

Twenty-four 7- to 9-month-olds (M = 8.50, SD = .77) formed the final sample of Experiment 1. All infants were from monolingual English-speaking homes and were full-term births. Equal numbers of males and females participated in Experiment 1. An additional 4 (14%) infants were excluded from further analyses due to fussiness (n = 1), low attention (n = 2), and side bias (n = 1).

2.2. Stimuli

The stimuli presented to infants consisted of animated motion events of a purple starfish (agent) performing an action relative to a stationary green ball (ground object) displayed in the center of the screen. During each motion event, the purple starfish performed simultaneously a component of path and a component of manner. Each motion event lasted a total of 12 sec. During this 12 sec. motion event, the starfish repeated the manner of action across its path for 6 sec., and then reversed its direction to continue back along the same path while performing the same manner for the remaining 6 sec. Six exemplars of path

("over", "under", "around", "past", "in front", and "behind") and six exemplars of manner ("spinning", "jumping jacks", "twisting", "touching toe", "side bending", and "bending forward") served as the stimuli for these experiments. Linguistic stimuli accompanied the motion events shown during the familiarization phase of the experiment. The linguistic stimulus was a novel verb label, "javing," that was produced in infant directed speech by a female.

The animated stimuli were generated using the animation program Strata 3Dpro™ version 3.9. The construction of the final movies and recording of linguistic stimuli was completed using the program Final Cut Pro HD™ version 4.5. Figure 1 illustrates only a subset of the paths and manners used across both experiments.

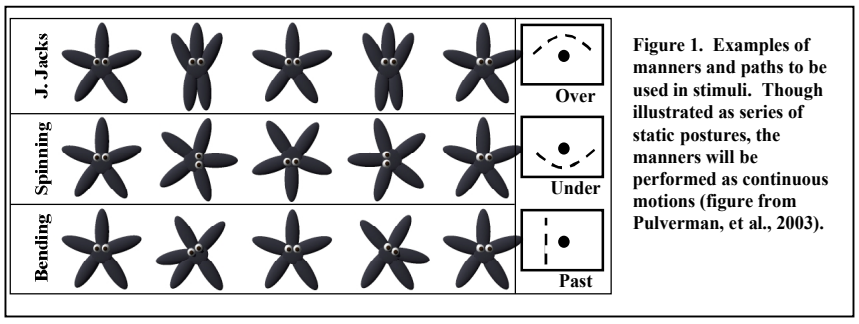

Figure 1. Examples of manners and paths to be used in stimuli. Though illustrated as series of static postures, the manners will be performed as continuous motions (figure from Pulverman, et al., 2003).

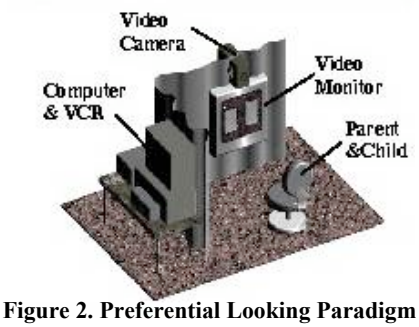

Figure 2. Preferential Looking Paradigm

2.3. Procedure

Infants were tested using the split-screen Preferential Looking Paradigm (Figure 2; Hirsh-Pasek & Golinkoff, 1996). They were seated on their caregiver's lap in front of a large screen television. Caregivers were asked to close their eyes during the experiment so as not to influence the child's direction of gaze. A video camera placed to the left of the television screen recorded the infants' eye gaze. Infants' looking times were discarded from further analyses if their caregivers looked at the stimuli or spoke to the infant during the study.

Infants participated in four phases of the experiment: 1) introduction phase; 2) salience phase; 3) familiarization phase; and 4) test phase. The purpose of the **introduction phase** was to ensure that infants looked to both sides of the screen. During the introduction phase, infants were introduced to the purple, animated starfish, first on one side of the screen for 6 sec., and then on the other side of the screen for 6 sec. During this introduction the starfish moved across the screen from left to right and back while stretching his arms and legs outward.

Following the introduction phase, infants saw the **salience phase**. The salience phase assessed any *a priori* preference for the video clips used later during the test phase. During the salience phase, infants viewed two, 12 sec. event clips simultaneously on the split-screen. These event clips were the same clips that infants would be shown during the test phase. The assumption was that infants would not have an *a priori* preference for either event clip during salience.

During the **familiarization phase**, infants were shown four different 12 sec. events, each depicting the purple starfish performing the same exact path with four distinct manners. By way of example, infants in the path condition "over" saw four consecutive exemplars of the starfish performing the same path, "over", across four distinct manners. For example, they saw "spinning *over*" followed by "twisting *over*", "bending *over*", and "jumping jacks *over*." During the presentation of these motion events, infants heard the novel verb label "javing" repeated a total of 16 times (4 times during each different motion event).

After the familiarization phase, infants participated in the **test phase**. The test phase was used to assess whether infants could abstract the invariant path across the four exemplars of manner. During the test phase, infants were shown two test events simultaneously on the split-screen for 12 sec. One of these clips depicted a familiar test event, with the same path as seen during familiarization, in conjunction with a novel manner (i.e., a novel exemplar from the familiar category). The other clip depicted a novel test event, with both a novel path and novel manner (i.e., a novel exemplar from a novel category). For example, infants familiarized with the events "spinning *over*", "twisting *over*", "bending *over*", and "jumping jacks *over*" would, at test, see the event clips "touching toe *over*" (i.e., novel *manner* and same *path*) and "touching toe *under*" (i.e., novel *manner* and novel *path*). **No linguistic stimuli** accompanied the clips during the test phase. Infant looking times to the motion events across all four phases of the experiment were recorded.

2.4. Results

Does a label increase attention to motion events during familiarization?

Do labels heighten attention to the motion events during the familiarization phase? We calculated the average looking time across all four familiarization trials (average can be between 0 and 12 sec.). These looking times were compared to the looking times of the 7- to 9-month-old infants who participated in our original, no-label study (Pruden et al., 2004). The average looking time during each familiarization trial for those infants participating in the present, label study was 10.47 sec. (SD = 1.34), while those participating in the original, no-label study looked an average of 9.90 sec. (SD = 1.52) during each familiarization trial. An independent-samples t-test comparing these two groups showed that there was not a significant difference in the average looking times

during the familiarization phase, t (52) = -1.46, $p > .05$. Infants in the label study did not increase their overall attention to the familiarization events.

Does a label facilitate the abstraction of path across multiple manners?

To assess whether a label facilitated the abstraction of *path* across multiple exemplars of *manner*, we calculated a novelty-preference score for each infant using the average looking time towards each test event. The novelty-preference score was calculated by taking the average looking time towards the novel test event and dividing by the sum of the average looking time towards both the novel test event and the familiar test event.

To determine whether infants had a salience preference for either event clip, a one-sample t-test (compared to chance) was conducted on the novelty-preference scores from the salience phase. Infants did not have any *a priori* preferences for either event clips during the salience phase, t (23) = .48, $p > .05$.

A one-sample t-test was also used to assess infants' preferences during the test phase. Infants displayed a significant preference for the *novel* test event during the test phase, t (23) = 2.58, $p < .05$.

We were also interested in comparing the 7- to 9-month-old infants participating in our original no-label study (Pruden et al., 2004) to those participating in the present, label study. An independent samples t-test using the novelty-preference scores from the test phase shows that infants participating in the present, label study performed slightly better, preferring to look at the novel exemplar during test, than those participating in the original, no-label study, t (52) = -1.90, p = 06. Figure 3 depicts the novelty-preference scores in the test phase for infants participating in the original, no-label study (Pruden et al., 2004) and the present, label study.

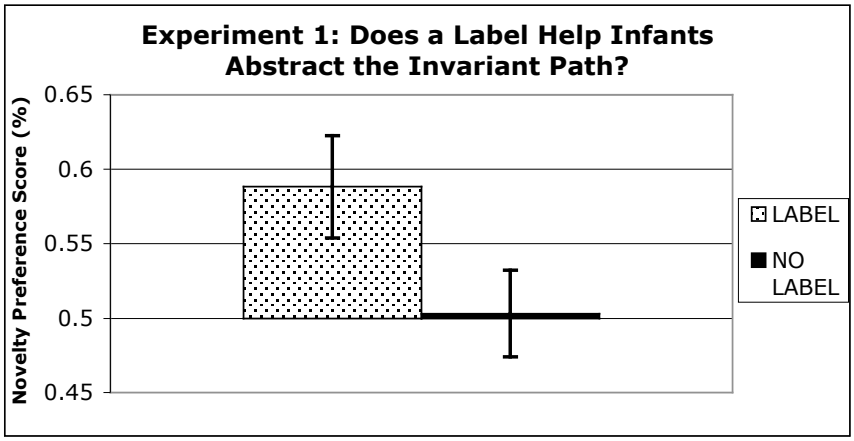

Figure 3. Novelty-preference scores during test phase for label and no-label study.

2.5. Discussion

Contrary to our initial prediction, infants did not show increased attention to the familiarization events when these events were presented in conjunction with a novel verb label. Despite the lack of an increase in attention during familiarization, infants were able to abstract the invariant path among several exemplars of manner. These data suggest that it may be the label providing the facilitative effect found in this study and not simply the heightening of attention to the semantic component, path.

3. Experiment 2: Do labels help infants' abstract *manner* across multiple *paths*?

3.1. Participants

Twenty-four 7- to 9-month-olds (M = 8.85, SD = .71) from monolingual English-speaking homes constituted the final sample for Experiment 2. Half of the participants were male and half were female. All infants were full-term at birth. An additional 5 (17%) infants were excluded from further analyses due to side bias (n = 1) and experimenter error (n = 4).

3.2. Stimuli

The stimuli for Experiment 2 were exactly the same as those used in Experiment 1 (see Figure 1). As before, infants saw a starfish perform both a manner and path, simultaneously. The same linguistic stimulus used in Experiment 1 was used in Experiment 2. Infants heard the novel verb label, "javing" during the familiarization phase.

3.3. Procedure

The procedure was exactly the same as Experiment 1. Infants participated in all 4 phases of the experiment as in Experiment 1. The only difference between Experiment 1 and Experiment 2 were the clips used for the salience, familiarization, and test phases.

As in Experiment 1, the **salience phase** in Experiment 2 assessed any *a priori* preferences infants might have for the test events. During the salience phase, infants viewed the same motion events that were to be presented during the test phase. Following the salience phase, infants were shown four different motion events during the **familiarization phase**. In each of these 12 sec. motion events, the animated starfish performed both a path and a manner. In Experiment 2, however, we were interested in whether infants could abstract the invariant manner. Thus, in each of these four different motion events, the animated starfish performed the same exact manner across four different paths. By way of example, infants participating in the manner condition "spinning" saw four exemplars of the starfish performing the same manner, "spinning", across four

distinct paths. For example, they saw ""*spinning* over", "*spinning* under", "*spinning* past", and "*spinning* behind." During each of these motion events infants heard the novel verb label "javing" repeated 4 times for a total of 16 times during familiarization.

During the **test phase** infants were presented with two, 12 sec. motion events simultaneously. One of these motion events depicted a familiar test event, with the same manner as seen during familiarization, in conjunction with a novel path (i.e., a novel exemplar from the familiar category). The other clip depicted a novel test event, with both a novel manner and novel path (i.e., a novel exemplar from a novel category). For example, infants familiarized with the events "*spinning* over", "*spinning* under", "*spinning* past", and "*spinning* behind" would, at test, see "*spinning* around" (same *manner*, novel *path*) and "*twisting* around" (novel *manner*, novel *path*). As in Experiment 1, **no linguistic stimuli** accompanied the clips during the test phase. Infants' looking times across all four phases of the experiment were recorded.

3.4. Results

Does a label increase attention to motion events during familiarization?

The average looking time across all four familiarization trials was computed. Infants participating in the present, label study looked on average 10.36 sec. (SD = 1.04) during each familiarization trial. Those participating in the original, no-label study looked only 8.86 sec. (SD = 1.94) during each familiarization trial. An independent-samples t-test comparing the average looking times during the familiarization phase showed that there was a significant difference between the those participating in the original, no-label study (Pruden et al., 2004) and those participating in the present, label study, t (52) = -3.42, $p < .05$. Infants in the present, label study increased their attention to the familiarization events as compared to their no-label counterparts.

Does a label facilitate the abstraction of manner across multiple paths?

Novelty-preference scores were calculated for each infant. To determine if infants had a preference for either event clip during the salience phase a one-sample t-test (compared to chance value of .50) was conducted on the novelty-preference scores from the salience phase. This test revealed that infants did not have an *a priori* preference for the event clips, t (23) = .82, $p > .05$.

A one-sample t-test was also used to assess infants' preferences during the test phase. Results indicate that infants did not have a significant preference for either event during the test phase, t (23) = .89, $p > .05$.

Further, an independent-samples t-test comparing infants in the present, label study to infants in the original, no label study (Pruden et al., 2004) finds that the looking times during the test phase are not significantly different from each other, t (52) = -.77, $p > .05$. Figure 4 depicts the novelty-preference scores during the test phase for the original, no label study (Pruden et al., 2004) and the present, label study.

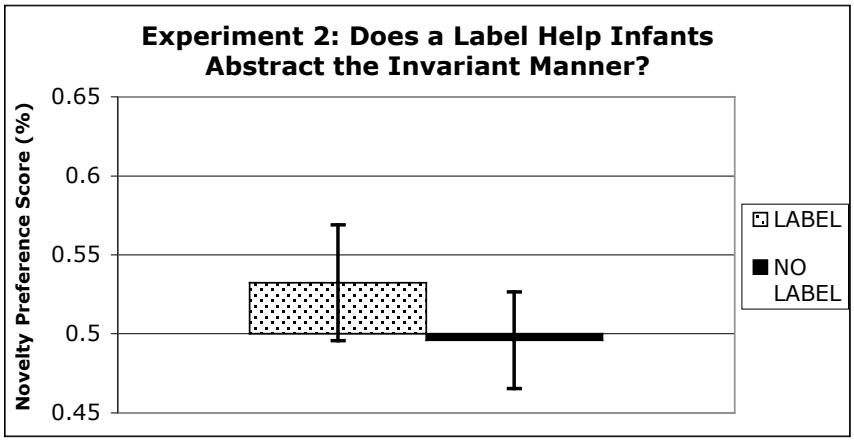

Figure 4. Novelty-preference scores during test phase for label and no-label study.

3.5. Discussion

As predicted, infants in Experiment 2 displayed heightened attention to the familiarization events relative to the infants participating in the original, no-label study (Pruden et al., 2004). Contrary to our initial predictions, infants in the present, label study did not have a reliable preference for either event during the test phase nor did their performance during the test phase differ from those infants participating in our no-label study. Thus, it appears that neither the introduction of a label nor the heightening of attention to the familiarization events helped 7- to 9-month-old infants abstract the invariant manner across multiple paths.

4. General Discussion

What role does language play in abstracting invariant semantic components like path and manner? Some suggest that the mere addition of auditory stimulation enhances attention (Baldwin & Markman, 1989). Others believe that labels are special and act as category markers, inviting the formation of categories (Balaban & Waxman, 1997; Waxman & Markow, 1995). Taken together the studies presented in this paper confirm and build on the findings from research on object categorization and nouns. The data from Experiment 1 suggest that labels may be playing an important role in abstracting semantic components that are lexicalized in language. Though 7- to 9-month-old infants did not show an overall increase in attention, they were now able to abstract the invariant path. In Experiment 2 we saw a different result. The introduction of the label heightened overall attention, but did not facilitate the abstraction of the invariant manner.

How are we to interpret these seemingly contradictory findings? On the one hand, it appears that language plays a special role in helping infants abstract semantic components. On the other hand, this facilitative effect appears to be limited to only one semantic component, path. Why might this be the case? There is reason to believe that path may be more fundamental or primitive in learning about the world (Mandler, 2004). Further, research suggests that path is abstracted earlier than manner in a non-linguistic categorization task (Pruden et al., 2004) and is produced more often in both hearing and deaf children's speech (Naigles et al., 1992; Zheng & Goldin-Meadow, 2002). Perhaps then, abstracting path is easier and requires less attention than abstracting manner. Likewise, if manner is more difficult to abstract than path, infants may need heightened attention in order to abstract an invariant manner.

Our findings provide support for both the "attentional" hypothesis, given by Baldwin and Markman (1989), and the "labels as category markers" hypothesis, given by Waxman and colleagues (Balaban & Waxman, 1997; Waxman & Markow, 1995). The present studies, however, do not allow us to say whether it is the label or some acoustic input that facilitated the abstraction of actions. To disentangle the two hypotheses, we need to ask whether there is there anything special about a label? Roberts and Jacob (1991) find that any auditory stimulation, including complex musical melodies, enhances attention to and facilitates the categorization of objects. Further, research by Namy (Campbell & Namy, 2003; Namy & Waxman, 1998) shows that toddlers are willing to map both verbal symbols and non-verbal symbols (i.e., sounds and gestures) to objects. We are currently investigating the impact of other auditory stimuli, such as tones, on the abstraction of invariant paths and manners.

Regardless of the role of language per se in this task, we did see a facilitative effect in both studies: one of attention and one of categorizing. These findings speak to the primary question: Are infants capable of paying attention to and abstracting actions and events that form a foundation for learning relational terms? These studies, in conjunction with those investigating other semantic components, like containment and support (Casasola, 2005; Casasola & Cohen, 2002; Choi et al., 1999), are among the first to shed light on whether pre-verbal infants bring to the verb-learning task a nascent ability to discriminate and abstract actions and spatial relations that are codified in language. The data force us to reexamine the question, what makes verbs so difficult to learn? Does the problem lie in conceptualizing actions and events? Some like Gentner and Boroditsky (2001) suggest that "it is not perceiving relations but packaging and lexicalizing relations that proves difficult" to the infant (p.326). Snedeker and Gleitman (2004) agree saying that "the young child's conceptual repertoire may be rich and varied enough from the start" (p.261) and that "vocabulary acquisition may reduce to mainly a mapping problem" (p.280). The body of evidence suggests that infants are sophisticated observers of actions and relations who attend to the semantic components encoded in spatial terms. The inherent problem in learning verbs and other relational terms *appears not to be* with conceptualizing events and actions in the

world. Rather, verbs may be difficult to learn because infants have trouble packaging relations, and mapping action words onto relations (Maguire, Golinkoff & Hirsh-Pasek, in press).

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