Foundations of Verb Learning: Infants Categorize Path and Manner in Motion Events

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1. Introduction

The last 20 years has seen a virtual explosion in research on children's verb learning. This research generally shows that verbs are harder to learn than nouns (Gentner, 1982, but see Tardiff, 1996). Gentner (1982; Gentner and Boroditsky, 2001) was among the first to address why. She suggested that verbs are ephemeral, whereas nouns tend to label objects that are concrete (e.g., car). Actions, on the other hand, are more abstract and fleeting, and are often labeled before or after the action has taken place (Tomasello & Kruger, 1992). Verbs are also polysemous. They tend to have multiple meanings, while nouns have more restricted meanings. For example, the Merriam-Webster Dictionary (1991) has over 40 entries for the verb "run", but only 9 entries for the noun "ball." In addition, objects can exist independent of actions, while actions require either an agent or object. As a result, children who hear action labels are faced with the problem of determining whether the label maps to the object or to the action. Finally, verbs can encode several components of an action, including, but not limited to, *path* (or the trajectory of agent; e.g. come, approach, enter), *manner* (or the way in which an agent moves; e.g. walk, dance, swagger, sway, stroll), *result* (e.g. open, close), and *instrument* (e.g. hammer, shovel), thus making the task of finding the referent harder.

Gentner's hypothesis about verb learning explains a tremendous amount of data in the field. By way of example, even in languages like Korean, in which

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the verb is in a perceptually favored sentence-final position and can appear alone, children tend to learn verbs later than nouns (e.g., Choi & Bowerman, 1991; Choi & Gopnik, 1995, but see Tardiff, 1996). Further, research by Meyer et al. (2003) and Imai, Haryu, & Hiroyuki (2003) showed that even well into the 5th year children still have trouble determining the referent of a novel verb in both English and in Japanese. Finally, studies using adult populations, like Gillette and colleagues' "Human Simulation Project" (1999) suggest that that even adults find it harder to clearly demarcate the meaning for a *verb* than for a *noun*. Adults asked to view a video and to guess which *nouns* the mother is likely saying have minor difficulty providing the correct referent. In contrast, when asked what *verbs* the mother is saying, agreement is disastrously low (15%). Adults could only solve this problem when they were given the syntactic information about the mystery verb.

While data mounts in favor of the "verbs are hard" hypothesis, there is a counterweight. Verbs still appear in children's earliest vocabularies. The paradox of verb learning, then, is that despite their apparent difficulty, children learn verbs (Choi, 1998; Choi & Bowerman, 1991; Fenson et al., 1994; Nelson, 1989; Tardiff, 1996). Any theory of language learning must explain both how children learn early verbs and why it takes so long for them to amass a verb lexicon.

To date, most of the research investigating verbs has explored only the early production of relational terms (Choi & Bowerman, 1991; Choi & Gopnik, 1995; Tardiff, 1996) or the mapping of relational terms onto actions (Choi et al., 1999; Maguire, Hirsh-Pasek, Golinkoff, & Pruden, 2003; Naigles, 1996). For example, research in our laboratory examined whether English-speaking toddlers attach a novel verb to the *manner* or *path* of an event (Maguire et al., 2003). Our results indicate that before the age of 3, toddlers prefer to attach the label to the *path* of action over the *manner* of that same action. It isn't until 3 years of age that children begin performing in ways similar to English-speaking adults.

However, building an arsenal of verbs requires more than just attaching labels to actions; it requires three important steps. Infants must first pay attention to the non-linguistic components of actions that words encode, such as *path* and *manner*. Next, when actions meet words, they attach a label to these actions. Finally, they begin to use these verbs productively in their grammar. The present studies investigate the first step in this process.

To date, only a few studies have been conducted to unpack how infants process action components like *path* and *manner* in non-linguistic motion events (Casasola, Hohenstein, & Naigles, 2003; Pulverman et al., 2003; in press). For example, Pulverman et al., (2003; this volume) studied infants' ability to pay attention to changes to both *path* and *manner* in non-linguistic motion events. Using an animated starfish (the very same one we use in our studies), Pulverman et al. (this volume) showed that infants as young as 7 months of age notice changes in both *path* and *manner*. Similarly, Casasola and colleagues (2003) demonstrated that 10-month-old infants could discriminate both *path* and *manner* in events involving naturalistic scenes and human agents (e.g., a young

child crawling in front of a bush vs. a young child hopping in front of a bush). While these studies provide us with information about infants' ability to attend to components of action, it is only the tip of the verb-learning problem. As Oakes and Rakison state, "words refer to categories of objects and events" (2003, p. 4). That is, verbs label not single actions, but categories of actions and events. Running, for example, is considered the same action whether performed by Carl Lewis or by my grandmother.

In the present studies, we investigate action categories by focusing on infant attention to two action components, *path* and *manner*. *Path* and *manner* are interesting not only because they are components of action that are universally coded across languages, but also because they are encoded differently across languages (Slobin, 2001). In English, *manner* is often encoded in the verb, while *path* is usually encoded outside the verb (often in the preposition). Spanish, on the other hand, usually encodes the *path* within the verb, while *manner* is optionally encoded in the adverb. Finally, prior research from our laboratories suggests that infants can and do attend to these components when they process actions.

Thus, our research takes a first small step in addressing the question of whether infants can form categories of actions in non-linguistic motion events. Two questions frame the current research: 1) can infants form categories of *path* across multiple exemplars of *manner*? and 2) can infants form categories of *manner* across multiple exemplars of *path*? Experiment 1 will address the first question. During familiarization infants will be exposed to four exemplars of exactly the same *path* across varying *manners*. Experiment 2 addresses the second question. Infants in this experiment were shown four exemplars of exactly the same *manner* across varying *paths*.

2. Experiment 1: Can infants categorize path across multiple manners?

2.1. Participants

Infants from three age groups were recruited for this experiment. Participants included twenty-four 7- to 9-month-olds (M = 8.72, SD = 1.01), twenty-four 10- to 12-month-olds (M = 11.29, SD = 0.87), and twenty-one 13- to 15-month-olds (M = 14.68, SD = 1.04). All infants were from monolingual English-speaking homes and were full-term at birth. Equal numbers of males and females were recruited. An additional 14 (17%) infants across these three age groups were excluded from further analyses due to fussiness (n = 8), low attention (n = 3), side bias (n = 1), and experimenter error (n = 2).

2.2. Stimuli

Stimuli were animated motion events of a purple starfish performing an action relative to a stationary green ball displayed in the center of the screen. Each action displayed a component of *path* and a component of *manner*. 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 stimuli for this experiment. Figure 1 illustrates just a few of the *paths* and *manners* used. 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* for another 6 sec. Stimuli were generated using Strata 3D animation, and the movies were created using Adobe Premier. **Importantly**, no linguistic stimuli accompanied these events.

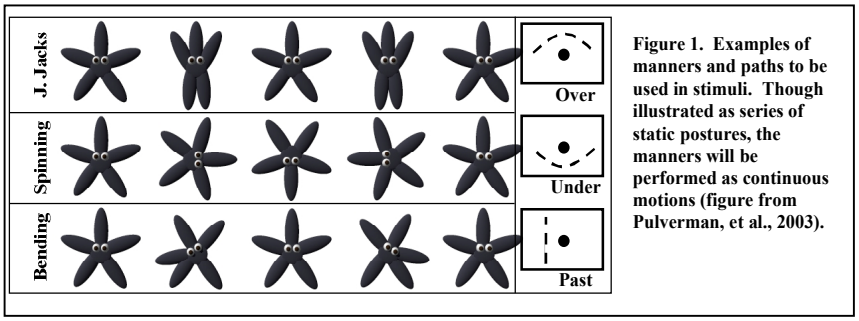

Figure 1. Examples of manners and paths to be used in stimuli. Though illustrated as series of static postures, the manners will be performed as continuous motions (figure from Pulverman, et al., 2003).

2.3. Procedure

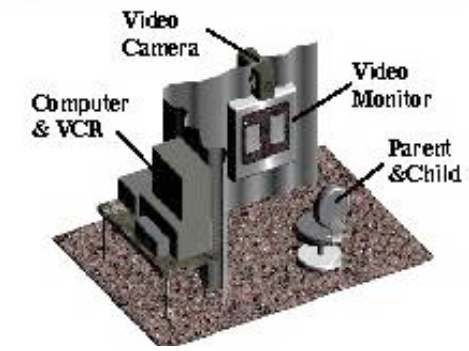

Figure 2. Preferential Looking Paradigm

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 were discarded if their caregivers looked at the stimuli during the test.

The experiment had four phases: 1) introduction phase; 2) salience phase; 3) familiarization phase; and 4) test phase. During the **introduction** phase, infants were introduced to the 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. The purpose of the introduction phase was to ensure that infants looked to both sides of the split-screen.

Next the infants saw the **salience** phase. The purpose of the salience phase was to measure any *a priori* preference for the event clips used later during the

test phase. Infants were presented with two event clips simultaneously and side-by-side for a total of 12 sec. These were the exact same event clips that would be seen during the test phase. The assumption was that infants would not have an *a priori* preference for either event clip.

During the **familiarization** phase, infants were shown four different event clips. Each event clip was 12 sec. long and demonstrated the animated star performing both a single *manner* and single *path*. These event clips all demonstrated an exemplar of the category being tested. 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*."

The purpose of the **test** phase was to assess whether infants had formed a category of *path* (in this case "over") across the four distinct exemplars of *manner*. Infants were presented with two test events simultaneously on the split-screen for 12 sec.: (1) a familiar test event, with the same *path* and a novel *manner* (i.e., a novel exemplar from the familiar category), and (2) a novel test event, with 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 *under*" (i.e., novel *manner* and novel *path*) and "touching toe *over*" (i.e., novel *manner* and same *path*). Infant looking times to each of these test events were recorded.

2.4. Results

A novelty-preference score was calculated for each infant using the average looking time towards each test event. This was calculated by taking the average looking time towards the novel test event and dividing by the sum of the average looking time towards the novel test event and the familiar test event. The average novelty-preference scores for each age group during the test phase are depicted in Figure 3.

To determine if infants in each age group had a **salience** preference for either event clip, one-sample t-tests (compared to chance) were conducted on the novelty-preference scores. Infants did not have any *a priori* preferences for the event clips at any age (7-9 mos.: t (23) = -.942, p = .356; 10-12 mos.: t (23) = -.820, p = .421; 13-15 mos.: t (20) = -1.417, p =.17). One-sample t-tests were also used to assess infants' preferences during the **test** phase. The results showed 7- to 9-month-olds (t (23) = .359, p = .723, d = .07) did not have significant preference for either test event. In contrast, 10- to 12-month-olds showed a significant preference for the *familiar* test event during the test phase (t (23) = -2.791, p = .01, d = .57). Finally, 13- to 15-month-olds showed no significant preference for either test event (t (20) = -1.454, p = .16, d = .32).

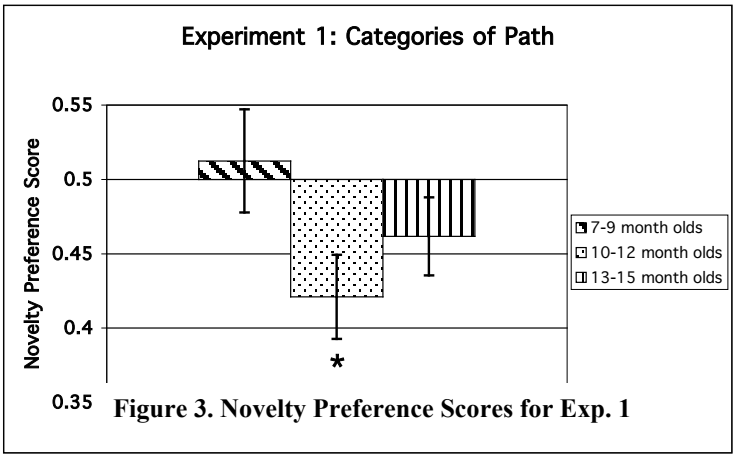

Figure 3. Novelty Preference Scores for Exp. 1

2.5. Discussion

This experiment investigated 7- to 15-month-old English-speaking infants' ability to categorize *path* across four distinct exemplars of *manner*. Our results indicate that infants as young as 10 months of age can categorize *path*. There were, however, some results that were not anticipated. First, despite a small to moderate effect size, 13- to 15-month-olds' preference for the familiar event was not statistically significant. Based on the effect size, we anticipate that if the sample is increased that this difference will be detectable.

A second result was also surprising. Those infants who had a preference for a test event preferred the *familiar* event rather than the novel event. Most studies using this paradigm show that infants prefer to look at novel stimuli, but there are some exceptions. Prior findings of a familiarity preference have been linked to stimulus complexity (Hunter et al., 1983). In fact, McDonough, Choi, and Mandler (2003) reported a similar result in their study of infant categorization of spatial relations. Experiment 1 showed that infants categorize *path* across four distinct *manners*. In Experiment 2, we investigate whether infants can categorize *manner* across four distinct *paths*.

3. Experiment 2: Can infants categorize manner across multiple paths?

3.1. Participants

Infants from three age groups were also recruited for Experiment 2. Participants included twenty-four 7- to 9-month-olds (M = 8.47, SD = 0.96), twenty-four 10- to 12-month-olds (M = 11.49, SD = 0.80), and twenty-three 13- to 15-month-olds (M = 14.72, SD = 0.87). All infants were from monolingual English-speaking homes and were full-term at birth. There were equal numbers of males and females. An additional 22 (24%) infants across these three age

groups were excluded from further analyses due to fussiness (n = 15), low attention (n = 2), side bias (n = 2), and experimenter error (n = 3).

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* with no accompanying linguistic stimulus.

3.3. Procedure

The general procedure was the same as in Experiment 1. However, the clips used for the salience, familiarization and test phases were different.

During the **salience** phase infants saw the exact same event clips that would be seen during the test phase. During the **familiarization** phase, infants were shown four different event clips. Each event clip was 12 sec. long and demonstrated the animated starfish performing both a *manner* and *path*. These event clips all demonstrated an exemplar of the category being tested. By way of example, infants 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."

The purpose of the **test** phase was to assess whether infants had formed a category of *manner* (in this case "spinning") across the multiple exemplars of *path*. Infants were presented with two test events simultaneously on the split-screen for 12 sec.: (1) a familiar test event, with the same *manner* and a novel *path* (i.e. a novel exemplar from the familiar category), and (2) a novel test event, with 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*). Infants' looking times to each of these test events were recorded.

3.4. Results

Novelty-preference scores were calculated for each infant. The average novelty-preference scores for each age group during the test phase are depicted in Figure 4.

To determine if infants, in each age group, had a **salience** preference for either event clip one-sample t-tests (compared to chance) were conducted on the novelty-preference scores. These analyses revealed that infants did not have any *a priori* preferences for the event clips (7-9 mos.: t (23) = -.174, p = .863; 10-12 mos.: t (23) = -.425, p = .674; 13-15 mos.: t (22) = -.958, p = .348). One-sample t-tests were also used to assess infants' preferences during the **test** phase.

Neither 7- to 9-month-olds (t (23) = -.224, p = .824, d = .05) nor 10- to 12-month-olds (t (23) = .944, p = .355, d = .19) showed a significant preference for either test events. In contrast, 13- to 15-month-olds showed a significant preference for the *novel* test event during the test phase (t (22) = 2.429, p = .024, d = .51).

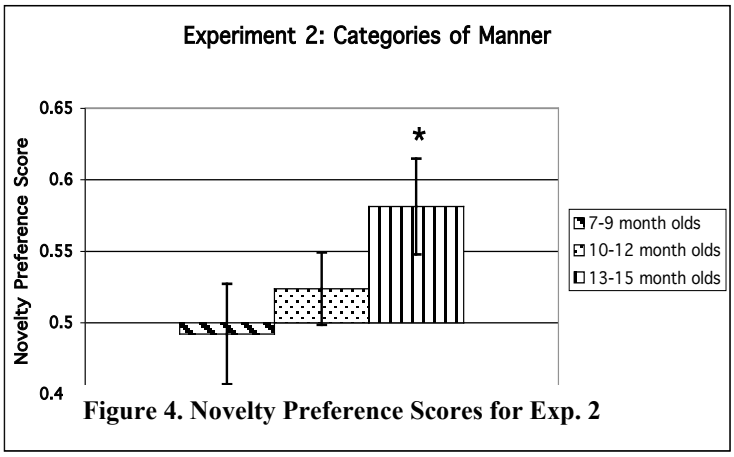

Figure 4. Novelty Preference Scores for Exp. 2

3.5. Discussion

This experiment investigated 7- to 15-month-old English-speaking infants' ability to categorize *manner* across multiple exemplars of *path*. Our results indicate that only the oldest children studied, 13- to 15-month-olds, were capable of categorizing *manner*, preferring the *novel* test event to the familiar test event.

4. General Discussion

Taken together, these studies provide the first evidence that infants can form action categories. In two studies each performed at three ages, infants demonstrated that by 10 months of age, they can find the invariant *path* amidst differing *manners* and by 15 months of age, they can attend to an invariant *manner* amidst varying *paths*. Thus it appears that infants can isolate and abstract the invariant properties across *path* and *manner* even when other features of the display are changing. Further, a developmental trajectory appears such that *path* is detected prior to *manner*.

This research raises several questions. First, why would *path* be preferred over *manner*? One possibility is that *path* is more perceptually salient than *manner*. This account is supported by numerous findings from research in our laboratories. For example, Maguire (2003; Maguire et al, 2003) found that English-speaking children under 3 years of age willingly attach a novel verb label to the *path* rather than to the *manner* of action. Even when provided with

additional syntactical information (e.g., "Starry is blicking *over* the ball), only those children with a large arsenal of relational terms (e.g., above, on, kick, tickle) behaved like native English-speaking adults and attached the label to the *manner* of action. Further, research by Pulverman et al. (2003) demonstrated that 14- to 17-month-olds with a rich vocabulary were more attentive to *manner* changes than to *path* changes, while their low vocabulary counterparts were more attentive to *path* changes. These studies demonstrate that children are initially biased to attend to and label *path*. Only as children acquire more language are they less driven by this bias.

These studies also force us to ask why children prefer novelty in the *manner* condition and familiarity in the *path* condition. Here too the rationale may come from the perceptual complexity of the stimuli. Infants in the first experiment see four clips where *path* is held constant, while *manner* is varied. If *manner* is more difficult to process then this is a difficult perceptual scene. On the other hand, infants in our second experiment see four clips where *manner* is held constant, while the *path* is varied. To the extent that they can in fact process *path* quickly, the changing *path* is not as challenging to process. Research by Hunter et al. (1983) confirms this intuition suggesting that infants will prefer to look at familiar stimuli when the stimuli are complex. As a result, these children continue to look at the complex stimuli, leading to a familiarity preference, rather than a novelty preference. To investigate this claim, we reasoned that we should see a difference in the amount of time infants spent looking at the events during familiarization across the two studies. If it is the case that infants need more time to process complex stimuli then they should spend more time looking at these stimuli. We compared the average looking time across the familiarization trials for Experiment 1 and Experiment 2. Infants in Experiment 1, who see four *manners* across the same *path*, are spending more time, on average, investigating the familiarization clips than are infants in Experiment 2 (M = 9.83, SD = 1.48 vs. M = 9.21, SD = 1.74 respectively, t [138] = 2.33, p = .02). This offers further confirmation that *manner* of action is more complex and requires additional processing time. It also explains why one might get increased looking to familiarity in Experiment 1 and increased looking towards novelty in Experiment 2.

4.1. Limitations and Future Directions

While these findings suggest that infants as young as 10 months can categorize *path* and infants as young as 13 months can categorize *manner*, these studies are not without limitations.

First, by asking whether infants can abstract the invariant *path* or *manner* from these displays we begin to address the question of categorization, but do not explore the full range of categorization. Categorization is much richer than simply abstracting an invariant from a scene. In each of our clips, children saw the exact same *path* across varying *manners* or the exact same *manner* across varying *paths*. In the real world, children rarely see such contrived scenes. The

present studies provide but a first step in understanding the categorization of action. Indeed, had the children failed at these tasks, there would be little reason to move to more complex stimuli. Their success gives us reason to now explore the range of variability that infants can process regarding categories of action. This is, in itself, an interesting question, for the boundaries of action (and spatial) categories seem to shift across languages (e.g., the word must refer to tight fitting in Korean, but can be loose fitting in English; Choi & Bowerman, 1991).

Second, although the title of this paper is "foundations of verb learning" this paper explores only those actions that encode relations – motion verbs. Further, these studies used a narrow focus on only *path* and *manner* in motion events, excluding *result* and *instrument*. Current research in our laboratories is examining this question (Salkind, Sootsman, Golinkoff, Hirsh-Pasek & Maguire, 2002).

Third, one could question the use of the animated character rather than more naturalistic stimuli. Studies from our laboratories often use perceptually simplified events to help children fast-map an action to a verb (Maguire et al, 2002). Future studies, however, should replicate using more naturalistic scenes and human actors. A replication of our results using these stimuli is needed in order to determine the full extent of infants' abilities to abstract out and categorize non-linguistic components of actions in complex scenes.

Fourth, it is important to do future research to ask whether infants can abstract out and categorize any non-linguistic components of action, even those not universally found in the world's languages (e.g., speed, or side of body doing the action). This will allow us to determine whether words tend to draw on perceptually privileged constructs in the flow of events.

Finally, these studies should be expanded to provide insight on generalization. What would happen if we introduced a new agent at test and used a different agent during familiarization? Generalization may be a more difficult task and we may see those infants who succeed at the present task fail a generalization task.

The studies reported in this paper represent only the beginning steps of a larger program of research. Indeed, most of the questions outlined above are currently being investigated in our labs.

5. Final Remarks

If we are to understand the development of language, it is imperative that we learn more about how children acquire verbs. Research on this topic has expanded exponentially in the last 5 years. Yet, the study of verb learning will require that we not only look at how children comprehend and produce verbs, but also how children abstract and categorize the actions and events that serve as a foundation for verb learning. These studies are among the first to address the non-linguistic components of the verb-learning problem. Infants can not only detect the perceptual components like *path* and *manner* that are codified in the

worlds' languages, but they also show nascent ability to categorize these components of motion events. These studies show that while verb learning is hard, the conceptual foundations necessary for verb learning are in place very early in life.

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