Conceptual foundations for verb learning: Celebrating the event

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At the critical juncture between words and grammar lie verbs. Verbs appear in children's earliest vocabularies (Choi, 1998; Choi & Bowman, 1991; Choi & Gopnik, 1995; Fenson, Dale, Reznick, & Bates, 1994; Nelson, 1973; Tardif, 1996). They also serve as the architectural centerpiece of the sentence, specifying argument structure. How young children learn verbs is thus fundamental to our understanding of language acquisition. Most of the research on lexical acquisition has focused on nouns. The tides, however, are turning. Research from the past several years is beginning to illuminate the verb learning process. This paper focuses on what children know about the conceptual foundations for verb learning.

Though the field is still in its infancy, general (though not unanimous) consensus is emerging: Learning verbs is hard. This fact is well documented in the literature and in many of the studies cited in this volume. By way of example, in laboratory tasks, infants appear to fast-map nouns at an earlier age than verbs (Golinkoff, Hirsh-Pasek, Bailey, & Wenger, 1992; Golinkoff, Jacquet, Hirsh-Pasek, & Nandakumar, 1996). Even in languages where verbs occur in the prominent, sentence final position, or in isolation as the result of argument drop, children

tend to learn verbs later than nouns (e.g., Au, Dapretto, & Song, 1994; Bornstein, et al., 2004; Caselli, Bates, Casadio, & Fenson, 1995; Imai, Haryu, Okada, Lianjing, & Shigematsu, this volume, but see Tardif, 1996). When choosing between a novel object and a novel action, children as old as 5 years have difficulty determining the correct referent for a novel verb in both English and Japanese (Meyer et al., 2003; Imai, Haryu, & Okada, 2002). Finally, even adults observing interactions between mothers and children on muted videos are less successful at picking out correct referents for verbs than for nouns (Gillette, Gleitman, Gleitman, & Lederer, 1999; Snedeker & Gleitman, 2004).

In light of this mounting evidence, two critical questions arise: First, what makes verb learning so difficult? And second, what does it take to learn a verb? Speculation abounds on the first of these questions. Gentner (1982) offered a menu of differences that might make verb learning harder than noun learning, concluding in 2001 (Gentner & Boroditsky) that among the key features differentiating the two word classes is the fact that nouns tend to label referents that are more individuated and less relational than the referents labeled by verbs. Snedeker and Gleitman (2004) suggest that the imageability of the referent is also a key distinction, with nouns tending to label referents that are more imageable. Tomasello (1992) contends that verbs are also difficult because they label referents that "unfold in time." Finally, Maguire, Golinkoff, and Hirsh-Pasek (this volume) suggest that there is an amalgamation of features including imageability, concreteness, individuability, and shape that make the referents for nouns more perceptually accessible, and hence easier, both for conceptual learning and for mapping.

Though we have numerous arguments and counterarguments for why verbs might prove more difficult, we have less data on the second question of what it takes to learn a verb. Do children have the prerequisite knowledge that would enable them to learn verbs as readily as

nouns? It is to this question that we now turn.

THE VERB LEARNING PROBLEM

What does it take to learn a verb? Several researchers have identified the theoretical prerequisites for verb learning. Gentner and Boroditsky (2001), for example, write in broad strokes that verb learning requires both the *conceptualization* of actions and events and the *mapping* of words to these events and packages of events. They further argue that the latter might prove more difficult than the former because, across languages, verbs do not package actions and events in the same way. For example, in English one can say, "The man limped down the stairs." In Spanish the sentence would read, "El hombre bajó las escaleras cojeando," and would be translated as, "The man went down/descended the stairs limping." How the man moves, or the *manner* of the action, is embedded within the English verb. In contrast, the manner in Spanish is expressed as a modifier of the verb, with the verb itself indicating only the *path* of the man's motion. Thus, it might take a long time to package the conceptual components for verbs and to map them onto words in a way consistent with the native language. Indeed, Gillette and colleagues (1999) make this point explicitly when they find that conceptually mature adults have difficulty mapping a verb onto an action or relation in their now classic human simulation task.

The question of what it takes to learn a verb was also discussed by Golinkoff and colleagues (2002). They delineated three fundamental tasks required for verb learning to take place: (1) attending to and individuating actions and relations in the environment; (2) forming categories of actions and relations without language; and (3) mapping words to actions (dynamic relations) and action (relational) categories. Though all agree that children must attend to events and dynamic relations to solve the verb learning problem, there has been scant research on

infants' knowledge of these conceptual constructs.

PREREQUISITES FOR VERB LEARNING: WHAT WE KNOW

Seeing It All in Motion

One place to begin the investigation is with the infant's attention to motion. Though not all activities, relations, and events include motion (e.g., sleep, explain, outside, between), motion tends to signal the presence of events. Furthermore, there is a rich literature suggesting that infants are very attentive to movement.

By way of example, a number of studies show that infants are better at perceiving objects when they are in motion than when they are statically displayed (Kellman, Spelke & Short, 1986; Smith, Johnson & Spelke, 2003; Werker, Cohen, Lloyd, Casasola, & Stager, 1998). In general, infants are more attentive to moving than to stationary objects (Slater, 1989). Further, 9-month-old infants can even form a *representation* of motion to predict the orientation of an object that is rotating *behind* an occluder (Rochat & Hespos, 1996). Attention to movement type (e.g., flexible versus rigid) signals classes of objects that are animate versus inanimate and is critical in determining causality (Golinkoff, Harding, Carlson-Luden, & Sexton, 1984; Kotovsky & Baillargeon, 2000; Mandler, 2004; Cohen & Oakes, 1993; Poulin-Dubois, Lepage, & Ferland, 1996; Rakison, 2003; Wang, Kaufman, & Baillargeon, 2003). Interestingly, while we know a great deal about infants' attention to movement, their understanding of movement has not been studied in its own right. Rather, movement was studied as a tool for discovering infants' understanding of the properties of objects (see Baillargeon, 2004 for a review).

The Great Divide: Using Movement Cues to Parse Events into Actions

Movement not only offers a perceptual tool for examining objects, but also serves as a

parsing tool for breaking events into individual actions. Several studies give us insight as to how children might use motion to parse events into segments. Loucks and Baldwin (this volume), for example, present some of the first research in this area. Sharon and Wynn's (1998) studies offer another example. Originally designed to investigate the enumeration of actions, these experiments showed that 6-month-old infants are sensitive to changes in the number of repetitions of an action. Infants in this study could distinguish between two or three repetitions of the same action (jumping) when they occurred in a continuous stream of movement (jumps and falls). It is likely that the infants in this experiment discriminated the sequences based on the number of repetitions of motion segments. Importantly, if infants do have a sense of 'number of actions' in a continuous action sequence, they must also have a sense of one action ending and the next beginning. Thus, Sharon and Wynn's experiments provide evidence that infants as young as 6 months can use movement cues to segment events.

Baldwin, Baird, Saylor and Clark (2001) also present important evidence suggesting that infants as young as 10 months use motion cues to parse sequences of actions. Their study was designed to investigate whether children could home in on an actor's social intent to parse an ongoing stream of action. After familiarizing infants with everyday events (a "cleaning the kitchen" scene), they viewed videos in which pauses were inserted that either interrupted (e.g., *during* the act of hanging up the towel) or allowed completion of (e.g., *after* the towel was hung up) the intended actions. The infants were overwhelmingly more interested in the disrupted actions than the completed ones, suggesting that they were sensitive to the action boundaries within the event. It is possible that this result emerged because children were attending to actor intent. It is equally possible, however, that, "perceptual sensitivity to physical and temporal regularities that *coincide with intentions* would enable them to achieve an organized parsing

of…novel action sequences, even when they do not understand the intentions involved" (Baldwin et al., 2001, p.715). Thus, the task might be solved through more 'impoverished,' 'bottom-up" parsing strategies that are visual in nature, including movement features such as head turns, gaze direction changes, and changes in body trajectory.

However we interpret this finding, it suggests that infants are sensitive, in some ways, to event structure and that they can parse events from the dynamic flow of action. Taken together, these studies on motion, number, and social intent suggest that infants have the capacity to perceive events and to divide events into individual actions.

Looking Within: Getting a Piece of the Action

The problem of verb learning requires that infants isolate actions and relations from the dynamic stream of events. Learning a relational term like a verb, however, involves more than simply isolating actions. It requires that children are also sensitive to intrinsic (manners) and extrinsic (paths) features of the action. Verbs, for example, tend not to label whole actions. Rather, they label a subset of the many, often simultaneously occurring semantic components of motion events. These components include *motion* (the general fact that motion is taking place), *figure* (the prominent entity in the event), *manner* (the way in which the action/motion is carried out), *path* (the trajectory of the figure with respect to some reference point), *ground* (the reference point for the event's path), and *cause* (the cause of the figure's motion), among others (Talmy, 1985). For example, imagine an event where a man passes through the banner at the end of the New York Marathon. The figure is the man, the manner running, the path through the banner, the ground the banner itself, and the cause the internal motivation for running the race.

Every motion verb conflates a subset of these conceptual components in its meaning such that there is a variety of types of motion verbs. Manner verbs encode motion conflated with

manner (e.g., *run, jump, float*). Path verbs encode motion and path (e.g., *enter, circle, descend*). There are also verbs that conflate more than one element along with motion, such as *deplane*, which encodes motion, path, and ground. But no verb encodes everything in a given event. Thus, while all of the elements of motion events may simultaneously meet the eye, only some of them will be relevant to learning any particular verb. As noted earlier, different languages also package event components in different ways (Talmy, 1985). In the majority of languages (e.g., Spanish, Turkish, Greek), path verbs are the most frequent. For example, to express an event in which a woman exited a house as she ran, a native Spanish speaker is most likely to say, "*Una mujer salió de la casa (corriendo)*" ('A woman exited the house (running)). In many other languages (e.g., English, German, Chinese), manner verbs and cause verbs are most frequent. To express the same event, a native English speaker is most likely to say, "*A woman ran out of the house.*" In a small minority of languages (e.g., Atsugewi), verbs most frequently conflate motion and figure. Verbs in these languages often express meanings such as 'action/movement of a long, thin object'. This variability among verb meanings both within and across different languages requires that the verb-learning problem be solved anew for each verb learned, and the most reliable solution varies depending on the language being acquired.

So what in the verb learning process is so difficult for children? To date, the majority of research on verb learning has focused on the mapping problem and on the ways in which older children learn to package conceptual information to master the verb and prepositional system of their native language (e.g., see Choi, this volume and Mandler, this volume). But do children have the conceptual prerequisites needed to build a semantic base for verb learning? Gentner (1982; Gentner & Boroditsky, 2001) hypothesizes that the conceptual prerequisites for the learning of verbs and other relational terms should be largely in place. She writes,

> It is important to note that the Natural Partitions hypothesis does not assume that relations themselves are perceived later than objects…even those sparse relations that act as predicates over objects are, I suspect, *perceived* quite early. Movement, change, directionality, and so on, seem quite interesting to infants…It is not perceiving relations but packaging and lexicalizing them that is difficult (Gentner, 1982, p. 326).

Cognitive linguists present a consistent, but largely untested theoretical view. They hold that the types of concepts verbs label, such as path, manner, and cause, may be pre-linguistic conceptual primitives from which all other relational terms are constructed (e.g., Mandler, 1991, 2004; Jackendoff, 1983). The challenge for the field is to determine whether these conceptual primitives are indeed in place to support the learning of verbs and relational terms. Research from Choi's laboratory (Choi, this volume), from Casasola's laboratory (Casasola, Bhagwat & Ferguson, this volume) and from our laboratories is beginning to address these questions. We are starting to examine whether infants are sensitive to the conceptual primitives that interactively support verb learning. To date, this research is playing out in two main areas: the study of spatial expressions and the study of motion verbs. Spatial expressions, including constructs of containment and support (e.g., *in* and *on*), as well as motion verbs, with components that include constructs like *path* and *manner*, offer a perfect looking glass for investigating the conceptual foundations of relational terms. In each case, the construct in question (different types of containment and support; different paths and manners) seems to be perceptually accessible. Further, and importantly, in each case there is considerable cross-linguistic variability. For example, the Korean word "kkita" means 'to put tight-fitting', regardless of whether the relation is one of containment (e.g., fitting a peg tightly into a hole) or support (e.g., fitting one Lego® tightly onto another). In English, however, the relevant

distinction is between containment ("in") and support ("on"), regardless of the tightness of fit. With motion verbs, the manner is often expressed in the verb for English speakers (e.g., *run, jump, skid*) while the path is often expressed in the verb for Spanish speakers (e.g., *enter, leave, descend*). Though this research is, quite literally, in its infancy, results are already emerging to suggest that infants are sophisticated observers of actions and relations who attend to conceptual primitives in the ways suggested by both Gentner (1982; Gentner & Boroditsky, 2001) and Mandler (1992, 2004).

CONCEPTUAL PRIMITIVES FOR VERB LEARNING: SPATIAL EXPRESSIONS AND MOTION VERBS

Spatial Expressions

There is a rich literature on spatial expressions (e.g. Bowerman, 1996; Landau, 1996; Landau & Jackendoff, 1993; Meints, Plunkett, Harris, & Dimmock, 2002). Some of the more interesting and now classic findings in this literature came from differences in the way that native Korean and English speakers codified containment and support relations. Choi and colleagues (Choi & Bowerman, 1991; Choi, McDonough, Bowerman, & Mandler, 1999) have found, in both production and comprehension studies, that children categorize spatial relations like containment and support in language-specific ways. In their now classic study, Choi and Bowerman (1991) found that 17- to 20-month-olds' use of spatial words was language-specific. For example, children raised in English-speaking homes used the words "in" and "on" to distinguish between containment events and support events, regardless of fit. Children raised in Korean-speaking homes made a different distinction that cross-cut the English "in" and "on" using the concepts of "tight-fit" or "loose-fit." Choi et al. (1999, see also this volume) found similar results when they looked at the comprehension of language-specific spatial words, like

"in" and "on" for English and "kkita" for native Korean. Using a preferential looking paradigm, they found that children as young as 18 months of age comprehend these spatial words and turn their attention towards the events depicting these spatial concepts. Infants raised in English-speaking homes look at an event depicting containment, regardless of tightness of fit, when they hear the word "in." Children raised in Korean-speaking homes directed their attention towards an event depicting tight fit, regardless of containment or support, when they heard the word "kkita."

These classic studies raised the question about when the differences that were evident across languages emerge in the course of development. Perhaps the most stunning of the recent demonstrations comes from Hespos and Spelke (2004), who investigated this question with 5-month-old infants. In a habituation task, they presented children with scenes of an object that was fit tightly (or loosely, depending on the condition) in a container. After infants habituated to the event, the experimenters presented either another object that fit tightly or one that fit loosely in the container. The preverbal English-learning infants overwhelmingly demonstrated their ability to distinguish the tight- and loose-fit dimension that is common in containment and support terms used in Korean. In many ways, this experiment is but a replication of one performed by McDonough, Choi, and Mandler (2003) in which 9-month-old infants from both English- and Korean-speaking environments demonstrated that they could discriminate between spatial concepts that are not typically codified in their language.

These empirical demonstrations suggest that, at an early age, infants are predisposed to note the kinds of conceptual divisions within the spatial arena that will be relevant to later language learning. As Mandler (2004) argues, these children seem to be able to do perceptual meaning analysis of the sort that will offer a strong foundation for language learning.

Motion Verbs

Motion verbs comprise only a small percentage of the verbs in an adult vocabulary. Yet, they offer a promising point of entry for verb research for several reasons. First, motion verbs, like spatial terms, appear relatively early in the corpus of early words (Fenson et al., 1994). Verbs like "fall," "jump," and "dance" are among the first set of words to enter the child's budding lexicon. Second, with motion verbs, the referent event is visible to both parent and child. To the extent that words are learned best in periods of joint attention (Adamson, Bakeman, & Deckner, 2005; Carpenter, Nagell, & Tomasello, 1998; Tomasello, 1992), motion verbs thus provide optimal learning opportunities. Third, verbs of motion are generally individuable and imageable, possessing exactly the characteristics that Gentner and Boroditsky (2001) thought would make words more learnable. Fourth, there is some (though limited) knowledge about how events codified in motion verbs are processed (Pulverman, Sootsman, Golinkoff, & Hirsh-Pasek, 2003; Pulverman, Golinkoff, Hirsh-Pasek, & Sootsman-Buresh, in preparation; Casasola, Hohenstein, & Naigles, 2003, in preparation). Fifth and finally, like the spatial concepts examined above, event components are packaged differently to yield the conceptual bases for verb learning.

Arguably, path is one of the most central concepts for learning relational terms such as verbs because it is the semantic component from which other notions, like animacy and causality, may be derived (Mandler, 2004). By extension, it is equally important to study manner because, in order for a path to be traversed, a manner is required to propel the moving figure. Thus, while the elements of motion to be discussed here are limited, our focus on path and manner will lay a solid foundation for understanding the development of the concepts underlying motion verbs.

In the past few years, we, along with Casasola (Casasola, Bhagwat, & Ferguson, this volume; Casasola, Hohenstein, & Naigles, 2003, in preparation), have embarked upon an innovative program of research exploring the cognitive foundations of motion verb learning. Using specially designed stimuli, integrated across a variety of studies using multiple experimental paradigms, we have been probing a wide range of sub-components in the verb-learning process and pinpointing infants' strengths and weaknesses with the goal of providing a detailed account of the development of essential pre-verb-learning skills. This research has taken place on several fronts. First, we explored infants' attention to motion events with respect to two questions: Do infants notice changes of individual elements of events, and are they able to decompose events into separable elements, such as path and manner? Casasola, Hohenstein, and Naigles (2003, in preparation) have relevant evidence on event discrimination as well. Second, we investigated the question of event categorization and asked whether infants can form categories of similar paths or manners amidst changes in the perceptual flow. If infants can solve these tasks in non-linguistic studies, it will further reinforce the view presented above, that infants are perceptually and conceptually prepared to learn verbs.

Attention to Events: Discrimination and Conceptual Decomposition

Path and Manner

Research on the parsing of events is rare, so we know relatively little about how infants find individual actions within the flux of dynamic events. Yet, there is evidence to suggest that they are competent to detect these actions. Thus, from the standpoint of prerequisites for verb learning, the relevant question becomes one of event decomposition. Can infants attend to aspects of motion or action that will be later codified in relational terms?

Our first pass at this question was with 14- to 17-month-olds in a habituation[1] task

(Pulverman et al., 2003, in preparation). Infants viewed silent, computer-animated motion events involving a moving starfish character (the figure) and a stationary ball (the ground). In the events, the starfish performed an action with both a manner (jumping jacks, spinning, or bending at the 'waist') and a path (over the ball, under the ball, or (vertically) past the ball) (see Figure 1). Once infants became habituated to a single event (e.g., jumping jacks over), they were then tested on four different types of events: (1) a control event identical to the habituation event (e.g., jumping jacks over); (2) an event with the same manner as the habituation event, but a different path (e.g., jumping jacks *under*); (3) an event with the same path as the habituation event, but a different manner (e.g., *spinning* over); and (4) an event in which both the manner and path differed from those in all other events (e.g, *waist bends past*). The results were impressive. Fourteen- to 17-month-old infants had no trouble discriminating between paths or between manners. They readily dishabituated to the path change, the manner change, and the both change events. In short, there was clear evidence that they noticed changes of paths and manners.

These initial results motivated several additional studies, all of which affirm the main findings. In our laboratory, Pulverman and Golinkoff (2004) examined attention to path and manner in 7-month-old infants. Using exactly the same habituation task, 7-month-olds successfully dishabituated to changes of manner, changes of path, and changes of both manner and path. This shows that, even before word learning begins, infants notice differences between events that could potentially distinguish between one verb and another. Pulverman and Golinkoff's (2004) study shows that preverbal infants are already equipped with one of the fundamental cognitive tools they will need to learn motion verbs.

A study by Casasola, Hohenstein, and Naigles (2003) makes a similar point. In their

study, 10-month old children participated in a habituation task in which they viewed videos of more natural action. In the habituation phase, a girl might be seen *crawling* towards a shrub. In the manner change condition the girl now *walked* towards the shrub. In the path change condition, the girl crawled away from the shrub. In the both change condition, the girl *walked* away from the shrub. Results suggest that 10-month-olds notice both manner and path changes.

Results from all of these studies demonstrate that, even in the first year of life, infants are aware of changes of manner and path. That is, they seem to be sensitive to the conceptual primitives required for later verb learning even in these non-verbal tasks. These studies also raise the question of whether the infants are really responding to path and manner as individual motion components within the event, or whether they might be responding to more holistic perceptual changes in events. That is, it is possible that children do not notice a path change *per se*, but rather that the entire scene has changed. An example might be useful. If path is represented by the color RED and manner by the color BLUE, then we can argue that the children actually note the separable motion components of path and manner, or RED and BLUE. Yet, it is possible that they are seeing something analogous to PURPLE and that when we change the path, for example, to YELLOW, that the children see GREEN rather than the change from RED to YELLOW. From what we have discussed so far, in the current studies, we cannot distinguish from among these alternatives.

To address this issue in 14- to 17-month-olds, Pulverman and colleagues (2003, in preparation) performed a second analysis. They reasoned that, if infants attend to manner and path as particular elements of interest, then all trials in which one of these elements has changed should be treated differently from all trials in which that element remains the same, regardless of whether the other element is the same or different. Furthermore, if manner and path are

independent conceptual elements for infants, then reactions to changes of manner and to changes of path should not interact with one another. Thus, to evaluate whether 14- to 17-month-olds treat manner and path as separate elements, an ability we term *conceptual decomposition*, Pulverman et al. analyzed the main effects and interaction of the factors 'manner' and 'path', each of which had two levels, 'same' and 'different' (see Figure 2). The main effects of both manner and path were significant, and no significant interaction between manner and path was found. This pattern of results suggests that, at least for the older children studied on these questions, manner and path may be *independent elements within a motion event*.

In this non-verbal study, mothers nonetheless filled out the MacArthur Communicative Development Inventory (CDI) Infant Short Form (Fenson et al., 2000) to note the productive and receptive vocabularies of the children, and receptive vocabulary (above or below the expected median for the age range) was included as a factor in the analysis. Interestingly, a significant interaction was found between the main effect of manner and vocabulary level. The manner effect was greater for the higher vocabulary infants than for their lower vocabulary counterparts. Furthermore, the manner effect was significant **only** in the higher vocabulary group. There are three possible explanations for these findings, two of which are related to the fact that manner verbs are more frequent than path verbs in English. First, perhaps accumulated knowledge of English verbs *teaches* infants that manner is important. If this is the case, then the adjustment of attentional biases may possibly be a tool infants use to make further verb learning more efficient. By increasing attention to manner, the likely referents for more verbs should stand out. Second, perhaps some infants happen to pay more attention to manner than others, and English-learners who pay more attention to manner notice the correct referents for more words, promoting higher vocabularies. Third, perhaps an unknown third factor promotes both vocabulary growth and

increased attention to manner. Preliminary data from a replication with infants learning Spanish (a language that expresses path more often than manner) supports the second explanation: that attention to manner influences lexical acquisition (Pulverman, Golinkoff, Hirsh-Pasek, & Jackson-Maldonado, 2005; Pulverman et al, in preparation).

The same analysis (omitting the vocabulary factor) performed on the 7-month-olds' data yielded different results. For those young, preverbal infants, a significant interaction of manner and path was found suggesting that manner and path are not independent elements at 7 months. The results of these two studies show that the ability to treat manner and path as independent elements of motion events develops somewhere between 7 and 17 months of age. Research currently underway on early categorization of motion components allows us to investigate this same question in yet another way, revealing that children might be able to note separable action components by as early as 10 months of age (Pruden, Hirsh-Pasek, Maguire, & Meyer, 2004).

Beyond Path and Manner: Speed

Path and manner offer one example of event discrimination and decomposition that taps into the kinds of perceptual and conceptual constructs that are known to influence later language learning (Langacker, 1987; Mandler, 2004; Talmy, 1985). As a final experiment in this set, however, we wanted to know if infants were also able to detect elements of events that are more subtly codified in the world's languages. Relational terms often mark relative speed[2] (e.g., *The boy ran* versus *The boy sprinted*), though not as frequently as manner or path. Relative speed can be considered a more subtle semantic element in that it is a subcomponent of manner, specifying additional detail about how the action is carried out. Would infants be sensitive to this kind of information in the perceptual stream? An experiment by Salkind (2003; Salkind, Golinkoff, & Brandone, 2005) was designed to find out.

Salkind (2003; Salkind, Golinkoff, & Brandone, 2005) tested 9- to 11-month-old infants' discrimination of repetitive actions performed at different rates. Stimuli were events with a human figure performing complex actions, including both arm and leg movements, such as one might see in an aerobics class. Participants were habituated to an event with one of the actions performed at a particular rate – either 60, 80, 100, or 120 beats per minute. They were then tested on the same action at the same rate and the same action at a new rate, either 20 beats per minute faster or 20 beats per minute slower. Infants looked significantly longer at all of the rate changes, both faster and slower than the original rate, showing that they successfully discriminate rate differences of 20 beats per minute. Salkind's finding that 9- to 11-month-olds can discriminate between the same action performed at different speeds provides evidence that, from a very young age, infants are prepared to make at least one of the distinctions that is necessary for learning subtly different manner verbs. Taken together with the studies on path and manner, this result strongly suggests that infants attend to a number of verb-relevant perceptual elements within the motions that they see.

Does Language Itself Influence Attention to Events?

The Pulverman et al. (2003, in preparation) results suggest that, even in this non-verbal task, language is somehow directly related to children's attention to and conceptual decomposition of motion events. Of course, in a "real world" potential verb-learning situation, children view motion events accompanied by language. Would the addition of language exert any noticeable change in the way infants approach these tasks? There are two possibilities. On the one hand, research suggests that nouns amplify attention to objects (Baldwin & Markman, 1989) and to categories of objects (Balaban & Waxman, 1997; Waxman, 2003; Waxman & Markow, 1995). Thus, we might expect verbs to amplify attention to motion. On the other hand,

the introduction of words might be disruptive to infants' performance because it adds to the processing load of the task. For example, Stager and Werker (1997) found that 14-month-olds could discriminate between two minimal pair syllables ("bih" versus "dih") when they were presented in the context of a checkerboard that filled a video screen. But when the syllables were presented in the company of objects – as if it were a word learning task – infants could no longer distinguish between the sounds. To investigate the role of language on the processing of motion components, we added language to the Pulverman et al. study.

Pulverman, Brandone, and Salkind, (2004) conducted this research with English-learning infants between 14 and 17 months of age. The procedure and stimuli are identical to those in Pulverman et al. (2003, in preparation), described above, except that language has been added. In the habituation phase, concurrent with the presentation of the motion event, infants hear a novel verb ("He's *jaiming!* Wow! He's *jaiming!* Oh, boy! He's *jaiming!…"*). The habituation phase of the experiment thus constituted a potential verb-learning situation. Importantly, the test phase of the experiment paralleled the test phase in Pulverman and colleagues' non-linguistic study. That is, this was *not* a test of verb learning. Instead, the verb was removed from the audio ("Wow! Oh, boy! Wow!…") so that the events in the test trials only tap the representation of the event previously formed during the habituation phase. The question is whether the addition of language in the habituation phase of the experiment would influence infants' attention to motion events? The answer is yes. Preliminary results indicate that, in a potential verb-learning context, English-learning infants notice manner of motion more than they do when watching motion events in silence. Attention to path appears to be unaffected. Furthermore, preliminary results suggest that infants in the potential word-learning task look significantly longer at the event with the changed manner than at the event with the changed path, a finding that was not

evident in the silent version of the study.

These results suggest that, in parallel with Baldwin and Markman (1989), adding language heightens attention to the visual event. Interestingly, however, language appears to differentially affect infants' responses by increasing attention to only the manner of the event – the most likely referent for novel motion verbs. This finding can be interpreted in a number of ways. First, perhaps this is an instance of 'thinking for speaking' (Slobin, 2001), a weak form of linguistic relativity whereby thought *for linguistic purposes* is influenced by one's native language. Under this interpretation, the English-learning infants in this task increased their attention to manner in the potential verb-learning situation because manner is the event component most frequently expressed by verbs in English. The second possibility is that increasing attention to manner is a language-general verb learning strategy. Regardless of the language being learned, manner should always be the more likely referent for a novel word. This is because manner concepts are an open set, while path concepts are a closed set. So, even if there are more *tokens* of path terms in a given language, there should nonetheless be more *types* of manner words. A third alternative is more perceptual in nature. If path is considered the more fundamental aspect of these events (Mandler, 2004), perhaps the addition of language serves to bring less potent elements of events, like manner, to the foreground. Extremely preliminary evidence from infants learning Spanish (a language that expresses manner less frequently than path) suggests that infants increase their attention to manner in linguistic contexts regardless of their native language. These data are consistent with both the second (language-general) and third (perceptual) explanations. But regardless of the ultimate reason, Pulverman, Brandone, and Salkind's (2004) results are an instance of language heightening attention to the part of events that is most likely to be the referent for a novel verb.

The findings on event discrimination and conceptual decomposition suggest that infants can look within motion events to find the primitives that form the basis for verb learning. Infants notice not only robust (e.g., path and manner), but also more subtle (e.g., speed) perceptual elements that are conflated in the relational terms of languages across the world. Furthermore, the presence of accompanying language in the input seems to promote attention to the elements of events encoded by a greater number of different relational terms. Attention to this information is a key prerequisite for the learning of motion verbs, manner adverbs, and path prepositions. Yet, attending to and conceptually decomposing events, while necessary, is not sufficient to prepare infants for the learning of relational terms. To learn action terms, infants must be able to categorize these conceptual building blocks. Research in our laboratories is beginning to address this critical issue as well.

Event Categorization

Verbs and prepositions do not refer to individual events. As Oakes and Rakison (2003, p. 4) have stated, "words refer to *categories* of objects and events" (emphasis added). Just as the noun *chair* refers to dining room chairs, office chairs, and recliners, a motion verb refers to a category of perceptually differing actions. Picture a track star running. Now picture your grandmother running or a cheetah running. These actions look very different, yet they all fall into the category labeled by the English verb *run*. Even when performed by the same person, running can vary dramatically when it occurs on different surfaces, or when performed with different purposes. To complicate matters further, some actions that are perceptually similar fall into different linguistic categories. The action a track star performs when leaping over a hurdle might be considered perceptually similar to the way she runs. How do children ever solve this complicated problem? Why do they call each of these instances, except leaping hurdles, by the

same name?

These issues raise a number of ancillary questions. What types of invariants can infants use as a basis for event categories? What kinds of variation can they disregard in their categorization of events? Several studies from our laboratories are among the firsts to address these issues.

Categorizing Human Action

Salkind, Sootsman, Golinkoff, Hirsh-Pasek, and Maguire (2002) were among the firsts to examine event categorization. They tested 9- to 11-month-old infants' categorization of events based on manner, across a variety of figures. Infants were habituated to one of several complex novel actions, performed by two different female actors in random order. The actions were like those one might see in an aerobics class. Infants were then tested on two novel events: an event with a new actor performing the same aerobic action (in-category event), and an event with the same new actor performing a new aerobic action (out-of-category event). The results suggested that, regardless of the particular combination of actions used in this counterbalanced design, infants could indeed categorize motion events. The children looked significantly longer at the out-of-category test event than at the in-category test event. They also looked longer at the in-category test event than at the last three habituation trials, demonstrating that they discriminated between the new actor and the old actor. Infants formed a category of events based on a common manner *despite* detectable variation in the person performing the action. The ability to find common action across variation in the actor is critical to learning motion verbs. Walking is walking, no matter who is doing it. Salkind et al's study shows that, by 9 months of age, infants can categorize events in one of the most fundamental ways necessary for learning manner verbs.

Categorizing Events Based on Path and Manner

Pruden and colleagues extended this research on categorization by investigating whether infants could categorize events based on path across varying manners and based on manner across varying paths (Pruden et al., 2004; Pruden, Pulverman, Hirsh-Pasek, & Golinkoff, 2003). Pruden and colleagues (2004) used English-reared infants between 7 and 15 months of age. The stimuli for these studies were computer-animated motion events involving a starfish and a ball as figure and ground, respectively. Using a superset of the stimuli used by Pulverman et al. (2003, in preparation; Pulverman & Golinkoff, 2004), 6 manners (e.g., "spinning", "jumping jacks", "twisting", "toe-touching", "side bending", and "bowing") and 6 paths (e.g., "over", "under", "around", "past", "in front of", and "behind") were created. In a modified version of the split-screen Preferential Looking Paradigm (Hirsh-Pasek & Golinkoff, 1996; see Figure 3) infants viewed events with this animated starfish. Importantly, *no linguistic stimuli* accompanied these events. Infants 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. The amount of time and direction of the child's gaze were recorded.

Infants participated in four phases during the study: 1) introduction phase; 2) salience phase; 3) familiarization phase; and 4) test phase. During the **introduction** phase, infants were introduced to the animated starfish. During this introduction the starfish moved across the screen from left to right and back while stretching his arms and legs outward.

During the **salience** phase, infants were simultaneously presented with two event clips, side-by-side. These were the exact same event clips that would be seen later during the test phase. The purpose of the salience phase was to measure any *a priori* preference for the event clips to be used in the test phase. The underlying assumption here 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 clip demonstrated the animated star performing both a single *manner* and single *path*. These event clips all demonstrated an exemplar of the category being tested. Finally, during the **test** phase infants were presented with both an in-category event and an out-of-category event. The purpose of the **test** phase was to assess whether infants had formed a category.

To test categorization based on *path*, participants were familiarized with four events on a video screen, one after another, each of which had different manners, but shared a common path (e.g. "spinning *over*" followed by "twisting *over*", "bending *over*", and "jumping jacks *over*"). They were then tested with 2 novel events, an in-category event and an out-of-category event, which appeared side-by-side. The in-category event had a novel manner and the familiar path (e.g., "toe-touching *over*"), while the out-of-category event had the same novel manner and a *novel path* (e.g., "toe-touching *under*"). Infants first showed evidence of successful categorization between 10 and 12 months, with these infants looking significantly longer at the in-category event than at the out-of-category event. These findings demonstrate that, by 10 to 12 months of age, but perhaps not before, infants are able to categorize events based on path, disregarding variations of manner.

To test categorization based on *manner*, 7- to 15-month-old infants were familiarized with four events with different paths, but the same manner (e.g., "*spinning* over", "*spinning* under", "*spinning* past", and "*spinning* behind"). They were then tested on an in-category event with a novel path and the familiar manner (e.g., "*spinning* around"), and an out-of-category event with the same novel path and a novel manner (e.g., "*twisting* around"). Thirteen- to 15-month-olds looked significantly longer at the out-of-category event than the in-category event, while the

younger infants showed no reliable preference. These findings suggest that, by 13 to 15 months of age, but perhaps not sooner, infants are able to categorize events based on manner, disregarding variations of path.

Pruden et al.'s studies show that categorizing events along the lines of an invariant conceptual primitive (like manner or path) does not come "for free". Event categorization skills develop in infancy, with different types of categorization becoming accessible at different points in development. Infants can categorize events based on a common path across varying manners before they can categorize events based on a common manner across varying paths. These findings raise several important points. First, they suggest that infant categorization of actions does not come on line at the same time for each conceptual construct. Some semantic components of events are easier to categorize than others. The second point is that these findings relate to the findings of Pulverman and colleagues (2003, in preparation). In order to form categories, infants must be able to isolate the conceptual primitives of path and manner rather than viewing them as interactive wholes. Third, this finding challenges researchers to move beyond a surface view of categorization in which infants are but finding the *invariant* feature of the action. Each of these points deserves further elaboration.

The first point, that different categories are formed at different points in development, has been suggested before. Quinn and colleagues (Quinn, Cummins, Kase, Martin, & Weissman, 1996; Quinn, Norris, Pasko, Schmader, & Mash, 1999), for instance, previously showed that the ability to form categories of static spatial relations develops at different times for different spatial relations. For example, infants can form a category of the location 'over' before they can form a category of the location 'between.' Casasola and Cohen (2002) showed that the ability to categorize *dynamic events* based on their ultimate spatial relations across a variety of figure and

ground objects develops on different time scales for different spatial relations. For example, the category 'put in' can be formed at an earlier age than the categories 'put on' or 'put tight-fitting.' Finally, in related research, Baillargeon (2004) demonstrates that infants notice different perceptual features within different types of events. Thus, the feature of height is paramount for 4 1/2-month-olds in an occlusion event, but does not surface as a key construct in containment events until children are 7 1/2 months of age.

The results presented here suggest that path might be more basic than manner for young children. This is consistent with claims forwarded by Mandler (2004) and others who view path as one of the cornerstones for the conceptual development of motion. As Mandler writes, "…PATH is the simplest conceptualization of any object following any trajectory through space" (p. 28). It should thus come as little surprise that path seems to be categorized before manner.

The second point is that these data add force to the suggestion that, by 10 months of age, children are noting conceptual primitives as separable units rather than as united or interactive perceptual wholes. The infants in Pruden et al's (2004) research had to isolate the common element among ever-changing perceptual displays, in this case, path or manner. If the children viewed these dynamic displays as integrative wholes rather than as componential, they could not have solved this task because both test events were novel. Each scene varied by at least one element. Each would thus be viewed as different rather than similar *unless* the child focused on the individual components of the action portrayed (i.e., conceptual decomposition).

Third and finally, Pruden et al.'s (2004) research is but a first step in our understanding of infants' ability to categorize motion events. In these tasks, infants needed only to abstract the invariant perceptual features from the events that they saw. To form the types of event categories that verbs label, children must look beyond these *perceptual* invariants and recognize

conceptual invariants despite perceptual variation in the event component in question. For example, the manner category "run" applies both to Carl Lewis's running and to Grandma's running, even though these actions perceptually differ. Likewise, the path category "over" applies to both a little over and a lot over, even though the trajectories of the actions are not identical. Can infants form categories of perceptually variable manners and paths? Studies by Salkind and colleagues (2002, 2003, 2005) begin to shed light on this question.

Categorizing varying manners. Salkind et al.'s (2002) finding that 9- to 11-month-olds can categorize events based on manner across varying figures (discussed earlier) *may* have involved categorization of perceptually differing manners. Each particular aerobic action was performed differently by each actor and these differences were clearly perceptible to adults. However, since it is impossible to determine whether the manner differences were perceptible to infants, we cannot be certain of whether the task included categorization of varying manners. Since detecting the variability of manner introduced by different actors will always be necessarily confounded with discrimination between the actors themselves, we may never be able to determine whether children who cannot yet explicitly answer questions notice such differences of manner in the presence of different actors. But despite the fact that it is unclear whether infants' solution of the Carl Lewis versus Grandma problem is conceptual categorization or merely perceptual, this study shows that they have the ability to overcome the problem.

In another study, Salkind (2003; Salkind, Golinkoff, & Brandone, 2005) tested infants' categorization of events based on manner across varying rates. Rate is a sub-component of manner – subtle differences between manner verbs can be based on relative speed (e.g., *run* vs. *sprint*). Thus, this experiment directly addresses the issue of categorization of perceptually varying manners. Stimuli were the same events used in the rate discrimination study described

earlier. Each event was comprised of the same female actor performing one of 4 aerobic actions at either 60, 80, 100, or 120 beats per minute. From the previous discrimination study, we know that infants detect the differences between the rates of these events. Nine- to eleven-month-old infants were habituated to three different events in random order, all of which had the same general manner performed at different rates. They were then presented two test events – an in-category event with the same manner at a novel rate, and an out-of-category event with a novel manner at the same novel rate. Participants looked significantly longer at the out-of-category event than at the in-category event, showing that, by 9 to 11 months of age, infants are able to categorize manner across varying rates. Since variations in rate or speed are extremely common in the world, this ability constitutes an important foundational skill for learning verbs. Further research is needed to determine the other ways in which infants can categorize perceptually variable manners, and the ways in which they can categorize other perceptually varying semantic components of motion verbs such as path and figure.

PRELINGUISTIC FOUNDATIONS FOR VERB LEARNING

In 1982, Gentner hypothesized that, "It is not perceiving relations but packaging and lexicalizing them that is difficult." Twenty-two years later, Mandler (2004) added, "our conceptualizing baby is observing what the objects around her are doing in the sense that she is analyzing the paths the objects take…" (p.85). In some ways, the research presented here is a test of the hypotheses that babies are making sense out of the world of events that surrounds them. The field of infant event perception is young, yet data are already beginning to confirm these hypotheses.

The portrait of infant abilities that is emerging suggests that, by the second half of the first year of life, babies begin to parse and categorize events into objects and actions (Baldwin, et

al., 2001; Baillargeon, 2004; Casasola, Bhagwat, & Ferguson, this volume; Choi, this volume; Mandler, this volume; Sharon & Wynn, 1998). As babies view the world, they are also capable of looking "within" the individual actions they witness to find components like containment, support, path, and manner that will form the foundations for verb learning. This nascent ability is necessary if we want to explain how children acquire relational terms, but it is not sufficient. To learn these terms, infants must also demonstrate the ability to categorize across instances of path and manner and then to package these primitives in ways used in their native language. Progress on the first of these questions is just beginning, but the evidence suggests that, by the second half of the first year, children are beginning to pull invariant features of paths and manners from a changing display. Interestingly, the data also suggest that by 10 months of age, infants see separable components of these actions rather than unanalyzed wholes (e.g., Pruden et al., 2004). The data further suggest that not all action components are created equal. As suggested by Mandler (2004), even for the highly salient features of path and manner, path might prove more accessible than manner and be more basic than manner (Pruden et al.). Finally, language heightens attention to certain features over others, encouraging infants to preferentially notice elements of events encoded by a greater variety of words (Pulverman, Brandone, & Salkind, 2004). This research program is just beginning. There are already, however, several implications of the work. First, this research speaks to questions about event perception in infants. Second, it invites us to reexamine what it is about verbs that makes learning them so difficult relative to learning nouns. Third and finally, this research opens new avenues for further investigation.

The question of what babies have demonstrated in these tasks is of paramount importance. Indeed, the answer to that question is nested in the debates that plague the

categorization literature: are these mere perception tests or might they unveil the conceptual primitives that form the foundations for the learning of relational terms (see Rakison & Oakes, 2003 for a review). The research presented in these pages offers no way to disentangle this question. Perhaps, in these tasks, children are forming the conceptual foundations that support verb learning. The more parsimonious explanation is that at least they notice the kinds of information in the dynamic display that is embedded in relational terms like motion verbs. Current research in our lab asks whether children would as easily learn dynamic contrasts that are never represented in languages. Salkind (2003; Salkind, Golinkoff, & Brandone, 2005), for example, is exploring whether infants can categorize events based on rate across varying manners. Languages do not have 'rate verbs' with meanings such as "to move at 60 beats per minute". Yet, the preliminary results suggest that infants, nonetheless, can form these kinds of categories. "Language-relevant" categories may not be privileged. Young children seem attentive to any number of dynamic perceptual contrasts and language chooses from among these to form conceptual primitives for relational words. More research is desperately needed to secure this interpretation. Whatever the ultimate explanation, though, there is no doubt that infants have the requisite ability in the first year of life to represent at least some relational concepts. This raises the second question of why verbs are harder to learn than nouns (though see Tardif, this volume). The problem might not be in the "world" part of the word-to-world mapping. Children seem to notice and attend to the requisite categories in the environment around them, and do so at only slightly older ages than is apparent for object learning. To learn a relational term, however, the child must go beyond just noticing and categorizing a unit like path or manner; she must figure out how to package these components together in ways that are codified in the relational terms of her language. A number of researchers suggest that this is

indeed a hurdle for young children (Gentner & Boroditsky, 2001; Imai, Haryo, & Okada, in press) and adults (Gillette et al., 1999). The research presented in this paper suggests even more strongly that the mapping problem might prove the bigger hurdle for young verb learners.

Finally, the research presented here points the way towards new studies that are required if we are to fully understand how children build the conceptual foundations for learning verbs from rather meager perceptual beginnings. Talmy (1985) and Langacker (1987), among others, have identified a host of conceptual primitives that are packaged together to form the verb and prepositional system across languages. One of our goals then is to broaden the scope of the investigation and to do so in a cross-linguistic way. A second avenue of research is to better understand the relationship between the perceptual sensitivities that we have found here and the kind of conceptual categories that form the basis for word learning. Third, it is imperative that we turn attention to the ways in which children map language onto these perceptual and conceptual units. This has been a goal of our research that is discussed more fully in Chapter X of this volume (Maguire, Golinkoff, & Hirsh-Pasek).

There is much more to be done in the field, both in terms of the development of infants' event processing abilities and in terms of how infants' understanding of events plays into the learning of relational terms. The investigation of the perceptual and conceptual precursors to language is truly in its infancy. The studies presented here strongly suggest that, in this virgin area of research, infants have competencies heretofore unappreciated and unseen.

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[1] In the visual habituation paradigm (Bornstein, 1985), infants are repeatedly presented with the same stimulus or stimuli for as long as they choose to look. When their interest in the stimulus decreases, as determined by a decline in visual fixation time of a predetermined percentage, they are said to be 'habituated.' The habituated infants are then presented with test stimuli that differ from the habituation stimuli in carefully manipulated ways, and with a control stimulus that is equivalent to the event that they saw during habituation. If the differences in the test stimuli are detected, the novelty should attract infants' attention, resulting in longer visual fixation times.

[2] Words encoding relative speed must be interpreted with respect to a contextually appropriate norm.