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Current Events: How Infants Parse the World and Events for Language

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Verbs are windows onto language that capture our descriptions of events. Though verbs appear in the vocabulary of very young children (Choi, 1998; Choi & Bowerman, 1991; Choi & Gopnik, 1995; Fenson, Dale, Reznick, & Bates, 1994; Nelson, 1989; Tardif, 1996), noun acquisition has been the dominant focus for the field. Understanding early verb learning in children is fundamental to developing a comprehensive theory of word learning. Research in recent years is beginning to paint a portrait of the verb learning process. This paper focuses on what children need to know about events before they learn their first verbs. What are the conceptual foundations of verb learning? How do children process actions and events and what happens when actions meet words?

The last 20 years has seen a virtual explosion in research on children's verb learning (see Behrend, 1995; Bowerman & Choi, 2001; Choi & Bowerman, 1991; Choi & Gopnik, 1995; Fisher, 2002; Forbes & Farrar, 1993; Gallivan, 1988; Gleitman & Gillette, 1995; Golinkoff, et al, 2002; Golinkoff, Jacquet, Hirsh-Pasek, & Nandakumar, 1996; Hirsh-Pasek, Naigles, Golinkoff, Gleitman, & Gleitman, 1988; Imai & Gentner, 1997; Imai, Haryu, & Hiroyuki, 2003; Naigles, 1990; 1996; Poulin-Dubois & Forbes, 2002; Sandhofer, Smith, & Luo, 2000; Slobin, 2001; Smiley & Huttenlocher, 1995; Snedeker & Gleitman, 2004; Tardif, 1996; Tardif, Gelman, & Xu, 1999; Tomasello, 1992; Tomasello & Merriman, 1995). This research generally shows that verbs are harder to learn than nouns (Gentner, 1982; also see Bornstein et al., 2004; but see Tardif, 1996). Even in languages like Korean, where 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 Tardif, 1996). Meyer et al. (2003), Imai, Haryu, & Hiroyuki (2003) and others show that well into the 5th year children still have trouble

determining the referent of a novel verb in both English and in Japanese. Research with adult populations, like Gillette and colleagues' "Human Simulation Project" (1999), suggests that conceptually mature 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. Presumably, the problem in learning verbs does not lie in event processing per se; adults have had enormous experience interpreting events in the world.

These studies force us to ask two very critical questions: (1) why are verbs so difficult to learn? and, (2) what does it really take to learn a verb? Several theories have been put forth to answer this first question. Gentner (1982; Gentner & Boroditsky, 2001) was among the first to address why verbs are so difficult to learn. In her classic article (Gentner, 1982) offered several reasons for why verbs are so difficult to learn relative to nouns. First, verbs are 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*. Second, 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. Third, verbs are ephemeral, whereas nouns tend to label objects that are concrete (e.g., car; Langacker, 1987; Slobin, 2001; Smith, 2001). 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). In more recent writings Gentner and Boroditsky (2001) has expanded on this latter reason, concluding that the key

difference in learning verbs and nouns is that nouns tend to label referents that are more individuated and less relational than those referents labeled by verbs. Other researchers agree with this argument. For example, Snedeker and Gleitman (2004) suggest that the chief difference between nouns and verbs is that nouns tend to label referents that are more imageable. Hirsh-Pasek and colleagues (Maguire, Golinkoff, & Hirsh-Pasek, in press) similarly argue that nouns are generally easier to learn because they label referents that are more imageable, concrete, and individuable than the referents of verbs.

While there exist numerous theories on why verbs are more difficult to learn relative to nouns, there is less research on the question of what it takes to learn a verb. Recently some have directed attention to whether children have the prerequisite knowledge needed to learn verbs.

What does it take to learn a verb?

Gentner and Boroditsky (2001) outlined the prerequisites for learning verbs. They believe that verb learning, specifically, requires two critical components: (1) the conceptualization of actions and events and, (2) the mapping of words to these actions and events. Golinkoff and colleagues (2002) argued that building an arsenal of verbs requires three important steps. First, infants must first pay attention to and individuate actions that verbs encode. Second, infants must form categories of these actions and relations prior to language learning. Finally, where actions meet words, infants must map words to these actions and relations.

One of the hurdles for those who want to investigate early verb learning is that little is known about how young children process dynamic events, actions, and spatial relations. One major reason for why there has been little research on this topic is massive disagreement among researchers regarding the definition of *event*. Some define events broadly as “what happens to things” (Kabel, Lease-Spellmeyer, & Chatterjee, 2002, p.795). Others are more specific in their

criteria. Miller and Johnson-Laird (1976) for example, hold that an event must have at least two actors and include a causal relationship. Still others claim that an event has to take place with reference to a point in both space and time and has both a distinct beginning and end point (Zacks & Tversky, 2001). Events also have several notable characteristics. First, events occur across a span of time (Huttenlocher & Smyth-Burke, 1987). Second, events have boundaries that denote the beginning and end of an event (Hanson & Hirst, 1989). As Hanson and Hirst write:

> These boundaries may be fuzzy; the exact moment of transition between one event and the next may not be clear. As one reaches for a piece of toast and picks it up, the transition between *reaching* and *picking up* may be smooth, but the lack of a precise boundary does not imply that *reaching* and *picking up* are not discrete events. Events, like object categories, can have fuzzy boundaries and yet still be distinguished from one another. (p. 136)

Finally, events can be divided into smaller events or into actions units (Hanson & Hirst, 1989). For example, the event *putting gas in a car* can be divided into smaller units such as *purchasing the gas, opening the gas tank, lifting the gas pump hose*, and *pressing the gas pump lever*. Indeed, even the event *purchasing the gas* can be divided into *getting out a wallet, giving money to a cashier*, and so forth. Before they can map words onto these events, infants must have a basic understanding of how to process events and actions in their environment (Nelson, 1997). That is, infants must understand that the events *giving money to a cashier* and *taking money from the cashier* are different before they can attach corresponding labels, *give* and *take*. In this paper, we will adopt Avrahami and Kareev's (1994) broad definition of an event as the "basic unit in the organization of experience, memory, and meaning" (p. 239).

Golinkoff and colleagues (2002) proposed that verb learning requires that infants pay attention to and isolate actions and spatial relations within a larger event. This prerequisite is necessary, but not sufficient, to solving the verb-learning problem. Infants must also be sensitive to the specific event features that are codified in their particular language. For example, verbs do not unambiguously label actions. Rather, they label a subset what occurs when an action takes place. According to Talmy (1985), these subsets of actions or semantic components include *path* (or the trajectory of object agent; e.g., come, approach, enter), *manner* (or the way in which an agent moves; e.g., walk, dance, swagger, sway, stroll), *motion* (the general fact that motion is taking place), *figure* (the primary agent or object in the event), *ground* (the reference point for the event's path), and *cause* (the cause of the figure's motion).

Talmy (1985) was the first to point out that within the class of motion verbs specific subsets of these semantic components are combined or configured to generate the verb system in a language (i.e., manner, path, figure, ground, and cause; see also Langacker, 1987). For example, manner verbs, like *run*, *jump* and *swagger,* encode motion, but conflate the manner of motion. Path verbs, like *enter*, *approach,* and *ascend,* encode motion, but conflate the path of the figure. There also exists a subset of motion verbs that conflate more than one element. The motion verb *deplane*, for example, conflates two semantic components, path and ground. Infants must learn which semantic components are relevant to learning a particular verb and must learn to pay attention to just those semantic components that are used together to form a particular verb.

Gentner and Boroditsky (2001) contend that verb learning is further complicated by the fact that across languages, verbs package actions and events in different ways (also see Slobin, 2001 and Talmy, 1985). To illustrate this particular difficulty Gentner (1982) writes,

> A language has more degrees of freedom in lexicalizing relations between coherent objects than in lexicalizing the objects themselves. Thus, for verbs and other relational terms, children must discover how their language combines and lexicalizes the elements of the perceptual field…verb meanings are learned as part of a system of semantic distinctions… (pp. 324-325).

What Gentner (1982) refers to has also been dubbed the "packaging problem" (Tomasello, 1995). The packaging problem suggests that many different elements of meaning can be encoded in a verb. Tomasello (1995) further defines the packaging problem as "the problem of how the child knows the aspect of the action to which the adult is referring" (p. 138).

Languages like English, German, and Chinese tend to package the *manner* of motion or how one moves, in verbs (e.g., jumping, skipping, running, and hopping). These languages often reserve information about the *path* or trajectory of the agent/object for other word classes (e.g. in, out, exit, enter). Other languages, like Spanish, Turkish, and Greek, tend to encode *path* information in their verbs and *manner* information in other word classes, if at all. Consider the English sentence "The man limped down the stairs." In this example, the *manner* of motion is encoded in the verb (limped), while the *path* or trajectory of motion is encoded in the preposition (down). In Spanish, this same sentence would be translated to "El hombre bajó las escaleras cojeando" or "The man went down/descended the stairs limping." Now the *manner* of motion is encoded in a modifier of the verb, while the *path* of motion is packaged in the verb. These examples illustrate that relational terms can package actions and events differently across languages as Talmy (1985) and others (Slobin, 2001) suggest. As a result, infants may need considerable experience with their native language before they can: a) notice which conceptual

components are encoded in their languages relational terms, and b) map these conceptual components onto relational terms themselves.

Perhaps then, it should not be surprising that verbs are so difficult to learn. Most of the research investigating verbs has explored only the early production of relational terms, like prepositions (Choi & Bowerman, 1991; Choi & Gopnik, 1995; Tardif, 1996) or the mapping of relational terms onto actions (Choi, McDonough, Bowerman, & Mandler, 1999; Maguire, Hirsh-Pasek, Golinkoff, & Pruden, 2003; Naigles, 1996). Little research exists on the question of whether children have the necessary conceptual prerequisites to build an arsenal of relational terms. Such prerequisites must include infants' ability to perceive and understand motion events. Gentner (1982; also see Gentner & Boroditsky, 2001) hypothesizes that the conceptual prerequisites for the learning of verbs and other relational terms might be in place at an early age. She writes,

> …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. (p. 326)

Snedeker and Gleitman agree (2004) saying that "…vocabulary acquisition in the real case may reduce mainly to a mapping problem…" (p. 280). Further, they assert, "the young child's conceptual repertoire may be rich and varied enough from the start…" (p. 261).

Gentner is not the only one to propose such an idea. Some cognitive linguists suggest that the semantic components that verbs label (i.e., path, manner, etc.) may be built from pre-linguistic conceptual primitives rooted in event perception from which all other relational terms are constructed (e.g., Jackendoff, 1983; Mandler, 1991; 1992; 2004). Pre-verbal infants might be equipped with a language-ready organizational system as Mandler argues (2004). Mandler

proposes that infants construct what are called "image schemas," or "spatial representation[s] that express primitive or fundamental meanings…Common image schemas are notions such as PATH, CONTAINMENT, UP-DOWN, and LINK" (Mandler, 2004, p.78). Furthermore, image schemas form the basis for conceptual categories like ANIMACY, CAUSALITY, and AGENCY. Mandler suggests that infants first extract aspects of an event that are potential concepts to which a verb could refer. Only after experience with their native language however, do infants begin to carve up these concepts into categories that are lexicalized in their native language.

These hypotheses have gone largely untested until recently. The challenge for researchers interested in solving the verb-learning problem is determining if infants have a set of conceptual primitives rooted in event perception that support the learning of relational terms.

Research is just beginning to shed light on this issue. Both cognitive linguists and developmental psychologists have started to examine whether infants are sensitive to the conceptual primitives that support verb learning. Research on this topic can be broken up into two main areas: the study of spatial expressions like prepositions and the study of motion verbs. These areas have seen a recent surge in research that can be attributed to two characteristics. First, both spatial prepositions and motion verbs offer a window into the conceptual foundations of verb learning. Spatial prepositions encode constructs like containment and support, while motion verbs encode action components like path and manner. For both spatial prepositions and motion verbs, the action components or constructs being investigated appear to be perceptually accessible. Second, and importantly, there is cross-linguistic variability in the lexical patterning of relational terms. For example, Korean- and English-speakers lexicalize different conceptual constructs in their spatial prepositions. Korean speakers make a distinction in their spatial

prepositions between the tightness of fit (i.e., tight-fit vs. loose-fit) regardless of containment (e.g., fitting a peg tightly into a hole) or support (e.g., fitting one Lego® tightly onto another). In Korean, both of these examples receive the same label, *kkita*. English-speakers, on the other hand, make a distinction in their spatial prepositions between containment and support relations, regardless of the tightness of fit. Unlike Korean-speakers, English-speakers would assign two different labels, *in* and *on*, respectively, to the examples above. Similarly, we see cross-linguistic variability in the lexicalization patterns of motion verbs. English-speakers often encode the *manner* of action in motion verbs (e.g., *run*, *jump*, *swagger*). Spanish-speakers typically encode the *path* of the agent in motion verbs. (e.g., *enter*, *leave*, *ascend*). Though all agree that children must attend to events and dynamic relations to solve the verb-learning problem, there has been little research on infants' knowledge of these conceptual primitives.

In this paper we will explore each of the conceptual prerequisites necessary for learning relational terms. First, we explore infants' abilities to attend to motion and parse actions from ongoing events. Second, we describe research that shows infants can discriminate among actions that are codified in relational terms. Third, we present the research addressing infants' abilities to categorize spatial relations and actions. Finally, we discuss what we believe is the problem that children encounter when trying to learn relational terms. Taken together, the body of evidence suggests that infants are sophisticated observers of actions and relations who attend to the conceptual primitives in the ways suggested by both Gentner (1982; Gentner & Boroditsky, 2001) and Mandler (1991; 1992; 2004). Thus, the inherent problem in learning relational terms *appears not to be* with conceptualizing events and actions in the world. Rather, the difficulty in learning verbs and other relational terms is with mapping words onto actions.

Attending to Motion and Parsing Events into Actions

Infants are faced with an insurmountable task: they must take a "blooming, buzzing world" (James, 1890, p.488) consisting of vast amounts of sensory information and organize it into separate, bounded actions and events. Golinkoff et al. (2002) contend that one prerequisite for learning relational terms is paying attention to motion and actions within events. Clark (2003) further emphasizes, "Children who wish to talk about events need to be able to analyze what they observe and to know how to decompose scenes into the constituent parts relevant to linguistic expressions in the language they happen to be learning" (p. 168). Initially, children must detect scenes or events to determine which aspects require attention. Then, children must break the scene or event into parts that correspond to those that are lexicalized in their native language. To date, little is known about how infants analyze actions and events, and how they decompose events into distinct actions.

One finding that *is* well established is that newborns are sensitive to the motion of an object. Kremenitzer and colleagues (1979) show that newborns track an object's motion. With additional experience, they track object motion using smooth pursuit tracking eye movements and begin to predict the future position of an object (Aslin, 1981; von Hofsten & Rosander, 1996; 1997).

Findings also suggest that infants are more attuned to and better at perceiving objects when they are in motion (Kellman, Spelke & Short, 1986; Slater, Morison, & Town, 1985; Smith, Johnson & Spelke, 2003; Werker, Cohen, Lloyd, Casasola, & Stager, 1998). Slater and colleagues (1985) show that newborns pay more attention to objects that are in motion than objects that are stationary. Infants use motion to predict and mentally track the orientation of a rotating object that has been occluded (Rochat & Hespos, 1996) and they use motion to

distinguish between point-light displays of an upright person walking and an inverted person walking (Bertenthal, Proffitt, & Cutting, 1984). Motion also serves as a cue to animacy and causality. Infants use movement type (i.e., whether the movement is flexible or rigid) to distinguish between animate and inanimate objects (Mandler, 1992; Rakison, 2003; Rakison & Poulin-Dubois, 2001; Spelke, Phillips, & Woodward, 1995), to infer causality (Cohen & Oakes, 1993; Golinkoff, Harding, Carlson-Luden, & Sexton, 1984; Kotovsky & Baillargeon, 2000; Oakes & Cohen, 1990; Wang, Kaufman, & Baillargeon, 2003), and to perceive object unity (Johnson & Aslin, 1995; Johnson, Cohen, Marks, & Johnson, 2003; Kellman & Spelke, 1983; Kellman, Spelke, & Short, 1986; Smith, Johnson, & Spelke, 2003). Further, motion appears to play a special role in the acquisition of words, more specifically object labels. Werker and colleagues (1998) show that infants can learn a label for moving objects, but not for static objects.

These studies examining infants' perception of motion have generally looked at how infants use motion to learn about the properties of objects. Research conducted on infants' understanding of motion itself is limited to investigating simple causal events or the ability to discriminate actions within larger events. One body of literature focuses on infants' perception and discrimination of causal events. For example, research shows that before their first birthday, infants can discriminate among causal and non-causal launching events (Cohen & Amsel, 1998; Cohen & Oakes, 1993; Leslie, 1984; Leslie & Keeble, 1987; Oakes, 1994; Oakes & Cohen, 1990). By 6 months of age, infants respond to the physical changes occurring in causal events, but cannot yet organize these events based on causality (Leslie, 1984). By 10-months of age, infants begin to process causal launching events in terms of the relationship between the objects

in the event and they organize these events based on causality (Cohen & Oakes, 1993). Infants' perception of causal events appears to be tied to the agent of the action (Cohen & Oakes, 1993).

Some have also investigated infants' ability to discriminate actions within larger events. Five-month-olds detect the invariant property of rigid motion and can differentiate between rigid movements (Gibson, Owsley, & Johnston, 1978). In more recent research, 5.5-month-old infants (Bahrick, Gogate, & Ruiz, 2002) had a significant preference for a novel action showing that they were able to focus on the action rather than the actor and could discriminate among the differing actions. Golinkoff and colleagues (Golinkoff, 1975; Golinkoff & Kern, 1978) found that 14-month-old infants seem to be sensitive to who plays what role in a dynamic event. Under some circumstances infants can distinguish the agent from the patient of an action. Casasola and Cohen (2000) add further data demonstrating that 14-month-olds discriminate between *pushing* and *pulling* actions. These findings provide further support for infants' ability to discriminate actions within larger events. Though these studies suggest that infants are equipped with the ability to notice motion and discriminate actions and perhaps even action roles, they tell us little about what sorts of information infants are using to carve up these events.

Adults appear to use a number of cues, including perceptual information within an event and information about the goal or intention of the actor, to parse events into distinct actions. For example, there is evidence that adults use perceptual break points in an event to determine where one action ends and another begins (Newtson, 1973). Adults also use information about the goals and intentions of an actor to help them determine the starting and ending points of an action (Graziano, Moore, & Collins, 1988; Hanson & Hirst, 1989; Markus, Smith, & Moreland, 1985; Newtson, 1973). Can infants carve up an ongoing stream of events into distinct actions? If they can, what kind of information are they using to accomplish this task?

Research by Sharon and Wynn (1998; Wynn, 1996) investigated how 6-month-old infants parse a stream of motion into distinct actions. Six-month-old infants were familiarized to a puppet either performing the action "jumping" or the action "falling". At test, results indicated that infants looked significantly longer at a novel action than at a familiarized action. These results give us reason to believe that children can segment an ongoing stream of motion into distinct actions. But how do they do it?

Research by Baldwin, Baird, Saylor and Clark (2001) begins to address this issue. Baldwin and colleagues investigated infants' ability to separate dynamic actions into continuous, everyday events. Ten- and eleven-month-old infants were familiarized to continuously flowing action sequences (e.g., a women notices a towel on the floor, reaches for and grasps it, then moves toward and places it on a towel rack). The test phase involved showing infants two different versions of the original action sequence, each containing a still-frame pause inserted at certain points in the course of the action sequence. One still-frame occurred just as the actor in the action sequence completed their intended act. The other still-frame occurred in the midst of the ongoing intentional action sequence. Infants looked longer at the test trial that interrupted the intended act than at the test trial that did not.

In light of these results, Baldwin and colleagues (2001) suggested that infants as young as 10 months are able to parse sequences of actions, and do so based on boundaries that coincide with *the initiation and completion of intention*. The authors argue that infants are using information about an agent's intention in order to parse this event. These results are central to our understanding of infant event processing. Yet, they can be interpreted in another way. Perhaps the children are using perceptual features of the events, such as the cessation of motion to parse these events. Research using point-light displays (Bertenthal, Proffitt, & Cutting, 1984),

shows that even very young infants, 5-month-olds, are sensitive to breaks in biological motion. Although there is some debate about what cues infants use to carve up these events, these findings support the claim that infants can parse actions from a dynamic flow of events.

To summarize, infants are sensitive to and aware of the motion of an object (Aslin, 1981; von Hofsten & Rosander, 1996; 1997; Kremenitzer et al., 1979) and movement also acts as a cue to animacy and causality (Mandler, 1992; Rakison, 2003; Rakison & Poulin-Dubois, 2001; Spelke, et al., 1995), and motion appears to play a special role in infants' understanding of objects and their properties (Johnson & Aslin, 1995; Johnson et al., 2003; Kellman & Spelke, 1983; Kellman et al., 1986; Smith et al., 2003). Furthermore, infants also have the remarkable ability to perceive actions and events and to carve up larger events into individual actions (Baldwin, et al., 2001; Casasola & Cohen, 2000; Sharon & Wynn, 1998; Wynn, 1996). However, as Clark writes (2003), infants also need "to know how to decompose scenes into the constituent parts *relevant to linguistic expressions* [italics added for emphasis] in the language" (p. 168). That is, infants must pay attention to and discriminate components of actions that are encoded in language. In the next sections we discuss the research on infants' ability to discriminate semantic components that are codified in relational terms. We begin with a discussion of spatial expressions, like prepositions, that codify concepts like containment and support. We then talk about the semantic concepts, *path* and *manner*, that are conflated in 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). A classic study by Choi and colleagues (Choi & Bowerman, 1991; Choi, et al., 1999) shows that English-speaking children and Korean-speaking children organize the same spatial relations differently. For

example, English-speaking children organize their spatial concepts into two distinct categories: containment (lexicalized by the English word *in*) and support (lexicalized by the English word *on*). Korean-speaking children, on the other hand, organize their spatial concepts into two semantically different categories: tight-fit (lexicalized by the Korean word *kkita*) and loose-fit (lexicalized by the Korean word *nehta*). These semantic categories, tight-fit and loose-fit, collapse across containment and support. Further, children use these semantic categories in language-specific ways (Choi & Bowerman, 1991). English-speaking toddlers used the words *in* and *on* to distinguish between containment events and support events, regardless of fit, while Korean-speaking toddlers made a different distinction that collapsed the English *in* and *on* using the semantic categories of tight-fit or loose-fit. Recent language comprehension studies by Choi and colleagues (1999) found similar results. They found that English- and Korean-speaking toddlers comprehend these spatial words and turn their attention towards the events depicting these spatial concepts. These studies raise the question about when children begin to attend to spatial concepts that are lexicalized in spatial expressions.

Research on the spatial relations of containment and support shows that young infants have an early understanding of these relations, (Baillargeon, 2001; 2002; Baillargeon & Wang, 2002; Hespos & Baillargeon, 2001a; 2001b) and that infants can discriminate between instances of these types of spatial relations (Hespos & Spelke, 2004). Baillargeon and colleagues (Baillargeon, 2001; 2002; Baillargeon & Wang, 2002; Hespos & Baillargeon, 2001a; 2001b) examined what infants know about the ways in which objects can behave in relation to each other. More specifically, they were interested in infants' rudimentary knowledge about containment and support events. To test this, 2.5-month-old infants were shown two types events: a possible event and an impossible event. In the possible event, infants viewed a scene in

which an object was lowered into an open container. This event depicted a possible containment relation. In the impossible event, infants saw the same object lowered into a closed container. This event depicted an impossible containment relation. Infants looked longer at the impossible event indicating that they have some understanding what happens in both a containment event, when something is lowered into an open container it is a containment event, and a support event, when something is lowered onto a closed container it is a support event, not a containment event.

Hespos and Spelke (2004) asked whether 5-month-olds could discriminate spatial relations not lexicalized in their native language (i.e., degree of fit is lexicalized in Korean: tight-fit vs. loose-fit). Infants from English-speaking homes were habituated to an event in which an object either fit tightly or fit loosely in a container. During the test phase, infants viewed both the familiar relation and a novel relation. For example, infants habituated to the spatial relation tight fit were shown this familiar relation (tight-fit) and a novel relation (loose-fit) at test. Infants exhibited an increase in looking to the novel relation during test. Thus, they demonstrated an ability to discriminate between spatial concepts (i.e., degree of fit) that are not typically codified in their native language. These empirical studies suggest that, at an early age, infants are predisposed to pay attention to the kinds of semantic components that may be relevant to later language learning and that may be lexicalized in spatial expressions.

Motion Verbs

While *motion verbs* make up only a very small percentage of verbs (~10%) in the adult vocabulary, they offer a window in to how verbs, in general, are acquired. We choose here to look only at motion verbs and do so for several reasons. First, motion verbs are among the first *verbs* to appear in children's vocabulary (Fenson, et al., 1994). For example, some of the first words to emerge in children's lexicons are motion verbs like, *dance*, *jump*, and *fall*. Second, the

referent of motion verbs – an event – is observable. Dancing, jumping, and falling are events visible to both children and adults. Thus, motion verbs not only provide the most optimal learning opportunities for children but they also provide the most optimal teaching opportunities for both parents and researchers. Third, motion verbs should be more learnable than mental verbs because they tend to be individuable and imageable (Gentner & Boriditsky, 2001). Fourth, there is some research that shows that infants can process events that are typically codified in motion verbs (e.g., path and manner; Casasola, Hohenstein, & Naigles, 2003; Pulverman & Golinkoff, 2004; Pulverman, Sootsman, Golinkoff, & Hirsh-Pasek, 2003). Finally, motion verbs are of interest here because, like spatial prepositions, the semantic components that they package are different cross-linguistically. By looking at how infants parse, categorize and package the events that are typically codified in motion verbs we can begin to uncover the conceptual primitives needed for verb learning.

We will reserve our discussion to only two of the semantic components codified in motion verbs: *path* and *manner*. *Path* and *manner* were chosen for further investigation for three reasons. First, these semantic components are among the most widely studied in psycholinguistics today. Second and importantly, both *path* and *manner* are universally codified within the languages of the world (Jackendoff, 1983; Langacker, 1987; Talmy, 1985). Third, the semantic component of *path* may be one of the most central concepts for learning motion verbs. Mandler (2004) suggests that *path* is a conceptual primitive used to acquire concepts like ANIMACY and CAUSALITY. *Manner* is equally important to study manner because when a *path* is traversed, a *manner* is required to propel the moving figure. Finally, *path* and *manner* are of interest because they are encoded differently across languages. 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. While we limit our discussion here to the semantic components, *path* and *manner*, we believe that a thorough investigation of these two components will lay a solid foundation for understanding the conceptual development underlying motion verbs.

Discrimination of Path and Manner in Motion Events

A few studies have unpacked how infants process components like *path* and *manner* in non-linguistic motion events (Casasola, Hohenstein, & Naigles, 2003; Pulverman et al., 2003; 2004). For example, Pulverman et al., (2003) studied infants' ability to pay attention to changes to both *path* and *manner* in non-linguistic motion events. Fourteen- and 17-month-old infants were habituated to an animated starfish performing both a path and a manner (e.g., a starfish spinning over a ball). Once infants were habituated to this clip, they were shown 4 test trials: a control trial (e.g., starfish spinning over a ball), a manner change trial (e.g., starfish bending over a ball), a path change trial (e.g., starfish spinning under a ball), and a path and manner change trial (e.g., starfish flapping past a ball). Infants of both ages dishabituated to the path and manner change test trials. However, upon further examination Pulverman and colleagues demonstrated that 14- to 17-month-olds with a rich vocabulary were more attentive to *manner* changes than to *path* changes. These results suggest that infants as young as 14 months notice components of actions typically encoded in their language, and that language may play a role in the ability to notice and attend to these components. More recently, Pulverman et al. (2004) showed that even younger infants (7-month-olds) notice changes in both *path* and *manner,* using the same stimuli and methods.

Casasola and colleagues (2003) also demonstrated that 10-month-old infants could pay attention to and 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). Using a habituation paradigm, 10-month-old infants were habituated to a young child demonstrating both a path (e.g., in front of a bush) and a manner (e.g., skipping). At test, infant were shown clips demonstrating a change in *path*, a change in *manner*, a change in both *path* and *manner*, and the clip they had habituated to. Infants increased their attention to changes in both *path* and *manner*. These results provide additional evidence that infants do pay attention to the non-linguistic components, such as *path* and *manner*, that motion verbs typically encode.

These studies provide us with information about infants' ability to parse dynamic events and to attend to components of action. Yet, it is only the tip of the word-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. As this example illustrates, after children have the ability to parse events into distinct actions, they must look for similarities across these actions and categorize these actions before they can then attach a relational term to the action. Little is know about infants' categories for actions or relations that serve as the foundation for verb learning. Furthermore, as Nelson argues (1997), to predict and understand the world around them, infants must have an understanding of events. We believe that this understanding of events will consist of the abilities to focus on, abstract out and categorize actions within events. The next section will explore what we currently know about infants' ability to categorize both static and dynamic spatial relations.

Categorization of Actions and Events

The literature presented thus far paints a portrait of an infant who is capable of attending to motion, parsing and discriminating among actions that are encoded in our lexicon of relational

terms. However, once children learn how to parse events into distinct actions they also must learn how to categorize these actions into meaningful units. In the categorization of objects, infants have to learn that both perceptually similar and dissimilar objects can be categorized (i.e. a category of vehicles includes perceptually dissimilar airplanes and cars). Likewise, in the categorization of actions, infants have to learn that both *perceptually* similar and dissimilar actions can be categorized. For example, infants must learn that *Dad giving a ring to Mom* and *Brother giving a soda to Sister*, despite their perceptual dissimilarity, are categorized as the same action -- giving. This particular area of research is relatively new. As researchers have become more attuned to the fact that a comprehensive theory of word learning must account for all word classes, including nouns, verbs, prepositions, and adjectives, they have explored more thoroughly the prerequisite knowledge needed to acquire relational terms like verbs and prepositions.

Before we examine the literature on categorization of spatial relations it is important to understand the advantages of categorization. What does categorization allow us to do? Categorization allows for "organized storage, efficient retrieval, and the capability of responding equivalently to an indefinitely large number of exemplars from multiple categories" (Quinn, 1994, p. 58). Forming categories reduces the demand on our limited memory storage and allows us to make inductive inferences about the world. As a result, infants who form categories of spatial relations and events are capable of experiencing objects in a coherent spatial layout, rather than experiencing objects as spatially unrelated.

The categorization of spatial relations appears to be a prerequisite to host of many skills, including spatial memory, locomotion, understanding geographic or travel maps, object recognition, word recognition and reading, reasoning about dynamic spatial events, like collision and support, and acquiring a lexicon of spatial terms (Quinn, 2003). Spatial memories are likely

to include information about the relations or arrangements of objects in our environment, allowing us to move and avoid obstacles in a planned route. When we read a geographic map we are processing the relations between landmarks. Spatial relation information is crucial for object recognition in that "an object is believed to be represented as a set of parts in particular spatial relations" (Quinn, 2003, p.54). Reading and word recognition require spatial relation skills like recognizing the individual features of a letter, the left-right relations in words and sentences, and the above-below relations in sentences. Finally, there appears to be a link between acquiring a lexicon of spatial terms and categorizing spatial relations. Categorization and language are linked in that words often refer to categories of objects, events, and relations (Oakes & Rakison, 2003).

The research on spatial categorization can be divided into three major topics. The first major topic is the categorization of static spatial relations. Static spatial relations involve static or non-changing displays. Quinn and colleagues have investigated what infants know about static spatial relations, like *above*, *below*, and *between* (Quinn, 1994; 2003; Quinn, Cummins, Kase, Martin, & Weissman, 1996; Quinn, Norris, Pasko, Schmader, & Mash, 1999). The second major topic is the categorization of dynamic spatial relations. This research generally explores what infants know about dynamic events or displays that are changing. Examples of these events include containment, support, path, and manner events. A third area concerns abstract spatial categorization. Infants must be able to generalize a category of a spatial relation to objects that were not depicted in the original event. The studies presented in the following section try to identify the universal conceptual primitives and conceptual categories that are eventually codified in relational terms (Clark, 2001; Mandler, 1991; 1998; 2004; Slobin, 2001).

Categorization of Static Spatial Relations

The first studies examining categorization of spatial relations looked at static relations like *above*, *below*, and *between* (Quinn, 1994; 2003; Quinn, et al., 1999). Research on this topic shows that even young infants can form categories of static spatial relations. Quinn (1994) was among the first to ask whether infants can form categories of spatial relations. Quinn tested whether 3-month-olds infants categorize *above* and *below* spatial relations between a dot and a horizontal reference bar. Results indicate that 3-month-old infants categorically represent the spatial relations *above* and *below* and can distinguish between these two relations. A more recent study pushes the boundaries of their original finding by asking whether infants can also categorically represent more complex spatial relations, such as *between* (Quinn, et al., 1999). The spatial relation *between* is akin to location coding in relation to two landmarks, rather than just one landmark (e.g., a diamond is located in relation to two bars for the between spatial relation). Findings suggest that 6-month-old infants categorically represent the spatial relation *between*.

These studies illustrate that infants are capable of categorizing simple spatial relations like *above*, *below*, and more complex spatial relations like *between*. However, these studies leave many aspects of spatial categorization uncharted. Categorizing simple spatial relations, like *above* and *below*, is just the first step in the development of spatial categorization. Infants need to be able to take the next step and categorize spatial relations that will later allow the acquisition of spatial terms, like *on* and *in*. The following section reviews studies that have explored the non-linguistic dynamic, spatial categories, such as support, containment, path and manner, that later become spatial semantic categories used for acquiring spatial language.

Categorization of Dynamic Spatial Relations: Spatial Expressions

By 18 months infants already comprehend the spatial terms, *up*, *down*, *in*, and *on* (Choi, et al., 1999) and use these spatial terms in language-specific ways (Choi & Bowerman, 1991).

Cross-linguistic research has shown that English-speaking and Korean-speaking adults not only use spatial terms in language-specific ways (Bowerman, 1996), but also categorize spatial relations in language-specific ways (McDonough, Choi, & Mandler, 2003). For example, English-speaking adults categorized based on what their native language lexicalized, containment (*in*) and support (*on*) only. Korean-speaking adults, on the other hand, categorized degree of fit (e.g. tight- fit, *kkita* vs. loose-fit, *nehta*), a relation lexicalized in their language. These results suggest that adults categorically represent only those spatial relations lexicalized in their languages. But do infants, who have limited experience with their native languages, categorize these spatial relations in the same way as their adult counterparts? Or do infants categorize all three of these spatial relations: containment, support, and degree of fit? By answering these questions we begin to address whether infants have the conceptual foundations needed for learning spatial expressions in their native languages.

McDonough and colleagues (2003) asked whether infants could categorize spatial relations like adults do. Nine-, eleven-, and fourteen-month-old infants from monolingual English-speaking homes were familiarized with six scenes depicting either tight-fitting containment or loose-fitting support events. Both of these spatial relations are lexicalized in English and correspond to the prepositions *in* and *on*, respectively. After familiarization, infants were shown one scene depicting the same relation as seen during familiarization (familiar category exemplar) paired with another scene showing the contrasting/novel relation (novel category exemplar). Fourteen-month-old infants showed a preference for the contrasting/novel relation at test, while 11-month-olds showed no preference, and 9-month-olds preferred to look at the familiar relation. The authors suggest, based on these findings, that infants at all three ages categorize the spatial relations tight-fitting containment and loose-fitting support. These findings

suggest that infants can abstract a common relational element lexicalized in their native language.

In additional experiments, McDonough and colleagues (2003) tested the spatial relations tight-fitting containment and loose-fitting containment, a contrast that is lexicalized in Korean (*kkita* and *nehta*, respectively), but not in English. Preverbal infants (9-, 11-, and 14-month-olds) from both monolingual English-speaking homes and Korean-speaking homes were familiarized with one of these spatial relations and tested with a relation from the familiarized category paired with a relation from the contrasting/novel category. Infants from both the English- and Korean-speaking homes preferred to look at the familiar relation during test. These results indicate that infants from both language groups categorize the spatial relations tight-fitting containment and loose-fitting containment. These results are not surprising for those infants raised in the Korean environment because these spatial relations are lexicalized in Korean. In sharp contrast, these results are surprising for those infants raised in English-speaking homes since English does not lexicalize degree of fit. These findings suggest that infants across all languages in the world have a set of primitive concepts that they use to build their language-specific semantic spatial categories.

Casasola and Cohen (2002) also examined the types of spatial relations infants categorize prior to the acquisition of spatial language. These studies provided a more challenging task by presenting them 9-month-old infants with more complex, ecologically valid objects, like toys, and by varying the objects presented to the infants during the familiarization trials. Infants were habituated to four events depicting different pairs of objects in the same spatial relation (e.g., either containment: putting a cup in a dog bowl, support: putting a cup on an inverted dog bowl, or tight-fit: fitting a green peg in a yellow block). After habituation, infants were shown four test

trials: (1) a *control* trial during which they saw familiar objects in the familiar relation, (2) an *object change* trial during which they saw novel objects in the familiar relation, (3) a *relation change* trial during which they saw the familiar objects in a novel relation, and (4) an *object/relation change* trial during which they saw novel objects in a novel relation. Infants looked significantly longer at the novel versus familiar relationship, regardless of the object change, for the spatial category containment only. Nine-month-olds were unable to form a spatial category for support or tight-fit. Further, recent work with 6-month-olds shows that they can categorize the spatial relation of containment (Casasola, Cohen, & Chiarello, 2003).

The results from these studies highlight three important points. First, preverbal infants can form spatial categories of relations that are codified in spatial expressions, like prepositions. This additional evidence provides further support for the hypothesis that infants have the conceptual foundations necessary for early verb learning. Second, and important to our later discussion of abstract spatial categorization, infants are initially unable to form abstract categories of events and actions. If older infants are able to do this it would reveal a developmental trend in the categorization of spatial relations. Finally, Casasola and Cohen's (2002) data show that some spatial concepts are more accessible than others. English-learning preverbal infants were able to form an abstract spatial category for containment, but not for support, even though both are lexicalized in English. These results and those from McDonough and colleagues (2003) provide empirical evidence that infants both attend to and categorize the conceptual primitives in the ways proposed by both Gentner (1982; Gentner & Boroditsky, 2001) and Mandler (1991; 1992; 2004). In the next section, we review research from our laboratories on the semantic components *path* and *manner* that are typically codified in motion verbs.

Categorization of Dynamic Spatial Relations: Motion Verbs

Infants are not only capable of noticing changes in both *path* and *manner* (Pulverman, et al., 2003; 2004), but are also capable of preliminary categorization (i.e., finding the invariant across motion events and actions) of these components of motion events prior to the time that they have much language at all.

Salkind, Sootsman, Golinkoff, Hirsh-Pasek, and Maguire (2002) examined infants' ability to categorize *manner* across a change in an action's agent. Nine- to eleven-month-old infants were habituated to two clips, each with a distinct actor performing the same full-body action (e.g., jumping jacks). At test, infants were shown three clips, one of a novel actor performing the same full-body action, one of a novel actor performing a novel full-body action, and a control trial. Infants showed increased attention to the test trial with a novel actor performing a novel action. Salkind and colleagues concluded that 9-month-old infants had formed a category of *manner* across multiple actors.

This research suggests that infants can categorize *manner* in "real-world" events. Can they also find both the invariant *path* and invariant *manner* in non-linguistic motion events using animated and more tightly controlled stimuli (Pruden, Hirsh-Pasek, Maguire, & Meyer, 2004)? In Study 1, we investigated whether infants could abstract the invariant *path* across multiple exemplars of *manner.* Study 2 asked whether infants had the ability to abstract the invariant *manner* across multiple exemplars of *path*. Using the split-screen Preferential Looking Paradigm (Hirsh-Pasek & Golinkoff, 1996), infants were familiarized to four different event clips. Each event clip was 12 sec. long and depicted an animated starfish performing both a single *manner* and single *path*. These event clips all demonstrated an exemplar of the category being tested. After familiarization infants were presented with a test phase. To assess whether infants had formed a category of either *path* (Study 1) or *manner* (Study 2) infants were shown two test

events simultaneously on a split-screen for 12 sec.: (1) *a familiar test event*, (i.e., a novel exemplar from the familiar category), and (2) *a novel test event* (i.e., a novel exemplar from a novel category).

In Study 1, we asked whether infants could find the invariant path across several exemplars of manner. Three age groups, 7- to 9-months-olds, 10- to 12-month-olds, and 13- to 15-month-olds were tested. During familiarization infants viewed an animated starfish perform the same path across four distinct manners. For example, infants in the *path* condition "over" saw four consecutive exemplars of the starfish performing the same *path*, "over", across four distinct *manners* (e.g., "spinning *over*", "twisting *over*", "bending *over*", and "jumping jacks *over*"). At test, infants were shown two events simultaneously: one depicting a novel exemplar of the familiar category and the other depicting a novel exemplar of a novel category. For example, infants who were familiarized with the path "over" saw the event clips "touching toe *under*" (i.e., novel *manner* and novel *path*) and "touching toe *over*" (i.e., novel *manner* and same *path*). Seven- to nine-month-olds did not have significant preference for either test event. In contrast, our older infants showed a significant preference for the *familiar* test event during the test phase. These results suggest that infants as young as 10 months find the invariant *path* across multiple exemplars of *manner.*

In Study 2, we investigated whether infants at the same ages could abstract an invariant *manner* across multiple exemplars of *path.* During familiarization infants viewed four event clips, each depicting the same exact *manner* across varying *paths.* For example, infants saw four exemplars of the starfish performing the same *manner*, "spinning", across four distinct *paths* (e.g., "spinning over", "spinning under", "spinning past", and "spinning behind"). Those infants who were 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).* Neither 7- to 9-month-olds nor 10- to 12-month-olds showed a significant preference for either test event. In contrast, 13- to 15-month-olds showed a significant preference for the *novel* test event during the test phase, suggesting that infants as young as 13 months can abstract the invariant *manner* across multiple exemplars of *path*.

While these findings suggest that infants as young as 10 months can find the invariant *path* and infants as young as 13 months can find the invariant *manner*, these studies are not without limitations. 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. These preliminary 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.

Moving Beyond the Immediate Event: Categorizing Abstract Spatial Relations

The literature presented thus far supports the idea that preverbal infants appear to have a set of conceptual primitives from which to build their lexicon of spatial words. By 13 months, well before comprehension and production of spatial terms, infants are able to categorically represent containment, support, degree of fit, path, and manner (Casasola & Cohen, 2002; Casasola, et al., 2003; McDonough et al., 2003; Pruden et al., 2004; Pulverman et al., 2003). However, as Casasola and Cohen (2002) have shown, these categories are extremely fragile;

Both preverbal and older infants were unable to categorically represent the spatial relations support and tight-fit when the objects used to perform the relation were novel. The ability to form an abstract spatial category is crucial if infants are to acquire semantic spatial categories and a language-specific lexicon of spatial terms. For example, the English spatial term *on* applies to the spatial relation of support, regardless of the objects that are used to demonstrate the relation. Thus, researchers must address the whether and when infants form abstract spatial categories regardless of the objects depicting the original relationship. The studies presented next suggest that there is a developmental trend in the categorization of spatial relations. Infants are first unable to abstract away from the objects initially used in a spatial relation and to form abstract spatial categories.

Baillargeon (1998; 2004) argues that infants acquire event and object categories that ultimately allows them to make inferences about the physical world. Indeed, research shows that 2.5-month-old infants possess expectations about occlusion, containment, and covering events (Aguiar & Baillargeon, 1999; Hespos & Baillargeon, 2001a; Wang, Baillargeon, & Paterson, 2005). However, in all three types of events, very young infants have great difficulty in generalizing what they know about these events to new instances. As infants form event categories, they begin to include information about the physical events that they have encountered and they ultimately acquire the capability to predict the outcome of new instances of events. Furthermore, the inclusion of new information in event categories is category-specific. There is a different developmental trend for each type of event category – occlusion, containment, and covering. Four-and-a-half-month-old infants are able to use height information to reason about occlusion events, however they are unable to use the same information to reason about containment events and covering events until 7.5 and 12 months of age, respectively

(Hespos & Baillargeon, 2001b; Wang, et al., 2005). Similarly, 7.5-month-olds are able to use transparency information to reason about occlusion events. However, it is not until 10 months of age that infants are able to use this type of information to reason about containment events (Baillargeon, 2004).

Casasola (2005a) investigated whether 10- and 14-month-olds can form an abstract spatial category for the spatial relation of support. She was interested in determining if the number of category exemplars presented would either hinder or facilitate category formation. To address these questions, she habituated infants to either 2 exemplars of the spatial relation containing different sets of objects or to 6 exemplars of the spatial relation. Results indicate that 10-month-old infants could not form an abstract category of support in either the 2-exemplar or 6-exemplar condition. Fourteen-month-olds showed a different pattern of results, forming an abstract category of support, but only when they were presented with 2 exemplars during habituation. Casasola argues that infants failed to form a category of support in the 6-exemplar condition for two reasons: 1) infants were attending to the objects and not the relations, and 2) infants did not have enough time to compare the relations in the 6-exemplar condition.

These studies suggest that there is a developmental progression in infants' ability to categorize spatial relations. As Casasola (2005a) writes, "infants' initial reliance on familiar objects for recognizing a spatial relation eventually gives way to recognizing the relation with novel objects as well" (p. 279). At first, infants' spatial categories are limited to the original objects and events that depict them. Only later are infants able to break away from these original objects and events that depict the spatial relation and form abstract spatial categories.Given that infants are learning language at the same time they are becoming capable of forming more

abstract spatial categories, perhaps there is reason to believe that language itself might influence the formation of more abstract categories.

Language as a Bootstrap: Language Aids in Discrimination and Categorization of Spatial Events

A large body of research on the role of language in forming categories of objects already exists. This research demonstrates that infants' object categorization is facilitated by use of a common label and that language heightens attention to objects (Balaban & Waxman, 1997; Baldwin & Markman, 1989; Booth & Waxman, 2002; Gentner & Namy, 1999; Namy & Gentner, 2002; Waxman & Markow, 1995). We know very little about this same phenomenon in the realm of spatial discrimination and categorization. Would the addition of language help infants discriminate and categorize spatial relations? Two possibilities exist. The addition of language to previous discrimination and categorization tasks could heighten attention to spatial relations and facilitate discrimination and categorization as it did in the object categorization studies. However, the addition of language could also disrupt or hinder performance in spatial discrimination and categorization tasks. That is, the introduction of language may further increase the processing demands required to succeed in these tasks. This possibility is supported by Stager and Werker's (1997) research. In a phoneme discrimination task, 14-month-olds could only discriminate between two minimal pair phonemes (/b/ vs. /d/) when the phonemes were presented in the absence of an object, apparently outside what infants considered a word-learning task. When the phonemes were presented in the company of an object infants were no longer able to discriminate the phonemes. The point is that the addition of an object increased the processing demands of the task and caused infants to fail to discriminate. There exists the possibility that introducing a label will increase the cognitive processing load in these spatial

discrimination and categorization tasks. Several studies have been conducted to test this empirical question.

Casasola and Cohen (2002) found that English-speaking infants could not form an abstract spatial category of either support, a spatial relation lexicalized in English with the word *on*, or of tight-fit, a spatial relation lexicalized in Korean with the word *kkita*. Would language heighten infants' attention to the common spatial relation of support facilitating the formation of an abstract category of support? Using the same design used in Casasola and Cohen (2002), Casasola (2005b) habituated 18-month-old infants to four different exemplars all depicting a support event. Importantly, each support event was accompanied with the familiar label, *on*. At test, infants saw an exemplar from the familiar category (i.e., a novel support event) and an exemplar from a novel category (i.e., a novel containment event). Infants showed an increased interest in the novel spatial relation (containment) at test. Thus, children were able to form an abstract spatial category of support that excluded the containment event. A familiar word *can* aid infants in forming *abstract* spatial categories.

Pulverman, Brandone and Salkind (2004) also examined the role of language in the processing of motion events. Using the same events from Pulverman et al. (2003), language was added to see if 14- and 17-month-old infants' processing of *path* and *manner* would be influenced. During the habituation phase, the event of a starfish flapping over a ball was accompanied by a novel verb. For example, infants heard "He's *jaiming*! Wow! He's *jaiming*! Oh, boy! He's *jaiming*! The novel verb was removed from the linguistic stimuli at test and replaced with "neutral" audio, "Wow! Oh boy! Wow!" The habituation phase was analogous to a potential verb-learning situation in that infants heard a novel verb in the presence of a novel event. Importantly, the purpose of this study was not to teach a novel verb label, but to explore

the facilitative effects of a label on the processing of motion components (path and manner). We already know that infants notice and discriminate both *path* and *manner* in non-linguistic motion events (Casasola, et al., 2003; Pulverman, et al., 2003; 2004). Thus, the purpose of this study was simply to see if the addition of language would *increase* attention to these components of action. Preliminary results indicate that English-learning infants who heard a novel verb label during habituation noticed the *manner* of motion more when compared to those infants who participated in the original, non-linguistic version of this study. Infants who heard the novel verb label during habituation did not however, increase their attention to Starry's *path*. It appears that when English-learning infants hear a novel verb label while watching an event, they *increase* their attention to the *manner* of the action, a good thing when English uses many manner verbs.

Pulverman and colleagues' (2004) showed that the introduction of a label differentially heightens attention to motion components. A key prerequisite to learning relational terms, such as verbs, prepositions, and adverbs, is that infants pay attention to motion components that are encoded in language. Paying attention to and conceptually decomposing events is but a first step to learning relational terms. Building an arsenal of relational terms also requires that infants form categories of these conceptual building blocks.

Since labels refer to categories of actions and events (Oakes & Rakison, 2003) and we know that language heightens attention to objects (Balaban & Waxman, 1997; Baldwin & Markman, 1989; Booth & Waxman, 2002; Gentner & Namy, 1999; Namy & Gentner, 2002), the introduction of language may have the same facilitative effects in a spatial categorization task. Pruden et al. (2004) saw that infants younger than 10 months of age could not abstract the invariant *path* in a series of motion events, and that infants younger than 13 months of age could not find the invariant *manner*. That is, in both studies, 7- to 9-month-old infants were unable to

abstract the invariant *path* and invariant *manner*. This failure provides us with the opportunity to test whether the addition of language can assist in categorization of these action components. Using the same procedure and stimuli, Pruden et al. (2005) added a label during familiarization to see if it would help infants abstract the invariant semantic component.

In the path study, we familiarized infants to four motion events. Within each event, our animated starfish performed the exact same *path* (e.g., "over"), but varied his *manner* of motion (e.g., "flapping", "spinning", "twisting", "bending"). During the familiarization phase, infants heard the novel verb label "javing" repeated four times during each of the familiarization trials, for a total of 16 times. At test, infants were simultaneously shown a familiar event (i.e., familiar *path*, novel *manner*; "toe-touching over") and a novel event (i.e., novel *path*, novel *manner*; "toe-touching under"). Despite the fact that the introduction of the novel verb label during the familiarization trials creates a potential-verb learning situation, we were not interested in seeing whether infants had attached the label to an event. Rather, we were interested in whether the common label helped the infants find the invariant semantic component across these events. We predicted that if infants could abstract out the *invariant path* they would have a significant preference for one of the test events presented without any language stimuli. Preliminary results indicate that 7- to 9-month-olds do benefit from the addition of a common label. Infants now show a significant preference for the novel test event (e.g., "toe-touching under") during the test phase. Thus, the inclusion of language appears to facilitate the abstraction of *path* from a series of motion events.

The same design was also conducted to investigate whether the introduction of a common label would help infants abstract the invariant *manner* across a series of events (Pruden et al., 2005). Seven- to 9-month-olds viewed four familiarization events, each depicting the same exact

manner across varying *paths* (e.g. "spinning over", "spinning around", "spinning behind", and "spinning past"). During the familiarization phase, infants heard the novel verb label "javing" repeated a total of 16 times. At test, infants were presented simultaneously with the familiar *manner*/novel *path* and a novel *manner*/novel *path* (e.g., "spinning under" vs. "twisting under"). Unlike our previous label study, infants did not show a significant preference for either test event. Infants were not able to use the common label to abstract the invariant *manner*.

Taken together, the results from both Pulverman et al. (2004) and Pruden et al. (2005) suggest that, as in the object categorization tasks, labels heighten attention to features of the event and actions. However, labels do not always work. For Pruden et al's (2005) 7- to 9-month-olds, the presence of a label helped them to abstract an invariant *path*, but not an invariant *manner*.

Bringing it All Together: Events and Actions in Infancy

The preceding sections offer a glimpse into how infants process and abstract relations in events are lexicalized in spatial expressions and motion verbs. There is a common thread that brings all of these studies together to form a complete story.

First, there is a developmental trend in the ability to process and categorize events. Research has shown different semantic components are processed and abstracted at different points in development. For example, Quinn and colleagues (Quinn, 1994; Quinn, et al., 1996; Quinn, et al., 1999) showed that the ability to form categories of static spatial relations develops at different times for different spatial relations. Infants showed the ability to categorize the static spatial relations, *above* and *below*, before they could categorize the spatial relation *between*. In addition and entirely consistent, the ability to categorize *dynamic events* develops on different time scales for different spatial relations (Casasola & Cohen, 2002; Casasola, Cohen, &

Chiarello, 2003). Categories of the dynamic spatial relation of containment were formed before categories for the dynamic spatial relations of support or degree of fit. Finally, in related research, Baillargeon (2004) showed that infants pay attention to different perceptual features within different types of events. In these studies, 4.5-month-olds could reason about occlusion events when they were given height information, but were unable to use this same information to reason about containment events until 7.5 months of age.

Pruden et al.'s (2004) findings suggest that the categorization of semantic components, like *path* and *manner*, does not come online at the same time. Infants abstract invariant *paths* across varying *manners* before they can abstract invariant *manners* across varying *paths*. These results, along with Pulverman et al.'s (2003; 2004), suggest that the semantic component *path* might be more fundamental than *manner* in building a conceptual foundation for verb learning. Indeed, this argument is consistent with the claims put forth by Mandler (2004) who views *path* as one of the conceptual primitives needed for the conceptual development of motion. As Mandler writes, "…PATH is the simplest conceptualization of any object following any trajectory through space" (p. 28). Thus, it should thus come as little surprise that *path* seems to be processed and abstracted before *manner*.

We also see a developmental trend in how children categorize spatial relations and events. Early on infants are unable to abstract away from the objects seen in a particular spatial relation to reason about that relation in an abstract way. Beginning with Quinn and colleagues' (Quinn, et al., 1996; Quinn, et al., 1999) research, we see that infants are at first only able to form very specific, object-reliant, static spatial relations, like *above*, *below*, and *between*. Any changes in the objects representing the relation leads to a failure in young infants to form these spatial categories. Within a few months of acquiring the ability to form very specific categories

for *above*, *below*, and *between*, infants then do form abstract categories for these relations that are not contingent on the particular objects displaying the relation (Quinn et al., 2002).

A similar pattern is seen when we look at the categorization of *dynamic* events, such as *support*, *path*, and *manner*. Casasola and Cohen (2002) showed that 9-month-olds were unable to form an abstract spatial category for support and tight-fit. Later studies by Casasola (2005a) showed that 14-month-olds could form an abstract category of support, but only when infants were presented with 2 exemplars during habituation. Casasola reasoned that infants failed to form an abstract category of support when they were given more than 2 exemplars because they were attending only to the objects, not to the spatial relation represented by these objects.

Pruden et al.'s (2004; 2005) research takes a first small step in addressing the question of whether infants can form categories of actions in motion events. These studies asked whether infants could abstract the invariant *path* or *manner* from events displays. While these studies begin to address the question of categorization, they do not move beyond a surface view of categorization in which infants are but finding the invariant feature of the action. As Pulverman, Hirsh-Pasek, Golinkoff, Pruden and Salkind (in press) write, "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" (p. 26). These studies should be expanded to provide insight on generalization and the factors that influence the formation of abstract categories.

Conclusions

To understand how verbs are learned by young children investigations of the conceptual foundation of verb learning are essential. As this chapter demonstrates, we are only just beginning to comprehend how infants process and detect actions and events. How do infants'

perception and conception of events map onto the world's languages? How do children learn to attend to the particular semantic components their language favors?

Gentner (1982) has hypothesized that the problem in verb learning is with packaging relations and mapping words onto relations. The research we present here supports this hypothesis. Indeed, infants seem capable of making sense of the world of both objects and events. The studies presented in this chapter support the hypothesis that infants have the conceptual prerequisites needed to learn verbs and more broadly, relational terms. The current research emerging in this field paints a portrait of a child who is not just learning the foundations for verb learning, but of an infant who is interpreting the "current" events in his world. However, the field of infant event perception and conception is literally in its infancy.

This brings us back to the question of why are verbs so much harder to learn than nouns. The research presented in this chapter suggests that the difficulty in verb learning does not primarily rest in the conceptualization of events and actions in the world. Children have many of the prerequisite abilities needed to map a relational term onto an action. They can notice action components that eventually get codified in languages and they can form categories of the spatial relations that both verbs and prepositions encode. However to learn a relational term, children must also figure out *how* their native language packages action components, like path and manner. Several researchers argue that it is not the conceptualization of actions and events that makes verb learning so difficult. Rather they argue that it is the mapping of relational terms onto actions that might prove difficult for early word learning (Maguire et al., in press).

Lastly, the research we present in this chapter illustrates that we are only in the beginning stages with this research. If we want to fully understand how children build the conceptual foundations for learning relational terms, we need to explore at least three related paths of future

research. First, as we have already seen, there appears to be a set of conceptual primitives that are packaged to form our relational term system (Langacker, 1987; Talmy, 1985). It appears that these conceptual primitives consist of semantic components like *path*, *manner*, and *containment* (Mandler, 2004). Future research needs to explore these conceptual primitives in much more detail and to address if infants across all languages possess the same conceptual primitives. Second, research needs to fully address the relationship between perceptual sensitivities that we have found here and the kind of conceptual categories that form the basis for word learning.

This chapter demonstrates that infants are at the very least sensitive to the spatial relations encoded in relational terms. As we begin to understand how infants and young children process events, we can ask how they might come to package these events for use in language. Only then will we be able to truly understand the many forces that lead from event perception to relational term learning.

References

Aguiar, A., & Baillargeon, R. (1999). 2.5-month-old infants' reasoning about when objects should and should not be occluded. *Cognitive Psychology, 39*, 116-157.

Aslin, R. (1981). Development of smooth pursuit in human infants. In D.F. Fischer, R.A. Monty, & E.J. Senders (Eds.), *Eye movements: Cognition and visual development* (pp. 31-51). Hillsdale, NJ: Lawrence Erlbaum Associates.

Avrahami, J., & Kareev, Y. (1994). The emergence of events. *Cognition, 53*, 239-261.

Bahrick, L.E., Gogate, L.J., & Ruiz, I. (2002). Attention and memory for faces and actions in infancy: The salience of actions over faces in dynamic events. *Child Development, 73*, 1629-1643.

Baillargeon, R. (1998). Infants' understanding of the physical world. In M. Sabourin & F. Craik (Eds.), *Advances in psychological science, Volume 2: Biological and cognitive aspects* (pp. 503-529). Hove, England: Psychology Press/Erlbaum.

Baillargeon, R. (2001). Infants' physical knowledge: Of acquired expectations and core principles. In E. Dupoux (Ed.), *Language, brain, and cognitive development: Essays in honor of Jacques Mehler* (pp. 341-361). Cambridge, MA: The MIT Press.

Baillargeon, R. (2002). The acquisition of physical knowledge in infancy: A summary in eight lessons. In. U. Goswami (Ed.), *Blackwell handbook of childhood cognitive development* (pp. 47-83). Malden, MA: Blackwell Publishers.

Baillargeon, R. (2004). Infants' physical world. *Current Directions in Psychological Science, 13*, 89-94.

Baillargeon, R., & Wang, S. (2002). Event categorization in infancy. *Trends in Cognitive Science, 6*, 85-93.

Balaban, M.T., & Waxman, S.R. (1997). Do words facilitate object categorization in 9-month-old infants? *Journal of Experimental Child Psychology, 64*, 3-26.

Baldwin, D.A., Baird, J.A., Saylor, M.M., & Clark, A.M. (2001). Infants parse dynamic actions. *Child Development, 72,* 708-717.

Baldwin, D.A., & Markman, E.M. (1989). Establishing word-object relations: A first step. *Child Development, 60*, 381-398.

Behrend, D.A. (1995). Processes involved in the initial mapping of verb meanings. In M. Tomasello & W.E. Merriman (Eds.), *Beyond the names for things: Young children's acquisition of verbs* (pp. 251-275). Hillsdale, NJ: Lawrence Erlbaum Associates.

Bertenthal, B.I., Proffitt, D.R., & Cutting, J.E. (1984). Infant sensitivity to figural coherence in biomechanical motions. *Journal of Experimental Child Psychology, 37*, 213-230.

Bloom, L. (1978). The semantics of verbs in child language. Paper presented at the meeting of the Eastern Psychological Association, New York.

Booth, A.E., & Waxman, S. (2002). Object names and object functions serve as cues to categories for infants. *Developmental Psychology, 38*, 948-957.

Bornstein, M., Cote, L., Maital, S., Painter, K., Park, S. Y., Pascual, L., et al. (2004). Cross linguistic analysis of vocabulary in young children: Spanish, Dutch, French, Hebrew, Italian, Korean and American English. *Child Development, 75*, 1115-1140.

Bowerman, M. (1996). Learning how to structure space for language: A crosslinguistic perspective. In P. Bloom, M.A. Peterson, L. Nadel, & M.F. Garrett (Eds.). *Language and space: Language, speech, and communication* (pp. 385-436). Cambridge, MA: The MIT Press.

Bowerman, M., & Choi, S. (2001). Shaping meanings for language: Universal and language specific in the acquisition of spatial semantic categories. In M. Bowerman & S.C. Levinson (Eds.), *Language acquisition and conceptual development* (pp. 475-512). New York, NY: Cambridge University Press.

Casasola, M. (2005a). When less is more: How infants learn to form an abstract categorical representation of support. *Child Development, 76*, 279-290.

Casasola, M. (2005b). Can language do the driving? The effect of linguistic input on infants' categorization of support spatial relations. *Developmental Psychology, 41,* 183-192.

Casasola, M., & Cohen, L.B. (2000). Infants' association of linguistic labels with causal actions. *Developmental Psychology, 36*, 155-168.

Casasola, M., & Cohen, L.B. (2002). Infant categorization of containment, support, and tight-fit spatial relationships. *Developmental Science, 5*, 247-264.

Casasola, M., Cohen, L.B., & Chiarello, E. (2003). Six-month-old infants' categorization of containment spatial relations. *Child Development, 74*, 679-693.

Casasola, M, Hohenstein, J., & Naigles, L. (2003, April). Ten-month-old infants' discrimination of manner and path in motion events. In M. Casasola (Chair), *From infancy to adulthood: Exploring the effect of linguistic input of the discrimination of manner and path in motion event.* Symposium presented at biennial meeting of the Society for Research in Child Development, Tampa, FL.

Choi, S. (1998). Verbs in early lexical and syntactic development in Korean. *Linguistics, 36*, 755-780.

Choi, S., & Bowerman, M. (1991). Learning to express motion events in English and

Korean: The influence of language-specific lexicalization patterns. *Cognition, 41*, 83-121.

Choi, S., & Gopnik, A. (1995). Early acquisition of verbs in Korean: A cross-linguistic study. *Journal of Child Language, 22,* 497-529.

Choi, S., McDonough, L., Bowerman, M., & Mandler, J.M. (1999). Early sensitivity to language-specific spatial categories in English and Korean. *Cognitive Development, 14*, 241-268.

Clark, E.V. (2001). Emergent categories in first langauge acquisition. In M. Bowerman & S.C. Levinson (Eds.), *Language acquisition and conceptual development* (pp. 379-405). New York, NY: Cambridge University Press.

Clark, E.V. (2003). *First language acquisition.* New York: Cambridge University Press.

Cohen, L.B., & Amsel, G. (1998). Precursors to infants' perception of the causality of a simple event. *Infant Behavior and Development, 21*, 713-731.

Cohen, L.B., & Oakes, L.M. (1993). How infants perceive a simple causal event. *Developmental Psychology, 29*, 421-433.

Fenson, L., Dale, P.S., Reznick, J.S., & Bates, E. (1994). Variability in early communicative development. *Monographs of the Society for Research in Child Development, 59* (5, Serial No. 242).

Fisher, C. (2002). Structural limits on verb mapping: The role of abstract structure in 2.5-year-olds' interpretations of novel verbs. *Developmental Science, 5*, 55-64.

Forbes, J.N. & Farrar, J.M. (1993). Children's initial assumptions about the meaning of novel motion verbs: Biased and conservative? *Cognitive Development, 8,* 273-290.

Gallivan, J. (1988). Motion verb acquisition: Development of definitions. *Perceptual and Motor*

Skills, 66, 979-986.

Gentner, D. (1982). Why nouns are learned before verbs: Linguistic relativity versus natural partitioning. In. S. Kuczaj (Ed.), *Language development: Language, thought, and culture, Volume 2* (pp. 301-334). Hillsdale, NJ: Lawrence Erlbaum Associates.

Gentner, D., & Boroditsky, L. (2001). Individuation, relativity, and early word learning. In M. Bowerman & S.C. Levinson (Eds.), *Language acquisition and conceptual development* (pp. 215-256). New York, NY: Cambridge University Press.

Gentner, D., & Namy, L.L. (1999). Comparison in the development of categories. *Cognitive Development, 14*, 487-513.

Gibson, E.J., Owsley, C.J., & Johnston, J. (1978). Perception of invariants by five-month-old infants: Differentiation of two types of motion. *Developmental Psychology, 14*, 407-415.

Gillette, J., Gleitman, H., Gleitman, L., & Lederer, A. (1999). Human simulations of vocabulary learning. *Cognition, 73,* 135-176.

Gleitman, L., & Gillette, J. (1995). The role of syntax in verb learning. In P. Fletcher & B. MacWhinney (Eds.) *The handbook of child language* (pp. 413-427). London: Blackwell.

Golinkoff, R.M. (1975). Semantic development in infants: The concepts of agent and recipient. *Merrill-Palmer Quarterly, 21*(3), 181-193.

Golinkoff, R.M., Chung, H.L., Hirsh-Pasek, K., Liu, J., Bertenthal, B. I., Brand, R., Maguire, M.J., & Hennon, E. (2002). Young children can extend motion verbs to point-light displays. *Developmental Psychology, 38,* 604-614.

Golinkoff, R.M., Harding, C.G., Carlson-Luden, V., & Sexton, M.E. (1984). The development of causality in infancy: A symposium. *Advances in Infancy Research, 3*, 125-165.

Golinkoff, R.M., Jacquet, R.C., Hirsh-Pasek, K., & Nandakumar, R. (1996). Lexical principles

may underlie the learning of verbs. *Child Development, 67,* 3101-3119.

Golinkoff, R.M., & Kerr, J.L. (1978). Infants' perception of semantically defined action role changes in filmed events. *Merrill-Palmer Quarterly, 24*(1), 53-61.

Graziano, W.G., Moore, J.S., & Collins, J.E. (1988). Social cognition as segmentation of the stream of behavior. *Developmental Psychology, 24*, 568-573.

Hanson, C., & Hirst, W. (1989). On the representation of events: A study of orientation, recall, and recognition. *Journal of Experimental Psychology: General, 118*, 136-147.

Hespos, S.J., & Baillargeon, R. (2001a). Knowledge about containment events in very young infants. *Cognition, 78*, 207-245.

Hespos, S.J., & Baillargeon, R. (2001b). Infants' knowledge about occlusion and containment events: A surprising discrepancy. *Psychological Science, 12*, 140-147.

Hespos, S.J., & Spelke, E.S. (2004). Conceptual precursors to language. *Nature, 430,* 453-456.

Hirsh-Pasek, K., & Golinkoff, R.M. (1996). *The origins of grammar: Evidence from early language comprehension*. Cambridge, MA: The MIT Press.

Hirsh-Pasek, K., Naigles, L., Golinkoff, R.M., Gleitman, L.R., & Gleitman, H. (1988, October). *Syntactic bootstrapping: Evidence from comprehension*. Paper presented at the Boston University Conference on Language Development, Boston, MA.

von Hofsten, C., & Rosander, K. (1996). The development of gaze control and predictive tracking in young infants. *Vision Research, 36*, 81-96.

von Hofsten, C., & Rosander, K. (1997). Development of smooth pursuit tracking in young infants. *Vision Research, 37*, 1799-1810.

Huttenlocher, J., & Smyth-Burke, T. (1987). Event encoding in infancy. In P. Salapatek & L. Cohen (Eds.), *Handbook of infant perception, Volume 2* (pp. 209-231). New York:

Academic Press.

Imai, M. & Gentner, D. (1997). A crosslinguisitc study of early word meaning: Universal ontology and linguistic influence. *Cognition, 62,* 169-200.

Imai, M., Haryu, E., & Hiroyuki, O. (2003). Is verb learning easier than noun learning for Japanese children? Three-year-old Japanese children's knowledge about object names and action names. In the *Proceedings of the 26th Annual Boston University Conference on Language Development.* Somerville, MA: Cascadilla Press.

Jackendoff, R. (1983). *Semantics and cognition: Current studies in linguistics series, No. 8*. Cambridge, MA: The MIT Press.

James, W.T. (1890). *The principles of psychology*. New York, NY: Holt, Rinehart, and Winston.

Johnson, S.P., & Aslin, R.N. (1995). Perception of object unity in 2-month-old infants. *Developmental Psychology, 31*, 739-745.

Johnson, S.P., Cohen, L.B., Marks, K.H., & Johnson, K.L. (2003). Young infants' perception of object unity in rotation displays. *Infancy, 4*, 285-295.

Kable, J.W., Lease-Spellmeyer, J., & Chatterjee, A. (2002). Neural substrates of action event knowledge. *Journal of Cognitive Neuroscience, 14*, 795-805.

Kellman, P.J., & Spelke, E.S. (1983). Perception of partly occluded objects in infancy. *Cognitive Psychology, 15*, 483-524.

Kellman, P.J., Spelke, E.S., & Short, K.R. (1986). Infant perception of object unity from translatory motion in depth and vertical translation. *Child Development, 57*, 72-86.

Kotovsky, L., & Baillargeon, R. (2000). Reasoning about collisions involving inert objects in 7.5-month-old infants. *Developmental Science, 3*, 344-359.

Kremenitzer, J.P., Vaughan, H.G., & Kurtzberg, D. (1979). Smooth-pursuit eye movements in

the newborn infant. *Child Development, 50*, 442-448.

Landau, B. (1996). Multiple geometric representations of objects in languages and language learners. In P. Bloom, M.A. Peterson, L. Nadel, & M.F. Garrett (Eds.). *Language and space: Language, speech, and communication* (pp. 317-363). Cambridge, MA: MIT Press.

Landau, B., & Jackendoff, R. (1993). "What" and "where" in spatial language and spatial cognition. *Behavioral & Brain Sciences, 16,* 217-265.

Langacker, R.W. (1987). *Foundations of cognitive grammar*. Stanford, CA: Stanford University Press.

Leslie, A.M. (1984). Spatiotemporal continuity and the perception of causality in infants. *Perception, 13*, 287-305.

Leslie, A.M., & Keeble, S. (1987). Do six-month-old infants perceive causality? *Cognition, 25,* 265-288.

Maguire, M.J, Hirsh-Pasek, K., Golinkoff, R.M., & Pruden, S.M. (2003, April). The way you do that thing you do: Attention to path and manner in action words. In L. Wagner (Chair), *How event cognition turns into event language*. Symposium presented at biennial meeting of the Society for Research in Child Development, Tampa, FL.

Maguire, M.J., Golinkoff, R.M., & Hirsh-Pasek, K. (in press). It's not about nouns and verbs. In K. Hirsh-Pasek & R.M. Golinkoff (Eds.), *Action meets word: How children learn verbs*. New York: Oxford University Press.

Mandler, J.M. (1991). Prelinguistic primitives. In L.A. Sutton & C. Johnson (Eds.), *Proceedings of the seventeenth annual meeting of the Berkeley Linguistics Society* (pp. 414-425). Berkeley, CA: Berkeley Linguistics Society.

Mandler, J.M. (1992). How to build a baby II: Conceptual primitives. *Psychological Review, 99*, 587-604.

Mandler, J.M. (1998). Representation. In W. Damon (Eds.), *Handbook of child psychology, Vol. 2: Cognition, perception, and language* (pp. 255-308). New York, NY: Wiley.

Mandler, J.M. (2004). *The foundations of mind: Origins of conceptual thought.* New York: Oxford University Press.

McDonough, L., Choi, S., & Mandler, J.M. (2003). Understanding spatial relations: Flexible infants, lexical adults. *Cognitive Psychology, 46*, 229-259.

Markus, H., Smith, J., & Moreland, R.L. (1985). Role of the self-concept in the perception of others. *Journal of Personality and Social Psychology, 49*, 1494-1512.

Meints, K., Plunkett, K., Harris, P.L., & Dimmock, D. (2002). What is "on" and "under" for 15-, 18-, and 24-month-olds? Typicality effects in early comprehension of spatial prepositions. *British Journal of Developmental Psychology, 20,* 113-130.

Merriam-Webster's collegiate dictionary (9th ed.). (1993). Springfield, MA: Merriam Webster.

Meyer, M., Leonard, S., Hirsh-Pasek, K., Imai, M., Haryu, R., Pulverman, R., & Addy, D. (2003). *Making a convincing argument: A cross-linguistic comparison of noun and verb learning in Japanese and English*. Poster presented at the Boston University Conference on Language Development, Boston, MA.

Miller, G.A., & Johnson-Laird, P.N. (1976). *Language and perception.* Cambridge, MA: The Belknap Press.

Naigles, L. (1990). Children use syntax to learn verb meanings. Journal of Child Language, 17, 357-374.

Naigles, L. (1996). The use of multiple frames in verb learning via syntactic bootstrapping,

Cognition, 58, 221-251.

Namy, L.L., & Gentner, D. (2002). Making a silk purse out of two sow's ears: Young children's use of comparison in category learning. *Journal of Experimental Psychology: General, 131*, 5-15.

Nelson, K. (1989). *Narratives from the crib.* Cambridge, MA: Harvard University Press.

Nelson, K. (1997). Event representations then, now, and next. In P.W. van den Broek, P.J. Bauer, & T. Bourg (Eds.), *Developmental spans in event comprehension and representation: Bridging fictional and actual events* (pp. 1-28). Mahwah, N.J.: Lawrence Erlbaum Associates.

Newston, D. (1973). Attribution and the unit of perception of ongoing behavior. *Journal of Personality and Social Psychology, 28*, 28-38.

Oakes, L.M. (1994). Development of infants' use of continuity cues in their perception of causality. *Developmental Psychology, 30*, 869-879.

Oakes, L.M., & Cohen, L.B. (1990). Infant perception of a causal event. *Cognitive Development, 5*, 193-207.

Oakes, L.M., & Rakison, D.H. (2003). Issues in the early development of concepts and categories: An introduction. In D. H. Rakison & L. M. Oakes (Eds.), *Early category and concept development: Making sense of the blooming, buzzing confusion* (pp. 3-23). New York, NY: Oxford University Press.

Poulin-Dubois, D. & Forbes, J.N. (2002). Toddlers' attention to intentions-in-action in learning novel action words. *Developmental Psychology, 38,* 104-114.

Pruden, S.M., Hansell, N., Albertson, G., & Hirsh-Pasek, K. (2005, April). *Finding the invariant*

path and manner in motion events: Do labels help? Poster presented at biennial meeting of the Society for Research in Child Development, Atlanta, GA.

Pruden, S.M., Hirsh-Pasek, K., Maguire, M.J., & Meyer, M.A. (2004). Foundations of verb learning: Infants form categories of path and manner in motion events. In A. Brugos, L. Micciulla, & C.E. Smith (Eds.), *Proceedings of the 28th annual Boston University Conference on Language Development* (pp.461-472). Somerville, MA: Cascadilla Press.

Pulverman, R., Brandone, A., & Salkind, S. J. (2004, November). *One-year-old English speakers increase their attention to manner of motion in a potential verb learning situation*. Paper presented at the 29th Annual Boston University Conference on Language Development, Boston, MA.

Pulverman, R., & Golinkoff, R.M. (2004). Seven-month-olds' attention to potential verb referents in nonlinguistic events. In A. Brugos, L. Micciulla, & C.E. Smith (Eds.), *Proceedings of the 28th annual Boston University Conference on Language Development* (pp. 473-480). Somerville, MA: Cascadilla Press.

Pulverman, R., Hirsh-Pasek, K., Golinkoff, R.M., Pruden, S.M., & Salkind, S.J. (in press). Conceptual foundations for verb learning: Celebrating the event. In K. Hirsh-Pasek & R.M. Golinkoff (Eds.), *Action meets word: How children learn verbs*. New York: Oxford University Press.

Pulverman, R., Sootsman, J.L., Golinkoff, R.M., & Hirsh-Pasek, K. (2003). The role of lexical knowledge in nonlinguistic event processing: English-speaking infants' attention to manner and path. In *Proceedings of the 27th Annual Boston University Conference on Language Development* (pp. 662-673). Somerville, MA: Cascadilla Press.

Quinn, P.C. (1994). The categorization of above and below spatial relations by young infants.

Child Development, 65, 58-69.

Quinn, P.C. (2003). Concepts are not just for objects: Categorization of spatial relation information by infants. In D.H. Rakison & L.M. Oakes (Eds.), *Early category and concept development: Making sense of the blooming, buzzing confusion* (pp. 50-76). New York, NY: Oxford University Press.

Quinn, P.C., Cummins, M., Kase, J., Martin, E., & Weissman, S. (1996). Development of categorical representations for above and below spatial relations in 3- to 7-month-old infants. *Developmental Psychology, 32*, 942-950.

Quinn, P.C., Norris, C.M., Pasko, R.N., Schmader, T.M., & Mash, C. (1999). Formation of a categorical representation for the spatial relation between by 6- to 7-month-old infants. *Visual Cognition, 6*, 569-585.

Rakison, D.H. (2003). Parts, motion, and the development of the animate-inanimate distinction in infancy. In D.H. Rakison and L.M. Oakes (Eds.), *Early category and concept development: Making sense of the blooming, buzzing confusion* (pp.159-192). New York, NY: Oxford University Press.

Rakison, D.H., & Poulin-Dubois, D. (2001). Developmental origin of the animate-inanimate distinction. *Psychological Bulletin, 127*, 209-228.

Rochat, P., & Hespos, S.J. (1996). Tracking and anticipation of invisible spatial transformation by 4- to 8-month-old infants. *Cognitive Development, 11*, 3-17.

Salkind, S.J., Sootsman, J.L., Golinkoff, R.M., Hirsh-Pasek, K., & Maguire, M.J. (2002, April). *Lights, camera, action! Infants and toddlers create action categories*. Poster presented at the biennial meeting of the International Conference on Infant Studies, Toronto, Canada.

Sandhofer, C.M., Smith, L., & Lou, J. (2000). Counting nouns and verbs in the input: Differential frequencies, different kinds of learning? *Journal of Child Language*, 27, 561-585.

Sharon, T., & Wynn, K. (1998). Individuation of actions from continuous motion. *Psychological Science, 9*, 357-362.

Slater, A., Morison, V., & Town, C. (1985). Movement perception and identity constancy in the new-born baby. *British Journal of Developmental Psychology, 3*, 211-220.

Slobin, D.I. (2001). Form-function relations: How do children find out what they are? In M. Bowerman & S.C. Levinson (Eds.) *Language acquisition and conceptual development* (pp. 406-449). Cambridge, MA: Cambridge University Press.

Smiley, P., & Huttenlocher, J. (1995). Conceptual development and the child's early words for events, objects, and persons. In M. Tomasello & W.E. Merriman (Eds.), *Beyond the names for things: Young children's acquisition of verbs* (pp. 21-62). Hillsdale, NJ: Lawrence Erlbaum Associates.

Smith, L.B. (2001). How domain-general processes may create domain-specific biases. In M. Bowerman & S.C. Levinson (Eds.), *Language acquisition and conceptual development* (pp. 101-131). Cambridge, MA: Cambridge University Press.

Smith, W.C., Johnson, S.P., & Spelke, E.S. (2003). Motion and edge sensitivity in perception of object unity. *Cognitive Psychology, 46*, 31-64.

Snedeker, J., & Gleitman, L.R. (2004). Why is it hard to label our concepts? In D.G. Hall & S.R. Waxman (Eds.), *Weaving a lexicon* (pp. 257-293). Cambridge, MA: The MIT Press.

Spelke, E.S., Phillips, A., & Woodward, A.L. (1995). Infants' knowledge of object motion and

human action. In. D. Sperber and D. Premack (Eds.), *Causal cognition: A multidisciplinary debate* (pp.44-78). New York, NY: Oxford University Press.

Stager, C.L., & Werker, J.F. (1997). Infants listen for more phonetic detail in speech perception than in word-learning tasks. *Nature, 388*(6640), 381-382.

Talmy, L. (1985). Lexicalization patterns: Semantic structure in lexical forms. In T. Shopen (Ed.), *Language typology and syntactic description* (pp. 57-149). New York, NY: Cambridge University Press.

Tardif, T. (1996). Nouns are not always learned before verbs: Evidence from Mandarin speakers' early vocabularies. *Developmental Psychology, 32*, 492-504.

Tardif, T., Gelman, S.A., & Xu, F. (1999). Putting the "noun bias" in context: A comparison of English and Mandarin. *Child Development, 70*, 620-635.

Tomasello, M. (1992). *First verbs: A case study of early grammatical development.* New York: Cambridge University Press.

Tomasello, M. (1995). Pragmatic contexts for early verb learning. In M. Tomasello & W.E. Merriman (Eds.), *Beyond the names for things: Young children's acquisition of verbs* (pp. 115-146). Hillsdale, NJ: Lawrence Erlbaum Associates.

Tomasello, M. & Kruger, A. (1992). Joint attention on actions: Acquiring verbs in ostensive and non-ostensive contexts. *Journal of Child Language, 19,* 311-333.

Tomasello, M. & Merriman, W.E. (1995). *Beyond names for things: Young children's acquisition of verbs.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Wang, S., Baillargeon, R., & Paterson, S. (2005). Detecting continuity violations in infancy: A new account and new evidence from covering and tube events. *Cognition*, 95, 129-173.

Wang, S., Kaufman, L., Baillargeon, R. (2003). Should all stationary objects move when hit?

Developments in infants' causal and statistical expectations about collision events. *Infant Behavior and Development, 26*, 529-567.

Waxman, S.R., & Markow, D.B. (1995). Words as invitations to form categories: Evidence from 12- to 13-month-old infants. *Cognitive Psychology, 29*, 257-302.

Werker, J.F., Cohen, L.B., Lloyd, V.L., Casasola, M., & Stager, C.L. (1998). Acquisition of word-object associations by 14-month-old infants. *Developmental Psychology, 34*, 1289-1309.

Wynn, K. (1996). Infants' individuation and enumeration of actions. *Psychological Science, 7*, 164-169.

Zacks, J.M., & Tversky, B. (2001). Event structure in perception and conception. *Psychological* Bulletin, 127, 3-21.