

Infants' Nonlinguistic Processing of Motion Events: One-Year-Old English Speakers Are Interested in Manner and Path

Rachel Pulverman Jennifer L. Sootsman Roberta Michnick Golinkoff
University of Delaware

Kathy Hirsh-Pasek
Temple University

“A picture is worth a thousand words, but that’s the problem” (Gleitman, 1989)

Introduction

How do infants learn to map verbs onto the particular aspects of events to which they refer? Events are complex, and verbs are highly ambiguous. A novel verb used in describing even what seems to be a relatively simple event can have a multitude of possible meanings. Consider an event in which a boy kicks a ball across a field. If someone should say, “Look, he’s *blicking!*”, how should *blicking* be interpreted? In addition to the *kicking* action performed by the boy, the ball *distances* itself from the boy, *rolling* and *bouncing* as it *crosses* the field. Each of the italicized words in the preceding sentence is a possible referent for the word *blicking*. None of these words refers to a ‘whole action’, but rather each refers to a subset of elements in the motion event including factors such as *how* the ball moves (its manner) or the *trajectory* of the ball (its path). In some languages, other factors such as the shape and consistency of the prominent entity, the ball, (the event’s figure) (e.g., Atsugewi (Talmy, 1985)) or the properties of the medium traversed by the prominent entity, the field, (the event’s ground) (e.g., Japanese (Muehleisen & Imai, 1995) can also constitute elements of verbs’ meanings. Thus, learning motion verbs involves disentangling a variety of simultaneously occurring components of events and deciding between a plethora of possible meanings (Gentner, 1982).

Despite the ambiguity of verbs and the complexity of their referents, children must learn them. Verb learning lies at the core of language acquisition, not only because it comprises a considerable sub-component of lexical acquisition, but also because verbs are the centerpieces of syntactic structure. Yet, how children learn verbs has been one of the more intractable problems for researchers. Learning verbs seems to be a difficult task for children (e.g., Gentner, 1982), even in languages where they occur in the prominent, sentence final position, or in isolation as the result of argument drop (e.g., Imai, Haryu, & Okada, in press). While there has been much speculation about what makes verb learning so difficult (see Golinkoff, Jacquet, Hirsh-Pasek, & Nandakumar, 1996 for a brief summary), the root of the problem remains unclear. In an important contribution to this debate, Gentner (1982) proposed that the solution might lie in the interplay between language and conceptual development. Verb learning should be difficult (or impossible) if children’s event concepts differ from the concepts lexicalized as verbs in language.

When children’s nonlinguistic concepts are aligned with the concepts expressed by words, learning those words should be naturally facilitated. Many studies have provided evidence that noun learning is much easier than verb learning (e.g., Nelson, 1995; but see Choi & Gopnik, 1995). There is also much evidence supporting the idea that infants naturally perceive objects in ways that should help them learn nouns (e.g., Hollich, Golinkoff, Arnold, & Hirsh-

Pasek, 2002). All languages have words naming individual objects and categories of objects. Perhaps even at birth, infants perceive objects as separate elements in their environments (Spelke, 1990), and by 3 months can form at least some broader categories of objects, such as animals versus vehicles (Arterberry & Bornstein, 2001). Conversely, in no language would a noun ever mean something like ‘a bird’s feet and the branch they are wrapped around’, and infants would be unlikely to view this as a single object or as separate objects belonging to the same category.

Motion verbs, in contrast, are highly ambiguous in that they have the potential to label a number of abstract event concepts, such as manner (e.g., *run*), path (e.g., *exit*), ground (e.g., *deplane*), or cause (e.g., *push*) (Talmy, 1985). Thus, there is no single simple concept that could allow children to pick out all possible verb referents. This necessitates making use of either multiple, conflicting event concepts (e.g., ‘actions are defined by manner’ and ‘actions are defined by path’ and ‘actions are defined by path and ground’...) or complex, ambiguous event concepts (e.g., ‘actions can be defined by manner, or path, or path and ground...’). Furthermore, which aspects of motion events are most likely to be verb referents varies across languages (Talmy, 1985). For example, to describe a scene in which a woman ran as she exited a house, an English speaker would most likely say *The woman ran out of the house*, using a manner verb, while a Spanish speaker would say *La mujer salió de la casa corriendo* (‘The woman exited the house running’), using a path verb. Hence, how event concepts are implemented as verb learning tools (for example, the relative importance of different event components) should ideally have some flexibility.

There is evidence that, at least for adults, event concepts are flexible. In a forced choice task, Naigles and Terrazas (1998) found that adult English- and Spanish-speakers differed in their expectations as to whether a novel verb encoded manner or path, the latter favoring path and the former favoring manner overall. Additionally, the participants in both language groups somewhat adjusted their assumptions about whether a novel verb expressed manner or path based on the syntactic frame in which the verb was presented. This serves as evidence for the flexibility of event concepts both between adult individuals and within an adult individual’s own conceptual system. Hohenstein (2001) found that 7-year-old Mexican and American children performed differently on a nonlinguistic match-to-sample task that pitted manner against path. The English-speaking children chose the manner match more often than their Spanish-speaking counterparts. The differential performance between language groups shows that children do, in fact, have more than a single simple concept of what is important in an event, and furthermore, that at least some flexibility is evident in children’s event concepts by 7 years of age.

But how do they get there? One possibility is that children notice the elements of motion events that will enable them to learn verbs. Another possibility is that *language* focuses attention on certain aspects of the world so that they can form the necessary concepts to learn motion verbs. We can begin to evaluate these hypotheses about the origins of verb-friendly event concepts by asking if infants are even able to *notice* and *attend to* verb-relevant components of motion events. The ability to attend to individual elements of motion events would be evidence that infants conceptualize events in a way conducive to picking out possible verb referents. Below, we present an investigation addressing the following questions:

- (1) Do infants attend to aspects of motion events that are potential verb referents?
- (2) Do infants pay more attention to some verb-relevant parts of motion events than to others?

(3) How might infants' attentional patterns interact with lexical acquisition?

To our knowledge, the current study is the first to explore these crucial issues. We examined English-speaking infants' attention to two of the semantic components of motion events most frequently encoded in motion verbs – path and manner. We hypothesized that infants would attend to one or both of these elements because, as Mandler (1992) pointed out, there appear to be many parallels between the types of semantic categories posited by linguists and the pre-verbal event concepts represented by infants. However, as the relative frequencies of manner verbs and path verbs vary cross-linguistically, exactly which element(s) of events children might attend to was not clear. Since languages tend to have both manner verbs and path verbs, in the spirit of Mandler, we might expect infants to attend to both manner and path. Furthermore, since it is impossible to learn path verbs without attending to path (or manner verbs without attending to manner), it is *necessary* for infants to attend to both of these things *at some stage in development*.

On the other hand, there are also reasons we might expect infants to pay attention to only manner or only path. It may be less cognitively taxing to attend to only one event component at a time. But which one? If attention to motion events is to undergird lexical acquisition, it would be beneficial to attend to the elements of events that are most frequently lexicalized. Cross-linguistically, languages most commonly express path in their motion verbs more frequently than manner, so we might expect infants to attend to path. On the other hand, there are many languages, including English, in which manner is more commonly expressed in motion verbs than path. Perhaps, in alignment with Slobin's (1987, 2001) "thinking for speaking" theory, exposure to one's native language has an influence on how infants attend to motion events. If this is the case, then once infants have had a chance to learn how their language works, we might expect them to attend to whatever is more commonly lexicalized in their language. This could then, in turn, assist them in learning verbs in their language more efficiently.

Below we report the first in a series of studies designed to examine infants' attention to motion events. It is a first step in exploring the answers to questions (1) through (3) presented above. A habituation paradigm was used to determine if English-speaking infants attend to manner and path when watching motion events in a non-linguistic context. Infants were habituated to an event including a manner and a path, and then presented with events in which the manner and/or path had been changed. If infants attend to path or manner when watching motion events, they should notice, and therefore dishabituate to, changes in path or manner, respectively. Vocabulary data were collected for each participant in order to examine the relationship between attention to manner and path and lexical acquisition.

Participants

Full-term, monolingual infants between the ages of 14 and 17 months were recruited from English-speaking households. Participants were assigned to either the High Vocabulary (HV) group or the Low Vocabulary (LV) group based on comprehension scores from the MacArthur Communicative Development Inventory (CDI) Infant Short Form. Infants scoring 43 or above were assigned to the HV group and those scoring below 43 were assigned to the LV group. This value was chosen as the cut-off score because it is the estimated median for children of 15 1/2 months (the center of our age group) based on Fenson et al. (2000). Twenty LV infants (10 male, 10 female, $M=15,04$) and 20 HV infants (10 male, 10 female, $M=15,14$) were tested. The ages of the participants were not significantly different between vocabulary groups ($t(38)=$

1.48, $p > .10$). Data from an additional 26 infants were excluded for a variety of reasons: failure to complete the experiment due to fussiness or crawling out of the coder's view (12), experimenter or equipment error or background noise (8), parental interference (4), and failure to habituate (2).

Stimuli

Stimuli were computer-animated motion events featuring a purple starfish character performing an action, and a stationary green ball on a black background. Each action included one of 3 manners (jumping jacks, spinning, or bending at the "waist") and one of 3 paths (over the ball, under the ball, or past the ball) (see Figure 1) resulting in 9 distinct actions (jumping jacks over, jumping jacks under, etc.). The starfish traversed its path over six seconds and then reversed its direction to continue back along the same path. The manners were all repetitive actions, and reversed their direction concurrently with the paths' direction changes. Crucially, no language accompanied these events.

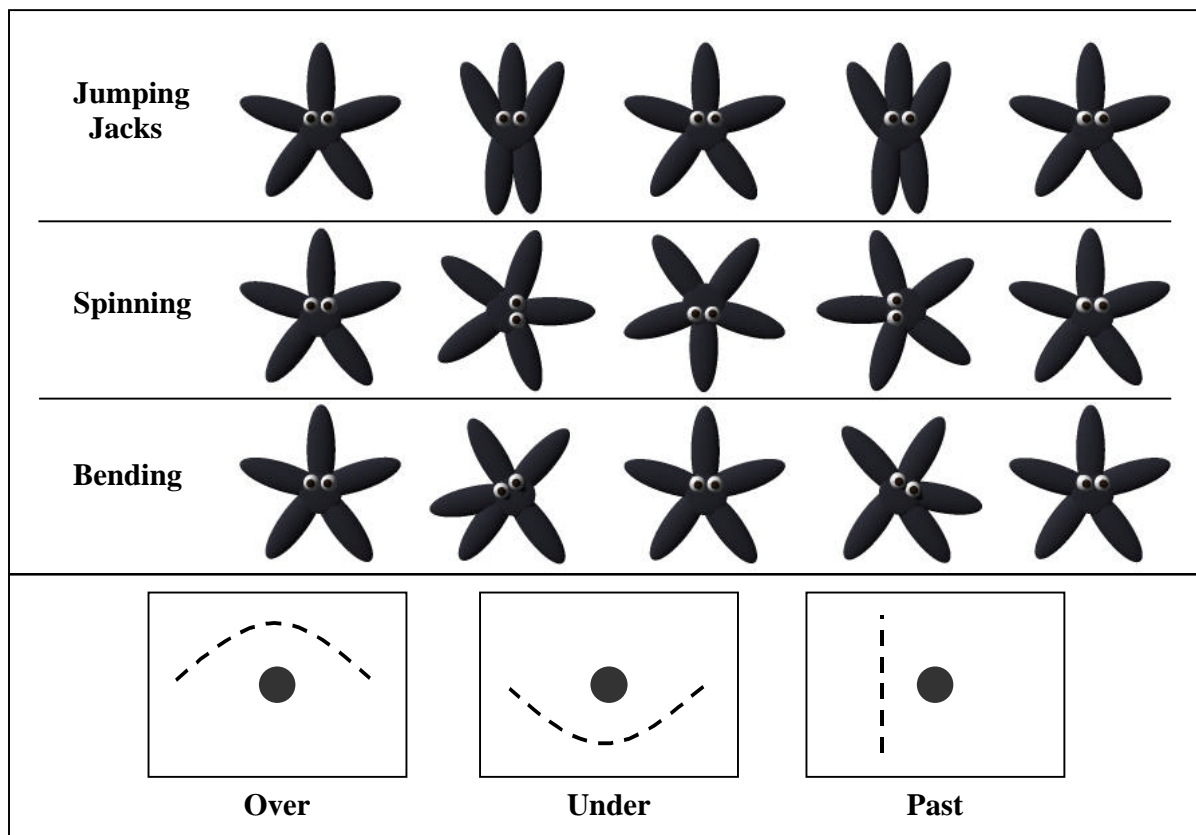


Figure 1. Manners and paths used in stimuli. Although illustrated as a series of static postures, the star performed the manners as continuous motions.

Procedure

Participants were habituated to one of the 9 stimulus events (e.g., jumping jacks over). Infants were said to have habituated when their visual fixation time to the stimulus in a fixed window of 3 trials (trials 4-6, trials 7-9, etc.) dropped below 65% of their visual fixation time in

the first window (trials 1-3). Once habituated, each participant was presented with four test trials: a control trial with the same event as the habituation trials (e.g., jumping jacks over); a path change trial with the same manner as the habituation event but a different path (e.g., jumping jacks *under*); a manner change trial with the same path as the habituation event, but a different manner (e.g., *spinning* over); and a both change trial whose manner and path were both different from those in all of the other events (e.g., *bending past*). Nine stimulus sets were created to counterbalance which event was presented as the habituation event, which events were used for each type of test trial, and the order of presentation of the four types of test trials. Participants were each randomly assigned one of the stimulus sets. In both the habituation phase and the test phase, a trial ended either when the participant looked away from the stimulus for 2 consecutive seconds, or when the trial had lasted 30 seconds.

Results

A 4 x 2 x 2 mixed model ANOVA with the within subjects factor of trial type (control vs. path change vs. manner change vs. both change) and the between subjects factors of vocabulary group (LV vs. HV) and gender revealed only a significant main effect of trial type ($F(3,114)=9.61, p<.001$). The main effects of vocabulary group and gender were not significant (F 's <1). The interactions involving gender did not approach significance (F 's <1), so the factor of gender was dropped from further analyses. However, the trial type x vocabulary group interaction showed a trend toward significance ($F(3,114)=2.41, p=.070$) and may, with additional participants, reach significance. Due to the preliminary nature of this work, we took this trend seriously and further analyzed the trial type by vocabulary group interaction.

To break down the main effect of trial type, we conducted a one-way ANOVA of a priori within subjects contrasts individually comparing each of the change trials (path, manner, and both) to the control trial. This revealed a significant effect of each type of change (path change: $F(1,38)=16.34, p<.001$; manner change: $F(1,38)=19.68, p<.001$; both change: $F(1,38)=29.53, p<.001$). As compared to the control trial, infants looked a mean of 4.7s longer at the path change, 5.3s longer at the manner change, and 7.1s longer at the both change (see Figure 2).

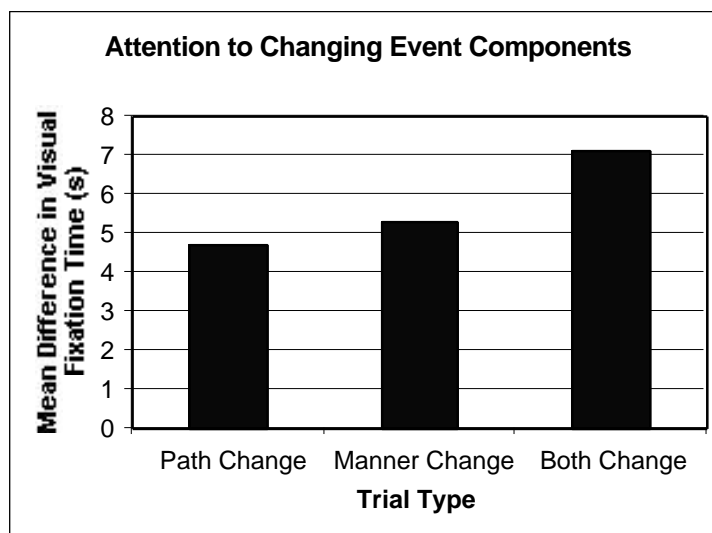


Figure 2. Mean differences in visual fixation time between each type of change trial and the control trial.

The same within subjects contrasts as above were repeated as simple contrasts within each vocabulary group. As compared to the control trial, infants in the LV group looked a mean of 6.2s longer at the path change ($F(1,19)=13.23, p<.003$), 3.9s longer at the manner change ($F(1,19)=7.25, p<.015$), and 5.2s longer at the both change ($F(1,19)=12.47, p<.003$) (see Figure 3). All of these differences were significant. Infants in the HV group looked 3.2s longer at the path change ($F(1,19)=4.12, p=.058$), 6.7s longer at the manner change ($F(1,19)=12.43, p<.003$), and 9.0s longer at the both change ($F(1,19)=17.40, p<.002$) (see Figure 3). The manner change and the both change significantly differed from the control. The difference between the path change and the control trial bordered on significance.

A 2 (path change vs. manner change) x 2 (vocabulary group) ANOVA was also conducted. The main effect of trial type was not significant ($F(1,38)=.168, p>.684$). However, the trial type x vocabulary group interaction was nearly significant ($F(1,38)=3.490, p=.069$). While the LV infants looked a mean of 2.2s longer at the path change than at the manner change, the HV infants looked 3.4s longer at the manner change than at the path change (see Figure 3).

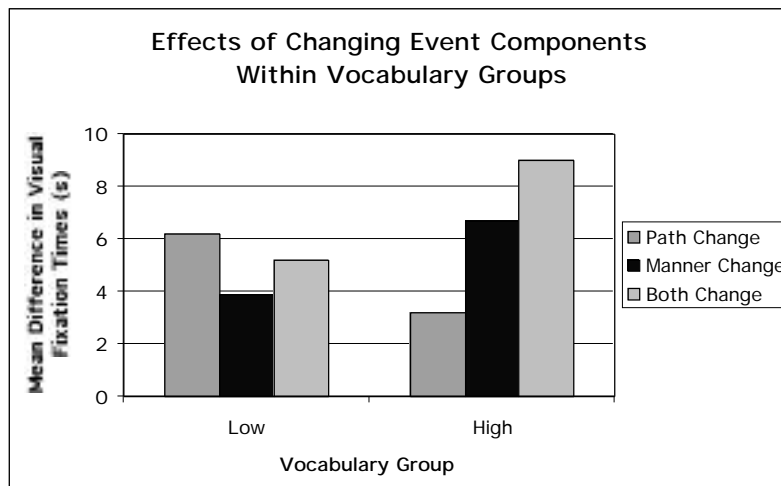


Figure 3. Mean differences in visual fixation time between each type of change trial and the control trial within each vocabulary group.

Discussion

This study investigated 14- to 17-month-old English-speaking infants' performance on a fundamental skill in the verb-learning process – attending to possible referents for motion verbs. Specifically, attention to path and manner were tested. Results indicate that these infants do, in fact, attend to both manner and path, as evidenced by their dishabituation to an event in which only the manner or only the path, respectively, differed from the habituation event. This is an important finding because, in order to learn the verb lexicon of their language, infants must be able to attend to any aspect of an event that may be lexicalized as a verb. Since path and manner are two of the event components most commonly encoded in verbs, both in English and cross-linguistically, the ability to attend to these elements in particular shows that, by 14 months of age, infants at the very least have a foot in the door for learning a large variety of motion verbs.

Furthermore, as the habituation events in this study included both a manner and a path, infants' detection of manner changes and path changes shows that they are able to pay attention

to the individual elements of manner and path in an event that contains a complex of simultaneously occurring motion components. This is a crucial skill because verb referents do not usually occur in isolation. There are many manner verbs, such as *walk* or *slide*, that inherently propel their performers along some path. Conversely, it is impossible for an entity to move along a path without being propelled in some manner. Thus, isolating possible verb referents in the real world necessarily involves separating co-occurring elements of action. Our results suggest that infants are competent at this task.

As mentioned above, manner verbs and path verbs are not equally frequent in all languages. In the majority of languages, path verbs occur more often than manner verbs. However, in many other languages, including English, manner verbs are more common than path verbs. Hohenstein (2001) found that 7-year-old English speakers were more likely to match events to one another based on manner than were Spanish speakers. But perhaps this linguistic influence on event concepts begins much earlier. We predicted that, with experience, disparities between the frequencies of manner and path verbs in a given language might impact the way infants attend to events. While the result is not significant at this time, we discovered a trend in our data toward an interaction between trial type and vocabulary group. It tentatively appears that infants with higher vocabularies might be more interested in manner and less interested in path than infants with lower vocabularies.

Despite the possible manner/path disparities, it appears that both LV and HV infants may pay at least some attention both to manner and to path. This is crucial to verb learning because, even if infants adjust their distribution of attention to focus more on what is emphasized most in their language, they must still remain prepared to learn any type of novel verb they encounter, however infrequent. Should the path versus control contrast within the HV group not turn out to be significant, a theory will be needed to explain how children at that age and vocabulary level can continue to learn path verbs

The nature of verbs makes attending to their possible referents a potentially difficult task. It is a complex undertaking involving parsing a scene in a number of different ways simultaneously: (1) The movement of an entity or entities must be pulled out from a complex scene; (2) Discrete actions must be individuated from a continuous stream of motion; and (3) Simultaneously occurring semantic components of an event such as manner, path, ground, and cause must be individually extracted from the event as a whole. Spelke's (1990) work has demonstrated that infants are capable of (1), possibly even from birth. Sharon and Wynn (1998) have reported evidence that infants as young as 6 months have competence at (2). The current study is the first to demonstrate that infants have the ability to do (3).

The ability to attend to path and manner in nonlinguistic events, two of the elements most commonly expressed in motion verbs, shows that by 14 months of age, infants are equipped with an essential tool for learning a wide variety of verbs. Our findings, taken together with those of Spelke (1990) and Sharon and Wynn (1998), suggest that, by the time infants are learning their earliest words, they may be prepared to view the world in a way that will help them to learn not only nouns, but also verbs.

Limitations of the Present, Preliminary Study

To draw conclusions about whether infants' ability to attend to manner and path is a *pre-linguistic* underpinning to verb learning, we must first establish that younger infants who have not yet begun learning verbs are able to attend to these event components as well. This is especially important if language proves to have already had an impact on the infants in the study

reported here. For this reason, we are currently also testing infants between 7 and 9 months of age.

As our results become clearer, even if they do show that the HV infants attend more to manner, such data alone cannot be taken as proof that language-specific knowledge shapes infants' event concepts. It is possible that, for some unknown reason, all infants preferentially attend to manner when they have vocabularies comparable to those of the infants in our HV group. Thus, parallel research in a language with a path verb bias will be necessary to adequately interpret a vocabulary effect. For this reason, we have begun testing Spanish-speaking infants in the same task.

Another limitation of the current study is that we used stimuli that were perceptually much simpler than most events in the real world. Maguire et al. (in press) reported that infants could fast-map a novel verb to a novel action when presented in point-light displays (videos with a black background containing only moving dots corresponding to the major joints of a human body) while they could not fast-map the same action to the same verb when presented in live-action videos. This suggests that perceptually simplified events may help infants to demonstrate abilities related to event concepts by eliminating distracting information less central to the task in question, such as background and facial expressions. In light of this finding, we chose to use perceptually simple, non-human stimuli on a black background in order to give infants the best chance possible to demonstrate their action-parsing abilities. Further investigation, including replication of this study using live-action videos, is needed to determine the full extent of infants' ability to extract manner and path information from complex scenes.

Finally, while manner and path are two of the most frequent referents of motion verbs, there are other verb-relevant elements of events (e.g., cause, effect, figure, and ground) that need to be studied as well. Additionally, just because infants are able to attend to a variety of lexicalized event components in a nonlinguistic task does not necessarily mean that they attend to events in the same way in a linguistic context. Stager and Werker (1997) found that 14-month-old infants could lose the ability to discriminate a native phonemic contrast during a word learning task. Eight-month-old infants, who are not yet readily learning words, discriminated the phonemes equally well in the word learning task as they did in the straight speech perception task. This suggests that, at certain stages in development, adding linguistic demands to a task can initiate the re-allocation of other linguistic or cognitive resources. Thus, an important piece of our future research must include adding language to this task. Clearly, much more research is needed to determine the extent to which infants' perceptual and conceptual systems prepare them for and are influenced by verb learning.

Final Remarks

When Gleitman writes that "a picture is worth a thousand words, but that's the problem," she points out that verb learning is more than a matter of simple word-to-world mapping. Given the sheer number of potential referents for any given verb, how do children focus on the correct mapping from word to world? There are several proposals for how this might be done. Gleitman and her colleagues suggest that syntactic information is necessary to disambiguate verb meanings (Gillette, Gleitman, Gleitman, & Lederer, 1999). Additionally, this paper has provided evidence that infants may be sensitive to certain features of events, thereby simplifying the mapping problem. Thus, even though verb learning seems to pose a special problem for young children (Golinkoff et al., 1996; Hollich, Hirsh-Pasek, & Golinkoff, 2000), results from our laboratories have been suggesting that some of the same solutions can be used for learning both

nouns and verbs (Golinkoff, Hirsh-Pasek, Mervis, Frawley, & Parillo, 1995). We have now uncovered evidence that infants' conceptual systems may guide their attention to assist them not only in noun learning, but in verb learning as well. This is an important step toward developing a unified theory of word learning.

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