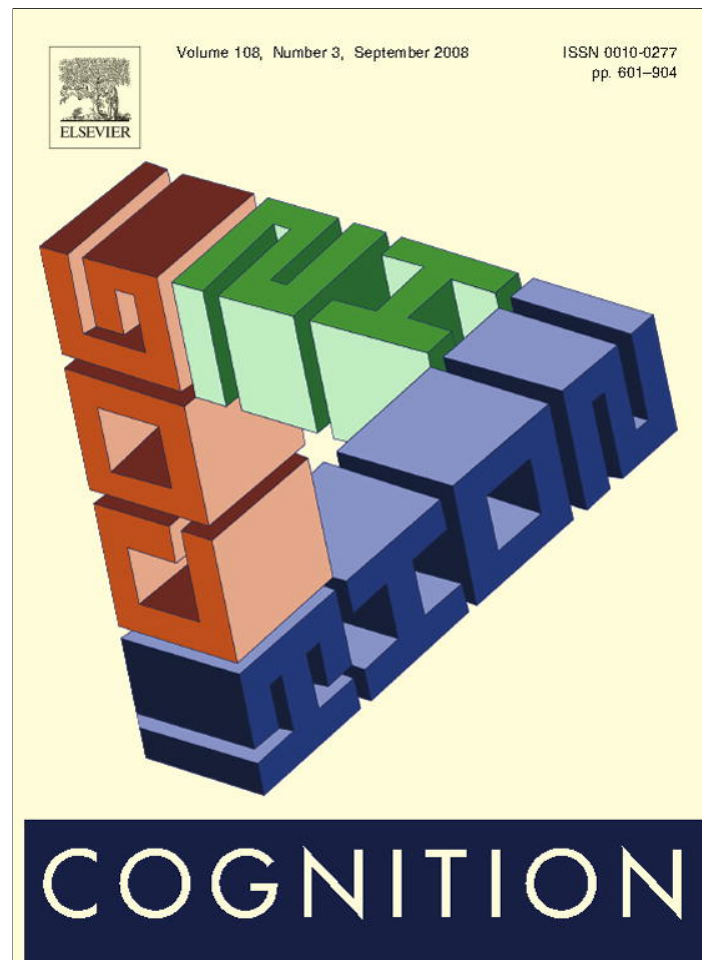


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Brief article

Infants discriminate manners and paths in non-linguistic dynamic events [☆]Rachel Pulverman ^{a,b,*}, Roberta Michnick Golinkoff ^c, Kathy Hirsh-Pasek ^d,
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ABSTRACT

Do 14- to 17-month-olds notice the paths and manners of motion events? English- and Spanish-learning infants were habituated to an animated motion event including a manner (e.g., spinning) and a path (e.g., over). They were then tested on four types of events that changed either the manner, the path, both, or neither component. Both English- and Spanish-learning infants attended to changes of manner and changes of path. Thus, infants from two different language communities proved sensitive to components of events that undergird relational term learning.

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1. Introduction

To learn verbs, children must perceive and conceptualize aspects of event structure that are codified in their language and map words onto those concepts (see Gentner, 1982; Gillette, Gleitman, Gleitman, & Lederer, 1999; Hirsh-Pasek & Golinkoff, 2006). This paper investigates the cognitive foundation for learning motion verbs by probing infants' awareness of two purportedly universal "ontological categories," (Jackendoff, 1983; Langacker, 1987) – path and manner. Path – the trajectory of an entity with respect to some reference point (e.g., *out* of a box; *approaching* a stranger) – relates the movement of an entity to a landmark. Manner – how an action is carried out (e.g., *walking*; *stretching*) – comprises a dynamic relation between an entity's internal parts. These primitives of event structure are particularly ripe for research for three reasons. First, they are represented to different degrees in all of the world's languages. Second, Mandler

(2004) argues that path in particular might prove to be the most basic semantic component of events, underlying children's understanding of causality and animacy. Finally, path and manner, surfacing mainly in verbs and prepositions, are lexicalized differently across languages (Talmy, 1985). For example, in Spanish, one would likely describe an event in which a woman runs as she exits a house as, "Una mujer *sale* de la casa *corriendo* ('A woman *exits* the house *running*'). Here, as in the majority of languages, the motion verb expresses *path*, with *manner* expressed via satellites such as adverbs. In many other languages, like English, motion verbs commonly express *manner*, using particles or adpositions to express *path*, as in *A woman is running out of the house*. In addition to differences in how manner and path are lexicalized, there are also differences in how often they are expressed at all. Though path is expressed frequently in both English and Spanish, manner information is often omitted from Spanish sentences altogether, making manner less frequent in Spanish than in English. In fact, Naigles, Eisenberg, Kako, Highter, and McGraw (1998) reported that adult English speakers expressed manner more often than Spanish speakers when describing short video clips of the same events. Because attention to both path and manner is fundamental for the learning of relational terms across the globe, and because path and manner are expressed differently across languages, the cross-cultural study of infants' processing of these elements of event structure offers potential insight into the acquisition of verbs and prepositions.

The investigation of infants' perception of events is relatively recent. Studies are just beginning to probe children's processing of events in ways that are directly related to language. For example, Choi and colleagues (e.g., Choi, 2006; Choi & Bowerman, 1991; Choi, McDonough, Bowerman, & Mandler, 1999) and Casasola and colleagues (e.g., Casasola & Cohen, 2002; Casasola, Bhagwat, & Ferguson, 2006) examined infants' ability to recognize objects in spatial relations corresponding to the English prepositions "in" (containment) and "on" (support) and the Korean verb "kkita" (meaning 'to put tight-fitting,' with no distinction between containment and support). Results suggest that preverbal infants can form categories of containment and support, and that even English-reared 5-month-olds are sensitive to the Korean contrast of tight- versus loose-fit (Hespos & Spelke, 2004). Whether something fits tightly or loosely into a container, however, requires only perceptual examination of the boundaries around the object at the static endpoint of the event. Thus, it is unclear whether infants' processing of these events is based on the *dynamic* properties of motion per se.

Other promising avenues for studying event components come from Wagner and Carey (2005), and Lakusta, Wagner, O'Hearn, and Landau (2007) on infants' attention to sources and goals in events. This research suggests that 12-month-old infants are more likely to notice goal changes than source changes. The movement of the figure in these events was clearly important, as sources and goals can only be identified as a function of the figure's path.

1.1. The current study: Infants' processing of manner and path

The research reviewed above suggests that infants are sensitive to several aspects of motion events that will be relevant for learning verbs and other relational terms. However, little emphasis has been given to how infants process the characteristics of the motion itself. Yet motion processing is essential to how children perceive and eventually conceptualize events that will form the foundation for verb learning. The current research is the first to explore whether 14- to 17-month-old English- and Spanish-reared infants discriminate between paths and between manners in tightly controlled, animated motion events.

We compare infants learning English and Spanish primarily for two reasons. First, given that path and manner words are universally present across languages, the ability to process these elements in events should be universal. Second, given the cross-linguistic differences in the expression of manner and path, generalizations about infants' manner- and path-processing abilities can only be made if we find converging evidence from infants learning languages that express manner and path differently.

2. Experiment

2.1. Methods

2.1.1. Participants

Full-term, monolingual infants between the ages of 14 and 17 months were recruited from English-speaking households in the northeast of the United States ($n = 37$, 17 male, $M = 15.07$, range: 14.02–16.21) and from Spanish-speaking households in a middle-class city in central Mexico ($n = 33$, 16 male, $M = 15.07$, range: 13.28–17.05). Data from an additional 41 English-learning and 29 Spanish-learning infants were excluded for a variety of reasons (numbers reported as English/Spanish): failure to complete the experiment due to fussiness (11/8); computer or experimenter error (9/1); background noise (8/2); parental interference (6/4); fatigue (3/4); movement preventing accurate coding (2/5); and failure to reach the habituation criterion (2/4). A 50% retention rate is not uncommon for habituation tasks (e.g., Bornstein, 1985). Attrition did not significantly differ between language groups ($\chi^2(1, N = 140) = 0.46, p = .496$).

2.1.2. Stimuli

Stimuli were computer-animated motion events featuring a lavender starfish character performing an action and a stationary pale green ball on a black background. Since path is defined semantically as a moving entity's trajectory with respect to a reference point (Talmy, 1985), the ball was included to serve as the reference point for the starfish's paths. Each action included one of three manners (jumping jacks, spinning, or bending at the 'waist') and one of three paths (over, under, or past the ball) (see Fig. 1) resulting in nine distinct actions (jumping jacks over, etc.). The starfish traversed its path over 6 s and then returned along the

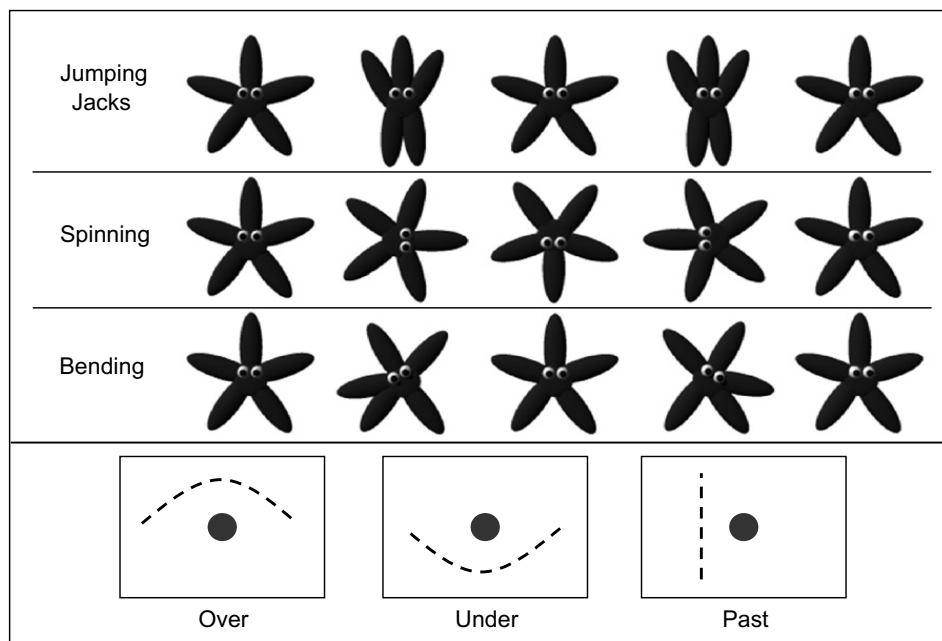


Fig. 1. Manners and paths used in stimuli. Although illustrated as a series of static postures, the starfish performed the manners as continuous motions. (Fig. 5.1 from Pulverman, R., et al. (2006). *Conceptual foundations for verb learning: Celebrating the event*. In K. Hirsh-Pasek & R. M. Golinkoff (Eds.), *Action meets word: How children learn verbs* (p. 142). Oxford University Press, Inc.

same path repeatedly. These back-and-forth paths were chosen so the starfish would not disappear and reappear in a different location between repetitions. They also ensured that children had to process dynamic motion and could not rely on sources or goals to infer the paths. The manners were repetitive actions, and reversed direction concurrently with the paths' direction changes. For example, in the 'spinning over' event, the starfish took 6 s to cross from the left side of the screen to the right, passing over the ball while continuously spinning clockwise. In the next 6 s, the starfish passed over the ball from right to left while spinning counter-clockwise. No language accompanied the events.

2.1.3. Procedure

A habituation procedure was used to determine whether infants would detect differences in manners and paths between motion events. Infants were seated in a dimly lit room on a parent's lap at a table in front of a computer monitor, with the monitor subtending approximately 24 deg of their visual field horizontally. Parents were instructed to close their eyes and refrain from speaking or directing their child's attention. Stimuli were presented via the computer program Habit 2000 (Cohen, Atkinson, & Chaput, 2000). An experimenter blind to the stimuli being displayed observed the infants through a peephole and recorded their visual fixation via the computer keyboard. The single coding experimenter in Mexico was one of the coding experimenters in the U.S. All experimenters were required to establish coding reliability within the research group prior to acting as coders for the study. Additionally, 15% of the participants' tests (6 English, 6 Spanish) were re-coded offline from videotapes by someone other than the original coder to check reliability.

Multiple coders performed reliability checks, and codings from every experimenter were included among those checked for reliability. For all second codings, visual fixation times during trials had a Pearson correlation of at least .930 with the original online codings (mean = .985, $SD = .027$) for the English group and at least .978 (mean = .994, $SD = .01$) for the Spanish group.

Participants were habituated to one of the nine 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 three trials (trials 4–6, trials 7–9, etc.) dropped to or below 65% of their visual fixation time in the first window (trials 1–3). They were given a maximum of 15 trials in which to habituate. Once habituated, each participant was presented with four test trials whose order of appearance was counterbalanced across participants: a control trial identical to the habituation trials (e.g., jumping jacks over); a path change trial with the habituated manner, but a different path (e.g., jumping jacks under); a manner change trial with the habituated path, 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). If infants notice the manners and/or paths of motion events, they should detect the corresponding differences between events and dishabituate to the changed scenes. Immediately following the test phase, a highly attractive recovery stimulus (a video of a laughing baby's face) was presented to ensure that participants were not too fatigued to look at the display at the conclusion of the study.

Nine stimulus sets were created to counterbalance which event served 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

randomly assigned one of the stimulus sets. In all phases of the experiment (habituation, test, and recovery) a trial ended either when the participant looked away from the stimulus for two consecutive seconds, or when the trial had lasted 30 s, whichever came first.

2.2. Results

2.2.1. Do infants notice changes in event components?

A $4 \times 2 \times 2$ mixed model ANOVA with the within subjects factor of Trial Type (control versus path change versus manner change versus both change) and the between subjects factors of Language (English versus Spanish) and Gender revealed significant main effects of Trial Type ($F(3,198) = 14.18, p < .001$) and Language ($F(1,66) = 5.61, p = .021$). The main effect of Gender and all of the interactions involving Gender were non-significant (all p 's $> .17$), as was the Trial Type \times Language interaction ($F < 1$). Thus, it appears that infants do notice changes in event components, and that their attention to those changes is independent of gender and language. The main effect of Language indicates that the Spanish-learning infants attended longer than the English-learning infants during the test phase as a whole, but as Language did not interact with Trial Type, this is not a concern.

2.2.2. Which types of changes in event components do infants notice?

To break down the 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. Since neither Language nor Gender was involved in significant interactions in the previous analysis, those variables were collapsed. All three contrasts were highly significant (path: $F(1,69) = 17.39, p < .001$; manner: $F(1,69) = 31.73, p < .001$; both: $F(1,69) = 42.75, p < .001$).

To ensure that the above effects were not carried primarily by a single language group, the analysis was repeated within each language. As compared to the control trial, English-learning infants looked a mean of 4.1 s longer at the path change ($F(1,36) = 14.504, p = .001$), 5.9 s longer at the manner change ($F(1,36) = 22.16, p < .001$), and 7.5 s longer at the both change ($F(1,36) = 28.06, p < .001$), and Spanish-learning infants looked a mean of 4.6 s longer at the path change ($F(1,32) = 6.09, p = .019$), 5.4 s longer at the manner change ($F(1,32) = 11.05, p = .002$), and 7.1 s longer at the both change ($F(1,32) = 15.80, p < .001$) (see Fig. 2). Hence, it appears that both English- and Spanish-learning infants notice both path and manner changes in motion events.

2.3. Discussion

Infants are capable of detecting elements of motion events that will be relevant to language learning even before they have a strong cadre of verbs in their receptive and productive vocabularies. Previous research has shown that infants can process some aspects of motion events that underlie linguistic categories, such as endpoint spatial relations (e.g., Casasola, Bhagwat, & Ferguson, 2006; Choi,

2006), sources, and goals (Lakusta, Reardon, Oakes, & Carey, 2007; Lakusta, Wagner, et al., 2007; Wagner & Carey, 2005). The current work, however, is among the first experiments to ask whether infants detect simultaneously occurring *dynamic* components of motion events that are relevant for learning relational terms. In particular, the study examined infants' sensitivity to *manner* (how an action is performed) and *path* (the trajectory of the action). Attention to path and manner were tested in a habituation paradigm using tightly controlled, animated events. These studies were motivated by the fact that a fundamental requirement for learning relational terms – regardless of native language – is the ability to note changes in path and manner. We found that 14- to 17-month-old infants succeeded at this task regardless of gender or of cultural and linguistic differences, suggesting that it may be a robust ability common to all normally developing children. This is important because, in order to learn the relational lexicon of a language, infants must be able to attend to any aspect of an event that may be lexicalized as a relational term. Path and manner are two of the event components most commonly encoded in motion verbs across the globe (Talmy, 1985). The ability to detect these elements by 14 months suggests that infants may be ready to learn a large variety of motion verbs and other relational terms.

However, it remains unclear whether infants' successful discrimination between the events reflects conceptual distinctions, or lower level perceptual distinctions. The habituation paradigm is sensitive to both percepts and concepts (e.g., Arterberry & Bornstein, 2002), but the research presented here is unable to definitively distinguish between the two interpretations. Despite this ambiguity, these findings are nonetheless important. Crucially, in order to extract invariants from different events, infants must first recognize that the events are indeed different. On this leaner view, the conceptualization of path and manner may be an emergent abstraction across distinct perceptual episodes. Thus, if infants cannot detect when elements of motion events have changed, it is difficult to imagine how they would ever form concepts of path and manner.

Nor can we simply stipulate that children can make these discriminations as they approach language learning. Research is just beginning to identify the factors that contribute to the difficulty children have with verb learning (relative to noun learning) across diverse languages (e.g., Hirsh-Pasek & Golinkoff, 2006; Imai et al., *in press*) and perceptual factors should not be discounted. Unlike when processing enduring stimuli such as objects or static (or endpoint) spatial relations, motion events include the additional dimension of change over time. Most of the existing literature on infants' processing of dynamic events has focused on properties of the objects in the scenes (e.g., using motion cues to individuate objects; Kellman & Spelke, 1983), rather than on the properties of the motion itself. Perhaps we will discover that the biggest problem in accounting for language acquisition is not how infants come to detect perceptual differences between events, but rather how they discern which among a large set of detectable differences are the ones relevant to linguistic meaning in their language.

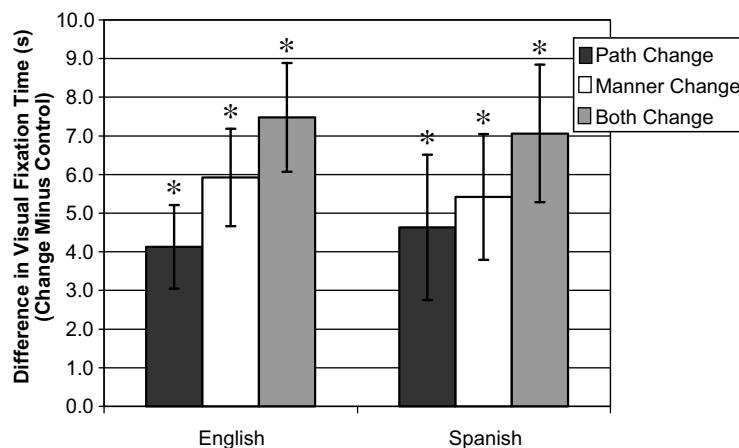


Fig. 2. Differences in visual fixation times between each type of change trial and the control trial for infants learning English and Spanish.

There is much to explore in the relationship between infants' sensitivity to primitives of event structure like path and manner and their ability to acquire linguistic terms that turn on these distinctions. Surely, sensitivity to these components of events is necessary but not sufficient to learn words that entail them. Yet even before relating infants' performance on this non-linguistic task to language knowledge, one might ask whether the stimuli in the current study bear on the perception of events in the real world. The stimuli used here were artificial and perceptually much simpler than most events in vivo. Perceptually simplified events may help infants by eliminating distracting information less central to the task in question, such as facial expressions (Maguire, Hirsh-Pasek, Golinkoff, & Brandone, 2008; Pulverman, Hirsh-Pasek, Golinkoff, Pruden, & Salkind, 2006). Only further investigation, including replications of these studies using live-action videos, can determine the full extent of infants' ability to extract manner and path information from complex scenes. Two studies have asked if infants can discriminate between such events using videos of human beings. Casasola, Hohenstein, and Naigles (2003) reported that English-learning infants could indeed discriminate manners and paths in real life videos. Song, Golinkoff, Ma, Seston, and Hirsh-Pasek (2008) showed that infants could form a category of the manner 'jumping' as distinct from 'marching' across five different human actors and five different paths. These findings complement the results reported here.

Another possible concern with these stimuli has to do with the selection of via paths (i.e., over, under, and past) as opposed to source paths (e.g., away from) and goal paths (e.g., toward), since infants appear to pay most attention to goals (Lakusta, Wagner, et al., 2007; Wagner, 2006). Via paths might be more difficult for babies to interpret than events that included sources or goals. However, the selection of via paths was made with the express purpose of guaranteeing that any results obtained were not about goal or source objects and not about location at the beginning or endpoints of action. Rather, these events were designed explicitly to test infants' ability to distinguish between the *dynamic* properties of motion events. The data suggest that

via paths were not a problem: infants were capable of discriminating between paths in these events.

The fact that infants noticed a variety of lexicalized event components in silence does not necessarily mean that they would attend to events in the same way in a *linguistic* context. Adding a word-learning component to the task might divert infants' cognitive resources from the otherwise manageable discrimination task (Stager & Werker, 1997). Or, hearing language might help infants to further focus on the relevant aspects of the events (e.g., Baldwin & Markman, 1989; Waxman & Markow, 1995). In a follow-up study, we have found that adding language to the present task induces English-learning infants to adjust their attention to manner and path in ways that may help them pick out the referents of novel words (Pulverman, Golinkoff, Hirsh-Pasek, Brandone, & Seston, 2006; Pulverman, Golinkoff, Hirsh-Pasek, & Brandone, in preparation). This provides further evidence that infants are prepared to learn motion verbs by early in their second year.

3. Conclusions

This experiment provides a glimpse at the developing cognitive foundation for learning motion verbs and other relational terms. As Gleitman (1989) and Mandler (1990, 1992, 2004) argued, infants seem to be working out the cognitive underpinnings for language acquisition very early. Across two languages, one of which emphasized manner in its verb lexicon and the other path, infants between 14 and 17 months of age appeared to discriminate between silent, simple animated events in which the manner or the path of the event changed. The present results suggest that infants are able to home in on elements of motion events that undergird the learning of a language's relational terms. It remains for us to investigate how sensitivity to these elements links up to the acquisition of linguistic terms that express them.

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