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# The Adaptability of Language Specific Verb Lexicalization Biases

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## Abstract

Languages vary in how they encode motion events. For example, English motion verbs often encode the manner of the motion while Spanish motion verbs encode the path. Efficient verb learning has been argued to involve the acquisition of language specific lexicalization biases. When given a novel verb paired with a single motion event, English speakers interpret it as a manner verb, Spanish speakers as a path verb. The present study examines the nature and plasticity of this lexicalization bias. Do lexicalization biases result in a permanent alteration of the semantic interface? Or are these biases continually shaped through our experiences with word learning? English-speaking adults were taught 12 motion verbs. The composition of the set of verbs was varied from 100% manner to 100% path with 3 levels in between. Lexicalization biases were monitored by testing verb extension after the first ambiguous exemplar of each verb. We replicate the finding that English speakers have an initial manner bias. However, we find that this bias changes over time in response to the input: Participants who learned path verbs developed a path lexicalization bias. Experiment 2 replicates this result with a different syntactic frame.

## Introduction

Children's early lexicons are curiously lopsided. Across a variety of linguistic environments, nouns dominate early vocabularies, while verbs are initially scarce (for a review see Gentner & Boroditsky, 2001). There are a number of explanations for initial noun dominance, which are by no means mutually exclusive. Verbs differ from nouns in the frequency with which they occur in isolation or in salient positions within the utterance and they also differ in the types of concepts that they encode and the types of entities that they pick out in the world. All of these factors have been argued to play a role in early noun dominance (Gleitman, 1990; Tardif, Shatz & Naigles, 1997; Caselli, Casadio & Bates, 1999; Snedeker & Gleitman, 2004).

Gentner and her colleagues have argued that nouns are prominent in the early lexicon because they typically denote physical objects which can be individuated (and presumably conceptualized) on the basis of the child's perceptual experience of the world (1982; Gentner & Boroditsky, 2001). Verbs, they argue are more difficult for novice language learners because perception does not package events into stable individuals. Instead languages decide how to conflate the conceptual components of events into lexical items. This results in greater cross-linguistic

differences in the meanings of verbs than in the meanings of nouns. To learn verbs, they argue, children must first discover how their language chooses to package events. To the extent that lexicalization patterns are systematic within a language, children should be able to draw generalizations from known instances, developing lexicalization biases which allow the pace of verb learning to accelerate.

The parade case for systematic cross-linguistic variation in lexicalization is the conflation patterns that occur in verbs of motion (Talmy, 1975). A motion event consists of a thing that is moving (the figure), the location it is moving relative to (the ground), the manner in which it is moving and the path along which it moves. All languages have ways of expressing these elements, but how they do so varies. 'Manner' languages, such as English and Mandarin, typically pack manner of motion into the verb, leaving path for an optional prepositional phrase ("He ran into the store"). In contrast, 'path' languages, such as Spanish and Greek and typically encode path in the verb and fob off manner on an optional gerund ("Él entró en la tienda corriendo"). In English, path verbs are relatively scarce (Gutiérrez, 2001; Talmy 1975). This cross-linguistic difference in verb use shows up in distributional analyses and production studies with both children and adults (Aske, 1989; Jackendoff, 1990; Berman & Slobin, 1994).

This systematic difference in lexicalization patterns also results in differences in how the speakers of manner and path languages learn new motion verbs, consistent with the predictions of Gentner's relational relativity hypothesis (1982). When confronted with a novel verb used to describe a single motion event, English speaking adults and seven year olds will extend the word to other events with the same manner of motion but not to events that have the same path (Naigles & Terrazas, 1998; Hohenstein & Naigles, 2000). In contrast Spanish speaking adults and seven-year olds extend the verb to events that have the same path but not the same manner. Thus each group has developed a lexicalization bias that is consistent with the primary verb lexicalization pattern in their language.

While verb lexicalization biases clearly exist, we know little about how they might develop or how they are mentally represented. One intriguing hypothesis comes from the literature on the development of the shape bias in noun learning. Smith and colleagues have argued that the shape bias is a generalization based on the words that the child has previously acquired (Smith, Jones, Landau, Gershkoff-Stowe & Samuelson, 2002). Children, they

claim, are initially unbiased learners who acquire their first nouns by patiently waiting for the situational concomitants of word use to tease apart the many alternate hypotheses about how a word might be extended. In this way, they manage to acquire a sizeable number of nouns, many of which are well-organized by shape. They argue that the shape bias is simply a second-order generalization of these known words. This account is supported by two lines of evidence. First, in the studies of Smith and her colleagues children fail to show a systematic shape bias until they have acquired a substantial number of nouns (but see Waxman, 1999). Second, toddlers who are trained on shape-based categories develop a shape bias and show accelerated acquisition of nouns, while those who are trained on substance-based categories or given an unsystematic training set do not.

While Gentner makes no specific proposal for how verb lexicalization biases could be acquired, the mechanism laid out by Smith seems consistent with the relational relativity hypothesis. Children learn a number of verbs that follow a language specific lexicalization pattern and then form the expectation that verbs in the same semantic field will be extended in a parallel fashion. But what does this expectation consist of? There are at least three possible explanations for how cross-linguistic differences in word learning biases could be instantiated.

First, children's word learning experiences could permanently alter their conceptual systems resulting in a change in the repertoire of possible concepts or in their relative salience or stability. This is an unlikely explanation for the manner-path lexicalization bias. Speakers of the two languages show similar behavior on nonlinguistic memory and categorization tasks, suggesting that verb conflation patterns do not affect the accessibility of manner or path concepts (Papafragou, Massey & Gleitman, 2002). Furthermore, since both languages have ways of expressing both manner and path, the linguistic evidence itself radically limits the degree to which conceptual alteration can be invoked. Thus we have to look to changes in the semantic interface which maps between linguistic forms and concepts.<sup>1</sup>

Second, lexicalization biases could be permanent alterations in the semantic interface. The mappings between linguistic forms and concepts could be altered so that certain conceptual dimensions are unavailable as candidates for verb meanings, although they might be used in nonlinguistic tasks or even as meanings for other terms. This mechanism would be the semantic parallel of Werker's functional reorganization hypothesis for phonological development (1995). Finally, lexicalization biases may be more plastic mappings between linguistic forms and concepts which can be modified as the child gains access to new information sources. Critically, if lexicalization biases are generalizations on the basis of known words, then they may

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<sup>1</sup> We follow Jackendoff's (2002) suggestion that language specific semantics are most parsimoniously described as an interface between linguistic forms and conceptual representations, rather than as a separate level of representation, but nothing in our argument rests upon this distinction.

be dynamically updated as children learn a larger and more varied set of verbs. To date there has been little work on the plasticity of the semantic interface between words and concepts. While several studies have examined the effects of age of acquisition on semantic processing of a second language, the results vary with the measures and contrasts that are studied (compare e.g., Weber-Fox and Neville, 1996 with Munnich, 2002). To the best of our knowledge no one has looked at the plasticity of lexicalization biases. Experiment 1 explores the possibility that manner lexicalization bias for motion verbs continues to be malleable into adulthood and is shaped by the set of verbs that a person learns. Experiment 2 replicates this finding when the verb is presented in a different syntactic context.

## Experiment 1

Each participant learned twelve new motion verbs. For each novel verb, participants (1) saw a single ambiguous scene with a salient path and manner of motion, (2) were tested to determine their initial interpretation of the verb, (3) saw five additional instances of the new verb which disambiguated its meaning (e.g. five scenes with same manner but a novel path), and finally, (4) were tested again to ensure that they had learned the novel verb.

Critically, the proportion of path and manner verbs was varied across participants. Some participants learned only manner verbs, some learned only path verbs, and others received different proportions of both types. We predicted that our adult participants would have little difficulty learning either the manner or the path verbs. The critical measure was the participants' responses to the initial test trials, which followed the first ambiguous scene. Because a single verb-scene pair is consistent with either a manner or path interpretation, responses to this test sequence reveal the participants' verb lexicalization bias. Since our participants are English speakers, we expect that they will begin with an initial bias to interpret the novel verbs as encoding manner of motion. However, if these estimates of prior probability are updated in response to the verbs that the participant has learned, then responses on the initial test trials should change in response to novel verbs. Thus we predict that over the course of the experiment participants who learn path verbs will develop a path bias, while those who learn manner verbs will retain the manner bias.<sup>2</sup>

## Methods

**Participants** 56 adult native English speakers participated in this study. Since our goal was to determine how previously learned verbs influence the interpretation of future verbs, we eliminated all participants who failed to

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<sup>2</sup> Similar issues have been explored in artificial category learning studies. Critically, Kersten, Goldstone & Schaffert (1998) found that adults who learned manner event categories were more likely to focus on the manner feature of an ambiguous category. They used simple animated events with bug-like agents and no sentential context. These stimuli did not appear to engage participants' prior lexicalization biases: English speakers showed a strong initial path bias. Unlike the present work, the study did not examine generalization after a single ambiguous exemplar.

learn 5 or more of the verbs after viewing the disambiguating scenes. Sixteen participants were excluded for this reason.

**Stimuli** Participants saw short video clips of motion events. Each event depicted an actor moving in a salient manner and in a salient path with respect to some reference object (e.g., a woman walking tip-toe behind a large sign). Twelve manner and twelve path concepts were selected as target verb meanings. Some concepts corresponded to English verbs, some to English prepositions, and some had no monomorphemic English equivalent. The path verb meanings were: *around, between, down, up, in front of, along, in, diagonal to, over, across, and behind*. The manner verb meanings were: *crab-walk, crawl, swirl, flap-walk, hop on 1 foot, hop on 2 feet, march, run, skip, stoop-walk, tiptoe, and walk*.

Participants were presented with a block of questions and videos for each of 12 novel nonce verbs. Each block was identical in layout and was made up of 4 phases: an initial ambiguous scene, an initial bias test, training and a final test phase. An example test block for a manner verb is shown in Table 1 and an example for a path verb is shown in Table 2.

Table 1: Sample block for a novel manner verb.

Target Concept: Crab-Walk	Manner	Path
Ambiguous Scene	Crab-walk	Out
Initial Test: Manner	Crab-walk	Behind
Initial Test: Path	Skip	Out
Training One	Crab-walk	Front
Training Two	Crab-walk	In
Training Three	Crab-walk	Between
Training Four	Crab-walk	Across
Training Five	Crab-walk	Diagonal to
Final Test: Path	March	Out
Final Test: Manner	Crab-Walk	Between

Table 2: Sample block for novel path verb.

Target Concept: Out	Manner	Path
Ambiguous Scene	Crab-walk	Out
Initial Test: Manner	Crab-walk	Behind
Initial Test: Path	Skip	Out
Training One	Hop 2 Feet	Out
Training Two	Walk	Out
Training Three	Run	Out
Training Four	Stoop-walk	Out
Training Five	Dance	Out
Final Test: Path	March	Out
Final Test: Manner	Crab-Walk	Between

In the ambiguous scene, the participant saw a written sentence containing a new nonce verb (e.g. “*She is going to torg out the door.*”) and a video which illustrates the sentence (e.g., a woman crab walking out of the door). The initial test consists of two clips which are presented

sequentially. The participant is asked if clip is an instance of the new verb (“Is this torging?”). One test clip matches the manner of the ambiguous event but not the path; the other matches the path but not the manner. During the training phase, participants are presented with 5 video clips which disambiguate the meaning of the word. If the verb is being taught as a path verb, then all 5 clips will show the same path as the ambiguous training clip but vary in their manner. If the word is being taught as a manner verb, the reverse will be true. The final test parallels the initial test; one video matches the path of the ambiguous clip, the other matches it in manner. This test allows us to determine if the participant has succeeded in learning the verb.

Each manner verb was arbitrarily paired with a path verb. The paired verbs shared the same initial scene and the same test scenes (see Tables 1 & 2). Pairing the items in this way allowed us to examine how participants with different verb learning experiences responded to identical stimuli. The disambiguating videos were different for each member of a pair. Subjects were assigned to one of five conditions which differed in the proportion of the novel verbs that encoded path (0, .25, .50, .75 or 1). The 12 verb pairs were randomly ordered and half of the participants in each condition were tested with the blocks in reverse order.

**Procedure** Stimuli were presented on a computer which using custom software. The participants were told that they would be watching videos that would teach them new words and answering the questions about these words.

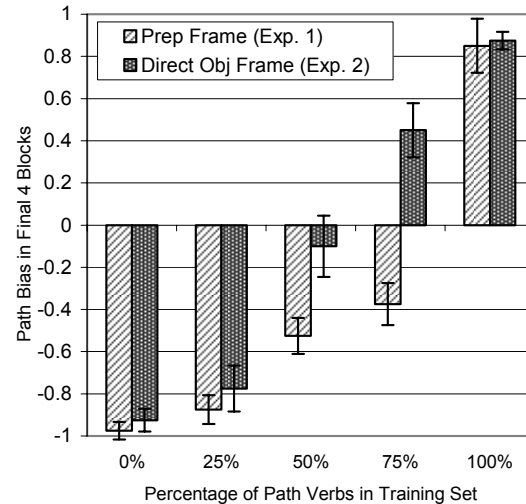


Figure 1: Path Bias on Final Blocks

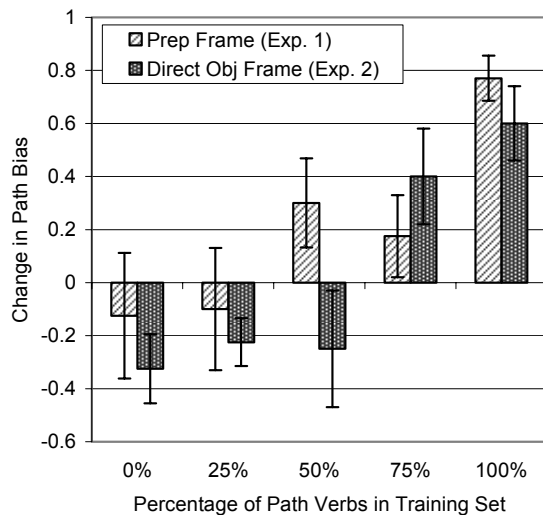
## Results

Responses to the final test questions were used to exclude participants who failed to learn the verbs. Our analyses focused entirely on participants responses in the initial test. To explore how bias changed over time we examined responses to the first four verb blocks and the last four verb blocks. The participants’ responses were converted to path bias scores by taking the proportion of blocks where the subject extended the word to the path match and subtracting the proportion of blocks where they extended the word to

the manner match. This number would equal -1 for a perfect manner bias and 1 for a perfect path bias.

The ANOVA of the first four blocks revealed that these English speaking subjects entered the study with a strong manner bias ( $M = -.58$ ,  $F(1,40) = 145.69$ ,  $p < .001$ ). 76% of the participants responded yes to a manner video while only 5% responded yes to a path video. However, there were also differences between the training condition demonstrating that the verbs in the training set were already beginning to shape participants interpretations of the initial ambiguous scenes ( $F(4,40) = 12.97$ ,  $p < .001$ ). This effect was driven by participants in the 100% Path Verbs Condition who had no systematic bias in these early blocks ( $M = .08$ ).

In the final four blocks of the experiment, the initial bias trials are clearly shaped by the set of verbs that the participant has learned (see Figure 1,  $F(4,40) = 45.14$ ,  $p < .001$ ). Participants in the 100% Path Condition have developed a strong, consistent path bias in their interpretation of new verbs ( $M = .85$ ). Those in the 0% and 25% Path Conditions show an equally clear manner bias ( $M = .98$ ,  $M = .88$ ). In the 50% and 75% Path Conditions participants flout the input, continuing to show a mild preference to interpret the new word as a manner verb.



**Figure 2: Change in Path Bias between the First 4 and Last 4 blocks.**

To further explore how lexicalization biases changed over the course of the experiment, we directly compared the results of the first and final blocks. In Figure 2 this is graphed as the change in path bias. There was a substantial increase in path bias in the final trials ( $F(1,40) = 7.45$ ,  $p < .009$ ) and a reliable interaction between the time in the experiment and the Training Condition ( $F(4,40) = 4.75$ ,  $p < .003$ ). Participants in the 100%, 75% and 50% Conditions showed an increase in path bias, while participants in the 25% and 0% retained or strengthened their manner bias.

### Experiment 2

In Experiment 1, the nonce verbs appeared with prepositional phrase arguments. In English, this syntactic

frame is used more frequently with manner verbs, although it can be used colloquially with path verbs as well (e.g. “*She ran around the tree.*” or “*She circled around the tree.*”). In English path verbs are often used in simple transitive frames (“*She circled the tree.*”) and this usage is typically considered more proper. Naigles and Terrazas (1998) found that both English and Spanish speakers were more likely to interpret novel verbs as encoding manner when syntactic frames with semantically rich prepositions were used. If the participants assume that each component of the motion event is encoded in only one word of the sentence, they may be reluctant to conflate path in the verb when it is already marked in the preposition. In Experiment 2 we used simple transitive sentences to explore whether the syntactic context influenced participants’ initial lexicalization biases or the changes in these biases in response to newly learned words.

### Methods

**Participants** 52 English-speaking adults participated in this study. Responses from 2 participants were excluded because they failed to learn 5 or more target verbs.

**Stimuli, Procedure and Coding** Participants were tested on the same verbs sets as before (100%, 75%, 50%, 25% or 0% Path Verbs). The procedure was identical to Experiment 1 except that verbs were introduced with simple transitive frames. Thus “*He torged down the stairs*” became “*He torged the stairs.*”

### Results

When the novel words were presented in transitive frames, subjects showed only a weak bias in the first four verb blocks ( $M = -.14$ ,  $F(4,40) = 3.56$ ,  $p = .067$ ) which may reflect the early effect of Training Condition on path bias ( $F(4,40) = 6.56$ ,  $p < .001$ ). Participants in the 0% Path Condition show a manner bias ( $M = -.60$ ) while those in the 100% Condition have a path bias ( $M = .28$ ). By the final four verb blocks, participants’ initial interpretations of the new nonce verbs are essentially categorical and closely match the set of words that they have learned ( $F(4,40) = 60.17$ ,  $p < .001$ ). There is a reliable shift in bias between the first and final blocks, which interacts with Training Condition ( $F(4,40) = 21.56$ ,  $p < .000$ ). Participants who learned all path verbs showed an increase in path bias ( $M = .60$ ) while participants who learned all manner verbs showed an increase in manner bias ( $M = -.33$ ). A direct comparison of Experiments 1 and 2 demonstrates that syntactic frame influenced participants’ performance on both the final and first 4 blocks. These differences are limited to the 50% and 75% Path conditions, conditions where subjects are given weak evidence for a lexicalization pattern which differs from the dominant pattern in English.

### General Discussion

These experiments 1) replicate Naigles & Terrazas’ findings that adult speakers of English have a bias to assume that novel verbs encode the manner of motion rather than the path; 2) demonstrate that this lexicalization bias remains

plastic into adulthood; and 3) demonstrate that this lexicalization bias can be influenced by the words that a person learns. English speaking adults who were taught new motion verbs developed lexicalization biases that matched the verbs in their training set. This pattern was observed regardless of whether the ground nominal was presented as the object of a preposition (consistent with a manner verb) or as the direct object of the verb (consistent with a path verb). In the remainder of the discussion we re-examine Gentner's relational relativity hypothesis in the light of these findings and discuss the development of verb lexicalization biases.

### Reexamining Relational Relativity

Gentner's relational relativity hypothesis proposes that the acquisition of verbs is delayed because children must discover how their language packages and categorizes events (1982). Naigles and colleagues have extended this argument by suggesting that efficient verb learning requires the acquisition of language-specific semantic patterns, which we have called lexicalization biases (Naigles & Terrazas, 1998). The current study demonstrates that learners retain a remarkable degree of plasticity in lexicalization biases. They can not only learn verbs which violate the lexicalization pattern of their language; they can actually change their lexicalization biases to reflect the patterns in newly acquired words. These results suggest that verb lexicalization biases are not the result of permanent alterations in conceptual structure or unalterable changes in the semantic interface. Instead these biases appear to be plastic generalizations based on the words the learner has acquired. In essence a lexicalization bias results from a change in the prior probability of a class of hypotheses based on the prior success of hypotheses from that class.

The flexibility of these biases raises questions about the role that they play in potentiating early verb learning. If stable lexicalization patterns are required to repackage relational components into the individuated events, then why do adults have little difficulty in rapidly and spontaneously recombining these components?<sup>3</sup> We would argue that this ability is essential for learning the range of verbs that exist within any one language. While the variability of cross-linguistic encoding of events has received much attention, there is considerable variation in verbs that can be used to describe a single event within a language (Gleitman, 1990). For example, we can refer to an event in which a girl kicks a ball to her mother as *giving*, *passing*, *kicking*, *rolling*, *receiving*, *moving*, *crossing* or *contacting* depending on the components of meaning that we wish to include in the verb or the perspective that we are

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<sup>3</sup> Perhaps that the manner-path distinction is the wrong place to search for stable lexicalization biases, since both manner and path languages have verbs of each type (Ashe, 1989). We challenge the reader to come up with a better example of a systematic lexicalization pattern which applies to a large number of verbs. The explanatory potential of the relational relativity hypothesis depends on the prevalence of this predictable variation.

taking on the scene. In light of such variability, rigid lexicalization biases are likely to be counterproductive. Within language variation in lexicalization also seriously limits the role that these biases can play in constraining word learning, and thus limits the explanatory potential of the relational relativity hypothesis.

If language-specific semantic mappings cannot eliminate the ambiguity inherent in events, then how do children ever become rapid and efficient verb learners? We believe that two factors are at play. First, children may improve in their ability to make use of cross-situational observation. Much of the work in early word learning has focused on what children are able to learn from a single word-scene pair. In the case of nouns it may be possible to make a meaningful conjecture about the meaning of a word on the basis of a single referent. Many of children's early nouns label artifacts and natural kinds. Concepts of these kinds are organized in taxonomic hierarchies, which have multiple levels (animal, mammal, dog, poodle) and categories which are mutually exclusive at a given level (Markman, 1989). This conceptual structure helps bridge the gap between reference and meaning. Once the observer has correctly picked out the referent of an artifact or natural-kind term, then its meaning can be limited to concepts on the path from the individual exemplar up to the top of the hierarchical tree. If there is a conceptually or perceptually privileged basic level, then a single referent might provide enough information to map the word to the correct node of that tree (Rosch et al., 1976; Markman, 1989).

But in the case of verbs, cross-situational observation may be essential. There is little evidence that the concepts encoded in verbs form complex taxonomic hierarchies. Instead most observers have argued that states and events are grouped into semantic fields which are organized as a cross-cutting lattice of concepts rather than as mutually exclusive categories (Talmy, 1985; Behrend, 1995). Identifying a single referent event merely identifies a point in this multi-dimensional conceptual space but it does not tell the observer which dimension(s) of the event are encoded in the verb. Multiple exemplars, however, can be used to rule out the relevance of some dimensions and provide convergent evidence for the importance of others.

Second, children's verb learning also benefits from their increasingly sophisticated representations of the utterances in which new verbs appear. Initially children must learn the meanings of new words by observing the nonlinguistic contexts in which those words are used. This initial information source provides ample support for noun learning but provides inadequate information about meanings of many verbs (see e.g., Snedeker & Gleitman, 2004). More sophisticated learners can use the known words which co-occur with novel verbs to focus their attention on the relevant events. As the child gains knowledge about the syntax of her language, the structural environments in which the verb occurs can also provide increasingly fine-grained information about its meaning

## Examining the Early Development of Verb Lexicalization Biases

Clearly the present experiments cannot rule out the possibility that young language learners have relatively inflexible language-specific lexicalization biases which serve as sharp constraints on children's hypotheses about verb meaning. Furthermore, even plastic and probabilistic biases could provide useful guidance for verb learning. Understanding the role of lexicalization biases in early verb learning clearly requires studying how these biases develop in young children. The limited information that we have about the development of the manner-path bias suggests that this bias may emerge quite late: Hohenstein and Naigles (2000) have found the 3 year old English speakers and Spanish speakers show no differences in their extension of novel motion verbs (both populations prefer to extend the words to events with the same manner of motion). The obvious explanation is that children this age simply lack the ability to derive lexicalization biases from the words they learn. But this seems unlikely in light of Smith and colleagues' finding (2002) that children under two can develop a shape-bias after learning just a handful of exemplars. The alternative explanation is that the verbs that 3-year-olds know simply don't support this generalization. In elicited production tasks English speaking adults show a clear preference for manner, however, speakers of path languages like Greek and Spanish often produce equal numbers of manner and path verbs when describing motion events (Papafragou et al., 2002; Naigles et al., 1998), suggesting that young Spanish speakers may have little evidence for a path lexicalization bias. To determine whether young children can form verb lexicalization biases in response to clear category structure, we are currently testing three- and five-year old children in a modified version of Experiment 1. Our preliminary findings ( $N = 9$ ) suggest that five-year-olds will rapidly form a bias for the dimension which has been relevant on previous trials. Children who are given six path verbs select path as the relevant dimension on 67% of all trials, while those who are given manner verbs do so only 25% of the time ( $p < .05$ ).

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