# Extracting Paths and Manners: Linguistic and Conceptual Biases in the Acquisition of Spatial Language

**Dimitrios Skordos and Anna Papafragou**
**University of Delaware**

## 1. Introduction

It has been established that spatial language emerges quite rapidly in young children and that spatial vocabulary is mapped onto prelinguistic space and motion concepts (Piaget & Inhelder 1956; Bowerman 1978, 1980, 1996; Johnston & Slobin 1979; Gibson & Spelke 1983; Johnston 1984, 1985; Lakoff 1987; Spelke et al. 1992; Clark 1993, 1996; Needham & Baillargeon 1993; Quinn 1994; Baillargeon 1995). This finding together with the fact that spatial language is necessarily constrained by our cognition and the geometry of our environment has led to the expectation that languages around the world would structure spatial semantics in a similar way (Landau & Jackendoff 1993; Bowerman & Choi 1996). However, relatively recent work has shown that a lot of cross-linguistic variation exists in spatial semantics (Talmy 1985; MacLaury 1989; Choi & Bowerman 1991; Brown 1994; Levinson 1994, 1996; Bowerman & Choi 1996; Naigles & Terrazas 1998; Papafragou et al. 2002; Hohenstein, Naigles & Eisenberg, 2004; Papafragou & Selimis 2010). In this paper, we focus on one such area of cross-linguistic variability, the semantics of motion.

Languages analyze motion as the displacement of an object with respect to a reference object. The moving object is simply called "figure", while the reference-object is often referred to as "ground" (Talmy 1975). Languages also possess the means to encode both the path and manner of motion (Talmy 1975; 1985; 1991; 2000; Jackendoff 1990). Path refers to the trajectory of the figure object with respect to the reference object, while manner is used to refer to other attributes of motion like the rhythm, motor patter and rate of motion (Slobin 2004). Here we focus on cross-linguistic differences in how path and manner are encoded. Some languages such as English and Chinese encode manner of motion in the main verb (cf. English *run, swim*) and use a satellite (path modifier) to encode path information (*to the station, into the hole*). Other languages such as Greek and Spanish encode path of motion in the main verb (e.g. Greek *vgeno* 'exit', *diashizo* 'cross') and use additional Path and Manner Modifiers (e.g. in Greek *sto spiti* 'to the house', *trehontas* 'running' respectively).

It has been convincingly shown that adults and older children (around the age of 5) tend to respect these language-specific biases in motion verb encoding

when confronted with novel verbs, conflating the manner or path of motion with the verb according to the typology of their native language (Naigles & Terrazas 1998, Papafragou & Selimis, in press). However it is not yet clear whether 3-year-olds respect these biases. In Hohenstein et al. (2004), for example, both English and Spanish speaking 3 year olds extended novel motion verbs in intransitive frames on the basis of sameness of manner and novel motion verbs in transitive frames on the basis of sameness of path. Additionally, there is some evidence that suggests that children first talk about paths of motion rather than manners cross-linguistically (Choi & Bowerman 1991).

The present studies looked at how lexical (language specific) and structural constraints are used by adults and young children in hypothesizing meanings for motion verbs and how these constraints interact with the non-linguistic categorization of motion scenes. Our fist experiment looked at how language-specific lexicalization biases are used by 3- and 5-year-olds and adults to produce meanings for new motion verbs and how these biases interact with the non-linguistic categorization of motion events. Our second experiment looked at how these biases combine and interact with structural cues, namely transitive syntax, to produce meanings for new motion predicates.

## 2. Experiment 1

### 2.1 Method

#### 2.1.1 Participants

The participants for our first experiment were 60 native Greek speakers and 60 native English speakers. They were organized into three age groups (younger children, roughly 3-year-olds, older children, or 5-year-olds and adults) with ten participants in each group. In the group of Greek speakers, the 3-year-olds were between the ages of 2;4 and 3;8 with a mean age of 3;4, and the 5-year-olds were between the ages of 4;5 and 5;6 with a mean age of 4;9. The children were recruited from daycare centers in Ioannina, Greece. The Greek speaking adults were college students recruited from the University of Ioannina, who volunteered to participate. All Greek data were collected in Greece by Greek native speakers, who also did the coding.

In the group of English participants, the 3-year-olds were between the ages of 2;6 and 3;9 with a mean age of 3;2, and the 5-year-olds were between the ages of 4;6 and 5;6 with a mean age of 5;0. The children were recruited from daycare centers in Newark, DE. The English speaking adults were college students recruited from the University of Delaware, who received course credit for their participation.

#### 2.1.2 Materials

Our stimuli consisted of a series of 9 pairs of animated clips depicting fish performing simple motion events. (An additional set of 3 pairs was included but will not be discussed here for brevity.) In the first clip of each pair, Teacher Fish

flipped once forwards while moving through a barrel. Little student fish were watching. In the second clip of each pair, a student fish tried to imitate the teacher with varying degrees of success. The movements of the student fish crossed one of 3 manners of motion (flipping, bobbing or dancing) with one of 3 trajectories (through, over and under) to give us a total of 9 trials (see Table 1). See Figure 1 for examples:

**Table 1- List of trials by manner/path combinations. The plus sign shows which component, if any, of the original event was preserved; the minus sign shows which component, if any, was removed.**

| | ***through*** | ***over*** | ***under*** |
|---|---|---|---|
| ***flipping*** | +manner+path | +manner-path | +manner-path |
| ***bobbing*** | manner+path | -manner-path | -manner-path |
| ***dancing*** | -manner+path | -manner-path | -manner-path |

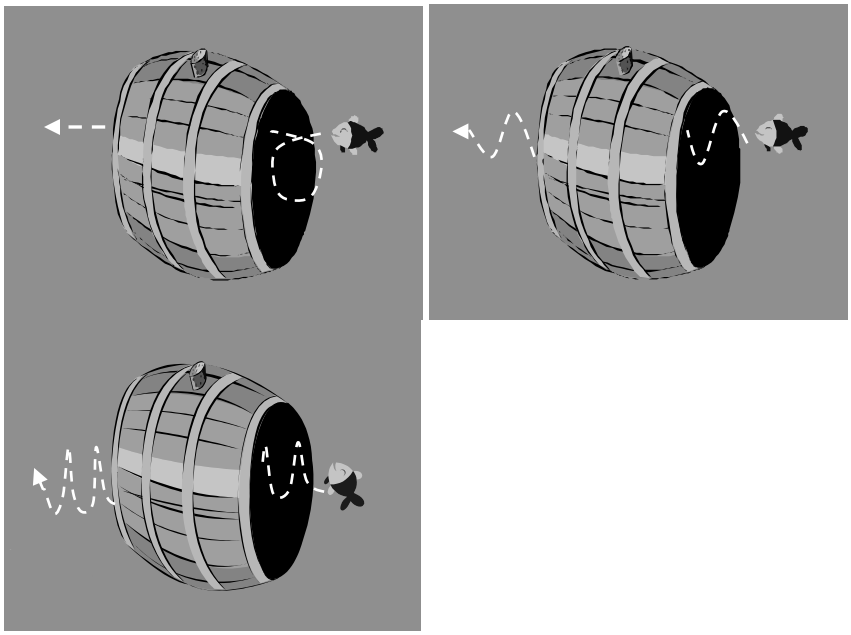

**Figure 1- Examples of the 3 manners (flipping, bobbing, dancing) combined with the 'through' path.**

Materials were arranged in 10 pseudo-randomized lists, one for each subject per experimental condition.

### 2.1.3 Procedure

While seeing an introductory screen the participants heard the following script: "Teacher Fish is taking her class to play in the ocean. She wants to show her students new fish-tricks today. After swimming in the seaweed for a while she finds a nice barrel! I am going to describe what Teacher Fish is doing in fish language, which is the same as English apart from a few words…" After being read the script, the participants were shown the series of 9 pairs of animated clips. There were two between subjects' conditions: In the Intransitive Verb condition, subjects heard: "Look! Teacher Fish is acorping!" during the first clip of each pair and **"**Is the little Fish acorping, or not?" during the second clip. In the Non-linguistic condition subjects heard: "Look! Look what Teacher Fish is doing!" during the first clip of each pair, and "Is the little fish doing the same, or not?" during the second clip. Below you can see the Greek equivalents with the corresponding glosses:

(1)

| | | | | | | |
|---|---|---|---|---|---|---|
| *Kita!* | *I* | *Daskala* | *psari* | *feni!* | | |
| Look! | (The) | Teacher | Fish | is acorping! | | |
| *To* | *mikro* | *psaraki* | *feni* | *i* | *oxi?* | |
| (the) | little | fish | is acorping | or | not? | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *Kita!* | *Kita* | *ti* | *kani* | *i* | *Daskala* | *Psari!* | |
| Look! | Look | what | (is)doing | (the) | Teacher | Fish! | |
| *To* | *mikro* | *psaraki* | *kani* | *to* | *idio* | *i* | *oxi?* |
| The | little | fish | (is) doing | the | same | or | not? |

The subjects were expected to answer either "Yes" or "No" after each trial according to the generalization they had made about the novel term with regard to the motion scene.

### 2.2 Predictions

For the Intransitive Verb condition we expected that language-specific lexicalization biases should guide English speakers towards more manner interpretations and Greek speakers towards more path interpretations. It is not

clear whether 3-year olds would follow a similar pattern, or not. In the Non-linguistic condition, if language does not affect spatial cognition, then the absence of linguistic biases should leave subjects free to generalize according to conceptual preferences - no difference is predicted between English and Greek speakers, or children and adults. Alternatively, if language does affect spatial cognition, then we expect English speakers to generalize more on the basis of manner, and Greek speakers to generalize more on the basis of path. Children are more likely to be similar to each other across language groups, to the extent that lexicalization biases have not been acquired yet. If language specific lexicalization biases have been already acquired, then we expect them to be more adult-like.

### 2.3 Results and Discussion

Overall, our participants correctly gave "*No"* responses when neither the Path nor the Manner component of the original was preserved (M = .97) and "*Yes*" responses when both components were preserved (M = .97). For the remaining trials, we calculated the Path-bias score as the percentage of "*Yes"* responses in +path-manner trials of Table 1 (trials in which only the path of the original clip was preserved) minus the percentage of "*Yes"* responses in -path+manner trials (trials in which only the manner of the original clip was preserved). A score of +1 would indicate an absolute Path bias, while a score of -1 an absolute Manner bias.

Results are presented in Figure 2. An analysis of variance with Path bias score as the dependent variable and Age and Language as factors was conducted for each condition separately. For the Non-linguistic condition we found a main effect of Age ($F(2, 54) = 4.03$, $p = .02$), with 5 year olds more likely to show a Path bias than either 3 year olds or adults ($p<.05$). There was no effect of Language or any interactions with Language. For the Intransitive Verb condition we found a main effect of Age ($F(2, 54) = 4.8$, $p = .01$), with 3 year olds more likely to show a Path bias than either 5 year olds or adults ($p<.05$), and a main effect of Language ($F(1, 54) = 13.17$, $p = .0006$), with the Path bias being significantly stronger in Greek. An analysis comparing the two conditions found effects of Age ($F(2, 108) = 7.08$, $p = .01$), Language ($F(1, 108) = 6.69$, $p = .001$), and a Language by Condition interaction ($F(1, 54) = 8.84$, $p = .0036$), with the Intransitive Verb condition making the Path bias stronger only for Greek speakers.

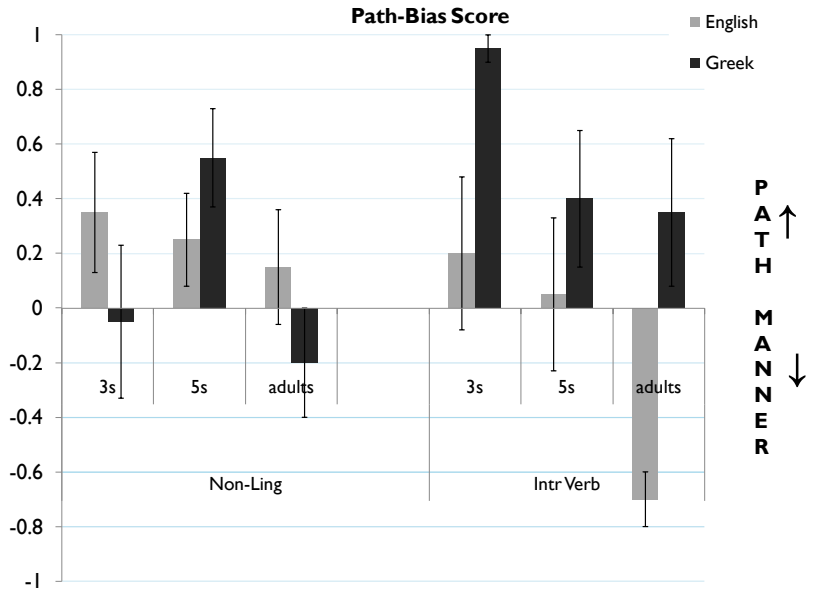


**Figure 2- Non-linguistic and Intransitive Verb Conditions**

We conclude that lexical cues have an effect on adults', 5-year olds' and 3-year olds' conjectures about the meaning of novel motion verbs: as expected, the Greek speakers were in general more path-oriented, while, in English, at least the adult speakers were more-manner oriented (as Fig.2 shows, English-speaking children appeared to be neutral between path and manner interpretations). Interestingly, the non-linguistic categorization of motion does not seem to vary between languages: as the comparison between the two conditions showed, the introduction of a bare (intransitive) verb shifted the responses of the Greek but not the English speakers towards more path interpretations, in accordance with the motion verb biases of each language.

## 3. Experiment 2

We next turn to the question of how lexical biases combine with structural cues in the interpretation of novel motion verbs. Children and adults have been shown to discover crucial components of a predicate's meaning from syntactic information (Landau & Gleitman 1985; Gillette, Gleitman, Gleitman & Lederer, 1999). Transitive verb frames affect adults' conjectures about motion verb meaning and they have been found to interact with lexical biases (Naigles & Terrazas 1998; Papafragou & Selimis, in press). Here we ask how the biases we discovered in experiment 1 combine with structural cues such as transitivity in both children and adults speaking different languages.

Prepositions are also transitive predicates, encoding relational content. We know that prepositional phrases with novel locative prepositions lead to geometric interpretations in both infants and older children (Landau & Stecker 1990; Fisher, Klinger & Song 2006). Here we ask whether novel prepositions in transitive frames are interpreted as path-oriented, and whether these conjectures are affected by the subjects' native language.

### 3.1 Method

#### 3.1.1 Participants

For our second experiment the participants were 60 native Greek speakers and 60 native English speakers. They were again organized into three age groups (3-year-olds, 5-year-olds and adults) with ten participants in each group. In the group of Greek speakers, the 3-year-olds were between the ages of 2;8 and 3;7 with a mean age of 3;2, and the 5-year-olds were between the ages of 4;2 and 5;4 with a mean age of 4;10. The children were recruited from daycare centers in Ioannina, Greece. The Greek speaking adults were college students recruited from the University of Ioannina, who volunteered to participate. All Greek data were collected in Greece by Greek native speakers, who also did the coding.

In the group of English participants the 3-year-olds were between the ages of 2;6 and 3;8 with a mean age of 3;2, and the 5-year-olds were between the ages of 4;7 and 5;6 with a mean age of 5;0. The children were recruited from daycare centers in Newark, DE. The English speaking adults were college students recruited from the University of Delaware, who received course credit for their participation.

#### 3.1.2 Materials

Our materials for experiment 2 were identical to those of experiment 1.

#### 3.1.3 Procedure

The procedure followed for experiment 2 was identical to that followed for experiment 1 but there were two new between subjects' conditions: In the Transitive Verb condition, subjects heard: "Look! Teacher Fish is acorping the barrel!" (first clip of each pair) and "Is the little Fish acorping the barrel, or not?" (second clip). In the Preposition condition, subjects heard: "Look! Teacher Fish is going acorp the barrel!" (first clip) and "Is the little Fish going acorp the barrel, or not?" (second clip). Below we present the Greek equivalents with the corresponding glosses:

(2)

| | | | | | | |
|---|---|---|---|---|---|---|
| *Kita!* | *I* | *Daskala* | *psari* | *feni* | *to* | *vareli* |
| Look! | (The) | Teacher | fish | is acorping | the | barrel. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *To* | *mikro* | *psaraki* | *feni* | *to* | *vareli* | *i* | *oxi?* |
| The | little | fish | is acorping | the | barrel | or | not? |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| *Kita!* | *I* | *Daskala* | *psari* | *pai* | *fena* | *apo* | *to* | *vareli!* |
| Look! | (The) | Teacher | fish | (is)going | acorp | (from) | the | barrel! |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *To* | *mikro* | *psaraki* | *pai* | *fena* | *apo* | *to* | *vareli* | *i* | *oxi?* |
| The | little | fish | (is)going | acorp | (from) | the | barrel | or | not? |

### 3.2 Predictions

For the Transitive Verb condition we predicted that transitive syntax should overcome language specific lexicalization biases and guide both English and Greek speakers towards more path interpretations. Since structural cues seem to be available from early on, children were also expected to generalize more according to path. For the Preposition condition we expected that the fact that prepositions are transitive predicates encoding relational content should lead subjects to path interpretations for both English and Greek. Again no difference was predicted between children and adults.

### 3.3 Results and Discussion

Once more, our participants correctly gave "*No"* responses when neither the Path nor the Manner component of the original was preserved (M = .95) and "*Yes"* responses when both components were preserved (M = .97). We calculated a Path bias score, as in the previous experiment, for all test trials. Results are presented in Figure 3.

We conducted an analysis of variance for each condition using Path Bias as the dependent variable and Age and Language as factors. In the Transitive Verb condition we found no effects of Language, or Age, or any interactions. Inspection of Figure 3 reveals that, in this condition, there is a clear overall Path bias. In the Preposition condition, the ANOVA yielded a main effect of Age ($F(2, 54) = 4.7$, $p = .01$), with 3-year-olds and 5-year-olds more likely to show a Path bias than adults ($p<.05$). As shown in Figure 3, there is again a clear Path bias in this condition.

In a further analysis, we compared the Transitive Verb condition with the Intransitive Verb condition from Experiment 1. We found a Language by Condition interaction, with the Transitive Verb condition making the Path bias stronger only in English ($F(1, 54) = 9.72$, $p = .0023$).

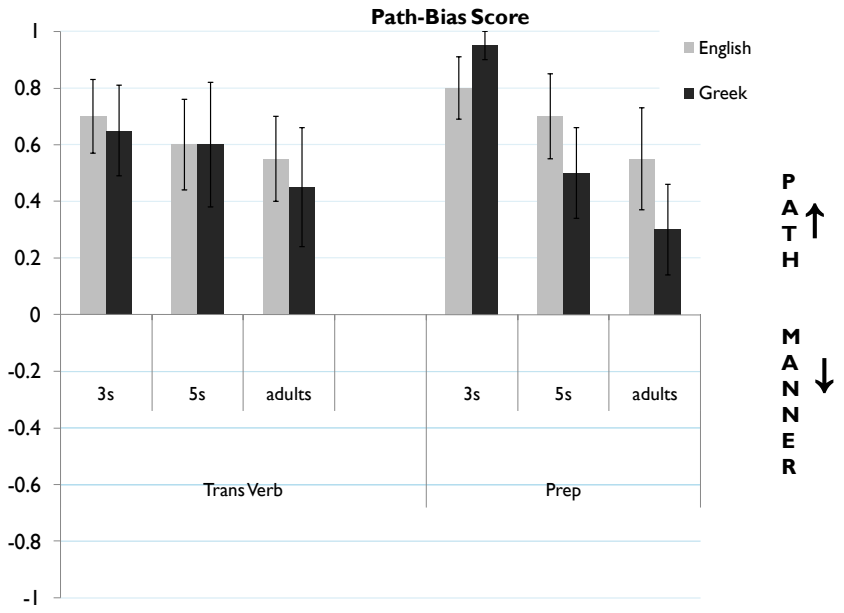


**Figure 3-Transitive Verb and Preposition Conditions**

In sum, transitivity, either in verb syntax or in prepositional phrases, creates a strong bias towards relational or path interpretations. This is true for both English and Greek and it seems to apply to both adults and young children. The structural cue of transitivity overcomes verb lexicalization biases in English speaking adults and the relative lack of a bias in English speaking children, making them more likely to generalize according to path when presented with a transitive verb frame compared to an intransitive verb frame. In Greek we observe no real difference, possibly because Greek speakers are already path oriented.

## 4. General Discussion

Our study led to several major findings. First, both language-specific motion lexicalization biases and structural cues affect conjectures for novel motion predicates – even though the potency of lexicalization biases seems restricted in English. Specifically, a path lexicalization bias surfaces clearly in Greek speakers' conjectures about new motion verbs when these are presented

intransitively. Unlike prior work (e.g., Hohenstein et al. 2004), we found evidence that the bias is already in place in Greek-speaking 3-year-olds (and persists in 5-year-olds and adults). By contrast, English-speaking 3-year-olds and 5-year-olds do not show the expected manner lexicalization bias, although their judgments still contrast sharply with those of their Greek peers, which are clearly path-biased. The manner bias does emerge clearly in the group of English-speaking adults. Why should young English learners fail to exhibit a manner preference? One possibility is that the motion verb vocabulary of these learners is not dominated by manner verbs, as is the case for adults, and so the grounds for a manner bias are absent. However, this possibility is unsupported by production data showing that manner verbs appear early and are used productively in English (e.g. Papafragou & Selimis 2010). Another possibility is that the manner bias requires a longer and more nuanced set of manner verbs to serve as its basis compared to the path bias – and thus might take longer to develop. This possibility, however, is at odds with recent results (Papafragou & Selimis in press) suggesting that, at least when given a choice between path and manner conjectures for novel verbs, English-speaking 5-year-olds do demonstrate a manner bias. We are currently investigating whether methodological differences between the present and prior studies might be responsible for the lack of a manner bias in the present data from English-speaking children.

Second, structure interacts with and overcomes language-specific lexical biases (or the lack thereof). In English, transitive verb syntax encourages path interpretations. This is especially striking for 3-year-olds who have not yet acquired path verbs such as *enter* or *exit* in English (Papafragou & Selimis, in press), but are led by the syntax to hypothesize the existence of such verbs in their language. In Greek, where there is no conflict between the motion verb lexicalization bias and transitivity, transitive frames do not seem to boost the path bias for novel verbs. Transitivity also promotes path interpretations for novel prepositions. Finally, we observed no real differences in motion event categorization between language groups in the absence of linguistic cues. Lexical means of encoding motion do not seem to percolate into the conceptual representation of motion events. We take this as evidence for shared and possibly universal biases in approaching motion events.

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