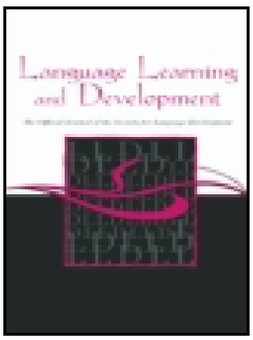

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Lexical and Structural Biases in the Acquisition of Motion Verbs

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It is well known that languages differ in how they encode motion. Languages such as English use verbs that communicate the manner of motion (e.g., *climb*, *float*), while languages such as Greek often encode the path of motion in verbs (e.g., *advance*, *exit*). In two studies with English- and Greek-speaking adults and five year olds, we ask how such lexical constraints are used in combination with structural cues in hypothesizing meanings for novel motion verbs cross-linguistically. We show that lexicalization biases affect the interpretations of motion verbs in both young children and adults across different languages; furthermore, their scope of application is larger than previously thought, since they also extend to the domain of caused motion events. Crucially, we find that the language-specific effects of such biases interact with universal mappings between syntactic structure and semantic content. Finally, we demonstrate that the combined effects of lexical and structural cues shift nonlinguistic biases observed during event categorization: even though speakers of English and Greek share nonlinguistic preferences in categorizing spontaneous and caused motion, they focus on different components of motion events when building hypotheses about the meaning of novel motion verbs.

1. INTRODUCTION

One of the most vexing tasks facing the young language learner is acquiring the meaning of verbs. In approaching this problem, the learner has to collect and organize complex observations about event referents across multiple situations (Behrend, 1990; Forbes & Farrar, 1995; Gentner, 1978; Gropen, Pinker, Hollander, & Goldberg, 1991; Kersten & Smith, 2002; Mandler, 1996) and combine such observational evidence with lexical (Berman & Slobin, 1994) and structural (Brown, 1957; Fisher, 1996; Gleitman, 1990; Landau & Gleitman, 1985; Naigles, 1990; Pinker, 1989) properties of linguistic stimuli to build hypotheses about verb interpretation.

An important source of information about verb meanings is knowledge of form-meaning mappings that are specific to the child's native language. Since languages differ in how they

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segment and package even the simplest and most 'natural' events, such knowledge can be useful in narrowing interpretations for new words. For instance, languages differ in terms of the elements of a motion event they prefer to lexicalize in verbs (Allen, Özyürek, Kita, Brown, Furman, Ishizuka, & Fujii, 2007; Berman & Slobin, 1994; Choi & Bowerman, 1991; Hickmann, 2003; Naigles, Eisenberg, Kako, Highter, & McGraw, 1998; Özçalışkan & Slobin, 1999, 2003; Papafragou, Massey, & Gleitman, 2002, 2005, 2006; Selimis, 2007; Selimis & Katis, 2003; Slobin 1996a, 1996b, 1997, 2003; Talmy, 1985, 1991). English and other *Manner* languages (e.g., German, Russian) encode manner information in the main verb (*Mary jumped*. . .) and path information in further modifiers (*to the window*). Greek, Spanish, and other *Path* languages often encode path information in the main verb (Greek *I Maria pige sto parathiro 'Det Mary went to-Det window'*) and may delegate manner information in a modifier (*pidontas* 'jumping'). These verb lexicalization biases affect the way novel motion verbs are acquired cross-linguistically. In one study, after watching a simple motion event (e.g., a woman skipping towards a tree) and hearing a nonsense verb describing the event, Spanish-speaking adults preferred path and English-speaking adults preferred manner interpretations of the new verb (Naigles & Terrazas, 1998, Exp. 2; cf. also Cifuentes-Férez & Gentner, 2006).

Interestingly, the same study found that motion verb interpretations in both language groups were also affected by semantic constraints placed by the syntactic frame that the novel verb appeared in: transitive frames with NP-direct objects (*She's kradding the tree*) elicited more path interpretations, whereas intransitive frames with directional modifiers (*She's kradding towards the tree*) elicited more manner interpretations across both languages (Naigles & Terrazas, 1998). Perhaps most strikingly, lexical preferences interacted with frame information. Specifically, when the semantic implications of a frame agreed with a language's lexical conflation patterns, speakers were consistent in following the demands of the frame: English speakers presented with intransitive-with-directional modifier (or 'manner') frames offered predominantly manner choices; Spanish speakers presented with transitive (or 'path') frames offered predominantly path choices. In contrast, when the semantic implications of the frames were inconsistent with a language's conflation patterns (transitive/'path' frames for English, intransitive-with-directional modifier/'manner' frames for Spanish), speakers were ambivalent and less consistent in their choices.

Our goal in this paper is to consider more closely the nature, scope, and potential usefulness of verb lexicalization biases for verb acquisition, focusing on the domain of motion. One question that is raised by earlier findings is how early these biases emerge. Hohenstein, Naigles, and Eisenberg (2004) and Hohenstein (2005) have shown that verb lexicalization preferences are already emerging at the age of 7 in English- and Spanish-speaking children. However, they found no evidence of such language-specific biases in younger children: according to Hohenstein et al. (2004), both English- and Spanish-speaking 3 year olds extend novel motion verbs on the basis of sameness of manner of motion if the verbs are presented in an intransitive frame with a source or goal PP but prefer path interpretations for verbs embedded in transitive frames. The problem does not seem to lie with learners' ability to form lexical-semantic biases: we know that children below the age of 3 are able to form generalizations about word extensions on the basis of a few exemplars in laboratory settings (Smith, Jones, Landau, Gershkoff-Stowe, & Samuelson, 2002). It could be, therefore, that the limited repertory of verbs 3 year olds know simply does not support such lexicalization biases (see Havasi & Snedeker, 2004). At this point, it is an open question whether different methods might reveal the presence of verb lexicalization biases in children

below the age of 7 and, if so, how tightly coupled these biases are with the internal composition of the verb lexicon.

A separate (but related) question is whether the observed lexicalization patterns generalize beyond the class of (spontaneous) motion verbs to caused motion verbs. Consider a complex event where an agent brings about a change of state/result in an object by interacting with it in a certain way: for instance, a girl kicking a ball into a basket. A novel transitive verb describing the event (*The girl is V-ing the ball*) could describe either the Means subevent (the kicking action) or the Result subevent (the sending-into-the-basket outcome). The Means-Result distinction is related to the Manner-Path distinction for spontaneous motion: both distinctions refer to the How vs. the Where To of an event (for full discussion, see section 1.1 below). Furthermore, both distinctions raise similar perspective-taking problems for the learner: given two simultaneously present aspects of an event in the extra-linguistic context, the learner needs to decide which one is a better candidate for the meaning of a novel verb. Given their underlying semantic similarities, it is reasonable to hypothesize that the lexical bias we find for spontaneous motion events might generalize to the much broader class of caused motion events cross-linguistically. If so, this bias might be implicated in the acquisition of caused motion (or action) vocabulary more broadly (with motion being one subtype of action; see Talmy, 1991).

Language-specific biases in encoding aspects of caused motion, if they exist, are expected to interact with the semantic implications of transitivity. We know that novel verbs in transitive frames are predominantly interpreted as Result-oriented rather than Means-oriented. This is because there is a tight connection between transitivity and causativity across languages (Bowerman, 1989; Slobin, 1985), and Result but not Means verbs incorporate a causative component (in our earlier example, *The girl is sending the ball* means that the girl is causing the ball to go somewhere, but *The girl is kicking the ball* encodes no causation; Carter, 1976; Dowty, 1979; Jackendoff, 1990; Levin & Rappaport-Hovav, 1995). This bias for Result/causative interpretations of novel transitive verbs has been observed in verb learning studies with English-speaking children (Behrend, 1990; Forbes & Farrar, 1993, 1995; Gropen et al., 1991; cf. also Behrend, Harris, & Cartwright, 1995; Gentner, 1978) and is known to exist already at the age of 2 (Naigles, 1996; Naigles & Kako, 1993; Bunger & Lidz, 2007). The question is whether this bias might turn out to be even stronger in learners of languages which are less consistent in lexicalizing Means information in the main verb.

In the studies that follow, we compare the way English- and Greek-speaking 5-year-old children and adults approach spontaneous (Exp. 1) and caused (Exp. 2) motion events in situations where they either have to describe these events or learn a novel verb that refers to them. Our general goal is to look at how the lexical form and syntactic environment of a newly encountered motion verb are recorded to yield language-specific meaning conjectures. We expect children (and adults) in verb learning contexts to weigh event components such as manner and path or means and result of motion differentially depending on whether their native language tends to encode the corresponding meaning elements in the main verb or not. More specifically, we expect manner (and means) conjectures in English speakers to be more numerous than in Greek speakers. Furthermore, we expect these lexical preferences to combine with the semantic implications of the syntactic frames (intransitive vs. transitive) in which these verbs appear. Crucially, language-internal (lexical and structural) cues should lead to different conjectures about the meaning of novel verbs describing motion events in the two languages even if native speakers of English and Greek share underlying preferences for categorizing those same motion events nonlinguistically.

1.1. Spontaneous and Caused Motion Verbs

In this section, we take a closer look at the encoding of spontaneous versus caused motion events. Our goal is to motivate the claim that the Manner/Path verb distinction in the spontaneous motion domain is related to the Means/Result verb distinction in the caused motion domain.

Beginning with the Manner-Means dimension, both (intransitive) verbs of spontaneous motion such as *run, dance,* and *swim* and (transitive) verbs of motion such as *kick, shove,* and *push* have the underlying semantic representation in (1) (after Levin, 2008):

(1) [x ACT $_{<MANNER>}$]

In this representation, Manner modifies the action denoted by the verb (and, being a modifier rather than an argument of ACT, it is indicated in a subscript). For purposes of this paper, we will restrict the term *Manner* to intransitive/spontaneous motion verbs, and we will use *Means* to refer to transitive motion verbs (even though both types of verb include a Manner component in their semantic representation).[1]

Turning to the Path-Result dimension, there is a relationship between (mostly intransitive) verbs of spontaneous motion along a path such as *ascend, descend,* and *enter* and (transitive) Result verbs denoting caused motion such as *put*, *lower,* and *transfer* (or Result verbs denoting caused change of state more broadly such as *open* and *clean*). Some researchers take spontaneous path traversal verbs to be a type of Result verb (Levin & Rappoport Hovav, 1992) or subsume both under the rubric "directed change" verbs (Levin & Rappoport Hovav, 1995). To illustrate the reasoning behind this kind of proposal, consider the standard representation of Result verb meanings in the literature which is given in (2) (see Levin, 2008):

(2) [[x ACT] CAUSE [y BECOME <*RESULT-STATE*>]]

According to this representation, a Result verb such as *clean* or *lower* indicates that an agent brings about a certain change of state or change of location of an object by acting on it. (Notice that the Result-State has the status of an argument, rather than a modifier, in the representation in (2).) Path verbs of spontaneous motion such as *ascend, descend,* and *enter* lack the causative component in (2) but share the change-of-state aspect of the schema in (2). More specifically, a verb such as *enter* denotes a change of state undergone by the subject, such that the resulting state of the subject is *in* the reference object; a verb such as *ascend* also denotes a change of state that has to do with height. More generally, verbs denoting path traversal (and hence change of location) are semantically related to verbs denoting result (and hence change of state), since location can be considered a type of state.

It is possible to be more precise about the similarity between the Manner/(directed) Path and the Means/Result distinction by considering the type of change encoded by the corresponding predicates (see Levin, 2008, for details of this proposal). Briefly, both Path and Result verbs

[1]Additional support for the underlying semantic similarity between Manner and Means verbs comes from the fact that, at least in English and Greek, the two types of verb seem to have similar distribution: in English, such verbs can appear in resultative frames denoting culminated action (e.g., *The ball rolled into the basket, She kicked the ball into the basket*) but in Greek, such constructions have limited acceptability (see Horrocks & Stavrou, 2007; Giannakidou & Merchant, 1999; Snyder, 2005; Markantonatou & Trapalis, 2003). This fact restricts the frequency of Manner/Means verbs in Greek, since speakers need to switch to a different type of verb in resultative frames (e.g., the equivalent of *The ball went into the basket; She sent the ball into the basket*).

denote scalar change, that is, change in an entity defined in terms of a set of degrees ordered along a particular dimension. For instance, the Path verb *ascend* denotes a scale of increasing values on a dimension of height; the Result verb *clean* denotes a scale of increasing values on a dimension of cleanliness. Some of the scales associated with Path/Result verbs are multiple-point scales (e.g., *ascend, clean*) while others are two-point scales (e.g., *arrive, crack;* Beavers, in press). By contrast, verbs encoding Manner/Means encode nonscalar change, since the relevant change lacks an ordering relation and is typically complex, involving many dimensions at once (e.g., *jog, push*). On this analysis, then, (directed) Path verbs are a subtype of Result verbs and differ from Manner/Means verbs in core aspects of their internal semantic structure.

If, as we have argued, Manner/Path verbs in the spontaneous motion domain are akin to Means/Result verbs in the caused motion (or action) domain, lexicalization biases that have been shown to characterize the domain of spontaneous motion might have counterparts in the domain of caused motion (or more generally, caused action). We pursue this hypothesis in the experimental part of the paper.

2. EXPERIMENT 1: INTRANSITIVE (SPONTANEOUS MOTION) VERBS

In our first study, we compared construals of novel intransitive motion verbs offered by native speakers of Greek and English (adults and 5 year olds). Inspired by earlier studies examining the role of lexical biases cross-linguistically (Naigles & Terrazas, 1998; Hohenstein et al., 2004; Hohenstein, 2005), we sought to extend evidence for the role of such biases in verb interpretations and test whether lexicalization effects could be observed in young children. We also sought to examine the relationship between cross-linguistic conjectures for novel motion verbs and the availability of lexical resources for encoding manner and path information in both the adult and the child vocabulary across the two languages.

To ensure that any English-Greek differences in the present study would not be due to nonlinguistic salience factors, we used a set of stimuli and presentation conditions that had elicited similar categorization preferences from both English and Greek speakers in a prior experiment (Papafragou & Selimis, 2010, Exp. 2). In our earlier study, a group of adults and 5 year olds were shown a motion event that consisted of an agent moving in a salient manner along a path. They were next shown two other events, one of which preserved the manner of the original motion and the other the path, and were asked to indicate whether they saw ‘the same’, and if so, where. In that task, English and Greek speakers in both age groups predominantly (60% or more of the time) chose events that preserved the path of the original motion (those path preferences were significantly different from those predicted by chance). The question of interest now was whether, despite these shared nonlinguistic preferences, speakers of the two languages would diverge in their interpretive patterns when presented with sentences containing motion verbs for these very same events.

2.1. Participants

Participants were randomly assigned to either a Verb Learning or a Production task. Participants in the Verb Learning task consisted of 10 Greek-speaking children between 4;1 and 5;10 years (mean age 5;1), 10 English-speaking children between 4;7 and 5;8 years (mean age 5;0), and 10 adults

from each language. An additional 10 Greek-speaking children between 4;5 and 5;10 years (mean age 5;3) and 10 English-speaking children between 4;5 and 5;7 years (mean age 4;9), together with 12 Greek-speaking and 10 English-speaking adults participated in the Production task. Children were recruited from daycares at Newark, Delaware (United States) and Northern Evia (Greece). Adults were mostly drawn from the undergraduate populations of the University of Delaware and the University of Athens (Greece).

2.2. Method

2.2.1. Materials. Stimuli consisted of 48 short silent animated motion clips in PowerPoint 2003 format organized in 16 triads (see Table 1; cf. also Papafragou & Selimis, 2010). Each triad consisted of a sample event and two variants. Sample events depicted entities spontaneously moving along a path in a certain manner (e.g., a ball bouncing to a box). Both path and manner components were salient in these events. Each of the variants presented a specific change to the original event. In the Same-Path variant, the manner of movement was changed whereas path

TABLE 1
Stimuli for Experiment 1

Sample	*Same Manner*	*Same Path*
1. A ball is bouncing to a box.	. . .bouncing past a box.	. . .rolling to a box.
2. An eagle is flying and passing over a cage.	. . .flying and passing by a cage.	. . .zooming over a cage.
3. Two balloons are floating up to the sun.	. . .floating down to a tent.	. . .spinning up to the sun.
4. A dog is walking and ends up behind a tree.	. . .walking to his house.	. . .jumping and ends up behind a tree.
5. A water lily is floating across a river.	. . .floating along a river.	. . .swirling across a river.
6. A bottle is floating down to the bottom of the sea.	. . .floating up to the surface of the sea.	. . .spinning down to the bottom of the sea.
7. A duck is ice-skating across a ring.	. . .ice-skating around a ring.	. . .roller-blading across a ring.
8. A leaf is spinning away from a tree.	. . .spinning down from a tree.	. . .blown away from a tree.
9. A bee is flying to a flower.	. . .flying up to a beehive.	. . .walking to a flower.
10. A horse is running and ends up behind a fence.	. . .running past a fence.	. . .galloping and ends up behind a fence.
11. A frog is jumping in front of a rock.	. . .jumping on top of a rock.	. . .hopping in front of a rock.
12. A turtle is swimming out of a cave.	. . .swimming over to the other side of a cave.	. . .jumping out of a cave.
13. A bottle is floating from a cave to a boat.	. . .floating from a boat to a cave.	. . .bobbing from a cave to a boat.
14. A guy with a parachute is going off a plane.	. . .is going up to a plane.	. . .zigzagging down off a plane.
15. A snowball is rolling down a hill and onto a bush.	. . .rolling down a hill and into a bush.	. . .bouncing down a hill and onto a bush.
16. A flower is swirling around a house.	. . .swirling past the house.	. . .blown around the house.

was kept the same (the ball rolled to the box). In the Same-Manner variant, the path was changed whereas manner remained the same (the ball bounced past the box). Half the triads involved animate and the other half inanimate agents.

2.2.2. Procedure. In the Production condition, the motion stimuli were presented on two identical laptop computers placed next to each other. Participants watched the sample event and the two variants (one on the screen on the left and one on the screen on the right) and were asked to describe all events. Their responses were tape recorded.

In the Verb Learning condition, children were introduced to a puppet who enjoyed describing the clips using strange words. They were asked to help the experimenter understand what the puppet meant. Children then watched each sample event play twice, once on the screen on the left and once on the screen on the right. While the sample event was playing, the puppet described the scene with a novel, 'mystery' verb (e.g., English *Look! The ball is gorping!*; Greek *Kita! I bala tili!*). The sentence was repeated while the sample played a second time. Then participants watched the two variants, one on the left and the other on the right screen. While watching the variants, children were asked: *Do you see the ball gorping now? On which screen?* (English)/ *Tora vlepis oti i bala tili? Se pia othoni?* (Greek).[2] Participants had to pick the scene that could best be described by the same 'mystery' word. For adults, the procedure was the same, but the experimenter rather than a puppet offered the 'mystery' words.

In detail, the presentation sequence for each Verb Learning triad was as follows:

a. Sample event shown on the left screen (the right screen is black).
b. Sample event replayed on the right screen (the left screen is black).
c. Both screens are black.
d. First alternate shown on the left screen (the right screen is black). The last frame of the event freezes on screen.
e. Second alternate shown on the right screen. At the end, the last frame freezes on screen.

'Mystery' verbs were two-syllable forms with English verb morphology (present progressive) for the English part of the experiment and two-syllable forms with Greek verb morphology (e.g., third-person/plural present with imperfective/progressive aspect) and stress on the first syllable for the Greek part. All verbs were designed so as not to resemble existing verbs in the two languages (English: *glorp, krad, blick, zick, nib, gorp, rog, kleb, wug, gort, gnare, kurp, stort, fliff, rolt, kenn*; Greek: *tilo, zerko, levro, difo, klavro, tsoklo, kluto, rozo, hrumo, brelo, thopo, rapo, samo, matro, lago, kardo*).

We included a practice triad in the beginning of each session that did not involve pure motion/ displacement events but showed a man manipulating a box. Three Greek-speaking and two English-speaking children who did not pass the practice triad were replaced.

Participants were tested individually in a single session. Screen allocation (left-right) for Same-Path and Same-Manner variants was counterbalanced for each participant, with the constraint that, on consecutive trials, variants playing on the same screen were never of the same type (i.e., Same-Path or Same-Manner). Order of presentation of the triads was counterbalanced within each task.

[2]We chose *oti*-complementation over a bare infinitive (*Tora vlepis ti bala na tili?*) in Greek for clarity, since *na tili* could have been misparsed as a single word (for discussion of the two options, see Giannakidou, 1998, among others).

TABLE 2
Verb Types in the Descriptions of Sample Events (Exp. 1)

	English		*Greek*	
Percent of Verb Types	*Children*	*Adults*	*Children*	*Adults*
Path V only	23.7	9	65	48.9
Manner V only	70	85	26	29.1
Path V + Manner V (2 clauses)	2	0	5	18.7
Other V	4.3	6	4	3.3
Total	***100***	***100***	***100***	***100***

2.3. Results

2.3.1. Production task. We focus on the descriptions of sample events, since they offer the best comparison point to the verb conjecture data presented below. Verbs in these descriptions were coded as Manner if they encoded the speed, rate, gait, or other internal details of the motion (e.g., English *jump*, Greek *pido*); Path if they encoded the trajectory of the moving agent (e.g., English *leave*, Greek *fevgo*); or Other if they did not encode motion at all (e.g., English *play*, Greek *pezo*). A summary of the production data for these events is given in Table 2 (for a full list of Path and Manner verbs and their distribution, see Appendix A). As is clear from Table 2, there is an asymmetry in the expected direction between English and Greek: English speakers used many more Manner verbs than Greek speakers, and the opposite pattern holds for Path verbs — see examples in (3) and (4):

(3) He jumped out of the airplane. (5 year old)
(4) Kateveni kato to pedaki. (5 year old)
is descending down the little child
"The little child is going down."

We entered the proportion of responses containing exclusively Manner verbs into an ANOVA with Language and Age as factors. The analysis revealed a main effect of Language ($F(1, 38) = 77.61$, $p < .0001$), with English speakers offering Manner-verb only responses 77% of the time compared to only 27% in Greek speakers. There were no other main or interaction effects (for English, $M_{ch} = .70$, $M_{ad} = .85$; for Greek, $M_{ch} = .26$, $M_{ad} = .29$).

A similar ANOVA on the proportion of Path verb-only responses revealed a main effect of Language ($F(1, 38) = 80.42$, $p < .0001$; $M_{Eng} = .16$, $M_{Gr} = .56$), a main effect of Age ($F(1, 38) = 11.38$, $p = .0001$; $M_{ch} = .44$, $M_{ad} = .29$), and no interaction between these two factors. Overall, responses containing exclusively a Path verb were infrequent in the speech of native English speakers ($M_{ch} = .23$, $M_{ad} = .09$) but were very frequent in the speech of native Greek speakers ($M_{ch} = .65$, $M_{ad} = .48$).

2.3.2 Verb Learning task. The proportion of Manner conjectures was entered into an ANOVA with Language (English, Greek) and Age (Children, Adults) as between-subjects factors. Results are presented in Figure 1. The analysis revealed a main effect of Language ($F(1, 38) = 28.94$, $p < .001$), with English speakers offering Manner guesses 60% of the time and Greek speakers 33% of the time. There was no effect of Age or interaction between Language and Age. The proportion of Manner guesses in both English and Greek differs significantly from chance

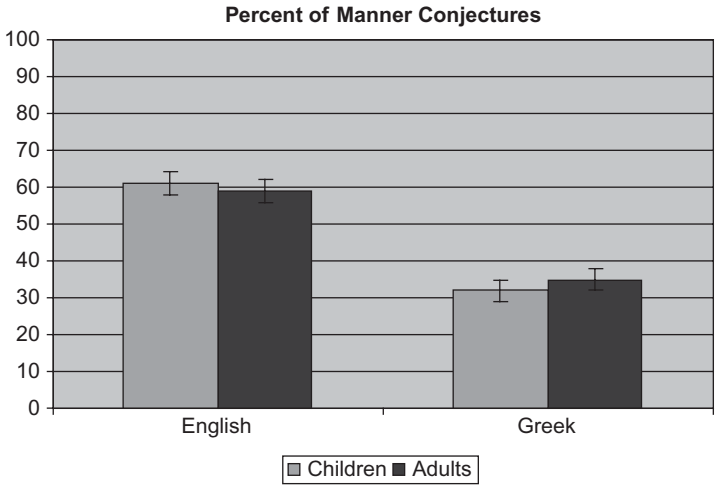

FIGURE 1 Verb conjectures for intransitive frames (Exp. 1).

($t(17) = 3.3$, $p = .0035$, and $t(19) = -4.1$, $p = .0005$, respectively). This shows that English speakers had a reliable preference for Manner conjectures and Greek speakers a reliable dispreference for Manner conjectures (hence a bias for Path responses). A separate ANOVA revealed that there was no effect of the type of Agent (Animate, Inanimate) on Manner conjectures or interactions of this factor with either Language or Age.

2.3.3. Codability effects on verb conjectures? One concern with the present method is that participants might be simply translating the novel verbs into existing verbs in their language. If so, this method would not reveal much about learning new verbs but simply mirror the existing make-up of the motion lexicon in English and Greek. To address this possibility, we calculated how codable each sample event was for both children and adults within each language — that is, how often it was named with the same verb by participants in the Production task. We used a strict criterion of verb identity that excluded responses containing multiple verbs (see Table 3). We then selected for each language four high-codability items (where the sample event was named by the same frequent verb — a manner verb in English and a path verb in Greek — by at least half of the participants) and four low-codability items where responses were mixed (fewer than half of the participants chose the same verb for the sample). For English-speaking children and adults, the high-codability items were 1, 2, 7, and 15 *(bounce, fly, skate,* and *roll,* respectively), and the low-codability items were 3, 4, 6, and 16. For Greek adults, the high- and low-codability items were 4, 6, 12, and 14 (*go* and *ascend/descend* items) and 1, 5, 13, and 16, respectively. For Greek children, the corresponding items were 3, 5, 9, and 14 (*go* and *descend*) and 4, 8, 11, and 12, respectively. In a further step, we ensured that the verbs used for coding the sample event in the high-codability items were typically (M = .75) used to code the corresponding variant (manner in English, path in Greek).

We then compared the proportion of manner matches for each language group in the high- versus low-codability trials: if implicit naming with existing labels drives subjects' responses, we should see more manner matches for high- than low-codability items in English and fewer manner matches for high- than low-codability items in Greek. We found no such effects of

TABLE 3
Preferred Labels for Sample Events in Experiment 1 (ø Indicates That No Single Verb/Verb Sequence Was Used More Than Once)

	English		*Greek*	
Item	*Adults (n = 10)*	*Children (n = 10)*	*Adults (n = 12)*	*Children (n = 10)*
1	Bounce: 10	Bounce: 7	Fevgo & pao 'leave & go': 2	Pao 'go': 5
2	Fly: 10	Fly: 8	Peto 'fly': 8	Pao 'go': 5
3	Rise: 4	Go: 3 Float: 3	Fevgo & pao 'leave & go': 3	Pao 'go': 7
4	Walk: 4	Go: 3	Pao 'go': 5	Krivome 'hide': 3
5	Float: 7	Float: 5	Pao 'go': 3	Pao 'go': 8
6	Sink: 4	Go: 4	Pefto 'fall, descend': 5	Pao 'go': 5
7	Skate: 9	Skate: 7	Kano patinaz 'do skating': 7	Kano ski 'do skiing': 5
8	Fall: 5	Fall: 5	ø	Pao 'go': 2
9	Fly: 8	Fly: 8	Pao 'go': 3	Pao 'go': 9
10	Walk: 5	Walk: 4	Pao 'go': 3	Pao 'go': 3
11	Jump: 8	Hop: 4	Pido 'jump': 2 Pao 'go': 2	Pido 'jump': 3
12	Swim: 6	Swim: 4	Pao 'go': 6	Pao 'go': 3
13	Float: 5	Float: 4	Fevgo & pao 'leave & go': 3	Pao 'go': 8
14	Fall: 5	Go: 3 Fall: 3	Pefto 'fall, descend': 6	Kateveno 'descend': 6
15	Roll: 5	Roll: 6	Kilo 'roll': 3	Pao 'go': 5
16	Fly: 4	Spin: 3	ø	Jirno 'spin': 4

codability: separate ANOVAs for each language-age group returned no main effect of codability on the proportion of manner conjectures (English adults: $M_h = .57$ vs. $M_l = .42$; English children: $M_h = .57$ vs. $M_l = .70$; Greek adults: $M_h = .33$ vs. $M_l = .35$; Greek children: $M_h = .45$ vs. $M_l = .32$). We conclude that even when there was a highly accessible and appropriate existing verb in their native language that could be used to name the sample event (as well as one of the variants), participants did not use it to paraphrase the novel verb.

2.4. Discussion

Our data point to three major conclusions. First, they offer support to the idea that language-specific lexicalization biases shape lexical learning. When exposed to a new motion verb (in an intransitive frame), adults' and children's conjectures about its meaning are consistent with the way motion is lexicalized in their native language: English speakers generally interpret it as a manner and Greek speakers as a path verb. These results confirm and extend earlier studies on the potency of lexicalization biases in adults speaking Path or Manner languages (Naigles & Terrazas, 1998, Exp. 2) and lower the age at which these cues have been found to be usable by language learners (cf. Hohenstein et al., 2004).

Second, our data suggest that linguistic cues can function as a 'zoom lens' for event construal (cf. also Gleitman, 1990; Naigles, 1990; Fisher, 1996, among others). Recall that in a prior line of experiments (Papafragou & Selimis, 2010, Exp. 2), the very same motion events used in the present study elicited overwhelmingly path-based choices from both English- and Greek-speaking

adults and 5 year olds in a nonlinguistic categorization task. As the present data show, this preference is reversed for English speakers as a result of linguistic (lexical-structural) information (the statistical preponderance of manner of motion verbs in the language). For Greek speakers, linguistic information does not go against nonlinguistic biases in categorizing these events (since Greek frequently uses path verbs in describing motion). We conclude that language-specific lexicalization biases in combination with structural information can direct adults' and younger learners' attention away from salient event features and towards linguistically relevant event dimensions in the process of word learning.

Third, the present data differ from previous studies in a way that is worth addressing in some detail. Naigles and Terrazas (1998, Exp. 1) have suggested that the presence of an intransitive frame encourages manner interpretations across languages, unlike transitive frames with NP-direct objects (*V-ing the X*), which favor path interpretations. Using a task similar to ours, these researchers found that novel bare motion verbs were assigned manner meanings by both English- and Spanish-speaking adults. For instance, when shown a clip of a woman skipping towards a tree, both groups interpreted bare intransitives (*She's kradding/ Ella está mecando*) as referring to the skipping action. In that study, language-specific lexicalization biases emerged only when novel verbs were embedded into transitive syntactic frames or intransitive frames with a directional modifier (*She's kradding the tree*; *She's kradding towards the tree*; and their Spanish equivalents): under these conditions, English speakers were overall more likely to form manner interpretations and Spanish speakers path interpretations (*ibid.*, Exp. 2; see also Introduction).

Why should bare intransitive frames prompt manner verb conjectures in Spanish but path verb conjectures in Greek? We can see two possible explanations. One possibility is that is the specific morphology that was used in the Spanish stimuli encouraged manner interpretations. In Spanish, an ongoing event in the present (e.g., a girl walking) can be described either with the present progressive (*ella está caminando*, literally 'she is in the process of walking') or with the simple present tense (*ella camina*, 'she is walking'). Because both tenses can be used, the use of the progressive emphasizes what the agent is actively doing; the simple present tense does not have this specific interpretation and can have other uses (e.g., it appears in habitual sentences such as 'she smokes'). It is possible, therefore, that the use of the present progressive in the Naigles and Terrazas' study (*ella está mecando*) encouraged a manner interpretation of the nonsense verbs by bringing to mind something the agent is actively doing with his/her body. (Greek has no such distinction in the present tense.) If this explanation is along the right lines, a change the morphology of the nonsense verbs in the Spanish study (e.g., the use of past tense, or simple present) should give rise to different, perhaps more path-oriented responses.

A second possibility is that the distribution of manner and path verbs in bare intransitive frames may differ across Greek and Spanish. Both languages belong to the group of Path languages and both allow omission of overt subjects and sometimes objects (e.g., the majority of Greek path verbs elicited in Exp. 1 can appear without overt direct object NPs, either because they do not require direct objects as in *Ta balonia anevenun* 'The balloons are rising', or because the direct object can be dropped without infelicity as in *I bala pernai* 'the ball is passing'). Nevertheless, the frequency with which Greek and Spanish drop direct objects for path verbs may differ. In a corpus of elicited descriptions of motion events collected by Naigles et al. (1998, Exp. 1), bare intransitive sentences account for about one-fourth of Spanish speakers' responses; furthermore, the vast majority (77%) of such bare intransitives contains a manner verb and only 3% (1 out of 31 utterances) contains a path verb. In the present Greek data, even though the number of bare

verb utterances is very low, the manner bias for bare verbs seems weaker, with about 70% of bare intransitives containing manner and 30% path verbs (in adults' responses, bare path verbs account for about 2% and bare manner verbs for 4% of total responses; for children, the corresponding proportions are 6% and 16%). In other Greek corpora, the manner bias for bare intransitives is reversed or disappears altogether: Papafragou et al. (2005) report that bare path verbs in children's productions are three times more frequent than bare manner verbs (17% and 5%, respectively), while in adults' productions bare verbs are negligible (about 3% of total responses) in either class. Finally, in a recent production study in which Greek-speaking adults were asked to describe motion events using a single (bare) verb, responses were split between path and manner predicates (M_{Path} = .43, M_{Manner} = .57; Papafragou, Mojaverian, & Trueswell, in preparation). It is not clear whether these distributional differences between Greek and Spanish are due to lexical-structural factors (e.g., the argument structure of individual path verbs in Greek vs. Spanish), or discourse factors (e.g., conditions on argument omission in the two languages). If this explanation is correct, in Spanish, the strong distributional facts for bare intransitives override the preference for path verb lexicalization and lead to more manner verb conjectures. In Greek, the semantic implications of structures without overt complements are more diffuse and leave more room for the lexical bias to exert its influence, leading to path-oriented interpretations for newly encountered motion verbs.

At present, we cannot distinguish between these two explanations for the fact that Spanish and Greek speakers produce different learning outcomes in what otherwise appear to be identical combinations of lexical and structural pressures (path lexical conflation patterns plus intransitive frames). Further research would be needed to throw light on this question. Regardless, the Spanish-Greek comparison shows that (bare) intransitive structures in the input do not unambiguously point to manner of motion interpretations cross-linguistically (and, in this respect, they differ from transitive frames with direct object NPs which seem clearly path-biased).

3. EXPERIMENT 2: TRANSITIVE (CAUSED MOTION) VERBS

In this second study, we asked whether the lexicalization biases observed for spontaneous motion events generalize to the more complex domain of caused motion. Specifically, we explored how these lexical biases combine with the semantic implications of transitive (causative) frames to produce verb interpretations in English and Greek. To isolate effects of linguistic (lexical-structural) versus nonlinguistic (e.g., salience-driven) biases on participants' conjectures, we also elicited nonlinguistic categorization judgments for the target events.

3.1. Participants

Participants were randomly assigned to either a Verb Learning or a Production task. Participants in the Verb Learning task consisted of 16 English-speaking children between 4;5 and 5;9 years (mean age 5;2), 20 Greek-speaking children between 4;1 and 5;10 (mean age 5;0), as well as 16 English-speaking and 25 Greek-speaking adults. An additional 10 Greek-speaking children (range: 4;5–5;10, mean: 5;3) and 10 English-speaking children (range: 4;2–5;11, mean: 5;0), together with 10 adults from each language, participated in the Production task. Participants were recruited from the same populations as in Experiment 1.

3.2. Method

3.2.1. Materials. Stimuli consisted of 24 short silent animated motion clips in PowerPoint 2003 format organized in 8 triads (see Table 4). Each triad consisted of a sample event and two variants. Sample events depicted an Agent interacting with a Theme and bringing about a Result through some Means (e.g., a girl pushing a snowball down a hill). Both Result and Means subcomponents were salient in the sample events. Each of the variants presented a specific change to the original event. In the Same-Result variant, the Means of movement was changed whereas Result was kept the same (the girl hit the ball with her head and made it go down the hill). In the Same-Means variant, the Result was changed whereas Means remained the same (the girl pushed the ball but the ball rolled in place). All Agents were animate (human), with the exception of one event where the Agent was a self-propelled object (a tugboat) and another event where it was a physical force (a wave). All Themes were inanimate objects. Events always involved direct physical causation.

3.2.2. Procedure. The basic two-screen display in the Production condition followed that of Experiment 1. Participants in this condition initially completed a Categorization task: They were shown the sample event and heard a sentence which did not contain a specific verb (e.g., English: *Look! Something's happening!*; Greek: *Kita! Kati ginete!*). After the sample was repeated on the second screen, participants were shown the two variants and were asked to pick the one that best matched the sample: *Do you see the same thing happening now? On which screen?* (English)/*Tora vlepis oti ginete to idio? Se pia othoni?* (Greek). After completion of the Categorization task, participants were shown all events (samples and variants) again and had to describe them (Production task). Unlike the Categorization phase of the experiment, sample events were viewed only once during the Production task.

The Verb Learning task was also modeled after Experiment 1 except that participants were introduced to a novel verb in a transitive frame (e.g., English: *Look! The girl is snerging the snowball!*;

TABLE 4
Stimuli for Experiment 2

Sample	*Same Means*	*Same Result*
1. A girl pushes a snowball; the snowball rolls downhill	A girl pushes a snowball; the snowball rolls in place	A girl hits a snowball with her head; the snowball rolls downhill
2. A boy rakes a leaf; the leaf goes into a pile of other leaves	A boy rakes a leaf; the leaf spins in place	A boy uses a leaf blower to blow a leaf into a pile of other leaves
3. A large wave thrusts a bottle lying on a beach; the bottle floats out to the sea	A large wave thrusts a bottle lying on a beach; the bottle ends up further back on the beach	A large wave lifts a bottle gently from the beach; the bottle floats out to the sea
4. A girl pushes a toy boat; the boat goes across a river	A girl pushes a toy boat; the boat drifts along a river	A girl launches a toy boat with a stick; the boat goes across a river
5. An elf hits a can with a cane; the can rolls down the street	An elf hits a can with a cane; the can rolls in place	An elf kicks a can; the can rolls down the street
6. A girl pushes a ball; the ball rolls across a pool table	A girl pushes a ball; the ball rolls in place on a pool table	A girl kicks a ball; the ball rolls across a pool table
7. A tugboat pulls a paper boat; the boat goes down a stream	A tugboat pulls a paper boat; the boat lands onto the river bank	A tugboat pushes a paper boat; the boat goes down a stream
8. A boy pulls on a kite string; the kite comes down from the sky	A boy pulls on a kite string; the kite moves slightly in the air	A boy clasps a kite string; the kite comes down from the sky

Greek: *Kita! To koritsi miri ti hionobala!*). While watching the variants, participants had to pick one variant that could best be described by the same 'mystery' word (English: *Do you see the girl snerging the snowball now? On which screen?;* Greek: *Tora vlepis oti to koritsi miri ti hionobala? Se pia othoni?*). Novel verbs were monosyllabic forms with English verb morphology (present progressive, i.e., 'Ving') for the English part of the experiment and two-syllable forms with Greek verb morphology (e.g., third-person-singular present forms) and stress on the first syllable for the Greek part. All verbs were constructed so as not to resemble existing verbs in the two languages (English: *snerg, blork, klorn, lurp, meck, crat, ling, granch*; Greek: *miro, boko, zavro, trabo, lieto, greko, pufo, giado*).

Both the Categorization and the Verb Learning tasks included a practice triad, which did not involve pure motion/displacement events.

3.3. Results

3.3.1. Categorization task. The proportion of Same-Means choices in the categorization task was entered into an ANOVA with Language (English, Greek) and Age (Children, Adults) as between-subjects factors. Results are presented in Figure 2. The analysis revealed a main effect of Age ($F(1, 36) = 21.33$, $p < .0001$), with children offering Same-Means choices 53% and adults 28% of the time. There were no other main or interaction effects. Children did not choose Same-Means variants at rates different from chance ($t(19) = 1.18$, $p = .24$, n.s.) but adults did ($t(19) = -5.08$, $p < .0001$); that is, adults showed a Result bias.

3.3.2. Production task. As in Experiment 1, we report results for descriptions of sample events only (e.g., the event in which the girl pushed the ball, the ball rolled and went down the hill). We were mostly interested in Agent-oriented descriptions, that is, sentences where the subject NP was the Agent (here, the girl) and the verb was transitive (e.g., *The girl is Ving the snowball*),

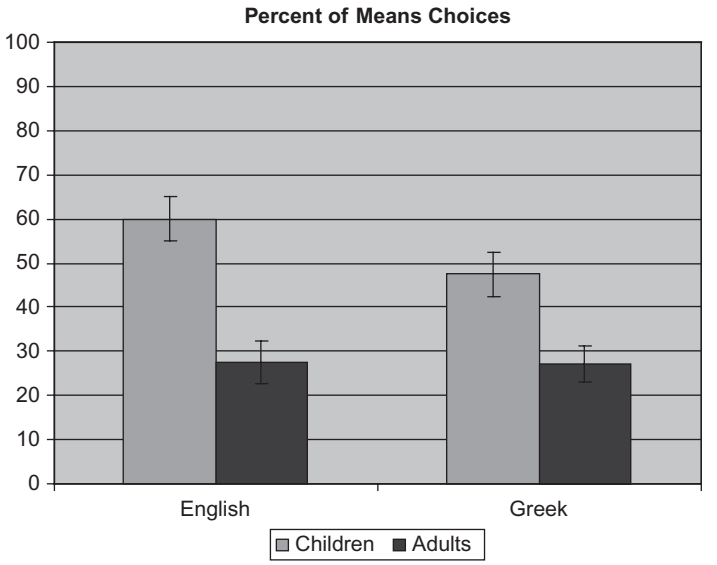

FIGURE 2 Categorization results (Exp. 2).

with or without further modifiers. Such descriptions were similar to the presentation conditions of the Verb Learning condition (*Look! The girl is snerging the snowball! Do you see the girl snerging the snowball now?*) and therefore were most relevant to the hypothesis tested in this experiment (namely, the presence of a relationship between lexicalization biases in production and verb learning). Main verbs in Agent-oriented descriptions were coded as Means if they encoded the activity of the Agent (e.g., English *push*, Greek *sprohno*) or Result if they encoded the change of state brought about by the Agent (e.g., English *send*, Greek *stelno*), as in (5)–(6):

(5) a. The girl is pushing a snowball down the hill.
b. Ena koritsaki sprohni ti hionobala.
'a little-girl is-pushing the snowball'

(6) a. The girl is sending the ball down the hill.
b. To koritsi stelni ti bala makria.
'the girl is-sending the ball away'[3]

We also coded descriptions that referred to the motion of the affected object (here, the ball). In these Theme-oriented descriptions, the subject NP was the inanimate object and the verb was often intransitive (e.g., *The ball Ved*). Such descriptions contained either Manner verbs, which encoded the way the object moved (e.g., English *roll*, Greek *katrakilo*), or Path verbs, which encoded the trajectory of the object (e.g., English *go*, Greek *prohoro*) — see (7)–(8):

(7) a. The snowball rolls down the hill.
b. I hionobala katrakilai.
'the snowball is-rolling'

(8) a. The snowball went down the hill.
b. I bala prohorai kato.
'the ball is-advancing down'

A summary of the linguistic production data is given in Table 5 (for a full list of Result, Means, Path and Manner verbs and their distribution, see Appendix B; cf. also Table 6 for the preferred lexicalization for each item). As these data show, there is an asymmetry in the expected direction between English and Greek: English speakers used many more Means verbs than Greek speakers, and the opposite pattern holds for Result verbs — see examples from 5-year-olds' speech in (9) and (10):

(9) He pulled the kite down.

(10) Ton katevase.[4]

[3]Even though *send* and *stelno* were among the elicited verbs in Exp. 2, the examples in (6) were not attested for this item and are used for illustration only.

[4]Greek has rich morphology which includes resultative affixes (e.g., Giannakidou & Merchant, 1999). A few Result verbs in our production data contain resultative affixes (e.g., in *kate-vazo* 'put down' of example (10), the first part of the verb is the 'down' morpheme) but most Result verbs in our sample do not contain such affixes (e.g., *stelno* 'send', as in (6)). It is an interesting question whether (and how early) Greek learners can benefit from the relevant morphology in their language to interpret novel transitive verbs. However, the present study is not designed to address such contributions of morphology: the novel verbs in the Verb Learning condition purposefully contained only 2 syllables so as to exclude mini-syntax inside the word (and hence resultative morphology as a potential cue to verb meaning).

TABLE 5
Verb Types/Combinations in the Descriptions of Sample Events (Exp. 2)

	English		*Greek*	
Percent of Verb Types	*Children*	*Adults*	*Children*	*Adults*
Means V only	52	73.75	40	31.25
Means V + Path V	3.70	5	7.50	20
Sub-total Means V	*55.70*	*78.75*	*47.50*	*51.25*
Result V only	4.93	3.75	15	18.75
Manner V + Result V	0	0	1.25	0
Path V + Result V	2.46	1.25	2.50	3.75
Sub-total Result V	*7.39*	*5*	*18.75*	*21.50*
Means V + Result V	1.23	1.25	3.75	7.50
Path V only	20.98	1.25	23.75	7.50
Manner V only	8.64	7.50	2.50	3.75
Manner V + Path V	0	0	2.50	0
Other responses	6.01	6.25	1.25	7.50
Total	***100***	***100***	***100***	***100***

TABLE 6
Preferred Labels for Sample Events in Experiment 2 (ϕ Indicates That No Single Verb Was Used More Than Once). Numbers in Parentheses Show Additional Uses in Multiverb Responses

	English		*Greek*	
Item	*Adults (n = 10)*	*Children (n = 10)*	*Adults (n = 10)*	*Children (n = 10)*
1	Push: 7 (+1)	$Roll_T$: 4 (+1)	Sprohno ‘push’: 2 (+4)	Rihno ‘throw’: 2 Sprohno ‘push’: 2 (+1)
2	Rake: 9 (+1)	Rake: 5	Mazevo ‘gather’: 7 (+1)	Mazevo ‘gather’: 5 (+1)
3	Float: 3	Go: 7	ø	Pao ‘go’: 5
4	Push: 8 (+2)	Push: 4	Sprohno ‘push’: 2 (+4)	Sprohno ‘push’: 4 (+2)
5	Hit: 2 (+2) Kick: 2	Hit: 2 Push: 2	Sprohno ‘push’: 2 (+3) Htipo ‘hit’ : 2 (+3)	Sprohno ‘push’: 3 (+1)
6	Push: 4 (+1)	Push: 6 (+1)	Sprohno ‘push’: 4 (+1)	Rihno ‘throw’: 3
7	Pull: 5	Go: 3 Float: 3	Serno ‘drag’: 2 (+3)	Pao ‘go’: 2 (+2)
8	Pull: 4 (+2)	Go: 3 Pull: 2 (+1)	Katevazo ‘take down’ : 2 (+2)	Travo ‘pull’: 5

‘it made-descend’
“(He) got it (=the kite) down.”

We entered the proportion of responses containing only a Means verb (and no other verbs) into an ANOVA with Age and Language as factors. The analysis revealed a main effect of Language ($F(1, 36) = 15.47$, $p = .0004$; $M_{Eng} = .63$ vs. $M_{Gr} = .35$), no main effect of Age, and an interaction between Age and Language ($F(1, 36)=4.60$, $p = .03$): pairwise comparisons revealed that adults’ responses differed significantly across languages ($M_{Eng} = .73$, $M_{Gr} = .31$, $p < .05$) but in children’s data the difference did not reach significance ($M_{Eng} = .52$ vs. $M_{Gr} = .40$).

The same analysis on the proportion of Result verb-only responses returned a main effect of Language ($F(1, 36) = 19.35$, $p < .0001$), with English speakers including exclusively Result verbs in their responses 4% of the time and Greek speakers 16% of the time, but no main effect of Age and no interaction between Age and Language (for English: $M_{ad} = .03$, $M_{ch} = .05$; for Greek, $M_{ad} = .18$, $M_{ch} = .15$). For completeness, we performed the same analysis on the proportion of Path verb-only sentences. We found a main effect of Age ($F(1, 36) = 17.32$, $p = .0002$), with adults offering Path-verb-only responses 4% of the time and children 22% of the time, but no main effect of Language or interaction between Age and Language (for English, $M_{ad} = .01$, $M_{ch} = .21$; for Greek, $M_{ad} = .07$, $M_{ch} = .23$). We did not analyze Manner-verb only responses statistically since their overall frequency was very low (8% of total responses).

Participants' responses often included both Agent-oriented and Theme-oriented descriptions and hence multiple verbs, as in the following example from an English-speaking adult:

(11) She pushes it, and the snowball rolls down the hill.

We repeated all three analyses using the proportion of answers in each language that contained a Means, Result, or Path verb irrespective of other verbs. The new analyses again confirmed the presence of cross-linguistic differences. For Means verbs, the analysis revealed a main effect of Age ($F(1, 36) = 16.24$, $p = .0003$), with adults offering Means verbs 74% of the time and children 52% of the time, as well as a main effect of Language ($F(1, 36) = 6.89$, $p = .01$), with Means verbs being offered in 70% of English and 56% of Greek responses, and no interaction. The same analysis on the proportion of Result verbs returned only a main effect of Language ($F(1, 36) = 19.02$, $p < .0001$), with English speakers including Result verbs in their responses 7% of the time and Greek speakers 26% of the time. Finally, the same analysis for Path verbs yielded only a main effect of Language ($F(1, 36) = 6.19$, $p = .01$), with Greek speakers producing Path verbs 35% of the time and English speakers only 18% of the time.

3.3.3. Verb Learning task. The proportion of Means choices was entered into an ANOVA with Language (English, Greek) and Age (Children, Adults) as between-subjects factors. Results are presented in Figure 3. The analysis revealed a main effect of Language ($F(1, 73) = 7.63$, $p = .0072$), with English speakers offering Means guesses 42% and Greek speakers 30% of the time. There were no other main or interaction effects. Although English speakers were more likely to offer Means conjectures than Greek speakers, both languages showed a Result bias, since their (low) proportions of Means choices were significantly different from chance (English: ($t(31) = -2.2$, $p = .03$), Greek: ($t(31) = -6.1$, $p < .0001$).

We next wanted to see whether the linguistic (lexical and structural) cues in the Verb Learning condition affected participants' pattern of responses compared to the baseline (nonlinguistic) categorization task. A comparison of participants' Means choices in the Categorization and Verb Learning task revealed a (marginal) difference for English-speaking adults ($t(24) = 1.9$, $p = .06$): the linguistic cues in the Verb Learning condition increased Means choices (M = .44) compared to the Categorization task (M = .27). There was no such difference for Greek-speaking adults, who had low rates of Means choices in both the Categorization and the Verb Learning task ($t(34) = -.10$, $p = .9$; M = .26 vs. .27, respectively). For children in both language groups, the linguistic cues in the Verb condition reduced Means choices compared to the Categorization task (English: $t(24) = -3.14$, $p = .004$, M = .41 vs. .60 respectively; Greek: $t(28) = -2.25$, $p = .03$, M = .33 vs. .47, respectively).

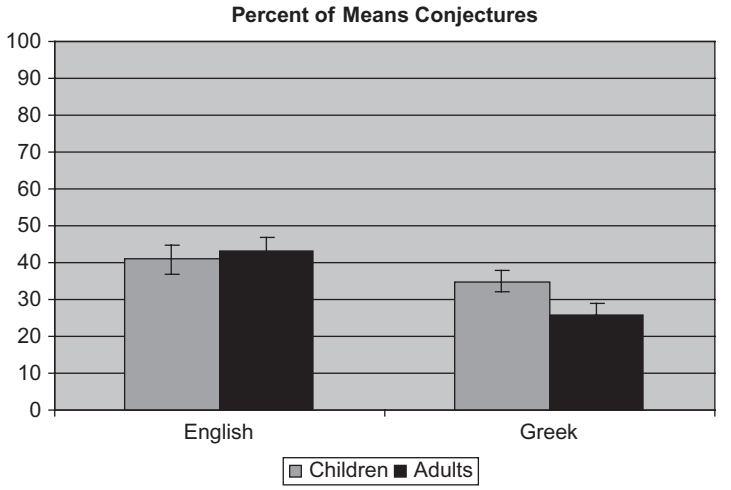

FIGURE 3 Verb conjectures for transitive frames (Exp. 2).

3.3.4 .Codability effects on verb conjectures? As in Experiment 1, we wanted to address the possibility that participants in the Verb Learning task might be simply translating the novel verbs into existing verbs in their language. To test this possibility, we calculated how codable each sample event was for children and adults separately within each language, that is, how often it was named with the same verb by the corresponding group of participants in the Production task (see Table 6). Because of the high degree of variability among participants, we used a more lenient criterion of verb identity compared to Experiment 1 that also took into account responses containing multiple verbs. We focused on Means verbs for both languages because they were more likely to occur in highly codable items (notice that the issue of whether linguistic labels are used to paraphrase the novel verbs is independent of whether these labels are themselves Means or Result). For each language and age group, we selected two high-codability items (where the sample event was named by the same frequent Means verb by at least half of the participants) and two low-codability items (where responses were mixed). In selecting high-codability items, we also ensured that the verb used for coding the sample event in these items was also typically (M = .71) used to code the corresponding (same-means) variant. The high- versus low-codability items for each group were 1, 2 versus 3, 5, respectively, for English-speaking adults; 1, 6 versus 7, 8 for English-speaking children; 4, 6 versus 3, 8 for Greek-speaking adults; and 4, 8 versus 6, 7 for Greek-speaking children.

If implicit naming with existing labels drives subjects' responses in the Verb Learning task, we should see more Means matches for novel verbs in the high- than the low-codability items regardless of language or age. We found no such effect of codability: separate ANOVAs for each language-age group returned no main effect of codability on the proportion of Means conjectures (English adults: M_h = .35 vs. M_l = .25; English children: M_h = .37 vs. M_l = .40; Greek adults: M_h = .30 vs. M_l = .30; Greek children: M_h = .20 vs. M_l = .17). We conclude that even when there was a highly accessible and appropriate existing verb in their native language that could be used to name the sample event (as well as one of the variants), participants did not use this verb to paraphrase the novel verb.

3.4. Discussion

The present data point to several major conclusions. The production results offer a clear demonstration of language-specific patterns in both adults' and young learners' descriptions of caused motion. Specifically, when selecting a verb to describe an internally complex event in which an Agent physically acts upon a Theme and causes it to undergo a change of location, English speakers are more likely than Greek speakers to produce a verb naming the Agent's physical activity (the Means component) and Greek speakers are more likely than English speakers to produce a verb naming the causative action that produced the Theme's motion (the Result component). Furthermore, this pattern affects conjectures about novel transitive verbs naming the Agent's action in the two languages, with English speakers being more likely to extend a novel caused motion verb on the basis of sameness of physical activity (Means) compared to Greek speakers.

Second, despite these cross-linguistic differences, both English and Greek speakers converge in their overall interpretive preferences for novel verbs of caused motion appearing in transitive frames: both groups select Result conjectures for the majority (M_{Eng} = .58, M_{Gr} = .70) of newly encountered such verbs. Furthermore, this preference characterizes both young learners and adult speakers. This finding is consistent with prior results showing a bias for Result-oriented over Means-oriented interpretations of novel transitive verbs in English (see Behrend, 1990; Bunger & Lidz, 2007; Forbes & Farrar, 1993, 1995; Gropen et al., 1991; Naigles, 1996; Naigles & Kako, 1993; cf. also Bowerman, 1989; Slobin, 1985). In addition, these preferences demonstrate that verb learning crucially relies on the presence of strong and principled links between syntactic structure and semantic content which work along similar lines across languages and individual events (see also Landau & Gleitman, 1985; Gleitman, 1990; Naigles, 1990; Fisher, Gleitman & Gleitman, 1991).

Even though our study did not include separate manipulations of transitivity and lexical bias, it offers a basis for indirectly comparing the potency of the two types of cue for building verb conjectures. Specifically, the fact that both English and Greek speakers converge on Result-based interpretations for novel caused-motion verbs in transitive contexts seems to suggest that the semantic implications of transitivity are stronger than (language-specific) lexical biases in determining which event subcomponent should be labeled by a novel verb: when transitive syntax and the lexical statistical tendencies of the language work in opposite directions (as was the case with English speakers), the semantic demands of syntax trump the language-specific lexical biases. Notice that, even though Result verbs were produced very infrequently (less than 7% of the time) in English, transitive syntax led English speakers to hypothesize Result interpretations of the target verbs about 60% of the time.[5] These data are reminiscent of other studies where

[5]One might argue that the Same-Means vignettes might also be nameable by a causative verb, albeit of a different kind. Recall that, in these vignettes, the Theme does undergo some (minimal) change of state: in the example of the girl pushing the snowball down a hill, the Same-Means variant shows the girl pushing the ball and the ball rolling in place. Perhaps a novel transitive verb could be made to label both the sample and the Same-Means variant, if the verb encoded a specific Means plus a more general causative/Result meaning (something like 'cause to undergo some change by pushing'). The problem with this view is that the combination of a specific Means and a causative meaning to the exclusion of a specific Result is an illicit linguistic representation: there are no (morphologically simple) verbs cross-linguistically that encode simply a Means + CAUSE combination of features (Harley, 1996; McCawley, 1968; Bunger & Lidz, 2007). We take it, therefore, that Means choices in our Verb Leaning task reflect interpretations that maintain the specific Means of the original event but lack a causative component.

universal syntactic cues to verb meaning (more specifically, the very same link between transitivity and causativity) proved more powerful than strong language-specific lexical-probabilistic cues (concretely, the link between individual morpholexical items and causative interpretations; Lidz, Gleitman, & Gleitman, 2003). They are also in the same direction as findings emphasizing the potency of syntactic cues over strong contextual cues for the acquisition of verb meanings (Papafragou, Cassidy, & Gleitman, 2007).

Finally, one of the most striking results of the present study is that people's construals of caused motion events in the absence of linguistic information shift with the introduction of linguistic cues. For adults, we found a strong bias for Result/causative construals of caused motion events regardless of native language: when instructed to find a clip where 'the same thing is happening', the majority (73%) of adults in each language picked the Same-Result variant (see also Kersten, Goldstone, & Schaffert, 1998, for evidence from artificial category learning literature that English-speaking adults have strong result biases in categorizing novel event exemplars). For children in both languages, the pattern of responses was more mixed with no clear preference for either Result or Means. Critically, when linguistic cues were introduced (novel caused motion verb in transitive frame), they shifted adults' nonlinguistic biases and swayed children away from their previously neutral construals. Specifically, English-speaking adults increased their Means responses (in accordance with lexical statistics in their language) and children in both English and Greek developed a preference for Result choices (presumably due to the pressures of transitivity; cf. Naigles & Kako, 1993; Naigles, 1996). Taken together, these results strongly cohere with those from Experiment 1: word learning contexts impose a perspective on the scenes which is distinct from the nonlinguistic representation of events used for purposes of categorization (cf. also Fisher, Hall, Rakowitz, & Gleitman, 1994; Hirsh-Pasek & Golinkoff, 1999, for similar results with toddlers in the domain of event construals, and Landau, Smith, & Jones, 1992; Subrahmanyam, Landau, & Gelman, 1999, for related results with 3 year olds in the domain of object construals). As in the previous Experiment, cross-linguistic similarities in event categorization observed in nonlinguistic contexts give way to language-specific perspectives on events when children and adults are in the process of building conjectures about the meaning of novel verbs.

4. GENERAL DISCUSSION

Our studies explored the explanatory potential of language-specific lexicalization biases for a theory of verb learning. We were particularly interested in motion events involving simultaneous and salient competing dimensions (e.g., the manner vs. the trajectory of motion), for which lexical biases might provide a useful source of semantic constraints. Our studies provide evidence that verb lexicalization biases shape motion verb learning cross-linguistically: when English and Greek speakers are presented with a motion verb in a simple intransitive structure and asked to map it onto either the manner or the path of a motion event, their conjectures exhibit an asymmetry which mirrors facts about the verb typologies in the two languages (English speakers prefer manner and Greek speakers path conjectures; Exp. 1). Our data also offer evidence for effects of lexicalization biases beyond the spontaneous motion domain, with verbs of caused motion being subject to language-specific lexicalization pressures (Exp. 2). In both of these empirical domains, effects of the lexicalization bias are already present in 5-year-old learners revealing language-specific expectations about what novel verbs can refer to that are similar to

adults'. These findings confirm and extend prior evidence about the presence of such biases in adults and older children (Naigles & Terrazas, 1998; Hohenstein et al., 2004).

In addition, our studies offer indirect evidence that the syntactic structures in which novel motion verbs appear in interact with lexical tendencies. Specifically, when there is a clash between syntactic frame and lexical bias (cf. Exp. 2), the effects of lexical bias are constrained. Particularly clear support for this conclusion comes from the observation that English speakers who rarely produce transitive Result verbs spontaneously adopt Result interpretations for novel caused motion verbs embedded in transitive structures (Greek speakers, who include Result verbs more regularly in their speech, are even more likely to hypothesize Result meanings in these contexts). Again, children seem to have access to the same set of syntactic cues to verb interpretation as adults, and to weigh them in heavily when applying lexical cues: their verb extension patterns in both English and Greek are identical to those of adults. Our findings add to a body of evidence demonstrating learners' strong commitment to syntax and its semantic implications, even compared to other cues to verb meaning (Gleitman, 1990; Gillette, Gleitman, Gleitman, & Lederer, 1999; Fisher et al., 1991; Lidz et al., 2003; Naigles, 1990; Naigles & Terrazas, 1998; Papafragou et al., 2007; Snedeker & Gleitman, 2004).

Finally, our data offer evidence that the combined effects of lexical information and structural frame can change non-linguistic biases observed when motion events are processed independently of linguistic input (Experiments 1 and 2). Nonlinguistically, the cross-linguistic categorization of spontaneous motion seems to be guided by similar considerations in speakers of different languages. The introduction of linguistic information in contexts of verb learning biases both young and more experienced speakers of the language towards language-specific perspectives on motion events. Interestingly, our data offer no evidence for the inverse effect, whereby linguistic labeling might percolate and affect non-linguistic categorization patterns (see Gennari, Sloman, Malt, & Fitch, 2002; Papafragou et al., 2003; Papafragou, Hulbert, & Trueswell, 2008, for similar conclusions).

Several questions remain about the nature of language-specific lexical biases and their contribution to verb learning. A first question concerns the scope of such biases. One of their limitations is clear: even though they promote certain lexical candidates over others (path vs. manner, result vs. means) within the semantic field of motion, lexicalization biases themselves do not tell us how the semantic field of motion is chosen over other possible semantic spaces when a new verb is encountered (this problem is, of course, far from trivial; see Chomsky, 1959; Gleitman, 1990; Pinker, 1989).

Even within the semantic space of motion, lexicalization biases may need to combine with more general principles to guide verb interpretation. It has been suggested that, since Manner/Means and Path/Result capture complementary aspects of verb meaning, languages resist naming both Manner/Means and Path/Result components with a single (monomorphemic) verb (Levin & Rappaport Hovav, 1992; Kiparsky, 1997): even though there are pairs such as *beat-mix*, *wipe-clean*, or *drag-bring*, in which the first verb denotes the manner and the second the result/endpoint of an action, there is no single-morpheme verb that encodes both.[6] Even if this observation corresponds to a universal tendency rather than an absolute lexical gap, it could be a powerful source of constraints on verb meaning assignments. In trying to obey this general lexicalization

[6]This observation applies to morphologically simple verbs; in languages with complex morphology, this generalization applies to "pieces of verbs" (Levin, 2008; cf. Giannakidou & Merchant, 1999).

principle, children should resist conflating both the manner in which an action is performed and the ensuing result within a single verb, even when manner (or means) of motion and endpoint (or result) are salient in a scene. Furthermore, logically, the choice of which component to encode in a verb should be determined in part by language-specific lexical biases (together with syntactic factors) and should lead to different solutions of this puzzle across languages. In our studies, we solved this verb conflation puzzle for our participants by presenting them with a choice between segmented manner/means or path/result event components. It would be interesting to explore whether, in a more unconstrained task, learners could use lexicalization biases in choosing a single sub-component of a complex motion event to be the meaning of a newly encountered verb.

A second question that arises is how early lexicalization biases emerge, and how input supports the earliest forms of these generalizations across languages. Recall that Spanish and English learners at the age of 3 are not different in their verb extension preferences, which are mostly frame-driven (Hohenstein et al., 2004; cf. Introduction). In English, path verbs are vanishingly rare in the input and relatively infrequent in young children's speech, with the exception of *come* and *go* (see Experiment 1; cf. Papafragou et al., 2002; Papafragou & Selimis, 2010). In Spanish and Greek, however, both manner and path verbs appear in the input (Naigles et al., 1988; Papafragou et al., 2002). Furthermore, early acquired verbs of motion in Greek include path verbs such as *perno* ('cross/pass'), *kateveno* ('descend'), and *beno* ('enter') but also several manner verbs such as *pido* ('jump'), *perpato* ('walk'), and *peto* ('fly') (Selimis & Katis, 2003; Selimis, 2007). As a result of these asymmetries, the manner verb bias in English might emerge earlier and more clearly than the path verb bias in Spanish or Greek.

A related issue is how flexible these biases are when first developed. There is evidence that, at least in adults, lexicalization generalizations are malleable: after being exposed to brief training on corpora of verbs with different manner/path compositions, English-speaking adults adapted their generalizations of novel motion verb meanings to the statistics of the training corpus and were able to learn path verbs if such verbs were dominant in the training set (Havasi & Snedeker, 2004). Similarly, there is preliminary evidence that English learners at the age of 5 years can form path lexicalization biases in response to a clear category structure (*ibid.*). These results confirm the conclusion that verb lexicalization biases in the domain of motion emerge as a consequence of experience with previously learned motion verbs and can change as a function of the input.

Finally, it is an open question how motion verb biases operate across different languages. Recall that our findings revealed subtle differences in the way lexical and structural cues combine in languages (Spanish and Greek) that otherwise share motion lexicalization biases. Recent linguistic evidence suggests that there is considerable variation even within the traditional Path and Manner typological groups (e.g., Beavers, Levin, & Tham, 2004). It remains to be seen how morpho-syntactic properties of languages within these broad classes combine with lexical biases and general structural factors to guide learners' hypotheses about how novel verbs map onto event meanings.

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APPENDIX A: LINGUISTIC ELICITATION DATA FROM EXP. 1 (SAMPLE EVENTS)

A1. Path Verbs

English			*Greek*			
	Children	*Adults*		*Gloss*	*Children*	*Adults*
circle	1	–	**aneveno**	*ascend/rise*	1	2
come	9	–	**beno**	*enter*	3	–
cross	1	–	**diashizo**	*cross*	–	2
go	36	11	**erhome**	*come*	–	1
hide	3	–	**fevgo**	*leave*	3	30
leave	1	–	**ftano**	*arrive/reach*	–	19
rise	–	4	**jirno/jirizo**	*return*	4	–
start	1	–	**kataligo**	*reach/end-up*	–	8
			katefthinome	*head-for*	–	6
			kateveno	*descend*	9	4
			krivome	*hide*	6	7
			ksekino	*start-out*	–	2
			ksekolo	*move-away*	–	1
			metakinume	*move/change-place*	–	7
			pao	*go*	83	64
			periferome	*roam-around*	–	1
			perno	*pass*	1	1
			plisiazo	*approach*	–	1
			prohoro	*advance*	3	3
			sikonome	*get-up*	1	–
			vjeno	*exit*	4	2
			vrisko	*reach*	–	2
			periphrases		3	6
Total number	52	15	***Total number***		121	169

A2. Manner Verbs

English			*Greek*			
	Children	*Adults*		*Gloss*	*Children*	*Adults*
blow(n)	–	5	**eorume**	*swing/sway*	–	3
bounce	10	10	**anapido**	*jump-up*	–	2
dance	1	–	**vuliazo**	*sink*	1	1
drift	–	2	**vithizome**	*sink*	1	3
drown	1	–	**jirno/jirizo**	*turn/roam-around*	3	–
fall	9	16	**epipleo**	*float*	–	1
float	15	22	**kalpazo**	*gallop*	–	1
fly	21	22	**katrakilo**	*come-tumbling-down*	–	2
hop	8	2	**klotso**	*move in spurts*	–	1
ice skate	2	–	**kilo**	*roll*	–	5
jump	7	10	**parasirome/parasernome**	*get-swept-away*	–	6
leap	–	1	**perpato**	*walk*	6	–
parachute	–	1	**peto**	*fly*	6	15
pop	1	–	**pefto**	*fall*	6	19
roll	7	5	**pido**	*jump*	4	4
run	6	6	**strifojirizo/strifojirno**	*twist-and-turn*	1	3
sink	2	6	**strovilizome**	*whirl-around*	–	5
skate	7	9	**treho**	*run*	3	2
skydive	–	2	**horopido**	*jump-up-and-down*	7	2
spin	4	1	periphrases		9	22
swim	8	6				
tumble	1	–				
turn (=spin)	1	–				
twirl	–	1				
walk	5	9				
Total number	116	136	***Total number***		47	94

APPENDIX B: LINGUISTIC ELICITATION DATA FROM EXP. 2 (SAMPLE EVENTS)

I. Agent-oriented Descriptions

B1. Result Verbs

English			*Greek*			
	Children	*Adults*		*Gloss*	*Children*	*Adults*
get (+NP+PP)	1	2	**diohno**	*send-away*	1	1
put	5	–	**ferno**	*bring*	–	3
release	–	1	**katevazo**	*take-down*	2	4
send	1	–	**mazevo**	*gather/put-together*	6	9
take	1	2	**metafero**	*carry*	–	1
			pao (+NP+PP)	*take*	1	1
			perno	*take*	8	4
			prohoro (+NP)	*make-go-forward*	–	1
			vazo	*put*	–	4
Total number	8	5	***Total number***		18	28

B2. Means Verbs

English			*Greek*			
	Children	*Adults*		*Gloss*	*Children*	*Adults*
blow	2	–	**dino othisi**	*give a push*	–	1
drive	1	–	**fiso**	*blow*	1	–
float	2	–	**htipo**	*hit*	–	7
fly (+NP)	3	–	**kilo (+NP)**	*roll*	–	1
hit	3	6	**klotso**	*kick*	4	–
kick	1	2	**paraserno/parasiro**	*sweep-away*	–	4
knock	–	3	**peto (+NP)**	*throw/fly*	5	3
pull	3	12	**rihno**	*throw*	7	3
push	17	26	**serno**	*drag*	–	5
rake	5	10	**skunto**	*push*	–	1
reel	–	1	**skupizo**	*sweep*	1	1
roll (+NP)	7	2	**sprohno**	*push*	16	25
sail (+NP)	–	1	**travo**	*pull*	5	5
scrape	2	–	**tsulo (+NP)**	*tug*	–	1
smack	–	2				
tug	–	3				
Total number	46	68	***Total number***		39	57

II. Theme-oriented Descriptions

B3. Path Verbs.

English			*Greek*			
	Children	*Adults*		*Gloss*	*Children*	*Adults*
come	1	1	**aneveno**	*ascend*	1	–
get (+ PP)	–	1	**apomakrinome**	*move-away*	–	1
go	22	6	**beno**	*enter*	2	–
			diashizo	*cross*	–	2
			erhome	*come*	–	1
			fevgo	*leave*	5	3
			ftano	*arrive/reach*	–	3
			kano diadromi	*follow trajectory*	–	1
			kataligo	*end-up/reach*	–	1
			katefthinome	*head-for*	–	1
			kateveno	descend	1	1
			katiforizo	*descend/go-down*	–	1
			ksefevgo	*slip-out*	2	–
			metakinume	*move/change-place*	–	1
			pao/pijeno (+PP)	*go*	20	10
			perno	*pass*	2	–
			prohoro	*advance*	2	1
Total number	23	8	***Total number***		35	27

B4. Manner Verbs.

English			*Greek*			
	Children	*Adults*		*Gloss*	*Children*	*Adults*
fall	1	–	**horopido**	*jump-up-and-down*	1	–
float	4	4	**htipieme**	*move violently*	–	1
fly	–	1	**katrakilo**	*roll-down*	1	–
roll	–	1	**kilo**	*roll*	–	3
sail	2	2	**odigo**	*drive*	2	–
walk	–	1	**pefto**	*fall*	2	2
			pleo	*float*	–	1
Total number	7	9	***Total number***		6	7

Note to Appendix B: For verbs that have common intransitive uses, we note the transitive uses in our sample.