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The Source-Goal asymmetry in spatial language: language-general vs. language-specific aspects

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ABSTRACT
Prior research has demonstrated a linguistic asymmetry between the sources and goals of motion events, with goals being mentioned more frequently compared to sources in motion descriptions by both children and adults. Here we explore the potency and features of this asymmetry comparing linguistic production data from children and adults who speak typologically different languages (English vs. Greek). We show that the asymmetry is robust cross-linguistically and can therefore plausibly be considered a shared, potentially universal feature of spatial language. However, the Source-Goal asymmetry does not surface uniformly across different morphosyntactic devices (verbs vs. adpositions) used to encode motion across languages. Thus a shared bias in spatial language interacts with language-specific aspects of spatial encoding.

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Spatial language; source; goal; motion; Greek; acquisition

Introduction

It is widely acknowledged that aspects of the structure and acquisition of spatial language may reflect a shared, perhaps universal, conceptual system of space (Bowerman, 1996; Mandler, 1992; Pinker, 1994). For instance, Johnston and Slobin (1979) compared children learning English, Italian, Turkish, and Serbo-Croatian and found that these children learned spatial words in a broadly consistent pattern, acquiring expressions that meant something close to "in", "on", and "under" before expressions that meant "beside", "behind", "front", and "between". The researchers concluded that children's conceptual biases were responsible for this consistent timetable of spatial language acquisition.

Despite commonalities in the cross-linguistic encoding of space, languages are also characterised by important differences in spatial encoding (Bowerman, 1996; Hickmann, 2003; Levinson, 1997; Tseng, Carstensen, Regier, & Xu, 2016); furthermore, the acquisition of spatial expressions follows language-specific patterns early in language development. One example of a commonly studied difference between languages in the encoding of spatial relations is the degree-of-fit distinction that Korean speakers generally encode and English speakers do not (Bowerman & Choi, 2003; Choi & Bowerman, 1991). Specifically, putting a cap *on* a pen and putting a key *in* a lock both result in a tight-fitting relation and would be described using the same expression in Korean. English, however, cuts across this boundary by describing whether the relation involves support (*on*) or containment (*in*) regardless of how tight- or loose-fitting the relation is. In this case, as in many others, language-specific encoding patterns seem to be acquired early by children learning their native tongue (Bowerman & Choi, 2003; Choi & Bowerman, 1991).

Our objective is to examine the contributions of language-general and language-specific factors in language acquisition and use by focusing on the language used to describe motion events – more concretely, the path followed by a moving entity. Specifically, we look at an asymmetry between sources and goals in the encoding of motion paths as a way of studying how shared, potentially universal features of spatial language interact with language-specific aspects of spatial encoding.

Motion language and the Source-Goal asymmetry

Motion events are composed of a Figure (the object that moves), a Reference or Ground Object (the object with respect to which the Figure moves), Path (where the Figure moves), and Manner (how the Figure moves; Talmy, 1985). For example, in English the sentence *Mya ran to the window* includes a Figure (Mya), a Ground Object (window), a Path (to the window), and a

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Manner (ran). This sentence depicts a Goal path, since the window is the goal or endpoint of the motion. Other sentences depict Source paths: for instance, in the sentence *Mya ran away from the window*, the window is the starting point of the motion event. There is a third type of path that we will not consider here known as Route path (Jackendoff, 1983). For instance, in the sentence *Mya ran past the window*, the window is neither the starting point nor the endpoint of the event.

The linguistic encoding of motion events is characterised by an asymmetry between Source and Goal Paths. The clearest evidence for this asymmetry (otherwise known as a *goal bias*) is the tendency to encode goal path information (e.g. "The ball went *into the hole*") more frequently and systematically than source path information in a motion event (e.g. "The ball moved *away from the wall*"). This tendency is seen in production data from normally developing children, children with Williams Syndrome (a disorder resulting in a deficit of spatial cognition), and adults (Bowerman, de León, & Choi, 1995; Ihara & Fujita, 2000; Lakusta & Landau, 2005, 2012; Lakusta, Muentener, Petrillo, Mullanaphy, & Muniz, 2017; Landau & Zukowski, 2003; Papafragou, 2010; Regier & Zheng, 2007). The Source-Goal asymmetry has even been found in the gestures of children who are congenitally deaf, even though these children have no experience with conventional language (Zheng & Goldin-Meadow, 2002). Further evidence supporting the asymmetry comes from the observation that languages appear to have higher numbers of goal than source expressions in their lexicons (Regier, 1997). Furthermore, there is some evidence suggesting that both adults and children use source expressions to refer to a wider set of spatial scenes and relations compared to goal expressions (Bowerman et al., 1995; Regier & Zheng, 2007). Similarly, in comprehension, both adults and children expect novel motion expressions to encode more fine-grained lexical distinctions when they refer to goal compared to source configurations (Papafragou, 2010; cf. Fisher, Hall, Rakowitz, & Gleitman, 1994).

This linguistic asymmetry has a corollary in a non-linguistic asymmetry between source and goal representations. For example, children and adults are more likely to notice changes to Ground objects in goal compared to source paths (Lakusta & Landau, 2012; Papafragou, 2010; Regier & Zheng, 2007). Similar effects have been found even with prelinguistic infants (Lakusta & Carey, 2015; Lakusta & DiFabrizio, 2017; Lakusta, Spinelli, & Garcia, 2017; Lakusta, Wagner, O'Hearn, & Landau, 2007). Nevertheless, the homology is imperfect: the linguistic Source-Goal asymmetry seems to be in place across a variety of motion instances whether the moving Figure is animate/intentional or inanimate/non-intentional, but the cognitive advantage for goals arises only for events that involve animate/intentional Figures (Lakusta & Landau, 2012; cf., 2015; Lakusta et al., 2007 for infant data). In sum, the linguistic Source-Goal asymmetry is at least partly rooted in a cognitive bias: to the extent that preverbal infants are able to encode goal information in events better than source information, the asymmetry must be present in the spatial concepts that infants possess well before they learn to speak. In addition, there seem to be language-internal factors that contribute to the prominence of goal over source paths, even though the nature of these factors is unsettled (cf. Lakusta & Landau, 2012). For instance, some linguists have proposed incorporating many Goal paths into the argument structure of verbs (thereby treating them as verb arguments) but assigning Source paths adjunct status (Filip, 2003; Markovskaya, 2006; Nam, 2004 – but see Arsenijević, 2005; Gehrke, 2005 for criticism).

Current study: language-general and language-specific aspects of the Source-Goal asymmetry

There is currently some evidence that the Source-Goal asymmetry emerges in both adult and child speakers of different languages in ways that suggest a shared bias in spatial information encoding (see especially Bowerman et al., 1995; Ihara & Fujita, 2000; Regier & Zheng, 2007; Zheng & Goldin-Meadow, 2002). However, existing studies have not systematically compared children's and adults' path language cross-linguistically to establish how the Source-Goal asymmetry shapes the motion lexicon. Such a comparison is necessary for two reasons. First, strong cross-linguistic evidence for the Source-Goal asymmetry would lend support to the hypothesis that the asymmetry stems at least partly from non-linguistic cognition. Such evidence would be consistent with a broad position according to which core spatial-linguistic distinctions reflect shared spatial concepts (e.g. Bowerman, 1996) and develop similarly in learners of different languages (Johnston & Slobin, 1979).

Second, as alluded to already, even within the studies conducted with English-speaking adults and children, there is evidence that the linguistic Source-Goal asymmetry does not simply arise from a mapping to non-linguistic motion representation but is also subject to language-internal factors. Most of the current proposals addressing these factors have limited their attention to the status of path adpositional phrases (*into the house*, *from the cave*; cf. Nam, 2004). However, as is well known, many languages express path information (including sources and goals) in verbs (Talmy, 1985). Verbs, unlike adpositional phrases, cannot be omitted from a sentence. These cross-linguistic differences raise the possibility that properties of individual languages might shape the manifestation of the Source-Goal asymmetry during language use and acquisition – specifically, that the goal bias might be decreased or absent in languages that encode path information in the main sentential predicate.

In the experiment that follows, we address these issues by comparing motion descriptions in adult and child speakers of English and Greek. We draw from a large dataset collected as part of a cross-linguistic project on the expression of motion (see also Johanson & Papafragou, 2014). We focus on self-propelled, intentional motion events that have been shown in prior work with English speakers to induce a goal bias in both language and cognition (Papafragou, 2010). We chose to study English and Greek because they differ in how they encode path information. English expresses manner information in the verb (e.g. *run*, *walk*, *hop*) and path information in adpositions (e.g. *into*, *towards*, *from*). Greek commonly encodes path information in the verb (e.g. *vjeno* "exit", *beno* "enter", *plisiazo* "approach", *fevgo* "leave") as well as in adpositions (e.g. *mesa se* "into", *pros* "towards", *apo* "from") and manner information elsewhere in the sentence if at all. For example, the English sentence "The cat ran out of the house" encodes path information in the prepositional phrase *out of the house* and manner in the verb *ran*. In Greek, the same event would be described with the sentence "I gata vjike ekso apo to spiti" (lit. "The cat exited from the house") that encodes path in the main verb and offers additional information about the path and the Ground object in a complex prepositional phrase (but does not mention manner). In general, Greek exhibits a stronger tendency to describe exclusively path information (and to encode it across different expressions, such as verbs and adpositions) compared to English, and a correspondingly weaker tendency to express manner information. These language-specific ways of encoding motion have been extensively documented in prior work with adults (Papafragou, Hulbert, & Trueswell, 2008; Papafragou, Massey, & Gleitman, 2002, 2006) and have been shown to be available to children in both languages as early as 3 years of age (Papafragou & Selimis, 2010; Selimis & Katis, 2010; Skordos & Papafragou, 2014). Our present sample included 4- and 5-year-olds because children of this age are expected to follow language-specific patterns of encoding motion in both languages but their motion descriptions are known to be much sparser compared to those of adults (Bunger, Trueswell, & Papafragou, 2012; Papafragou, 2010).

Our experimental investigation is structured around three interrelated questions raised by these typological differences. These questions concern both the cross-linguistic robustness of the Source-Goal asymmetry and the interactions of this asymmetry with language-specific factors in spatial encoding. A first question is simply whether the Source-Goal asymmetry surfaces across these two typologically different languages. As mentioned earlier, there are good reasons to expect that the asymmetry is an in-built feature of spatial encoding and thus should broadly characterise production data across different languages. However, given that the Source-Goal asymmetry has not been extensively studied across languages, it remains an open possibility that the asymmetry is more limited (or even non-existent) in languages such as Greek that possess a number of dedicated, highly frequent verbs encoding source and goal paths.

A second, related question is how the Source-Goal asymmetry affects particular types of spatial expression (adpositions vs. verbs) in individual languages. One salient possibility is that the asymmetry would affect both the adpositional and verbal systems in English and Greek: that is, regardless of whether path information is encoded in adpositions or verbs, and regardless of the target language, goal information should be marked more consistently than source information. Another possibility is that specific morphosyntactic devices might affect the extent of the Source-Goal asymmetry cross-linguistically. For instance, since adpositions are practically the sole carriers of Path information in English but not in Greek, it is possible that the use of source adpositions is less vulnerable to the goal bias in English than in Greek. Furthermore, as mentioned already, since Greek possesses a number of dedicated source and goal verbs that cannot be freely omitted from the sentence (unlike Path adpositional phrases that are optional), the Source-Goal difference may not surface in Greek speakers' verb use.

A third question is whether (and how) the Source-Goal asymmetry impacts the structure of the motion lexicon cross-linguistically. It has been suggested in the literature that source expressions in languages are fewer in number and broader in meaning compared to goal expressions (cf. Bowerman, 1996; Bowerman et al., 1995; Papafragou, 2010; Regier, 1997; Regier & Zheng, 2007). However, the degree to which this assumption holds across both languages in our sample (and across age groups within each language) remains open. Furthermore, the poverty of the source lexicon might exhibit unexplored interactions with language-specific morphosyntactic factors. For example, since adpositions are the main vehicle of encoding path information in English but only one of such vehicles in Greek, the motion adpositional system might be more detailed/ differentiated in English compared to Greek and the loss of specificity in the source adposition lexicon might be more dramatic in Greek than in English.

Experiment

Participants

Participants were 30 English and 30 Greek speakers that fell into three different age groups: 4-year-olds, 5-year-olds, and adults. There were 10 participants in each age group for each language. For English speakers, the 4-year-olds were between the ages of 3;8 and 4;3 with a mean age of 3;11, and the 5-year-olds were between the ages of 4;9 and 5;5 with a mean age of 5;0. The child participants were recruited at the Early Learning Center in Newark, DE. The adult group was between 18;6 and 21;1 years (mean age 19;8), was recruited from the undergraduate population of the University of Delaware and received course credit for participation.

For the Greek-speaking participants, the 4-year-olds were between 3;9 and 4;3, with a mean age of 4;0, and the 5-year-olds were between 4;10 and 5;3, with a mean age of 5;0. The Greek-speaking children were recruited from the municipal daycare centre of Istiea (Evia, Greece). The Greek-speaking adults were between 18 and 40 years (mean age 27;0) and were students at an informatics seminar offered by the Institute of Continuing Adult Education (IDEKE), at Istiea-Edipsos (Evia, Greece). All Greek data were collected and coded by a native speaker of Greek.

Materials

Materials consisted of 8 different 3-sec motion configurations, each with a source and a goal path version. There were 3 examples of each path version of these configurations for a total of 48 events. Each event was presented in Microsoft PowerPoint and consisted of a soccer ball (the moving object, or Figure) and an abstract 3D object varying in colour and size (the Ground object). The same scenes were used for the Source and Goal versions, with the only change being in the direction of motion and the colour of the Ground object (see Figure 1). We designed these events to be simple and schematic, so as to deemphasize manner of motion and to promote the use of path expressions. The motion configurations (with the corresponding source/goal versions) were the following: Containment (IN/OUT OF), Cover (UNDER/FROM UNDER), Contact (TO/FROM), Support (ONTO/OFF OF), Vertical Proximity (TOWARDS THE SIDE OF/AWAY FROM THE SIDE OF), Horizontal Proximity (TOWARDS THE TOP OF/AWAY FROM THE TOP OF), Occlusion (BEHIND/FROM BEHIND), and Front (IN FRONT OF/FROM IN FRONT OF).

The stimuli were arranged in a pseudo-randomized order such that scenes of the same configuration did not appear within 3 items of each other. Once this list was set, we created a reverse version of it.

Procedure

The participants were told that they would see a series of motion events involving a ball and another "toy". After viewing each event, the participants had to describe, in their native language, what the ball did in each event. Events remained on the screen until a key press. The adult participants performed one practice trial. Half of the participants received the original and half the reverse stimulus list.

For the children, the procedure was slightly different. First, the children were told that they were going to play a game where animals play with balls and "toys". They were then shown a screen with all Reference (Ground) objects used in the materials and told to call them all "toys". Second, in order to help the children maintain attention, a slide with a small cartoon animal in one of the bottom corners was presented before each motion event. The children's attention was drawn to the animal by the experimenter saying "Look at the (animal)! Let's see what the (animal)'s ball will do!" The motion clip was then played and remained on the screen; then the experimenter asked the child to describe what the animal's ball did. The children completed at least three practice trials before beginning the experiment. Finally, the set of events was distributed over two sessions, usually a few days apart.

Coding

A native speaker coded all sentences in each language. For preliminary analyses, we coded for the presence of manner verbs such as *roll* and *jump* in English and *kilo* "roll" and *pido* "jump" in Greek. These verbs were not the main focus of our analyses, and our stimuli were designed specifically to deemphasize manner of motion so as to elicit path descriptions as noted above. Nevertheless, we wanted to ensure that their distribution would conform to the typological tendencies previously noted for the two languages (e.g. Papafragou et al., 2002; Talmy, 1985). For the same reason, we also coded for

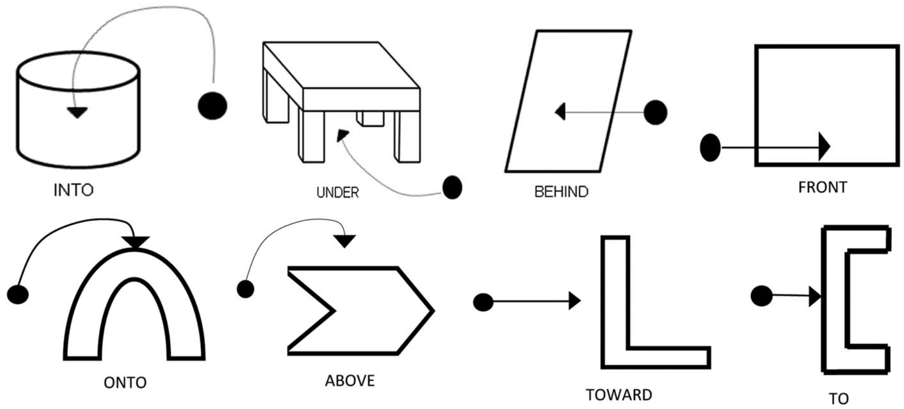

Figure 1. Examples of goal motion scenes for INTO, UNDER, BEHIND, FRONT, ONTO, ABOVE, TOWARD, and TO configurations. Source versions reversed the paths for the exact same scenes. Stimuli were three-dimensional, colour objects (and are only schematically presented here).

general motion verbs such as the English *come*, *go*, *move* and their Greek equivalents *erhome*, *pao*, *kinume*.

For our main purposes, we coded for the presence of path (specifically, source or goal) verbs. We restricted attention to path verbs whose type corresponded to the test events (i.e. source verbs given in source scenes and goal verbs given in goal scenes). See Appendix A for a complete list of path verbs in English, and Appendix B for the corresponding list in Greek. We also coded for the presence of source and goal adpositions. Again we restricted attention to path adpositions that matched the type of the test events (i.e. source adpositions given in source scenes and goal adpositions given in goal scenes). We included place adpositions that are regularly co-opted to encode paths (e.g. English, *behind, by, under,* and the corresponding Greek *piso, dipla, kato*). We coded all complex adpositions giving axial information separately (e.g. in English, *from left*, *from right*, *from top*, etc. were coded individually and distinctly from *from* alone). See Appendices C1 and C2 for lists of goal and source adpositions in English, respectively, and Appendices D1 and D2 for the corresponding lists in Greek.

If a sentence contained one of the above verbs/adpositions, we determined that it contained *target* information. We also coded for *non-target* (but still path) information. This information occurred when verbs/adpositions did not match the test events, such that goal information was given for source scenes (either alone or in addition to the target, i.e. source, information), or source information was given for goal scenes (either alone or in addition to the target information). For example, a participant might say, "The ball went *from the side of the screen* into the toy" during a goal containment event. Here, the target information is given in the goal phrase *into the toy*; *from the side of the screen* is additional non-target information about the event (since test events included a single Ground object, the additional, non-target information typically contained a landmark postulated by the participant). For the source version of this scene, a participant might say, "The ball went from the toy *to the side of the screen*", *to the side of the screen* being additional, non-target goal information.

Results and discussion

Do English and Greek speakers differ in how they encode motion?

We ran a preliminary set of analyses to ensure that our sample of English and Greek speakers behaved consistently with the expected typological patterns of motion encoding (Papafragou et al., 2002; Talmy, 1985, among others). Beginning with manner verbs, an ANOVA with Language (English, Greek) and Age (Adults, 5-year-olds, 4-year-olds) as factors and the proportion of manner verb tokens as the dependent variable revealed effects of both Age ($F(2, 54) = 3.77$, $p = .03$, *partial* $\eta^2 = .12$; $M_{AD} = .22$, $M_{5Y} = .13$, $M_{4Y} = .08$), and Language ($F(1, 54) = 5.65$, $p = .02$, *partial* $\eta^2 = .09$; $M_{ENG} = .20$, $M_{GR} = .09$) but no interaction between Age and Language. Further one-way ANOVAs exploring the effect of Age showed that only the difference between the 4-year-old children and the adults was significant ($F(1, 38) = 5.79$, $p = .02$). As expected, English speakers were more likely than Greek speakers to use manner verbs. However, overall, our stimuli succeeded in deemphasizing manner of motion. As a result, unlike most prior studies (Gennari, Sloman, Malt, & Fitch, 2002; Papafragou et al., 2002; Papafragou & Selimis, 2010), English speakers here used manner of motion verbs in a minority of their motion descriptions.

We next looked at the proportion of target path verb tokens for English and Greek speakers. This proportion was entered into a similar ANOVA with Language and Age as factors. The analysis returned a main effect of Language ($F(1, 54) = 151.22$, $p < .0001$, *partial* $\eta^2 = .73$): Greek speakers used significantly more path verbs than English speakers did ($M_{ENG} = .01$, $M_{GR} = .32$). In addition, there was a significant effect of Age ($F(2, 54) = 11.28$, $p < .0001$, *partial* $\eta^2 = .29$) and a significant Age by Language interaction ($F(2, 54) = 10.50$, $p < .0001$, *partial* $\eta^2 = .28$). Additional ANOVAs revealed that this interaction was due to the fact that there was no Age effect for English speakers ($F(2, 27) = .53$, $p = .55$, n.s.) but there was a significant Age effect for Greek speakers ($F(2, 27) = 10.95$, $p < .0001$). Specifically, in Greek, the adults used significantly more path verbs ($M_{AD} = .48$) than both the 5-year-old ($F(1, 18) = 17.12$, $p = .001$; $M_{5Y} = .23$) and 4-year-old children ($F(1, 18) = 20.20$, $p < .0001$; $M_{4Y} = .23$). The 5- and 4-year-old children did not differ from each other ($F(1, 18) = 0.005$, $p = .94$, n.s.). Thus in English use of path verbs was very low across all ages but in Greek path verb use increased with age.

For completeness, we also compared general path or motion verb tokens (mainly deictic ones) across languages and age groups. The analysis revealed only a main effect of Language ($F(1, 54) = 28.31$, $p < .0001$, *partial* $\eta^2 = .34$), with English speakers using more tokens of verbs such as *come*, *go* and *move* compared to Greek speakers ($M_{ENG} = .60$, $M_{GR} = .30$). The high use of such verbs in English may seem surprising. Recall, however, that our stimuli deemphasized manner and purposely turned English speakers into Greeks, so to speak. Even so, cross-linguistic differences in verb use persisted: unlike Greek, specific (source-goal) path verbs such as *exit* and *enter* were dispreferred in English, and English speakers massively turned to general path or motion verbs to express change of location.

Finally, we looked at the use of target path adpositions. We entered the proportion of path adposition tokens into an ANOVA with Language and Age as factors. As expected, the analysis returned a main effect of Language ($F(1, 54) = 15.18$, $p < .0001$, *partial* $\eta^2 = .21$), with English speakers using more path adpositions than Greek speakers ($M_{ENG} = .72$, $M_{GR} = .55$). Again, there was a significant effect of Age ($F(2, 54) = 20.96$, $p < .0001$, *partial* $\eta^2 = .43$): adults used more path adpositions ($M_{AD} = .84$) than either 5-year-olds ($F(1, 38) = 23.35$, $p < .0001$, $M_{5Y} = .56$) or 4-year-olds ($F(1, 38) = 35.76$, $p < .0001$, $M_{4Y} = .51$), but the two groups of children did not differ from each other. There was no Age by Language interaction.

Taken together, the results in this section confirmed the presence of typological differences in how English and Greek speakers linguistically encode motion information (Papafragou et al., 2002, 2006; Talmy, 1985; among others). English speakers were more likely than Greek speakers to use manner verbs (even though, overall, the use of such verbs was diminished in our data because of the nature of our stimuli), and the opposite was true of path verbs. Moreover, target (source/goal) adpositions were used more frequently in English than in Greek, since they were the sole means of encoding path information in that language. We next proceeded to the main questions motivating this work.

Do English and Greek speakers observe the Source-Goal asymmetry?

We began with the first question raised at the end of the Introduction, namely whether the Source-Goal asymmetry was strong enough to persist across these two typologically different languages. First, we looked at the frequency of target source and goal information that speakers provided in their descriptions of the scenes. That is, we looked at the proportion of goal information provided for goal scenes and source information provided for source scenes regardless of whether this information was encoded in a verb or adposition. We conducted a MANOVA with the proportion of target information as the dependent variable and Language (English, Greek), Age (Adults, 5-year-olds, 4-year-olds), and Scene Version (Source, Goal) as factors (see Figure 2). The results from this analysis reveal a significant effect of Age ($F(2, 54) = 22.04$, $p < .0001$, *partial* $\eta^2 = .44$) as well as a significant effect of Scene Version in the expected direction ($F(1, 54) = 71.25$, $p < .0001$, *partial* $\eta^2 = .56$; $M_{SOURCE} = .55$, $M_{GOAL} = .84$). There was also a marginal interaction of Age with Scene Version ($F(2, 54) = 5.22$, $p = .08$, *partial* $\eta^2 = .16$). The interaction was due to the fact that both the 4-year-old ($F(1, 19) = 31.96$, $p < .0001$; $M_{SOURCE} = .42$, $M_{GOAL} = .74$) and the 5-year-old children ($F(1, 19) = 26.27$, $p < .0001$; $M_{SOURCE} = .49$, $M_{GOAL} = .81$) showed a preferential bias to encode goal over source information. Adults, however, showed less of a difference between use of target information in Source and Goal scenes, though the difference was still significant ($F(1, 19) = 18.95$, $p < .0001$; $M_{SOURCE} = .85$, $M_{GOAL} = .97$). Generally, adults almost always included target information, probably because the events were very simple, with only one ground object and one figure object. Finally, there was no effect of Language and no other interactions. Therefore, the Source-Goal asymmetry here affected the amount of target information given in both languages to the same extent – i.e. the asymmetry persisted despite the typological differences between the two languages.

We next took a look at non-target information provided in these event descriptions. Recall that non-target

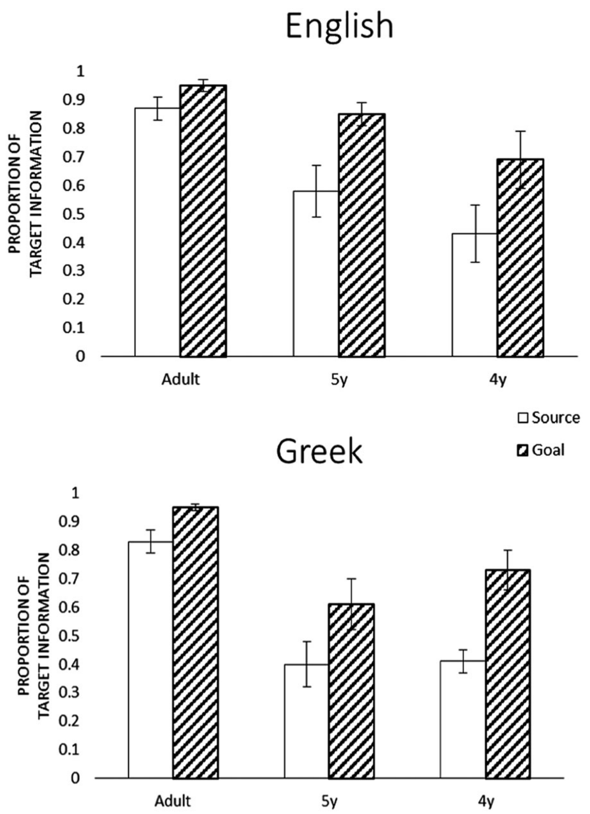

Figure 2. Proportion of target information given by English and Greek speakers in Source and Goal Scenes.

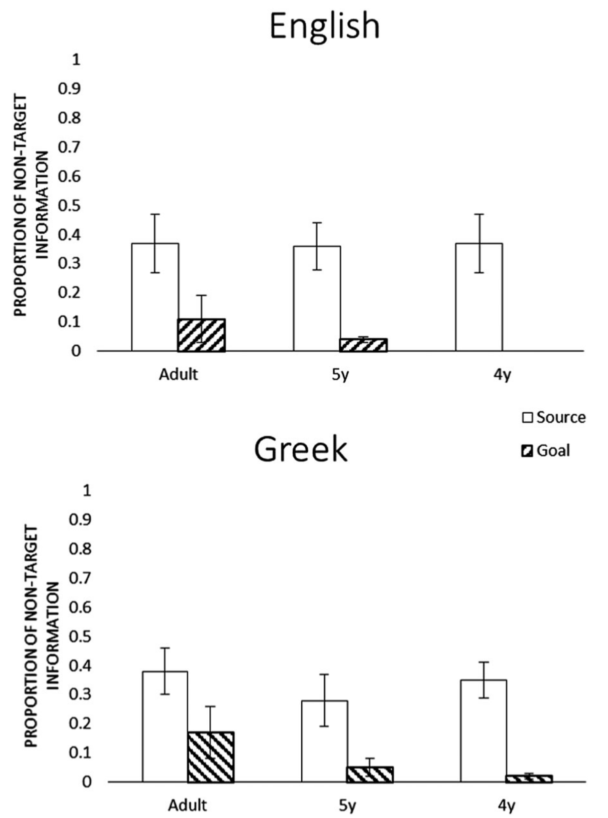

Figure 3. Proportion of non-target information given by English and Greek speakers in Source and Goal Scenes.

information refers to extra information that was occasionally added to the sentence even though it did not describe the test event itself, but instead described some other aspect of motion. If goal information was encoded more consistently than source information, we might expect non-target (=goal) information to appear more often in source scenes than non-target (=source) information in goal scenes. Figure 3 represents the proportion of non-target information given by English and Greek speakers. A MANOVA with proportion of non-target information as the dependent variable and Language, Age, and Scene Version as factors revealed only a significant effect of Scene Version in the expected direction ($F(1, 54) = 46.11$, $p < .0001$, *partial* $\eta^2 = .46$; $M_{\mathrm{GOAL}} = .07$, $M_{\mathrm{SOURCE}} = .35$). When speakers offered additional, non-target information about the motion events, goal information was added more consistently to the description of the main event in source scenes compared to source information in goal scenes.

How does the Source-Goal asymmetry surface cross-linguistically?

A second major question concerned how the Source-Goal asymmetry would manifest itself cross-linguistically given that English and Greek make different use of types of spatial expression (adposition or verb). A first possibility was that the asymmetry might be strong enough to affect both the adpositional and verbal systems in English and Greek. A second possibility was that the asymmetry might show some language-specific aspects. For instance, the asymmetry might be less evident in English compared to Greek adpositions, since these adpositions are the only means of encoding path information in English but not in Greek. Alternatively, the Source-Goal asymmetry might be diminished in or absent from uses of the Greek path verb system either because verbs (unlike adpositional phrases) cannot be omitted, and/or because Greek possesses dedicated source and goal path verbs. To explore these questions, we examined the frequency of source versus goal encoding split by syntactic expression (adposition or verb).

Path adpositions

Beginning with the target adposition data, we ran a MANOVA with Language, Age, and Scene Version as independent variables and proportion of adposition tokens as the dependent variable (see Figure 4). There was a main effect of Language ($F(1,54) = 15.18$, $p < .0001$, *partial* η^2

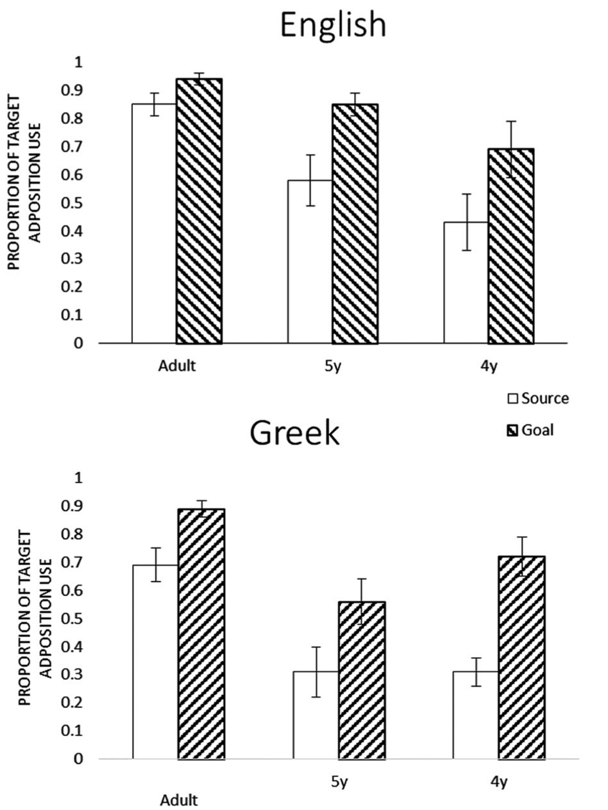

Figure 4. Proportion of target adpositions given by English and Greek speakers in Source and Goal Scenes.

$= .21$; $M_{ENG} = .72$, $M_{GR} = .55$): as expected from prior literature on cross-linguistic motion encoding, English speakers used target path adpositions more frequently compared to Greek speakers. Furthermore, there was a main effect of Age ($F(2,54) = 20.96$, $p < .0001$, *partial* $\eta^2 = .43$; $M_{AD} = .84$, $M_{5Y} = .57$, $M_{4Y} = .51$). In addition, there was a main effect of Scene Version ($F(1,54) = 57.24$, $p < .0001$; $M_{SOURCE} = .53$, $M_{GOAL} = .78$), qualified by interactions between Scene Version and Age ($F(2,54) = 3.801$, $p = .03$, *partial* $\eta^2 = .12$), and Scene Version and Language ($F(2,54) = 4.55$, $p = .04$, *partial* $\eta^2 = .08$). Separate analyses investigating the first of these interactions found a significant difference in use of adpositions for source and goal scenes in adults ($F(1, 19) = 11.14$, $p = .003$; $M_{GOAL} = .91$, $M_{SOURCE} = .77$), 5-year-olds ($F(1, 19) = 14.71$, $p = .001$; $M_{GOAL} = .69$, $M_{SOURCE} = .43$), and 4-year olds ($F(1, 19) = 28.57$, $p < .0001$; $M_{GOAL} = .68$, $M_{SOURCE} = .34$), though the difference was greater in children than in adults. Furthermore, analyses pursuing the Scene Version by Language interaction revealed that English speakers used target adpositions in source scenes more frequently than Greek speakers ($F(1, 58) = 10.20$, $p < .0001$; $M_{ENG} = .64$, $M_{GR} = .39$) but this difference was marginal for goal scenes ($F(1, 58) = 3.30$, $p = .07$; $M_{ENG} = .81$, $M_{GR} = .70$).

Overall, these data strongly support the presence of the Source-Goal asymmetry: across languages and ages

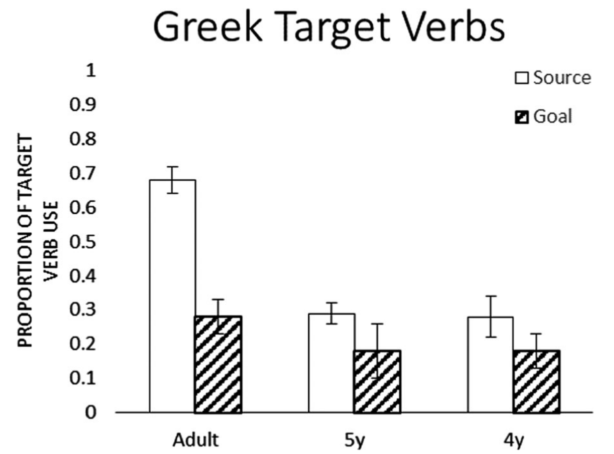

Figure 5. Proportion of target path verbs given by Greek speakers in Source and Goal Scenes.

participants were more likely to use path adpositions in goal scenes than in source scenes. The asymmetry was especially pronounced in children who used source adpositions infrequently (in less than half of their responses). Furthermore, this asymmetry interacted with features of the specific language: source adposition meanings were particularly vulnerable in Greek compared to English speakers. This is consistent with the fact that Greek distributes path meanings across verbs and adpositions and is overall less likely to use adpositions to encode path meanings compared to English.

Path verbs

Turning to the Greek target path verb data (path verb use in English was negligible), we ran a MANOVA with Age and Scene Version as independent variables and proportion of path verb tokens as the dependent variable (see Figure 5). The results showed a main effect of Age ($F(2, 27) = 12.32$, $p = .0002$, *partial* $\eta^2 = .47$) and a main effect of Scene Version ($F(1, 27) = 24.09$, $p < .0001$, *partial* $\eta^2 = .47$) – but in an unexpected direction ($M_{SOURCE} = .42$, $M_{GOAL} = .21$). Furthermore, there was an Age by Scene Version interaction ($F(2, 27) = 5.31$, $p = .01$, *partial* $\eta^2 = .28$). Follow-up analyses revealed an Age effect in the source ($F(2, 27) = 25.27$, $p < .0001$, $M_{AD} = .68$, $M_{5Y} = .29$, $M_{4Y} = .28$) but not the goal scene versions ($M_{AD} = .28$, $M_{5Y} = .18$, $M_{4Y} = .18$). Specifically, Greek-speaking adults used more path verbs in source scenes than either 5-year-old ($F(1, 18) = 49.14$, $p < .0001$) or 4-year-old children ($F(1, 18) = 31.18$, $p < .0001$) but there was no such difference in the goal scenes. A complementary set of follow-up analyses showed that Greek-speaking adults demonstrated a *source* bias in their use of path verbs ($F(1, 9) = 51.25$, $p < .0001$), but there was neither a source nor a goal bias in 5-year-old ($F(1,9) = 1.46$, $p = .26$) and 4-year-old children ($F(1, 9) = 2.62$, $p = .14$).

Overall, path verbs behaved differently from adpositions, which displayed a clear goal bias in both English and Greek. This fact supports the hypothesis that morphosyntactic properties of different languages affect the manifestations of the Source-Goal asymmetry. Recall that, according to one hypothesis, the asymmetry between source and goal encoding might be diminished or eliminated in the use of the verb system. This was confirmed in the use of path verbs by Greek-speaking children, where there was no asymmetry between source and goal verb uses. In Greek-speaking adults, because of increased use of source verbs, the goal bias was *reversed*.

These frequency patterns cannot be explained by the fact that, unlike path adpositional phrases, path verbs cannot be freely omitted from the sentence: this fact could explain the resilience of source verbs but not the *reversal* of the goal bias in the verb domain. Notice that path verbs (just like adpositions) are members of a closed word class and encode a relatively restricted and abstract set of spatial meanings (see also Skordos & Papafragou, 2014). This is confirmed by the observation that, in Greek, the inventory of source- or goal-oriented path verbs appears limited overall (see Appendix B). We probe further into the properties of such verbs in the next section.

Is goal encoding more fine-grained than source encoding cross-linguistically?

A third issue was whether the number of different adpositions and verbs used by speakers of each language would vary between sources and goals (with more options available for goal compared to source encoding), and whether source expressions would be used in a wider range of scenes than goal expressions (i.e. whether they would be less specific in their meaning; cf. Bowerman et al., 1995; Papafragou, 2010; Regier, 1997; Regier & Zheng, 2007). One possibility was that these lexical facts, if true, would characterise the lexicon in both English and Greek. Another possibility was that both the number and the semantic specificity of source and goal terms might differ by language. For example, since adpositions are the main means of encoding Path information in English but not in Greek, the motion adpositional system might be more fine-grained in English compared to Greek and the loss of distinctions in source terms might impact Greek more than in English.

Path adpositions

To ask whether goal adpositions would be more heavily represented in the lexicon compared to source adpositions, we conducted a MANOVA using the number of distinct target adposition types used by each speaker as the dependent variable and Language, Age, and Scene Version as factors (see Figure 6). The analysis returned main effects of Language ($F(1, 54) = 8.35$, $p = .006$, *partial* $\eta^2 = .13$; $M_{ENG} = 5.77$, $M_{GR} = 4.85$) and Age ($F(2, 24) = 46.70$, $p < .0001$, *partial* $\eta^2 = .63$; $M_{AD} = 7.48$, $M_{5Y} = 4.28$, $M_{4Y} = 4.18$). In addition, there was an Age by Language interaction ($F(2, 54) = 10.62$, $p < .0001$, *partial* $\eta^2 = .28$) due to significant differences in the number of path adposition types between English and Greek speakers in the 5-year-old group ($F(1, 18) = 7.76$, $p = .012$) and the adult group ($F(1, 18) = 26.71$, $p < .0001$), but not the 4-year-old group ($F(1, 18) = 2.47$, $p = .13$; n.s.): as expected, more mature English speakers (i.e. adults and 5-year-olds) used more path adposition types compared to Greek speakers – but at younger ages, this difference disappeared.

The analysis also revealed an effect of Scene Version ($F(1, 54) = 223.23$, $p < .0001$, *partial* $\eta^2 = .80$), with higher numbers of distinct path adposition types in goal compared to source scenes ($M_{GOAL} = 7.07$, $M_{SOURCE} = 3.55$). There was also a marginal interaction of Scene Version, Age and Language ($F(2, 54) = 2.95$, $p = .06$, *partial* $\eta^2 = .09$). Tentative further analyses showed that there was an interaction of Scene Version and Language in 5-year-olds only ($F(1, 18) = 6.63$, $p = .02$): in adults and

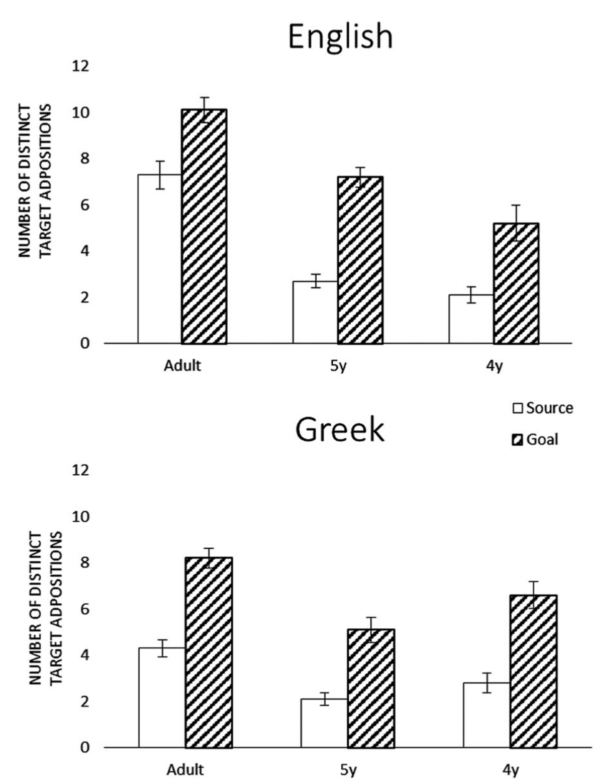

Figure 6. Number of distinct target path adpositions used by English and Greek speakers in Source and Goal Scenes.

4-year-olds, the number of adposition types was higher in English-speaking compared to Greek-speaking participants regardless of Scene Version but in 5-year-olds this was only true of goal scenes ($M_{ENG} = 7.20$, $M_{GR} = 5.10$) but not source scenes ($M_{ENG} = 2.70$, $M_{GR} = 2.10$).

To look at the meaning specificity of these adposition types, we measured their *referential spread* defined as the total number of stimuli a target adposition type was used for by each participant regardless of specifics of the stimuli (cf. also Regier & Zheng, 2007). We ran a MANOVA using the average referential spread for each target adposition type as the dependent variable and Language (English, Greek), Age (Adults, 5-year-olds, 4-year-olds), and Scene Version (Source, Goal) as factors. The analysis returned an effect of Language ($F(1, 54) = 14.10$, $p = .0004$, *partial* $\eta^2 = .20$; $M_{ENG} = 2.42$, $M_{GR} = 3.49$), as well as an effect of Scene Version ($F(1, 54) = 4.09$, $p = .048$, *partial* $\eta^2 = .07$; $M_{GOAL} = 2.70$, $M_{SOURCE} = 3.21$), but no effect of Age (see Figure 7). In addition, there was a significant Language by Scene Version interaction ($F(1, 54) = 13.03$, $p = .001$, *partial* $\eta^2 = .19$): there was a significant effect of Scene Version in the Greek data ($F(1, 27) = 9.84$, $p = .004$; $M_{GOAL} = 2.78$, $M_{SOURCE} = 4.20$), but only a marginal such effect in the English data ($F(1, 27) = 3.24$, $p = .08$; $M_{GOAL} = 2.62$, $M_{SOURCE} = 2.22$). That is, Greek speakers used each source adposition type to describe a higher number of scenes compared to each goal adposition type – but no such difference emerged reliably in English speakers (even though a trend in this direction was found). Note that the overall referential spread was lower in English than Greek adpositions – and thus the increased specificity in the uses of the adpositional system in English may have counteracted the workings of a bias to encode goal scenes.

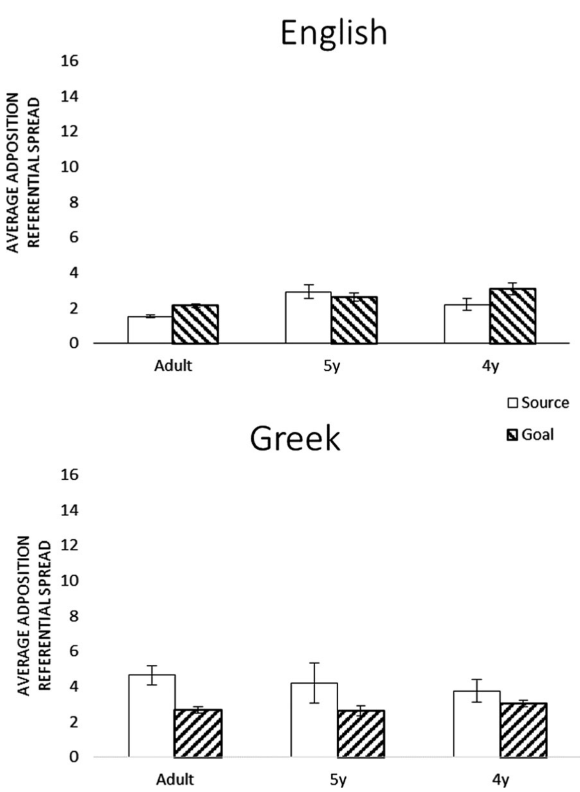

Figure 7. Average referential spread of source and goal adpositions.

Path verbs

Finally, we examined the variety and meaning specificity of target path verbs in Greek. Given the absence (or reversal) of the Source-Goal asymmetry in our earlier analysis of the token frequency of Greek path verbs, it is of interest whether the semantic structure of the Greek path verb system – especially in its fully mature, adult form – offers a genuine counterexample to the Source-Goal asymmetry. If so, further measures such as the number of different source and goal verb types and/or the referential spread of such verb types should also fail to reveal an advantage for goal paths. Alternatively, further measures might show that the general bias favouring goal paths surfaces selectively in the profile of Greek path verbs.

We conducted a MANOVA with the number of distinct path verb types used by each Greek speaker as the dependent variable and Age and Scene Version as factors (see Figure 8). The analysis revealed only an effect of Age ($F(2, 27) = 13.05$, $p < .0001$, *partial* $\eta^2 = .49$; $M_{AD} = 2.7$, $M_{5Y} = 1.25$, $M_{4Y} = 1.35$) and an effect of Scene Version – but in an unexpected direction ($F(1, 27) = 18.93$, $p < .0001$, *partial* $\eta^2 = .41$; $M_{SOURCE} = 2.03$, $M_{GOAL} = 1.43$): contrary to the predictions arising from the Source-Goal asymmetry, Greek speakers used more source verb types on average than goal verb types. This asymmetry needs to be interpreted with caution

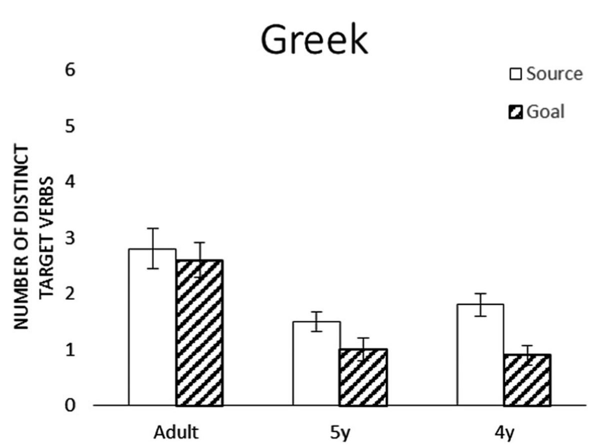

Figure 8. Number of distinct target path verbs used by Greek speakers in Source and Goal Scenes.

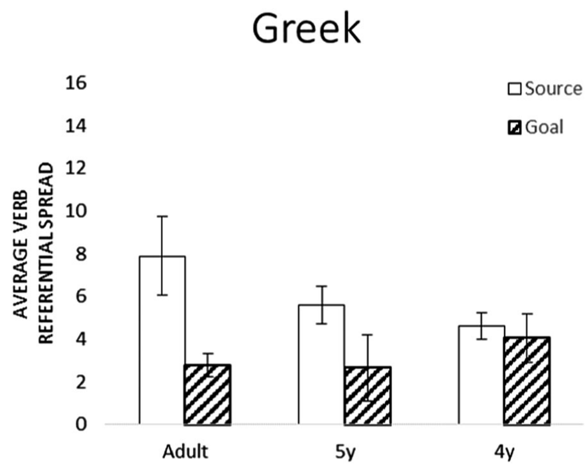

Figure 9. Average referential spread of Greek source and goal verbs.

because the number of distinct source or goal verb types was very low (see also Appendix A that summarises all verb types present in the dataset). Nevertheless, this result is reminiscent of the finding that source verb tokens in Greek were used more frequently than goal verb tokens by adults (and as frequently as goal verb tokens by children).

We also conducted a MANOVA using the average number of stimuli a verb type was used to describe (i.e. its referential spread) as the dependent variable and Age (Adults, 5-year-olds, 4-year-olds) and Scene Version (Source, Goal) as factors (see Figure 9). Only a main effect of Scene Version was found ($F(1, 27) = 8.33$, $p = .0008$, partial $\eta^2 = .23$; $M_{\mathrm{GOAL}} = 3.5$, $M_{\mathrm{SOURCE}} = 6.04$): source verb types were used to describe, on average, a larger number of scenes compared to goal verb types. Thus the semantic specificity of the Greek path verb system confirms the Source-Goal asymmetry, with more acute loss of specificity characterising source compared to goal meanings. We conclude that the Source-Goal asymmetry is not inert in the case of Greek path verbs but surfaces differently depending on different demands on the use of these verbs (see also next section).

Conclusion

Our aim in this paper was to explore language-general and language-specific aspects of the Source-Goal asymmetry to gain a better understanding of the factors that shape motion vocabularies across languages. We asked child and adult speakers of English and Greek to describe simple motion events and analyzed the descriptions to detect similarities and differences between the languages. English and Greek provided an interesting comparison for our purposes because of the differences in encoding motion information. Briefly, English encodes path information in adpositions whereas Greek encodes path information both in verbs and in adpositions. This pattern was confirmed in our own data and provided the rationale for further exploring the ways in which the Source-Goal asymmetry might interact with specific morphosyntactic properties of the two languages.

As a first step, we assessed whether the Source-Goal asymmetry would be equally strong in terms of the total amount of motion information provided in English compared to Greek, regardless of the particular devices for encoding such information and any language-specific patterns in how these devices are employed. Our analyses confirmed this expectation: both English- and Greek-speaking adults and children provided target information more often for goal than for source scenes. Moreover, speakers of both languages in all age groups were more likely to include goal information rather redundantly when describing a source scene than to include source information when describing a goal scene. These data offer strong cross-linguistic confirmation for the existence of the Source-Goal asymmetry (e.g. Lakusta & Landau, 2005, 2012; Landau & Zukowski, 2003; Regier & Zheng, 2007), and extend previous work by showing how the asymmetry impacts language production across young and more mature speakers from different language backgrounds (cf. also Lakusta, Yoshida, Landau, & Smith, 2006).

We next explored how source and goal information was encoded in the specific devices used in the two languages to encode motion (adpositions vs. verbs). In the domain of path adpositions, despite cross-linguistic and developmental differences in how often such adpositions were mentioned (with English speakers mentioning them more often than Greek speakers, and adults mentioning them more often than children), the Source-Goal asymmetry was confirmed: across languages and ages, the frequency of path adpositions was higher in goal scenes than in source scenes. Similarly, despite the fact that older learners and adults speaking English used a greater number of distinct path adpositions than Greek speakers of the same age, a shared tendency emerged: the number of such adpositions was higher in goal than source scenes across languages and age groups. Our data did reveal some language-specific patterns, however. Source adpositions were more vulnerable in Greek compared to English speakers, presumably because of the more robust adpositional encoding of paths in English. Furthermore, when the semantic specificity of each adposition was measured in terms of the number of different events for which it was used (what we called its *referential* *spread*), it was found that source adpositions were referentially more permissive than goal expressions in Greek but there was only a trend in this direction in English. Thus, even though the Source-Goal asymmetry impacts the semantic specificity of individual path adpositions, this effect is obscured when adposition meaning is already quite specific (as in English). Together, these data reveal robust cross-linguistic similarities in how the Source-Goal asymmetry impacts the distribution of spatial adpositions in language production, and support the hypothesis that the source domain captures fewer meaning distinctions compared to the goal domain (cf. Bowerman, 1985; Bowerman et al., 1995; Papafragou, 2010; Regier, 2007; Regier & Zheng, 2007). They also point to ways in which language-specific aspects of adposition systems either protect or make more vulnerable the encoding or the specificity of source meanings.

In the domain of path verbs in Greek, a more nuanced pattern of results emerged. Unlike adpositions, path verb use showed no evidence of a goal bias: Greek-speaking children used target path verbs equally frequently in source and goal scenes and, most surprisingly, Greek-speaking adults provided such verbs more often in *source* than in goal scenes. Similarly, the number of different path verbs used in Greek was higher in source than in goal scenes, showing no evidence of a tendency to carve up the semantic space of motion more finely in the goal compared to the source domain. However, when the referential spread of Greek source and goal verbs was compared, source verbs were found to be referentially broader compared to goal verbs, thereby confirming a key component of the Source-Goal asymmetry. This last result is reminiscent of the finding that, in a word learning context, both adults and children expect novel motion verbs to encode more fine-grained lexical distinctions when those verbs describe goal compared to source configurations (Papafragou, 2010).

Taken together, our data offer support for the conclusion that the goal bias emerges out of robust, possibly universal ways of processing motion linguistically but manifests itself somewhat differently across individual languages and types of expression used to encode motion. This perspective is consistent with the view that there is a complex interaction between spatial conceptualisation and language, and that language does not seem to fully and directly reflect the non-linguistic encoding of sources and goals (Lakusta & Landau, 2012).

Universal and language-specific aspects of spatial language

Recall that classic theories of language learning assume that spatial language relies on underlying conceptual representations of objects and spatial relations that are accessible to both adults and children and structure the acquisition of spatial vocabulary (cf. Bowerman, 1996; Mandler, 1992; Pinker, 1994). Other theories point out that individual languages differ in how they map linguistic forms onto the semantic space and propose that the task of acquiring spatial language may involve quite different representations for learners of different language systems (Bowerman & Choi, 2003; Levinson, 1997).

Bridging these two perspectives, we suggest that both language-general and language-specific patterns play a role in the structure and acquisition of spatial language (see also Landau & Jackendoff, 1993; Levinson, 1997; Malt et al., 2008; Papafragou et al., 2002). In our data, an underlying, shared spatial bias (a preference for goal encoding) was shown to constrain young and more experienced (adult) users' spatial terminology in two typologically different languages – precisely as expected by the classical theories described above. Importantly, the non-linguistic bias motivated but did not completely determine the linguistic data: motion descriptions showed a strong language-specific signature even in young learners (cf. the division of labour between motion path verbs and adpositions). Furthermore, different morphosyntactic options (such as lexical verbs and adpositions) in the two languages in our sample did not submit in identical ways to the general bias underlying the expression of source and goal paths.

These results cohere with findings on other aspects of the acquisition of spatial language that are also subject to a complex interplay between universal and language-particular factors (see Maguire et al., 2010; Naigles & Terrazas, 1998; Skordos & Papafragou, 2014, on manner and path of motion; and Bowerman & Choi, 2003; Choi & Bowerman, 1991; Johnston & Slobin, 1979, on spatial relations, among many others). In a recent demonstration of how commonalities in cognition surface differently in learners of individual languages (Ünal, Trueswell, & Papafragou, 2017), 3- and 4-year-old learners of English and Turkish described motion events consisting of an Agent using an Instrument to move a Patient towards a Goal (e.g. a woman using a tennis racket to hit a ball into a basket). Prior to the linguistic task, the children were given a change-detection task that measured their sensitivity to (non-linguistic) Agents, Instruments, Patients and Goals. Despite broad similarities in how children from both language communities detected changes to individual event components, Turkish learners were much less likely to mention Agents in their verbal descriptions compared to English learners, since Turkish allows dropping subjects (often, Agents) from overt sentences. Thus broad cognitive similarities in how learners encoded events non-linguistically were mapped differently onto linguistic structures because of language-specific syntactic constraints on argument realisation.

Extensions and future directions

Several directions remain open for future work. First, our study elicited a goal bias using an inanimate but self-propelled object (a ball) as the agent. Recall that children were informed that the ball belonged to an animal and may have reasonably assumed that its motion was caused by that animal. Similarly, for adults, the fact that the ball in our stimuli was self-propelled presumably led to the background assumption that its movement was intentional (i.e. caused by an unseen agent). In terms of these design features, our study differs from prior work that had reported that the goal bias does not emerge when infants conceptually represent motion events with inanimate agents (since those agents were nonintentional/non-self-propelled; Lakusta & Carey, 2008, 2015; Lakusta et al., 2007). It is an open question whether similar results would emerge if our events involved a different type of inanimate agent (e.g. a piece of paper blown about by the wind). However, in light of more recent work reporting that the linguistic goal bias characterises both intentional and non-intentional/physical events (Lakusta & Landau, 2012), it is reasonable to assume that the present finding would generalise to contexts where the agent lacks intentionality or control of the motion.

Second, the present stimuli were highly schematic: they purposefully downplayed manners of motion and highlighted contrasts between simple source and goal paths. These features might have promoted the use of source expressions, especially in Greek speakers whose language has several means for expressing path information. Future work should continue to explore cross-linguistic differences in source and goal path encoding using a greater variety of visual objects and scenes.

Third, the present findings underscore the importance of looking at both verbs and adpositions when studying the use and acquisition of spatial language cross-linguistically (cf. also Landau, Johannes, Skordos, & Papafragou, 2017, for a similar point). In our data, the broad developmental trajectories of these devices across languages reveal interesting patterns. An important observation is that, even for 4- and 5-year-old children, the production of spatial verbs and adpositions is often not adult-like in the languages we studied. Thus the development of these spatial expressions continues into later years (see also Bunger et al., 2012; Papafragou, 2010). Furthermore, despite the fact that Greek and similar languages (e.g. Spanish) have been widely reported to be path-verb-oriented (e.g. Gennari et al., 2002; Papafragou et al., 2002, 2006; Selimis & Katis, 2010), these reports have focused on the class of path verbs broadly defined (including widely used general path verbs such as *erhome* "come" and *pao* "go"). In our data, the distribution of more specialised source or goal path verbs such as *beno* "enter", *vjeno* "exit" and *fevgo* "leave" was relatively sparse in the speech of Greek-speaking children; even in adults their use was restricted – with the notable exception of source verbs (Figure 5 and Appendix B). Similarly, in both adults and children, the repertoire of distinct source and goal verb types was limited (Figure 8). The acquisition of the division of labour between path verbs and adpositions as well as of types of spatial meanings encoded by each device remain ripe for future work.

Final summary

Prior research has demonstrated a linguistic asymmetry between the sources and goals of motion events, with goals being mentioned more frequently compared to sources in motion descriptions by both children and adults. Using production data from child and adult speakers of English and Greek, we showed that the asymmetry is robust cross-linguistically and can therefore plausibly be considered a shared, potentially universal feature of spatial language. However, the Source-Goal asymmetry does not surface uniformly across different morphosyntactic devices (verbs vs. adpositions) used to encode motion across languages. We conclude that a shared bias in spatial language interacts with language-specific aspects of spatial encoding, and this interaction shapes the nature and acquisition of motion vocabularies across languages.

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