Cross-Linguistic Biases in the Semantics and Acquisition of Spatial Language

Megan Johanson[1], Stathis Selimis[2] and Anna Papafragou[3]
[1, 3] University of Delaware [2] National and Kapodistrian University of Athens

1. Introduction

What is the relationship between spatial language and cognition? It is widely assumed that spatial language builds on non-linguistic shared spatial concepts (Landau & Jackendoff, 1993; Miller & Johnson-Laird, 1977; Talmy, 1985) – even though the nature of these concepts is still under investigation (Levinson & Meira, 2003; Li & Gleitman, 2002). There are several pieces of evidence that support this position. First, children develop spatial language in a similar pattern cross-linguistically (Johnston & Slobin, 1978; Leikin, 1998). According to this basic, perhaps universal, order of acquisition, expressions equivalent to *in/on/under* are acquired very early on followed by synonyms of *beside* and later by expressions denoting *back/front/between*.

A second piece of evidence for the role of non-linguistic spatial concepts in the acquisition of spatial language comes from children's overextension patterns. For example, Bowerman and Choi (2001) discuss an early extension pattern of the expression "open." When children learning English first begin using this expression, they use it not only for doors and windows, but also for pulling apart two Frisbees or for turning on the lights. In English, this extension is inappropriate. However, in some other languages, such as Greek, the verb for "open" (*anijo*) is appropriate for some of those situations (e.g., *anijo ta fota*, lit. 'open the lights'). This shows that English-learning children are behaving unlike adults in their own language but similar to adult speakers of a different language. Such overextensions are thus evidence of learner-driven contributions to the structure of spatial language.

---

* This research was supported by NSF grant BCS#0641105 to Anna Papafragou. The authors would like to thank the members of the Language and Cognition Lab at UD as well as the Early Learning Center (UD).

These two pieces of evidence are taken as support for a reliance on language independent spatial concepts (Bowerman, 2001; Mandler, 2004). They also show that cross-linguistic patterns in the acquisition and extension of spatial language might reveal natural concepts or biases in spatial cognition. With this idea in mind, in the present research we explore how adults and children who speak different languages express spatial relations – specifically relations that characterize motion paths. We focus on speakers of English and Greek, since the two languages differ in how they encode motion paths (Papafragou, Massey, & Gleitman, 2002; Talmy, 1985). In English, path information is most commonly encoded in prepositions. In Greek, however, path information can be encoded in either prepositions or verbs.

For current purposes, our investigation concentrates on two questions. First, we ask whether the expression of motion paths in Greek obeys a well-documented asymmetry in the linguistic and non-linguistic representation of motion events: people give preferential focus to the endpoint of a motion event over the starting point. This asymmetry has been shown with adult speakers of languages that encode path information in different ways (Regier & Zheng, 2007). In addition, this asymmetry has been found in the language of children with and without William's Syndrome, a rare disorder which results in a unique impairment of spatial cognition (Landau & Zukowski, 2003; Lakusta & Landau, 2005). This bias has been shown to occur not only in linguistic tasks, but also in non-linguistic tasks of memory and comprehension (Regier & Zheng, 2007; Papafragou, 2009) and to be present already in pre-linguistic infants (Lakusta, Wagner, O'Hearn, & Landau, 2007).

A second, more specific question concerns the expression of motion to/from a container. Containment is an important spatial relation and is among the first relations to be expressed in child language cross-linguistically (Johnston & Slobin, 1978, a.o.). In addition, very young children are able to differentiate containment relations from other types of relation such as support and occlusion (Casasola, 2008). We ask how containment expressions in the motion domain are acquired and used in younger and more experienced users of English and Greek.

2. Method

2.1. Participants

There were 30 English speaking participants and 30 Greek speaking participants. Participants fell into three age groups (younger children, older children and adults) with ten people in each group. In the English speaking group, the younger children were between the ages of 3;8 and 4;3 with a mean age of 3;11, and the older children were between the ages of 4;9 and 5;5 with a mean age of 5;0. These children were recruited from a daycare center in Newark, DE. The English speaking adults were recruited from the University of Delaware and received course credit for participation.

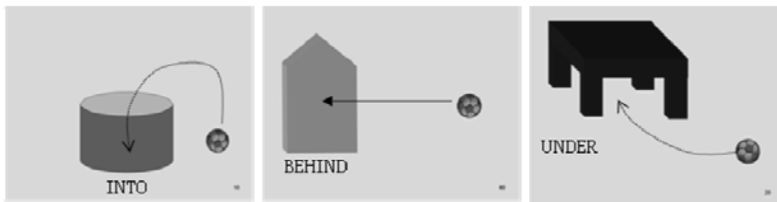
In the group of Greek participants, the younger children were between 3;9 and 4;3, with a mean age of 4;0, and the older children were between 4;10 and 5;3, with a mean age of 5;0. The Greek speaking adults were mostly University students. All Greek data were collected in Greece and coded by a native speaker.

2.2. Materials

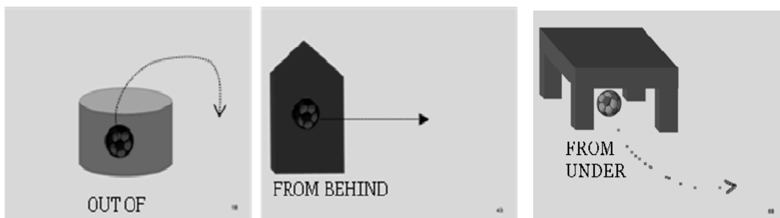
The stimuli consisted of 48 dynamic motion events presented in Microsoft PowerPoint. Each event consisted of a Figure, which was always the same soccer ball, and a Ground object which was selected from a set of simple, abstract 3D objects. Very simple stimuli were used to make sure we elicited only or mainly path information (even from speakers of a language such as English which regularly encodes manner of motion), and to minimize cross-linguistic encoding differences for object names.

The motion events depicted eight different spatial relations, each with a source and a goal version: 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). Three exemplars were shown for each different relation, and each exemplar had a source and a goal version. The source and goal versions of the same exemplar were exactly the same except for the color of the ground object and the direction of the motion path (see Figure 1 for example scenes).

A pseudo-random presentation order was used to ensure that no scenes of the same type of relation were within 3 scenes of each other. Once this list was set, we created a reversed version of it, so that half of the participants received the original and half the reversed version. The motion events lasted for three seconds and then remained on the screen until the participant finished describing the scene.



Panel 1 – Goal versions of Containment, Occlusion and Cover



Panel 2 – Source versions of Containment, Occlusion and Cover (the ball was occluded in the beginning of the first and second event)

Figure 1 – Examples of motion scenes for Containment (INTO/OUT OF), Occlusion (BEHIND/FROM BEHIND) and Cover (UNDER/FROM UNDER) relations

2.3. Procedure

The experiment was an elicited production task. All participants were told that they would see a series of motion events involving a ball and another “toy” and then they would describe what the ball did. The adult participants saw one practice trial before beginning the experiment.

The procedure was modified for children in the following ways. 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 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. Materials were distributed over two sessions, usually a few days apart.

3. Results and Discussion

3.1. The Source – Goal Asymmetry

First, we looked at whether a source-goal asymmetry was present in our data. Beginning with English, we entered the percentage of target (relation-appropriate) adpositions as the dependent variable in an ANOVA with Scene Version (source, goal) as a within subjects factor and Age Group (adults, older children, younger children) as a between subjects factor. The results showed a significant effect of Scene Version ($F(1, 27) = 18.86$, $p = .0002$; $M_{SOURCE} = .67$, $M_{GOAL} = .83$). There was also a main effect of Age Group ($F(2, 27) = 7.28$, $p = .003$). More specific analyses showed that adults used target expressions significantly more often than either the younger ($F(1, 18) = 13.42$, $p = .0018$) or the older ($F(1, 18) = 5.11$, $p = .036$) child group. In addition, there was an interaction between Scene Version and Age Group ($F(2, 27) = 3.94$, $p = .03$). Specifically, target expressions were used significantly more frequently in goal scenes than in source scenes for the children in both the younger group ($F(1, 9) = 9.16$, $p = .014$) and the older group ($F(1, 9) = 10.04$, $p = .011$), whereas no such difference existed in adults ($F(1, 9) = .36$, $p = .565$, n.s.).

The same ANOVA on the Greek adposition data yielded similar results. There was a main effect of Scene Version ($F(1, 27) = 18.62$, $p = .0002$; $M_{SOURCE} = .62$, $M_{GOAL} = .81$). There was also a main effect of Age Group ($F(2, 27) = 23.06$, $p < .0001$): adults used target expressions more frequently than either the younger ($F(1, 18) = 60.45$, $p < .0001$) or the older ($F(1, 18) = 33.57$, $p < .0001$) child groups. Finally, there was a significant interaction between Scene Version and Age Group ($F(2,27) = 4.80$, $p = .017$). Specifically, the younger children used target expressions in the goal scenes significantly more often than in the source scenes ($F(1, 9) = 30.94$, $p = .0004$) but this difference disappeared in older children ($F(1, 9) = 2.15$, $p = .18$, n.s.) and adults ($F(1, 9) = 1.29$, $p = .286$, n.s.).

An additional ANOVA adding Language to the factors of Scene Version and Age Group produced no main effect of Language and no interactions with that factor. This showed that both languages appear to follow the same pattern regarding the source-goal asymmetry even though they are typologically different.

Overall, our results provide additional developmental and cross-linguistic support for the well-documented goal bias. However, in contrast to previous research (Landau & Zukowski, 2003; Regier & Zheng, 2007), the adults in our study (and the older Greek children) did not demonstrate a goal bias. The most likely explanation for this finding is that our scenes were very simplified (having only a Figure and a single Reference Object) and the older participants always encoded the Reference Object when describing the scenes - thereby appearing to eliminate the goal bias.

3.2. The Expression of Containment (adpositions)

Next, we looked at the use of English and Greek containment expressions beginning with adpositions (prepositional forms in both languages). We coded the English *in, into, inside, out,* and *out of* and the Greek *mesa (se)* 'in' and *ekso (apo)* 'out (of)' as containment adpositions. Figure 2 depicts the distribution of such adpositions separately for each language. As the figure shows, containment adpositions were used very frequently in the canonical Containment scenes both in English and in Greek (M_{ENG} = .86, M_{GR} = .73). In addition, containment adpositions were less frequently but still very consistently extended to the Occlusion (M_{ENG} = .32, M_{GR} = .24) and Cover (M_{ENG} = .34, M_{GR} = .12) scenes. Containment adpositions were almost never used in the other types of relation combined (M_{ENG} = .04, M_{GR} = .02).

We performed an ANOVA on the proportion of containment adpositions using Relation (Containment, Cover, and Occlusion) as a within subjects factor and Language (English, Greek) as a between subjects factor. Results showed a significant main effect of Relation ($F(2, 57) = 142.18$, $p < .0001$), a significant main effect of Language ($F(1, 58) = 9.66$, $p = .0029$) but no interaction. Thus even though English uses containment adpositions more frequently than Greek overall, both languages have canonical containment expressions (used most frequently for Containment relations) but seem to extend their use beyond true physical containment (see Table 1 for examples of such extensions from our adult and child data). The difference between canonical Containment and the other two types of spatial relation indicate that the source of these extensions cannot be due to lack of awareness of the canonical containment meaning for the relevant expressions but must be sought in an underlying bias in conceptualizing spatial relations.

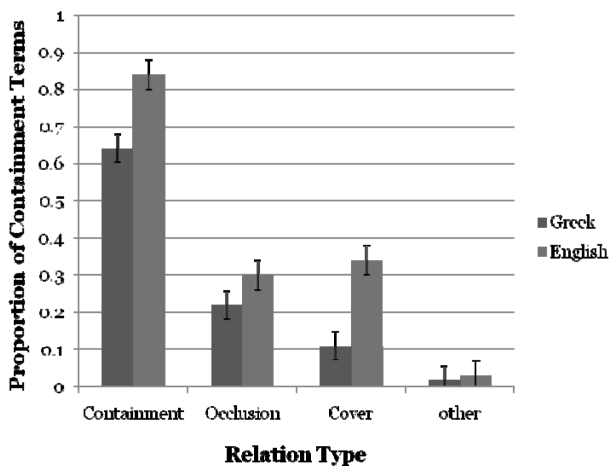


Figure 2 – Proportion of uses of containment adpositions

Table 1-Examples of the use of containment adpositions

Relation (Source version)	**English**	**Greek**
Containment	It popped **out of** the toy. (5;3)	I bala vjike **mesa** apo to antikimeno. (adult)
		‘the ball exited inside-from the object’
Occlusion	It came **out** from behind the toy. (4;9)	Vjike **ekso** apo to kuti. (3;10)
		‘exited out from the box’
Cover	It went **out** from underneath the toy. (4;9)	Vjike **ekso**. (3;10)
		‘exited out’

To explore this finding further, we next investigated more closely the use of containment terms in different types of paths (source, goal) for each language. Results are presented in Figure 3. Beginning with English (see first panel of the figure), we conducted an ANOVA using the proportion of containment adpositions as the dependent variable and Relation (Containment, Occlusion, Cover) and Age Group (adults, older children, younger children) as factors. The ANOVA was conducted separately for goal and source scenes. For source scenes, the ANOVA found only a significant effect of Relation ($F(2, 26) = 14.26$, $p < .0001$): participants used *out (of)* most frequently in the Containment scenes despite the consistent presence of extensions. For goal scenes, the analysis showed a significant effect of Relation ($F(2, 26) = 95.40$, $p < .0001$) as well as a significant effect of Age Group ($F(2, 27) = 8.44$, $p = .0014$).

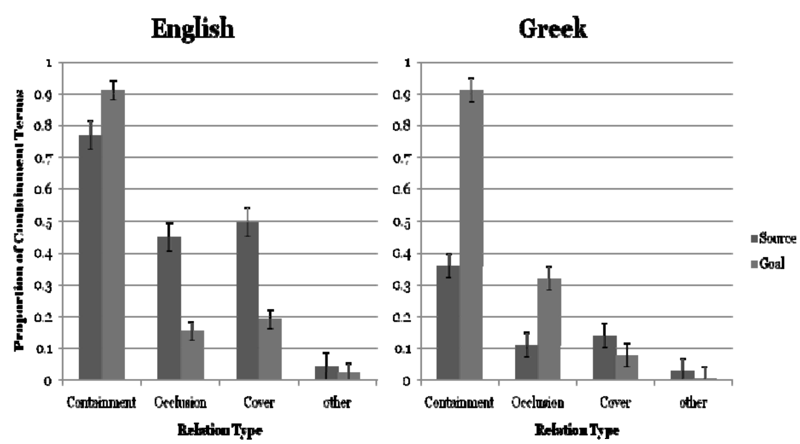


Figure 3 – Proportion of uses of English and Greek containment adpositions in Source and Goal versions of motion events

Turning to the Greek data (see panel 2 of Figure 3), we performed the same types of analysis. Again, the effect of Relation was significant both in the goal scenes ($F(2, 26) = 115.94$, $p < .0001$) and in the source scenes ($F(2, 26) = 11.82$, $p = .0002$). No other main or interaction effects were found. In general, we see the same extension pattern in the Greek data as we did in the English data.

3.3. The Expression of Containment (verbs)

Greek speakers encoded containment information not only in prepositions but also in path verbs such as *beno* 'enter' and *vjeno* 'exit'. Therefore, it was important to look at whether the extension pattern we discovered holds for Greek verbs as well. (In our English data, such path verbs were vanishingly rare so no such analysis could be performed.) Results for Greek containment verbs are presented in Figure 4. As shown in the figure, the extension pattern emerges here as well. An ANOVA on the proportion of containment verbs in the goal scenes only using Relation and Age Group as factors revealed a significant effect of Relation ($F(2, 26) = 17.04$, $p < .0001$). An identical ANOVA for the source scenes also revealed an effect of Relation ($F(2, 26) = 21.61$, $p < .0001$). Again, Greek containment verbs were used most often in true Containment scenes, but were often extended to Occlusion and Cover scenes.

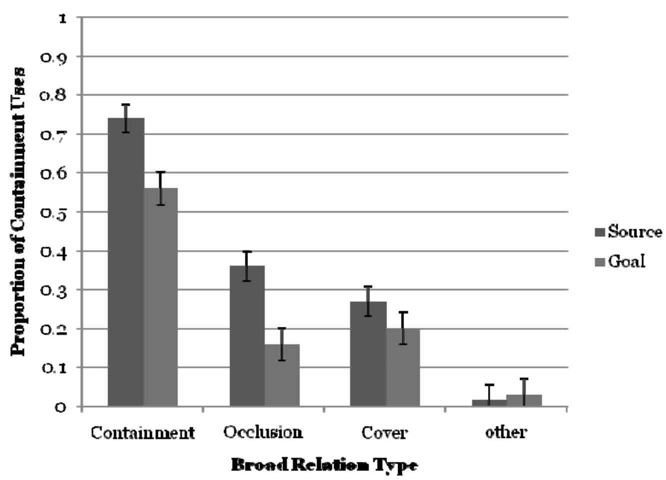


Figure 4 – Proportion of uses of Greek containment verbs in Source and Goal versions of motion events

4. General Discussion

Our data point to two major conclusions about the nature and underpinnings of spatial language. First, they confirm and extend evidence for the presence of a goal bias in the linguistic expression of motion paths that has been observed in the literature (Lakusta & Landau, 2005; Regier &

Zheng, 2007, a.o.) using new cross-linguistic data. This bias is particularly clear in the data from the youngest children in our sample (for older participants, the simple nature of our stimuli may have masked the presence of the bias.)

Second, and most importantly, our results reveal a novel cross-linguistic bias in spatial language: motion expressions of containment (adpositions/verbs) are extended in a predictable way to relations of Occlusion and Cover in addition to their regular uses denoting (true) Containment. This holds for both source and goal expressions of containment (i.e., expressions denoting motion out of/ into a container). It seems unlikely that participants fail to treat the three relations as different. First, there is a clear preference for using containment expressions in Containment scenes compared to other types of scene: this shows that participants recognize spatial expressions such as *into* and *out of* (and their equivalents in Greek) as *bona fide* containment terms. Furthermore, previous research has demonstrated that even infants can distinguish Containment from Occlusion and Cover events (Baillargeon & Wang, 2002; Casasola, Cohen, & Chiarro, 2003).

Nevertheless, it appears that the Containment, Occlusion, and Cover scenes share some feature(s) such that speakers of different languages frequently extend the same type of expression to refer to all of them. We propose that this extension pattern occurs because of a shared underlying spatial concept of Virtual Containment. We hypothesize that speakers abstract the three-dimensional space in, behind, and under the Ground object in our events and construe it as a type of container. This construal licenses the application of containment terms to events that lack canonical (physical) containment. The extension of containment terms is particularly useful for children who acquire containment terms early (Johnston & Slobin, 1978; and our own data above) but may lack the corresponding Occlusion or Cover terms (ibid.). Indeed, in our sample, English speaking children in the younger group used *under* only 33% of the time and *behind* 30% of the time in the appropriate scenes (Cover and Occlusion respectively). Since children lack the lexical resources to encode these scenes, they seem to co-opt containment terms. Such uses remain present in adult speech.

Based on these results, we can make the following two predictions about the scope of Virtual Containment. First, if the extension of containment terms truly reflects the structure of an underlying spatial concept, it should occur in a wider sample of languages. This prediction is supported by more extensive cross-linguistic work in our lab that uses the present task (Johanson, Selimis, & Papafragou, 2009); it is also consistent with reports that, in Australian languages, ‘in’ and ‘under’ scenes are often encoded by the same expression (Levinson & Wilkins, 2006). Second, the concept of Virtual Containment should license extension patterns for other configurations beyond Occlusion and Cover provided that such configurations include Ground objects that can be construed as containers. This prediction is also borne out: young children frequently use containment terms to refer to the space *between* two objects (see Johanson et al., 2009 for evidence from Greek and English; cf. also Johnston & Slobin, 1978).

In conclusion, the present data offer support for the presence of a natural bias in parsing motion events – namely, they point to a concept of Virtual Containment that relies on quite abstract and schematic spatial representations which go well beyond physical boundaries. Further research is needed to elucidate the nature and properties of this concept. For now, it seems clear that this abstract spatial concept structures both the semantics and the acquisition of spatial language cross-linguistically.

References

Baillargeon, Renée & Wang, Su-hua (2002). Event categorization in infants. *TRENDS in Cognitive Sciences, 6(2)*, 85-93.

Bowerman, Melissa & Choi, Soonja (2001). Shaping meanings for language: Universal and language specific in the acquisition of spatial semantic categories. In M. Bowerman and S.C. Levinson (Eds.), *Language acquisition and conceptual development*. Cambridge: Cambridge University Press, pp. 475-511.

Casasola, Marianella (2008). The development of infants’ spatial categories. *Current Direction in Psychological Science, 17(1),* 21-25.

Casasola, Marianella, Cohen, Leslie B. & Chiarro, Elizabeth (2003). Six-month-old infants’ categorization of containment spatial relations. *Child Development, 74(3)*, 679-693.

Johanson, Megan, Selimis, Stathis & Papafragou, Anna (2009). *A cross-linguistic bias in the expression of spatial containment.* Manuscript in preparation.

Johnston, Judith R., & Slobin, Dan I. (1978). The development of locative expressions in English, Italian, Serbo-Croation and Turkish. *Child Language, 6(3),* 529-545.

Lakusta, Laura & Landau, Barbara (2005). Starting at the end: The importance of goals in spatial language. *Cognition, 96,* 1-33.

Lakusta, Laura, Wagner, Laura, O’Hearn, Kirsten & Landau, Barbara (2007). Conceptual foundations of spatial language: Evidence for a goal bias in infants. *Language Learning and Development, 3(3)*, 179-197.

Landau, Barbara & Jackendoff, Ray (1993). "What" and "where" in spatial language and spatial cognition. *Behavioral and Brain Sciences,* 16, 217-265.
Landau, Barbara & Zukowski, Andrea (2003). Objects, motions, and paths: Spatial language in children with Williams Syndrome. *Developmental Neuropsychology, 23 (1&2),* 105-137.
Leikin, Mark (1998). Acquisition of locative prepositions in Russian. *Journal of Psycholinguistic Research, 27(1)*, 91-108.
Levinson, Stephen & Miera, Sérgio (2003). 'Natural concepts' in the spatial topological domain-adpositional meanings in crosslinguistic perspective: An exercise in semantic typology. *Language, 79(3),* 485-516.
Levinson, Stephen & Wilkins, David, Eds. (2006). *Grammars of space: Explorations in cognitive diversity*. Cambridge: Cambridge University Press.
Li, Peggy & Gleitman, Lila (2002). Turning the tables: Language and spatial reasoning. *Cognition, 83,* 265-294.
Mandler, Jean M. (2004). Thought before language. *TRENDS in Cognitive Science, 8(11),* 508-513.
Miller, George & Johnson-Laird, Philip. (1976). *Language and perception.* Cambridge, MA: Harvard University Press.
Papafragou, Anna (2009). Source-goal asymmetries in motion representation: Implications for language production and acquisition. Manuscript submitted for publication.
Papafragou, Anna, Massey, Christine, & Gleitman, Lila (2002). Shake, rattle, 'n' roll: The representation of motion in language and cognition. *Cognition, 84,* 189-219.
Regier, Terry & Zheng, Mingyu (2007). Attention to endpoints: A cross-linguistic constraint on spatial meaning. *Cognitive Science, 31,* 705-719.
Talmy, Leonard (1985). Lexicalization patterns: Semantic structure in lexical forms. In T. Shopen (Ed.), *Language typology and syntactic description*, 57-149. New York: Cambridge University Press.