

Integrating the Spatial Semantics of Verbs and Prepositions

Ben Acland¹, Nicole Baggette¹, Henry Bley-Vroman¹, Natalie Klein¹, Elspeth Llewellyn², Gabrielle Osborne³, Jacob Stiglitz¹, Andrew Waser¹, Robert Thornton¹, & Martin Hackl¹
¹Pomona College, ²Scripps College, ³Claremont Graduate University

Introduction

Many sentence processing studies have examined semantic processing, but most focus on how it influences syntactic processing. Fewer studies have examined how semantic information is integrated and interpreted in real time.

Recently, several studies have addressed this question by looking at enriched semantic composition (McElree et al. 2001; Traxler et al. 2002). We build on that work by examining how spatial information from verbs and prepositions is integrated, enriched, and interpreted.

Locatives and Motion Verbs

Locative expressions specify where the event described in a clause takes place. In English they are realized predominantly as prepositional phrases such as *inside the house*, *to the store*, *along the river*. Two main classes of locative PPs can be distinguished (e.g., Miller & Johnson-Laird 1976, Jackendoff 1983):

Directional PPs characterize a **PATH** along which the event described in the clause unfolds.

(1) John drove **from Denver to LA**.

Non-directional PPs characterize the **PLACE** within which a state exists or an event unfolds.

(2) John was/sat/exercised **inside the house**.

P-Flexibility

The classification of a preposition as directional ("PATH") or non-directional ("PLACE") is not always clear cut. In particular, a variety of PLACE prepositions can give rise to directional readings when combined with verbs of motion:

(3) The bird darted at the hunter.

(4) The freshmen stormed outside the building.

This raises an important processing issue: what mechanisms governing the real time interpretation of this type of spatial information?

Manner of Motion Verbs

Spatial verbs parallel this PATH vs. PLACE distinction. Even though all motion verbs **conceptually** imply a path, they can be classified **linguistically** into **directional motion verbs**, which necessarily imply traversal of a path, or **non-directional motion verbs**, which don't (Jackendoff, 1983, Tenny 1995). As in the case of prepositions, many manner of motion verbs can be used both directionally and non-directionally.

(5) The child wandered to the school.

(6) The child wandered at the school.

Co-occurrence Restrictions between Motion Verbs and Locative PPs

Dir. motion verb → PATH PP (PLACE PP)
 Non-dir. motion verb → (PATH PP) (PLACE PP)
 Non-motion verb → *PATH PP (PLACE PP)

What We Did

We investigated real time mechanisms of semantic integration of locative PPs by juxtaposing motion verbs with PLACE prepositions. We reason that there are two ways by which this conflict can be resolved: 1. **Verb Priority**: the verb semantics determines the interpretation of the preposition. 2. **Preposition Priority**: the preposition determines the interpretation of the verb.

Verb Priority

		Preposition	
		+ Path	- Path
Verb	+Mot.	No conflict	P coerced into Path reading
	-Mot.	Dir. of P too strong; P takes priority	No conflict

Preposition Priority

		Preposition	
		+ Path	- Path
Verb	+Mot.	No conflict	Location of motion spec.
	-Mot.	V. coerced into dir. reading	No conflict

Predictions

1. No conflict conditions: no processing cost because spatial semantics of V and P are consistent.
2. Non-motion Verbs + PATH P: the directionality of the preposition cannot be dropped; the non-motion verb needs to be coerced into a motion verb, hence processing cost in all cases.
3. Dir. Motion Verb + PLACE P:
 - a. **Verb Priority**: the meaning of the preposition has to be coerced into a PATH reading resulting in processing cost.
 - b. **Preposition Priority**: The meaning of the preposition is unchanged. Because the verb's path argument is optional it is simply not specified and understood to be within the location named by the PLACE PP. Hence no processing cost.

Crucial prediction: For Motion+PLACE items, Verb Priority RTs should be longer than Preposition Priority RTs because of coercion.

Method

20 participants, native English speakers
 24 items, 12 each preposition & verb priority
 Single-word, self-paced reading

Two main factors: verb type (motion vs. non-motion) and prep type (PATH vs. PLACE)

Items were classified by intuition as either verb priority or preposition priority. Then the items were normed to verify classifications

Results

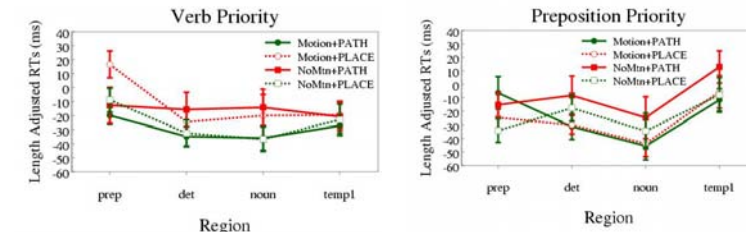
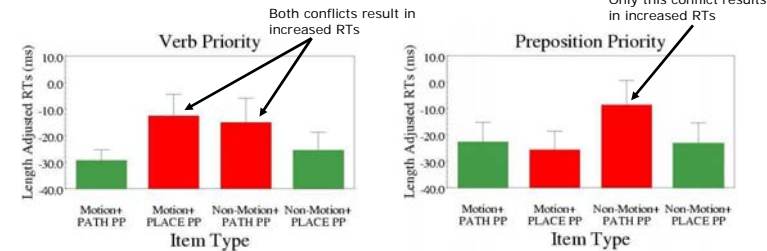
Reading times were trimmed and length-adjusted. For purpose of analysis, reading times were summed over four critical words, in brackets in the sample items below. This region began with the preposition, as it was the earliest point at which effects might appear.

For the verb priority items, RTs were longer in both of the conflicting conditions, consistent with the idea that the conflict results in coercion. For the preposition priority items, RTs were longer only in the Non-Motion+PATH PP condition.

Sample Items

Verb Priority:
 Motion verb, PATH preposition: To protect her nest, the bird darted [to the hunter just] now.
 Motion verb, PLACE preposition: To protect her nest, the bird darted [at the hunter just] now.
 Non-motion verb, PATH preposition: To protect her nest, the bird squawked [to the hunter just] now.
 Non-motion verb, PLACE preposition: To protect her nest, the bird squawked [at the hunter just] now.

Preposition Priority:
 Motion verb, PATH preposition: Because he woke up early, the child wandered [to the school last] Tuesday.
 Motion verb, PLACE preposition: Because he woke up early, the child wandered [at the school last] Tuesday.
 Non-motion verb, PATH preposition: Because he woke up early, the child slept [to the school last] Tuesday.
 Non-motion verb, PLACE preposition: Because he woke up early, the child slept [at the school last] Tuesday.



Interpretation Norms

20 participants selected from a list the paraphrase that best matched their interpretation for each item. Paraphrases were designed to unambiguously pick out a directional or locative interpretation. All proportions listed in the tables differed significantly from chance, all p's < .005.

	Interpretation		
	Direct	Loc	Other
Motion+PLACE	15.3%	84.1%	0.6%
Non-Mot.+PATH	61.3%	36.9%	1.8%

	Interpretation		
	Direct	Loc	Other
Motion+PLACE	79.9%	20.1%	0.0%
Non-Mot.+PATH	79.7%	15.6%	4.7%

Alternative: Co-occurrence

A possible alternative is that RTs were driven by co-occurrence frequency rather than semantic integration. Using the standard corpora resulted in a sparse data problem because of low frequency verbs like "squawked" and "scurried". Instead used Google to get co-occurrence frequencies for all 96 verb+prep pairs. The mean frequencies are presented below. Several patterns argue against a strong frequency account: The cells in green are low frequency items with short RTs and in yellow are higher frequency items with longer RTs

	Verb Pri.	Prep Pri.
Motion+PATH	127,966	78,296
Motion+PLACE	25,926	9,292
No-mot.+PATH	30,878	37,169
No-mot.+PLACE	4,137	134,699

Conclusions

Consistent with strongly incremental models of semantic interpretation (e.g., Sedivy et al., 1999). Cost of coercion evidence on preposition or word after.

The data support the distinction between directional motion verb that require a PATH PP and non-directional motion verbs that optionally combine with a PATH PP (e.g., Jackendoff, 1983).

PLACE PPs can be coerced into PATH PPs, consistent with Jackendoff (1983) where PATH PPs are analyzed as (PATH(PLACE(NP)))

More generally, directionality either from the verb or preposition cannot be removed.