

The Semantics of Motion

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Abstract

In this paper we present a semantic study of motion complexes (ie. of a motion verb followed by a spatial preposition). We focus on the spatial and the temporal intrinsic semantic properties of the motion verbs, on the one hand, and of the spatial prepositions, on the other hand. Then we address the problem of combining these basic semantics in order to formally and automatically derive the spatiotemporal semantics of a motion complex from the spatiotemporal properties of its components.

1 Introduction

Most of natural languages provide two types of lexical items to describe the motion of an entity with respect to some location: **motion verbs** (*to run; to enter*) and **spatial prepositions** (*from; towards*). Motion verbs can be used directly with a location, when they are transitive (*to cross the town*) or with a spatial preposition, when they are intransitive (*to go through the town*). The latter case is more interesting: most of the French motion verbs are intransitive and the interaction between motion verbs and spatial prepositions gives detailed informations about the way human beings mentally represent spatiotemporal aspects of a motion. When we describe a motion, the fact to choose a verb instead of another, a preposition instead of another, a syntactic structure instead of another, reveals our mental cognitive representation. We claim that natural languages can be considered as a trace of these representations, in which it is possible, with systematic and detailed linguistic studies, to light up the way spatiotemporal properties are represented and on which basic concepts these representations lie. We present such linguistic investigations on French motion verbs and spatial prepositions and the basic concepts we have found. We also address compositional semantics for motion complexes (ie. a motion verb followed by a spatial preposition) and

show that the complexity and the refinements of the linguistic studies presented just before are justified and required at the compositional level in order to capture the different behaviours in the compositional processes that exist with the French language. We also compare with the English language and draw some conclusions on the benefits of our approach.

2 Lexical Semantics for Motion Verbs

Following Gruber (1965), Jackendoff (1976), Boons (1985), we approach motion verbs in terms of some “localist semantical” role labels. The linguistic study of French intransitive motion verbs (see eg. (Asher & Sablayrolles, 1994a)) we have realized has allowed the definition of an ontology for “location” in three basic concepts:

- **locations** which are concrete places (*a room; a house; a street*);
- **positions** which are parts of a location (*the position where I am in this room*);
- **postures** which are ways to be in a position (*to be standing, sitting, lying*).

With the help of this ontology we have realized a typology for intransitive motion verbs. We distinguish 4 categories on the basis of which kind of “location” they intrinsically refer to.

- **Change of location (CoL)** verbs (*entrer-to enter; sortir-to go out*) denote a change of location. When we enter some place or go out of some place, we have different spatial relation with the location (ie. inside/outside) before and after the motion.
- **Change of position** verbs (*voyager-to travel; courir-to run*) denote a change of position. When we travel or run, we go from some part to another part of a same global location. Such verbs do not behave all homogeneously.
 - Some denote a change of position which always occur (*voyager-to travel*). For

example, we cannot say **voyager sur place**—to travel in place. We call these verbs **change of position (CoPs)** verbs.

- Others denote only possible change of position (**courir**—to run). For example, we can say **courir sur place**—to run in place. We call these verbs **inertial change of position (ICoPs)** verbs.
- **Change of posture (CoPtu)** verbs (**s'asseoir**—to sit down; **se baisser**—to bend down). They denote a change of the relations between the parts of an entity.

For the following, we will focus on **CoL** verbs (the Change of Location verbs), mainly because they are rich in spatiotemporal informations, but also because we have at disposal exhaustive lists of French **CoL** verbs. We have realized a systematic and fine linguistic study on these verbs, looking carefully at each of them, one by one (and we have 440 **CoL** verbs in French), in order to extract their intrinsic spatiotemporal properties. These semantic properties can be characterized by a re-structuration of the space induced by the so-called **reference location (lref)** (cf. (Talmy, 1983)). This **lref**, implicitly suggested by each **CoL** verb, can be either the initial location (as with **partir**—to leave; **sortir**—to go out), or the path (**passer**, **traverser**—to pass through) or the final location (**arriver**—to arrive; **entrer**—to enter) of the motion. Indeed, verbs like **sortir** intrinsically suggest a location of which we have gone out. This space, induced by the **lref**, is characterized by most of the authors in the literature by a two-part spatial system consisting in the inside and the outside of the **lref**. We propose to refine this structure with two new concepts, required to distinguish minimal pairs like **sortir** (to go out)/**partir** (to leave), and **entrer** (to enter)/**atterrir** (to land). These concepts are:

1. a limit of proximity distinguishing an outside of proximity from a far away outside; indeed, if **sortir** simply requires to go out of the **lref**, **partir** in addition forces the mobile to go sufficiently far away from that **lref**.
2. an external zone of contact required by verbs like **atterrir** for which the final location is neither the **lref** (in contrast with **entrer**) or the outside (or proximity outside) of the **lref** (in contrast with **s'approcher**—to approach).

We have so defined a structuration of the space based on 4 zones :

- the **inside**;
- the **external zone of contact**;
- the **outside of proximity**;
- the **far away outside**.

This structuration is close to the way Jackendoff and Landau (1992) encode the space induced by the reference object introduced by a static spatial preposition. As we have come to these distinctions by examining different linguistic material, we conclude that language structures space in the same way whatever sort of lexical items (motion verbs (dynamic)/(static) spatial prepositions) we examine. This has allowed us to classify **CoL** verbs into 10 classes on the basis of which zones the mobile is inside, at the beginning and at the end of its motion. Note that all the geometrical possibilities are not lexicalized in French.

3 Lexical Semantics for Spatial Prepositions

We have followed the same approach with French spatial prepositions, but using a structuration of the space induced by the location introduced in the PP by the preposition, and not induced by the **lref** as for verbs. Following Laur (1993), we consider simple prepositions (like *in*) as well as prepositional phrases (like *in front of*). We have classified 199 such French prepositions into 16 groups using in addition of our zones two other criteria:

- prepositions can be:
 - positional (like *in*)
 - directional (like *into*)
- directional prepositions can be:
 - Initial (like *from*)
 - Medial (like *through*)
 - Final (like *to*)

depending if they focus on the initial location, on the path or on the final location of the motion.

4 Compositional Semantics for Motion Complexes

The linguistic studies, used for the typologies of **CoL** verbs and spatial prepositions, have been realized on verbs considered without any adjuncts, in their atemporal form and independently of any context, on the one hand, and on prepositions considered independently of any context, on the other. This methodology, discussed in Borillo & Sablayrolles (1993), has allowed us to extract the intrinsic semantics of these lexical items.

Since natural languages put together verbs and prepositions in a sentence, we have developed a formal calculus (see (Asher & Sablayrolles, 1994b)), based on these two typologies, which computes, in a compositional way, the spatiotemporal properties of a motion complex from the semantic properties of the verb and of the preposition. For reason of space we cannot detail our formalism here, but we intend to present it in the talk.

The semantics of a motion complex is not the simple addition of the semantics of its constituents. On the contrary, it is the result of a complex interaction between these properties. It is often the case that from this interaction appear new properties that belong neither to the verb or the preposition. These new properties are only the result of the interaction of the verb with the preposition.

Let us consider for example the following VP: *sortir dans le jardin-to go out into the garden*. The verb *sortir-to go out* implicitly suggests an initial location; the preposition *dans-* (which means *in*, but which is translated here by *into*) is a positional preposition and, as so, only denotes the static spatial relation *inside*. The location *le jardin-the garden* is the final location of the motion. This *final* information was contained neither in the verb or in the preposition. This information is the result of the interaction of the verb *sortir-to go out* with the preposition *dans-in/into*.

Note that the combination for such items does not behave the same in English, where the *final* information is explicitly brought by the preposition *into*, which is a directional preposition, and where this particular combination does not create new information.

This shows the necessity to take into account such language specific behaviour in natural languages understanding systems and in natural languages machine translation. We formalize with 11 axioms in a non-monotonic first order logic the behaviour of all possible kinds of verb-preposition association for the French language. We use non-monotonic logic in order to represent defeasible or generic rules and also in order to encode defaults about lexical entries.

These axioms are based on the lexical semantics of CoL verbs and of spatial prepositions. They also take into account the syntactic structure of the sentence (we have supposed an X-bar syntax with a VP internal subject, though this is not essential) and the links which exist at the level of discours between this sentence and the previous and following sentences of the text. These links, called discourse relations, are basic concepts on which texts are structured (cf. (Asher, 1993)).

5 Conclusion

The study and the first results we have here presented cover from lexical semantics to discourse structures, with strong interactions between these two ends. Indeed, lexical informations can be used to disambiguate the structure of the discours, as well as discourse relations can be used to disambiguate lexical entries, as shown in (Asher & Sablayrolles, 1994b). Our work is based on systematic and very detailed linguistic studies which lead to rather complex computations for calculat-

ing the spatiotemporal semantics of a motion complex. But we have seen that this level of detail and complexity is necessary if one want to understand, to formalize and to compute a right spatiotemporal semantics for motion complexes. We continue our investigations on two directions:

1. we compare our results with similar works in course of realization on the Basquian language (by Michel Aurnague) and on the Japanese language (by Junichi Saito);
2. we use the results presented here for refining the notions of the Aktionsart, where the structuration of the space in 4 zones can be used to distinguish sub-classes inside the traditional well known classes of aspectual studies.

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