

The Semantics of French Transitive Movement Verbs and the Ontological Nature of their Objects

1 Introduction

The issue of representing spatial knowledge has been addressed in such diverse fields as psychology, linguistics and artificial intelligence (AI). Our approach is based on the assumption that language is among the few means available for laying bare space conceptual structures. Thus, we present some properties of “common sense space” (cf [Hobbs *et al.*, 1987] or the naïve physics of [Hayes, 1985]) through a detailed analysis of linguistic spatial markers, more specifically here a class of motion verbs.

Formal accounts of motion verbs semantics generally choose to represent motion as a temporally ordered sequence of positions occupied by a trajector¹. These positions can correspond to a set of Cartesian coordinates (as in [Hays, 1989]), which makes problematic the definition of natural language predicates in a non *ad hoc* way. The positions can also be a sequence of disconnected lexicalised locations [Jackendoff, 1991] (and inferences about the other positions occupied are very constrained by such representations) or a continuous sequence of locations, only some of which are expressed in discourse [Asher and Sablayrolles, 1995, Asher *et al.*, 1996]. In this last approach continuity of the movement is explicitly represented since movement is a transition between zones defined with respect to the landmark, but also depending on information from the trajector and (without much specification) the context. We differ from such approaches in so far as we represent motion as a change in relations between trajector and landmark (using a relational model for space as in [Aurnague and Vieu, 1993, Randell *et al.*, 1992] without presupposing pre-existing locations whose definition would be problematic, and moreover take into account the ontological distinctions presented in [Aurnague, 1994, Vieu, 1991]).

We present here a study of a class of French movement verbs, namely direct transitive movement verbs such as *traverser* (to cross), *quitter*, (to leave), *atteindre*, (to reach). Most existing approaches to motion verbs focus on intransitive verb classes (such as to go, to arrive, ...) and have consequently focused more on the relations between verbs and locative prepositions [Laur, 1991, Asher and Sablayrolles, 1995] than on the relations between the verb and its arguments. However, it has been shown in [Sarda, 1996] the importance of the ontological properties of verbal arguments for characterising a transitive process, taking over the distinctions proposed by [Aurnague, 1994, Vieu, 1991].

2 An ontology for spatial entities

2.1 Ontological categories

An ontology has emerged from the analysis of linguistic markers and of their referential properties in which the concepts of location, object and space portion are distinguished by Aurnague and Vieu².

¹The trajector is the entity being localised, the landmark the localising one, following the terminology of [Vandeloise, 1986]; in addition we make a distinction between these entities and the noun phrases referring to them at the sentence level, noted NP_{landmark} and NP_{trajector}.

²Further distinctions can be found in [Vieu, 1991] and [Aurnague, 1994, Aurnague, 1996].

Space portions The definition of space portions depends on lexicalised material entities: they can only be named via objects or locations, as in *l'espace entre x et y* (the space between x and y), *le trou dans le mur* (the hole in the wall), or using Localisation Nouns (henceforth LN, described in [Aurnague, 1991]) such as *le fond du verre* (the bottom of the glass), *le haut de la colline* (the top of the hill).

Locations Typically represented by geographical entities (*Toulouse, la ville* (the city)), they are material entities fixed in a terrestrial frame of reference and determine a containing space portion. Localisation Nouns which are always defined in a frame of reference (the very entity on the basis of which they are defined), also belongs to that category. Indeed, they share the same intrinsic properties of fixity within a determined frame of reference.

Objects are material entities, typically mobile (such as 'a chair', 'a glass', 'a car') but can also be static without any well-specified position (like 'a tree').

This ontology characterises lexical units independently of any context; in discourse they can acquire other properties according to their degree of specificity.

2.2 Ontology and Specification

According to the distinctions we have just presented, locations differ from objects in that they are fixed in a determined frame of reference whereas objects are material entities without any specified frame of reference. The static phrase *être à* (corresponding more or less to "to be at/in") shows that the distinction remains relevant at the discourse level. Indeed examples 1a (*être à* + a location) are more acceptable than 1b (*être à* + an object) [Vandeloise, 1988].

- 1a. *Léon est à Toulouse, à la maison, au coin de la rue, au sommet de la colline.*
Léon is in Toulouse, at home, at the corner of the street, at the top of the hill.
- 1b. *?Léon est à la chaise, à l'arbre.*
Léon is at the chair, at the tree.

However to possess the ontological properties of a location is not enough to fulfil a localising function, as specification plays an important part in this at the discourse level. Beside proper nouns of geographical locations and LN, always specified with respect to a frame of reference, other expressions qualify more or less as localisations according to the level of specification they can have in discourse (e.g. 2a is more acceptable than 2b).

- 2a. *Léon est à la banque.*
Léon is at the bank.
- 2b. *?Léon est à une banque.*
Léon is at a bank.

Eventually, NP denoting objects (devoid of any ontological a priori localising properties) need to be more specified in order to refer to a fixed space portion in a known frame of reference, as location NPs do. A rigid definite description, as in 3b, meets this requirement.

- 3a. *?Il est au rocher.*
She is at the rock.
- 3b. *Il est au Rocher de la Vierge.*
She is at the Virgin's Rock.

Through these examples, a concept of "functional location" appears which is wider in scope than the ontological concept of location, as it includes certain objects denoted by NPs which shows the localising properties of locations through specification in discourse.

The test using *être à* can however sometimes be misleading as it can imply the expression of a regular activity more than the expression of a localisation. For instance *Il est au piano* (He is at the piano), more than a mere localisation, implies that "he" is playing the piano. We will see in section 4 that the choice

of the spatial interpretation or of the “regular activity” interpretation depends on the properties of the entities the verb selects.

Localising properties of an entity depend on their ontological characterisation and on their degree of specification (introduced by discourse); the combination of the two determines what qualifies as a “functional location”.

3 Classification of the verbs

We aim to show what kind of information about the localisation of an entity with respect to another is recovered from the combination of a verb (expressing the movement of that entity) and its arguments. Three criteria are used for that purpose: the aspectual polarity of a verb, the type of localisation relation established between NP_{trajector} and NP_{landmark}, and the change/absence of change of that localisation relation during the process. All this is formally expressed in predicate logic, also using the calculus of individuals of [Clarke, 1981, Randell *et al.*, 1992, Aurnague and Vieu, 1993], where regions of space are taken as primitives³.

Polarity Following [Asher *et al.*, 1996] we assume the existence of three phases in a movement event: an initial, a median and a final phase. It turns out that verbs generally focus on one of the phases, expressing a relation between the arguments which holds during that phase. For instance *quitter la ville* (to leave the city) implies that the trajector of the process is located in the city during that initial phase of the process; *traverser le pont* (to cross the bridge) implies that the trajector is on the bridge during the median phase (leaving the question of its location during the other phases unresolved). We have separated movement verbs into three classes accordingly: initial, median and final verbs focus respectively on the initial, the median and the final phase of the movement by expressing a localisation of the trajector with respect to the landmark during that phase (noted SPP for Salient Process Phase). A1-A2 defines an event as consisting of three temporally ordered phases; A3 express the fact that the SPP is one of these (\oplus represents ‘exclusive or’).

A1 $\forall e_1, e_2, e_3 \quad e_1 < e_2 < e_3 \rightarrow e_1 < \text{init}(e_2) < \text{end}(e_2) < e_3$

A2 $\forall e \quad \text{init}(e) < \text{med}(e) < \text{end}(e)$

A3 $\text{movement}(e) \rightarrow (\text{SPP}(e) = \text{init}(e)) \oplus (\text{SPP}(e) = \text{end}(e)) \oplus (\text{SPP}(e) = \text{med}(e))$

Type of localisation relation Linguistic localisation in space is largely based on inclusion and contact (as shown by the importance of the functional notions of containment and support, clearly underlined by [Vandeloise, 1986]). It is therefore natural to distinguish verbs according to the type of localisation they involve (which mostly are topological in nature). Thus a verb can describe an inclusion between its trajector and its landmark (4a), a contact (4b), or the absence of either⁴(4c).

4a. *Léon parcourt le pays.*

Léon travels up and down the country.

4b. *Léon percute un arbre.*

Léon hits a tree.

4c. *Léon contourne la ville.*

Léon drives around the city.

Verbs which imply an inclusion, a contact or neither of these at the moment of their SPP are classified respectively as internal, contact or external verbs (A4). This static description expresses localisations associated with a specific point in the process, whose formal definitions are given in

³Space constraints prevent us from giving a full account of the choices that have been made in the formal model on the basis of the linguistic analysis.

⁴In that case the semantics of the verb consists in some other kind of localisation, linked to the orientation of the path followed rather than to a topological relation between two entities, but this is beyond the scope of this paper.

A5, A6 and A7. The topological relations C (“is connected to”), P (“is a part of”), the contact relation, the interior (int) of an entity are axiomatised or defined in [Aurnague and Vieu, 1993]; $P(x/e, \text{int}(y))$ reads “x during e is part of the interior of y”. For instance A5 reads as “if the process e described by a movement verb is internal then the trajector is part of the interior of the landmark during the SPP”.

A4 $\text{movement}(e) \rightarrow \text{internal}(e) \oplus \text{external}(e) \oplus \text{contact}(e)$

A5 $\text{internal}(e) \equiv P(\text{traj}(e)/\text{SPP}(e), \text{int}(\text{lmdk}(e)))$

A6 $\text{contact}(e) \equiv \text{contact}(\text{traj}(e)/\text{SPP}(e), \text{lmdk}(e))$

A7 $\text{external}(e) \equiv \neg C(\text{traj}(e)/\text{SPP}(e), \text{lmdk}(e)) \wedge \neg C(\text{traj}(e)/\text{SPP}(e), \text{int}(\text{lmdk}(e)))$

Change of localisation relation Another distinction can be introduced between verbs to account more accurately for the movement of the trajector. Some of these verbs presuppose that the localisation relations they introduce actually hold during the whole event whereas other presuppose some kind of change e.g. if *Léon quitte la ville* (Léon leaves the city) Léon is expected to be out of the city at some point in the future whereas if *Léon parcourt le pays* (Léon travels up and down the country) he is implicitly always moving within the country. All initial and final verbs entail a change of the relation of localisation (A8) as do some median verbs (which behave in a more complex way and will be studied in the next section), whereas the other median verbs imply that the relation does not change (A9).

A8 $(\text{initial}(e) \vee \text{final}(e)) \rightarrow \exists e'(e' \subseteq_t e \wedge \neg C(\text{traj}(e)/e', \text{int}(\text{lmdk}(e))))$

A9 $(\text{median}(e) \wedge \text{no_change}(e)) \rightarrow \text{med}(e) = e$

4 Verb classes and ontological classes

Through the observation of the various possible combinations between the types of verbs and the type of entities used as landmarks, it becomes possible to specify the necessary conditions for a localising process between two entities. If some movement verbs accept both locations or objects as landmarks (5a), others preferably accept locations (5b).

5a *Longer la rivière, le mur, le bus.*

to go along the river, the wall, the bus.

5b *Quitter la ville > ?la voiture, l'arbre, le livre.*

to leave the city, the car, the tree, the book.

It seems that the verbs selecting locations directly establish a localisation relation between the NP_trajector and the NP_landmark. On the contrary, those which can select both locations or objects seem to establish a localisation relation not between the NP_trajector and the NP_landmark but between the NP_trajector and a inferred-landmark (a landmark inferred from the NP_landmark). This inferred-landmark corresponds to a space portion selected by the verb and defined with respect to the NP_landmark.

The first class of verbs is typically represented by initial and final verbs describing a change of localisation relation from inclusion to exclusion or from exclusion to inclusion or contact with respect to the boundary of the landmark. Space and time being tightly linked, the more precise the boundaries of the landmark are, the more precise the temporal boundaries of the event phases will be. Indeed these verbs describe either accomplishments or achievements, implying precise representations of the culmination point.

On the contrary, verbs selecting both locations or objects (establishing a relation between the NP_trajector and the inferred-landmark) describe localisation relations between space portions whose boundaries are vague (e.g. The cat is on the edge of the carpet, can refer to a situation where the cat is on the carpet,

beside the carpet, or overlapping it). This lessens the relevance of the internal/external distinction for those verbs which describe a change of relation of localisation. For instance, to describe *y traverse x*, *y* crosses *x*, it is not relevant to know whether the verb is internal or external, since the trajector does not move from the inside to the outside (whose boundaries are clear-cut) but moves from one side of *x* to the other (whose boundaries are vague). This is formally expressed for all the verbs of this class in A10.

$$\mathbf{A10} \ [median(e) \wedge (change(e) \vee (no_change(e) \wedge external(e)))] \rightarrow \\ \exists y \exists z (depend(y, ldmk(e)) \wedge depend(z, ldmk(e)) \wedge \neg C(y, z) \wedge P(traj(e)/init(e), y) \wedge P(traj(e)/end(e), z))$$

Eventually, we would like to point out that these verbs constitute the expression of an activity more than just the expression of a localisation, and this could account for apparent counter-examples to our assumption. In the case where a verb usually selecting a location (as in 6a) accepts an object (as in 6b), it actually describes an activity (in 6b the ceasing of a regular practise).

6a *Léon abandonne la ville.*

Léon leaves the city.

6b *Léon abandonne le piano.*

Léon gives up the piano.

It seems that the special character of the event is inversely proportional to the likelihood of a specific interaction between trajector and landmark. There seems therefore to be a continuum between pure spatial cases and pure activities depending on the functional use of the entities involved.

5 Conclusion

We have addressed in the above the problem of the representation of movement representation in natural language through a descriptive study of French transitive verbs. We classified these verbs according to the combination of three criteria (aspectual polarity, localisation type and change in localisation relations). We have stressed the importance of defining an ontology of entities related to each other by these verbs, as all verbs do not always accept both locations or objects as landmarks. From the observation of possible combinations of verb and type of entity, we have come to the conclusion that a localisation process can only be established by verb with respect to an entity which belongs to the location category or an NP sharing the same properties (functional locations). This seems consistent with the observation that verbs which also accept objects and locations as landmarks establish a localisation between a trajector and a part of the landmark inferred from the sentence and possibly expressed as a localisation noun. This is only an approximation and need to be qualified, since the correlation is not absolute between, on the one hand, a direct localisation (at sentence level) and the use of a location as a NP_landmark and, on the other hand an indirect (inferred) localisation and the undifferentiated use of a location or an object as a landmark. We have given a formal model of the phenomena described (adding functional knowledge to the more geometric aspects). This makes reasoning about those representations possible and at the same time is a preparatory stage for what should be a qualitative representation of movement by giving qualitative natural classes of movement (a basis lacking for instance in the otherwise remarkable work of [Galton, 1993] on qualitative motion). The aspects of the semantics of movement verbs which are described in our classification are however mainly topological (i.e. the relative positions of the trajector and the landmark regardless of orientation or distance). This is only a first step towards a fuller description which should integrate other spatial aspects (orientation, distance, shape of the arguments), the intentionality of the processes described and metaphorical uses.

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