

# Linking Theory and Lexical Ambiguity: The Case of Italian Motion Verbs

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## 1 Introduction

One of the major sources of inefficiency in traditional, declarative, NLP systems is represented by lexical ambiguity. Nevertheless, lexicalist principle based theories such as HPSG (in its standard formulation, Pollard and Sag(1994)) rely on the multiplication of lexical entries (sometimes exploiting generative mechanisms such as lexical rules) to account for phenomena which would be otherwise analysed through particular phrase structure rules. This makes it difficult to integrate such theories into practical NLP systems. Here we will try to show that a careful reconsideration of certain phenomena can overcome this conflict between efficiency and linguistic adequacy.

The paper<sup>1</sup> takes into account the case of motion verbs and spatial prepositions in romance languages, considering Italian as a case study. We will show that, contrary to traditional accounts (Zingarelli(1995), Serianni(1988)), there is no need assuming that spatial prepositions in romance languages are almost systematically ambiguous between a *static* and a *dynamic* interpretation. Such an assumption, which is made in analogy with Germanic languages, hides the generalization that monosyllabic static and dynamic Italian locative prepositions are not distinct. On the computational side, the traditional sense enumeration strategy overloads implemented grammars with the burden of systematically disambiguating spatial PPs.

In our approach Italian monosyllabic spatial prepositions, with the exception of *per* ('to/towards'), have *only* a static meaning. The alleged goal interpretation of these prepositions is derived by letting them interact compositionally with verbal semantics, in such a way that the state they denote becomes the resulting state of the dynamic event, meanwhile triggering a shift of aktionsart from atelicity to telicity. Since it has been proven that aspectually relevant constituents behave as arguments rather than adjuncts (Tenny(1994) Verkuyl(1993) Krifka(1992)), our analysis will provide a compositional mechanism which relates the syntactic argument structure to the semantic representation (Linking Theory). Control Theory will supply this representation with the proper index binding.

The present approach has been developed with the purpose of providing an efficient way of parsing Italian locative expressions, while retaining a principle based organization of the grammar (HPSG). A full implementation has been given using the DISCO system of the DFKI (Krieger and Schäfer(1994a), Krieger and Schäfer(1994b), Neumann(1993)). In the following we will rely on a *typed feature structure* language (Carpenter(1992)) where *sort resolvedness* is assumed. The organization of the grammar conforms standard HPSG (Pollard and Sag(1994)), except for a revision of the semantic part of the sign.

## 2 Related Works

The class of "motion verbs" (and of "motion complexes", i.e. verb plus preposition) has been considered a central case study in many linguistic theories: decompositional analysis (Jackendoff(1983) 1990), formal semantics (Asher and Sablayrolles(1995), Verkuyl(1993)), typological description of regularities either within a single language (Sablayrolles(1993), Boons(1987), Laur(1991)), or across languages (Talmy(1985)), interface between semantic structure and argument structure (Levin and Rappaport(1995)), compositional analysis of aspectual properties (Tenny(1995)). Lack of space prevents us from reviewing in detail all these approaches; our analysis is close to Levin and Rappaport(1995)'s view that many of the properties of motion verbs are syntactically represented, but semantically determined.

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<sup>1</sup>We are deeply indebted to Pier Marco Bertinetto, Diego Marconi and James Pustejovsky. All errors are ours.

The problem of representing knowledge about motion is also central for Artificial Intelligence, although the majority of AI works which take into account the linguistic level seem to concentrate more on static locative expressions than on dynamic ones (Herskovits(1986), Lang(1993), Olivier and Gapp(1995)). Nevertheless, a detailed treatment of dynamic locative expressions is provided by Kalita and Lee(1995), where the goal of “developing a semantic representation which can be implemented in order to drive execution of physical tasks” leads the author to consider concepts close to physical world, such as force, motion and geometry, as integral part in the specification of lexical meanings (cf also Hobbs et al.(1987), and several works on the interaction between language and vision (Mackevitt(1995))).

### 3 Lexical Meanings

In this section we will describe the information to be encoded in lexical entries in order to avoid prepositional ambiguity and to build the proper semantic representation for locative expressions. The role played by the information concerning geometrical features of objects (or, to be more precise, the spatial region they identify) is outside the scope of this paper: we assume that alternative geometric conceptualizations (Talmy(1983), Herskovits(1986), Lang(1993)) are specified via coercion functions implemented along the lines of Dini and Busa(1994) and Dini and Di Tomaso(1995)

#### 3.1 Prepositional Relations

Prepositional relations are encoded as types which introduce two attributes: LOCATUM and REF-OBJ. Each of them requires its filler to be of a certain type: the LOCATUM is either an individual or an event, while the REF-OBJ is a region of space identified by an object. For instance the semantic content of a preposition expressing a *spatial relation* will look like the following, where the type *index* subsumes both *event-index* and *ref-index*:

$$(1) \quad \underset{\text{spatial-relation}}{\left[ \begin{array}{ll} \text{LOCATUM} & \text{index} \\ \text{REF-OBJ} & \text{region} \end{array} \right]}$$

We assume two types of locative prepositional relations: *static* and *dynamic*. Static locative expressions are classified into relations stating the presence of the LOCATUM in (outside, next to, etc.) the region identified by REF-OBJ and relations (only one relation, to be precise) stating the absence of the LOCATUM from the spatial region identified by the REF-OBJ. In Italian, static relations are also used with motion verbs to express the destination of the moving object (the LOCATUM). The central claim of this paper is that this coincidence is not by chance: lack of a clear explanation for the identity of these two classes of prepositions turns into the loss of a generalization which, according to Talmy(1985), holds for a whole class of indoeuropean languages. On a more abstract level, the different behaviour of Romance and Germanic languages depends on a difference in the semantic components of locative expressions which are incorporated in verbal roots. For instance, English motion verbs do not incorporate the path along which the motion takes place, whereas Italian motion verbs do incorporate the path (Talmy(1985)).

Even though the class of Romance Path prepositions is smaller than the Germanic one, also in a Romance language like Italian there are prepositions (*per* (‘to/towards’), *verso* (‘towards’), *lungo* (‘along’)) which are used only in dynamic cases. Such prepositions differ from the static ones in that (i) the LOCATUM has to be an event (type: *ev-ind*) whereas standard static prepositions, as we have seen, can range over both events (*the cat ran on the floor*) and individuals (*the cat is on the ground*); (ii) they never change the verbal aktionsart; (iii) they always behave as adjuncts rather than complements (they are never obligatory). We distinguish purely dynamic relations into: *destination* (*verso*, *per*) and *path location*, the latter being specialized into path location *within* the reference object (*per*) and path location *through* the reference object (*attraverso*).

These distinctions, which are still coarse-grained, are reported in the hierarchy in fig. 1.

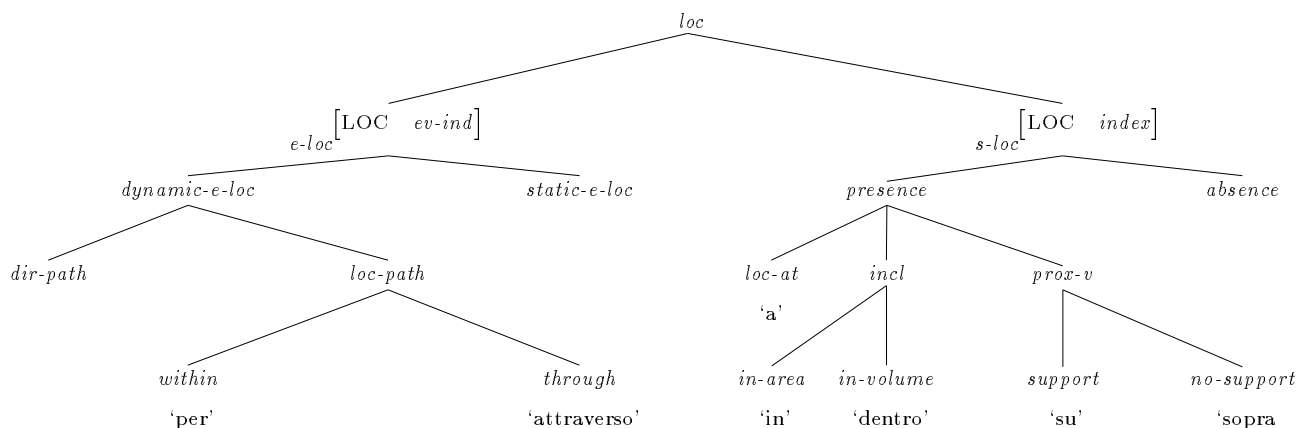


Figure 1: A hierarchy of Italian locative relations with their lexical realizations

## 3.2 Events

We assume an *event structure* along the lines of Pustejovsky(1995), which incorporates some revisions by Dini and Bertinetto(1995). An event structure is defined as a matrix of type *aktionsart* with at most two attributes, EVENT and TELOS. The value of the attribute EVENT is a relation which is of type *dynamism* (for instance, a *motion* relation); the value of the attribute TELOS is a relation which is of type *state* (for instance, a stative relation). In turn, every relation has an attribute INDEX, whose value is either a plural index or a singular index<sup>2</sup>. If both the attributes EVENT and TELOS are well typed for a certain semantic representation, the feature structure has to be interpreted as *the event denoted by the relation in EVENT will prototypically result into a state, which is in the denotation of the relation in TELOS*.

The traditional vendlerian classes (plus the class of punctual events, which has been identified by Moens and Steedmann(1988)) are defined as subtypes of *aktionsart* with the following constraints:

- **process**: a subtype of *aktionsart* for which only the attribute EVENT is appropriate and the index of the relation in EVENT is plural;
- **punctual**: a subtype of *aktionsart* for which only the attribute EVENT is appropriate and the index of the relation in EVENT is singular;
- **accomplishment**: a subtype of *aktionsart* for which both EVENT and TELOS are appropriate and the index of the relation in EVENT is plural;
- **achievement**: a subtype of *aktionsart* for which both EVENT and TELOS are appropriate and the index of the relation in EVENT is singular;
- **state**: a subtype of *aktionsart* for which only TELOS is appropriate.

The type *aktionsart* appears as the value of the standard HPSG attribute NUCLEUS; its subtypes are hierarchically represented as in fig. 2.

## 4 Motion Verbs

### 4.1 Verbal Semantics

On the basis of the theory of *aktionsart* defined above we identify three main classes of motion verbs:

- pure achievements (*partire*, ‘to leave’, *arrivare*, ‘to arrive’, *uscire*, ‘to go out’);
- pure accomplishments (*andare*, ‘to go’, *attraversare*, ‘to cross’, *tornare*, ‘to come back’);

<sup>2</sup>Here we are going to assume that such an index ranges over events, but different ontological commitments can be casted in this schema.

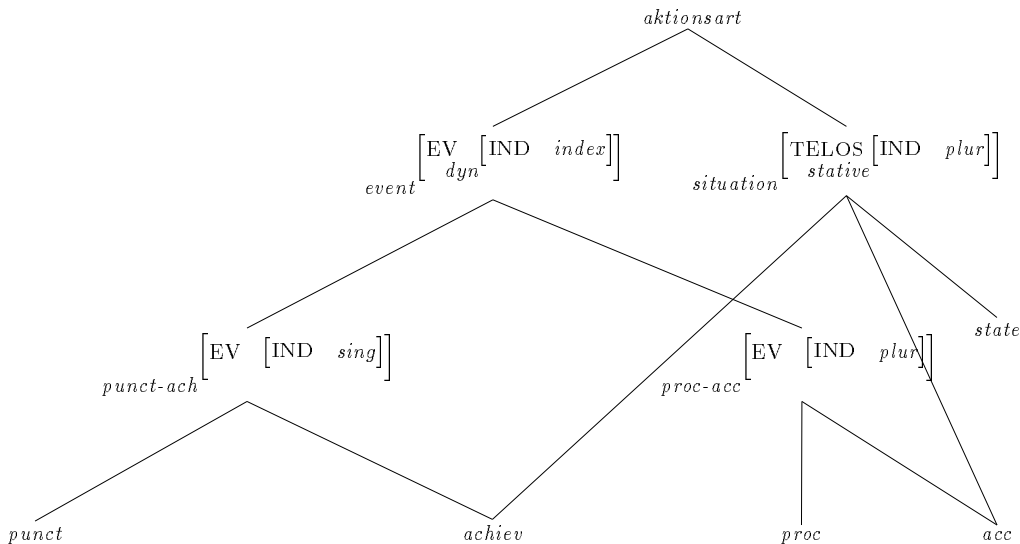


Figure 2: The hierarchy of Aktionsart

- pure processes (*nuotare*, ‘to swim’, *galleggiare*, ‘to float’);

We can compare this classification with the one proposed by Talmy(1985), which takes into account the lexicalization patterns, i.e. the incorporation of semantic components such as *Path*, *Manner* and *Cause* in the verbal root. According to the parameter of path/manner incorporation, we distinguish between:

- *path-motion verbs*, which incorporate the path (*arrivare* (‘to arrive’), *tornare* (‘to come back’));
- *manner-motion verbs*, which incorporate the manner of motion (*nuotare* (‘to swim’), *galleggiare* (‘to float’), *camminare* (‘to walk’)).

Path motion verbs are syntactically distinguished from manner motion verbs in that only the latter admit a goal PP introduced by a locative static preposition<sup>3</sup>. Since in our system the presence of these PPs is always associated with telicity (because they denote a state which occurs as an attribute of TELIC), the following constraints on the interaction between aktionsart and path/manner incorporation are predicted<sup>4</sup>:

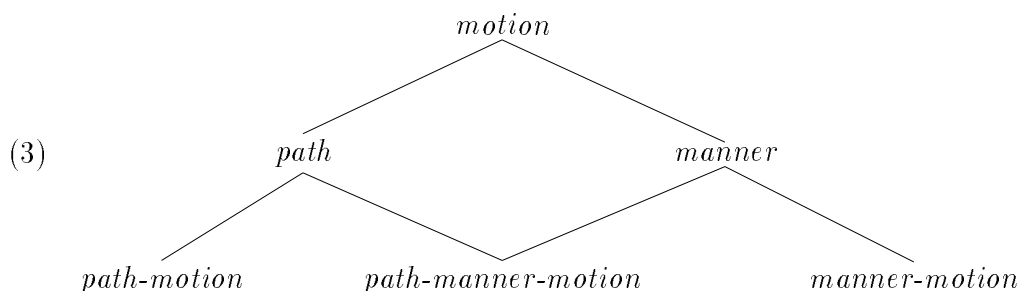
- (2) a.  $\left[ \begin{array}{l} \text{EV} \\ \text{path-motion} \\ \text{TELOS} \end{array} \begin{array}{l} [\text{IND} \text{ index}] \\ \\ \text{state} \end{array} \right]$
- b.  $\left[ \begin{array}{l} \text{EV} \\ \text{manner-motion} \\ \text{proc} \end{array} \begin{array}{l} [\text{IND} \text{ plur}] \\ \\ \end{array} \right]$

The validity of this generalization can be tested on a class of verbs which has been at the center of a long discussion in the aktionsart literature (cf. Dowty(1979), Levin and Rappaport(1995), Pustejovsky(1995), Verkuyl(1993)): this class contains lexically underspecified verbs like *correre*, (‘to run’), *rotolare*, (‘to roll’), *strisciare*, (‘to crawl’), *volare*, (‘to fly’), which can be realized either as unergative processes or as unaccusative accomplishments. These verbs are basically *manner-motion* verbs, in that they specify the *modality* of the change of place. However, they can also be used as telic predicates, and thus can have a static PP as goal. Since the information about the way in which the movement is performed should be preserved also when these verbs are used as accomplishments, a revision of

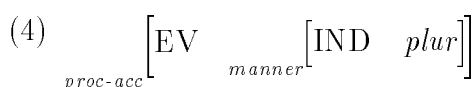
<sup>3</sup>They are also distinguished by a different behaviour with respect to Unaccusative Hypothesis: path motion verbs are always unaccusative whereas manner motion verbs are unergative.

<sup>4</sup>Although the first class can be further specified as achievements-path-motion and accomplishments-path-motion, depending on the plurality of the index, there is no need to specify these possible completions in the metalanguage we have adopted.

Talmy's stipulation, according to which only one parameter is incorporated in the verbal root, is strongly called for<sup>5</sup>. The hierarchy ruling path/motion incorporation is revised in the following way:



Verbs belonging to the underspecified class of process-accomplishment, will receive the following lexical classification, from which all their properties are deduced through type inference:



## 4.2 Mapping the Event Structure into Syntax

Linking theory is the compositional mechanism which maps the denotation of a static PP onto the TELOS attribute of the NUCLEUS of the heading verb. Here we will follow the syntactic tradition (Chomsky(1981) Grimshaw(1990), Levin and Rappaport(1995)) according to which the alleged goal PPs are considered syntactic arguments. However, we refuse the strict HPSG (and GB) assumption that the only semantic contribution of the arguments of a relation is binding the participants' indices. This may be the case of elements which do not introduce any relation, such as NPs, but considering locative PPs as semantically 'inert' w.r.t. the verbal relation has the undesirable consequence of obscuring the compositional mechanisms which rule the human language faculty.

Informally, our linking theory is based on the following assumptions (we adopt the valence structuring of Pollard and Sag(1994),Ch.9):

- If a situation has an EVENT with an ARG1, unify the ARG1 value with the index of the unique NP in SUBJ.
- If a situation has an EVENT with an ARG2, unify the ARG2 value with the index of the first NP in COMPS.
- If a situation has a TELOS, unify its value with the content of the last PP in COMPS.
- Every element in SUBJ or COMPS has either its index or its content structure shared with some value in NUCLEUS.

Contrarily to the standard assumption, the semantic import of a PP is not an *index*, but a whole relation, which becomes part of the semantics of the verb through structure sharing. This explains why, in Romance languages like Italian, the same prepositions head stative modifiers and arguments of dynamic relations: it is not the semantic value of the preposition which changes, but its role, i.e. whether it is a predicate of a whole event or it is a part (TELOS) of an event structure<sup>6</sup>.

More formally, linking theory is conceived, along the lines of Davis(1995), as a set of types which relates the attribute NUCLEUS of the lexical sign with its valence lists. These types are hierarchically organized as described in fig. 3.

<sup>5</sup>Such a revision has been independently argued by Aske(1989).

<sup>6</sup>It might be argued that two entries of the same preposition are needed anyway, in order to satisfy the HPSG Content Principle. However, it has been shown in Dini et al.(1995) that a less constrained version of the content principle is desirable in order to reduce the possible sources of ambiguities in the lexicon. Such a version has been adopted also in our TDL grammar.

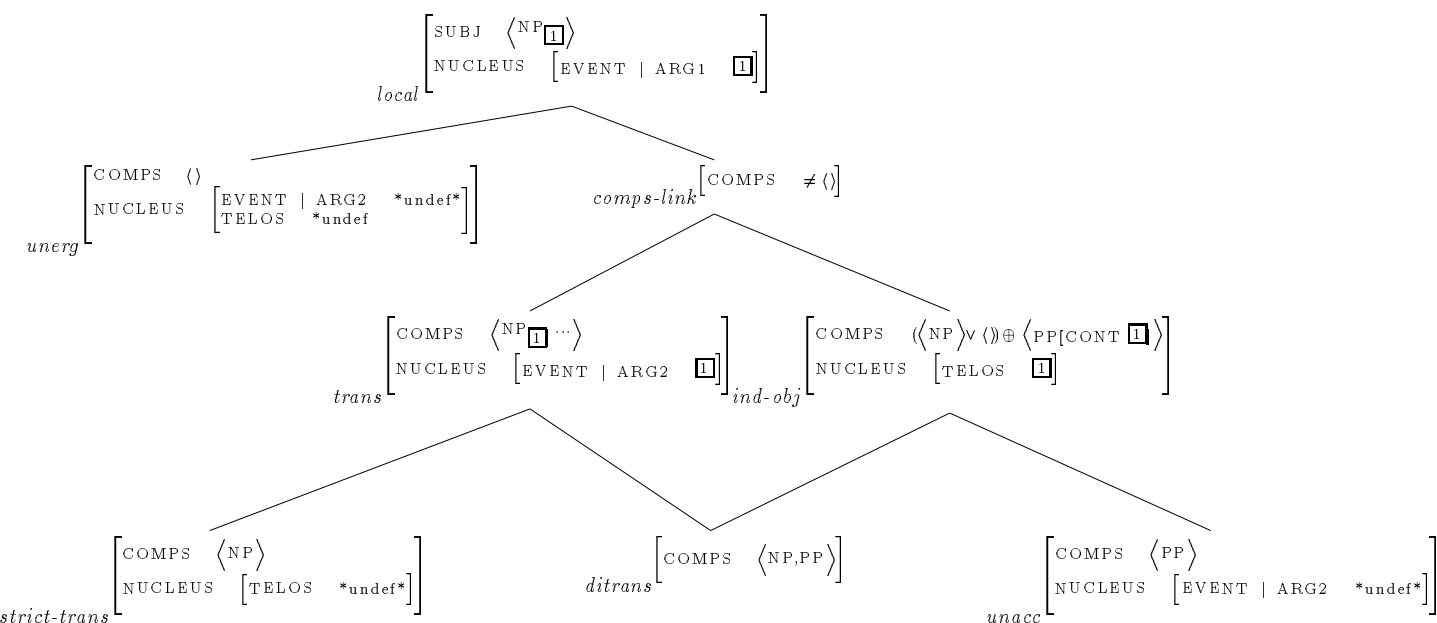


Figure 3: Linking Theory for locative expressions

### 4.3 Interactions with Control Theory

In order to identify the participant which effectively undergoes a change of position in the motion event, an index of the dynamic relation (EVENT) has to be associated with the LOCATUM of the stative relation in TELOS. Assuming a standard HPSG architecture, a module able to perform such an index identification is already available, i.e. Control Theory. Consider the following sentences:

- (5) a. Leo è andato a comprare il latte  
 Leo has gone to buy the milk  
 b. Leo ha mandato Lia a comprare il latte  
 Leo has sent Lia to buy the milk

The motion verbs in (5) head an infinitival clause, whose unexpressed subject is identified with the matrix subject in (5a) and with the matrix object in (5b). This behaviour patterns with the one of control verbs which in Pollard and Sag(1994) are semantically classified as either *orientation* or *influence*. For this reason motion verbs are considered as falling within the domain of control theory. If this is the case, no additional tool is needed to perform a correct coindexation in sentences such as the ones in (6)<sup>7</sup>:

- (6) a. Leo è andato a Torino  
 Leo has gone to Turin  
 b. Leo ha mandato Lia a Torino  
 Leo has sent Lia to Turin

The generalization is the following: whenever a static relation enters into the context of an *influence* verb such as *mandare* we predict that the locatum is coindexed with the filler of the INFLUENCED role (*Leo* in (6a)); whenever it enters into the context of an *orientation* verb, such as *andare*, we predict that the locatum is coindexed with the EXPERIENCER role (*Lia* in (6b)). Thus the fact that (6a) predicates the final position of *Leo*, whereas (6b) predicates the final position of *Lia* simply follows as a consequence of Control Theory<sup>8</sup>.

<sup>7</sup>For spatial PPs to fit the standard HPSG control theory we are forced to assume that they have a non empty SUBJ list. This assumption is independently supported by the fact that this PPs can appear in copular constructions.

<sup>8</sup>We predict that no transitive verb can exist in Italian, and, arguably, in any language, such that the goal phrase expresses the position of the subject rather than the object. Note that this could be

The central role played by Control Theory in determining the binding of the indices explains why no verb can surface with a dynamic preposition (such as *per* and the polysyllabic prepositions) as an argument. Since motion verbs with an argumental PP fall under the Control Theory, we should expect either the subject or the object to control the unbound index of such a PP. However, since *per* PPs are typed as having an event filling the role of their first argument (cf. fig. 1), an index clash would be generated (an attempt to unify *ref-ind* with *ev-ind*), thus resulting in a semantically uninterpretable sentence (cf. Dini and Di Tomaso(1995)). This is the reason of the ungrammaticality of sentences such as the following, under the goal interpretation of the *per*-PP:

- (7) a. \* E' corso per Torino  
He has run to Turin
- b. \* Ha mandato un pacco per l'America  
He has sent a parcel to USA
- c. \* E' andato per l'America  
He has gone to USA

## 5 Conclusion and further research

We have presented an analysis of motion verbs and spatial prepositions which eliminates the need to treat as homonymy the use of the same prepositions in static and dynamic locative expressions. The semantics of the verbal complexes can be compositionally built using only the static sense of prepositions. This result has been obtained by exploiting the interaction of three modules of the grammar: aktionsart, linking theory and control theory. As far as motion verbs are concerned, the analysis has been proven able to capture the well known influence of locative arguments on aktionsart.

Three points have been so far identified, which will be explored in the prosecution of our research:

- On the computational side, the system will be expanded in such a way that also non locative prepositions which are ambiguous between an argumental and a non argumental use can receive an analogous unitary treatment.
- On the semantic side, our hierarchies need to be further elaborated in order to capture more fine grained interactions between verbal semantics and the semantics of spatial relations.
- On the syntactic side, the well know interaction between the Unaccusative Hypothesis and the use of certain locative PPs will be taken into account

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a perfectly logical possibility: there could be some verb like \**puscerellare* with the meaning *I pushed something, and, as an effect of this act, I found myself in a certain place*. However, as a matter of fact, no such a verb exists in Italian, the reason being that it would overtly violate the principles governing Control Theory.

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