Abstract

In this paper we propose a system to parse and annotate motion constructions expressed in Italian language. We used NooJ as a software tool to implement finite-state transducers in order to recognize linguistic elements constituting motion events. In this paper we describe the model we adopted for semantic description of events (grounded on Talmy’s Cognitive Semantics theories) and then we illustrate how the system works with a domain-specific corpus, the structure of annotation that our system will perform, some annotation structures of example sentences expressing motion and then an attempt to evaluate the system’s performance.

1 Introduction

The building of models of semantic knowledge to be implemented in language recognition and analysis systems shares some features with the theory of perception (Piotrowski and Palibina, 1973). In a Cognitive Linguistics paradigm this task should be viewed as the modelling of the human ability to map concepts onto syntactic-semantic constructs. The aim of this contribution is to describe an approach to the annotation of expressions of motion in Italian. The set of concepts (i.e. the semantic model) is grounded on a cognitive semantics theory where knowledge representation constitute both the basis of the construction process of meaning and also the goal of the proposed application. From the computational point of view we make use of recursive transition networks (RTNs) used for recognition and subsequent annotation of text with the domain’s concepts. To implement RTNs we used NooJ development environment (Silberztein, 2004). We used NooJ because in this way we can easily write local grammars describing the elements to be recognized. From the technical point of view, at the dawn of NLP research on pattern recognition, experimentation started using the so-called rule-based paradigm. This entailed the processing of a large amount of grammar rules and the need of storage-consuming electronic dictionaries. These drawbacks caused these methods to be substantially impractical thus shifting rapidly the mainstream to the now widespread statistical corpus-based approach. In this paper we then propose a system that, using a cascade of transducers, deterministically recognizes semantic patterns describing motion events (Abney, 1996). These patterns show a large variety of diverse expressions and lexical choices (in one word lexicalization patterns) to describe motion. Such a variety is easily accounted for by a set of finite-state automata. The formalism used here to extract semantic components of the patterns is grounded on cognitive semantics theories attempting to describe the lexicalization processes that underlie the production of the syntactic and semantic structures expressing concepts related to motion and, consequently, to space.

2 Theoretical Framework

Spatial notions form the kernel of linguistic knowledge from which all other concepts are derived from, giving to the spatial knowledge a primary role on the conceptualization of the reality. This stance is called localism. Localism is the “hypothesis that spatial expressions are more basic, grammatically and semantically, than various kind of spatial expressions [...] spatial organization is of central importance in human cognition” (Lyons, 1977) and such approaches date back to the early comparative studies on prepositions and cases (Wüllner, 1827), where their meaning is viewed as grounded on spatial subjective intuition. Concepts related to space hold a basic role in the conceptualization process of the human’s mind (and in child’s development of con-
cepts) and they serve as a major source of lexicalization of more abstract ones. These views regained importance with the rise of cognitive science in the 1970’s, with the dominance of universalist studies on categorization. According to these theories, abstract concepts are thought to be derived from spatial primitives by using cognitive tools like conceptual metaphor (Lakoff, 1980) or derivation from universal representations like image-schemata (Johnson, 1987). Space-related constructs can thus refer also to a wider semantic area than just concepts closely related to space and motion: in this way a system extracting motion events will recognize also events other than motion-related ones, if expressed metaphorically with motion verbs. Sentences expressing motion events are generally characterized by a set of thematic roles from the semantic domain of concepts related to motion. Our purpose is to parse simple sentence constructs, more specifically we focus on compound nouns and predicate-argument structures, which bear most of the meaning (Surdeanu et al., 2003). Our final goal is to recognize the type of motion described and to semantically annotate the text with the related concepts.

3 The proposed system

The system implements semantic role labeling techniques (Gildea and Jurafsky, 2002) to parse predicate-arguments structures. Lexical constructs are connected to their corresponding roles selected by the verb. These latter will be recognized and annotated with their respective information elements related to the motion event. Predicate-argument structures are constituted by a main verb and a set of nouns or prepositional phrases specifying the meaning of the verb, which works as the head of the structure. Semantic model maps lexical elements into their respective semantic roles. In the following section we will describe the model we used for structure detection and annotation, then detail the mapping layers implemented according to the annotation to be performed and finally we will illustrate some of the transducers used for the recognition of lexical elements and also we give some examples of possible practical uses of our system.

3.1 Semantic model of the motion event

To choose a suitable representation of motion events we need to consider different semantic roles expressed by lexical elements in order to map the predicate-argument structures onto elements of the semantic model of the event (Exner and Nugues, 2011). The model is thus constituted by a set of domain-specific semantic roles belonging to motion. To choose them we have considered the notion of motion event as introduced by Talmy (1985) where motion events are described as “situation containing movement or the maintenance of a stationary location [...]. The basic motion event consists of one object (the Figure) moving or located with respect to another object (the reference-object or Ground)”. Talmy’s approach is based on perception and on neuropsychological theories: Figure and Ground are, for example, concepts borrowed from the so-called Gestalt Theory, a theory of mind opposed to structuralist and behaviorist approaches aiming to describe the mind/brain through holistic, analog and emergent mechanisms. This has led to choose a semantic model that is both cognitive-grounded and comprehensive of all necessary conceptual elements (Mosca, 2010). In Table 1 are listed the elements we choose to extract. As Italian is a pro-drop language, subject is often omitted and then Figure is seldom lexicalized.

| Element     | Description                                                                 |
|-------------|-----------------------------------------------------------------------------|
| FIGURE      | The object that moves or is located with respect to another object.          |
| GROUND      | The reference object with respect to which the motion takes place or another object is located. |
| SOURCE      | The place where the described motion event starts.                          |
| GOAL        | The place where the described motion event ends.                            |
| DIRECTION   | The relative direction taken with respect to a ground or reference point (as left, right, north, west, ...). |
| VECTOR      | The axis along which the motion takes place and/or the absolute direction of the moving element. |
| PATH        | The type of path performed by the moving element involving a ground element (inwards, outwards, crossing, passing through). |
| SHAPE       | The shape of movement performed. (circular, straight, curvilinear)          |
| PROXIMALITY | The distinctive feature of motion with respect to a ground or reference point (near, along or throughout). |
| MANNER      | The manner of performed motion (walking, running, wandering,...)            |

Table 1: Elements of motion
3.2 Description of the system

The elements previously listed constitute the set of semantic roles of our model. They can be beared by the verb itself or explicitly lexicalized as syntactic elements of the sentence as direct objects, indirect objects or adverbial phrases (i.e. they are satellites of the verb). We need to implement a set of lexico-syntactic transducers to parse every single semantic elements. According to Mosca (2010), motion event sentences can be grouped in eight syntactic patterns with increasing analyticity. For our purposes we select the following ones:

1. Motion verbs that can stand alone with no adjoints.
2. Motion verbs accepting a noun phrase as direct object.
3. Motion verbs accepting a prepositional phrase as object.
4. Motion verbs expressed with a generic motion verb with prepositional phrase(s) plus one or more satellites to specify motion event roles.
5. Motion events analytically expressed with support verbs\(^1\)

Verbs of the first type bear a lot of information and accept none or few satellites: according to Talmy’s terminology they conflate semantic elements. A verb like fiancheggiare “conflates” all the information about the fact that a figure is moving in proximity to a reference ground. Conflation is “any syntactic process [...] whereby a more complex construction turns into a simpler one.” (Talmy, 2000). More analytic verbs bear few information and devolves their meaning to their satellites\(^2\). Satellites are lexicalized with different syntactic constructs. Our system recognizes locative adverbial phrases representing position or direction, deictic elements expressing proximal or distality (frequently referred to a reference ground) and so on. The system also maps satellites to the corresponding semantic roles and “deflates” the meaning of the verbs making it explicit.

Motion verbs are grouped in semantic clusters according to their meaning (Mosca, 2007). For each cluster we need to implement a set of transducers. We have considered motion verbs with the meaning of a generic motion from and/or to a ground object, verbs indicating a continuing motion along the same direction (called source-destination verbs), verbs indicating motion along a direction or towards something that specifies the followed path (direction verbs), verbs with the meaning of passing beyond, crossing, exiting or entering a ground, or with the meaning of moving along a direction or near a ground (path verbs), verbs indicating a proximal motion passing near a ground (proximity verbs), verbs specifying the shape of a path (curvilinear, circular, straight, etc.) (called shape verbs) and verbs that specifies the manner of motion (manner verbs).

Semantic patterns are represented with formalisms involving lexical, syntactic and semantic elements (local grammars) implemented on NooJ\(^3\). Local grammars are formal descriptions of morpho-syntactic and/or semantic regularities represented with finite-state transducers (Harris, 1991; Gross, 1993).

3.2.1 Annotation layers

The annotation is performed using a cascade of transducers. Parsing is done incrementally: annotations at one level make use of the ones performed on previous levels. We have implemented seven different layers, each defined by the type of structure(s) recognized, as described below.

Simple compound nouns This layer recognizes compound nouns with patterns like N+Adj (e.g. lago blu), Adj+N (e.g. nuovo sentiero), N+N (e.g. piazza Garibaldi, N+Prep+N (e.g. casa di pietra). These listed above are the most frequent patterns in Italian (Voghera, 2004). Below is reported the corresponding local grammar reported in NooJ’s format\(^4\).

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SC::= NA | AN | NP| NFV | NN | NoN
AN::= <A> <N>
NA::= <N> <A>
NP::= <N> P <N>
NFV::= <N> (a|da|per) +Inf>
NN::= <N> <N>
P::= (d|a|in|con|su|per|tra|fra) <DET>*
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Complex compound nouns The second layer refers to complex compound nouns: this layer recognizes compound nouns corresponding to forms as strada ripida sterrata, bivio segnalato da bolli gialli, casa vicino all’incrocio di tre strade, versante occidentale della catena montuosa. The head can be one of the cases listed

\(^1\)Support verbs are constructions where the predicative role is taken by the noun (object) and the verb lose its meaning as fare una curva VS curvare

\(^2\)They are “the grammatical category of any constituent other than a noun-phrase or prepositional phrase complement that is in a sister relation to the verb root”

\(^3\)NooJ standard dictionary with other resources for Italian are developed and maintained by Simonetta Vietri of Università di Salerno and are available at http://www.nooj4hlp.net/pages/italian.html. (Elia and Vietri, 2002).

\(^4\)Angle brackets denote a POS element of standard dictionary and asterisk refers to optional elements.
above and the modifier can be an adjectival or a prepositional phrase. Corresponding transducers are shown in Figure 1 and below is presented the related local grammar. As the former, this layer recognizes structure type, number, gender and head of the extracted nouns.

CCN::= (<N>|SC> | (A_modifier | P_modifier | N_modifier))
A_modifier::= <AVV>* <A> ((e|ed)<A>)*
P_modifier::= P (<V+Inf>|<AVV>*) (<N>|SC>)
N_modifier::= N

Figure 1: Transducer recognizing complex compound nouns

Noun phrases This layer annotates noun phrases and extracts their head. Transducer is shown in Figure 2.

Prepositional phrases This layer annotates prepositional phrases and extracts their prepositional head and the dependent noun (or noun phrase). Respective transducer is shown in Figure 3.

Motion verbs This layer recognizes motion verbs. The ones recognized by our system are extracted from a list compiled through a statistical analysis of a corpus of spoken Italian. This corpus was collected from experiments for which the goal is to solve a spatial description task. Verbs forming this list are a set of frequently used verbs while describing motion events in Italian. We adopted the classification and the set of lemmas proposed in Mosca (2007). The local grammar that recognizes motion verbs is reported in Figure 4. Transducers are shown in Figure 5.

Verb phrases This layer recognizes different syntactic realizations of motion verb phrases distinguishing between active and passive form. The corresponding transducer is shown in Figure 6.

4 Motion Events’ elements recognition

The two upper layers (i.e. the last processed ones) are used for recognizing the different elements
of motion event: the first is dedicated to the recognition of satellites. They consist mainly of prepositions expressing information about motion (Mosca, 2012) such as Prepositional Case-Markers (PCM) and satellites-prepositions. Prepositional Case-Markers are prepositions with a weak or no meaning that serve to introduce a prepositional phrase as in salire su sul tetto. Satellite-preposition Satpreps are intended as prepositional particles fulfilling both the functions described before. For our purposes we have distinguished the following satellite types:

- **DIRECTION**: satellites expressing direction. They can be specified using an absolute or an intrinsic frame or reference (Levinson, 2003) (as in direzione est or a destra). The system also recognizes deictic relative reference grounds to/from an origo\(^5\).
- **POSITION**: satellites expressing proximality, i.e. object located in areas expressed with respect to a ground (lungo, accanto, di fianco, nei pressi, vicino).
- **PROXIMITY**: satellites expressing proximity, i.e. object located in areas expressed with respect to a ground (lungo, accanto, di fianco, nei pressi, vicino).
- **STRAIGHT**: satellites expressing motion events in which the taken direction is straight (as dritto).
- **CIRCULAR**: satellites expressing motion events where the motion is circular (as intorno, attorno).
- **THROUGH**: satellites expressing motion events whose GOAL is reached via a path (as attraverso) or through a reference ground (as in fondo, a fine).

These transducers recognize **FIGURE** and **GROUND** elements, satellites and PCM (see Figure 7).

Figure 7: Transducers for recognizing satellites, figure, ground, PCM and Satpreps elements

We have also distinguished five types of lexicalization structures according to the meaning of the verb:

1. Structures expressing a generic motion with a source and/or a destination explicitly expressed.

2. Structures describing a movement in a particular direction and/or along a particular vector. The direction can be expressed by a conflation of the directional element of meaning in the verb root (as in scendere, salire, indietreggiare) or by a satellite.

3. Structures expressing a motion along a path where the moving element can enter, exit, pass over or going through a reference ground (verbs as entrare, attraversare, percorrere, sbucare).

4. Structures expressing proximal motion. We distinguish a motion along (costeggiare, seguire), near (sfiorare, toccare) or passing through a GROUND (sorpassare, superare).

5. Structures expressing a straight or round shape of the motion path. A round path can be a complete circular loop, a circle arc (circoscrivere, aggirare) or a curved trajectory as in curvare, svoltare. Note that in this latter case the motion will change vector so the system will note this explicitly with a dedicated annotation (+VECTOR_CHANGE).

Note that if the elements about motion are conflated in the verb root the information should be extracted by putting an empty-string transducer before the matching element with the desired annotation in output (see Figure 9).

Arguments of the verbs are extracted with the transducer shown in Figure 10. Elements lexicalized by satellites are extracted using transducers as the one shown in Figure 11. These latter have been designed according to the structure of related verb(s).
Transduction is performed when we need to annotate text chunks: annotation is given in the NooJ’s XML-like form, i.e. using a node-label and a series of attribute-value pair specifying motion elements. Annotation and extraction are done simultaneously for every stage of the transducers’ cascade. A comprehensive list of the annotations performed by our system is shown in Figure 8 where, for every layer, the annotation tree is detailed (annotations introduced by the standard dictionary are not reported).

4.1 Source-destination

These automata describe basic motion events (annotated as +SD) starting from a SOURCE and ending in a GOAL. These can be described by verbs as andare, venire, spostarsi, tornare. SOURCE and GOAL can be of different types: we have considered the following three cases:

1. The simplest case where the SOURCE and/or the GOAL are reference grounds expressed with prepositional phrases as partire da casa or andare a casa.

2. The case where the SOURCE and/or the GOAL are areas defined with respect to a reference ground as in partire davanti la stazione. The GOAL can be reached via a path or through a reference ground (spostarsi in fondo al viale, andare alla fine della strada, partire da davanti la stazione).

A generic motion should be expressed with a verb whose meaning focuses alternatively on different phases of the event as the reaching of a point or a place (+TO), the leaving from a point or a place (+FROM) as in partire or the continuing (+CONT) of the motion along a path as in proseguire, continuare, andare avanti. The system also distinguishes from terminative verbs +TERM involving the reaching of a goal (raggiungere, arrivare, giungere) or the reaching of a generic point along a translation process (ritrovarsi, incontrare). Examples of extracted structures are shown in Figure 12.

4.2 Path

The system distinguishes four types of paths (+PATH), involving four different configurations of the motion:

1. A motion event which PATH entails that the FIGURE moves THROUGH a GROUND. The reference ground can be a road, a trail or a path (verbs as passare, percorrere, seguire).

2. A motion event in which the FIGURE goes ACROSS a GROUND element (i.e. a river, a crossing, a wood). It can be described by verbs as incrociare, tagliare, attraversare.

3. A motion event in which the FIGURE enters in a GROUND element as a house, a road or a new path. It is described by verbs as entrare, imboccare, immettersi (INTO).

4. A motion event in which the FIGURE exits from a GROUND element (verbs as sbucare, uscire) (+OUT_FROM).

Examples of annotated structures are shown in Figure 13.
4.3 Proximality

The system extracts motion events’ structures where the FIGURE moves near a GROUND object (+PROXY). We call this feature proximity. Transducers extracting these structures are shown in Figure 9 and examples of annotated structures are shown in Figure 14. Our system distinguishes three cases:

1. The case in which the FIGURE passes near a GROUND object (verbs as rimanere, sfiorare, toccare).
2. The case where the FIGURE moves along a reference GROUND (as a border). (as verbs costeggiare, fiancheggiare).
3. The case where the FIGURE passes over a reference ground (over-stepping an obstacle or moving beyond a landmark). This is expressed with verbs as (oltrepassare, superare).

4.4 Direction

The system recognizes five different cases in respect to the lexicalization of DIRECTION and VECTOR features of motion:

1. The case where the FIGURE has to go back (+DIRECTION_BACK) in respect to the direction already taken (+VECTOR = BACKWARDS). Event is described by verbs like tornare (indietro), indietreggiare.
2. The case (+DIRECTION_DOWN) where the FIGURE moves downwards (+VECTOR = DOWNWARDS) (verb scendere).
3. The case (+DIRECTION_UP) where the FIGURE moves upwards (verb salire).
4. The case (+DIRECTION_DEV) where the FIGURE changes direction (+CHANGE_DIRECTION) (verbs as abbandonare, inclinarsi, rientrare, alzarsi). This case can involve the change of direction and/or vector of the FIGURE.
5. The case (+DIRECTION_GEN) where the direction of the FIGURE is explicitly expressed by a generic verb (as punta, dirigiti, muoviti) using a direction satellite with respect to a reference ground. The system recognizes the case where DIRECTION is taken toward a reference ground (+DIRECTION = TO_GROUND).

Examples of annotated structures are shown in Figure 15.

4.5 Shape

There are also cases where the motion involves a straight or a circular movement (+SHAPE). The motion can take place with respect to a GROUND following a circular trajectory (verbs aggirare, circondare, circonscrivere) or just a direction change, usually with a turn (verbs girare, curvare, svoltare). Examples are shown in Figure 16.

5 Evaluation of the system

In order to evaluate our system we have collected a corpus of about 300 texts describing hiking tours in Western Alps. Texts are extracted from hiker’s fan websites (our main source was the site http://www.inalto.org).

These descriptions, from the point of view of language variation determined by the medium of communication, share characteristics both of written and spoken language. This is due to the distinctive traits of Web-Mediated communication where the language, although written, shows features of spoken language and also to the reduced perceived distance between addresser and addressee. Route descriptions posted in a blog brings similar characteristics: in this way we can easily have a corpus positioned “half-way” along the diamesic dimension (Mioni, 1983).

A hiking tour description, also, contains motion events where all three space dimensions are involved while describing paths. These can run up and down, going along grounds elements with directions that can be expressed lexically through both absolute or relative frames of references. All these features make hiking descriptions a well suitable test corpus for the system.

The dimension of our corpus is around 100k words with a type/token ratio of 8%. In Table 2 we show the score of the system tested on the evaluation corpus at the current stage of development.

| Precision | Recall | F1 score |
|-----------|--------|----------|
| 70.5%     | 80.4%  | 75.1%    |

Table 2: System’s scores
Figure 17: Annotation structure of a sample sentence

The evaluation is conducted on recognized sentences not taking into account the annotation structure. We show in Figure 17 a sample of the annotation structure of a sample sentence.

The proposed system can be used to extract motion structures with complex combines of features. Here we extract events involving a changing vector to left (see Figure 18):

\[<\text{ME} + \text{CHANGE\_VECTOR} + \text{DIRECTION}=\text{LEFT}>\]

Figure 18: Samples of extracted motion structures

Our system can also make queries using lower annotation layers as in:

\[<\text{V} + \text{SD\_CONT}> <\text{PCM} + \text{PREP} = \text{su}> <\text{GROUND}>\]

where the system extracts all motion events in which the FIGURE continues along a PATH expressed by a GROUND and introduced by the preposition su (on) used here as a case-marker. Results are shown in Figure 19.

6 Conclusions and future work

We have described here a system that recognizes sentences expressing motion events and annotates them extracting the information about the type of performed motion. This information is gathered from the meaning of the verb and explicitly lexicalized by verb’s satellites expressing motion features such as position, direction or shape. Elements participating in motion process are annotated according to concepts borrowed from psychological theory of Gestalt as used in Talmy’s theory of motion events. It would be possible to expand the scope of our system making it able to recognize more complex and longer patterns of expressions. We could also make use of lexico-syntactic constraints in order to filter out relevant sentences and thus improve precision. Thanks to the integration capability of NooJ our system is designed to be also part of more complex applications in a NLP pipeline. As an example, it is possible to use the information extracted and reported on annotation layers to populate an ontology in the domain of space or motion (Salza, 2013). Moreover, the described system can be extended to recognize a large variety of lexical structures; among these, the vocabulary related to manner of motion lacks a deeper theoretical analysis and requires further work.

Figure 19: Samples of extraction of lower annotation layers
References

Steven Abney. 1996 Partial parsing via finite-state cascades. Natural Language Engineering, 1996.

Annibale Elia and Simonetta Vietri. 2002 L’analisi automatica dei testi e i dizionari elettronici, in E. Buarattini, R. Cordeschi, (eds.), Manuale di Intelligenza Artificiale per le Scienze Umane. Carocci, Roma, 2002.

Peter Exner and Pierre Nugues 2011 Using semantic role labeling to extract events from Wikipedia. In Proceedings of the Workshop on Detection, Representation, and Exploitation of Events in the Semantic Web (DeRiVE 2011). Workshop in conjunction with the 10th International Semantic Web Conference 2011 (ISWC 2011) Bonn, October 23–24 2011

Daniel Gildea and Daniel Jurafsky 2002 Automatic labeling of semantic roles. In Proceedings of the 38th Annual Conference of the Association for Computational Linguistics (ACL-00), pages 512–520, Hong Kong, October 2000.

Maurice Gross. 1993 Local grammars and their representation by finite automata. In M. Hoey - Data, Description, Discourse. Harper Collins, London, pages 26–38, 1993.

Zellig S. Harris. 1991 A theory of language and information: a mathematical approach. Clarendon Press, Oxford

Mark L. Johnson 1987. The Body in the Mind: The Bodily Basis of Meaning, Imagination, and Reason. University of Chicago Press, 1987.

George Lakoff and Mark L. Johnson 1980. Metaphors we live by. University of Chicago Press, Chicago, 1980.

Stephen C. Levinson 2003. Space in language and cognition. Cambridge, Cambridge University Press, 1977.

John Lyons 1977. Semantics. Cambridge, Cambridge University Press, 1977.

Monica Mosca 2007. Spatial language in spoken Italian dialogues. A cognitive linguistics perspective. Ph.D. Thesis, Pisa, Università di Pisa

Monica Mosca 2010. Eventi di moto in italiano tra sintassi e semantica. Uno studio cognitivo empirico. Edizioni Plus - Pisa University Press

Monica Mosca 2012. Italian motion constructions - Different functions of particles. In: Filipović, Luna and Kasia M. Jaszczolt (eds.), Space and Time in Languages and Cultures: Linguistic diversity . 2012. xv, 492 pp. (pp. 373394) John Benjamins John Benjamins

Marvin Minsky 1975. A Framework for Representing Knowledge. In The Psychology of Computer Vision, ed. P. H. Winston, 211 - 277. New York: McGraw-Hill.

Alberto M. Mioni 1983 Italiano tendenziale: osservazioni su alcuni aspetti della standardizzazione, in Scritti linguistici in onore di Giovan Battista Pellegrini, Pacini, Pisa 495-517.

R. G. Piotrowski and I. V. Palibina 1973. Automatic pattern recognition applied to semantic problems. In Proceedings of the 5th conference on Computational linguistics - Volume 2, COLING '73, pages 104–106 Stroudsburg, PA, USA, 1973. Association for Computational Linguistics.

Edoardo Salza 2013. Using NooJ as a system for (shallow) ontology population from Italian texts. Unpublished conference proceedings, NooJ International Conference. June 3–5 2013, Saarbrücken University.

Max Silberztein 2004. NooJ : an Object-Oriented Approach. In INTEX pour la Linguistique et le Traitement Automatique des Langues, C. Muller, J. Royauté, M. Silberztein Eds, Cahiers de la MSH Ledoux. Presses Universitaires de Franche-Comté, pp. 359-369.

Mihai Surdeanu and Sandra Harabagiu and John Williams and Paul Aarseth. 2003. Using predicate-argument structures for information extraction. In Proceedings of the 41st Annual Meeting on Association for Computational Linguistics-Volume 1, pages 8–15. Association for Computational Linguistics, 2003.

Henry S. Thompson and Anne Anderson and Ellen Gurman Bard and Gwyneth Doherty-Sneddon and Alison Newlands and Cathy Sotillo 1993. The hrc map task corpus: natural dialogue for speech recognition. In Proceedings of the workshop on Human Language Technology, HLT '93, pages 25–30, Stroudsburg, PA, USA, 1993. Association for Computational Linguistics.

Mark B. Turner and Gilles Fauconnier 1995. Conceptual Integration and Formal Expression (July 28, 1995). Metaphor and Symbolic Activity, Vol. 10, No. 3, pp. 183-203, 1995. Available at SSRN: http://ssrn.com/abstract=1650417

Leonard Talmy 1985. Lexicalization Patterns:Semantic Structure in Lexical Forms, in T.Shopen, Language Typology and Syntactc Description. Vol. III Gramamtical Categories and Lexicon. Cambridge, Cambridge University Press:57-149

Leonard Talmy 2000. Toward a Cognitive Semantics: Vol.I Concept Structuring Systems. Cambridge(MA), MIT Press

Miriam Voghera. 2004 Polirematiche. In Grossmann M., Rainer F., (a cura di) La formazione delle parole in italiano.Tbingen, Niemeyer, pages 56–69, 2004.

Franz Wullner 1827. Die Bedeutung der sprachlichen Casus und Modi. Münster, Theissigsche Buchhandlung