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SEMANTICS OF MOTION VERBS

- multiple inheritance of semantic features -

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1. Lexical Semantics and Classification Problems

1.1. Semantics, Representation and Ontology

In computer science, data lay at the base of information which in turn gives rise to knowledge. In linguistics, we may then consider that we deal with linguistic data. Once data are structured and enriched with contextual elements and pragmatic know-how, they are further transformed into pieces of knowledge which are the result of our understanding of linguistic messages.

We must distinguish between semantic mental representations, cognitive phenomenal representations and reality (World). Current research in Computational Intelligence aiming at building data-banks and systems for machine translation is becoming more and more knowledge-based[1]. In Natural Language Processing today, one of the crucial problem concerns the relation between language-specific information and eventually language-independent phenomenological knowledge. Languages share some concepts, but not all of them are universal.

In semantics we must define abstract concepts even if we have no simple terms in natural languages corresponding to those concepts (cf. B. Bojar's [1979] definitions of concepts that are necessary to describe motion verbs). We have to make a list of these concepts identified by numbers and symbolic conventions for mnemonic purposes.

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[1] As an example of this trend, let us mention the last Workshop on Ontologies and Multilingual NLP, held in Nagoya, Japan, August 23-25, 1997.

How can we trace the borderline between semantic and non-linguistic concepts? The distinction is fuzzy, but we must arrive at a compromise and delineate a more discrete border if we want to arrive at a relatively exhaustive description. Such a delineation is inevitable in any formalisation. In the case of motion, the problem is particularly crucial because we have to deal with a concrete domain, and it is difficult to avoid confusing the topological and physical properties of situations described with semantic features. As a matter of fact, many physical properties are not relevant in language, and the analysis of physical reality by means of languages makes use of discrete features which are counterparts of not clearly defined physical attributes.

1.2. Classification

Classification plays a prominent role in scientific research. This is obviously also the case in the field of lexical semantics. Recently, classification procedures have been applied to elementary semantic features aiming at establishing a set of attribute-valued data for each lexical item. Such sets of semantic data are known as *feature bundles* or *feature matrices*. Much has already been done in this particular framework. However, this kind of classification (in which embedded charts of conceptual data are used) fails to describe the meaning of lexical units.

Early classifications of motion verbs used only unstructured lists of semantic features even though the sets of features themselves have been carefully stratified. As an example of such procedures let us consider the pioneer work of [Bojar B., 1979] who proposed a classification of semantic features for Polish verbs of motion. In that work, lexical items were represented by enumeration of features. On the other hand, although Bojar B. was aware of the need to separate the knowledge of the World from semantic concepts, among the huge amount of features (124 features) she has distinguished belonging to 11 classes, some features seem not to be of semantic nature but rather belong to the common knowledge of native Polish speakers.

Yet, it is not easy to make a clear distinction between what belongs strictly to linguistic semantics and what belongs to the knowledge of the World. As far as the meaning of verbs is concerned, it is moreover not always possible to separate information comprised in the verbs themselves from information which is understood from the context.

Because of the limitations of the representation used, Bojar could not overcome difficulties encountered while designing her hierarchy of verbs (a binary tree), and this led her to divide one verbal lexeme into several units when all features were not present in a given verb in different contexts. For instance, in her "Table of Relevant Features of Motion Verbs", we find two verbs *biec1* and *biec2* (to run) depending on the value of the following features:

2a type of moving body: using legs or not,
4a space of motion: change of space during the motion, and
5a type of motion: change of location.

The existence of verb *biec2* is postulated to explain such utterances as *Êcie˝ka biegnie przez park* (lit. the path runs through the park). As a matter of fact, when using a motion verb with a subject NP denoting a way or a road, the only feature which remains can be formulated either as «trajectory from A to B» or as «trajectory from A to B through C». We shall see that heterarchy (especially within DATR formalism) is a more

convenient structure than feature matrices to deal with this kind of polysemy based on metaphorical use.

Nevertheless, we have determined which semantic features occur most frequently in Bojar's database. For all 332 verbs, the most frequent features are shown in table 1.

Table 1.

05a+	change of location resulting from the motion	296 verbs
03aW	internal motive power	185 verbs
09a+	presence of moving objects whose behaviour in space and number is not relevant	73 verbs
05d+	iterativeness of the elementary component movements	72 verbs
03fT	duration of action of the motive power	71 verbs
04bP	more than one simultaneous space of motion : motion on a surface	65 verbs
03e–	absence of preventing the body changing its location from falling, the prevention being due to the other body causing this change of location	63 verbs
03c+	contact between the moving body and the body causing motion	62 verbs
03aZ	external motive power	55 verbs
07aD	speed : high	51 verbs
09co	direction of the moving body towards other moving objects : ablative	47 verbs
03d–	absence of concomitant change of location of the body causing motion with the moving body	45 verbs
03bZ	motive power : external : applied where : behind the moving body	43 verbs

The combinations of two features that appear most frequently are shown in table 2.

Table 2.

<05a+, 05d+>	change of location, iterativeness of elementary component movements	69 verbs
<05a+, 04bP>	change of location, more than one simultaneous space (on the surface)	63 verbs
<05a+, 03c+>	change of location and contact with the body causing motion	62 verbs

B. Bojar is well aware of the type of classification she has built: "Such a classification is evidently not disjunctive since each verb is an element of as many classes

as many features of motion it can express[2]." Nevertheless, Bojar tried to avoid to some extent splitting the meanings of Polish verbs into different lexemes as it has been done in a previous work on Polish motion verbs in [Grochowski M., 1973]. Thus, for instance, Bojar does not distinguish between different *lecieç* verbs (to fly) when used with different subject NPs (playing the role of actors) as *bird, smoke, plane* or *man*, but she differentiates a special meaning of *lecieç* when used with *man, car* or *train*; i.e.: when the given space of motion is no more *gaz* or *vacuum* but *solid surface* and the verb has the meaning of "going fast".

In Talmy's typology of motion verbs [Talmy, 1975], English verbal roots incorporate "manner of motion" but not "path of motion" (here: trajectory of motion[3]): *to swim, to fly*, the trajectory being marked rather by pre- or postpositions. On the other hand, Romance languages usually incorporate "trajectory of motion": *entrer, sortir, arriver* and "manner of motion" is marked by gerundive phrases : *en nageant, en volant, en courant, en rampant*.. Slavic languages are from this typological point of view closer to English (and to Germanic languages) than to Romance languages. Moreover [Dini and Di Tomaso, 1997] pointed out the fact that "the introduction and/or determination of a specific trajectory and of a resulting state depends on the preposition in English and on the interaction of prepositions and actional features in Romance languages." Compare *Peter went to London.* and *Pierre est allé à Paris / Pierre est parti pour Paris*.

As far as French motion verbs are concerned, it is clear that the work of [Asher & Sablayrolles, 1995] follows the tradition of feature classification refining and formalising at the same time the concept of *trajectory*.

Another drawback of the traditional classificatory procedure is that it leads to a very high number of classes because, very few lexical items share exactly the same relevant features with others. In Bojar's table we find very few verbs sharing exactly the same features so as to constitute a class. It is worth noting that the use of classificatory matrices of relevant features leads to the same result (a high number of very small classes, very often singletons, i.e.: containing only one element) either when they are applied to the field of syntax (cf. Gross M. 1975) or to that of semantics (cf. Bojar B. 1979).

In semantics, as a matter of fact, it is quite obvious that each lexical item is unique. What we usually call **synonyms** always differ in one or another way. The Japanese linguist Watanabe Minoru [Watanabe M., 1984] noticed that - when working on feature matrices - it is necessary to establish a sort of hierarchy between first order features and second order features. In his view, synonyms are units which share first order features, their second order features being different.

In a recent work about English motion verbs, we find the same kind of observation about classification procedures: "In reality, there are many verbs that specify motion in a mixed fashion. In other words, many verbs that specify motion do so in a manner that is neither completely direct nor completely indirect." [KALITA J. K. and LEE J., 1997, p. 91]. And further, the same authors insist on the fact that "some verbs blur the distinctions we have made" [p. 93].

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[2] "Klasyfikacja taka nie jest oczywiÊcie klasyfikacjà rozłàcznà, gdy˝ ka˝dy czasownik jest elementem tylu klas, ile elementarnych cech ruchu wyra˝a." [Bojar B., 1979, p. 186]

[3] We use the term "trajectory" instead of "path" although it is often used in papers about motion verbs because we reserve the term "path" for "feature path" as it is used in DATR formalism.

2. Inheritance Hypothesis

The problem concerning the construction of any theory of lexical meaning should be addressed first in terms of feasibility. It is desirable that a lexical database exhibit a relational character. Searches in such kind of databases require deductive mechanisms. Deduction spares repetition and allows evaluation. The lexical meaning should then be described in terms of axioms (primitives) and theorems (definitions), if we wish the resulting descriptions to convey any truth about senses of words. Indeed, it is important to avoid inconsistency and the vicious circle leading to infinite regression. We must arrive at a compromise.

A semantic theory using multiple inheritance discharges linguists from classifying rigidly senses of lexical items because semantic properties of lexemes can be organised in a multiple hierarchy structure (known as heterarchy). We shall provisionally limit our work to the theoretical framework which is available within DATR formalism (see below) but we think it will be possible to broaden the scope of this research with implementation in SCOOL system[4] as soon as its design process [Hanakata K. - 1997] is terminated.

In order to obtain a full representation of the linguistic framework for our particular field of research, we mention the model designed as an example of formalisation in linguistics by Pogonowski J. (1994).

Let **M** = (**Lxm**, **Rel**) be a model (relational structure)

where:
Lxm is a domain (a lexicon of a Natural Language) and
Rel is a set of relations (between elements of Lxm) .

Examples of relations:

- hyponymy, synonymy, oppositions (antonymy, contrary, contradictory)
- distribution of elements (lexical elements Lxm) in compound expressions
- semantic fields (seen as unary predicates)
- inflexion, derivation

In our approach however, we advocate that linguistic phenomena being subject to constant change, non-monotonous logic[5] should be applied. Indeed, as we have said, meaning cannot be properly grasped using mere classification activity. Nevertheless, we accept the proposal of Pogonowski to consider linguistic units as a subset of a conceptual formal language.

2.1. Heterarchical Structure of Features

It is precisely DATR formalism[6] that exhibits characteristics which make it possible to avoid the problems encountered with classification procedures because it enables us to build a lexical knowledge base with heterarchical structure. (*"DATR is a*

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[4] For instance, in SCOOL, it is possible to consider that attributes (and their values) are characteristic of the most concrete levels of what we call 'lower hyponymic stratum' whereas procedures are peculiar to the most abstract levels of what we call upper hyperonymic stratum' .

[5] As Natural Language Processing belongs to the field of Artificial Intelligence, we recommend the book by [Grégoire É., 1990].

[6] cf. Evans R. and Gazdar G. - 1991 (for an introduction in Polish see: Czuba K.- 1995).

formal language for representing a restricted class of inheritance networks, permitting both multiple and default inheritance. The principle intended area of application is the representation of lexical entries for natural language processing..." [Evans R. and Gazdar G., 1989])

Thus, the meaning of verbs can be described as a path of several attributes and values within a heterarchy. Thanks to inheritance, we do not have to build classes of motion verbs. In fact, verbs are linked irregularly to different superior nodes in a way that does not make it possible to establish disjoint classes. One and the same verb can have different links. The important benefits of DATR formalism for lexical semantics are as follows:

(1) Some linguistic units inherit features from other units. Thus general features can be found in higher points of the heterarchy and need not be repeated on lower levels. All general information about lexical items is placed on upper levels in order to avoid repeating the same properties several times. For instance, motion verbs inherit features from dynamic situations (processes and events).

(2) The same lexeme is mostly polysemous, and we can describe it by adding or removing the links with higher nodes depending on the particular meaning in question. In this framework we can understand polysemy as the blocking of some links and the activation of some other new links. A property inherited from the upper node can be overridden (possibility of overriding one property in a particular context).

(3) DATR formalism offers the possibility to distinguish between polysemy and homonymy [KILGARIFF A. and GAZDAR G., 1993]: for polysemy we use one node representing one lexeme but different possible paths, for homonymy we use different nodes (lexeme1, lexeme2).

(4) In a traditional dictionary each item is independent, i.e. the only links (pointers) used concern the lists of synonyms or antonyms of a given entry.

In our approach[7], we consider that two heterarchical strata should be distinguished: (a) conceptual non-linguistic and (b) conceptual linguistic (lexical). Indeed, we believe that concepts and lexical units should be related to each other also in a hierarchical way: non-linguistic concepts constituting the upper (hyperonymic) stratum and linguistic concepts (lexemes) the lower (hyponymic) one. We do not think however, that some exceptions to this scheme cannot occur in different natural languages.

[7] We follow in this respect partially the idea of merging conceptual and thesaural analyses proposed by Kölzer A. (1994) and partially - as we have said - that of considering linguistic concepts as a subset of all the set of concepts supposed by Pogonowski J. (1994).

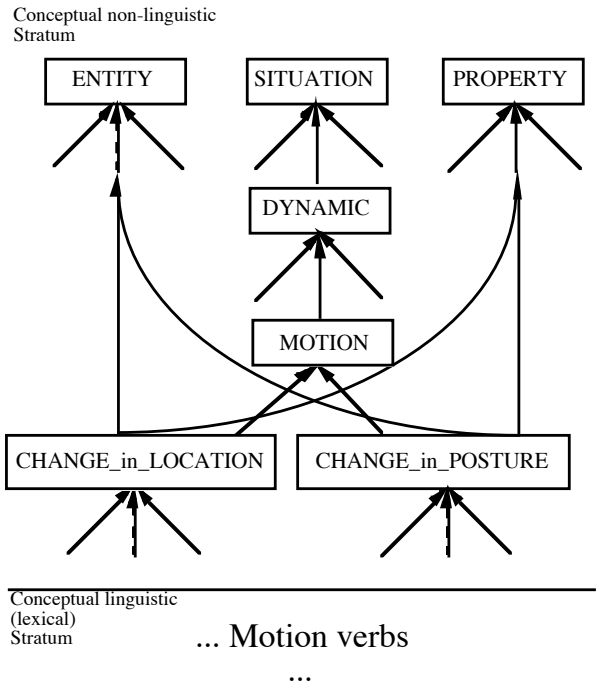

Fig. 1. A Lexical inheritance heterarchy

The semantic "head" of a lexical family is defined as a nest of features which can be inherited by other lexemes. The *semantic head* is a leading element of a structure and differs from a *semantic field* by the fact that a head is always a *lexical unit* of a given language. The peculiarity of heads consists in that they are lexemes which have other lexemes as dependants. Obviously, the dependants themselves may also have dependants and, in that case, they are "heads" of their dependants. From a linguistic point of view, the heads constituting the largest families are the most abstract units because they can depend but from conceptual nodes of the heterarchy.

In figures 2 and 3, we show two graphical representations of heterarchical relations between a few Polish and French verbs respectively.

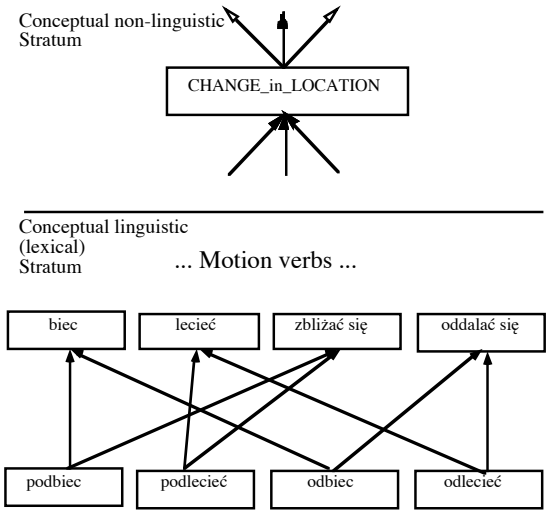

Fig. 2. A lexical inheritance heterarchy in Polish

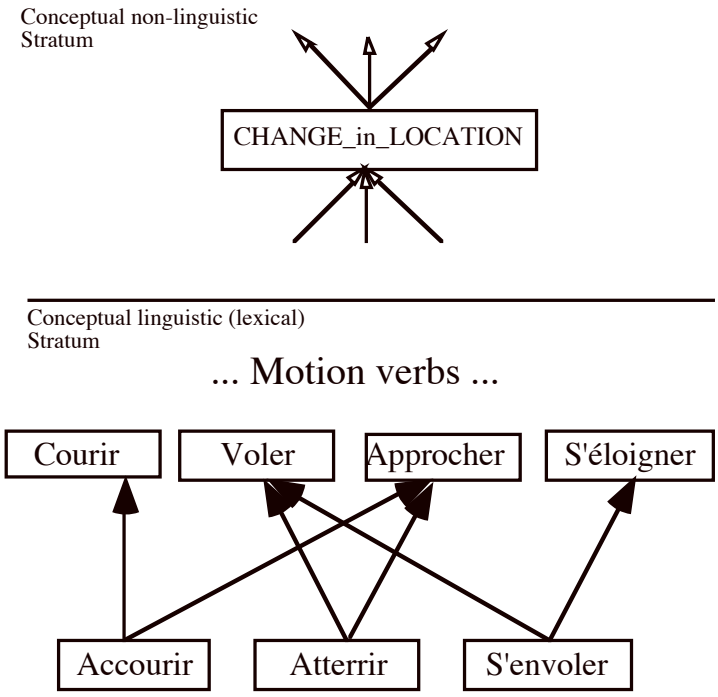

Fig. 3. A lexical inheritance heterarchy in French

In the examples of figures 2 and 3, Polish verbs *biec, lecieç, zbli˝aç si´, oddalaç si´* and French verbs *courir, voler, approcher, s'éloigner* are lexical heads.

2.2. Conceptual Model of Motion

In order to build the inferential model which would include the different semantic features we must first identify the general concepts relevant to Motion.

From a strictly physical point of view, Motion can be defined as a **structure M** (and specifically, as a partial structure) with a relation **change** *Ch* and three elements: a moving body(ies) B or/and its part(s) (B^p), time T and space S,

M = {*Ch,* B^p, S, T}

As we deemed it useful to see in the moving body (or entity) and the motive power the essential problem of motion, we obviously attempted to determine the nature of moving bodies, their shape, their capacity to move etc. as well as the motive power (force) itself.

We have introduced some other relations which may appear in the background instead of being obligatory in any semantic content (cf. Extended Situation Semantics [Nakagawa & Harada, 1995]). Among these relations are:

trajectory *Tr* as a function of a moving body(ies) B or/and its part(s) (B^p) over space and time. Because the trajectory indicates direction, it can be seen as a vector with a series of locations = $\{l_0, l_1, l_2, ..., l_n\}$ and a series of moments = $\{m_0, m_1, m_2, ..., m_n\}$,

contact *C* as a relation between moving body(ies) B or/and its part(s) (B^p) and space S and

velocity *V,* as a relation between space and time.

Thus, trajectories represent transitions (change of location) within the intervals of Time and Space. Trajectories are represented as topological intervals which can have open or closed boundaries. The left 'closed' trajectories have a «beginning-of» (here: Source) and the right 'closed' trajectories have an «end-of» (here: Goal). Trajectories being the result of a function, their orientation (shape) depends on the **restrictions** imposed by the moving body (its form and nature), the motive power and some other components of the semantics of motion. But this view seems to be too narrow for our model and will be developed below.

Motion as expressed by verbs of Natural Languages is viewed either as a **change-in-space** or as a **change-in-posture**. Most authors distinguish between these two types of motion. From [Asher and Sablayrolles, 1995] we borrow the definitions of the two concepts that seem to be relevant with the restriction however that we do not consider that these concepts can be used as classification criteria.

> "[A verb of] change of location entails that the moving entity changes location during the process, e.g.: entrer, arriver, atterrir, se déplacer, circuler, descendre.[...]
> [A verb of] change of posture entails that the moving entity stays inside the same location and at the same position during the whole process, but also changes of posture during the process, e.g.: se pencher, s'asseoir, se baisser. "

These two types of motion were also taken into account by [Bojar B., 1979] who called them *zmiana lokalizacji w wyniku ruchu* (change of location as a result of motion) and *zmiana zwrotu*. (change of orientation).

In this paper we will focus on the concept of change of location taking into account a contrastive point of view between Polish and French. Our source for Polish is Pola*ƒ*ski's dictionary of verbs [POLA¡SKI K. et al., 1980-1992] which is the best dictionary of verbs available in Polish, but the semantic indications are still limited to the so-called "syntactico-semantic features".

From [Asher and Sablayrolles, 1995, pp. 179-181], we retain formal definitions of trajectory features[8]: approach, arrive, enter, land, distance from, etc.

[8] [Asher and Sablayrolles 1995] used the following abbreviations: SIP : Strict Internal Path, LRef : Reference Location.

Table 3. Ten verb groups of change of location

Four groups indicate the final polarity of the motion : focus on the goal of the motion.

group 1 approcher

```
Approach(e)-> {P(Source(e),Z-outer-most(cible(e),Lref(e)))
              & P(SIP(e),Z-outer-transit(cible(e),Lref(e)))
              & P(Goal(e),Z-outer-halo(cible(e),Lref(e)))}
```

(A motion going from a far away outside to a near outside of a location of reference)

group 2 arriver

```
Arrive(e)->   {P(Source(e),Z-outer-most(cible(e),Lref(e)))
              & P(SIP(e),Z-outer-halo(cible(e),Lref(e)))
              & P(Goal(e),Z-inner-halo(cible(e),Lref(e)))}
```

(A motion going from a far away outside to the inside of a location of reference, via a near outside of this location)

group 3 entrer

```
Enter(e)->    {P(Source(e),Z-outer-halo(cible(e),Lref(e)))
              & P(SIP(e),Z-inner-transit(cible(e),Lref(e)))
              & P(Goal(e),Z-inner-halo(cible(e),Lref(e)))}
```

(A motion going from a near outside to the inside of a location of reference, crossing its 'frontier')

group 4 se poser

```
Land(e)->     {P(Source(e),Z-outer-halo(cible(e),Lref(e)))
              & P(SIP(e),Z-contact-transit(cible(e),Lref(e)))
              & P(Goal(e),Z-contact(cible(e),Lref(e)))}
```

(A motion going from a near outside of a location of reference to an external contact with this location of reference)

Four groups share the concept of initial polarity of the motion: focus on the source of themotion.

group 5 s'éloigner

```
Distance-from(e)->{P(Source(e),Z-outer-halo(cible(e),Lref(e)))
              & P(SIP(e),Z-outer-transit(cible(e),Lref(e)))
              & P(Goal(e),Z-outer-most(cible(e),Lref(e)))}
```

(A motion going from a near outside to a far away outside of a location of reference)

group 6 partir

```
Leave(e)->    {P(Source(e),Z-inner-halo(cible(e),Lref(e)))
              & P(SIP(e),Z-outer-halo(cible(e),Lref(e)))
              & P(Goal(e),Z-outer-most(cible(e),Lref(e)))}
```

(A motion going from the inside to a far away outside of a location of reference, via a near outside of this location)

group 7 sortir

```
Go-out(e)-> {P(Source(e),Z-inner-halo(cible(e),Lref(e)))
            & P(SIP(e),Z-inner-transit(cible(e),Lref(e)))
            & P(Goal(e),Z-outer-halo(cible(e),Lref(e)))}
```

(A motion going from the inside to a near outside of a location of reference, crossing its 'frontier')

group 8 décoller

```
Take-off(e)->{P(Source(e),Z-contact(cible(e),Lref(e)))
             & P(SIP(e),Z-contact-transit(cible(e),Lref(e)))
             & P(Goal(e),Z-outer-halo(cible(e),Lref(e)))}
```

(A motion going from an external contact with a location to a near outside of this location)

One group is defined by the median polarity : focus on the SIP of the motion

group 9 passer

```
Cross(e)-> {P(Source(e),Z-outer-halo(cible(e),Lref(e)))
            & P(SIP(e),Z-inner-halo(cible(e),Lref(e)))
            & P(Goal(e),Z-outer-most(cible(e),Lref(e)))}
```

(A motion going from a near outside of a location of reference, entering the location, crossing it, and going outside to a near outside of this location)

The tenth group has no polarity feature.

group 10 dévier

```
Deviate(e)-> {P(Source(e),Z-inner-halo(cible(e),Lref(e)))
              & P(SIP(e),Z-inner-transit(cible(e),Lref(e)))
              & P(Goal(e),Z-outer-halo(cible(e),Lref(e)))}
```

(A motion going from the inside to near outside of an ideal trajectory)

The above classification distinguishes three subclasses of locative verbs very similar to those described by [Boons, 1985], which are closely related to aspectual properties of the verbs.

Instead of using an English verb or noun to label the abstract concept which is formally defined in each one of the ten groups of [Asher and Sablayrolles 1995], we propose to denote each of these concepts by a number added to the general label of trajectory: **semantic feature trajectory 1, 2, or 3,** etc.[9] Actually, verbs of Natural Languages entail more features than formally defined as above. For instance, the term **take_off** chosen as a label for group 8 entails the feature of direction upwards (direction contrary to gravitation). We may, however, have to deal with verbs without this feature like verbs with the prefix *od-* in Polish, e.g. *odbiec* (to run off). Moreover, it is very probable that more trajectory features (formally defined on the basis of primary topological notions) will be needed to describe motion verbs in other languages.

Trajectory features must be combined with other relevant features to describe the meaning of a significant number of motion verbs. The most important of those features were proposed in Bojar's classification:

[9] In the following part of this paper , we use this sort of notation.

change of location
space of motion
- liquid
- solid
- gaz / vacuum

contact with space of motion
- constant
- intermittent

moving body (kind of, parts, number of moving bodies)
motive power
- external/internal
- position of the external motive power (before or behind the moving body)
- duration of action of motive power

direction of motion
- relation between direction of motion and direction of gravitational force
- change of direction
- relation of direction of motion to the initial location of the moving body

speed (irrelevant, constant or variable, high or low)
relation between moving body and other entities
- presence of other objects in the motion space
- point of reference
- presence of moving objects
- presence of the observer of the motion
- relation between directions of different moving objects
- direction of the moving body towards other moving objects

The feature "space of motion" (liquid, air surface) makes it possible to describe such verbs as English *to swim*, *to fly*, *to walk*.. In Polish, this feature combines with many different trajectory features in numerous verbs, such as: *przypłynàç* (to arrive swimming or navigating), *odlecieç* (to take off), etc. In English, trajectory features are mostly expressed by particles (off, up, away, etc.) which follow the verbs. In Japanese, the combination of space and trajectory features is marked by compound verbs, e.g.: hiki-dasu (bring out), hiki-modosu (bring back).

The feature "number of moving bodies" can be combined with different trajectory features in such verbs as *to scatter* or *to gather*, in Polish *zjechaç si´* (to gather into one point from different sources using some means of transportation), *rozjechaç si´* (to scatter from one point into different goal locations using some means of transportation), etc.

3. Typical structure of a Dictionary Entry

Motion verbs inherit:

- general semantic properties of situations (dynamic/non dynamic)
- syntactic properties of verbs (head of the clause, diathesis, types of actors)
- grammatical categories of verbs (person, mood, Aktionsart, aspect, sub-aspect, tense)

A typical dictionary entry should contain at least the following information:

Entry	: identifier	: number (and nickname)
	: type	: {Verb, Noun, Adjective, ...}
Phonology	: phonemic composition	
Orthography	: notational substitutes	
Morphology :	: Morphemes	:
	: Roots	: {structured, unstructured}
	: Forms	: {prefixes, suffixes, infixes, ...}
Syntax	: Operations	: {predication, determination, quantification...}
	: Structures	: relations between elements
Primary Meaning		
Semantics	: Valency	: Semantic Roles
	: Contents	: Structural Features (restrictors)
		: Procedures
Pragmatics	: Expressive Force	: (Speaker's attitude and others)
Derived Meaning		
polysemy		
Examples		
Collocations		
Idiomatic expressions		

As an example, we will mention excerpts of the description of primary meanings of three Polish verbs *biec, iÊç* and *lecieç* which are as follows:

```
Biec:
 ...
<sem feature ...
     speed magnitude> == speedy
     speed change> == unspecified
     actor> == agent
     trajectory> == unspecified
     m_body nature> == animate
     m_body entirety> == whole
     m_body number> == unspecified
     space type> == solid_surface
     space dimension> == bi_dimensional
     space direction> == unspecified ... .

Isc:
 ...
<sem feature ...
     speed magnitude> == normal
     speed change> == unspecified
     actor> == agent
     trajectory> == unspecified
     m_body nature> == animate
     m_body entirety> == whole
     m_body number> == unspecified
     space type> == solid_surface
     space dimension> == bi_dimensional
     space direction> == unspecified ... .
```

```
Leciec:
 ...
<sem feature ...
     speed magnitude> == normal
     speed change> == unspecified
     actor> == agent experiencer controller
     trajectory> == unspecified
     m_body nature> == animate inanimate_with_wings
     m_body entirety> == whole
     m_body number> == unspecified
     space type> == air cosmos
     space dimension> == tri_dimensional
     space direction> == unspecified ... .
```

3.1. The Polish verb *biec* as a semantic "head" of a lexical family

Those verbs which inherit some features from the "head" verb *biec* also inherit trajectory features from other verbs (*zbli˝yç si´, oddaliç si´, zebraç si´, wejÊç, wyjÊç*, etc.). Some of the derived lexemes inherit still more features: number of moving bodies, direction of motion, etc.

When a verb inherits an attribute with a value other than the same attribute in the definition of the main verb *biec*, the value of this feature of *biec* is no longer valid for the derived verb. For instance, while the value of the attribute "number of moving bodies" (m_body number) is unspecified for *biec,* it is "plural" for *zbiec si´*. The trajectory features are unspecified for *biec,* but have different values for derived verbs, etc. As proposed above, we label the trajectory features defined in Asher and Sablayrolles only by numbers.

```
Podbiec:
    <> = = Biec
      <sem feature trajectory> == 1
Dobiec:
    <> = = Biec
      <sem feature trajectory> == 1
      <sem feature Aktionsart> == termination at the ref.
location
 Nadbiec:
    <> = = Biec
      <sem feature trajectory> == 1
      <sem feature Aktionsart> == last phase before termination
Obiec:
    <> = = Biec
      <sem feature space direction> == around a ref. location
Odbiec:
    <> = = Biec
      <sem feature trajectory> == 8
Przebiec:
    <> = = Biec
      <sem feature trajectory> == 9
Przybiec:
    <> = = Biec
      <sem feature trajectory> == 2
Rozbiec sie:
    <> = = Biec
      <sem feature trajectory> == 5
      <sem feature m_body number> == plural
Wbiec1:
    <> = = Biec
      <sem feature trajectory> == 3
Wbiec2:
```

```
    <> = = Biec
      <sem feature space direction> == up
Wybiec:
    <> = = Biec
      <sem feature trajectory> == 7
Zabiec1:
    <> = = Biec
      <sem feature trajectory> == 1
      <sem feature trajectory> == behind a ref. location
Zabiec2:
    <> = = Biec
      <sem feature trajectory> == 1
      <sem feature Aktionsart> == expected termination
Zbiec1:
    <> = = Biec
      <sem feature space direction> == down
Zbiec2:
    <> = = Biec
      <sem feature trajectory> == 10
Zbiec3 :
    <> = = Biec
      <sem feature trajectory> == 6
Zbiec sie:
    <> = = Biec
      <sem feature trajectory> == 1
      <sem feature m_body number> == plural

Collocation
Zabiec droge:
    <> = = Biec
      <sem feature trajectory> == 10
      <rel. between directions of diff. m_bodies.> == contrary
```

3.2. Example of French verb *aller*

The French verb *aller* must be placed somewhere on the top of the hierarchy because almost all its motion attributes can take almost all different possible values. This means that *aller* in French is a hyperonymic lexeme for many other lexemes sharing with it the features "change of location" and "motion on the surface".

French verb *Aller*:

kind of motion :	change of location	
motion space:	not changing or changing	
	simultaneous spaces :	
		more than one
		motion on the surface : (air and solid surface)
		only one : (air or liquid)
kind of moving body[10] :	animate body with legs	
	means of transportation	
	roads	
posture of moving body :	(on feet or on knees)	
motive power :	kind :	internal
	duration :	all the time the motion lasts

[10] N.B. kinds of moving bodies that cannot match *aller* : liquid, part of the body...

iterativeness of component motions : frequency of iterative component motions
direction : to_or_from the initial location of the m_body : (back or away)
speed : unspecified
point of reference in space : other unspecified objects
other moving objects
person observing the motion : speaker
trajectory : unspecified

Although the feature trajectory is unspecified, the semantic features trajectory 5 and 6 (intervals with a closed left boundary) are almost never expressed with *aller* because, in that senses, French uses *s'éloigner, s'en aller, partir*. But the semantic feature trajectory 2 can be expressed by the context: *aller au bout de la rue (go to the end of the street).*

4. Polysemy

We must be careful not to multiply the meanings of one verb. The metaphoric sense is not really a new sense. The multiplication of senses (meanings) is sometimes due to the cognitive approach which distinguishes what a language labels as one type of situation. There is also a danger in the contrastive methodology : when comparing two lexical items in two different languages, the different translations of one verb give the impression that the original verb is polysemous. In fact, one item in one language may have a broader sense than its counterparts in another language.

The most frequent lexemes are often the most polysemous. Polysemy is caused by different evaluation of a feature in different contexts. The average number of meanings for one lexeme is two, but some lexemes may have as many as eight different meanings. Metaphorical sense consists in transferring an abstraction from one field of application to another.

Lexical polysemy must be distinguished from syntactic polysemy. In syntactic polysemy one expression can be interpreted by two different syntactic structures, e.g. *zaproszenie mojego przyjaciela* (invitation of or by my friend). With lexical polysemy, two interpretations are possible with no need for different syntactic structures. Moreover, language polysemy has to be distinguished from discourse polysemy: some lexical items may have different interpretations in different contexts. This does not mean that they are polysemous in the dictionary, but rather that they are not marked for the semantic feature that will be interpreted depending on the context : e.g. verbs which can be interpreted as deliberate or unconscious (volitive / non volitive) actions. Our concern is language polysemy, i.e. a feature can be alternatively evaluated in two or more different ways.

4.1. The Concept of Regular Polysemy and its treatment in DATR

For their treatment of polysemous lexical items in DATR, [Kilgariff and Gazdar, 1993] rely on the definition of **regular polysemy** by [Apresjan 1980, p. 240] : "the polysemy of an expression A having two senses a_i and a_j is known as "regular polysemy" if in the same language there exists at least one expression B with two senses b_i and b_j

such that the difference between b_i and b_j is the same as the difference between a_i and a_j, and moreover neither a_i and bi nor a_j and b_j are synonyms"[11].

In this way, regular polysemy can be compared to derivational morphology. A. Kilgariff and G. Gazdar propose to view polysemy as "null derivation" (i.e. derivation with zero marker). Like derivation, regular polysemy has many productive types, e.g. *cause*. Regular polysemy is characteristic of metonymic senses, whereas non regular polysemy is more characteristic for metaphoric senses. As an example of metonymic polysemy, the English word *cotton* can be used to denote a plant, a fibre, a yarn or a fabric, or a garment. The same relations hold between different senses of the word *silk*. Metaphoric polysemy appears, for example, in the Polish lexeme *korek* (cork) when used not with *butelka* (bottle) but with the word *jezdnia* (road) with the meaning of "traffic jam".

As Kilgariff and Gazdar put it "We need to distinguish secondary senses from primary ones in such a way that the paths for accessing information about them are different. We do this by prefixing the path with alt (for alternation)".

Observing feature paths that are characteristic of motion verbs, we noticed several cases of regular polysemy (comparable or different in different languages). Polysemy consists in attributing several different alternative values to an attribute in a feature path.

4.2. Regular Polysemy based on the feature 'moving body'

With the same verbs, the feature **moving body** can have different values: **animate** (human or animal) or **inanimate** (means of transportation, objects without internal motive power, way, time portion)).

- animate :
- human

(1) Pol. Piotr poleciał do Warszawy.

(Peter flew to Warsaw.)

(2) Pol. Piotr płynie jutro do Szwecji na wakacje.

(Peter is sailing off tomorrow to Sweden for holidays.)

This case is not attested in French where we cannot use *voler* or *nager* for a passenger or pilot (captain) of a plane or a ship. We have to use a periphrastic expression:

(3) Fr. Pierre est allé à Varsovie en avion.

(Pierre flew to Warsaw.)

- animal

(4) Pol. Lecà ptaki.

(Birds are flyingby.)

(5) Pol. ¸ajka pierwsza poleciała w kosmos.

(Lajka was the first living being to fly in outer space.)

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[11] WieloznacznoÊç wyrazu A o znaczeniach ai i aj nazywamy regularnà je˝eli w danym j´zyku istnieje co najmniej jeden wyraz B o znaczeniach bi i bj, które pod wzgl´dem semantycznym ró˝nià si´ od siebie tak samo jak ai i aj, i je˝eli ai - bi, aj - bj nie sà synonimami. [Apresjan Ju. D. 1980, 240]

- inanimate:

- means of transportation (machines):

(6) Pol. Pociàg jedzie, samolot leci, statek płynie.

(The train is riding, the plane is flying, the ship is sailing.)

- dropped or pushed objects:

(7) Pol. Lecà kamienie.

(Stones are falling.)

- way

We can speak of regular polysemy when a verb of motion is used wih a noun denoting a way

(8) Fr. La route va (mène, conduit) à Paris.

(The road goes - leads - to Paris.)

(9) Pol. Scie˝ka biegnie przez park.

(The path runs through the park.)

(10) Pol. Do chaty prowadziła stara dró˝ka.

(An old path was leading to the cottage.)

- a portion of time:

(11) Fr. Le temps passe. Trois ans se sont écoulés.

(Time goes by. Three years passed by.)

(12) Pol. Szybko biegły dni i miesiàce. Czas leci...

(Days and months were flying by. Time flies...)

- polysemy based on the feature 'moving body with legs'

The sub-aspectual pair of Polish verbs *iÊç / chodziç* and their prefixal derivates have the feature "on foot" but can be used in utterances where this feature is overridden:

(13) Pol. Statek pasa˝erski podchodzi do nadbrze˝a

(A liner is approaching the pier

4.3. Regular Polysemy based on the feature 'actor'

The actor of the same motion verb can take different values :

- agent (controller)

(14) Pol. Bociany lecà na południe.

(Storks are flying South.)

(15) Pol.Piotrpoleciał wczoraj samolotem typu Airbus do Pary˝a (on jest pilotem).

(Yesterday Peter flew an Airbus to Paris; he is a pilot).

(16) Pol. Piotr popłynie jutro do Kopenhagu (on jest kapitanem statku).

(Tomorrow Peter will sail to Copenhagen, he is the captain of the ship.)

- experiencer (the moving body appears as a passenger)

(17) Pol.Piotr jest biznesmenem, on poleci jutro do Nowego Yorku.

(Peter is a businessman, he is flying tomorrow to New -York.)

- objective

(18) Pol. Scie˝ka prowadzi do morza.

(19) Fr. Le chemin va (mène, conduit) à la mer

(The path leads to the seashore.)

4.4. Regular Polysemy based on the feature 'space type'

- air or liquid milieu instead of solid surface

In Polish, the verb *jechaç*, historically meaning a change of location on earth and on horse back and synchronically meaning using a terrestrial means of transportation (bike, car, train, bus) can serve as a hyperonym for all kinds of changes of location involving any sort of means of transportation, be it by earth, air or river or sea. When we use the utterance:

(20) Pol. Piotr wyjechał do Australii.

(Peter left for Australia)

we transmit partial information about the fact he has left the country where he was living before his departure, and that he went to Australia not on foot but by some means of transportation. Only from our knowledge of the world will we choose plane or ship. If we speak of some Peter living in the 19th century it will probably be by ship, at the end of the 20th century the default value will be rather "plane".

- solid surface instead of air or cosmos :

Verbs with the meaning of flying in the air or cosmic space are sometimes secondarily used to denote a change of location on a solid surface. In Polish, a secondary path of features for *lecieç* (to fly) exhibits as space motion not the air but a solid surface and as moving body not a winged entity but a body with legs. This is a metaphoric use : go so fast on a solid surface as if not touching it, thus being in the air 'flying' and the result is that the verb has the meaning of 'going quickly'.

(21) Pol. Lec´ do ciebie. Zaraz przylec´ do ciebie.

(I am rushing to you. In a minute I will arrive to your place.)

This type of polysemy is also attested for the verb *voler* in classical French:

(22) Fr. Va, cours, vole et nous venge! (Corneille, Le Cid)

(Go, run, rush and take revenge!)

5. Contrastive view: Motion Trajectory in two Languages

Very rarely do two verbs of different languages have exactly the same feature bundle. The heterarchy is very useful from the contrastive point of view because when translating from one language to another what we are interested in is semantic derivation (not morphological derivation). It is precisely semantic derivation that is given in the heterarchy. We will try to show a few examples of similar semantic derivation in two languages where morphological markers are quite different. In so far as we are able to exhibit some common properties between different languages we will have to put these common features on the top of the heterarchy above the level of particular languages.

In French there exists many verbs denoting trajectory without specifying the space and the kind of body. Although these verbs may be historically derived from simple verbs with locative prefixes, this composition is no longer productive and analysable in synchrony; e.g. practically no French native speaker is aware of the prefix a- in *approcher, arriver*, etc.

The classification of French verbs of change of location into 10 semantic groups proposed by Asher and Sablayrolles is essentially a classification based on the type of trajectory, whereas other features are omitted. We should not infer from this classification that French verbs of change of location specify only the trajectory and not the space of motion or the kind of moving body. The authors also ignore the difference between internal motive power (intransitive verbs) and external motive power (causative transitive verbs)

In French, we have mostly motion verbs that denote the trajectory and if we want to specify the space of motion or some other feature (e.g.: speed) we have to use a periphrastic expression:

przypłynàç: arriver à la nage, en bateau (to arrive swimming or sailing)
wybiec : partir ou sortir en courant (to run away or out)

A few French verbs, however, incorporate the two concepts of trajectory and space of motion because they were historically composed of a spatial prefix and a space of motion root:

atterrir : landowaç, przylecieç (to land)
accourir : przybiec (to arrive running)
s'envoler : odlecieç (to take off)

On the contrary verbs denoting only trajectory are not so numerous in Polish because in this language (and other Slavic languages) the trajectory is marked by a verbal prefix, that can be attached to a verbal root denoting the manner of motion. So the classification of Talmy should be reconsidered. We find the same observation in [Dini, Di Tomaso, 1997] who propose for Italian "path-manner" motion verbs.

In Polish we have a group of simple (non derived) motion verbs that denote first of all the space of motion and type moving body. Then, on the basis of these simple verbs, by the use of prefixes we can build regular series of derived verbs that denote different types of trajectory. Polish has only few very general (hyperonymic) verbs for different kinds of trajectory and very numerous hyponymic (prefixed verbs) indicating the space and the moving body.

In Table 4, we represent the formal definitions of trajectory features given in Asher and Sablayrolles by numbers.

Table 4. *The Notion of motion-trajectory in two languages*

	Hyperonymic lexemes	**Hyponymic lexemes**
1. MOTION GOAL (CLOSED RIGHT BOUNDARY)		
1.1. Semantic feature trajectory 1		
Fr.	approcher	approcher en bateau, en rampant , accourir
Pol.	zbli˝aç si´	podejÊç, podkraÊç si´
1.2. Semantic feature trajectory 2		
Fr.	arriver, venir	arriver en avion, venir en voiture apporter
Pol.	przybyç, dotrzec dojechaç, dopełznàç	przybiec, przyjechaç, przypłynàç,
1.3. Semantic feature trajectory 3		
Fr.	entrer, pénétrer	entrer en voiture, à cheval
Pol.	przedostaç si´	wbiec, wjechaç, wejÊç, wnieÊç, przeniknàç, wpuÊciç wwieêç
1.4. Semantic feature trajectory 4		
Fr.	se poser	atterrir, amerrir
Pol.	siàÊç, landowaç	przylecieç

1.5. Semantic feature trajectory 4 and plurality of moving bodies

Fr.	(se) réunir	
Pol.	zebraç (si´)	zlecieç si´, zjechaç si´, zbiec si´

2. MOTION SOURCE (CLOSED LEFT BOUNDARY)

2.1. Semantic feature trajectory 5

Fr.	s'éloigner	s'éloigner à la nage, en volant
Pol.	oddaliç si´	odejÊç, odpłynàç, odlecieç

2.2. Semantic feature trajectory 6

Fr.	partir	partir en avion, en voiture
Pol.	wybyç	wyjechaç

2.3. Semantic feature trajectory 7

Fr.	sortir	
Pol.	wydostaç si´, wydobyç si´	wyjÊç, wylecieç, wypłynàç

2.4. Semantic feature trajectory 8

Fr.	décoller	
Pol.	ruszyç, wy/startowaç	odlecieç, odpłynàç, odjechaç

2.5. Semantic feature trajectory 5 and plurality of moving bodies

Fr.	se disperser	
Pol.	rozejÊç si´	rozbiec si´, rozjechaç si´

3. MOTION TRAJECTORY WITH OPENED BOUNDARIES

3.1. Semantic feature trajectory 9

Fr.	passer	passer à pied, en voiture
Pol.	przeprawiç (si´), prejÊç	przelecieç, przepłynàç

5.1. Example 1 : how to translate French *approcher* into Polish

When translating the French "trajectory-motion" verbs into Polish we must take into account the space of motion and the kind of moving body or motive power. In the French-Polish dictionary [Wielki Słownik Fr.-P. 1983], only two Polish equivalents are proposed for French verb *approcher*: *zbli˝yç si´* and *nadejÊç/nadchodziç*. In fact, there exist many Polish verbs that inherit part of their features from the hyperonymic "*zbli˝yç si˝*" and part of their features from other superior verbs like *go on foot, go by transport, swim, fly, push* etc. and we can propose when inheriting from the feature "space type" the other following Polish verbs as counterparts for French *approcher* (with examples from Pola*f*ski 1980-92)

If we consider the feature **internal motive power**, we find different counterparts of *approcher* depending on the values of the following features:

2. space type
2.1. solid surface
podejÊç:

(23) Pol. Podchodzili do wsi od strony koÊcioła.
(They were approaching the village from the side of the church.)

podjechaç :

(24) Pol. Małe auto podjechało cicho pod hotel.
(The small car drove silently up to the hotel.)
(25) Pol. PodjechaliÊmy tylko do tego domku.
(We drove up only to this small house.)

2.2. liquid

podpływaç :

(26) Pol. Zm´czony pies podpływał ju˝ ku brzegowi.
(The tired dog was already swimming up to the shore.)
(27) Pol. Kuter podpłynął do mola.
(The fishing boat sailed up to the pier.)
N.B. the roots *iÊç* / *chodziç* may also be used:
(28) Pol. Statek pasa˝erski podchodzi do nadbrze˝a.
(The liner is sailing up to the pier.)

2.3. air

podlecieç :

(29) Pol. Bociany podlatywały ku niemu prawie bezszelestnie.
(Storks were flying up to him almost silently.)
(30) Pol. Goł´bie podleciały na parapet.
(Pigeons were flying up to the windowsill.)

3. kind of moving body

podbiec (to approach running) :

(31) Pol. Chłopcy podbiegli do piłki.
(The boys ran up to the ball.)

4. part of moving body

podpełznàç (to approach crawling), etc.

With the value **external motive power**, we find such verbs as:

zbli˝yç, podsunàç

(32) Pol. Anna bli˝ej podsun´ła ojcu fotel.
(Anna pushed the armchair towards her father.)

This possibility of multiple translation corresponds to the multiple inheritance database in Polish where verbs inheriting the trajectory feature "approach" also inherit many other features.

5.2. Example 2 : how to translate French *aller* into Polish

French verb *aller* can be used in many different contexts which indicate different types of trajectory. As a matter of fact, in French, boundaries are mostly expressed by prepositional phrases whereas in Polish they are often marked not only by prepositional phrases but also by verbal prefixes. Moreover French does not distinguish between static dynamic prepositions and dynamic ones. Polish does so using different cases (accusative for dynamic prepositions and locative for static ones)

(33) Fr. Pierre va à la poste. Pierre est à la poste.

(34) Pol. Pierre idzie na poczt´. Pierre jest na poczcie.

(Pierre is going to the post office. Pierre is at the post office.)

Not all occurrences of *aller* in French have the same feature trajectory. Depending on the different trajectory, we choose different prefixed Polish verbs in translation.

(35) Fr. Pierre est allé jusqu'au pont.

(36) Pol. Pierre doszedł do mostu.

(Pierre walked up to the bridge.)

Depending on the nature of the moving body and the motion space, we can translate *aller* by

iÊç (animate body with legs, solid surface),

jechaç (by car, by horse, means of transportation, solid surface),

płynàç statkiem (space is liquid),

lecieç samolotem (space is air).

Another problem is that when translating into Polish, because of the feature "aspect sub-cat"[12],of a small group of motion verbs we have to consider separately occurrences of *aller* in particular utterances (where a determined verb must be chosen: *iÊç, jechaç*) and in general, habitual, or potential utterances (where a non-determined verb occurs: chodziç, jeêdziç)**.** Here are a few examples:

- Particular utterances

(37) Fr. Pierre allait à la poste.

(38) Pol. Piotr szedł na poczt´.

(Peter was going to the post office.)

- General, habitual or potential utterances

(39) Fr. Les enfants vont à l'école.

(40) Pol. Dzieci chodzà do szkoły.

(Children go to school.)

(41) Fr. Le dimanche, nous allons nous promener au parc.

(42) Pol. W niedziel´ chodzimy na spacer do parku.

(On Sunday we go for a walk to the park.)

(43) Fr. L'enfant marche déjà.

(44) Pol. Dziecko ju˝ chodzi.

(The child can walk already.)

A regards the feature "kind of moving body", in French, very often, only extra-linguistic knowledge allows us to interpret *aller* as using one's own legs or as using a means of transportation.

(45) Fr. Pierre va à la poste.

(46) Pol. Piotr idzie/jedzie na poczt´.

(Peter goes to the post office on foot or by car.)

We use *jedzie* if we can infer from the context or from our knowledge of the extra-linguistic situation that Pierre uses a means of transportation.

6. Conclusion

[12] About aspect and sub-aspect in Polish and Russian motion verbs see [Włodarczyk H. 1997].

The complexity of linguistic facts is so great that we need to use computers in order to be able to verify our hypotheses and models. In the field of lexical semantics, classification of features is necessary at every stage of our research. Yet it is not easy to manipulate by hand long lists of lexemes with enumerated features. For example, one can make the most of the results of Bojar's research on Polish motion verbs only today when it became possible to handle data in many different ways. At present, we are using these results in order to find out which semantic features and their combinations are the most important (statistically significant). Moreover, inferential capacities of today's computers are such that we can imagine the possibility of applying different new (non-monotonous) logics and such tools can be of use in all areas of research with complex structure as an object, namely in Linguistics.

The heterarchical structure we have attempted to apply in our description of motion verbs is more complex than the simple classification table where nothing but the principles of logical division can be used. We interpreted semantic feature structures (which are a special kind of graphs: directed acyclic graphs) as a concept description language capable of building heterarchical relations. At this stage in our project we could establish a clear-cut distinction between *conceptual-only* (non-linguistic) and *linguistic-also* (conceptual with linguistic equivalence) strata in description heterarchy. It seems to us that these strata give good account of our intuition that there is a frontier (however fuzzy) between form (language) and meaning (conception/comprehension).

We introduced a new notion into the semantic theory of natural languages. This notion is the semantic "head" of a lexical family (a leading element of a structure) and has been defined as a nest of features which can be inherited by other lexemes.

Motion verbs appear to be a very interesting semantic field. The reason is not only that they may turn out to be relatively easy to grasp but because their proper description can have applications in other fields that develop very intensely: robotics, traffic control, means of transportation and computer animation. Their study may also become an example of how to build new types of (electronic) mono-lingual and bi-lingual dictionaries.

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