Semantic features in a generic lexicon

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Abstract

Considering that there are many different syntactic and semantic theories, this article is concerned with entering enough information into a generic lexicon to provide each of these theories with what it needs to work. Providing information for different uses implies organizing that information into a *hierarchy of pieces of information*. The first part of the article is devoted to this question. The hierarchy of information comes from an *observational level* and is based on a description of a language, paying attention to what constructions are permitted or not. The second part of the article defines a *description meta-language* for semantic information, linked to the phenomenological description of the syntax. In the third part, the authors examine *nouns*, and how the descriptions of meanings can be arranged in order to solve questions of *metaphor* and *polysemy*.

7 Semantic features in a generic lexicon

GABRIEL G. BÈS AND ALAIN LECOMTE

7.1 Introduction

7.1.1 *Some approaches to semantics*

Various theories[1] are nowadays used in linguistic analysis, particularly in syntax, and it does not seem reasonable to expect a reduction of their number in the near future. Nor does it seem reasonable to expect that one theory will cover them, as a kind of meta-theory. Nevertheless, all these theories have in common the need for a lexicon which would include the necessary and sufficient information for combining lexical items and extracting a representation of the meaning of such combinations.

If it is not possible to propose a canonical theory to organize the storage of the lexical information, it is necessary to adopt a "*polytheoretic*" conception of the lexicon. (Hellwig, Minkwitz, and Koch, 1991). A point shared by different theories concerns the need for some *semantic* information even for a syntactic parsing of a sentence (and a fortiori, beyond this level, for the parsing of a text).

During a first period, the semantic information required was above all concentrated on the *thematic roles* (Gruber, 1965; Jackendoff, 1972). These thematic roles were introduced because the grammatical functions were insufficient for discriminating between various interpretations and for describing the similarities of sentences. For instance, in:

(1) *The door opened*
(2) *Charlie opened the door*

the door is considered as having the same semantic function but not the same grammatical function – subject for (1) and object for (2). Gruber (1965) gives to *the door* in the two sentences the same thematic role of *theme*. A similar objective was assigned to the *case-theory* (Fillmore, 1968). This trend is still dominating the work done in the framework of the GB-(Government Binding) theory, under the aspect of *theta-roles*.

But, at the same time as the Chomskyan Generative Theory was developed, the theory of Montague proposed a very integrated theory of syntax and semantics. So, during a second period, the semantic information required has consisted of functional structures which are combined at the same time that the signs that denote them are syntactically combined. These structures are matters for the *typed lambda-calculus* and the *intensional logic*. The semantic information required

involves semantic categories assigned to words, which can be translated into *logical types*. A high level of integration between the generative model and the theory of Montague was reached by the GPSG (Generalized Phrase Structure Grammars) approach (Gazdar et al., 1985).

In a third period, so-called *post-Montagovian* theories were developed in order to solve questions the theory of Montague could not deal with: for instance, the questions of the *ambiguity of quantifier-scopes,* of the *de re/de dicto* ambiguity, and the question of the *dynamic scope of quantifiers* (linked to the problems of coordination between sentences, as in "Peter has a donkey. He beats it.").

The semantic information required is then more complex. It involves some kind of rules which determines what kind of semantic categories a word can belong to (for instance: rules of *type-lifting*). The *Flexible Montague Grammar* (Hendricks, 1989) is so-called because categories are not rigidly assigned to words. For instance, it is well known that since Montague's PTQ (Montague, 1973), it has assigned to NPs a semantic category **<<e,t>,t>** rather than merely **e** (in order to deal with the quantification phenomena). A consequence is that even a proper name is a functor over a predicate. This assignment is not necessary if we admit a type-raising rule according to which any unity of type **a** is also of type **<<a, b >,b>** for all **b**, and if we use this rule only if necessary.

In Categorial Grammars, the type-lifting of an argument corresponds to a unary rule. The question arises whether it is syntactic or semantic. But numerous works (mainly Dowty, 1988) have suggested that the type-raising of categories, being constrained by lexical types, must appear as a lexical rule. Other approaches consider that families of categories or categories with variables must be assigned to words in the lexicon. This opens the way to *polymorphism* (Moortgat, 1988; Calder, 1987; Klein, Zeevat, and Calder, 1987).

Among the post-Montagovian theories, much attention must be paid to the *Theory of Discursive Representations* of Hans Kamp, and to its linearized version by Zeevat, called *InL* (Zeevat, 1991). This theory requires assigning to lexical entries expressions with an *index* (corresponding to *referent markers* in the DRS theory), such that expressions can be combined by the operation of unification with a control on the index-type. It has been shown that the DRS (Discourse Representation Structure) theory has several possible translations into other formalisms. For instance, it can be expressed in the Montagovian framework (with some rather small extensions, like the notions of *states* and *state-switching*) (Groenendijk and Stokhof, 1990; Dekker, 1990). It can be expressed, too, in the *Constructive Type Theory* (Ahn and Kolb, 1990). But it is still an open question whether these various theories are only variants of each other, or if they constitute something specific of their own.

This last point leads us to the polytheoretic approach. We have to enter enough information into a lexicon to provide each of the previous theories with what it needs to work, even if specific modules of translation are required to transform the generic information into a specific one.

Otherwise, many recent approaches to the lexicon have shown how to integrate a semantic information consisting in *aspectual features* into the syntax (Dowty, 1979; Pustejovsky, 1990). They have insisted, too, on the possibility of solving questions of *metaphor, metonymy* and *polysemy* (Sowa, 1989; Boguraev and Pustejovsky, 1991; Boguraev, Briscoe, and Copestake, 1991). Dealing with these questions requires considering lexical entries as providing much more information than was previously assumed. We shall see later, for instance, how we can conceive a lexical entry for a *common noun,* the point being that several viewpoints on the "piece of reality" denoted by it are always possible.

Finally, if we wish to include semantic information in the lexicon for different uses, it seems necessary to introduce a *hierarchy of pieces of information.* This hierarchy will come from an *observational level,* and will be based on a description of a language, paying attention to what constructions are permitted and to what are not. That seems to be a preliminary question for any processing of metaphors and polysemy. In a perspective of parsing a sentence, it allows the parser to eliminate impossible sentences at a first glance, just as human readers do. The *first* part of this communication will thus be devoted to this question of *hierarchization.* The *second* part will be concerned by a level of *meta-description* of the semantic information, linked to the level of phenomenological description of the syntax. In the third part, we shall try to look at *nouns,* and how the descriptions of meanings can be arranged in order to solve questions of *metaphor* and *polysemy.*

7.1.2 *Methodological requisites*

We insist on the fact that we try here to present neither any new theory, nor any kind of meta-theory. We try only to introduce a *meta-language* of description of the *word meanings,* in order that special algorithms may perform the transformation of this kind of description into formulas and terms used in an appropriate theory. We do not think that these descriptions could be directly usable in a meta-theory because such a theory would probably be untractable. Specific theories are used to deal with specific processings of sentences and texts. They are designed to be tractable. To put them altogether in only one device would provoke an explosion in complexity.

Furthermore, the semantic information we seek to include in the lexicon must be the most "concrete" possible (cf. Hellwig et al., 1991). That is, it must be related systematically to observations on meaning. These, in their turn, must be founded, at least in principle, on operational tests and must be reproducible and intersubjective.

Lastly, this information must be systematically associated with linguistic forms, particularly syntactic frames (see the following section), with a large coverage. In the ideal case, it should tend toward exhaustivity.

7.2 Hierarchization of the semantic information in the lexicon

Semantic features included in the lexicon refer to an implicit structure (cognitively interpretable or not) which:

1. gives them a structural meaning (a meaning obtained by a position in a structure rather than an intrinsic meaning) and
2. must allow us to derive the kind of semantic entities we want to use in different approaches.

Minimal ingredients are necessary to build those formulas these approaches require. This program must be performed by stages and these stages reflect an implicit hierarchical organization of the semantic information.

We assume that the semantic information is organized in three systems: a grammatical system, as included in the grammar, a conceptual system and an encyclopedic system.

The grammatical system

The semantic information included in this part is the minimal semantic information required in order for the rules of grammar to construct, concurrently with the syntactic information (and other grammatical information) a minimal semantic representation. It is formally related to linguistic forms. It allows us:

1. to know whether an interpretation is obtainable from a given utterance
2. to construct the part of the semantic interpretation which is determined by the syntactic construction.

The conceptual system

The semantic information included in the conceptual system expands the grammatical information. It is founded in some more or less conventional and explicit classificatory or definitional system. It is not related to syntactic forms, by definition.

The encyclopedic system

The semantic information in the encyclopedic system reflects a state of knowledge at a given instant. Consider the following examples:[2]

(3) (a) *Jacques tourne la poignée*
(b) *La poignée tourne*
(c) *Jacques tourne la terre*
(d) *La terre tourne*
(e) *La terre tourne autour du soleil*
(f) *Le soleil tourne autour de la terre*

At the first level, the grammar will assign a non-deviant semantic representation to sentences from (a) to (f). At this level, (3)(c) differs from (3)(a) only with respect to the denotation of *la poignée* (*the door-handle*) and *la terre* (*the earth*).

At the second level, the anomaly of (3)(c) is indicated. At the third level, (3)(f) is considered true before Galileo and false after him, (3)(e) being considered false before and true after. As another example, let us consider the sentence:

(4) "*La lune tombe continuellement sur la terre*"
("The Moon is continually falling down to the Earth")

Here, the grammatical system can recognize this sentence as a meaningful sentence: that means a sentence which has a constructible interpretation. The syntactic construction associated with the verbal lemma *tomber* is sufficient to do that. We have: NP_0 surNP_1 as such a construction (where NP_i denote nominal phrases, complements of rank i in the sentence). Nevertheless, the conceptual system can recognize it as an anomaly because the denotation of the argument in the NP_0-place is a mobile entity, the movement of which is expressed by the verb. This movement is essentially *terminative* and requires a *termination point* located at the denotation of the argument which occurs at the NP_1-place. And the feature *terminative* is contradictory with the denotation of the adverb "continuellement". Thus, a metaphoric interpretation will necessarily be produced.

Lastly, the encyclopedic system could define "*tomber*" as "*to obey the gravitation law*" thus eliminating the iterative interpretation linked to the adverb.

These three levels are required if we want to avoid several pitfalls:

1. the pitfalls of a notion of lexicon assumed to exhaust the present knowledge,
2. the pitfalls of a definitional system based on necessary and sufficient conditions which immediately eliminates any seemingly deviant utterance, and
3. the pitfalls of a confusion between syntax and semantics which would lead us to a conception where "everything would be semantic", a conception which does not seem desirable in the present state of our knowledge.

7.3 The model

7.3.1 *Two kinds of semantic features*

We assume that a sentence must be described by a syntactic representation, a semantic representation and a mapping between them. Syntactic representations are built from syntactic constituents (NP, PP and the like). A semantic representation is a thematic structure where we distinguish thematic nodes. Syntactic constituents are mapped onto thematic nodes, and the semantic representation of the sentence is calculated from the semantic values (denotations) directly associated with the constituents, or transmitted by thematic nodes. A lexical entry presents typically a thematic structure, one or more syntactic frame(s) (subcategorization) and mappings between the former and each of the latter ones. In certain cases, the mapping function can be evaluated in terms of syntactic information alone. See for instance:

(5) (a) *Le prisonnier dort*[3]
(b) *La chaussée dort*
(c) *Isabelle a volé un bijou à Marie*
(d) *Isabelle a volé Pierre à Marie*
(e) *Isabelle a volé une pierre à ce bijou*

In (5)(a) to (e) a semantic representation is constructible by a mapping from the syntactic representation. In the thematic structure of *dormir,* the thematic node, associated with the subject will require some feature-value as [+*animate*], but this information is not needed to calculate the mapping. Compare with:

(6) (a) *Isabelle a volé Pierre*[4]
(b) *Isabelle a volé ce bijou*
(c) *Pierre rassemble ses habits*
(d) *L'armoire rassemble ses habits*
(e) *Le maire a élargi le prisonnier*
(f) *Le maire a élargi la chaussée*

In (6)(a), *Pierre* must be mapped to the same thematic node as *Marie* in (5)(d) and in (6)(b), *ce bijou* (*jewel*) must be mapped onto the same thematic node as in (5)(c). *Pierre* in (6)(a) and in (5)(d) is not mapped onto the same thematic node. That of *ce bijou* in (6)(b) cannot be the same as the one in (5)(e). Depending on their denotation, *Pierre* and *l'armoire* (*the cupboard*) must be mapped onto different thematic nodes in (6)(c) and (6)(d) (cf. Fradin, 1990). The same is true for *le prisonnier* (*the prisoner*) and *la chaussée* (*the roadway*) in (6)(e) and (6)(f) but for this latter case, two different thematic structures will be used because one thematic node is required for the first sentence and another is required for the second, and it does not make sense to have both together in the same thematic structure. Thus we are able to say that there are at least two lexical meanings for the verb *élargir* (one corresponding to *to release,* the other to *to widen*).

We distinguish thus crucially between denotational semantic features of the first level, which will affect the constituents of a syntactic frame, and denotational semantic features of the second level which will be represented in the semantic nodes of the thematic structure. The first are relevant to the mapping function and they occur as distinctive features in many situations (as for (6)(c) and (6)(d), for instance). In such situations, a semantic feature is required when pairing a particular syntactic frame and the thematic structure associated with the given verb. This is not the case for the second ones.

It follows from these considerations that it is impossible (and not only inelegant, non-explicative or redundant) to calculate semantic representations from an "autonomous syntax". In some cases, syntactic frames enforce the construction of some semantic representation (even if deviant) while, in other cases, the semantic features associated with particular constituents in given frames eliminate mappings which would be otherwise possible with other linguistic forms. Any model of the lexicon must carefully account for these two different kinds of situations.

Little will be said here about syntactic frames.[5] We assume a list of constituents and of syntactic functions, and we require that they be defined in purely syntactic terms, without any kind of symbol belonging to the semantic representations. Such indices are only added for the pairing operation between syntactic frames and thematic structures. We discuss hereafter thematic structures and this operation of pairing.

7.3.2 *Thematic roles and thematic structures*

Recently, many authors (Rappaport, Laughren and Levin 1987; Jackendoff, 1990; Ravin, 1991; Pustejovsky, 1990) advanced solid arguments in favor of derived thematic roles. For instance, Rappaport et al. point up the fact that lexical entries cannot merely consist in lists of theta-roles (so-called theta-grids). One of the reasons is that there is no one-to-one mapping between argumental positions (our "syntactic positions") and semantic notions such as: agent, patient, theme or goal. They prefer to describe the theta-roles assignment by means of linking rules dictating a particular association of variables in "Lexical Conceptual Structures" with variables in the "Predicate-Argument Structure" of a given verb. Concurrently, Pustejovsky (1990) calculates these roles by starting from a system with *aspectual values*. Our conception is very similar except that we are not bound to a particular theoretical framework (such as GB) and thus we express this association in our meta-language of description, rather than in generative terms.

We shall assume here a denotational universe U, and a set of relations *Rel* over U. *<U,Rel>* is exactly what we call a *structure* in mathematical logic.

> *Definition 1: a thematic structure,* for a verb v, is a subset of *<U, Rel>* selected by v.

The thematic structure expresses the kind of semantic information a verb brings to us in the language use. In a cognitive perspective, we can say that such verbal structures give access to a certain denotational universe, or that this latter universe is the "real universe" when filtered by verbal structures.

> *Definition 2:* we shall call a *thematic node* or thematic position a node in a thematic structure.

It is important to note that the relations over U are primitive entities.

7.3.3 *Associations between syntactic frames and thematic structures*

> *Definition 3:* we shall call *a reading* of an utterance e any association of a syntactic frame $\{P_i\}_{i\in I}$ belonging to the verbal entry, with a substructure *<U, Rel>*.

This association must be a morphism:

$$\phi: <U, Rel> \rightarrow \{P_i\}_{i\in I}$$

That means: if d associates with each P_i its denotation in the universe of reference, we have:

for each R and $\rho \in$ *Rel:* for all T_i and $T_k \in U$, $R(T_i, T_k) \Rightarrow R(d(\phi(T_i)), d(\phi(T_k)))$
and $\rho(T_i) \Rightarrow \rho(d(\phi(T_i)))$

This condition entails that the denotations of constituents must be compatible with the relations included in the thematic structure of the entry. The morphism is not necessarily an isomorphism because some relations can be missing in the syntactic frame and some syntactic positions can be missing, too.

As an example, we take the verb *rassembler* (Fradin, 1990) in the sentences (6) (c) and (d) recalled here in (7)(a) and (b), to which we add (7)(c).

(7) (a) *Pierre rassemble ses habits*[6]
(b) *L'armoire rassemble ses habits*
(c) *Pierre rassemble ses habits dans l'armoire*

L'armoire (*the cupboard*) in (7)(b) is associated with the same thematic role as *dans l'armoire* in (7)(c). Syntactically, (7)(a) and (7)(b) are associated with the same syntactic frame N_0VN_1. To make the necessary distinction, we have only to introduce the feature [*Nhum*+] as necessary for a syntactic frame:

N_0[Nhum+] V N_1

In doing so, we get a first-level feature which will be necessary to identify the appropriate reading of *l'armoire rassemble les habits*. [*Nhum*+] is a first-level feature which must be associated with the frame of (7)(a) and not with the frame of (7)(b). The denotation of *armoire* does not normally accept this feature because armoire denotes a physical non-animate entity. This situation triggers a necessary association with the syntactic frame which does not require this feature. This situation can be illustrated by the following figure, where SF_1, SF_2 and SF_3 correspond respectively to the syntactic frames of (7)(a), (b) and (c).

In Figure 7.1, the relations over the universe are represented by labeled arrows. Some of these are arcs joining two distinct vertices, and some are just loops. The former are binary relations and the latter unary ones (i.e., properties). The labels belong to a set of primitives such as: *loc, mobile,* or ©. This last label comes from the work of Desclés (cf. Desclés, 1990) where it is defined as an operator of intentional control. These relations give to their sources and goals specific interpretations which can receive appropriate names. For instance, many researchers will desire to interpret as **agent** the source of the ©-arrow. On the other hand, the status of the goal of such an arrow may depend on the kind of arrow it is composed with. For example, if it is composed with a *mobile* entity which is a physical object, the interpretation can be that of **theme**, if it is composed with a non-mobile entity that of a **patient,** etc.

There is another important feature of our meta-language: arrows can join not only a vertex to another one, but also a vertex to another arrow or even arrows between them. The best way to represent these situations is to make use of the recursively defined notion of *type,* as is done in the theory of semantic categories.

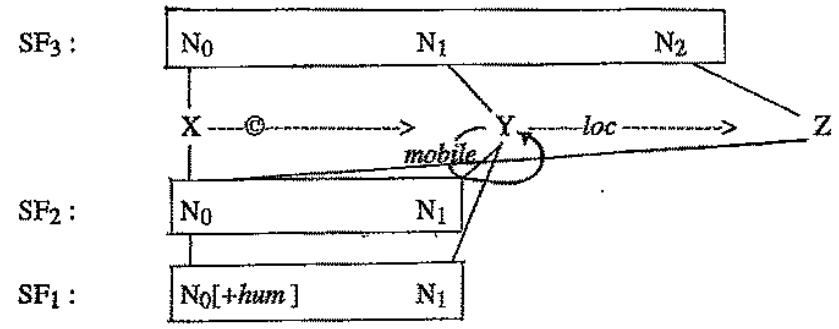

Figure 7.1.

Assigning an atomic type to the elements of U, and to the possible sorts of sentences, we define complex types in the following traditional manner:

if **a** and **b** are types, **a**→**b** is a type

We define the *composition of types* such as in the typed lambda-calculus by:

if **a** and **a**→**b** are types, the composition of objects inhabiting these types gives an object of type **b**.

We assume now the existence of atomic types for sentences, depending on what kind of entity it denotes: events, states or processes. We can use: **e**, **s** and **pr**. Elements in the universe U are assigned an atomic type **t**.

A thematic structure is given by a collection of *variables,* belonging to an atomic type, and a collection of *typed functors.* For instance, the thematic structure of *rassembler* contains:

$\copyright^{t\to(t\to(s\to e))}$, $\mathtt{mobile}^{t\to t}$ and $\mathtt{loc}^{t\to(t\to s)}$

These functors have appropriate types in order to be combined in convenient ways. For instance, the last one (loc) must take as argument the result of the previous one (mobile). It is the reason why loc will be defined as a λ-function: $\lambda V.\mathtt{loc}^{t\to(t\to s)}(V)$, which must take its argument *among* the results of the other functors. The thematic structure also contains variables, occurring as *parameters* of the functors: X, Y, Z . . . distinguished from other variables by the nature of punctuation signs surrounding them (brackets [. . .] instead of parentheses (. . .)) in order that the complete representation of the components of the thematic structure are:

$\lambda U.\copyright^{t\to(t\to(s\to e))}[X][Y](U)$, $\mathtt{mobile}^{t\to t}[Y]$ and $\lambda V.\mathtt{loc}^{t\to(t\to s)}(V)\ [Z]$

We call these functors: *parametrized functors.*

The associations of syntactic frames with thematic structures may be represented as *sets of equations* linking the parameters inside the parametrized functors and the variables denoting the syntactic positions in the frames. Finally, we will assume that a thematic structure is a λ-*scheme,* like:

$\lambda X.\ \lambda Y.\ \lambda Z\ [\lambda U.\copyright^{t\to(t\to(s\to e))}[X[Nhum+]][Y](U);$
$\mathtt{mobile}^{t\to t}[Y];$
$\lambda V.\mathtt{loc}^{t\to(t\to s)}(V)[Z]]$

Parameters (X, Y, Z, . . .) are implicitly typed according to the typing of the functors, for instance, X is of type **t** and Y, too. Types may be feature-types. Some (semantic) features are inherited from the syntactic frames via the equations. Features inherent to objects bound to the parameters must unify with these inherited features. In a given grammatical construct, this necessary condition permits the appropriate selection of the relevant component of the λ-scheme. Other semantic features are licensed directly on the parameters (see the following discussion). The components of a λ-scheme are reduced in parallel according to classical β-reduction in the λ-calculus. Results are objects of single or complex type. If of complex type, they are *ground* functors and may be applied to other components in order to give terminal objects expressing a meaning.

rassembler:

Them:: $\lambda X.\ \lambda Y.\ \lambda Z\ [\lambda U.©^{t\rightarrow(t\rightarrow(s\rightarrow e))}[X[Nhum+]][Y](U);$
$\mathtt{mobile}^{t\rightarrow t}[Y];$
$\lambda V.\mathtt{loc}^{t\rightarrow(t\rightarrow s)}(V)[Z]]$

SF1: $N_0[Nhum+]\ V\ N_1$
$N_0=X;\ N_1=Y$

SF2: $N_0\ V\ N_1$
$N_0=Z;\ N_1=Y$

SF3: $N_0\ V\ N_1$ prep_loc N_a
$N_0=X;\ N_1=Y;\ N_a=Z$

A semantic feature occurring in a syntactic frame takes priority over any other semantic feature. This is a preemption principle. It ensures that if some constituent in a sentence has a first-level feature, it must be assigned to the constituent in a frame which has this feature. A syntactic frame which does not require it is selected only if the sentence constituent does not possess it. This kind of preemption principle seems to have a high potential of generalization (cf. Lehrer, 1990). We can conclude that first-level features are *more salient* than others.

The semantic information can always be completed. For instance, in this example, we must accept sentences like: *l'anniversaire de Marie a rassemblé la famille dans la grande salle,*[7] even if the subject does not have the feature [Nhum+]. In this case, the thematic part of the lexical entry must be completed by another relation: a causation relation, which is of type **t**→(**s**→**e**), with parameters: X and S: $\mathtt{cause}^{t\rightarrow(s\rightarrow e)}(X, S)$, expressing that the event called *anniversaire,* linked to X, is the cause for Y (identified with *the family*) being located in *the big room* (linked to Z), this location being a state linked to the variable S. In this case, too, we have to define a variant of the first syntactic frame, which includes the feature [Nevent+] in place of [Nhum+]. We can express this information by means of a disjunctive syntactic frame:

rassembler:

Them:
$\lambda(X, Y, Z)[\lambda U.\textcircled{c}^{t\rightarrow(t\rightarrow(s\rightarrow e))}[X[Nhum+]][Y](U);$
$\texttt{mobile}^{t\rightarrow t}[Y];$
$\lambda V.\texttt{loc}^{t\rightarrow(t\rightarrow s)}(V)[Z];$
$\lambda U.\texttt{cause}^{t\rightarrow(s\rightarrow e)}[X[Nevent+]]\ (U)]$

SF1: $N_0[Nhum+] \vee [Nevent+]\ V\ N_1\ (prep\_loc\ N_a)$
$N_0=X;\ N_1=Y;\ (N_a=Z)$

SF2: $N_0\ V\ N_1$
$N_0=Z;\ N_1=Y$

Let us remark that adding this disjunctive frame necessitates adding semantic features to the parameters in the thematic structure, in order to perform the appropriate selection. A thematic structure is *not* a conjunctive set. That means that we do not interpret it as a conjunction of relations between the entities denoted by X, Y, Z and so on. All components of a λ-scheme are not necessarily realized in an utterance. (Let us recall that the mapping from thematic structures to syntactic frames is not an isomorphism.) Some components may be obligatory and conjunctively realized, but others are selected only by means of a sort of "case of".

From the point of view of the lexicographer, a particular interest of this kind of conception lies in the ability it provides to check the *coherence* of a lexical entry. A thematic structure will be coherent if there exists at least one way of combining components of the λ-scheme in order to get an object of a definite type. For instance, the functor $\texttt{mobile}^{t\rightarrow t}$ takes an argument of type **t** and gives a result of type **t**, otherwise, $\texttt{loc}^{t\rightarrow(t\rightarrow s)}$ takes two arguments of type **t** and gives an object of type **s** (a *state*), so for instance, *Peter* and *Paris* may be used as arguments for `loc` and give the location (*state*): *Peter in Paris*. In the same way, takes two arguments of type **t** and gives an object of type (**s**→**e**) which requires another argument, of type **s**, in order to give an object of a single type: **e** (an *event*). This typing thus requires the presence of the previously calculated location (it is an obligatory role in the thematic structure).

Furthermore, it is possible to express the meaning by starting from various components of *Them*. Various orders of enumeration of these components give rise to various expressions, and to various types of reality described. For instance, from the lexical entry for *rassembler,* we can get:

(8) *l'anniversaire de Marie rassemble la famille dans la grande salle*
(type: **event**)

(9) *la grande salle rassemble la famille*[8]
(type: **stative**).

(10) *la famille se rassemble dans la grande salle*[9]
(type: **event**)

The ways of composition are:

First stage: for (8) we apply the λ-scheme to variables instantiated by the appropriate syntactic frame.

X = *anniversaire_de_Marie*
Y = *famille*
Z = *grande_salle*

this yields:

$\lambda(X,Y,Z)\ [\lambda U.©^{t\to(t\to(s\to e))}\ [X[Nhum+]][Y](U\ ;$
$\texttt{mobile}^{t\to t}[Y]\ ;$
$\lambda V.\texttt{loc}^{t\to(t\to s)}(V)[Z]\ ;$
$\lambda U.\texttt{cause}^{t\to(s\to e)}[X[Nevent+]](U)]$ *(anniversaire_de_Marie , famille, grande_salle)*

Since X has not the feature [Nhum+], the component $\lambda U.\texttt{cause}^{t\to\ (s\to e)}[X[N\text{-}event+]]$ (U) is selected.

Second stage: "outer"-reduction. We obtain:

$[\texttt{mobile}^{t}[famille];$
$\lambda V.\texttt{loc}^{(t\to s)}(V)[grande\_salle];$
$\lambda U.\texttt{cause}^{(s\to e)}[anniversaire\_de\_Marie]\ (U)]$

Third stage: "inner"-reduction. The only appropriate argument for `loc` is: $\texttt{mobile}^{t}[famille]$. We thus obtain:

$[\lambda V.\texttt{loc}^{(t\to s)}(V)[grande\_salle]]\ [\texttt{mobile}^{t}(famille])$
$= \texttt{loc}^{s}(\texttt{mobile}^{t}[famille])[grande\_salle]$

This term is of type s and is thus appropriate to be an argument for `cause`:

$[\lambda U.\texttt{cause}^{(s\to e)}[anniversaire\_de\_Marie](U)](\texttt{loc}^{s}(\texttt{mobile}^{t}[famille])$
$[grande\_salle])$
$= \texttt{cause}^{e}(anniversaire\_de\_Marie](((\texttt{loc}^{s}(\texttt{mobile}^{t}[famille])$
$[grande\_salle]))$

and we get finally a term of type **e** (event).

First stage: for (9) we apply the λ-scheme to variables instantiated by the appropriate syntactic frame.

Y = *famille*
Z = *grande_salle*

this yields:

$\lambda(X,Y,Z)\ [\lambda U.©^{t\to(t\to(s\to e))}\ [X[Nhum+]][Y](U);$
$\texttt{mobile}^{t\to t}[Y]\ ;$
$\lambda V.\texttt{loc}^{t\to(t\to s)}(V)[Z]\ ;$
$\lambda U.\texttt{cause}^{t\to(s\to e)}[X[Nevent+]](U)]\ (X, famille, grande\_salle)$

Since X is not instantiated, all terms containing X are excluded from the structure.

Second stage: "outer"-reduction. We obtain:

[mobile^{t}[*famille*];
λV.loc$^{(t\to s)}$(V)[*grande_salle*];

Third stage: "inner"-reduction.

The only appropriate argument for loc is: mobile^{t}[*famille*]. We thus obtain:

[λV.loc$^{(t\to s)}$(V)[*grande_salle*]] (mobile^{t}[*famille*])
= loc^{s}(mobile^{t}[*famille*])(*grande_salle*)

and we get finally a term of type **s** (state).

First stage: for (10) we apply the λ-scheme to variables instantiated by the appropriate syntactic frame.

X = *famille*
Y = *famille*
Z = *grande_salle*

this yields:

λ(X,Y,Z) [λU.©$^{t\to(t\to(s\to e))}$ [X[Nhum+]][Y](U) ;
mobile$^{t\to t}$[Y] ;
λV.loc$^{t\to(t\to s)}$(V)[Z] ;
λU.cause$^{t\to(s\to e)}$[X[Nevent+]](U)] (*famille, famille, grande_salle*)

Since X has the feature [Nhum+], the component λU.©$^{t\to(t\to(s\to e))}$ [X[Nhum+]] [Y](U) is selected.

Second stage: "outer"-reduction. We obtain:

[mobile^{t}[*famille*];
λV.loc$^{(t\to s)}$(V)[*grande_salle*];
λU.©$^{s\to e}$[*famille, famille*](U)]

Third stage: "inner"-reduction.

The only appropriate argument for loc is: mobile^{t}[*famille*]. We thus obtain:

[λV.loc$^{(t\to s)}$(V)[*grande_salle*]] (mobile^{t}[*famille*])
= loc^{s}(mobile^{t}[*famille*])[*grande_salle*]

This term is of type s and is thus appropriate to be an argument for ©:

[λU.©$^{s\to e}$[*famille, famille*](U)](loc^{s}(mobile^{t}[*famille*])[*grande_salle*])
= ©^{e}[*famille, famille*]((loc^{s}(mobile^{t}[*famille*])[*grande_salle*]))

and we get finally a term of type **e** (event).

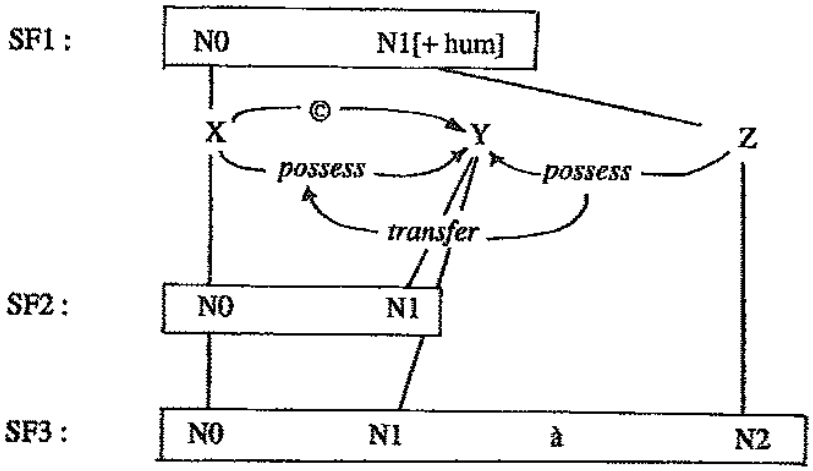

Figure 7.2.

7.3.4 *Other examples*

Let us look at other examples. For instance, the verb *voler* (to steal) has various syntactic frames:

(11) SF1: N_0 V N_1[Nhum+]: (a) *Pierre vole Marie*[10]
SF2: N_0 V N_1: (b) *Pierre vole un livre*
SF3: N_0 V N_1 à N_2: (c) *Pierre vole un livre à Marie*

The thematic structure is shown in Figure 7.2, expressed by the following simplified set of terms:[11]

$\lambda U.\copyright^{t\to(t\to(s\to e))}[X][Y](U)$,
$\mathtt{transfer}^{t\to(s\to(s\to s))}[Y]$
$(\mathtt{possess}^{t\to(t\to s)}[Y][Z])(\mathtt{possess}^{t\to(t\to s)}[Y][X])$

These descriptions give the following simplified entry:

voler:

Them:
$\lambda(X, Y, Z)$ $[\lambda U.\copyright^{t\to(t\to(s\to e))}[X][Y](U)$,
$\mathtt{transfer}^{t\to(s\to(s\to s))}[Y]$
$(\mathtt{possess}^{t\to(t\to s)}[Y][Z])(\mathtt{possess}^{t\to(t\to s)}[Y][X])]$

SF1: N_0 V N_1[Nhum+]
N_0=X; N_1=Z
SF2: N_0 V N_1
N_0=X; N_1=Y
SF3: N_0 V N_1 à N_2
N_0=X; N_1=Y; N_2=Z

which gives respectively for (11)(a), (b) and (c):

$©^{e}$[*Pierre*][Δ](transfer^{s}[Δ] (possess^{s}[Δ][*Marie*])
(possess^{s}[Δ][*Pierre*])[12]
$©^{e}$[*Pierre*][*un_livre*](transfer^{s}[*un_livre*]
(possess^{s}[*un_livre*][Δ])(possess^{s}[*un_livre*][*Pierre*])
$©^{e}$[*Pierre*][*un_livre*](transfer^{s}[*un_livre*]
(possess^{s}[*un_livre*][*Marie*])(possess^{s}[*un_livre*][*Pierre*])

Movement verbs are described with a relation of transfer, too. For instance:

envoyer:

Them:[13]
$\lambda(X, Y, S, T)$ [$\lambda U.©^{t\to(t\to(s\to e))}$[X][Y](U),
i_state$^{t\to(t\to s0)}$[Y][S],
f_state$^{t\to(t\to s1)}$[Y][T]
$\lambda V.\lambda W.$transfer$^{t\to(s0\to(s1\to s))}$[Y] (V)(W)]

SF: N_0 V N_1 (de N_a à N_b)
N_0=X; N_1=Y; N_a=S; N_b=T

The composition of arrows inherent to a sentence like:

(12) *Pierre envoie une lettre de Rome à Paris*[14]

gives the following expression:

$©^{e}$[*Pierre*][*une_lettre*](transfer^{s}[*une_lettre*](i_state^{s0}[*une_lettre*]
[*Rome*])(f_state^{s1}
[*une_lettre*][*Paris*]))

and results in a sentence of type **e**.

In such an entry, properties like initial_state or final _state are used to transform a *term* to a *state* (for instance the term denoting a city: "Paris" into the state of "being in Paris"). By the transfer relation, a term like "a letter" gives, via the states produced by initial_state and final_state, a new state (being in transfer from Rome to Paris), which can be an argument for the control relation, which transforms the arguments into an event.

It is worthwhile to notice here that these informations are able to determine the type of an index associated with an expression of the *InL* language. This formal language, due to Zeevat (1991) consists in linear formulations of Discourse Representation Structures (Kamp, 1981) and has been embedded in Unification Categorial Grammars (Klein, Zeevat, and Calder, 1987). Representations are made with formulas applying to other formulas, each of them being selected by an index. This kind of index is similar to discursive markers in DRS. And it corresponds to types of entities and events. The representation of (10) in *InL* would be:

[e][ENVOIE ([t][PIERRE], [t][LETTRE], [s][DE (s,[t]ROME),
A(s, [t]PARIS)])]

making apparent that the result is of type **e**, and is made with: entities of type **t** (*Pierre* and *une_lettre*) and an entity of the **s** type, resulting from entities of the **t** type (*Rome* and *Paris*).

We must take into account that if the verb *envoyer* is taken in another syntactic frame, as in:

(13) *Pierre envoie une lettre à Marie* (or *à la Sécurité Sociale,* or even: *à Paris*)[15]

the final state: *Marie,* or *la sécurité Sociale,* or *Paris* expresses not only the destination, but the "real goal", or the receiver (the one(s) to whom Pierre intended to send his letter). *Paris,* for instance is not assigned to the same thematic node as in (12). It will be necessary to interpret *Paris* as meaning: *some group of people,* or *some official living in Paris*. It would be unsatisfactory to deliver such roles as coming merely from a list, it is better to calculate them. Here, the lexical frame for *envoyer* must be completed in the following way:

envoyer:

Them:
$\lambda(X, Y, S, T)$ [$\lambda U.©^{t\to(t\to(s\to e))}[X][Y](U)$,
$\texttt{i\_state}^{t\to(t\to s0)}[Y][S]$,
$\texttt{f\_state}^{t\to(t\to s1)}[Y][T]$
$\lambda V.\lambda W.\texttt{transfer}^{t\to(s0\to(s1\to s))}[Y]\ (V)(W)$]

SF1: N_0 V N_1 de N_a à N_b
N_0=X; N_1=Y; N_a=S; N_b=T

SF2: N_0 V N_1 à N_2
N0=X=S; N1=Y; N2=T

As we can see, the thematic structure is preserved. The distinction comes only from the fact that special constraints, in the association of variables of the syntactic frame and variables of the thematic structure, make some semantic variables identical. The coincidence of the source of © with the initial state makes the final state become a receiver. The appropriate combination of the relations gives:

$©^{e}$[*Pierre*][*une_lettre*]($\texttt{transfer}^{s}$[*une_lettre*]($\texttt{i\_state}^{s0}$[*une_lettre*][*Pierre*])($\texttt{f\_state}^{s1}$[*une_lettre*][*Paris*]))

7.4 The construction of an interpretation in the case of an anomaly

If requisites on the first-level semantic features are fulfilled (and, above all, if there are none) a syntactic frame must be paired with the thematic structure. The identification of secondary features is sufficient to produce an effective interpretation. But it may happen that secondary features are not satisfied. Such cases are called *anomalies.* Anomalies are interpretable from the design of lexical entries for nominals. Pustejovsky has defined *Qualia Structures* for nominals (cf.

Pustejovsky, 1989; Boguraev and Pustejovsky, 1991; Boguraev, Briscoe, and Copestake 1991; Anick and Pustejovsky, 1991). A *Qualia Structure* is a structured representation. This structure specifies four aspects of a noun's meaning: its constituent parts, its formal structure, its purpose and function (i.e., its Telic Role); and how it comes about (i.e., its Agentive Role). For example, *book* might be represented as containing the following information:

book (X, Y)
[**Const**: information (Y)]
[**Form**: bound-pages(X) or disk(X)]
[**Telic**: read(T, w, Y)]
[**Agentive**: artifact(X) & write(T, z, Y)]

(cf. Anick and Pustejovsky, 1991).

This information is used to display different aspects of the meaning of *book*, as in the following sentences:

(14) *This book weighs four ounces*
(Formal Structure)

(15) *John finished this book*
(Telic Role: John finished READING this book)

(16) *This is an interesting book*
(Constituent Structure)

It seems, however that the telic component is actually not very well specified. How must we interpret, for instance, sentences in which a book refers to an instant of time, as in: "at the time of this book, people thought that it was right"? We are not quite sure that we must select a *reading* event or a *writing* event or even a *publishing* event. In fact, the thing denoted is not very well specified as a particular event. And it would not be economic to enumerate all the potential actions concerning a given object. In many contexts, a noun (like *book*) may be used merely as designating a temporal entity without making any precise reference to a particular action which concerns it; it then designates a kind of interval, here the interval of time during which the book in question was discussed, read, sold or in fashion. It must then be convenient to attribute *topological entities* to nominals. These entities are, for instance, intervals or other kinds of sets referring to periods during which the object denoted is active. This is particularly relevant in case of a noun like *conseil* studied by Kayser and Levrat (1990). These authors show the difficulty of encompassing all the contextual meanings of this kind of nominal. It is true that we can find the word *conseil* in many contexts such as:

(17) (a) *le conseil est composé de trente-six membres*[16]
(b) *le conseil a voté une motion*
(c) *le conseil est élu tous les cinq ans*
(d) *on ne peut joindre Paul durant le conseil*
(and many others)

and it is true, too, that in every context, the nominal *conseil* belongs to a particular semantic category: a set, an individual agent, an entity associated with some discrete time and an entity associated with an interval of time. We suggest that all these possibilities are considered as viewpoints on the concept denoted by the word. That means that we consider substantives as kinds of spaces over which many topologies can be defined. The selection of one topology dictates the kind of entity we consider under a given word. Such a selection is analogous to the selection of one aspect in the Qualia Structure. We can have, for instance, the following representation for *conseil:*

conseil:
[**Ext**: {member$_1$, member$_2$, . . . , member$_n$}]
[**Tcont**: {[t_1, t_2]; t_1, $t_2 \in {}^+$}]
[**Tdiscr**: {t_i; $t_i \in R^+$}]
[**Int**: {int$_1$, int$_2$, ..., int$_n$}]

(where **Ext** means the extensional viewpoint – membership – **Tcont** a topology on continuous time, **Tdiscr** a topology on discrete time and **Int** an intensional viewpoint – roles defining precisely for what the council is made).

When the identification of a sentence with a syntactic frame has been made (thanks to first-level semantic features), secondary semantic features, belonging to the conceptual system, are used to operate the correct selection of an aspect or a topology in the lexical entries for nominals. This selection is performed by means of a *mechanism of coercion* (see Pustejovsky, 1991).[17] We give the following example of the sentence:

(18) *le congrès s'amuse*[18]

In this example, it is assumed that the word *congrès* has received a lexical entry similar to that of *conseil.* The syntactic frame associated with the verb *s'amuser* is: N_0 Vref. No special first-level semantic feature is required to make the identification of a thematic structure with this frame. But there is a secondary feature ([+animate]), handled by the parameter, which enforces the N_0 to be interpreted as something animate.[19]

s'amuser

Them:
$\lambda U.©^{t\rightarrow(t\rightarrow(s\rightarrow e))}$[X[+animate]][X](U);
SF: N_0 V
N_0=X

The resulting category is: **s→e**. This makes it possible to predict utterances like:

(19) *le congrès s'amuse à imiter son président*[20]

The second-level features are introduced on the semantic parameters, in order to distinguish them from the first-level features (see note 18).

When faced with the sentence (19), the feature [+*animate*] is used to extract from the so-called Qualia-Structure of the word *congrès,* the extensional viewpoint, consisting of a set of members, each of which being [+human], because the entity *member[+human]* can be unified with X[+animate].

7.5 Conclusion: A work in progress

We have outlined a compositional framework attempting to provide a generic lexicon with semantic features. Genericity is a crucial constraint because it requires that features may be used by a system based on any particular theory (provided that there exists some translation module from the formal representations here involved to the desired ones). This constraint implies a theory-independent characterization of the semantic content of the lexicon. Among other things, it requires using abstract primitive relations that are not necessarily the ordinary thematic roles (the terminology of which being very dependent on a particular theory). On another hand, there must be a mechanism by which meanings are generated, depending on syntactic constructions and primitive relations. We introduce a grammatical system as opposed to a conceptual system in order that sentences are primilarly assigned to existing syntactic frames, and then interpreted on the basis of such an assignment. Thus syntax and semantics are deeply interrelated: the syntax appears as almost a component of semantics, and reciprocally, the semantics provides features necessary to syntax. The system proposed here has not been implemented yet, although plans are currently underway to develop a prototype. It will consist of a Knowledge Base, where the units will be expressed by *typed feature structures* and will be hierarchically organized, as in an Inheritance Network. The particular entries for verbs must be built with templates which express generalizations. For instance, a Movement Verb like *marcher* is the result of a combination (by a &-operator) of templates: *movement, intentional control, way* (instantiated by *earth*) and *manner* (instantiated by *foot*). It will be very interesting to go further on this kind of example and to show how preliminary assigned constants in templates may be changed or neutralized according to another instance of coercion mechanism in order to take into account sentences like: *le train marche à bonne allure,*[21] and to explain why *avec des chaussures neuves*[22] in *Pierre marche avec des chaussures neuves*[23] is necessary as an adjunct and is not contradictory with the feature corresponding to 'on foot' as a manner in the template corresponding to *to walk.*

Notes

1. The first version of this chapter was written (January 1992) before the authors were aware of Pustejovsky (1991). There are actually many similarities between the two papers. What is expressed here in terms of compositionality may appear to be said in Pustejovsky's paper in terms of generativity. Nevertheless, our framework is slightly distinct from Pustejovsky's in that (1) emphasis is put on a hierarchical typology of semantic features such that some features are necessary for an interpretable

construction and others are relevant only for a "normal" interpretation, (2) it does not take the denomination of thematic roles (agent, object, . . .) for granted, (3) the mapping from the lexicon to syntax is theory-independent (and based only on observations collected in tables), (4) elementary meanings are not predicates, but functions and allow one to compute resulting types according to combinations driven by the syntactic frames, and (5) Qualia Structures are enriched with Topologies.

2. (a) *Jacques turns the door-handle*
   (b) *The door-handle turns*
   (c) *Jacques turns the earth*
   (d) *The earth turns*
   (e) *The earth turns around the sun*
   (f) *The sun turns around the earth*
3. (a) *The prisoner sleeps*
   (b) *The roadway is asleep*
4. (a) *Isabelle stole from Pierre*
   (b) *Isabelle stole this jewel*
   (c) *Pierre gathers his clothes together*
   (d) *The cupboard keeps all his clothes together*
   (e) *The mayor released the prisoner*
   (f) *The mayor widened the roadway*
5. A notation similar to the LADL-tables (e.g., Gross, 1975) is used, but this is only a notational device.
6. (a) *Pierre gathers his clothes together*
   (b) *The cupboard keeps all his clothes together*
   (c) *Pierre gathers his clothes together in the cupboard*
7. *Mary's birthday gathers the family together in the big room*
8. *The big room is the gathering place for the family*
9. *The family gathers in the big room*
10. (a) *Pierre steals from Marie*
    (b) *Pierre steals a book*
    (c) *Pierre steals a book from Marie*
11. The semantic distinction between *voler, acheter, emprunter* . . . is not here taken into account – it is the reason why we speak of a simplified representation.
12. We assume here that when a variable is not instantiated in a component where another parameter is, it is replaced by a dummy constant like Δ.
13. s0 and s1 are projections of a state s. We assume that projections of states are still states. This gives an account to the fact that in some circumstances, a state may be considered as a pair <s0, s1>: it expresses for instance the colocalization of an entity (independently of time). The same solution could have been used in the previous example.
14. *Pierre sends a letter from Rome to Paris*
15. *Pierre sends a letter to Marie (the Social Security, Paris, . . .)*
16. (a) *The council consists of thirty-six members*
    (b) *The council carried a motion*
    (c) *The council is elected every five years*
    (d) *One can't reach Paul during council meetings*
17. Pustejovsky (1991) gives the following definition of Type Coercion: A semantic operation that converts an argument to the type that is expected by a function, where it would otherwise result in a type error.
18. *The congress has fun*
19. Features handled by parameters serve two purposes: one is just selection of the appropriate component in the thematic structure, thanks to a similar feature handled

by the nominal argument, and this merely results from *unification,* the other is transmission of the feature to the nominal argument by means of *coercion.* The first mechanism has priority on the second one.

20. *The congress has fun imitating its chairman*
21. *The train goes at a great speed*
22. *with new shoes*
23. *Pierre is walking with new shoes*

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