Linguistic Combination and Assignments to Predicative Roles

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Abstract

This paper discusses some model-theoretic hypotheses about both the notion of predicative role and the operation of role assignment. Our main assumption is that the operation of assigning an entity to a predicative role represents the mechanism on the basis of which the semantic content of complex expressions is composed. It is assumed, more precisely, that role assignments represent the main compositional operations in the semantic space. In order to account for such a viewpoint about compositionality, we will attempt to describe the internal structure, the conceptual properties as well as the logic type of role assignments.

1 Introduction

The main objective of this paper is to characterise semantic composition on the basis of a particular logical operation: the assignment of an entity to the role of a predicate. We assume that the essential process concerning semantic composition is not situated at the predication level, but at the level of the operation assigning an entity to a predicative role. Role assignment will be analysed as a binary operation combining two objects, both the assigned entity and the predicate itself, in order to construct a more complex entity. Role assignments will be considered as the linguistic operations that activate the process of semantic composition. This way, the notion of "role" is situated here at the centre of the meaning construction of complex expressions.

The fact of situating composition at the level of the role assignment operation is motivated by some theoretical assumptions concerning the meaning construction of complex expressions. More precisely, we assume that:

- Syntactic dependency relations between two linguistic expressions denote role assignments ;
- the meaning of the related linguistic expressions is elaborated in a "co-compositional" way so as to construct the more specific meaning of the complex expression ;
- meaning construction is the "parallel" processing of both lexical and syntactic information ;
- meaning construction is a recursive process.

In the following subparagraphs, we attempt to introduce in a more accurate way the content of these four assumptions.

1.1 Syntactic Relations Viewed as Compositional Operations

In a number of linguistic frameworks [14, 15, 11], it is argued that syntax should be endowed with some semantic content, in particular, it is asserted that syntactic constructions carry themselves a sort of meaning, independently of the lexical expressions constituting the sentence. However, it is not yet clear how that content could be characterised. One of the aims of this paper is to attempt characterising the meaning of some sorts of syntactic relations.

Consider the syntactic dependency relations such as subject, direct object, nominal modifier, or verbal modifier. They can be viewed as the constructional devices allowing two syntactically related expressions to be combined. They attend to build complex expressions at different levels of grammatical organisation. In the semantic space, we assume that a syntactic dependency relation *denotes* the compositional operation leading the semantic entities denoted by the two syntactically related expressions to be blended into a composite structure. The resulting composite structure represents a more specific semantic entity. Since this compositional operation will be defined in our framework as an assignment of an entity to a predicative role, we make the assumption that syntactic relations denote (or refer to) role assignments in the semantic space.

Syntactic relations are then perceived as dynamic objects activating and driving the composition process. They are not merely passive cues related in a particular way (linking rules, syntactic-semantic mappings, syntactic assignments, etc.) to thematic roles or lexical entailments of verbs [6]. They are conceived of as compositional operations taking part in the process of meaning construction.

Unlike most of previous work on formal semantics, we consider that the compositional mechanism is driven, not by the subcategorisation frames of lexical expressions (verbs, adjectives,...), but by the syntactic relations themselves. As we will show later, subcategorisation frames are not suitable to account for our notion of semantic composition, namely the "co- composition" process.

1.2 Co-composition

For some semantic frameworks, the main point of interest is centred on how the polysemic lexical content carried by the linguistic expressions is disambiguated in the process of composition. When interpreting a complex expression, the lexical meaning carried by each combined item restricts the polysemic lexical meaning related to the other items, and conversely. Lexical approaches call this process of mutual restriction "co-composition" [18, 17] or "sense dynamic construction" [25]. Co-composition (or sense dynamic construction) is the process of generating the meaning of a complex expression by merging and blending into a higher order semantic structure some of the semantic sub- structures related to the combined expressions. In other words, generating the complex expression's meaning is a process in which the combined entities "cooperate" together to restrict and specify the polysemic information carried by each expression [19]. Therefore, when interpreting a complex expression, the syntactic relation combining the constituent expressions should be conceived as the compositional device that actives dynamic co-composition to construct the complex meaning. Semantic composition and, then, meaning construction are activated and driven by the syntactic relations.

Let us take an example. The polysemic verb "load" can be combined with the polysemic noun "books" in order to build the composite expression "load the books". This complex expression carries a particular content of "load" and a particular content of "books".

When the linguistic context is not considered, the polysemic verb "load" can convey at least two alternate meanings: *bringing something to a location* (e.g., "Ann loaded the hay onto the truck"), and *modifying a location with something* (e.g., "Ann loaded the truck with the hay"). In order to disambiguate this verb, one needs to explore its specific linguistic context, that is, the expressions with which it combines within the sentence.

Consider now "book(s)". It is also a polysemic expression, since it may refer to different types of entities: *physical objects* ("rectangular book"), and *symbolic entities* ("naive book"). This way, in order to disambiguate its meaning, one should resort to the current linguistic context: whereas the adjective "rectangular" activates the physical sense of "book", the adjective "naive" makes reference to its symbolic content.

In "load the books", the verb "load" activates the physical sense of the noun, while "books" leads "load" to refer to the event of bringing something to a location. The interpretation of the complex expression is no more ambiguous. Both expressions, "load" and "books", cooperate to mutually restrict their meaning. Such a cooperation corresponds to the so-called dynamic co- composition. Co-composition is directly driven by the syntactic relation - namely the direct object relation - connecting "load" to "books". In the semantic space, the direct object relation denotes a conceptual operation independent of the lexical sense carried by the two combined words.

1.3 Parallel Processing

Since semantic composition depends on information about both syntactic relations and lexical items, the meaning interpretation of complex expressions should be conceived as a mechanism that processes in parallel syntactic and lexical information.

That assumption lies on the psycholinguistic hypotheses about the parallel processing of sentences [22, 23, 16]. In accordance with these hypotheses, the analysis of a sentence consists in processing in parallel both syntactic and lexical information. That is, the interpretation of a sentence is only achieved when syntactic markers and lexical content are processed at the same time. The parallel approach is opposed to those frameworks based on the syntactic autonomy [8]. Inspired by chomskian generativism, such approaches assume that the semantic interpretation can be activated only if the syntactic processing has been achieved in a previous stage. This way, lexical information becomes accessible once the syntactic structure of the sentence has been constructed.

According to the parallel approach, however, syntactic analysis depends on the simultaneous access to lexical information. In fact, both syntactic analysis and meaning interpretation are considered as the same semantic process. As a consequence, syntax appears as a linguistic module taking part in the process of meaning construction. Our conception of semantic composition will be situated within the parallel processing approach.

1.4 Composition as a Recursive Process

Expressions are combined to form more complex expressions at various levels of grammatical organisation. When two expressions are combined by means of a syntactic relation, they constitute a particular level of grammatical complexity. For instance, "Ann" can be combined with the verbal expression "is loading", by means of the subject relation, to form the complex expression "Ann is loading". Then, this complex expression may be combined with "the books", by means of the direct object relation, to form "Ann is loading the books", and so on. Each binary combination constitutes a particular level of grammatical organisation.

In the semantic space, organisation level changes correspond to the recursive application of the composition operation. For instance, when combining "Ann is loading" with "the books", the compositional operation denoted by the direct object relation is applied to the result of the previous processed operation, which is denoted by the subject relation. That means that each compositional operation is applied on the meaning that has already been constructed by the semantic processing of the previous combined expressions. Meaning is then incrementally constructed by the successive and recursive application of compositional operations.

Such an incremental conception of meaning construction can be related to works in Dynamic Logic [12], Discourse Representation Theory [13], and Semantics Situations [1]. In these theoretical works, the construction of meaning is situated at the discourse level. More specifically, they consider that meaning is constructed at the same time than discourse information is processed. Meaning construction relies on the fact that words are following each other in the discourse, respecting the order imposed by temporal linearity. Meaning is not longer a static object, independent from the comprehension process in context. Meaning does not exist out of time and out of discursive unfolding. It changes itself the discourse.

In a recursive and incremental semantic processing, the sense resulting from the previous processed expressions constrains the sense construction of the expressions to be processed. Consequently, semantic composition must work in a recursive and incremental way.

1.5 Organisation of the paper

The remainder of this paper is organised as follows. In the next section, we analyse the internal entities and operations constituting predication structures. It is argued that relational expressions (i.e., verbs, adjectives, etc.) cannot be semantically defined as predicative structures containing the compositional potentialities of the sentences. Special attention will be paid to the problems arising when compositionality is associated with the predicative structure of verbs. In section 3, we focus on a particular element of predication structures:

the assignment of an entity to a predicative role. Such an internal operation is described as a particular case of binary predication. In section 4, role assignment operations are considered as the semantic devices driving semantic composition. The fact of considering role assignments as compositional operations relies on four semantic assumptions: first, role assignments represent the semantic content of syntactic relations, which are the combinatory objects at the grammatical level. Second, in order to specify and elaborate the semantic content of role assignments, parallel processing of both lexical and syntactic information is needed. Third, role assignments activate the lexical disambiguating process, which is called co-composition. Fourth, the meaning construction of the more complex expressions is reached by the recursive application of role assignment operations. Finally, in section 5, some ideas are addressed to characterise the logic types organising the interpretative semantic space.

2 Predication Structures and Formal Semantics

2.1 Analysis of Predication

Some Formal Semantic approaches provides an accurate analysis of the notion of predication by enumerating the main entities and internal operations constituting predicative structures [5, 2]. A predication is defined as a set of objects and operations working on these objects. Among the constituents of a predicative structure, we will retain the following:

- a predicate ;

- the predicative roles ;
- the assignments of entities to the predicative roles ;
- a relation of adequacy.

Hence, a predicative structure is constituted by a predicate, the set of specific roles associated to the predicate, the assignments of external entities to those roles, and then the adequacy relation relating the predicate to its conceptually adequate assignments. The association between a predicate and its roles is perceived as the predicate's argument structure. Assignments of entities to roles represent the process of saturating the argument structure. The entities assigned to the predicate's roles become the predicate's arguments. Finally, adequacy can be considered as the set of conceptual constraints allowing only *adequate* entities to be assigned to the predicate's roles. That is, adequacy can be viewed as the set of selectional restrictions imposed on the assigned entities.

For example, consider the predication illustrated in 1, constituted by a 3-place argument structure and 3 adequate role assignments. On the one hand, the argument structure relates the predicate *load* to three roles (such as *agent, theme*, and *location*). On the other hand, the adequate assignments consist in associating three entities (e.g., *ann, books, truck*) to those predicative roles.

$$[\lambda x \lambda y \lambda z(load, x^{agent} y^{theme} z^{loc})] \left\{ \begin{array}{c} ann^{agent} \\ books^{theme} \\ truck^{loc} \end{array} \right\} \tag{1}$$

The argument structure is represented as a λ-expression, while the adequate assignments are noted as a list of arguments enclosed in curly braces. The act of predication may be described as the application of the argument structure to the adequate assignments. In order to simplify the analysis, neither the semantic nature of the parameters *x, y, z*, nor the λ-abstraction operations on those parameters will be analysed here.

2.2 Semantic Denotation of Relational Expressions

Most of work on formal semantics associates argument structures with the denotation of relational expressions. Relational expressions, such as verbs and adjectives, provide subcategorisation frames to their potential arguments. According to the Projection Principle, argument structures are projected from the lexicon, in that they observe the subcategorisation properties of relational expressions [20]. Each argument structure represents a particular subcategorisation frame. That means that relational expressions carry to a certain extent the compositional properties specifying how linguistic expressions should be combined.

Consider the verb "to load". As has been said, this verb is related to, at least, two different meanings: *bringing something to a location* and *modifying a location with something*. According to most formal semantic approaches, each verb meaning represents a particular argument structure.

$$[\lambda x \lambda y \lambda z (load\_bring, x^{agent} y^{theme} z^{loc})] \tag{2}$$

$$[\lambda x \lambda y \lambda z(load\_modify, x^{agent} y^{pacient} z^{instr})] \tag{3}$$

The argument structure illustrated in 2 represents one of the senses of "load": *bringing something to a place.* It is that structure that is involved to interpret an expression such as “Jean is loading the books into the truck”. In addition, one also needs to apply it to the three adequate role assignments illustrated in 4. The result of such an application could be either a truth value, a situation, a mental space, a propositional content, or whatever sentence content required by the current formal theory.

$$\left\{ \begin{array}{c} ann^{agent} \\ books^{theme} \\ truck^{loc} \end{array} \right\} \tag{4}$$

The argument structure illustrated in 3, on the other hand, represents the other sense of the verb: *modifying a location with something.* It is that structure that we need to interpret alternate expressions like “Jean is loading the truck with books”. For that argument structure, we cannot use the role assignments of 4. Instead, the adequate vassignments could be the list represented in 5.

$$\left\{ \begin{array}{c} ann^{agent} \\ truck^{patient} \\ books^{instr} \end{array} \right\} \tag{5}$$

Each verb’s meaning is then defined as a particular argument structure. Each argument structure contains the information about the compositional way in which expressions are combined to elaborate the meaning of the whole sentence. Yet, the fact of defining lexical structures of verbs as compositional devices leads to a too much rigid conception of meaning construction. We will show in the following paragraph some problems arising by this misleading conception of composition.

2.3 Some Problems

The main problem arising when the compositional mechanism is integrated into the lexical structure of verbs (or whatever relational expression) is the impossibility to account for the co-compositional device. Indeed, in that conception of compositionality, the meaning's verb must be disambiguated, not at the same time that it is combined with its arguments, but before the compositional process itself. Hence, the compositional process relating the arguments to the verb is only possible once the verb's sense has been disambiguated in a previous semantic analysis. In other words, the disambiguation of the verb's meaning must be achieved in a previous stage to the process of semantic composition.

This problem shows that most formal semantics frameworks provide a conception of composition that does not allow to model our notion of dynamic co-composition. That is, composition in formal semantics does not account for the fact that the verb both disambiguates the meaning of its arguments and is disambiguated by them. In formal semantics, disambiguation of verb's sense must take precedence over the mechanism of composition.

Such compositional ideas are also assumed by linguistic frameworks based on lexicalised grammars (Combinatory Categorial Grammars, Lexical Functional Grammar, Tree-Adjoining Grammars, etc.). In those grammars, each lexical meaning (e.g., the meaning *bringing something to a location* of the verb "to load") is associated with a particular syntactic construction. Syntactic composition, thus, depends on the information contained in the specific sense of lexical items. In these approaches, the way in which a specific verb sense is selected would be a problem addressed to other linguistic modules (namely semantic and pragmatic modules), independent of the syntactic level and, then, of the combinatorial device.

In our framework, however, compositional information will not be exclusively related to specific lexical information, such as the verb's meaning, but to the syntactic relationships themselves. To be more precise, we will analyse the dependency relations – e.g., subject, direct object, nominal modifier, etc. – as compositional operations leading verb or adjective expressions to be combined with their arguments. In the following section, we will introduce the semantic representation of such syntactic relations.

3 Representing Role Assignments as Predications

Our aim is that semantic composition lies on the assignment operations of arguments to predicative roles. We consider that co-composition and then mutual disambiguation are processes that should be implemented at the level of the assignment operation.

Intuitively, the adequate assignment operation of an entity to a predicate's role can be conceived as the process of combining the predicate and the assigned entity, that is, the process of associating the predicate to one of its arguments. This process results in a more specific entity, which integrates in a blended structure some of the lexical information carried by the combined entities.

When connecting an argument to its predicate, the role itself can be perceived as a particular case of binary predicate, namely the 2-place relation connecting the assigned entity to its predicate. The fact of defining a role as a particular case of predicate leads us to define role assignment as a particular case of predication structure.

Consider, for instance, the assignment of *book* to the *theme* role of the argument structure illustrated above in 2. Given that the *theme* role is a binary predicate, the role assignment showed in 6represents a predication relating *load* and *book* to the argument structure of *theme.*

$$[\lambda x \lambda y(theme, x^{\downarrow} y^{\uparrow})] \left\{ \begin{array}{c} load^{\downarrow} \\ \\ book^{\uparrow} \end{array} \right\} \tag{6}$$

The argument structure of the binary predicate *theme* represents, more precisely, a "whole-part" relation between the whole event of loading (*load*) and one of its internal participants: *book.* In that mereological argument structure, *load* plays the role of $whole^{\downarrow}$, while *book* plays the role of $part(icipant^{\uparrow}$. Concerning the notation of 6, the downward arrow marks the whole argument position of the mereological predication. At the opposite, the upward arrow marks the participant argument position.

The role assignments to the *theme* argument structure represent the associations of *load* and *book* to the parameterised arguments: both $x^{\downarrow}$ and $y^{\uparrow}$ internal parameters.[1] These internal arguments characterise the binary argument structure of *theme*. As we will show later, that binary argument structure contains some of the properties involved in dynamic co-composition. In other words, we situate the dynamic compositional mechanism at the level of the predicative structures of roles.

Note that Davidson also defined predicative roles as binary relations. Yet, he used them, not to describe the compositional mechanism itself, but to characterise the predicative structure of verbs. It is claimed here that verbal roles do not represent any more passive markers of predicative constructions, nor mere lexical entailments of verbal predicates [6]. Rather, they are viewed as dynamic operations used for the elaboration of the complex expressions' meaning. In the following, we will show how roles activate and drive co-composionality so as to reach lexical disambiguation.

[1] Note that these role assignments are not situated at the same logical level that the assignment of *book*to the *theme* role. The latter is a role assignment with regard to the argument structure of loading. $load^{\downarrow}$ and $book^{\uparrow}$, though, are role assignments with regard to the argument structure of the binary *theme* relation [9].

4 Roles and Compositionality

4.1 Syntactic Relations Viewed as Role Assignments

Syntactic dependency relations, such as subject, direct object, nominal modifier, or verbal modifier, may be viewed as binary operations. They combine two expressions with the aim of building a more complex expression at a higher level of grammatical organisation. In the semantic space, the dependency relation between two expressions represents the whole- part connection relating a predicate with one of its arguments. Hence, it denotes a role assignment.

In the previous section, role assignments have been considered as the predicative structures driving semantic composition. Now, it is assumed that role assignments are the conceptual denotation of syntactic relations. In other words, syntactic relations are endowed with a specific semantic content: the binary predicative structures that model the processes of role assignment.

It follows that syntactic relations activate and drive the semantic process of co-composition. This way, two polysemic expressions can be disambiguated when they are syntactically related by a dependency relationship. The complex expression obtained by co-composition denotes a more elaborate semantic entity which contains semantic facets shared by the constituent expressions. Co-composition, then, could be defined as a particular case of blending process. Indeed, the semantic process denoted by a syntactic relation is similar to the Fauconnier and Turner's *blending operation*, which allows two input spaces to be blended in a composite space [7]. Like blending operations, a syntactic relation works on two input semantic entities to produce a higher order semantic entity, containing information from both inputs.

Furthermore, thematic roles such as *theme, agent, instrument, location*, will be considered here as semantically determined whole-part relationships between verbal predicates and their arguments. A specific thematic role is obtained only once the co-composition process has been achieved. This way, syntactic relations, like subject or direct object, result in more specific thematic roles if the combined expressions have been correctly disambiguated during the co-composition process. For example, consider that the polysemic verb "to drive" refers to two different events: both the event of controlling a vehicle ("driving my car") and the event of producing a way ("driving a tunnel"). The direct object relation becomes a specific thematic role, either *mobile* or *produced*, only if co-composition has already disambiguated the polysemic sense of the verb. In order to know which is the current thematic role elaborating the direct object of "to drive", it is necessary to access previously to the specific verb sense. In addition, in order to elaborate the verb sense, it is also necessary to access to the specific sense of its nominal argument. A specific thematic role, thus, is obtained on the basis of two types of information: information about the particular syntactic relation linking the verbal to the nominal expression, and information about the lexical content of both expressions.

4.2 Composition and Parallel Processing

The model of linguistic composition introduced here uses at the same time morphosyntactic and lexical information. Meaning construction is viewed as a parallel processing of morphosyntactic markers and lexical content. From this viewpoint, semantic interpretation does not follows the syntactic analysis of the sentence. Rather, it is claimed that semantic interpretation consists in processing in parallel both morphosyntactic and lexical information. More precisely, the meaning construction of a complex expression is elaborated by using the following linguistic markers:

- the lexical content of the two combined expressions ;
- the morphosyntactic information that characterises the type of syntactic dependence relating the two combined expressions. That information contributes to select a particular syntactic relation, namely subject, direct object, indirect object, nominal modifier, verbal modifier, etc.

In our approach, lexical and morphosyntactic information cooperate together to build the meaning of complex expressions. Meaning construction is then viewed as a parallel linguistic processing, where lexical and morphosyntactic clues are treated and interpreted at the same time. There is no more a boundary between syntactic and semantic structures; on the contrary, we consider that syntax is a particular element of the semantic module. Unlike generative approaches, syntax becomes here a subdomain of semantics. Indeed, syntax is no longer conceived as the output of a particular linguistic analysis but rather as a sort of conceptual constraint used for the meaning construction of complex expressions and sentences. Syntactic information appears in our approach as a structured set of abstract semantic properties that work with lexical information to permit the understanding of complex expressions.

Let us give an example: the combination between “is loading” and “the books” to build the more complex expression “is loading the books”. The linguistic elements taking part in the compositional process are the following:

- the lexical information carried by “load” (which is the lexical head of “is loading”) ;
- the lexical information carried by “book” (which is the lexical head of “the books”) ;
- the morphosyntactic information characterising the direct object dependency relating the two expressions.[2]

4.2.1 Underspecified Lexical Information

As has been said in section 2.2, the polysemic lexical items “load” and “book” convey some sort of conceptual underspecification.

On the one hand, the verbal item “load” may refer to either the event of bringing something to a location (“Ann loaded the hay into the truck”) or the event of modifying a location with something (”Ann loaded the truck with the

[2]Note that the aspecto-temporal information related to the verb as well as the number and referential information related to the nominal are not taken into account in our compositional analysis.

hay"). On the other hand, "book" may denote either a solid physical object ("put the book on the table"), or an informative content ("naive book"). Given that the principles organising lexical meaning have not been considered in this article, we will not attempt to structure the lexical information constituting those polysemic senses. For the purpose of this paper, we consider only the following information:

- the entity *load* underspecifies two particular ontological events: *load_bring* and *load_modify* ;
- the entity *book* underspecifies two particular ontological objects: *book_phy* and *book_inf*.

4.2.2 Morphosyntactic Information

Morphosyntactic information leads us to characterise the direct object relation linking the two linguistic expressions. This syntactic relation denotes in the semantic space the assignment of *book* to a particular thematic role of *load*. As has been said, such a role assignment can be represented as a binary predication relating the nominal sense (i.e., *book*) to the verbal sense, (*load*), by means of a binary predicate, noted *dobject*. The argument structure associated to this predicate is illustrated in 7.

$$[\lambda x \lambda y(dobject, x^{\downarrow} y^{\uparrow})] \tag{7}$$

Such an argument structure represents the semantic content denoted by the direct object syntactic relation.

4.2.3 Morphosyntactic and Lexical Processing

Lexical and morphosyntactic information are processed in parallel in order to build the predication illustrated in 8.

$$[\lambda x \lambda y(dobject, x^{\downarrow} y^{\uparrow})] \left\{ \begin{array}{c} load^{\downarrow} \\ \\ book^{\uparrow} \end{array} \right\} \tag{8}$$

The two underspecified entities, *book* and *load*, fill the whole-part roles of the *dobject* predicate. This semantic predication is the result of analysing the lexical and morphosyntactic information directly available when processing the expression "is loading the books".

4.3 Dynamic Co-composition

As has been said, each syntactic relation denotes the process of blending two entities into a higher order unit. The blended entity contains some informative aspects of the related entities. In most cases, even though the lexical information of the combined entities is polysemic, the blending process itself restricts and disambiguates them in order to construct a more specific and, then, less polysemic blended entity. Hence, the related entities mutually restrict and determine their polysemic information. We use the term *dynamic co-composition* to refer to the mutual lexical restrictions driven by syntactic dependence relations.

Let's take again the expression "is loading the books". Co-composition is activated when the two underspecified entities, *load* and *book*, are applied to the internal roles of the *dobject* predicate. Co- composition works as follows.

On the one hand, *load* selects one of the specific senses of *book*. More precisely, it selects the sense referring to the physical book's facet: *book_phy*. Indeed, that sense shares lexical information with the general content of *load*, since it actually refers to some physical event. So, according to the physical information contained in *load*, *book_phy* is considered as the adequate sense of *book*.

On the other hand, *book_phy* selects one of the specific senses of *load*. More precisely, it selects the sense referring to the event of bringing something to a location: *load_bring*. Indeed, *book_phy* may fill the ontological conditions of the *theme* role constituting the event of bringing, but it cannot be adequate to the *patient* role of the event of modifying a location with something. Intuitively, a book cannot be considered as a spatial location likely to be loaded. Like any physical and moveable object, *book_phy* only can fill the conditions of the *theme* role of *load_bring*. As a consequence, the *theme* role elaborates the binary predicate *dobject* relating the two entities. For more details, see [10], where co-composition is described as an algorithm working on lexical structures.

The syntactic relation combining the polysemic expressions "load" and "books" finally results in a specific thematic relation, *theme*, relating a specific event, *load_bring*, with one specific participant, *book_phy*. Since thematic roles are taken here as conceptual elaborate syntactic relations, we should consider that both syntactic and thematic relations are semantic objects situated at different levels of conceptual elaboration. Syntactic relations are undetermined semantic objects perceived as more schematic relations than their conceptual instantiations: thematic roles. The semantic operations leading syntactic relations to be instantiated as thematic roles should not be considered as syntax-semantic mappings (namely “argument selection” or “linking rules”) based on the Projection Principle. According to the linguistic approaches based on this Principle, syntactic relations are not semantic objects ; syntactic relations and semantic roles are situated at different linguistic levels. By contrast, we consider the so-called syntax- semantics mapping as a process of conceptual instantiation at the semantic level.

In short, co-composition permits to disambiguate, not only the polysemic expressions “load” and “books”, but also the undetermined direct object relation. This schematic relation is coerced to refer to a specific event role: *theme*. The process of disambiguating two related lexical items is then associated with the process of specifying the syntactic relation combining them.

4.4 Incremental Sense Construction

Co-composition results in a blended structure which contains more specific information than the underspecified entities denoted by the related expressions. The blended structure represents a complex entity that may take part in further compositional mechanisms at higher order levels of grammatical organisation.

For example, consider the process of combining “is loading” with the noun “Ann” by means of the subject relation. This combination results in the blended entity denoted by “Ann is loading”. This entity contains the agentive relation between the specific individual denoted by "Ann" and the still underspecified event denoted by "load". Note that "Ann", even though is not able to semantic disambiguate the verb meaning, leads the subject relation to be elaborated as a specific thematic role: *agent*. Then, the blended entity may take part in further compositional processes. It can be combined, for instance, with the nominal "the books" by means of the direct object relation. That results in a higher order blended entity conceived as an event where the individual Ann is bringing the books to an underspecified location. Further compositional process could specify that location. This way, when "Ann is loading the books" is combined with "the lorry" by means of the prepositional complement introduced by the preposition "into", the *location* role is coerced to be filled by the specific entity denoted by "lorry".

Composition is viewed here as an incremental and recursive semantic process that works at various levels of grammatical organisation. The meaning resulting from the lower levels constrains the meaning of the higher levels. That is, the sense of the previously processed expressions takes part in the construction of the sense of the expressions that will be processed later.

Such an incremental and recursive construction does not obey the strict order imposed by the lexical subcategorisation of verbs. The number of verbal arguments and the order in which they are integrated to the verbal frame is not *a priori* established; it is rather flexible and adaptable to the particular conditions imposed by the syntactic markers of the sentence. This compositional flexibility seems to be in opposition to the rigidity of the type system that considers verbs as n-place functors and nominals as the functor arguments. Some intuitions are addressing in the following section with the aim of defining a type system suitable to account for the incremental and flexible construction of complex semantic entities.

5 Semantic Types

In the previous sections, we have essentially distinguished two types of linguistic units: lexical expressions (i.e., expressions constituted by one or more lexical items) and syntactic relations combining them.

Lexical expressions refers to the individual entities of a world-based ontology: events, physical objects, artefacts, states, natural objects, properties, humans, colours, etc. Consequently, all sorts of expressions – i.e., nominals, verbal phrases, adjectives, etc. – denote individual entities. They belong to the same basic logic type, noted $< e >$, regardless of the complexity of their ontological nature. Unlike the set-theoretical model, semantic space is not made up of atoms, on the one hand, and abstract (1- and n- place) properties or attributes, on the other. Rather, we consider that all sorts of lexical expressions refer to individual entities, which can be more or less complex from the ontological viewpoint. Indeed, even though individual entities can be lexically characterised at different levels of ontological complexity, they are logically categorised at the same basic level [21, 24]. For instance, "the books", "Ann", "the lorry", "is loading", "Ann is loading", "Ann is loading the books", "is loading the books", "is loading into the lorry", "Ann is loading the books into the lorry", etc. denote all of them individual entities. They are situated at the lowest logic level, even if they can be more or less complex from the ontological viewpoint. The semantic space is not then organised in atomistic terms. We do not postulate a lowest level of basic atoms from out of which successively higher logic levels of complex entities (n-1 place properties) are constructed. We do postulate that entities are situated, not at successive logical levels of organisation, but at countless levels of ontological complexity.

At the opposite, syntactic relations denote, not individual entities, but operations that work on individual entities to construct entities at various levels of ontological complexity. Syntactic relations denote objects of type $< e, < e, e >>$. They are functional operations taking as input a pair of individual entities corresponding to the two related lexical expressions, to produce a new individual entity which represents the denotation of the complex expression. This way, when combining "Ann is loading" with "the books", the compositional operation denoted by the direct object relation takes as argument two entities of type $< e >$, in particular, the entities denoted by "Ann is loading" and "the books". This operation produces a new entity of type $< e >$, which represents the denotation of the expression "Ann is loading the books". In our incremental approach, this new entity can be the input of further compositional operations. As a result, more elaborate entities are produced: for instance, the entity denoted by "Ann is loading the books into the lorry".

Among the entities of type $< e >$, it would be possible to distinguish various specific subsorts. The entities denoted by finite verbs or adjectives are not combined in the same way than the entities denoted by nominals. In the compositional process, i.e., in the binary predications representing role assignments, the entities denoted by relational expressions (finite verbs, adjectives,...) are associated with the $x^{\downarrow}$ role place (the *whole* role) of the binary predication, whereas the entities denoted by nominals are associated with the $y^{\uparrow}$ role (the *participant* role. These sorts of entities are then differentiated with regard to their combinatorial potentialities. Such ideas were accurately elaborated and expanded in previous work [9]. More precisely, we compared the couple $x^{\downarrow}$ / $y^{\uparrow}$ with the categorial couple "relation / thing" in Cognitive Grammar [14, 15], as well as with the distinction of the two operations "functionalisation / nominalisation" in Property Theory [4].

Furthermore, splitting entities of type $< e >$ into two separate subsorts leads us to distinguish among various sorts of compositional operations as well. In particular, we could separate the operations denoted by verbal complements from the operations denoted by nominal modifiers [9].

6 Conclusion

As recent work on linguistics, we assumed that syntactic relations are endowed with semantic meaning. We also considered that these meaningful objects represent the basic scaffolding of semantic composition. In addition, we also introduced a number of hypotheses about how semantic composition should be characterised. The main hypotheses assumed in this paper were the following:

- Compositional operations denoted by syntactic structures are binary predications representing the basic process of assigning an entity to a predicative role.

- A role assignment is a compositional mechanism that takes as input two lexical structures and results in a more specific lexical structure. That mechanism of specification consists of a particular blending process, called dynamic co-composition.

- We opposed this conception of compositionality to the frameworks based on lexicalised grammars (Lexical Functional Grammar, Combinatory Categorial Grammars, Tree-Adjoining Grammars, etc.). In those grammars, since each lexical meaning of an expression is associated with a particular subcategorisation frame, composition is mainly driven by the meaning of lexical items. Our approach, though, considers lexical meaning as merely semantic restrictions providing some of the constraints on the semantic compositional mechanism. Semantic composition is no longer exclusively dependent on lexical meaning. Lexical information interacts with syntactic information in order to construct composite semantic structures, which represent the complex expressions' meaning.

- Finally, contrary to currently prevalent view on set-theoretical approaches, we consider that the denotations of nominals, verbal phrases, or adjectives belong to the same basic semantic type: all of them are individual entities.

These entities are combined and merged at different levels of ontological complexity using other type of semantic entities: the binary operations denoted by relations of syntactic dependencies. In such a semantic model, verbs are not any more n-place functions, but individual entities that can be combined, at various levels of syntactic organisation, with other entities representing their internal participants.

We think that the assumptions about compositionality we have outlined in this paper could be explored in further works with the aim of testing their logical and linguistic potentialities.

References

[1] Barwise, J.: Recent Developments in Situation Semantics. Language and Artificial Intelligence. Berlin: Springer-Verlag, (1987)

[2] Chambreuil, M., Ben Gharbia A., Bernigot C., Gamallo P., Panissod C., Reinberger M-L.: Sémantiques. Paris:Hermès, (1998)

[3] Chierchia, G.: Formal Semantics and the Grammar of Predication. Linguistic Inquiry **16**(3), (1985) 417–443

[4] Chierchia, G. and R. Turner: Semantics and Property Theory. Linguistics and Philosophy. **11**(3), (1988) 261–302

[5] Cooper, R. and al.: FraCas Project, Framework for Computational Semantics, Deliverables D7, D8, D9, (1994)

[6] Dowty, D.R.: On the semantic content of the notion of Thematic Role. In: Properties, Types and Meaning, vol II. Kluwer Academic Publishers, (1989) 69-130

[7] Fauconnier, G. and Turner M.: Conceptual Integration Networks. Cognitive Science **22**(2), (1998) 133–187

[8] Frazier, L.: Against lexical generation of syntax, In: William Marsllen-Wilson, (ed.): Lexical representation and Process, Massachusetts, (1989) 505– 528

[9] Gamallo, P.: Construction conceptuelle d'expressions complexes : traitement de la combinaison nom-adjecif. Ph D. in Blaise Pascal University, France, (1998)

[10] Gamallo P., Reinberger M-L.: Modelización del proceso de combinación de estructuras léxicas". Procesamiento del Lenguaje Natural **25**, (1999) 83–91

[11] Goldberg, A.: Constructions: A Construction Grammar Approach to Argument Structure. University of Chicago Press, (1995)

[12] Groenendijk, J., Stokhof M.: Dynamic Montague Grammar. In: Stokhof, Groenendijk and Beaver, (eds.) (1991)

[13] Kamp H. and Reyle U.: From Disocurse to Logic: Introduction to Modeltheoretic Semantics of Natural Language. Formal Logic and Discourse Representation Theory. Kluwer Academic Publishers, (1993)

[14] Langacker, R.W.: Foundations of Cognitive Grammar, vol. I, Theoretical Prerequisites. Stanford: Standford University Press, (1987)

[15] Langacker, R.W.: Foundations of Cognitive Grammar, vol. II, Descriptive Applications. Stanford: Standford University Press, (1991)

[16] McRae, K., Ferreti T.R., Amoyte L.: Thematic Roles as Verb-specific Concepts. In M. C. MacDonald (ed.). Lexical Representations and Sentence Processing, (1997) 137–176

[17] Mineur, A., Buitelaar P.: A compositional treatment of polysemous arguments in Categorial Grammar. In: K. Van Deemter and S. Peters (eds.). Semantic Ambiguity and Underspecification. CSLI, Chigaco University Press, (1996)

[18] Pustejovsky, J.: The Generative Lexicon. Cambridge: MIT Press (1995)

[19] Ramsay, A.: The Co-opertative Lexicon. In: Harry Bunt, Reinhard Muskens, Gerrit Rentier, (eds.), Proceedings of International Workshop on Computational Semantics, (1994)

[20] Robert, J.P., Ingria P, Leland M.G..: Adjectives, nominals and the statuts of arguments. In James Pustejovsky, (ed.). Semantics and the Lexicon. Kluwer Academic Publishers, (1993) 107–127

[21] Smith, B.: Basic Concetps of Formal Ontology. In: N. Guarino (ed.). Formal Ontology in Information Systems. IOS Press (1998)

[22] Tanenhaus, M.K., Carlson G.N.: Lexical structure and language comprehension. In William Marsllen-Wilson, (ed.). Lexical representation and Process. Massachusetts, (1989) 530–561

[23] Truswell, J.C., Tanenhaus M.K., Garnsey S.M.: Semantic Influences on Parsing: Use of Thematic Role Information in Syntactic Ambiguity Resolution. Journal of Memory and Language **33**, (1994) pp. 285–318

[24] Varzi, A.C.: Parts, wholes and part-whole relations: the prospects of mereotopology. Data and Knowlodge Engineering **20**, (1996), 259–286

[25] Victorri, B., Fuch, C.: La polysémie: construction dynamique du sens, Paris: Hermes (1996)