A coordination treatment based on multiple and disjunctive subcategorization

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Abstract

This paper proposes a modelization of the coordination within the framework of Head-driven Phrase Structure Grammar (HPSG), based on concepts of functor, arguments and subcategorization requirements. It enables coordination of more than one constituent as well as of different categories. This modelization lies on a lexicalization of the coordination principle and two generalizations of the notion of syntactic category. First, the coordination of different categories requires *composite categories*: disjunctive for subcategorization requirement, conjunctive for the coordinate structures. Second, the coordination of more than one constituent assumes that a sequence of constituents is represented as a *tuple*.

1 Introduction

This paper proposes a modelization of the coordination within the framework of Head-driven Phrase Structure Grammar (HPSG), based on concepts of functor, arguments and subcategorization requirements. It enables coordination of more than one constituent as well as of different categories. This modelization lies on two main ideas. First, the coordination of different categories requires *composite categories*: disjunctive for subcategorization requirement, conjunctive for the coordinate structures. Second, the coordination of more than one constituent assumes that a sequence of constituents is represented as a *tuple* of categories.

The paper is organized as follows. The section 2 is devoted to present the concepts we need through typical examples. We formalize our concepts in section 3. We end by some comments and residual problems.

The french coordination with *et* serves throughout the paper as an example.

2 Coordination: subcategorization requirements, functors and arguments

The classical typology of coordination, i.e. coordinations of the same category, of different categories and of more than one constituent, hides the regularity of the phenomenon as it focuses on concepts of constituent and syntactic category. Since this regularity is functional, it would be more relevant to focus on concepts of functor, arguments and subcategorization requirements. Two roles will therefore be distinguished: the role of functor and that of argument. The *functors* are first the lexical heads that subcategorize

complements and then any expression that contains a functor. The *arguments* are the complements specified by the heads. An element can be both functor and argument. In the following sentence:

(1) Je pense *offrir* et *recevoir* des cadeaux.
(I expect to offer and receive gifts)

offrir and recevoir are arguments with respect to *penser*(expect) and functors with respect to *des cadeaux* (gifts). The previous sentence exemplifies a coordination of functors and arguments at the same time.

In this paper, we claim that elements can be coordinated if they satisfy the same (simple or multiple) subcategorization requirement and that they impose compatible subcategorization requirements. The reader may find in [3] an exhaustive description of coordination problems. We give hereafter only useful examples to understand the paper.

2.1 Arguments satisfying a requirement

A subcategorization requirement constraints the relation between a head and its arguments: it is called simple when the lexical head subcategorizes a single argument *(to know something)*, multiple when the lexical head subcategorizes several arguments *(to ask somebody something)*. In both cases, the arguments may be realized by different categories. For example the object required by *savoir (to know)* may be either an NP or a Completive (disjunctive requirement), or the coordination of the two:

(3) Je sais son âge / qu'elle est venue ici / son âge et qu'elle est venue ici.
(I know her age / that she came here / her age and that she came here).

To the extent that disjunction only appears on the level of specification of an argument, a multiple requirement is a set[1] of simple requirements and is satisfied either :

- by a series of arguments which satisfy respectively that set of simple requirements:

  (4) Je demande à Pierre son vélo / d'où il vient.
  (I ask Peter for his bike / where he comes from)

  (5) Je demande à Pierre son vélo et sa canne à pêche.
  (I ask Peter for his bike and his fishing rod)

  (6) Je demande à Pierre son vélo et d'où il vient.
  (I ask Peter for his bike and where he comes from)

- or by the coordination of a series of this kind:

  (7) Je demande à Pierre son vélo et à Marie sa canne à pêche.
  (I ask Peter for his bike and Mary for her fishing rod)

  (7') Je demande son vélo à Pierre et à Marie sa canne à pêche.

  (8) Je demande à Pierre son vélo et à Marie sa canne à pêche et d'où elle vient
  (I ask Peter for his bike and Mary her fishing rod and where she comes from)

2.2 Functors: inheritance and compatibility of requirements

The coordination of functors needs that their requirements are compatible. As shown in the following coordinations, functors may be

- unsaturated lexical heads:

(9) Jean *achète* et *répare* des vélos.
(John *buys* and *repairs* bikes)

- partially saturated:

(10) *Jacques aime* et *Marie déteste* ces spots lumineux.
(*Jack loves* and *Mary hates* these spotlights)

- or composed:

(11) Jacques *répare* et *prétend détester* ces spots lumineux.
(Jack *repairs* and *claims to hate* these spotlights)

In order to distinguish the different composed functors, we call functor-functor the first functor (*claims*), functor-argument the second (*to hate*), etc. The resultant functor may inherit the unsatisfied subcategorization of the functor-argument if the functor-functor is saturated and the functor-argument is its last argument. Compare (12) with (13-14):

(12) *Marie prétend avoir offert* et *Jane prétend avoir vendu* ces spots lumineux à Paul.
(*Mary claims to have given* and *Jane claims to have sold* these spotlights to Paul)

(13) * *Marie dit qu'elle déteste à Jacques* et *Jane dit qu'elle aime à Paul* ces spots lumineux.
(*Mary says that she hates to Jack* and *Jane says that she likes to Paul* these spotlights)

(14) * *Marie dit qu'elle déteste* et *Jane dit qu'elle aime* ces spots lumineux à Paul.
(*Mary says that she hates* and *Jane says that she likes* these spotlights to Paul)

In all cases, when two functors are coordinated, they share their arguments: there must therefore exist at least one possibility of satisfying them simultaneously; the specification imposed by their coordination is their common specifications which the com mon arguments must satisfy otherwise the coordination is agrammatical:

* *Je dépends* et *j'obéis* à mon frère. (*I depend* and *I obey* my brother)

2.3 Satisfying and imposing requirements

Our coordination criterion is the twofold one:

The conjuncts must *satisfy* the same simple or multiple subcategorization requirements and *impose* compatible subcategorization requirements.

Part one concerns arguments, part two, functors and both are necessary since an entity can be both functor and argument as illustrated in the following utterrances where conjuncts are:

- simple heads:

(15) Je pense *offrir* et *recevoir* des cadeaux.
(I expect *to offer* and *to receive* gifts)

- partially saturated:

(17) Je pense *recevoir de Jean* et *offrir à Pierre* du caviar de Russie.
(I expect *to receive from John* and *to offer to Peter* Russian caviar)

- with different structures:

(18) Je pense *offrir* et *que je recevrai* des cadeaux.
(I think *to offer* and *that I will receive* gifts)

(19) Je recommande à Pierre *la lecture* et *qu'il s'inspire* de la Bible.
(I recommend to Peter *the lecture* and *that he inspires himself* of the Bible)

- partially saturated with different structures:

(21) Je pense *recevoir de Jean* et *que j'offrirai à Pierre* du caviar de Russie.
(I think *to receive from John* and *that I will offer to Peter* Russian caviar)

- of more than one constituent, the last one unsaturated:

(20) Je recommande *à Pierre de lire* et *à Marie d'acheter* la Bible.
(I recommend *to Peter to read* and *to Mary to buy* the Bible)

The notions of functor and argument induce a new typology of coordinations which covers the classical typology:

coordin. of	**same categories**	**different categories**	**more than one constituent**
arguments	Je demande à Pierre *son vélo* et *sa canne à pêche*	Elle dit *son nom* et *qu'on l'appelait Bibi*	Je demande *à Pierre son vélo* et *à Marie sa canne à pêche*
		Je demande *à Pierre son vélo* et *à Marie d'où elle vient*	
functors	Jean *achète* et *répare* des vélos	* *offrir* et *que je recevrais* des cadeaux	*Jacques aime* et *Marie déteste* ces beaux spots lumineux
	fidèle et *dévoué* à sa femme	* *lis* et *par* les livres	*Jacques aime* et *Marie prétend détester* ces beaux spots lumineux
	il vit *par* et *dans* les livres	*achète* et *lis* des livres	
	Mon *collègue* et *ami* * Kim *préfère* et *promet* à Sandy de partir		
neither functor nor argument		*Jean* et *Marie*	
		Jean lit et *Marie joue*	
		**Jean lit* et *un vélo*	
arguments and functors	Je pense *donner* et *recevoir* des cadeaux	Je pense *offrir* et *que je recevrai* des cadeaux	Je pense *recevoir de Jean* et *offrir à Pierre* un vélo
		Je recommande à Pierre *la lecture* et *qu'il s'inspire* de la Bible	
		Je recommande *à Pierre la lecture* et *à Marie qu'elle s'inspire* de la Bible	

The formalization in section 3 takes care of all these situations.

3 Formalization in HPSG

The formalization of our twofold criterion needs to define satisfiability conditions of subcategorization requirements and compatibility of subcategorization requirements. Let us recall that in HPSG the feature *Synsem* contains both the semantic and syntactical information and that the value of subcategorization feature is a set (or list) of Synsem. In HPSG theory, the subcategorization principle covers such a treatment in case of non-disjunctive subcategorization. We extend here this principle in order to take care of disjunctive values.

3.1 Compatibility of subcategorization requirements

Definition 1 *The unification of two 1-requirements α and β is defined as follows:*
Let $\alpha = \{\bigvee_{i=1\ldots n} s_i\}$ and $\beta = \{\bigvee_{i=j\ldots m} t_j\}$, s_i and t_j are Synsem therefore: $\alpha \bigcup \beta = \bigvee_{i=1\ldots n, j=1\ldots m} s_i \bigvee t_j\}$

Definition 2 *The unification of two n-requirements[2] α and β is defined as follows:*
Let $\Phi = \{\alpha_i / i \in [1,n]\}$ and $\Psi = \{\beta_i / i \in [1,n]\}$ α_i and β_i are disjunctions of Synsem, therefore: $\Phi \bigcup \Psi = \{\alpha_i \bigcup \beta_{p[i]} / i \in [1,n]\}$ where p is a permutation on $[1,n]$.

The result of the unification of two n-requirements is therefore ambiguous. Two subcategorization requirements are compatible iff their unification succeeds.

3.2 Disjunctive and multiple satisfiability

Definition 3 *A subcategorization requirement of valence n or n-requirement is a set of n disjunctions of Synsem.*

Example 4 *demander (to ask):*[3]
$Subcat = \{ \quad [Synsem|Cat|[Part = NP]] \vee [Synsem|Cat|[Part = Compl]],$
$[Sysem|Cat|[Part = PP]]\}$
or in abbreviated form: $Subcat = \{NP \vee Compl, PP\}$.

Satisfiability conditions

(C1) A subcategorization 1-requirement is satisfied either by one of the disjuncts or by a coordination of disjuncts.

(C2) A subcategorization n-requirement is satisfied either by a sequence of n arguments such that each argument satisfies one and only one element of the requirement or by the coordination of such sequences.

If we want to capture coordinations of more than one constituent like (6,8) we need to compute both (C1) and (C2), hence extending [1]. We assume that the following coordinations have the following status:

(3) Je sais *son âge* et *qu'elle est venue ici* : $NP \wedge Compl$ [4]

(5) Je demande *à Pierre son vélo* et *à Marie sa canne à pêche* : $<PP,NP> \wedge <PP,NP>$

(6) Je demande *à Pierre son vélo* et *d'où il vient* : $<PP,NP \wedge Compl>$

(8) Je demande *à Pierre son vélo* et *à Marie d'où elle vient* : $<PP,NP> \wedge <PP,Compl>$

and we propose (as an extension of the present HPSG subcategorization principle) the general constraint (C1& C2) formalized as follows:

In a functor-arguments structure of the general following form:

$$\left[\begin{array}{l} Synsem|Cat|[Subcat = \Psi] \\ Branches \left[\begin{array}{l} B\text{-}Head|Synsem|Cat|[Subcat = \Phi \cup \Psi] \\ B\text{-}Comp = \Sigma \end{array}\right] \end{array}\right]$$

where $\Phi = \{\overbrace{S_{11} \vee \ldots \vee S_{1n_1}}^{\alpha_1}, \ldots, \overbrace{S_{p1} \vee \ldots \vee S_{pn_p}}^{\alpha_p}\}$ is a p-requirement, Ψ a requirement possibly empty, and $\Sigma =< C_1^1, \ldots, C_p^1 > \wedge \ldots \wedge < C_1^q, \ldots, C_p^q >$, a coordination of q tuples (if $q > 1$) or one tuple (if $q = 1$) of p composite Synsem $C_i^k = \bigwedge\{C_{im}^k / m \in [1, z_i^k]\}$,[5]

Σ satisfies ($\models$) Φ iff:

$\forall k \in [1, q], < C_1^k, \ldots, C_p^k > \models \Phi$ (each tuple of Σ satisfies Φ)

i.e.

$\forall i \in [1, p], \exists C_{p_k[i]}^k \models \alpha_i$ (each subcategorized argument α_i has one (and only one)[6] realization in the tuple)

i.e.

$\forall m \in [1, z_{p_k[i]}^k]$ (for each element of the composite Synsem $C_{p_k[i]}^k = \wedge\{C_{p_k[i],m}^k / m \in [1, z_{p_k[i]}^k]\}$

$\exists j \in [1, n_i]$ there is one disjunct of α_i

$/C_{p_k[i],m}^k \models S_{i_j}$ such as this disjunct legitimates the Synsem)

i.e.

$C_{p_k[i],m}^k \bigcup S_{i_j}$ (where $\bigcup$ is the usual unification between categories.)

The tuple $< S_1, \ldots, S_p >$ is defined below.

Let us mention that definitions and constraint given previously may be encoded in various ways, for example in some particular coordination rule schemata. We present in next section a lexicalized version following [5] that seems to us closer to HPSG methodology.

3.3 Lexicalization of the coordination rule

As subcategorization characterizes the individuality of a lexical unit, likewise the fact that the conjunction *et* requires two conjuncts is independent of the particular utterances in which it appears. It is therefore legitimate that the rule of coordination itself is encoded in the lexical entry of the conjunction *et*. The originality of [5] is to consider the conjunction as the head of the coordinated structure, not a lexical head but a functional head. Indeed he distinguishes among the HEAD features, the substantive features (noun, verb, adjective, preposi tion, agreement, case, tense, ...) which are called MAJOR features and the functional features (determinant, complementizer, ...) called MINOR features. This functional head subcategorizes two complements which are the conjuncts.

It is helpful to consider the conjunction as the head of the coordinated construction because the distribution of the conjuncts no longer has to be postulated in the grammar by a special rule of coordination: it stems simply from the specifications of the subcategorization of the conjunction. In [5] the sharing of arguments by the conjuncts stems from the *reentrancy* of the lexical entry of the conjunction, i.e. by the classical unification: the SUBCAT features of the conjuncts and of coordination as a whole share the same value marked [1] in the diagram below:

$$\left[\begin{array}{l} Synsem|Cat| \left[\begin{array}{l} Lex = +, \\ Head|[Minor = conj, Part = A], \\ Subcat = \left\{\begin{array}{l} [Synsem|Cat|[Head|[Part{=}A, Subcat{=}[1]]]], \\ [Synsem|Cat|[Head|[Part{=}A, Subcat{=}[1]]]], \\ [1] \end{array}\right\} \end{array}\right] \end{array}\right]$$

lexical entry of the conjunction "et " for M. Paritong,[5]

To extend this treatment to coordinations of different categories and of more than one constituent, we propose two extensions:

1) since the subcat feature may have *disjunctive* values, the classical unification must be replaced by unification $\bigcup$ such as we have defined in 3.1,

2) the feature Part (of speech) of the coordination of two Synsem is the *composite* of the features Part of the two Synsem.[7]

The lexical entry of the conjunction *et* is then:

$$\left[Synsem|Cat| \left[\begin{array}{l} Lex = +, \\ Head|[Minor = conj, Part = A \wedge B], \\ Subcat = \left\{ \begin{array}{l} [Synsem|Cat|[Head|[Part{=}A, Subcat{=}[1]]]], \\ [Synsem|Cat|[Head|[Part{=}B, Subcat{=}[2]]]], \\ [1] \bigcup [2] \end{array} \right\} \end{array} \right] \right]$$

Definition 5 *We define expressions of more than one constituent* $\langle S_1, \ldots, S_n \rangle$ *by the following rule, considering that, as shown in 2.2, only* S_n*, the last complement of the tuple, may be unsaturated:*

$$\left[\begin{array}{l} Phon = \backslash 1 \& \ldots \& n \backslash \\ Synsem\langle [1], \ldots, [n] \rangle | Cat| \left[\begin{array}{l} Head|[Part = \langle S_1, \ldots, S_n \rangle], \\ Coord = +, Subcat = \Phi \end{array} \right] \\ Branches \left[\begin{array}{l} \left[\begin{array}{l} Phon = \backslash 1 \backslash \\ Synsem[1]|Cat|[Head|[Part = S_1], Subcat = \{\}] \end{array} \right] \\ \ldots \\ \left[\begin{array}{l} Phon = \backslash n \backslash \\ Synsem[n]|Cat|[Head|[Part = S_n], Subcat = \Phi] \end{array} \right] \end{array} \right] \end{array} \right]$$

It remains for us to define how the functors are built by partial saturation, by composition. *Partial saturation* doesn't need any additional rule or modification as the subcategorization principle of HPSG allows unsaturated functors with the following description:

$$\left[\begin{array}{l} Synsem|Cat|[Head|[1], Subcat = \Psi] \\ Branches \left[\begin{array}{l} B\text{-}Head|Synsem|Cat|[Head = [1], Subcat = \Phi \cup \Psi] \\ B\text{-}Comp = \langle [Synsem = Y_1], \ldots, [Synsem = Y_n] \rangle \end{array} \right] \end{array} \right]$$

where $\Psi \neq \emptyset$ and $B\text{-}Comp \models \Phi$

However this expression induces a flexible constituency as needed in utterances like:

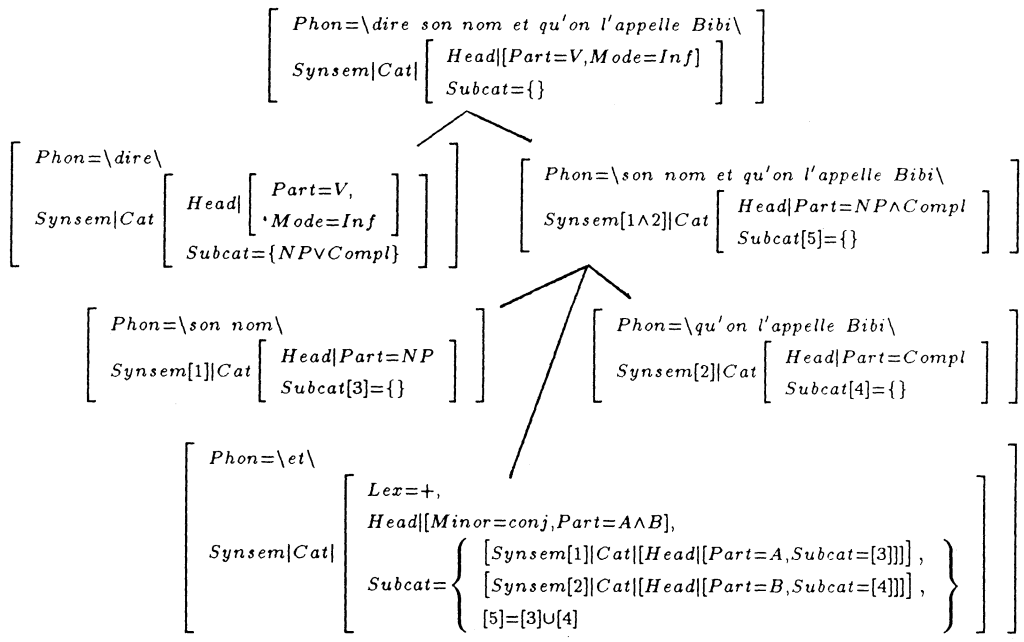
(10) *Jacques aime* et *Marie déteste* ces beaux spots lumineux.
(*Jack loves* and *Mary hates* these beautiful spotlights)

In order to overcome the problems of artificial ambiguity which result from it, one can use it only under a coordination: a feature Coord assures this control provided this feature appears both on the resultant category of partial saturation and on the conjuncts in the lexical entry of *et*. Last, in taking account that only S_n, the last complement of the tuple, may be unsaturated, the functors composition is allowed by the following description:

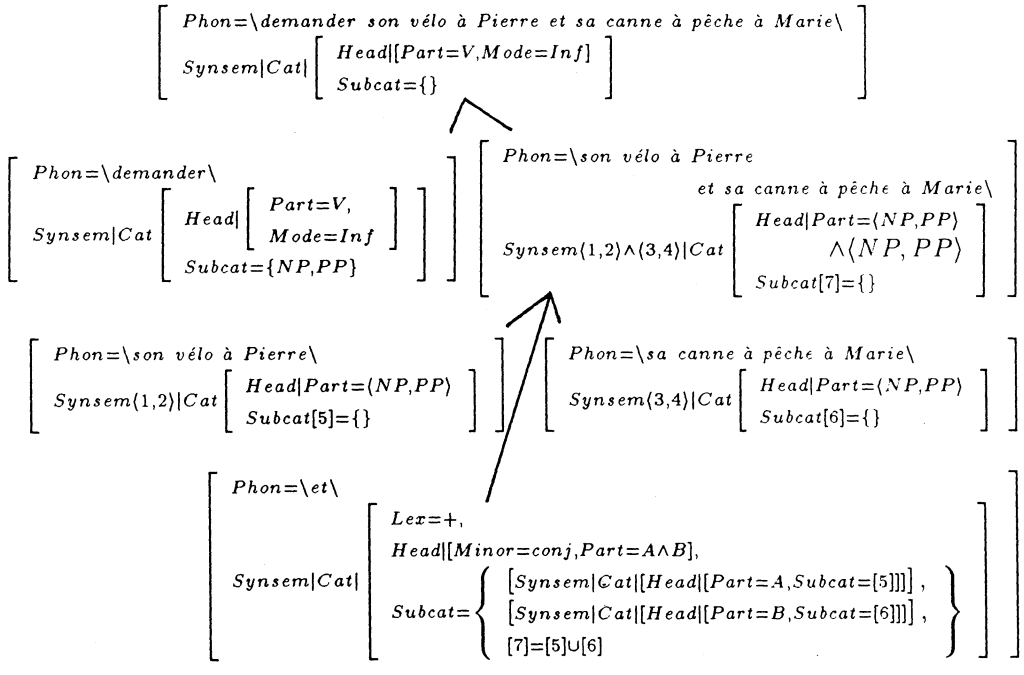
$$\left[\begin{array}{l} Synsem|Cat|[Subcat = \Psi] \\ Branches \left[\begin{array}{l} B\text{-}Head|Synsem|Cat|[Subcat = \Phi] \\ B\text{-}Comp = \langle [Synsem = Y_1], \ldots, [Synsem = Y_n[Subcat = \Psi]] \rangle \end{array} \right] \end{array} \right]$$

where $B\text{-}Comp \models \Phi$

The resulting tree for "dire son nom et qu'on l'appelle Bibi" is the following one, where the subcat feature for the subject is not mentioned for sake of readability:



The resulting tree for "demander son vélo à Pierre et sa canne à pêche à Marie" is the following one:



4 Other aspects and residual problems

- HPSG integrates linguistic information of all kinds in a single representation and allows to treat in one single principle (of subcategorization) a range of syntactical and semantical dependencies, lexically determined, e.g. case assignment, government (of particular prepositions) and role assignment. Indeed all this information is necessary to rule out the following sentences:

(1) * Jean connaît et semble une personne travailleuse.
(Jean knows and seems a trustworthy person)

(2) * Marie promet et ordonne à Luc de partir.
(Mary promises and orders Luc to go) [8]

- A status for sequences of more than one constituent is needed for the description of the coordination and likewise for other linguistic phenomenas with symetrical sequences of more than one constituent (comparative constuctions, alternative construction,etc.):

  Paul donne autant *de couteaux aux filles* que *de pièces aux garçons.*
  (Paul gives as much knifes to the girls as coins to the boys.)

  Paul donne soit *des couteaux aux filles*, soit *des pièces aux garçons.*
  (Paul gives either knifes to the girls or coins to the boys.)

  According to P. Miller [4], adjuncts could be accorded the same status as arguments by integrating them into the subcategorization requirement through an optional lexical rule. That would enable us to treat the coordinations of adjuncts of different categories as well as the coordinations of more than one constituent with adjuncts.

- All the modelisations of the coordination of different categories are insufficiently controlled. Let us take a closer look: in GPSG (Generalized Phrase Structure Grammar), the rule of coordination in its simplest version is: $X \rightarrow H$ *and* H', H and H' being minimally specified categories. In addition, by HFC, we have $X/HEAD = \cap H_i/HEAD$, that is to say from the point of view of the head features, X is a generalisation of two conjuncts.

  Due to ID rules description X is generally sufficiently specified to prevent unification with any generalisation of different categories. But that is not always the case: nothing will block the generation of utterances such as:

  (22) **Jean lit* et *une trottinette.* (John reads and a child's scooter)

  (23) **offrir* et *que je recevrais* des cadeaux. (to offer and that I receive gifts)

  (24) **lis* et *par* les livres. (read and by books)

  This criticism is also valid for the treatment of the Lexical Functional Grammar (LFG) (at least for that of [7] and [1]). The latter recognizes "our grammar admits *in the garden and chases Fido* as a constituent" but he reassures himself by adding: "though there may be no contexts which license such a constituent".

  Certainly no linguistic context exists which would be compatible with such sequences of words but they will be generable and analysable in our proposition, as in the others, unless we impose the constraint that any analysable chain must be of the type (S)entence which is likely to be quite restricting in the analysis of texts. Even if we analyze the categories in terms of the features N, V, it is not clear how to control these coordinations.

  However, the formal criterion we propose covers both coordination of arguments and functors introduced in a linguistic context ($\neq$ (23) and (24)). Let us finally recall that our criterion is valid in the two cases as well as for the coordination of more than one constituent and of different categories.

Notes

[1]The choice of a set (or more precisely multiset)-value status for SUBCAT rather than list will become clear with examples (7) and (7'). [2] makes the same choice. However our

criterion can be formalized in a theory whose order of arguments obeys to an obliqueness hierarchy.

[2]Following [6, page 45] and [4, page 26], we admit that the requirements are of the same cardinality. This condition "will forbide the conjunction of e.g. verbs with SUBCAT lists of different lengths, but which would have a unification under the alternative interpretation, thus avoiding sentences like **John bought and gave the book to Mary*".

[3]Part is the abbreviation of part of speech, i.e. classical categories as NP,PP, etc.

[4]Where, for example, $NP \wedge Compl$ is the abbreviated form of:
$[Synsem|Cat|[Part = NP]] \wedge [Synsem|Cat|[Part = Compl]]$

[5]If $m = 1$ then the category is "simple" and not composite.

[6]p_k is a permutation of $[1, p]$, so the choice of one Synsem $C^k_{p_k[i]} = \wedge\{C^k_{p_k[i],m}/m \in [1, z^k_{p_k[i]}]\}$ in the tuple my be different each time.

[7]Let us recall that $A \wedge A = A$, for instance $NP \wedge NP = NP$

[8](1) is ruled out because the two verbs don't assign the same case to the shared element "une personne travailleuse". (2) is ruled out because t two verbs don't assign the same control on the subjet of the object clause "de partir".

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