Dependency-based analyses for function words
Introducing the polygraphic approach

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Abstract

This paper scrutinizes various dependency-based representations of the syntax of function words, such as prepositions. The focus is on the underlying formal object used to encode the linguistic analyses and its relation to the corresponding linguistic theory. The *polygraph* structure is introduced: it consists of a generalization of the concept of *graph* that allows edges to be vertices of other edges. Such a structure is used to encode dependency-based analyses that are founded on two kinds of morphosyntactic criteria: presence constraints and distributional constraints.

1 Introduction

The general purpose of this paper is to show that dependency-based structures can theoretically be grounded, by making explicit theoretical motivations over the data encoded by the formal structure. To a certain extent, this contradicts the following assumption by Mel'čuk (1988:12): "By its logical nature, dependency formalism cannot be "proved" or "falsified". […] Dependency formalism is a tool proposed for representing linguistic reality, and, like any tool, it may or may not prove sufficiently useful, flexible or appropriate for the task it has been designed for; but it cannot be true or false." To achieve its goal, this paper focuses on descriptive options available in dependency-based frameworks to handle function words (especially prepositions). The choice of a particular dependency structure depends on various decisions (practical, formal, or theoretical decisions). Diverse concurrent structures can be assigned to the same sentence, depending on the semantics underlying the very concept of *dependency*, as well as the general formal constraints the linguist chooses to meet.

This study consists of two parts. The first part (sections 2-5) reviews the treatment of function words in various dependency-based models, namely Tesnière (1934, 2015), Meaning-Text Theory (henceforth MTT) (Mel'čuk 1988) and Stanford Dependency schemes (henceforth SD) (de Marneffe & Manning 2008).

The second part (sections 6 and 7) proposes an alternative approach to describing function words in a dependency-based analysis. Several theoretical motivations are chosen as the bases of the description, prior to selecting any formal constraint on the mathematical structure encoding the descriptions (except for the fact that we want to represent relations between linguistic objects by dependencies). From this stance it becomes necessary to introduce formal structures that are more general than either trees or graphs, that can be called *polygraphs*.

In the conclusion (section 8), the expressive power of polygraphs is compared with the power of the traditional structures presented in the first part.

2 Proposed representations

This section compares different dependency-based representations of constructions involving function words (mainly prepositions).

2.1 Sample data

The discussion is illustrated by the following examples (some examples are in French, when it behaves in a different way than English):

(1) Mary talked to Peter.
(2) le chien de Pierre
'Peter's dog'
(3) Marie part après Noël.
'Mary leaves after Christmas.
(4) I know Mary and Peter.

Our selection is motivated by the fact that these examples illustrate various behaviors of

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prepositions: in (1), *to* is an empty word, a marker of government, while in (3), *après* 'after' is a content word, part of an adjunct. Example (2) is intermediate: *de* 'of' can be analyzed as a marker of government (if it is considered that every dog has a master, and *Pierre* is an argument of the noun *chien* 'dog'), as well as a content word expressing possession. In (4), *and* is not a preposition of course, but this construction deserves to be compared with the previous ones.

Figure 1 presents the representation of the analysis of these utterances in several frameworks:

a) MTT's surface syntactic structure (SSyntS) (Mel'čuk 1988; Mel'čuk & Milićević 2014);
b) Universal Stanford Dependency scheme (USD) (de Marneffe et al. 2014);
c) Kern's representation (1883), later developped independently by Debili (1982);
d) Collapsed Stanford Dependency (CSD) (de Marneffe & Manning 2008);
e) MTT's Semantic Structure (SemS) (Mel'čuk 1988; Mel'čuk 2012-2015);
f) Tesnière's stemma (Tesnière 2015);
g) Interpretation of Tesnière's stemmas as *polygraphs* (Kahane's opinion in Kahane & Osborne 2015; Mazziotta 2014).

2.2 Modeling options

MTT considers 7 levels of representations and has even a deep-syntactic structure between the two structures we present. MTT makes a clear distinction between criteria to define surface syntax dependencies and semantic dependencies (Mel'čuk 1988; 2009).

The Stanford team also considers several kinds of representation, which mix semantic goals (to privilege relations between content words) and syntactic goals (to have a word-based structure representing phrases).

To these widely used representations, we add the representation proposed by Kern (1883) and later developed independently by Debili (1982), which prefigures CSD. Kern/Debili's aim was similar to CSD, that is, to obtain similar dependencies for *the nomination of Mary* and *to nominate Mary* (*nominate/nomination → Mary*).

Finally, we recall the structures proposed by Tesnière (1934, 2015), which, though often quoted, are not so well known. It is important to note that Tesnière's stemma was theoretically grounded but that his graphical representation remains mathematically undefined. This opens the possibility of several interpretations and *a posteriori* formalizations (an alternative interpretation of the so-called *transfer* operation is discussed in section 5).

Each of the representations in Figure 1 will now be surveyed. Section 3 describes tree-like structures in which all words are nodes in the tree. Section 4 describes tree-like structures in which function words are labels over branches. Finally, section 5 discusses Tesnière's stemma and its "retroformalization" and introduces the concept of *polygraph*.

3 Tree-based analyses

Most authors posit that the syntactic structure must be a tree, be it a dependency or a phrase structure tree. In most cases, this decision is not overtly motivated. The underlying motivations are often practical (a tree is a simple structure and many algorithms can handle it efficiently), pedagogical (a tree is easy to explain and to draw) or cultural (trees are widespread and have been used for centuries). From the theoretical point of view, it is much more difficult to motivate the choice: most of the time the principles adopted to define the syntactic structure force it to be a tree without any real justification.[1]

3.1 Tree-object

In phrase-structure grammar, one obtains a tree as soon as one considers that every unit has at most a unique possible decomposition and, for instance, that the analysis *Peter + thinks that it is possible* invalidates any other decomposition (such as *Peter thinks + that it is possible*) (Gleason 1969:130). In dependency grammar, you obtain a tree as soon as you consider that every unit has a unique governor, and thus a unique connection with the latter.

[1] SSyntS is based on the general assumption that the syntactic structure must be a tree. The recurrent justification given by Mel'čuk is: "A linguistic model must ensure the correspondence between two formal objects of a very different nature: the semantic network, a **multi**dimensional graph, and the morphological/phonological string, a **uni**dimensional graph. […] The correspondence between the dimensionality *n* and the dimensionality 1 must de done through an object of dimensionality 2. The simplest bidimensional graph is what is called a dependency tree." (transl. from Mel'čuk & Milićević 2014: 31-34).

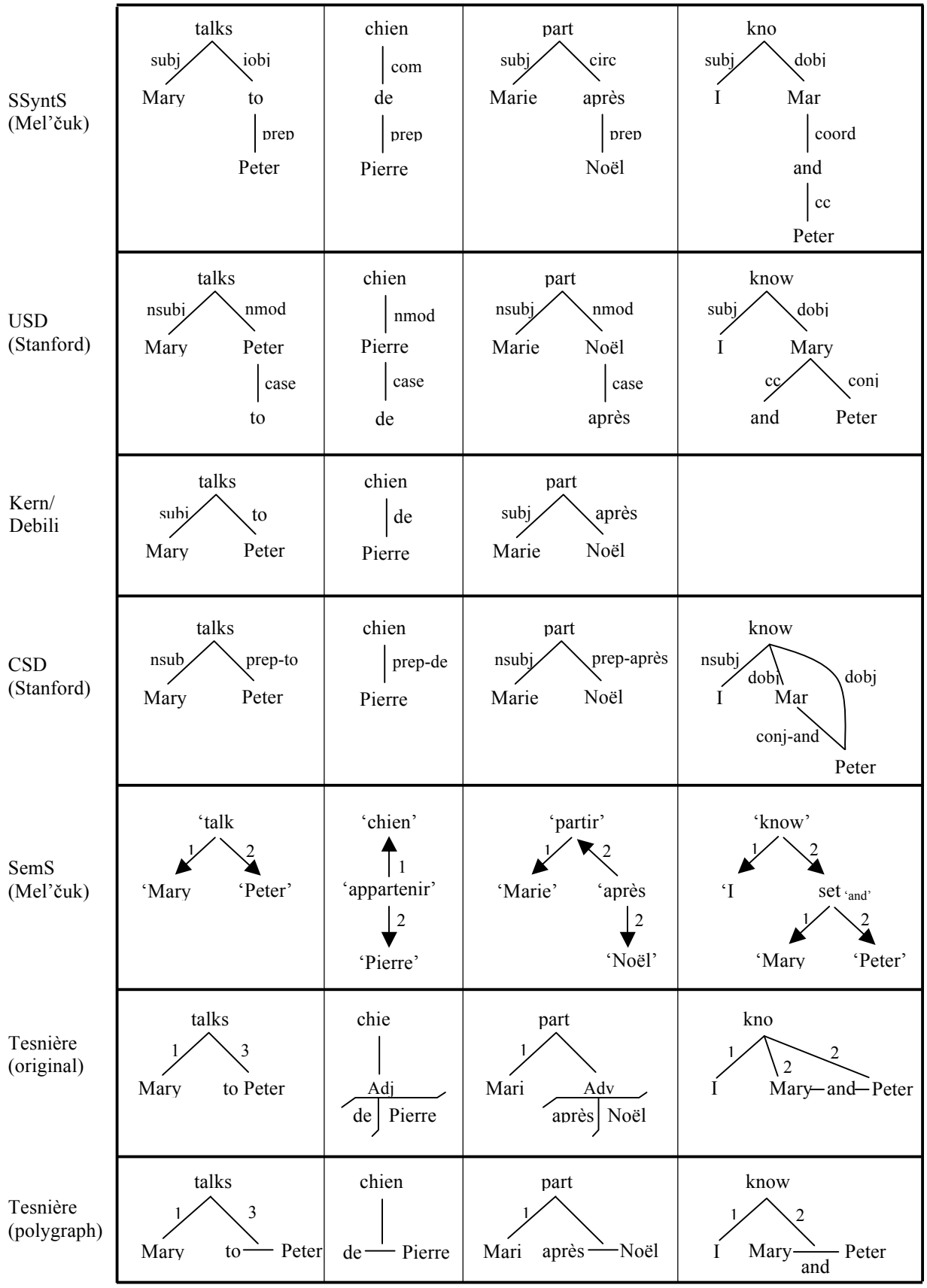

Figure 1. Dependency-based representations of function words

A tree is defined as a connected directed graph where all nodes but one appear exactly once as the second element of an ordered pair (and an indefinite number of times as the first element). The only exception, called the *root* of the tree only appears as the first element of pairs. In a labeled tree, each pair can be assigned a specific type. A tree is a formal structure, i.e. a *meaningless form.* Drawing a tree does not make it meaningful: it is the linguistic theory underlying the structure of the tree that achieves this purpose. The choice between one tree or the other is a matter of theoretical stance.

3.2 Making the tree meaningful: MTT

Defining the meaning of a tree consists in explaining what linguistic criteria are used to justify three parameters: 1) the grouping of words into a common pair; 2) the ordering of that pair;[2] 3) the labeling of that pair.

To be able to go beyond mere intuitions, one has to investigate tests that allow one to select the most appropriate hierarchy. The most explicit attempt to give a meaning to a dependency tree is Mel'čuk's linguistic criteria for SSyntS (Mel'čuk 1988).

The MTT framework posits several levels of syntactic analysis, that are part of a multidimensional modular approach involving phonological, morphological, surface-syntax and deep-syntax, as well as semantic analysis. The aforementioned criteria appear at the surface-syntax level, which encodes two-word phrases (criteria A) and identify the main word in each phrase, that is, preferably, the one constraining the syntactic distribution of the phrase (criterion B1).

A phrase is mainly defined by Mel'čuk in terms of (potential) prosody, that is the possibility for these two words to be isolated together. This is in particular the case if the two words can stand alone and form an utterance together. This use of the term *phrase* is different from the one imposed in linguistics by generativists. For instance, in *Peter reads a book*, *Peter reads* is clearly a phrase, which can form a perfect utterance. This notion of *phrase* is not far from what Saussure (1916) called a *syntagme*. Criteria B explains which of the two words of a phrase is the head of the phrase and governs the other word. For Mel'čuk, the *head* of a phrase is the word which mainly determines the passive valency of the phrase, that is, which determines in what syntactic context the phrase can be inserted. This approach consequently demotes lexical words as dependents and promotes function words as governors. The precedence of lexical words is highlighted at other levels of the linguistic description (deep-syntax and semantics).

In (1), *to Peter* forms a phrase because it can stand alone (*Who are you talking to? To Peter*). The preposition is the head because it characterizes *to Peter* as a possible complement of *talk*. The same reasoning can be applied to *de Pierre* 'of Peter' and *après Noël* 'after Christmas' in (2) and (3). In the same way, *and Peter* is a phrase of (4) because it can form a separate utterance (*I know Mary. And Peter.*) contrary to *Mary and*. Moreover *and* characterizes *and Peter* as a conjunct phrase.

While in SSyntS, relations are between words, in SemS, relations are between semantic units, that is, mainly meanings of lexical units. Empty words are eliminated. For instance, in SemS of (1), 'Mary' and 'Peter' are the two arguments of 'talk', which is indicated by arrows from the predicate to its arguments. The empty preposition *to*, which is imposed by the subcategorization of *talk*, is absent from the structure. On the contrary, in (3), 'after' is a content word, formalized as a binary predicate (X is after Y) expressing the temporal succession of two events (Mary's leaving and Christmas). The same formalization is proposed here for *de* 'of' in (2) which is analyzed as a binary predicate expressing a possessive relation between the dog and its master (*le chien **appartient** à Pierre* 'the dog **belongs** to Peter'). The case of coordination is more complex. Although *and* is treated similarly to the preposition at the syntactic level, it functions completely differently at the semantic level. The semantic role of 'and' is to form an additive set with 'Mary' and 'Peter' and it is this set that *I know*.

3.3 Making the tree meaningful: SD

Let us now compare MTT and SD. It was clearly demonstrated by Zwicky (1985) that the identification of the head in a binary rela-

[2] By definition, the elements of a pair are not hierarchized: a pair is a simple set of two elements. *Ordering* a pair means structuring it by giving precedence to one of its elements. Ordering has a meaning in a dependency-based approach: by declaring one element as the first one, one formally encodes that it is the governor of the other (which, conversely, is its dependent).

tion can rely on different criteria that can sometimes be contradictory. The major consequence of this fact is that favoring one criterion or another excludes a specific tree. The difference between MTT's analysis and SD's can be understood according to this theoretical contrast.

Nevertheless, the SD framework uses less clearly-defined criteria and does not analyze syntax in the same way, providing an analysis which, from MTT's point of view, merges several modules of description. This leads to trees where function words are governed by lexical words.

The main goal of SD schemes is to propose a universal representation, favoring the relation between content words, which is similar to SemS. While the representation proposed by USD for (1) is easily justifiable,[3] the representation for (3) becomes quite problematic because *après* 'after' is a content word and there is clearly a semantic relation between Mary's leaving and 'après'.

On the other hand, all words appear in USD and it is claimed that USD is a surface syntactic representation. Indeed syntactic arguments are sometimes used to justify certain analyses. For instance, de Marneffe et al. (2014) choose to reject the small clause analysis of *We made them leave* because "the small clause as a unit fails a considerable number of constituency tests". But if USD is supposed to represent phrases, USD's structure for (4) cannot be defended, because *Mary and* is not a possible phrase. In conclusion, the choices of SD seem to be partly arbitrary and they are not falsifiable, because they are not grounded on explicit criteria.

4 Function words as labels

Some frameworks consider function words as "markers" over a syntactic relation. The conception that grammatical markers *work as specifications over relations* is developed in Lemaréchal's work (mainly 1997). The basis of this idea is that dependencies (and syntactic relations in general) can work without the use of any grammatical marker: this is called a *minimal relation* (Fr. *relation minimale*). When one or several markers are present, they *stack* over this minimal relation. By doing so, they function as additional constraints on the distribution of the dependent, which they *specify* (hence the term *specification*). In Lemaréchal's view, specifications can be non-segmental (prosody, word order, etc.). This conception assumes that specifications are added to relations.

Such a statement corresponds very well with the syntactic representation proposed by Kern/Debili, where the preposition labels the dependency it marks. For instance, in Kern/Debili's representation of (1), *to* labels the dependency between *talked* and *Peter*. From a mathematical point of view, such a dependency is no longer a binary edge but a ternary edge: three words are linked by the same relation.[4] The representation types the three positions opened by this edge (that is, the three vertices): *talked* is the governor, *Peter* is the dependent, and *to* is a marker. (See section 7 for a third, polygraphic interpretation.)

The same graphical convention was used by Tesnière (1934) for coordination: the coordinate conjunction *and* is placed over the edge linking the two conjuncts — see our polygraphic interpretation of (4). Tesnière (1959) places the conjunction between the conjuncts, but he posits that the conjunction does not occupy a node, contrary to the conjuncts (see stemma 249 and Ch. 136, §6). Two interpretations of his stemma for (4) are possible: *and* is connected to both *Mary* and *Peter*,[5] or *Mary*, *Peter* and *and* are connected in a single ternary relation, where they assume a specific role according to their grammatical class (and the spatial position in the stemma).

Collapsed SDs operate in a similar way: the function word becomes part of the labeling of the relation it marks. But in the case of CSD the structure is declared as a tree and the function word is "dereified" (it is not a node any

[3] In fact, even the representation for (1) is problematic because due to preposition stranding, *to* can form a unit with *talk* in several constructions:
(i) the girl Peter **talked to**
(ii) Mary **talked to** Peter Monday and John Tuesday
(iii) We **talked to** and bantered with many students. (streetpastors.org)
Note that none of these constructions would be possible with Fr. *parler à* 'talk to' because French do not accept preposition stranding. Does it mean that the syntactic representation of *à* in *parler à* and *to* in *talk to* should be different?

[4] A structure with *n*-ary edges is called a *hypergraph* (Bergé 1973). A graph is a particular case of hypergraph, where all edges are binary.

[5] However, this former interpretation seems unlikely (Mazziotta 2014: 146).

longer, but a typed edge).[6] However, this implies the introduction of dozens of very specific syntactic relations, one for each function word.

5 Tesnière's transfer and polygraphic analyses

5.1 Tesnière's transfer

For Tesnière, most prepositions are *translatives*, i.e. grammatical tools that allow a unit of one syntactic category to occupy a position usually devoted to a unit of another syntactic category. The combination of a translative with a unit in order to change its category is called *transfer* (Fr. *translation*). Transfer is illustrated by (2): the preposition *de* 'of' transfers the noun *Peter* into an adjective, thus allowing *de Pierre* to modify the noun *chien* 'dog' asadjectives do (*gros chien noir* 'big black dog'). In his stemmas, Tesnière (2015) represent this operation by using a special T-like shape. This notation has three positional slots: one for the translative, one for the transferred word and the category of the phrase after the transfer on top (see figure 1).

When transfer does not change the part of speech of the main content word, but merely changes its function (Tesnière 2015: ch. 172), it may be qualified as "functional" and Tesnière no longer uses the T-like notation. Thus, the use of Fr. *à* allowing a noun to become an indirect complement expressing the recipient (*je donne une pomme à Jean* 'I give an apple to Jean') is not depicted as a classical transfer. See our representation for (1) in figure 1.

Tesnière made it clear that translatives and coordinate conjunctions do not share the same syntactic properties. From a theoretical perspective, he considered coordination to be orthogonal to subordination: the former adds elements that are at the same hierarchical level, whereas the latter creates the hierarchy. The geometric configuration of his stemmas is motivated by this theoretical choice. The conjuncts are placed equi-level and the coordinate conjunction is placed between them (see section 4). Conjuncts are treated as co-heads and are both connected to the governor of the coordinated phrase.

[6] This analysis can also compared with LFG's f-structure where function words are stored in special feature associated with the relation between the content words (Kaplan & Bresnan 1982).

5.2 Polygraphic analyses

Tesnière's stemmas lead to various interpretations. In section 4, we already discussed whether coordination involves a ternary edge or not. The T-like notation is also the source of debate (see Kahane & Osborne 2015: l-lxii). The translative combines with the transferred word in a way that is not represented with a vertical line, as subordination would be. Placing the two elements equi-level probably means that Tesnière considers this combination to be exocentric. Following Kahane (in Kahane & Osborne 2015) and Mazziotta (2014: 142), we represent transfer by a horizontal link. As a result, in figures 1 and 2a, the relation between *chien* and the transferred phrase it governs is expressed by a line between *chien* and the other line between *de* and *Pierre*. This representation is based on the idea that a two-word phrase and the connection link between these two words are in essence the same unique object. This formalizes Tesnière's well-known and insightful view of syntactic relations: they consist of objects as much as words do (Tesnière 2015: ch. 1, §5).

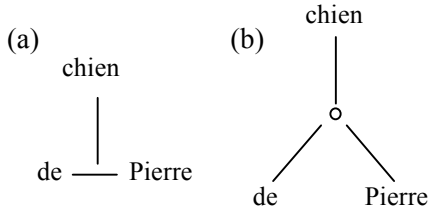

Figure 2. Interpretations of Tesnière's transfer

The formal object underlying the suggested representation of transfer can be defined from a mathematical perspective. Such an object allows some edges to have other edges as vertices in addition to nodes and will be called a *polygraph* (Kahane & Mazziotta 2015, following Burroni 1993; Bonfante & Guiraud 2008). As was already the case with the tree-object, the polygraph-object is meaningless *per se*. It is the theoretical grounding on the *transfer* concept that gives it a semiosis.

Transfer could also be encoded in a tree (Osborne in Kahane & Osborne 2015); see fig. 2b. As long as they convey the same amount of information, the depicted polygraph and its corresponding tree can be automatically converted into one another — i.e. they are formally equivalent. They have the same meaning, and the choice between one or the other can be motivated neither by formal nor by linguistic reasons. A polygraph is neverthe-

less more powerful because it does not need to add extra nodes to express the same amount of information. Moreover, the tree-based interpretation relies on three kinds of linguistic objects (words, phrases and relations), whereas the polygraph only needs two (words and relations). The iconic correspondence of the polygraph is direct: a node is equivalent to a word and an edge is equivalent to a relation. In the tree, one needs additional typing for the nodes to part words from phrases.

The next sections investigate how polygraphs can be used to express some properties of function words.

6 Presence constraints

When formalizing a linguistic analysis, one is deemed to provide:

1. a formal description of the mathematical object that encodes the analysis;
2. interpretation rules that govern the association between this structure as a semiotic device expressing the analysis.

The motivations underlying these choices should be expressed as well, since they are important from an epistemological perspective or to make it possible to evaluate the efficiency of the description.

In the scope of this paper, the chosen mathematical object is the aforementioned *polygraph*. How its interpretation rules help contrast function words according to their specific behaviors will be shown in this section and the next one, and is based on two theoretical motivations.

Some motivations can be stated prior to defining the phenomena at study. It is well accepted that a syntactic theory has to acknowledge the existence of *phrases*, i.e. syntactic constructions that can stand alone and be used as a speech turn under certain conditions, and thus become autonomous and form an utterance (criteria A of Mel'čuk 1988). Since the term *phrase* is widely preempted for something else by generativists, one can adopt another point of view and see these units as manifestations of presence constraints: some pairs of words must be grouped with other words to occur together, whereas others can stand alone.

Theoretical motivation 1. Presence constraints must be encoded.

6.1 Linguistic theoretical analysis

As a basis for this discussion, we will investigate the following sample material: (5) and (6) are in French, (7) is in Old French (Moignet 1988: 95), and (8) is in English.

(5) a. Marie parle à Pierre.
'Mary talks to Peter.'
b. *Marie parle à.
c. *Marie parle Pierre.

(6) a. Marie vient après Noël.
'Mary comes after Christmas.'
b. Marie vient après.
'Mary comes afterwards.'
c. *Marie vient Noël.

(7) a. le message de la roïne
'the message of the queen'
b. *le message de
c. le message la roïne
'the message of the queen'

(8) a. I know that you lie.
b. I know that.
c. I know you lie.

In (5), *Marie parle* and *à Pierre* can stand alone. It is also possible to consider that *parle à Pierre* can form a prosodic unit and stand alone when the verb is in another (non-finite) form. On the contrary neither *parle à*, nor *parle Pierre* have this kind of autonomy.

Encoding presence constraints automatically unveils their hierarchy. If one encodes presence constrains in (6), identifying the group *Marie vient après* as well as the group *après Noël* automatically identifies *après* as the governor, i.e. the word that must be present inside *après Noël.* On the contrary, in (5), since *parle à* and *parle Pierre* are not acceptable, whereas *à Pierre* is, both the preposition and the noun must be present.

It should be stressed that the preposition can also be optional. Such is the case in the so-called "absolute oblique" (Fr. *cas régime absolu*, Buridant 2000: §§59 sqq.) in Old French (7). Acknowledging the structure *le message la roïne* and *de la roïne*, but refusing **le message de* achieves the description.[7] Examples of such a structure are not seldom. Lat. *decedere (de) provinciā* 'leave (from) one's province' is similar, except that the optional expression of the preposition has a more obvious semantic value[8]. Fr. *Marie habite (à) Paris* 'Mary lives

[7] Note that the article is not compulsory in Old Fr. This issue will not be investigated here (see Mazziotta 2013).

[8] The clause usually appears with the preposition, but "verbs compounded with *ā, ab, dē*, etc., (1) take the simple ablative when used figuratively; but (2) when used literally to denote actual separation or motion, they

in Paris' displays the same feature: the locative preposition *à* is also optional.

The possibility for two words to be used independently or conjointly in the same construction is illustrated by (8). It is generally considered that *that* in *I know that* and *I know that you lie* are two different words, namely a pronoun and a conjunction. The hypothesis favored here is, on the contrary, that there exist two uses of the same lexical unit: the conjunction is described as a weakened form of the pronoun. In this sentence, *that* and *you lie* **co-occupy** the same position: they can appear alone as well as they can form a group and appear together.[9]

6.2 Encoding and representation

It is strikingly clear that the reciprocal constraints over the presence of the function word and the structure following it can be of four types, given that at least one of them is present: either both of them must be expressed (5), or only the function word (6), or only the following phrase (7), or one or the other (8). These four possibilities are theoretically predicted in Hjelmslev (1953) from a very general point of view. A formalism encoding presence constraints must therefore allow to distinguish between these possibilities.

The classical stance consists of encoding the structures by edges between nodes: for instance, *to* and *Peter* are nodes connected by a single edge between them. In (6), since *vient après* as well as *après Noël* are acceptable, the structure can be encoded by a "chain" of nodes linked by two edges, which is easily achieved in a graph.[10] The same convention can be used to encode (7). However, the graph object is not sufficient when a word or a group of words A can form a group with a group B, but no part of B can form a group with A. One needs a polygraph to encode the group B as a vertex of the edge representing the group A, which is the most direct way to achieve a formal description of such a configuration.[11] Thus, in (5), A = *talks* can form an acceptable independent construction with B = *to Peter*, but neither *to* nor *Peter* alone can be grouped with A. Therefore, there is an edge between *talks* and the edge between *to* and *Peter* (see figure 3).

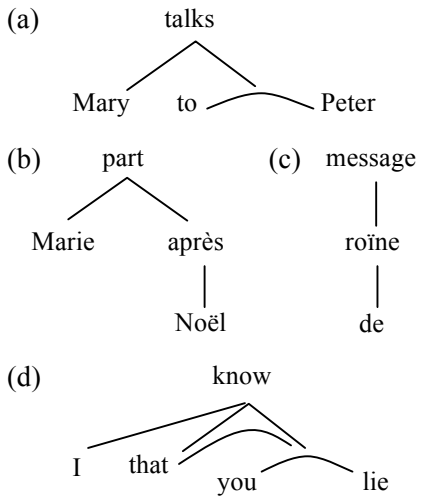

Figure 3. Presence constraints[12]

7 Distributional constraints

It also appears that the forms (lexical choice) of the function words can depend on the syntactic context of the group they appear in. I.e., their form is affected by their distribution.

Theoretical motivation 2. Form constraints affecting function words must be encoded.

7.1 Linguistic theoretical analysis

In Fr. *Marie va à Paris* 'Mary goes to Paris', the form *à* 'toward/to' is constrained by the use of the verb *va* (and expresses the destination of the movement). In Old Fr. *le message de la bone roïne* 'the message of the good

usually require a preposition". (Greenough *et al.* 1903: 302)

[9] To our knowledge, co-occupation is an overlooked phenomenon that should be investigated further. We have a quite similar situation in French where the subordinating conjunction is also a pronoun, more exactly the weak form of the interrogative pronoun *quoi*:
(i) Tu sais **quoi** ? 'You know what?'
(ii) **Que** sais-tu? 'What do you know?'
(iii) Je sais **que** tu mens. 'I know that you lie.'
However, *que* is not optional in (iii). Note that Gustave Guilleaume's followers (Moignet 1981: ch. 11 a.o.) suggest that the different uses of the forms *que* and *quoi* are instances of a unique lexical unit (Fr. *vocable* in Guilleaume's terminology).

[10] A similar structure is defined in Gerdes & Kahane (2011) and called the *connection structure*. They use an alternative mode of representation of edges based on bubbles rather than lines. (See Bergé 1973 for the equivalence between the two modes of representation.)

[11] It is possible to reify the edge as a node (as is often done in RDF), but the resulting structure contains more elements for the same amount of information.

[12] A presence-constrained structure could be called a "phrase structure". It is encoded in a non-directed polygraph. Polygraph are displayed here with the main verb on top in order to be as close as possible to a traditional dependency tree for the sake of simplicity. It must nevertheless be made clear that the hierarchization of the polygraph corresponds to other constraints that remain to be discussed.

queen', the preposition *de* 'of' is bound to the N + *de* + N construction that expresses a "genitive" relation. By contrast, the lexical choice of *bone* 'good' is not constrained by any relation or construction. Reevaluating the idea that function words may label relations or work as *specifications* over them (sec. 4), it seems reasonable to state that the form of a word can be constrained by the *relation* it is bound to at least as much as the words it connects with. In this case, function words specify the relation. For instance, in (1), the use of the preposition *to* is bound to the use of the lexical unit *talk* because only the second argument of *talk* can be introduced by such a preposition (for instance the subject cannot be: **To Mary talked to Peter*). Only one particular type of dependent can, which implies that the use of the preposition is specific to this particular relation.

This descriptive option reformulates the Mel'čukian *passive valency* criterion (see section 3 *supra*): the fact that *de* is bound to the dependency between *de la roïne* and its governor *message* is equivalent to the fact that not only *roïne* but also *de* controls the distribution of *de la roïne*. Indeed, *la roïne* and *de la roïne* do not have the same distribution: both can complement a noun, but only *la bone roïne* can be the subject of a verb.

Coordination as observed in (4) is also interesting. Any one of the conjuncts can be grouped with their common governor to form an acceptable utterance. It is a case very similar to co-occupation in (8), but for the presence of the coordinating conjunction. This conjunction is not compulsory (we consider that sentences such as *I know Mary, Peter* are acceptable), but it needs both the second conjunct and the coordination relation to be present. (See Mel'čuk 1988: 41, Gerdes & Kahane 2015 and Mazziotta 2013 for alternate theoretical stances in a dependency framework.)

7.2 Encoding and representation

With the expressing power of the polygraph structure, the relation between the function word and the relation that constrains it can be encoded as such. This introduces *specification*, a secondary dependency, between the function word and the primary dependency that binds it (figure 4). It encodes the fact that in *le message de la bone roïne*, both *de* and *bone* can group with *roïne* to form an acceptable utterance, but only *de* is bound to the relation between *message* and *roïne*. The representation proposed here contrasts a lexical dependent such as *bone* 'good' with the function word. The difference between primary dependency edges (*dependency edges* for short) and secondary dependency edges (*specification edges*) is expressed structurally by the type of the governing vertex. Specification edges are defined as having another edge as a governor.

The intricate set of relations at work with coordination structures can easily be encoded in a polygraph as well. Comparing figure 3 with figure 4 makes the similarity between coordination and co-occupation visible.

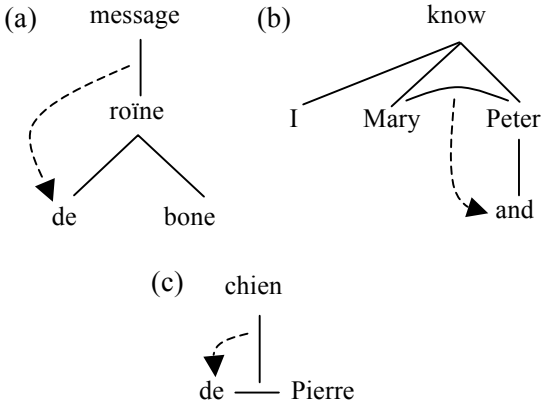

Figure 4. Distributional constraints

8 Conclusion

This paper has compared different dependency-based representations of the surface syntax organization, focusing on prepositions and function words. Several classical representations have been described (sections 2-5), as well as new representations (sections 6 and 7).

The main theoretical advantage of the stance adopted here is that it separates different primitive motivations into two sets of non-interfering linguistic relations: a relation grouping elements according to presence constraints (section 6), and a relation of co-presence between a word and another relation (section 7). Both motivations correspond to a specific set of relations, namely *dependency relations* and *specification relations*.

On the practical side, such an approach leads to much less complex structures for analyzing constructions where specification can be optional. On the computational side, it becomes possible to compute these sets separately (in a sequential or parallel process queue).

Another important feature of the present argumentation is that *a priori* formal constraints on the underlying mathematical object have been set to a minimum. Tree-based formalizations only envisage the relation of a function word in terms of stand-alone binary relations with other words. It has been shown that relations can involve secondary relations (*specifications*), i.e. relations over previously stated primary relations (*dependencies*). The networks of relations one needs to introduce when formalizing a particular property are naturally more complex than a tree.

The decision to build a dependency tree rather than a more complex structure can have practical, pedagogical or theoretical motivations. Using dependency trees because of pedagogical or practical motivations is not an issue. However, one has to admit that the theoretical arguments for a tree-based structure remain tenuous and poorly motivated in the literature.

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