

Drawing the syntactic space: choices in diagrammatic reasoning

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Abstract

This paper focuses on syntactic diagrams, i.e. formalized graphical representations (*inscriptions*) of dependency-based syntactic knowledge. In a simplified way, syntax can be described as the combination of three kinds of information: word order, dependencies and relations between equivalent terms. In the graphical space, pieces of information related to those different aspects combine. Hence, diagrams can be used as tools to investigate the interactions between them. Because of the graphical nature of the diagrams, some of their components are more salient than others. That fact implies that diagrams that represent similar information may differ in the contents to which they actually draw attention.

1 Introduction

This paper focuses on syntactic diagrams as tools to investigate linguistic materials. Although diagrams are part of the research process for many syntacticians, studies on their uses and on their semiotic properties are very sparse. With the development of treebanks, many tools have been implemented to provide visual representations of syntactic trees, but their elaboration is hardly ever discussed outside of private project meetings. In my opinion, representational conventions deeply interfere with research procedures. In several previous studies (some of them in collaboration with Sylvain Kahane), I focused on the formal, semiotic and grammatical aspects of diagrams (Kahane and Mazziotta, 2015; Mazziotta, 2019; Mazziotta, 2020). In this paper, I will mainly focus on the rhetorical consequences of diagrammatic choices.

The following study deals with the articulation between three different types of information in syntactic diagrams at use in dependency-based descriptions,¹ namely: word order, dependencies and relations between equivalent terms (coordinations and “paradigmatic piles”). I will address representational choices that make it possible to visualize simultaneously different aspects of the analysis. More importantly, I will question the value of such simultaneous representations. In order to do so, Section 2 introduces the semiotic notion of *diagram*. Section 3 illustrates frequently used diagrams that express the three aforementioned types of information. Section 4 focuses on the use of diagrams in syntactic reasoning, and highlights the concepts of *salience* and *exhibitive efficiency*. Section 5 concludes by highlighting major points.

2 Diagrams, reification and configuration

According to C.S. Peirce, diagrams are formalized icons of representations (Stjernfelt, 2007, 90-102). They act as complex signs, and their internal structure is similar to the one of the contents they mean to represent. In this paper, the use of the term *diagram* will be limited to the specific meaning of “formalized graphical figures”. I will follow the “theory of support” (Bachimont, 2007; Bachimont, 2010), according to which diagrams are devices (Fr. *dispositifs*) that are used to express and access knowledge. Diagrams are *inscriptions* of knowledge. The main point of this theory is that knowledge cannot be expressed

¹ICA-based diagrams are not discussed in this paper.

unless it is inscribed, and that such inscriptions are diverse. In the case of syntactic analyses, they can be inscribed in the form of tree-like diagrams or in an algebraic form. Moreover, several concurrent diagrammatic representations can effectively express the same knowledge about syntactic structures.

Since diagrams are formalized graphical structures, they are constrained by formal rules. Since diagrams are inscriptions on a medium, they are constrained by the physical properties of the latter. Formal rules consist of the inventory of the graphical entities (discrete symbols) that can be used in the diagrams, and rules governing their organization on the plane, i.e. configurational rules that constraint the spatialization of the symbols. This can be illustrated with a dependency tree of (1) such as Fig. 1: 1/ orthographic word-forms represent words; 2/ strokes placed between the words represent dependencies (such strokes are frequently supplemented with labels, that I abstract away from the discussion for the sake of simplicity).

- (1) The boy ate a cookie (Groß, 2003)

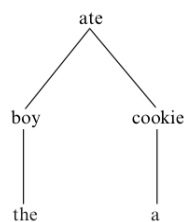


Figure 1: Diagrammatic inscription of a dependency tree (Groß, 2003, 331)

In my terms, syntactic concepts such as *words* and *dependencies* are *reified* by *graphical entities* (or *entities*, for short) (Groupe μ , 1992), i.e. discrete shapes. Syntactic concepts are not only inscribed by reification: reification is complementary to *configurational* rules regarding the relative spatialization of the graphical entities. Such configuration represents relations between terms of the syntactic analysis. In Fig. 1, *ate* appears higher on the plane than *boy*. This fact, combined with the fact that both terms appear at each ends of a stroke, express the fact that *ate* governs *boy*.

The limitations associated with the medium are very tangible. From a geometrical perspective, on the physical plane of a sheet of paper or on the screen of a computer, both the vertical dimension and the horizontal one must be present. Moreover, no additional geometric dimensions can be added to them. This limitation is crucial for the issues at study. Its main effect is that the contents that are inscribed in a diagram must be reduced accordingly.

3 Syntactic space and frequent diagrams

The complete *syntactic space* (henceforth *S*) corresponds to the set containing all the syntactic knowledge that can potentially be elaborated. I posit that *S* contains several subspaces (subsets), without specifying their exact number. This paper acknowledges a simplified syntactic space and focuses in particular on three of its subspaces, which correspond to aspects that frequently appear in diagrams: syntactic dependencies, word order and grouping of equivalent terms. For convenience, the three subspaces are considered axiomatic from the perspective of this paper.

Formally, it is possible to elaborate an algebraic structure that contains the whole syntactic information in a modular way – the objective of Mel’čuk’s “functional” approach to synthesis is to elaborate such a structure (Mel’čuk, 2021, 9). Provided that the linguistic analysis is done, it would be trivial to encode an algebraic structure into a computational object in a programming language. Similarly, diagrams are often regarded as graphical representations of a preliminary algebraic formalisation. In cases such as automatic generation of diagrams for the purpose of extracting data from a treebank, diagrams are indeed second-rank signs, *transpositions* (Hébert, 2020, 143-144) of another inscription (an algebraic encoding). However, in many cases of theoretical syntactic reasoning, diagrams are primary formal inscriptions of the analysis in a specific medium: the graphical space (henceforth *G*). For theoretical linguists who

use diagrams, syntactic theories are expressed through them, and would remain fuzzy and ill-defined without any kind of representation. Consequently, following the grounding assumptions of the theory of support, I consider that S is an abstract amorphous and unreachable knowledge that can be accessed only through an inscription. Conversely, the inscription of this knowledge in G is concrete, formalized and can be accessed.

Syntactic diagrams inscribe one or several subspaces of S in the graphical space G . The inscription of the subspaces grounds their formal definitions, that must conform to the limitations (notably, bidimensionality) of G , in which the inscriptions are embedded.

In this section, I briefly define the subspaces of dependencies (Subsection 3.1), word order (Subsection 3.2) and equivalences, i.e. grouping of equivalent terms (Subsection 3.3), and I illustrate the diagrams specifically used to inscribe them. It will quickly become obvious that diagrams often merge elements pertaining to different subspaces into a single inscription.

3.1 Dependencies

The subspace of dependencies (henceforth D) corresponds to the internal structure of so-called *rectional units*. Much could be discussed about the concept of *dependency*, its possible subdivision into “deep” and “surface” modules and the actual rules for identifying and classifying dependencies. This paper follows a classic general definition that remains implicit. D can be inscribed by the means of the rooted acyclic tree formalism. Each wordform is a node that appears exactly once as the second element of a couple of the tree, except for the single *root*, that only appears as the first element. Graphically, dependencies are inscribed in diagrams such as Fig. 1, which reads “*ate* governs *boy*”, “*boy* governs *the*”, etc. It is obvious that dependency trees like this one reify the relation of government by the means of strokes. In the case of Fig. 1, the vertical dimension is iconic of the hierarchy of the dependencies: governors are depicted higher than their dependents.

The tree formalism can encode branching relations. From the perspective of the inscription in G , branching necessitates the use of an additional dimension in order to avoid clashes between wordforms. Their reification must be spacialized in different positions on the plane.

3.2 Word order

Word order (henceforth O) corresponds to the encoding of the sequential order of the words in a well-formed oral or written construction (Tesnière, 2015, Chapters 5-9). For (1), O can be inscribed in the form of a *chain* (Mel’čuk and Milićević, 2014, 296-297) of words, as illustrated in Fig. 3.

the → boy → ate → a → cookie

Figure 2: Inscription of O in the form of a chain

In Fig. 3, arrows reify the relations of precedence between words. In Meaning-Text Theory (Mel’čuk, 1988, 48-49, 71), word order is encoded in the morphological module (“deep-morphological structure”), and precedence relations are not reified:

[The] arcs [of the morphological structure] are, so to speak, degenerated; they specify only the strict linear ordering of wordforms (“ w_1 immediately precedes w_2 ”), so that they need not be indicated explicitly. (Mel’čuk, 2009, 7)

In most cases, O is simply inscribed by the linear arrangement of orthographical symbols on the horizontal axis, that is, by a configurational convention, on a single dimension of G . The O subspace corresponds to the traditional inscription of written wordforms.

3.3 Equivalent terms and constructions

The third subspace, which I suggest to identify as the one of *equivalences* (henceforth E) contains information about equivalent terms and constructions. Contrary to O and to D , this subspace is not related to

all the words of the analyzed sentence. E is less universally acknowledged, and requires a more detailed introduction.

The adjective *equivalent* expresses that some words can be grouped with respect to the fact that they can be substituted to each other in the same syntactic position. That is the case when words are involved in coordination, such as *hooded* and *armed* in (2). In diagrams, coordination is often inscribed alongside dependencies.

(2) hooded and armed youngsters (Kahane et al., 2019, 74)

Section 4 will focus on simultaneous inscriptions. In this subsection, I will introduce a type of diagram specifically used to inscribe equivalence between terms. In several projects traditionally related to the description of spoken French, such as *Rhapsodie* (Lacheret et al., 2019), phenomena such as repetitions and dysfluencies are also described as a grouping of equivalent terms (Kahane et al., 2019). Since equivalent terms share syntactic properties, and can be classified as members of the same paradigm, such groupings are sometimes called *paradigmatic piles*.

During the 90s, French scholars who focused on the description of spoken French came up with the idea of grid-like diagrams that make use of the vertical dimension of G to generate an iconic visualisation of the paradigmatic piles (Blanche-Benveniste and Jeanjean, 1986), including coordinations (Bilger, 1999). An example of such a diagram is provided in Fig. 4.

hooded
and armed youngsters

Figure 3: Inscription of E in the form of a grid

O is represented iconically if no equivalence has to be inscribed, but *hooded* and *armed* are specialized one above the other in the vertical dimension.

As illustrated in (3), *Rhapsodie* (Lacheret et al., 2019; Kahane et al., 2019) adopts an alternative to the grid-like inscription: E is expressed by special entities ($\{$, $\}$, $|$ and \wedge) that correlate the elements of paradigmatic piles and their boundaries with the order of the words (O).

(3) { hooded | \wedge and armed } youngsters (Kahane et al., 2019, 74)

Those entities reify the limits of each pile in G . Configurationally, they interact with the rules related to the traditional inscription of O , because they appear on the same horizontal line. What makes it possible for O and E to be inscribed in the same dimension is the use of the space between words to reify elements that are not words. The reader must learn to interpret that curly braces function in pairs. Consequently, they allow for the inscription of recursive structures.

4 Joint inscriptions

The complete syntactic space S contains at least $D \cup O \cup E$ (notation: DOE). As illustrated in Subsection 3.3, traditional inscriptions of these subspaces in G often mix information from several of them, even if the focus is clearly on a single one. Diagrams are often grounded in polysemiotic systems (Hébert, 2020, 335 sv.): they express different contents according to different semiotic rules of interpretation. Consequently, diagrammatic inscriptions have to be built and interpreted by taking into account the relative *salience* of their components. Subsection 4.1 focuses on the joint inscription DO to illustrate that. On the other hand, joining the inscriptions of different subspaces on G allows for visual reasoning and visual investigations that take advantage of the polysemiotic environment (Subsection 4.2). In Subsection 4.3, I focus on the inscriptions of DO and DOE to show that not all representations are equivalent with respect to their exhibitiv efficiency.

4.1 Polysemiotics, efficiency and salience

Since the most early uses of diagrams that inscribe at least some part of the dependency structure (Mazzotta, 2020; Osborne, 2020), O has often been clearly separated from D . Tesnière's *Elements of structural*

syntax are often cited as an important milestone in this respect (2015, Chapters 6 and 7) and major approaches such as Meaning-Text Theory abstract word order away from their syntactic modules (Mel'čuk, 2021, Chapter 10, e.g.). However, for the sake of ergonomics or for theoretical reasons, some dependency linguists consistently inscribe *DO* in *G*. Several frequent ways to do it are illustrated in Fig. 4 and in (4).

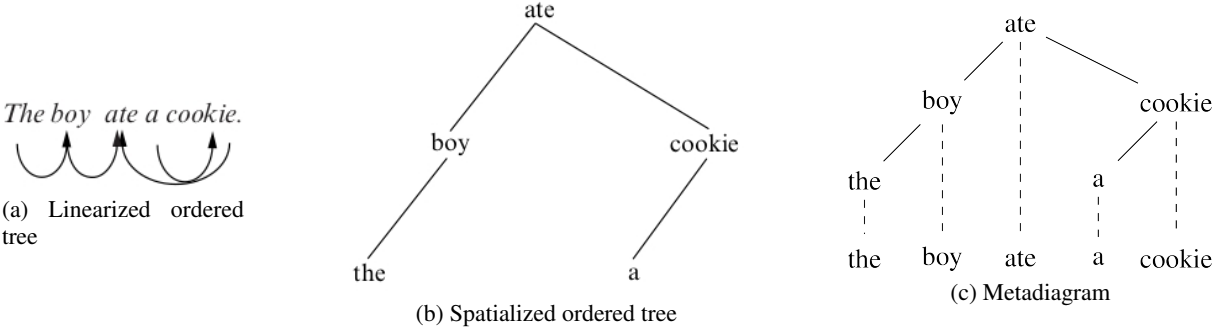


Figure 4: Alternative inscriptions of *DO*: (a) (Groß, 2003, 332); (b) (Groß, 2003, 332); (c) (Groß, 2003, 334), modified according to Osborne’s conventions (Osborne, 2019)

Fig. 4a illustrates a type of diagram that is extremely frequent for visualizing treebanks. However, for several scholars (Groß, 2003, 331) or (Osborne, 2019, 63), it lacks clarity. Indeed, the choice of one type of diagram or another depends on its *efficiency* with respect to the tasks/reading habits of the users (Bertin, 2005, 139), i.e. the relative speed at which they will be able to extract the piece of information they focus on. In Fig. 4a, the inscription of the hierarchy of syntactic dependencies (*D*) is made by the means of a symbolic reification: the arrowheads. The diagram makes a very restricted use of the vertical dimension, only to preserve the discreteness and readability of the arrows that reify them: the tree is linearized on one dimension. Therefore, the iconic inscription of the hierarchy that appears in Fig. 1 as well as in Fig. 4b and Fig. 4c is absent (hence the lack of clarity in Gross’s and Osborne’s opinion). The perception of the global structure of the dependencies is not the focal point of the diagram. From a phenomenological perspective, the inscription of *O* is more *salient* than the one of *D* (Hébert, 2020, 355-358).

Fig. 4b displays the opposite choice. Although the diagram also inscribes *DO*, the reader will find it difficult to extract *O*, because the graphical entities that reify the words are not aligned on a horizontal line. Instead, their position on the vertical axis depends on their status in *D*. The inscription of *D* is more salient since the tree is spacialized. If the intent of the reader is to access information related to *O*, the vertical dimension is not interesting. From a semiotic perspective, it consists only of *noise* (Hébert, 2020, 45).

Fig. 4c can be considered as a composition of one diagram containing only information from *O* and a diagram of the kind of Fig. 4b, where *D* is more salient. The saliences of both diagrams are similar, but the distance between them on *G* makes it possible for the reader to focus on either one aspect or the other. Fig. 4c can be classified as a *metadiagram*: on the one hand, both diagrams are represented conjointly, and, on the other hand, by reifying the projection of the words implied in *D* on the linear axis expressing *O* (Groß, 2003, 334), the dashed strokes perform as inscriptions of relations between diagrams. In this case, the inscription of *DO* in *G* overtly states the relations between the two subspaces of *S*.

While it is not very common, *DO* can also be inscribed using bracketing conventions (Osborne, 2019, 61-63), as illustrated in (4).

$$(4) \quad [[[the] boy] ate [[a] cookie]]$$

Bracketing introduces special entities (‘[’ and ‘]’) that inscribe *D* alongside *O* in the same horizontal dimension by means of configurational rules. The entities are interpreted in pairs as reifications of the limits of the dependency tree and its subtrees – similarly to the entities used in (3). Within each span

delimited by a pair of entities, the governing word is not surrounded by brackets. In such cases, word order is very salient, and the embedding of many subtrees can lead to difficulties in identifying each pair of entities. Moreover, since the brackets must appear within the same dimension as the chain of words that inscribes O , the diagram cannot express projectivity violations without the introduction of additional conventions, which are illustrated in the next subsection.

4.2 Heuristics and joint inscriptions

According to C.S. Peirce, diagrams make creative reasoning possible (Stjernfelt, 2007, 102-107). One way to use diagrams is to manipulate them in order to discover new properties of the concepts inscribed in them. From a practical perspective, one can either keep subspaces of S apart from each other, or decide to merge them in G . In this respect, decisions taken are constrained by the desired ergonomics and by representational habits, but they also depend on the objectives of the research program; e.g. describing the interferences between the subspaces.

The limitations of G can be exploited heuristically. The joint inscription of DO commented in Subsection 4.1 is a convenient way to visualize projectivity violation (Ihm and Lecerf, 1963, 10) (Fig. 5).

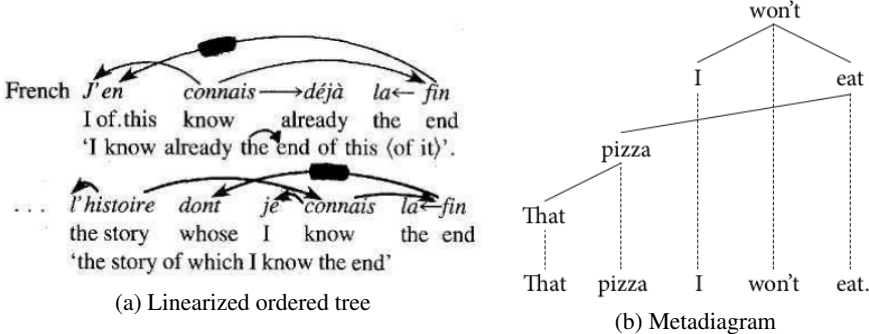


Figure 5: Heuristic use of inscriptions of DO : (a) (Mel’čuk, 1988, 37); (b) (Osborne, 2019, 204)

Fig. 5a makes use of conventions that are similar to the ones of Fig. 4a: both graphical dimensions are used to encode D : horizontally to encode the extremities of the dependencies and vertically to preserve the distinctiveness and the discreteness of the arrows. Since O is not inscribed in a separate graphical dimension, there is no way to prevent arrows from crossing each other in cases of projectivity violation. Non-projective structures can only be inscribed by crossing dependency arrows. In Fig. 5b (that follows the same conventions as Fig. 4c), projectivity violation are made even more explicit, since they correspond to the fact that dependency strokes cross the dashed lines that reify the correspondances between D and O . That is, due to the geometric properties of the plane, dependencies cross projection lines. The interaction is inscribed in a completely iconic way. Separate inscriptions do not contain that part of information on the data that emerges geometrically from their joint inscription.

4.3 Exhibititive efficiency

Diagrams allow graphical reasoning because the graphical inscription of syntactic contents *exhibits* structures and their interactions. The term *exhibit* corresponds to the fact that diagrams have purposely salient elements that are meant to be focalized by the reader, i.e. they have a rhetorical orientation. It is noteworthy to highlight that inscriptions such as Fig. 5 convey superfluous information for the reader who has no interest in projectivity: for them, lines crossing each other are undesirable noise. In such cases, diagrams exhibit information that the reader does not want to examine. As we have seen, the salience of the graphical entities and their configurations is more or less efficient in order to discover the linguistic properties of units pertaining to several subspaces of S .

Tesnière insists that O must be abstracted away from D and E . He suggests that coordinations and appositions are somewhat “orthogonal” to dependencies (Kahane, 2012). This orthogonality corresponds to a different dimension: Tesnière inscribes the part of E that corresponds to coordination directly in a

dependency structure that does not encode linear order.² In his view, coordination duplicates dependencies without affecting the valency of the governor (Tesnière, 2015, Chapter 135). Fig. 6 expresses this interaction between *D* and *E*.

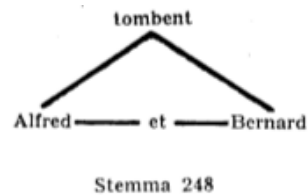


Figure 6: Inscription of *DE* (Tesnière, 1966)

The expression of *O* holds no theoretical basis and is only incidentally expressed (Mazziotta, 2019, 73). Hence, the diagram can use the horizontal dimension to inscribe two kinds of information: 1/ the distinction between elements from *D* (diagonal strokes are discrete and distinct from each other); 2/ the paradigmatic relation of *E* is reified by a horizontal stroke labeled with a conjunction.³ Tesnière's conventions exhibit the orthogonal nature of the relations between the two subspaces.

Following Tesnière, several attempts to encode *DE* and even *DOE* have been made. I will now focus on a sample selection and investigate their exhibitiv efficiency. For instance, Fig. 7 uses pseudo-tridimensional conventions to show that *D* and *E* belong to different planes.

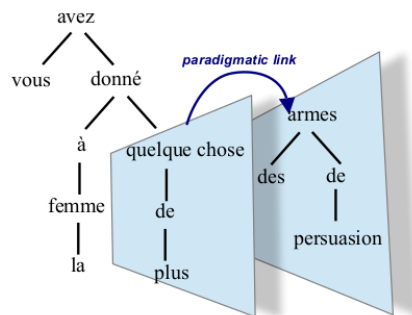


Figure 7: Inscription of *DE* (Kahane et al., 2019), original diagram provided by S. Kahane

Despite Fig. 7 being an hapax (such inscriptions are not generalized), it is crucial to my point: in this specific case, *DE* are inscribed, but the representational choices actually make *E* (front) more salient than *D* (back). The diagram exhibits the structure of equivalences, under the name of *paradigmatic piles*, precisely in a chapter that focuses on explaining the identification principles and the annotation procedures of paradigmatic piles. From a rhetorical perspective, the diagram is efficient.

Let us examine another case. Tesnière's diagrams are unable to assess recursion because the stroke that reifies the paradigmatic pile is spacialized on a single dimension. Osborne proposes diagrammatic conventions that solve this problem (2019, Chapters 10 and 11). He considers that the structure of *E* is actually constituency-based. Therefore, it justifies that the entities and configurations used to inscribe this subspace are different from the ones used to inscribe *D*: equivalences are reified by angled strokes and, with some redundancy (Hébert, 2020, 346-347), by squared brackets that interact with *O* as curly braces do in Fig.3.

The diagram simultaneously inscribes *DOE*: *O* and *D* are expressed as explained in Subsection 4.2; the entities used to express *E* obey configurational rules that make it possible to encode recursion. That kind of diagram, although it conveys a great amount of information, leaves to the reader the responsibility to

²Similar solutions had already been introduced by several American (Mazziotta, 2020) and German (Osborne, 2020) scholars in the 19th century.

³Tesnière explains that the conjunction is not connected to the conjuncts by two separate strokes: it labels a single stroke by interrupting it (Mazziotta, 2014).

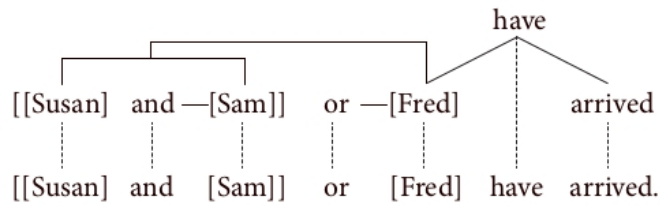


Figure 8: Inscription of *DOE* (Osborne, 2019, 323)

focus on various elements of similar salience. For instance, it expresses that the word *Fred* is part of *E* as well as a part of *D*, but it *does not exhibit it*. The reader has to navigate the diagram to evaluate it. They can understand by themselves that the perspective is not the same as Tesnière’s. Osborne considers that the members of equivalent relations are parallelized (2019, 324, in partic. note 247). Some conjuncts do not have an ancestor in the diagram: in such cases, the governor needs to be reconstructed by comparing other conjuncts until a governor is found. In Tesnière’s diagram, dependency strokes are multiplied (2015, Chapter 135), whereas in Osborne’s, they are not. None of this is purposely exhibited in the diagram.

Fig. 9 also inscribes simultaneously *DOE*, but the difference between *D* and *E* is symbolic. Arrows

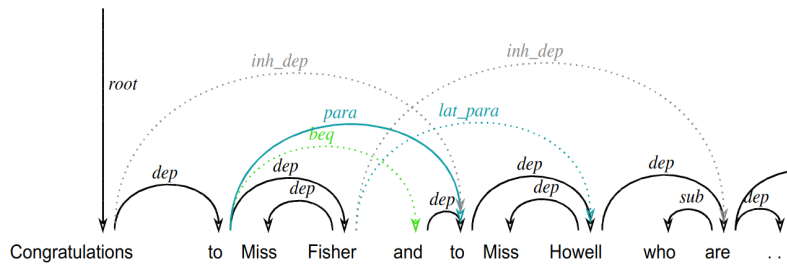


Figure 9: Inscription of *DOE* (Gerdes and Kahane, 2015)

are classified by the means of contrasts between colors and oppositions between plain and dotted strokes. Although all three subspaces are inscribed, if the objective of the reader is to process interactions between them, the diagram is even more cumbersome to handle than Fig. 4a is. However, it exhibits that subspaces can be efficiently encoded in a unique formalism from the perspective of the elaboration of treebanks.

As illustrated, there exist different ways to inscribe simultaneously the syntactic subspaces. However, even if information is similar in different diagrams, they do not exhibit the same contents. Since diagrams range from the most salience-neutral choices to the most rhetorically oriented, choosing between them in order to select the right one is crucial.

5 Conclusion

I have described the syntactic space (*S*) as a combination of three subspaces: dependencies (*D*), word order (*O*) and equivalences (*E*). In Section 3, I have introduced these subspaces and the diagrams frequently used to inscribe them in the graphical space (*G*). I have pointed out that, unless it is inscribed, *S* remains abstract and amorphous: one can model information only by communicating knowledge through an inscription. Graphical inscriptions of syntactic concepts combine graphical entities that reify conceptual units with configuration rules that govern the spatialization of those entities. They are genuine formalisms, relying on an inventory of units and rules that govern them.

On the other hand, the materiality of *G* greatly impacts how diagrams are elaborated and their practical exploitation. In Subsection 3.3, it became obvious that several subspaces of *S* are inscribed simultaneously in the same diagram. In Section 4, I have explored several cases of joint inscription of two or three subspaces in order to describe their heuristic power. Such diagrams pertain to polysemiotics that involve parts that can be contrasted with respect to their relative salience (Subsection 4.1). The polysemiotic

nature of the diagrams make it possible to discover new pieces of knowledge on the interactions between the subspaces of *S* (Subsection 4.2). In the last part (Subsection 4.3), I have insisted that diagrams are actually rhetorically directed by their exhibitivite intent. Consequently, they must be elaborated (and interpreted) by taking into account their practical use. Otherwise, they remain “noisy” inscriptions that transmit no relevant information.

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