THE LEXICAL CONSTRUCTIONAL MODEL MEETS SYNTAX: GUIDELINES OF THE FORMALIZED LEXICAL-CONSTRUCTIONAL MODEL (FL_CXG)

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Abstract: This paper offers the basic guidelines of a formalized version of the Lexical Constructional Model (LCM; Ruiz de Mendoza & Mairal Usón, 2008, 2011; Ruiz de Mendoza & Galera, 2014), the Formalized Lexical-Constructional Grammar (FL_CxG), which will pave the way for future computational developments, such as parsers or lexical databases. The FL_CxG deploys (i) the typologically oriented syntactic apparatus of Role and Reference Grammar (Van Valin, 2005; Van Valin & LaPolla, 1997), (ii) the catalogue of constructional units arranged in a 4-layer typology, as proposed by the LCM, and (iii) some insights for semantic representations from the Generative Lexicon Theory (Pustejovsky, 1995; Pustejovsky & Batiukova, 2019), and Minimal English (Goddard, 2018). All the components of the FL_CxG (lexical units and construct(ion)s) are formally encoded as Typed Feature Structures in the format of Attribute Value Matrixes. These units are to be understood as constraints operating in the unification processes which underlie the generation/decoding of a given fragment of language.

Key words: Lexical Constructional Model, Role and Reference Grammar, Unification grammars, Formal Lexical Constructional Grammar, Constructions.

1. INTRODUCTION

The Lexical Constructional Model (LCM; Ruiz de Mendoza & Mairal Usón, 2008, 2011; Ruiz de Mendoza & Galera, 2014) is a grammatical theory which seeks to provide explanations for the meaning intricacies of grammatical and lexical structures in a natural language. It is an integrative model since (a) it brings together constructs from both functionalist and cognitive approaches, especially from Role and Reference Grammar (RRG; Van Valin, 2005; Van Valin & LaPolla, 1997) and Construction Grammars; and (b) it incorporates all aspects of language, grammatical, semantic, pragmatic, and textual. However, neither the LCM nor RRG were initially designed for their computational implementation, and, therefore, no formal requirements are considered for the description of grammatical phenomena. The aim of this paper is to set up the basic guidelines of a formalized version of the LCM, the Formalized Lexical-Constructional Grammar (FL_CxG). Since the LCM incorporates insights from RRG at the level of core grammar, the FL_CxG can also be considered a formalized version of this model[1] which will pave the way for future computational developments, such as parsers or lexical databases.

As a matter of fact, the FL_CxG draws insights from different theories. It deploys (i) the functional and typologically oriented syntactic apparatus of RRG for the establishment of the set of Types and Feature structures that constitute the signature of this proposal, (ii) the catalogue of constructional units arranged in a 4-layer typology, as proposed by the LCM; (iii) the proposals for semantic representations from the Generative Lexicon Theory (Pustejovsky, 1995; Pustejovsky & Batiukova, 2019), and Minimal English (Goddard, 2018); and (iv) an extensive number of formalization features from unification grammars, specifically from Sign Based Construction Grammar (SBCG; Boas & Sag, 2012; Michaelis, 2013) and Head-Driven Phrase Structure Grammar (HPSG; Sag, Wasow & Bender, 2003; Müller et al., 2021).

As shall be described, all the components of the FL_CxG (lexical units and construct(ion)s) are formally encoded as Typed feature structures (Typed Fs) in the format of Attribute Value Matrixes (AVMs). All Typed Fs in the FL_CxG are to be understood as constraints operating in the unification processes which underlie the generation/decoding

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[1] There are other formalization proposals of RRG, among them: Diedrichsen (2014), Kallmeyer & Osswald (2017), Cortés-Rodríguez & Mairal Usón (2016), Nolan & Periñán-Pascual (2014), Nolan & Salem (2011), Osswald & Kallmeyer (2018), Van Valin & Mairal Usón (2014).

of a given fragment of language. Thus, the FL_CxG must be aligned within what we may call the Constructionist Space, and more specifically, it could be integrated in the group of Formal Grammars (FG; as termed by Sag, Boas & Kay, 2012:2), together with SBCG, Embodied Construction Grammar, or Fluid Construction Grammar.[2]

The FL_CxG shares with all these formal models a 'positive licensing strategy (ruling certain structures in)' as described by Michaelis (2013:34) according to which a grammar can be described as consisting of (Malouf, 2003:417) "a declarative set of constraints organized into a network, which mutually constrain the relationship between form and meaning". From this point of view, (ibid.) "(e)ach grammatical representation, rather than being the winner of a Darwinian competition [among rivals], is licensed by a set of constructions which cooperate to specify its properties". This approach is diametrically opposed to the Chomskyan grammar mechanisms of structure composition, which is based on a suppression strategy of pruning ('ruling out') potential structures by means of grammatical restrictions.

The Constructionist Space is not only occupied by the set of FGs, it also gives room to another research community: the TYP(ological) Construction Grammar (CxG). Sag, Boas & Kay (2012) characterize this research tradition in the following way:

> (TYP CxG) is concerned with descriptive observations of individual languages, with particularly concern for idiosyncrasies and complexities. Many TYP researchers eschew formal models (or leave their development to others), while others in this community refer to the theory as 'Construction Grammar'. (Sag, Boas & Kay, 2012:1)

This community agglutinates a wide array of proposals: Langacker's (2005, 2009b, a) Cognitive Grammar, Goldbergian analyses (Goldberg, 1995, 2006, a.o.), or Croft's (2001, 2012) Radical Construction Grammar. It is in this group that the LCM should also be located.

The common denominator of both FGs and TYP CxGs is the use of constructions as the central objects in grammatical analysis, even though their conception of what a construction is may diverge significantly among theories. What distinguishes both groups is the fact that TYP CxGs tend to avoid formal descriptions, and mostly concentrate on observing particular languages and providing quite complex descriptions of grammatical phenomena, whereas FG research (Boas & Sag, 2012:2-3) "has led to a mathematically grounded understanding of the relevant mathematical properties of various FG formalisms, as well as to computational implementations of significant fragments of natural languages". Despite this, TYP CxG and FGs are not separate fields, quite on the contrary, the computational formalization of some grammatical aspects may be seen as a further support for the theoretical assumptions and descriptions offered from the TYP CxG literature. This has been explicitly stated by different researchers from the FG camp, e.g. Sag, Boas and Kay (2012:3) state that "[p]erhaps the most important goal of … (SBCG) is to provide a formalized framework in which TYP [ological CxG] researchers can develop their ideas". In a similar vein, Steels (2011) remarks that Fluid Construction Grammar (emphasis is ours):

> […] does not want to commit to specific opinions about how certain grammatical phenomena need to be handled. Instead, it wants to be *an open instrument that can be used by construction grammarians* who want to formulate their intuitions and data in a precise way and *who want to test the implications of their grammar designs for language parsing, production and learning* (Steels, 2011:3).

The relation that holds between the LCM and the model that we propose should be understood within this frame of action. Whereas the LCM is a model which can naturally be located in the CxG spectrum, our proposal can be viewed as its FG counterpart – or more adequately, as a formalized extension – of the LCM, as is also the case with other unification grammars and their relationship with constructionist models.

Once the relationship of the FL_CxG and the LCM has been set, and their place within the gamut of constructionist models is also established, the remainder of this paper will spell out the basic principles and components of the FL_CxG. In order to do so, Section 2 offers a view of the general architecture of the LCM, which distinguishes a 4-tier classification of constructional structures. In Section 3, the guiding principles of the FL_CxG are expounded; special emphasis is given to the assimilation of the fundamental features of grammatical description from RRG into our proposal. Section 4 offers detailed descriptions of the different types of grammatical objects that form the backbone of our model. More specifically, a description is given of the way lexical and combinatory and non-combinatory constructional units are encoded. A detailed analysis of some linguistic entities (sentences, clauses, and phrases) is also provided. The paper is rounded off with some conclusions and future prospects in section 5.

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[2]   Note that 'Formal Grammar' does not refer here to the Chomskyan research tradition, as is usually employed in the classification of linguistic models. Sag, Boas & Kay (2012:1-5) use the term Universal Grammar (UG) for these models, and consider it a third differentiated research community.

2. THE LCM: AN OVERVIEW

The FL_CxG stems from the idea of endowing the LCM with a syntactic apparatus which, in turn, has a sufficient degree of formalization as to be further used for the development of different computational software devices involving language processing.

The LCM is a meaning construction model which accounts for the way in which meaning construction processes take place, at all descriptive levels, and considers the contribution of lexical, pragmatic, constructional and conceptual mechanisms in these processes. However, one issue pending development in the LCM is the establishment of a set of guidelines for the description of the morphosyntactic realization of those fully worked out meaning representations.

As can be seen in Figure 1, the first step in meaning construction in the LCM involves the interaction of lexical information and argument-structure (or Level 1) constructions at what has been termed the core grammar level. The semantics of lexical entries is encoded in lexical templates (LTs). The notion of LT is originally a development of the logical structures (LS) postulated in Role and Reference Grammar (RRG) (cf. Van Valin & LaPolla, 1997; Van Valin, 2005). In turn, LS are based on Vendler's *Aktionsart* distinctions (cf. Vendler, 1967) plus additional semantic information to characterize the peculiarities of each lexical item. This semantic information is retrieved from a set of semantic undefinables obtained from different sources, as are the set of archiunits proposed as definiens of extensive lexical domains in Faber and Mairal Usón (1999) and the primes from Wierzbicka's *Natural Semantic Metalanguage*, which has been shown to be valid in almost over a hundred languages (cf. Wierzbicka, 1999; Goddard & Wierzbicka, 1994, 2002).

In addition to this, the semantic representation of Level 1 argumental constructions makes use of the same high-level representational mechanisms that characterize lexical templates, except for the semantic specificities of lexical entries, since these are idiosyncratic to each verb and verb class. This feature of construction templates (CTs) is logical, since Level 1 constructions are built by abstracting away elements common to a number of lower-level predicate classes. Additionally, this guarantees that the integration between both types of structures occurs harmoniously and conforms to the Equipollence Hypothesis, according to which (Ruiz de Mendoza & Galera, 2014: 29) "linguistic processes that have been attested in one domain of linguistic enquiry may also be at least partially active in other domains".

The LCM recognizes the existence of three further constructional structures of different higher conceptual levels:

a. Level 2, or implicational constructions (such as 'Do I look like X', as in *Do I look like I'm happy?*), which describe low-level situational cognitive models (or specific scenarios), giving rise to meaning interpretations which carry a heavily conventionalized implication;

b. Level 3 deals with illocutionary constructions (e.g. 'Can you X', as in *Can you pay attention to what I'm saying?*), which are means of encoding high-level situational models (or generic scenarios); and

c. Level 4, or discourse constructions, based on high-level non-situational cognitive models (such as reason-result or condition-consequence; e.g. *Just because something is natural does not mean it is safe*), with particular emphasis on cohesion and coherence phenomena.

The interaction of LTs and argumental CTs yields the core or central meaning layer on which two peripheral cognitive processes can be applied in order to attain fully worked out representations. Such processes are conceptual cueing (or inferential cognitive activity in cases of underspecified structures like *we're fully prepared [for whatever may come]*) and constructional subsumption (or integration of lower level semantic structures into higher level constructions); e.g. the interpretation of *Who do you think you're talking to?* as a warning for the addressee to change his course of action involves the subsumption of the interrogative structure into the heavily conventionalized Level 2-constructional pattern 'Who Do You Think You're X?' used by the speaker to challenge the addressee's inappropriate behavior in ways which affects the speaker negatively. The integration of lower-to-higher level structures is constrained by the Override Principle (Michaelis, 2003), according to which lower level constructional structures must conform to the meaning of higher level ones. In Cortés-Rodríguez (2009) an Extended Override Principle was proposed, extending the effect of coercion to the grammatical contour. In section 4.2 we will see how this principle applies to the analysis of middle constructions.
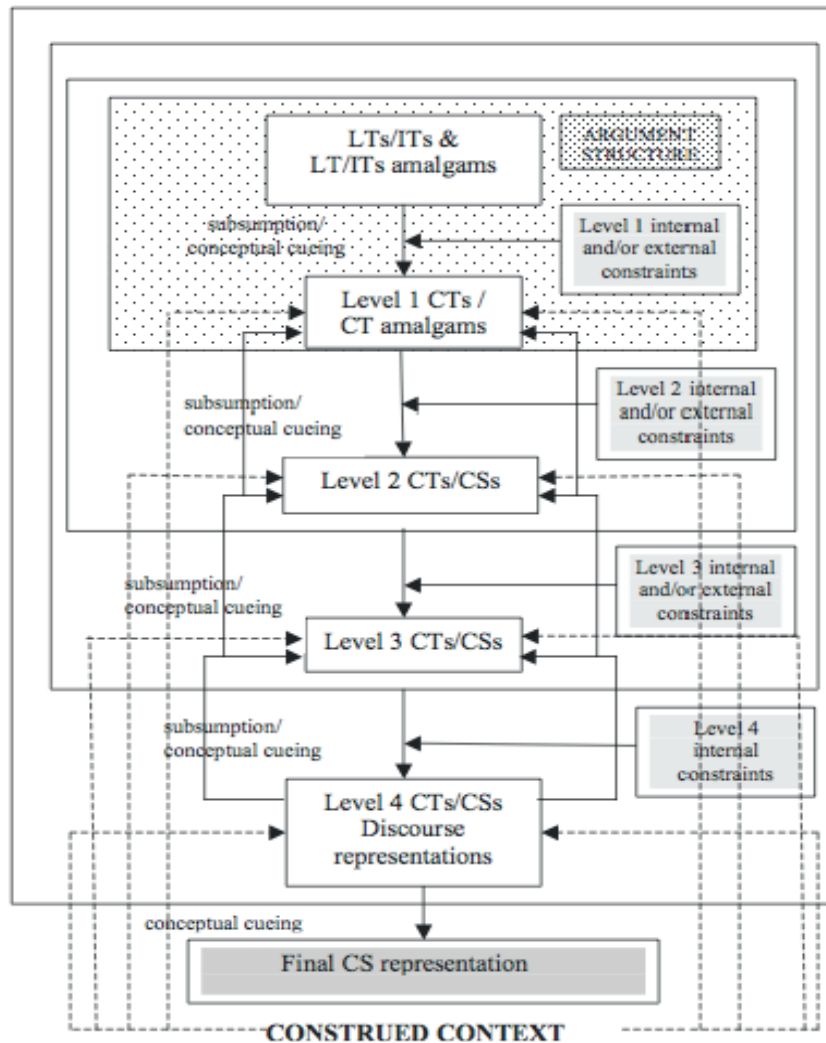
Figure 1. The Lexical-Constructional Model (Ruiz de Mendoza & Mairal Usón, 2007).
LT: Lexical Template; CT: Constructional Template; CS: Conceptual Structure.

Although the LCM provides us with very robust tools for the description of the semantics of lexical and constructional structures, they are, however, insufficient to attain an exhaustive understanding of a piece of natural language. To achieve this goal, it is crucial to consider not just the source of the meaning components of a linguistic fragment, or a sentence, but the processes involved in the generation of such sentences. To be more precise, neither the lexicon nor the 4-tier constructions as described in this model are sufficient to carry out the tasks of a grammar. In other words, apart from an organized storehouse of lexical and constructional units and the cognitive operations that explain their interaction at the conceptual level, it is necessary to develop an interface that enables the connection between the lexicon and the constructicon with morphological, syntactic, and phonological structures. Then, once this is accomplished, we can properly speak of a grammar. In order to attain this goal, the fact that the LCM already incorporates insights not only from constructionist theories but also from RRG will be especially useful, as it will allow us to assimilate a significant number of its syntactic descriptions into a formalized rubric.

In sum, our proposal seeks to fill this gap by developing a constructional unification-based grammar amenable to subsequent computational applications. The next section will offer a general overview of the formal grammar put forward in this paper.

3. OUTLINE OF THE FL_CXG

Any attempt of formalization must, firstly, consider which formal objects will be used for its descriptions. Similar to models like Sign-Based Construction Grammar (SBCG; Sag, Boas & Kay, 2012) and Head-Driven Phrase Structure Grammar (HPSG; Pollard & Sag, 1994; Müller et al., 2021), the FL_CxG makes a systematic use of feature-based

representations. Accordingly, all the components of the grammar (constructions and constructs) are formally encoded as Typed feature structures (Typed Fs) with the format of Attribute Value Matrixes (AVMs).[3] Typed Fs are then to be understood as constraints operating in the unification processes which underlie a given fragment of language. Their general format is as follows:
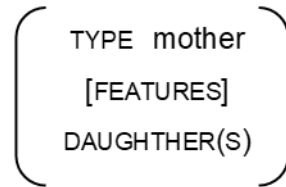
$$
\begin{bmatrix}
\text{TYPE} & \text{mother} \\
\text{[FEATURES]} \\
\text{DAUGHTHER(S)}
\end{bmatrix}
$$

Figure 2. Typed Fs in FL_CxG.

As the figure summarizes, a grammatical object in the FL_CxG will at least include a description of: (i) its type, (ii) a (number of) attribute(s) or features, and (iii) its immediate constituents (daughter nodes). Much like signs are conceived in SBCG (Michaelis, 2013:2), Typed Fs can be described as local trees. The local tree representation of a Typed Fs is as follows:
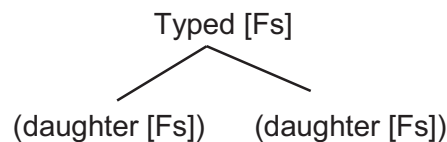
Typed [Fs]

(daughter [Fs])   (daughter [Fs])

Figure 3. Typed Fs as local trees.

The condition of localism does not preclude the possibility of capturing non-local relations. Distal phenomena are formally encoded as a succession of local relations within a given AVM. For a more detailed explanation see section 4 below, in which an account of non-local subject-verb agreement is provided.

The FL_CxG has been designed for the analysis of the *linguistic entities* or expressions of a given natural language. A linguistic entity is grammatically described by a fully saturated AVM, that is, by means an AVM in which all attributes have a specific value. The most basic linguistic entities are lexical units (words) and the highest ones are complex sentences, while phrases occupy an intermediate position. As an example of the description of a basic linguistic entity, the following figure shows the AVM for the English possessive determiner (DETP) *my*:

my

$$
\begin{bmatrix}
\text{TYPE} & \textit{possessive.word.} \\
\text{PHON} & [\text{´mai}] \\
\text{FORM} & \langle my \rangle \\
\text{CAT} & \text{DETP} \\
\text{OPERATORS} & \begin{bmatrix} \text{def = d} \\ \text{num = sg} \\ \text{per = 1} \end{bmatrix}
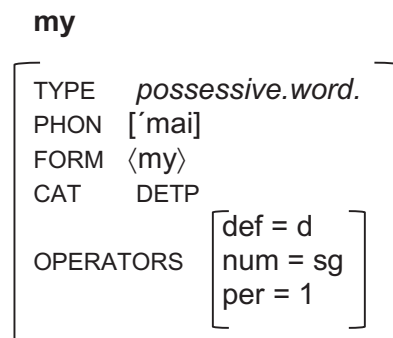\end{bmatrix}
$$

Figure 4. AVM for the possessive *my*.

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[3]   Pustejovsky & Batiukova (2019:151): "A feature structure is a way of identifying any kind of object as having different attributes, each of which has a distinct value".

Since the FL_CxG needs to provide an accurate analysis of phrases, sentences and sentence complexes, it must include all those grammatical objects which are necessary for an effective processing of such linguistic entities. Grammatical objects are also described as Typed Fs in which some or all of its attributes are not fully saturated by a specific value. Even simpler grammatical objects like functional word categories involve a number of features (cf. Cortés-Rodríguez, 2021:98); as an example, in Figure 5 the AVM for the lexical category DETP (possessive determiner) is provided:
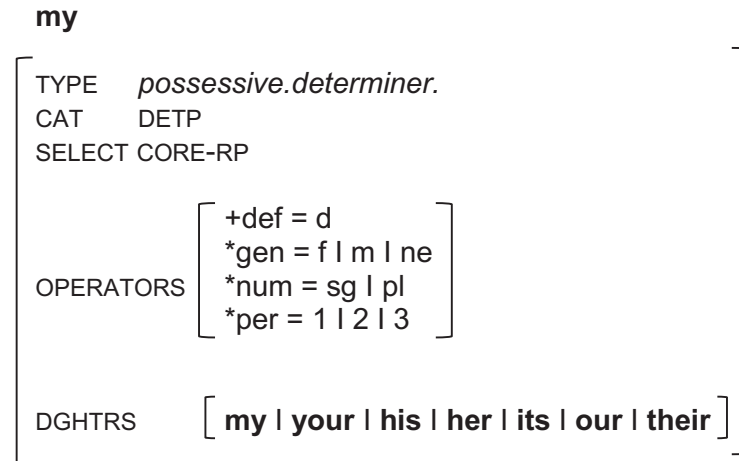
my

$$
\begin{bmatrix}
\text{TYPE} & \textit{possessive.determiner.} \\
\text{CAT} & \text{DETP} \\
\text{SELECT} & \text{CORE-RP} \\
\\
\text{OPERATORS} & \begin{bmatrix} +\text{def} = \text{d} \\ *\text{gen} = \text{f} \mid \text{m} \mid \text{ne} \\ *\text{num} = \text{sg} \mid \text{pl} \\ *\text{per} = 1 \mid 2 \mid 3 \end{bmatrix} \\
\\
\text{DGHTRS} & \begin{bmatrix} \textbf{my} \mid \textbf{your} \mid \textbf{his} \mid \textbf{her} \mid \textbf{its} \mid \textbf{our} \mid \textbf{their} \end{bmatrix}
\end{bmatrix}
$$

Figure 5. AVM for DETP category.

This AVM can help us illustrate the kind of information we can provide about functional words. Thus, the TYPE attribute assigns the label of the grammatical object formalized in the AVM. This label is part of a lattice-structure classification of the grammatical units, those which constitute the objects of the grammar's signature.[4] CAT refers to the functional category of the grammatical object; take, for instance, a linguistic entity like *the crooked house* in a sentence such as *the crooked house fell down to pieces*. Such an entity will be described formally as a TYPE of noun phrase but, since the grammatical object is also endowed with a functional status, following the premises of RRG, it will present the CAT value RP (that is, referential phrase). OPERATORS is a complex attribute which encompasses further attributes encoding the morphological features inherent to this grammatical object, here: definiteness and person (marked with a + symbol as they cannot be left unsaturated), and gender and number (marked as optional with the * symbol). Note that, except for the definiteness attribute, which is already saturated by a d (definite) value, all other attributes indicate an open set of value possibilities; e.g. 1st, 2nd, and 3rd for person; sg (singular) and pl (plural) for number; f (feminine), m (masculine) and n (neuter) for gender. Finally, since this is an AVM for a type of closed-class lexical units, the DAUGHTERS attribute provides the set of members which can instantiate this functional class. A detailed explanation of the OPERATORS and SELECT attributes will be offered in the following sections.

A distinguishing property of the FL_CxG in comparison with other unification models such as SBCG or HPSG, is the source and nature of several attributes of its Typed Fs. As already pointed out, the model integrates as part of its signature the components of the analysis of clauses, phrases and lexical units from RRG but there are two outstanding properties the FL_CxG inherits from this model: (i) grammatical structures are explained from a functional and communicative perspective, and (ii) grammatical structures are described from a strong typologically adequate stance. To these, a third feature must be added: (iii) the relevance of non-propositional aspects in the construction of meaning, in accordance with the insights of the LCM. In fact, the FL_CxG assumes the 4-tier typology of constructions, giving space to pragmatic and even textual features in its analyses.

Let us briefly consider which units from RRG are central in the signature of the FL_CxG. In RRG, clauses and phrases are syntactically represented by hierarchical structures, namely, by means of the layered structure of clauses (LSC) and the layered structure of phrases, respectively. Each of these structures consists of two different projections; a constituent projection and an operator projection. Thus, the LSC of a sentence like *My brother was washing some clothes in the garden* is analyzed in the following way:

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[4] The signature of a grammar is made up of (i) the type of objects, (ii) their hierarchical arrangement, and (iii) the nature and definition of their features (cf. Müller, 2016:207; Van Trijp, 2013).
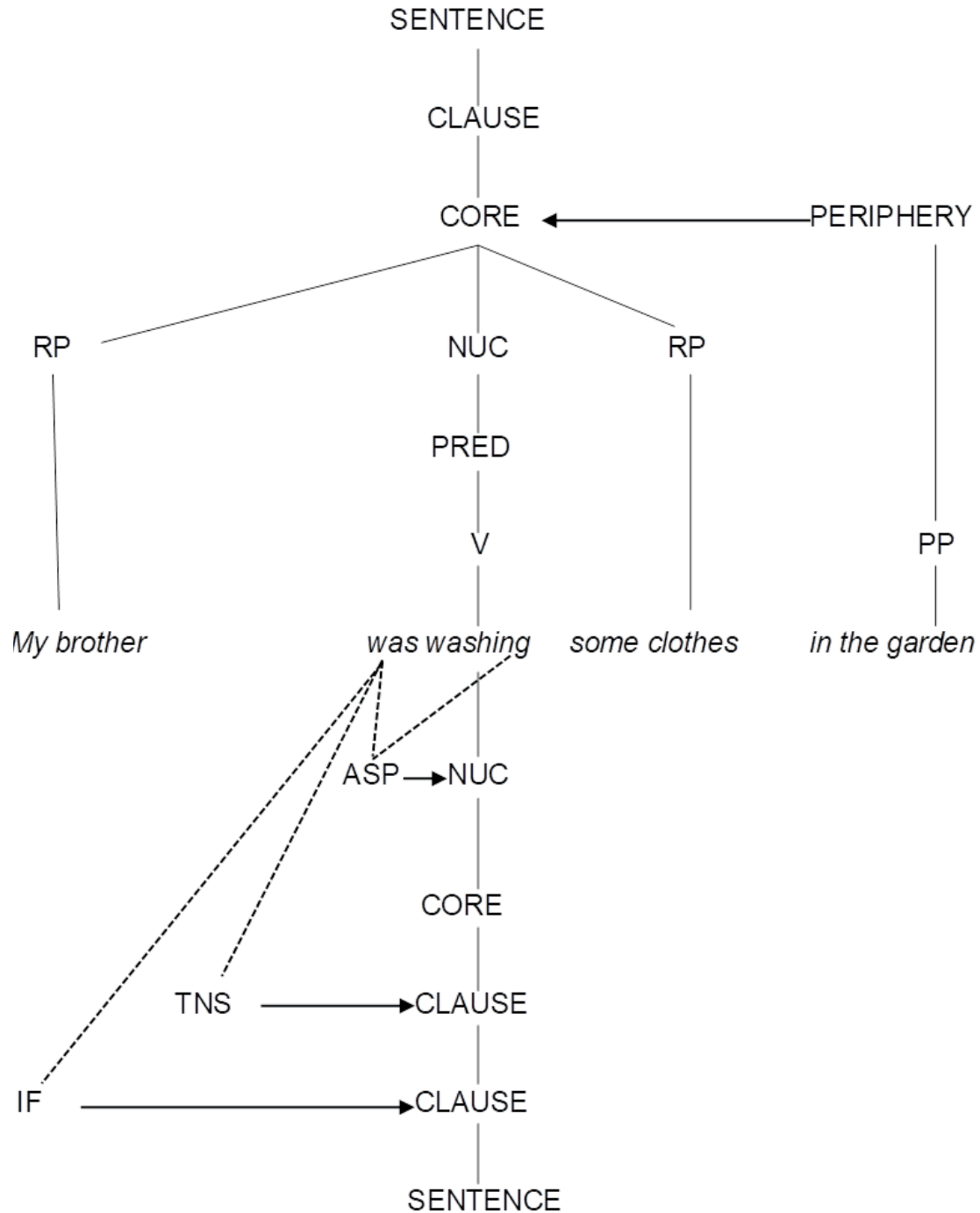
Figure 6. The LSC in RRG.

The constituent projection houses predicating and non-predicating units, both obligatory and optional. The NUCLEUS houses the PREDICATE (usually a verb); the CORE includes both the NUCLEUS and the ARGUMENTS of the predicate, and the PERIPHERIES are the default locus for non-arguments or ADJUNCTS. They are marked by arrows instead of branches to mark their status as modifiers of the respective layers. Some additional pragmatically marked nodes are the PRE-CORE SLOT (Pr-Cs) in which question words appear in languages in which they do not occur *in situ*, e.g. English, Spanish, and also some fronted elements in sentences like *Her attitude I hate*, and DETACHED POSITIONS, in which sentence initial and final constituents, are placed. They are set off from the rest of the clause by a pause, as is the case of the adverb in *Yesterday, I sold the cottage*. Note that in the sentence in Figure 6 above, auxiliaries and functional morphemes are analyzed separately as operators in a different projection modifying the different layers of the clause.

The formalization of these units and the integration of constructional elements involves some necessary modifications, as are: (a) the introduction of a CONSTRUCTION layer between the CORE and the CLAUSE to give room to the contribution of constructional units in the processing of sentences; (b) the reanalysis of peripheral units as subconstituents of the layer affected by them.[5] A simplified tree representation of the sentence *My brother was washing some clothes in the garden* incorporating these changes would be as follows:
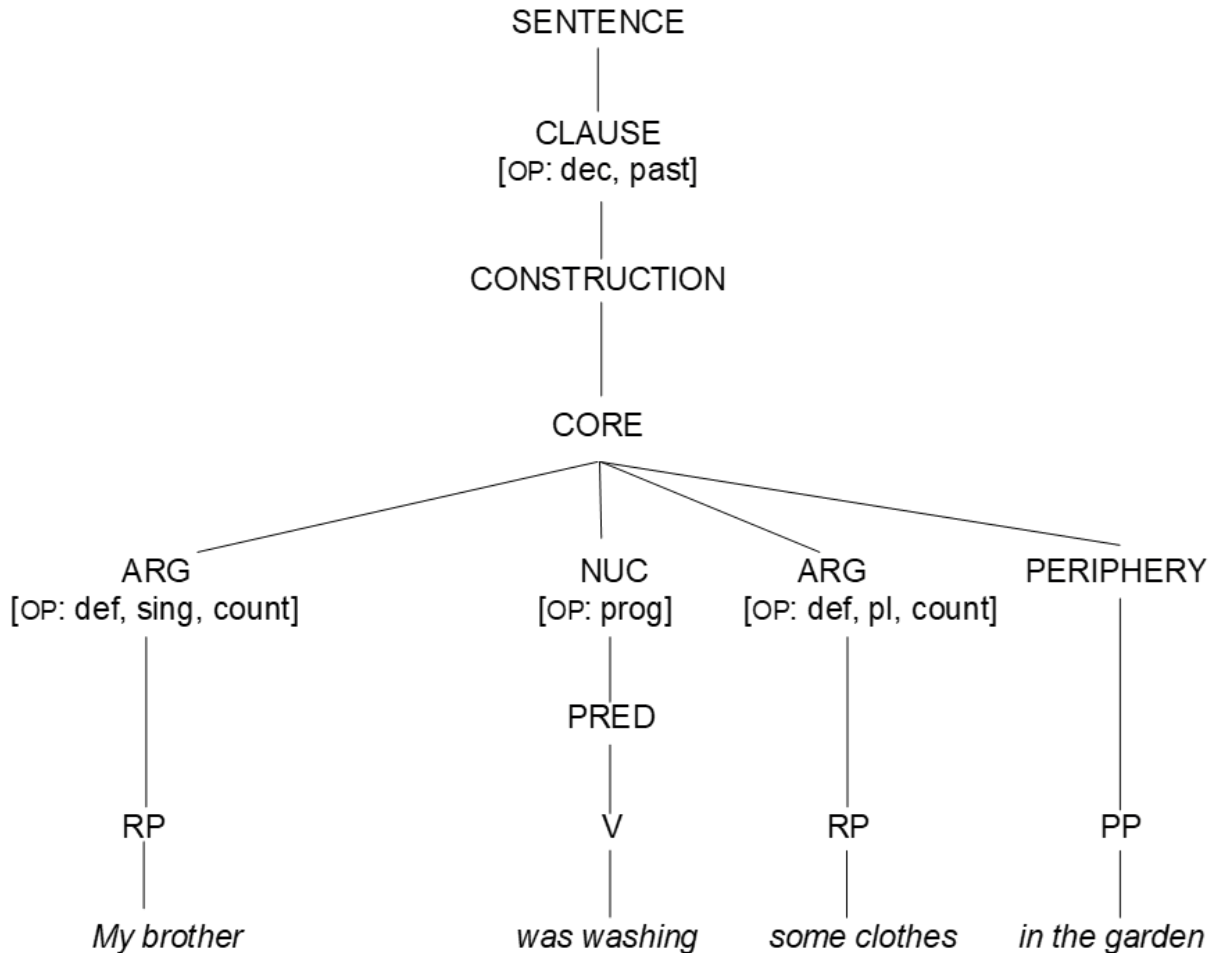

Figure 7. The LSC in FL_CxG.

A third fundamental modification of the original RRG analysis is the fact that the operator projections in clauses and phrases are dispensed with once the different syntactic nodes are conceived as grammatical objects (Typed Fs) endowed with their respective AVMs. The following figure illustrates the new format (as a Typed Fs) of the CORE node corresponding to the sentence analyzed above:

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[5] A similar approach is adopted by Kallmeyer and Osswald (2017), and Osswald and Kallmeyer (2018) where peripheries are treated also as subconstituents in their formalization of RRG under a Tree Adjoining Grammar format. This proposal makes use of a sister adjunction operation to their tree templates. A similar strategy can be adopted in our model provided that the Fs for peripheries include information of the layer they modify, which can be done by making use of a mod (modifies) attribute and tagging as proposed in HPSG contexts (cf. Abeillé & Borsley, 2021:29-30).
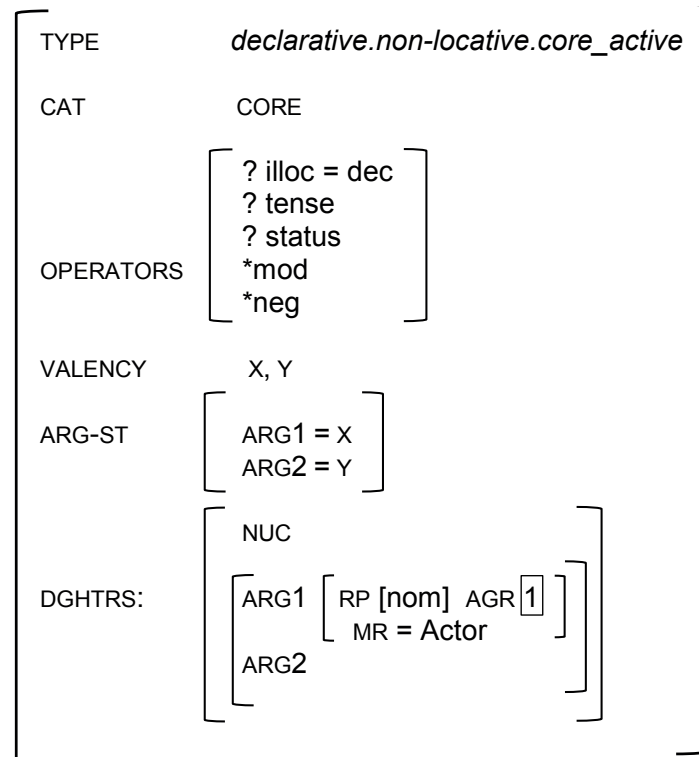
$$
\begin{bmatrix}
\text{TYPE} & \textit{declarative.non-locative.core\_active} \\[4pt]
\text{CAT} & \text{CORE} \\[4pt]
\text{OPERATORS} & \begin{bmatrix} \text{? illoc = dec} \\ \text{? tense} \\ \text{? status} \\ \text{*mod} \\ \text{*neg} \end{bmatrix} \\[20pt]
\text{VALENCY} & \text{X, Y} \\[4pt]
\text{ARG-ST} & \begin{bmatrix} \text{ARG1 = X} \\ \text{ARG2 = Y} \end{bmatrix} \\[12pt]
\text{DGHTRS:} & \begin{bmatrix} \text{NUC} \\ \text{ARG1} \begin{bmatrix} \text{RP [nom]} & \text{AGR} \boxed{1} \\ \text{MR = Actor} \end{bmatrix} \\ \text{ARG2} \end{bmatrix}
\end{bmatrix}
$$

Figure 8. CORE as a Typed FS. [6]

Notice that in this Typed Fs some of the attributes are left unspecified, while others are saturated with a value introduced by an (=) or 'equals to' symbol. This notational convention is used to provide definitions of different units, which are stated in terms of a closed set of attributes with a specific value. The following feature description by Sag, Wasow and Bender (2003:63) illustrates this:

$$
\text{NP} = \begin{bmatrix} \textit{phrase} \\ \text{HEAD} \quad \textit{noun} \end{bmatrix}
$$

This Fs can be interpreted as a definition of the NP category ('An NP equals to a phrase structure with a noun as Head'). This symbol is also used to state specific constraints which are captured by an atomic value of a given attribute, as happens in the AVM above, where it the illocutionary force for this Type of CORE has to be declarative (dec).

Another use of the (=) symbol refers to cases in which two attributes are necessarily described as identical. This often happens between the elements provided in the VALENCY and those of the ARG-ST. The VALENCY attribute refers to the number of entities that are logically involved in the semantics of a given structure; ARG-ST refers to the syntactic arguments of a given construct (see the description of the lexical entry for the verb *wash* in Figure 10 for a more detailed description of this attribute). Both attributes have frequently corresponding values, as happens in the Typed FS in Figure 11, which formalizes a type of declarative CORE. There are, however, some structures which present a mismatch between the values of these two attributes, this, for instance, is the case of imperative clauses, where the first element of the ARG-ST is left unexpressed (e.g. *Bring the tools*). Another important set of symbols is boxed numerals or 'tags'. As is standard practice in some programming languages or in logical algebra (Sag et al., 2003:56), boxed numerals indicate that two values within a Fs are identical.

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[6] In this AVM for the CORE we need to specify that we are describing a non-locative predication. In locative predications the alignment between valency and arg-st is different (arg1 = y) as it triggers a different assignment of macrorole status (locative predications are macrorole intransitive and assign undergoer, which in turn becomes subject and triggers AGR, that is, agreement).

4. GRAMMATICAL OBJECTS: TYPED FS, LEXICAL UNITS, COMBINATORY AND NON-COMBINATORY CONSTRUCTIONS

The representation of the CORE as a Typed Fs presented in Figure 8 is also a good illustration of the strategy adopted within the FL_CxG for the formalization of the constituents of both clausal and phrasal structures. All the nodes in any grammatical analysis based on RRG have been formalized as a collection of Typed FS, where each one captures the sets of attribute-value features relevant for every node in the Layered Structures of Clauses and Phrases, being operators a subset of these attributes.

It is worth noticing that the Typed Fs for the grammatical constituents are not fully saturated linguistic entities (i.e., they are not specific clauses or phrases), since some of their attributes are either unfilled with a specific value or are pending to re-entrancy operations via unification into higher constructs. This is the case of the illocutionary force and tense operators in the AVM for the NUCLEUS *was washing* of the sentence *My brother was washing some clothes* in Figure 9.
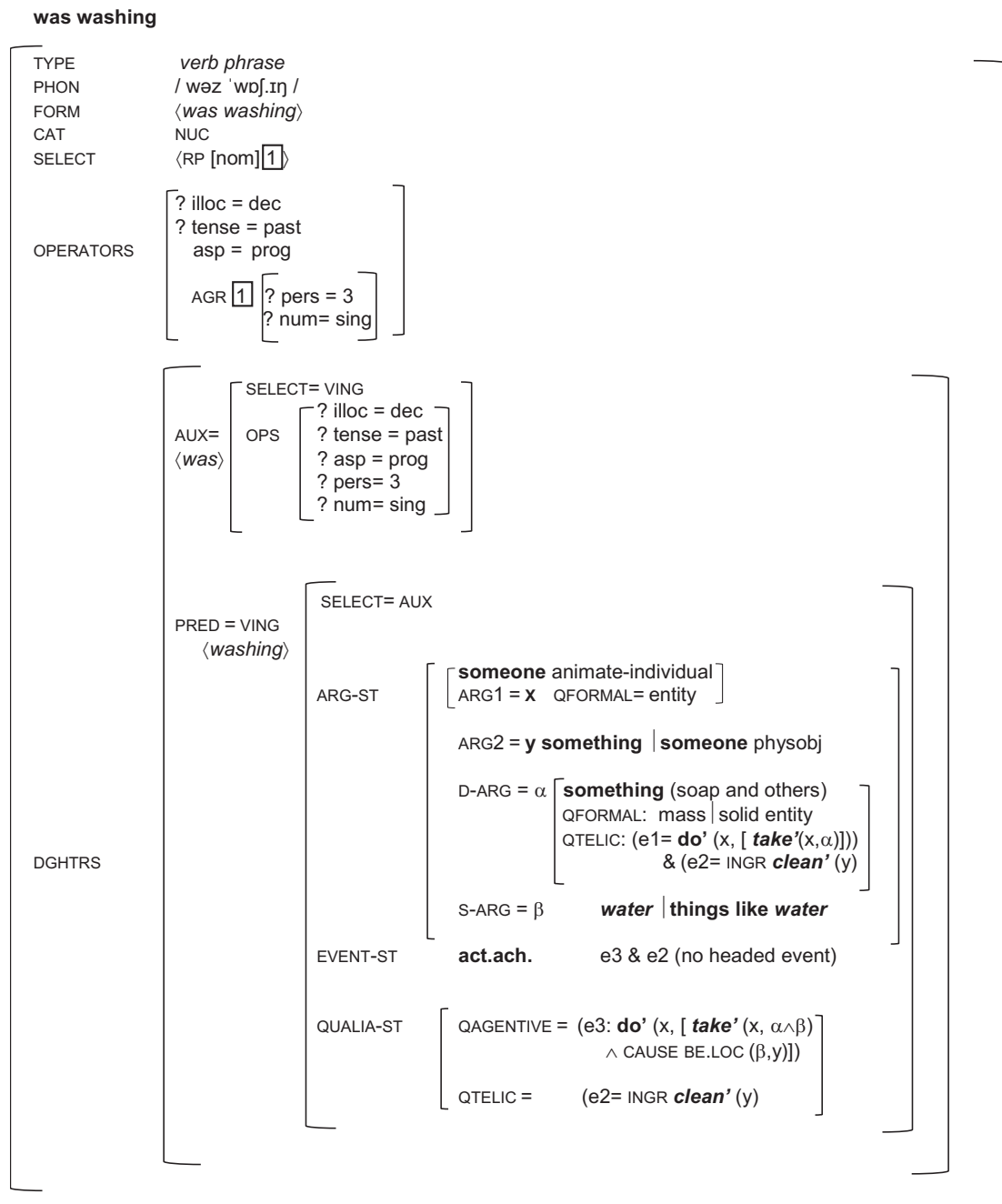

Figure 9. NUCLEUS as a Typed Fs.

Notice how the illocutionary force (illoc) and tense values in this Fs are considered as transient features because they will percolate up to the clause level, which is the higher node affected by their scope. Transiency is marked with the symbol ?; as mentioned previously, operators may also be marked as optional (with the symbol *) or obligatory (with a + symbol). Once they are saturated with a value for a specific structure, these symbols are deleted. The SELECT attribute expresses the selection of nonlocal units for certain grammatical phenomena such as case assignment or agreement. A lexical head selects nonlocal elements from its subconstituents via certain attributes like ARG-ST or AGR. The idea behind this is that a Fs not only needs to make a statement about its daughters, but it may also capture distal relations. These non-local relations have to be expressed in such a way that they are accessible locally by successive structural levels. In the AVM for the NUCLEUS *was washing*, the SELECT attribute indicates that this constituent shows agreement with an RP in the next higher Typed Fs CORE once they are unified as its daughters. Similarly, the two subconstituents of the AVM, that is, AUX and PRED, express in their SELECT attribute the fact that they each binds the other (i.e. its sister constituent) to yield a verb in progressive form as a NUCLEUS.

Other relevant attributes are ARG-ST (Argument structure), EVENT-ST (event structure) and QUALIA-ST (qualia structure), which together provide the syntactic and semantic contour of grammatical objects. The AVM in Figure 10, which encodes the lexical entry of the verb *wash*, will be of help to illustrate these attributes:

wash

TYPE   *trans-v-lxm*
PHON   /ˈwɒʃ /
FORM   ⟨*wash*⟩

ARG-ST

ARG1 = **x**
    someone animate-individual
    FORMAL= entity

ARG2 = **y**
    something │**someone** physobj

D-ARG = α
    something (soap and others)
    FORMAL = mass│solid entity
    TELIC = (e1: **do'** (x, [*take'* (x, α)])) & (e2: INGR *clean'* (y)

S-ARG = β
    water │**things like** *water*

EVENT-ST   **act.ach.**   e3 & e2 (no headed event)

QUALIA-ST
AGENTIVE =   (e3: **do'** (x, [*take'* (x, $\alpha \wedge \beta$)$\wedge$ CAUSE BE.LOC (β,y)])
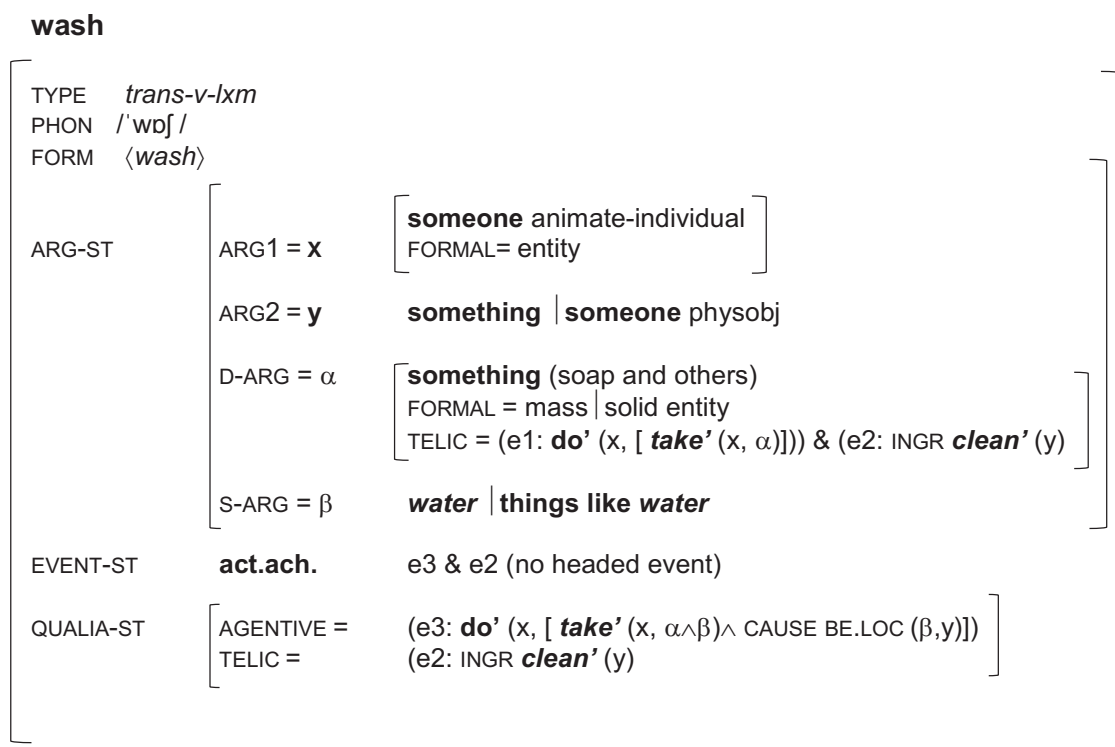TELIC =   (e2: INGR *clean'* (y)

Figure 10. AVM for the lexeme wash.

The characterization of the syntactic and semantic features of content lexical units is very close to the proposal from the Generative Lexicon Theory (Pustejovsky, 1995; Pustejovsky & Batiukova, 2019, among others). Following this theory, the lexicon is conceived in the FL_CxG as a computational system involving several levels of representation (cf. Pustejovsky, 1995:70), namely:

(i)   Argument structure (ARG-ST): number and type of logical arguments, and how they are realized syntactically;

(ii)   Event structure (EVENT-ST): Aktionsart characterization in terms of the typology from RRG; and

(iii)   Qualia structure (QUALIA-ST): modes of explanation; which include Formal, Constitutive, Agentive and Telic roles. According to Pustejovsky and Batiukova (2919), these express:

> four aspects that make up our knowledge of a word: the class of entities it denotes (the formal role or quale), how the denoted entity was created (the agentive role), the intended function of this entity (the telic role) and the internal makeup of this entity (the constitutive role) (Pustejovsky & Batiukova, 2019:162).

Van Valin and LaPolla (1997:184-186) already incorporated Qualia theory as part of the semantic representation of nouns within RRG.

These different levels of representation are expressed in Attributes within the lexical entry. ARG-ST is a complex attribute which may comprise three other types of Attributes: ARG (True Arguments), which are syntactically realized; D-ARG (Default arguments: entities that participate in the expression of the qualia, but which are not necessarily expressed. This is the case of 'soap' or any cleaning object in relation to the verb *wash*) and S-ARG (Shadow arguments), which are part of the semantics of the lexical unit (as is the case of 'water' or 'liquids' in the content of *wash*, 'to clean with water or other liquid'), but are not expressed in the syntactic structure unless they are subject to a given discourse requirement or any subtyping operation; e.g. *I washed the lingerie **in boiling water***. QUALIA-ST also includes other four possible attributes, each corresponding to one quale.

The Values for all the Attributes under ARG-ST, EVENT-ST and QUALIA-ST involve semantic descriptors. In order to attain maximal translatability (and even typological standardization), semantic descriptions are provided (to a significant extent) by means of semantic primes from the Natural Semantic Metalanguage (NSM; Goddard & Wierzbicka, 2018) and semantic molecules from Minimal English (Goddard, 2018), which is an extension of NSM designed as a tool to help people to express *their thoughts in a way that makes it easier to discuss them across a language barrier* (Goddard & Wierzbicka, 2018:6).

Minimal English is a reduced version of English that can find its equivalent in a shared core vocabulary (and syntax) of all languages. Terms in boldface are primes in NSM (e.g. **someone**, **something**, **things like**); terms in boldface and italics are semantic molecules in Minimal English (e.g. ***water, take, clean***). All other terms of semantic descriptions are concept types of common use in ontologies (cf. Pustejovsky & Batiukova, 2019:188-194) and are probable candidates to be defined as molecules in Minimal English. Minimal English includes not only the NSM primes (or atoms) and their associated grammatical words, but also semantic molecules which can be explicated into primes and are (near) universal or, at the very least, useful international words (Goddard & Wierzbicka, 2018:8) "more or less cross-translatable or more or less unavoidable in many contexts of modern, international discourse".

4.1 Combinatory constructions

The Typed Fs from Figures 11-13 are part of the set of Fs that participate in a construction. Constructions can be either combinatory or non-combinatory (Michaelis, 2013:3; Sag et al., 2012:105). The former are characterized by: (i) morphosyntactic transparency, which means that the combination of its immediate constituents and the saturation of its features are sufficient conditions to account for its grammatical contour; and (ii) lexically motivated semantics, subject to the Principle of semantic compositionality. This is another important principle that FL_CxG shares with SBCG (Sag et al., 2012:146) and HPSG (Sag et al., 2003). According to this principle, the semantics of compositional constructions results from merging the semantic attributes of its lexical constituents. As a consequence, in the Fs for combinatory constructions no semantic stipulation is included; only lexical units and non-combinatorial constructions will include this information (this is marked explicitly via a SEM attribute in non-combinatorial constructions; see Figures 16 and 17).

In addition to the AVM for NUC described in Figure 9 above, those in Figures 11-13 also belong in the family of Typed Fs for the Level 1 combinatory construction (declarative active clause) instantiated in the sentence *My brother is washing some clothes*:[7]

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[7]   There are other AVMs that participate in the unification process to obtain this sentence. See for instance Figure 15 for the RP my brother that is subsumed as first argument in the sentence my brother washed some clothes.
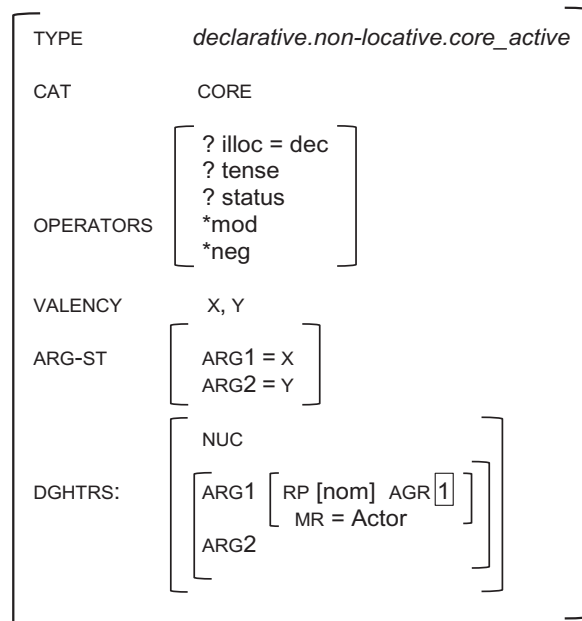
$$
\begin{bmatrix}
\text{TYPE} & \textit{declarative.non-locative.core\_active} \\[4pt]
\text{CAT} & \text{CORE} \\[4pt]
\text{OPERATORS} & \begin{bmatrix} \text{? illoc = dec} \\ \text{? tense} \\ \text{? status} \\ \text{*mod} \\ \text{*neg} \end{bmatrix} \\[20pt]
\text{VALENCY} & \text{X, Y} \\[4pt]
\text{ARG-ST} & \begin{bmatrix} \text{ARG1 = X} \\ \text{ARG2 = Y} \end{bmatrix} \\[12pt]
\text{DGHTRS:} & \begin{bmatrix} \text{NUC} \\ \text{ARG1} \begin{bmatrix} \text{RP [nom] \ AGR}\boxed{1} \\ \text{MR = Actor} \end{bmatrix} \\ \text{ARG2} \end{bmatrix}
\end{bmatrix}
$$

Figure 11. A declarative, non-locative, active CORE as a Typed Fs.

$$
\begin{bmatrix}
\text{TYPE} & \textit{monotrans. L1 constr.} \\[4pt]
\text{CAT} & \text{CONSTR} \\[4pt]
\text{OPERATORS} & \begin{bmatrix} \text{? illoc} \\ \text{? tense} \\ \text{*mod} \\ \text{*neg} \end{bmatrix} \\[18pt]
\text{VALENCY} & \text{X, Y} \\[4pt]
\text{ARG-ST} & \begin{bmatrix} \text{ARG1 = X} \\ \text{ARG2 = Y} \end{bmatrix} \\[12pt]
\text{DGHTRS} & \text{CORE}
\end{bmatrix}
$$
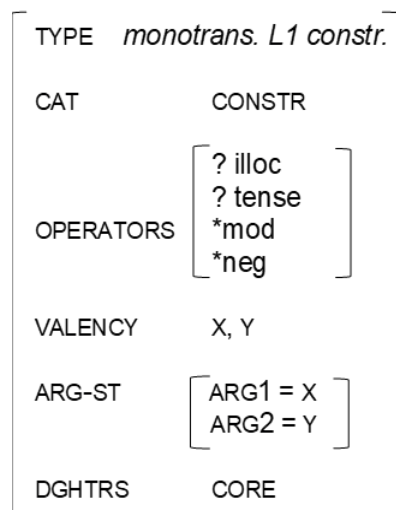
Figure 12. A monotransitive L1 non-combinatory construction as a Typed Fs.

$$
\begin{bmatrix}
\text{TYPE} & \textit{declarative clause.} \\[4pt]
\text{CAT} & \text{CLAUSE} \\[4pt]
\text{OPERATORS} & \begin{bmatrix} \text{+ illoc} \\ \text{* tense} \\ \text{* sta} \end{bmatrix} \\[14pt]
\text{DGHTRS} & \text{CONSTR}
\end{bmatrix}
$$

$$
\begin{bmatrix}
\text{TYPE} & \textit{simple.sentence.} \\
\text{CAT} & \text{S} \\
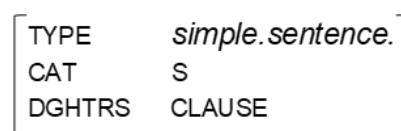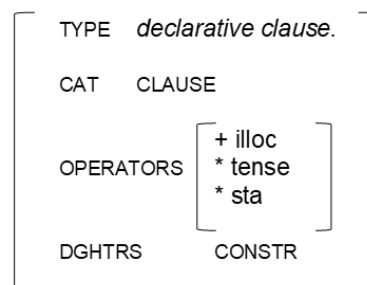\text{DGHTRS} & \text{CLAUSE}
\end{bmatrix}
$$

Figure 13. SENTENCE and CLAUSE as Typed Fs.

Figure 14 shows the output of the unification process of these Fs in order to obtain the sentence *My brother was washing some clothes*:

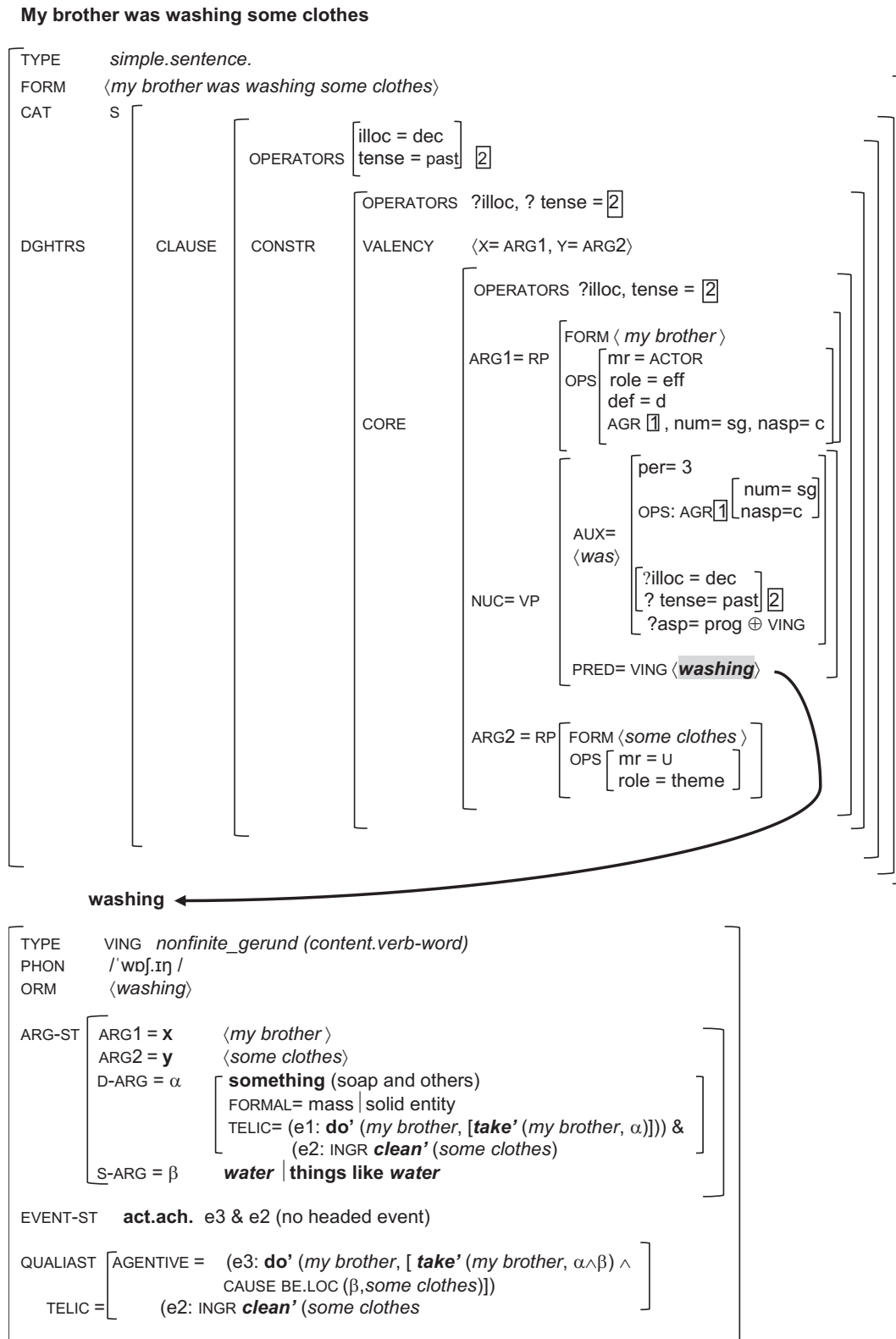**My brother was washing some clothes**

Figure 14. Example of unification – subsumption.

Note that in Figure 14, and due to space reasons, the only constituent that has been further analyzed is pred, the same procedure would have to be followed for the arguments *my brother* and *some clothes*. By way of illustration, in Figure 15 the Typed Fs for the RP *my brother* is provided:

my brother
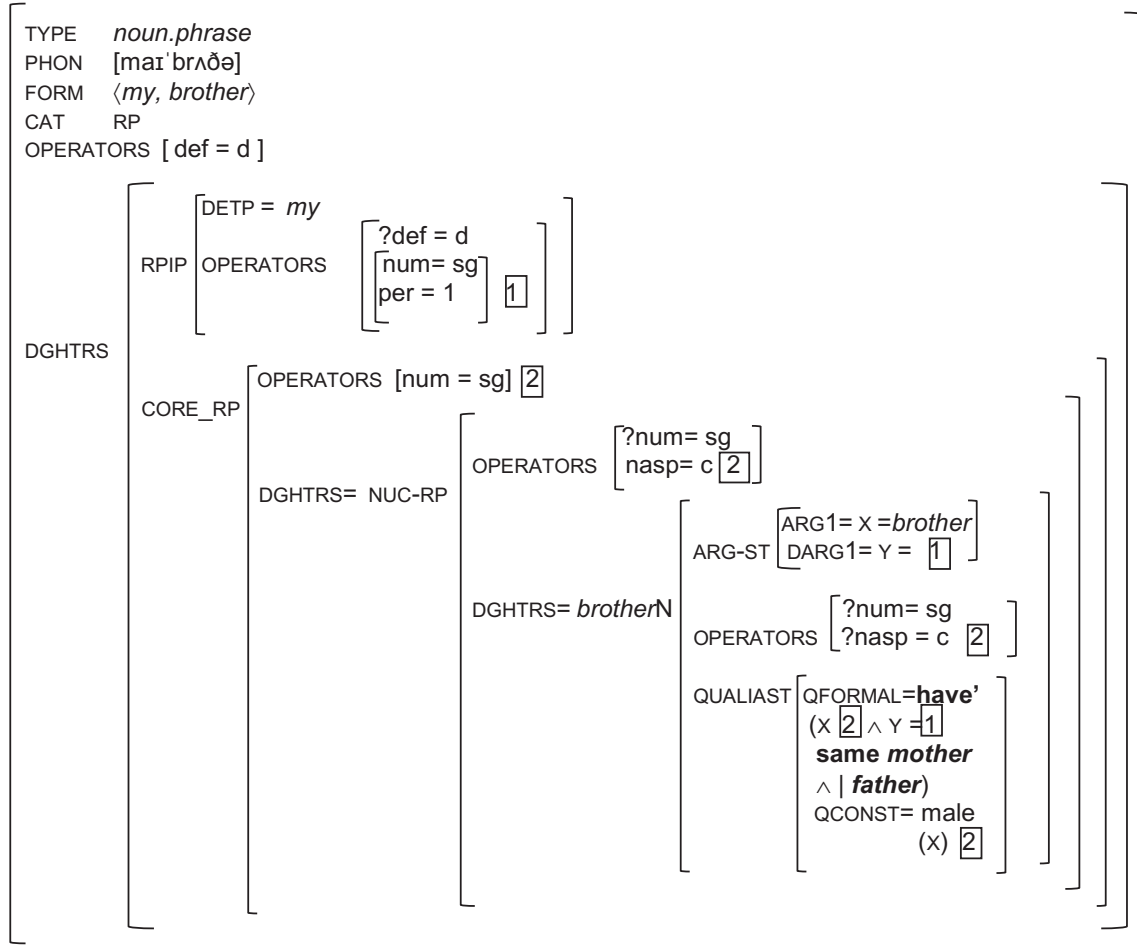
Figure 15. Typed Fs of the RP *my brother.*

4.2 Non-combinatory constructions

If a given linguistic entity (a clause or a phrase) flouts any of the conditions for combinatory constructions mentioned above, i.e. morphosyntactic transparency or meaning compositionality, it will be an instance of a non-combinatory construction. Non-combinatory Fs often include a SEM attribute. As a case in point, let us consider the following example which encodes the Typed Fs of prototypical L-1 middle clauses like *These clothes wash very well*:
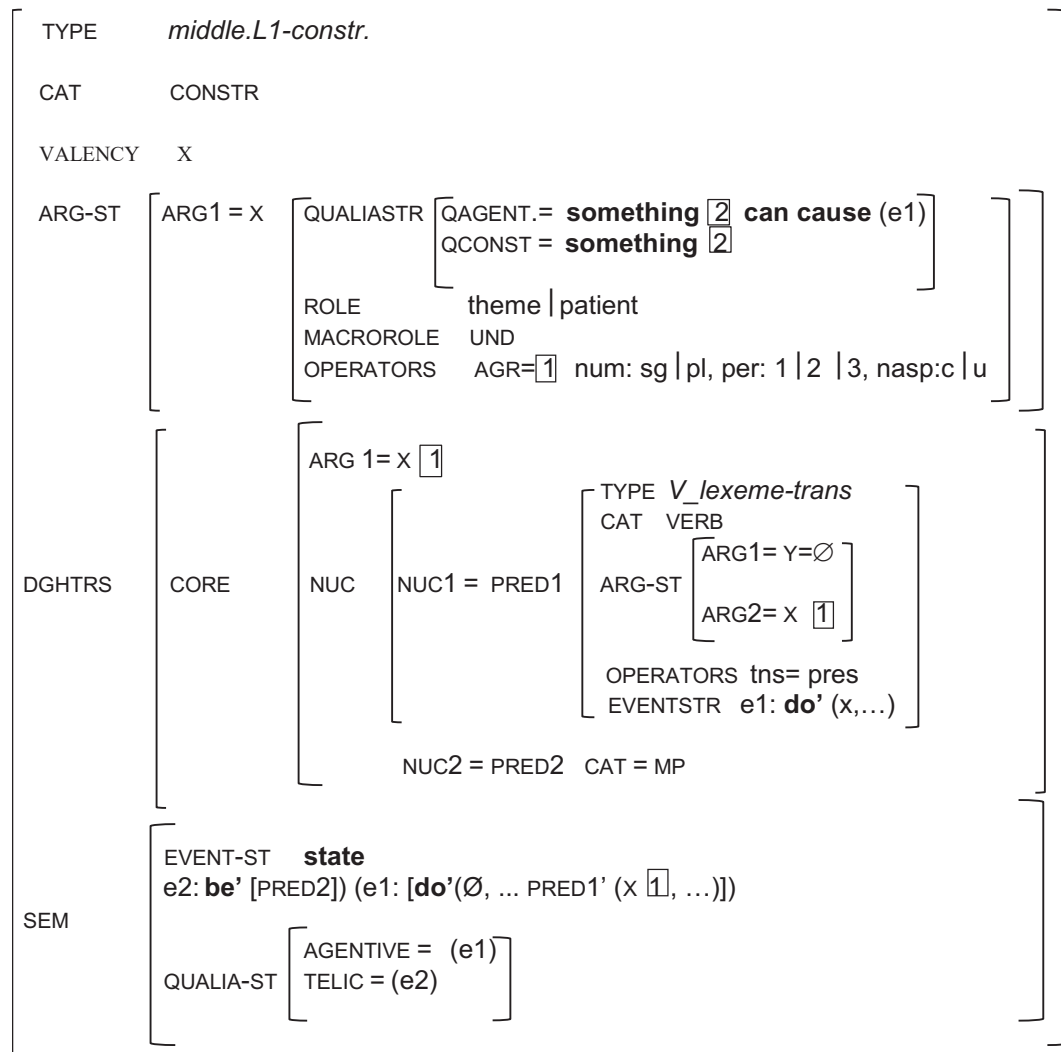
Figure 16. Typed Fs for the non-combinatory middle construction.

This AVM reveals the essential nature of attributes as constraints for the well-formedness of structures, as they capture the wide array of conditions to be satisfied by the lexical constituents of middle constructions as well as their grammatical and semantic overriding effects on the verbal predicate. One fundamental property of the middle construction in English is that it is always a coercive structure on transitive verbs, i.e. there are no English verbs which are inherently 'middle'. English middle clauses illustrate the effects of the Extended Override Principle proposed in Cortés-Rodríguez (2009), according to which the features of a lexical entry must conform to those of the construction in which the lexical predicate is subsumed. This principle is an elaboration on Michaelis' (2003) Override Principle, which states that the meaning of a lexical item conforms to the meaning of the structure in which it is embedded. The Extended Override Principle also captures grammatical coercion processes, one of such processes is the detransitivization inherent in the unification of any verbal predicate into a middle clause.

In the AVM for the middle construction, the detransitivizing nature of middles is reflected in the ARG-ST of the embedded PRED1 (*wash*) by means of the formula ARG1= Y=Ø. Note also that the TYPE feature of the PRED1 identifies it as transitive verbal lexeme (*V_lexeme-trans*). It is worth noticing, however, that not all transitive verbs can be subsumed in middle structures. As explained in Cortés-Rodríguez and Mairal Usón (2013:229-230), there are three basic RRG classes excluded: a) states (*this picture likes easily*) and internal-only (and, therefore, strictly inchoative) changes of states, that is, b) non-causative accomplishments (*peach trees blossom well*), and c) achievements (*this town arrives easily*). This restriction is reflected in the EVENT-ST attribute of PRED1(e1: do' (x, …)) which tells us that the predicate must have an (initial) activity (sub)event.

Middle structures involve a complex nucleus with two predicates, the verbal lexeme (PRED1) and a secondary modifier predicate (as expressed in the string PRED2 cat MP), typically realized by an adverbial (e.g. *Trucks don't drive easily*). This secondary predicate involves another coercive process affecting the aspectual features of the event depicted: the secondary predicate conveys a generic attributive predication that establishes an assessment

of the event depicted by the verbal predicate. As a consequence, the event-st of the middle AVM has the canonical format of an attributive state in RRG and the LCM. The basic formula for attributive structures is: **be'** (x, [pred']) (e.g. *milk is white* → **be'** (milk, [**white'**]). As explained in Van Valin and LaPolla (1997:416-417), these stative structures express inherent properties. In contrast, result state predications like *the window is broken* are represented differently: **broken'** (window). Therefore, the formula (e2: **be'** [pred2]) (e1: [**do'** (Ø,... PRED1' (x, …)])))) in the SEM of the middle Fs in Figure 16 expresses the fact that the event encoded in the verbal PRED1 has as a permanent feature the property expressed by PRED2.

There are two other features in prototypical middle constructions: (i) they quite frequently take simple tense (as encoded in the OPERATORS attribute of PRED1), a property that derives naturally form the stative character of the construction together with the permanent property expressed by PRED2 when assigned to the event of PRED1. And (ii) the subject of middles must include some semantic feature which facilitates the realization of the event depicted in PRED1. Dowty (2001:11-12) explains this latter constraint signaling that some verbal classes such as *break* verbs and *cut* verbs are more amenable to middle subsumption than others (such as those in the *touch* class or the *hit* class) because, in the case of the first, (2001:11-12) "the inherent physical properties of the Patient can affect the ease/difficulty of bringing about the physical change in it, whereas these inherent physical properties should not affect the ease/difficulty of performing this kind of action on the Patient", in the case of *touch* and *hit* verbs. In the AVM this constraint is captured in the QUALIA-ST of ARG1 by means of the NSM primes '**something can cause** (e1)' in the QAGENT and the QCONST attributes.

In line with the tenets of the LCM, in the FL_CxG model, Level 2, 3 and 4 constructions can also be formalized by means of Typed Fs. Figure 17 presents a sample of the AVMs that can be designed for non-compositional constructions at these levels. As can be seen, it captures the features of an illocutionary (Level 3) Request construction:
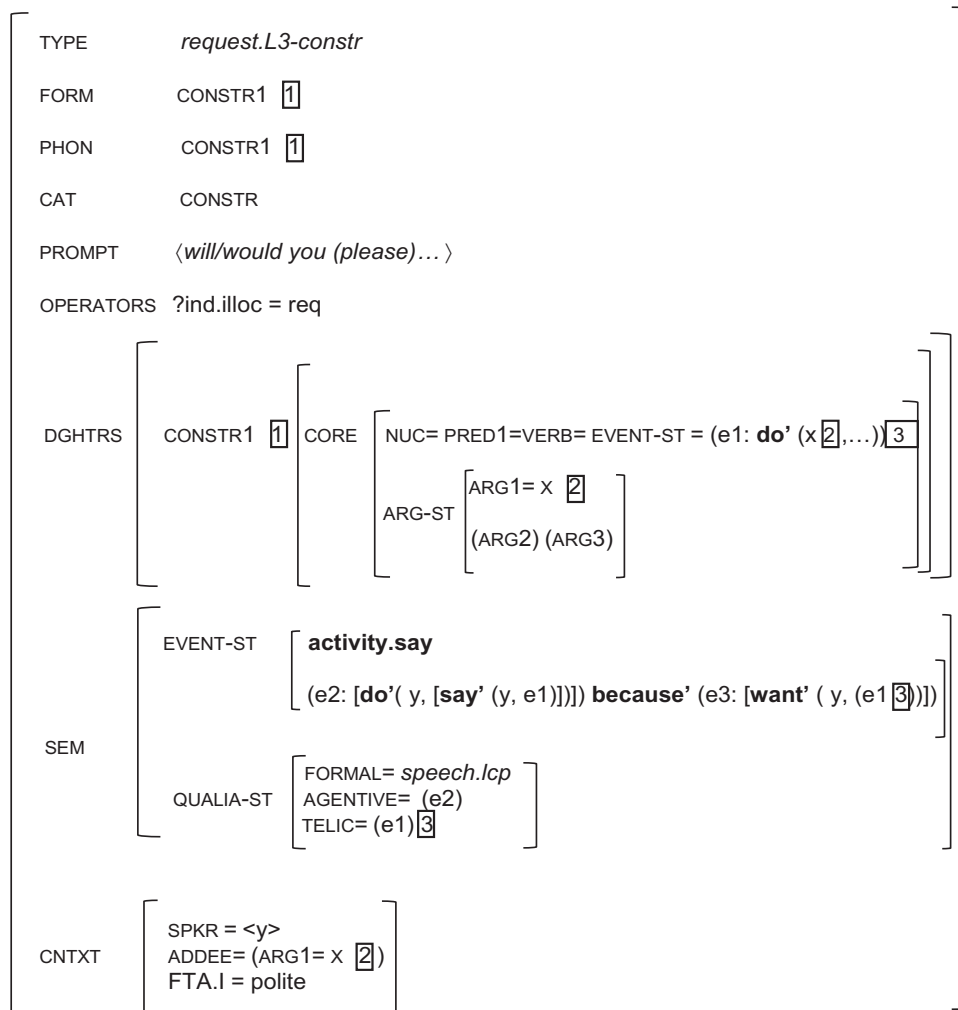

Figure 17. Level 3 or illocutionary non-combinatory construction.

Requests are, basically, indirect speech acts whose illocutionary force diverges from that of the syntactic form they present. This reinterpretation of the basic and direct interrogative force is triggered by a (semi)fixed string of words (*could/can/will/would you (please)...*), as encoded in the attribute PROMPT. By means of the FORM and PHON attributes, the AVM for this type of L3 constructions reflects the fact that this type of structures is syntactically and phonologically identical to a type of Level 1 construction, namely, to an interrogative clause. In fact, the Level 1 construction is the DAUGHTER constituent of this structure, as shown in the tree analysis of the sentence *could you water the plants?*.[8] As can be inferred from the syntactic analysis of this sentence in Figure 18, this type of construction involves embedding a combinatory Level-1 construction into a Level 3 construction (hence the introduction of a recursive CONSTRUCTION (CONSTR) node in the structure).
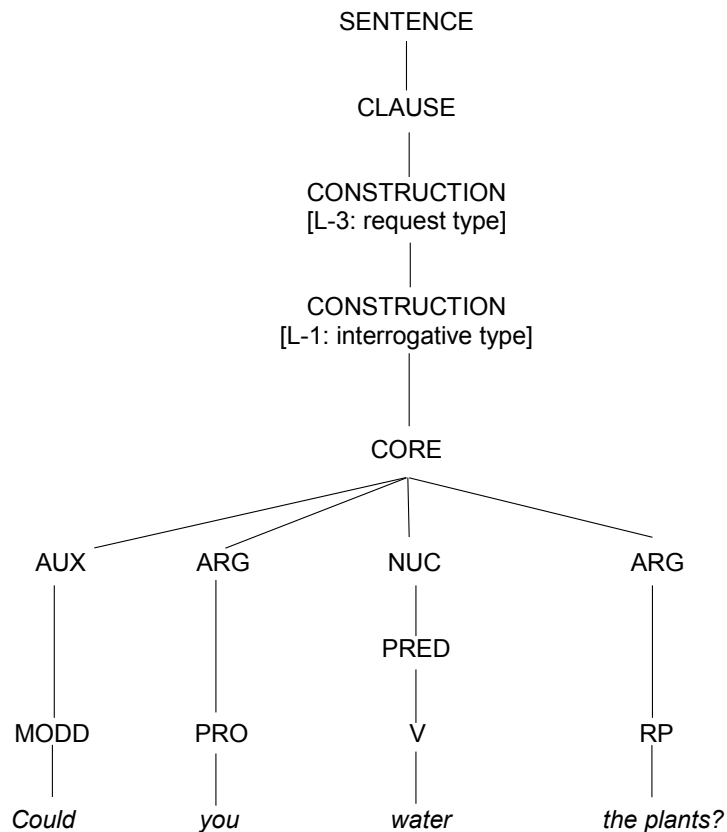

Figure 18. Tree representation of a Level 3 non-combinatory construction.

This grammatical analysis is mirrored in the design of the Typed Fs, with several overlaying effects:

a. The original interrogative illocutionary force is cancelled by a higher level indirect illocution, as described in the attribute IND.ILLOC, which presents a request (req) value.

b. The EVENT-ST attribute encodes a speech event (e2: [**do'**(y, [**say'** (y, e1)])]) by means of which a speaker (y) conveys a desire (**because'** (e3: [**want'** (y, (e1))]) for a hearer (x) to do what is expressed in the EVENT-ST of the DGHTR Level 1 construction (e1: **do'** (x,...)).

c. Given the fact that Level 3 constructions describe high-level situational scenarios, it is necessary to add a set of contextual (CNTXT) attributes for features like the Speaker (SPKR), the addressee (ADDEE) and a Face Threatening Act Index (FTA.I). This set of attributes establishes the pragmatic import that characterizes this type of constructions. The value for FTA.I, in the case of requests, is always 'polite'.

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8   Note that this kind of subsumption processes justifies the necessity of an intermediary Construction level between the CORE and the CLAUSE in the Layered structure of the clause.

5. CONCLUSION

In the preceding sections an outline of the FL_CxG has been offered. The outline has spelled out the goals of the model, the grammatical objects that populate it and the nature of the processes involved in the formal analysis of linguistic entities. All these properties bring the FL_CxG close to other models labelled as Formal grammars (FGs) and which constitute one of the research communities that belong in the constructionist space. Since the FL_CxG is a formalized version of the LCM, we have provided an overview of the basic features of this meaning construction model, which establishes several types of constructional structures, including pragmatic and discourse constructional patterns, and two conceptual mechanisms, subsumption and inferential cueing. We have addressed the challenges of adapting the constructional typology of the LCM and the syntactic paraphernalia of RRG into a unification-based format. This involves transducing grammatical constituents (from lexical to higher level constructional units) and morphological markers into an array of Typed Feature structures, which make up the signature of a unification-based model like the one proposed. Once the basic format of lexical and constructional AVMs has been explained, it was possible to deal with the intricacies of subsumption in structures which instantiate different types of constructions, both combinatory and non-combinatory.

Even though the proposal in this paper is still programmatic, it paves the way for a further development of the LCM from a descriptive meaning construction model into a fully-fledged formal grammar. Challenging tasks remain ahead, among them, making extensive analyses from an FL_CXG perspective which render an effective explanation of grammatical phenomena in different languages. This will not only bring about refinements in the signature of the model, but it will also reinforce its explanatory potential from a typological perspective.

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LIST OF ABBREVIATIONS:

AVM: Attribute Value Matrix

CxG: Construction Grammar

CS: Conceptual Structure

CT: Construction Template

FG: Formal Grammar

FL_CxG: Formalized Lexical-Constructional Grammar

Fs: Feature Structures

HPSG: Head-Driven Phrase Structure Grammar

LCM: Lexical Constructional Model

LT: Lexical Template

LS: Logical Structure

RRG: Role and Reference Grammar

SBCG: Sign Based Construction Grammar

ABBREVIATIONS FOR THE ATTRIBUTES AND VALUES IN THE AVMS:

ADDEE: Addressee

AGR: Agreement

ARG: Argument

ARG-ST: Argument Structure

asp: aspect (prog= progressive)

AUX: auxiliary verb

CAT: Category

CNTXT: Context

CONSTR: Construction

CONSTR1: Level 1 (argumental) construction

D-ARG: Default Argument

def: definiteness (d= definite, i= indefinite)

DETP: Possessive determiner

DGHTR: Daughter

EVENT-ST: Event Structure

FTA.I: Face threatening act index

gen: gender (f= feminine, m= masculine, n= neuter)

illoc: illocutionary force (dec= declarative

IND.ILLOC: indirect illocution

INGR: Ingressive

lcp: lexical-constructional paradigm

mod: deontic modality

MP: Modifier Phrase

MR: Macrorol (U= undergoer)

nasp: nominal aspect (c= count, u= uncount)

neg: negation

NUC: Nucleus

num: number (sg= singular, pl= plural)

OP: Operators

pers: person (1=1st, 2= 2nd, 3= 3rd)

PHON: Phonetics

PP: Prepositional Phrase

Pr-Cs: Pre-Core Slot

PRED: Predicate

QAGENTIVE: Agentive Quale

QFORMAL: Formal Quale

QTELIC: Telic Quale

QUALIASTR: Qualia Structure

RP: Referential Phrase

S-ARG: Shadow Argument

SEM: Semantics

SPKR: speaker

sta: status (epistemic modality)

VING: verb in the *-ing* form