



Onomázein

ISSN: 0717-1285

onomazein@uc.cl

Pontificia Universidad Católica de Chile  
Chile

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Argument-structure and implicational constructions in a knowledge base  
Onomázein, núm. 35, marzo, 2017, pp. 25-48  
Pontificia Universidad Católica de Chile  
Santiago, Chile

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## Argument-structure and implicational constructions in a knowledge base

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ONOMÁZEIN 35 (marzo de 2017): 25-48

DOI: 10.7764/onomazein.35.04



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Fecha de recepción: octubre de 2015

Fecha de aceptación: enero de 2016

## Abstract

This paper provides formalized, machine-tractable representations of two broad kinds of constructional configuration, *argument-structure* and *implicational* constructions, on the basis of previous linguistic analyses. It discusses computational implementation requirements on constructional description. In this respect, the paper argues that the Goldbergian approach (cf. Goldberg, 2006) provides the best fit for the implementation of implicational constructions, while a “mini-constructionist” account (cf. Boas, 2014) is suitable for argument-structure constructions. Because of their representativeness, we have chosen to illustrate our discussion by making reference to the family of English *resultatives*, which are argument-structure constructions, and to the family of *Wh-attitudinal* constructions, which are implicational. Computational implementation demands that the members of the family of the resultative be split into mini-constructions, while the complexity of implicational configurations requires that different formal variants be grouped together under one single computational representation. The paper further makes explicit proposals for the machine tractability of lexical-constructional integration and of meaning implications that have reached constructional status through entrenchment, two problems that remain unsolved within standard computational approaches to language processing.

**Keywords:** Constructions; Construction Grammar; cognitive models; knowledge-base; Lexical Constructional Model; Natural Language Processing.

## 1. Introduction

Work on Natural Language Processing (NLP), also called Computational Linguistics (Kumar, 2011: 1), is almost eight decades old. Megerdooomian (2003) notes that this discipline has been characterized by the conflict between symbolic approaches, i.e. those in which “knowledge about language is explicitly encoded in rules or other forms of representation” (Dale, 2000: 1), and statistical approaches, which, since the 1990s, have become the standard in the field. Although NLP seems to have lost interest in linguistic theorizing, scholars like Callison-Burch and Osborne have pointed out that, while statistical NLP “can be an extremely powerful tool and is able to produce impressive results, recent trends indicate that *using naïve approaches that are divorced from linguistics can only go so far*” (Callison-Burch and Osborne, 2003: 271, our emphasis).

In this context, we present an interdisciplinary, applied approach whose aim is to contribute to the reconciliation of NLP and linguistic theory. More concretely, this paper combines two compatible areas of research. First, the linguistic analysis presented here abides by the constructionist approach to linguistic explanation. Broadly speaking, *Construction Grammar* (CxG; Hoffmann and Trousdale, 2013) recognizes the existence of *constructions* as entrenched form-meaning/function pairing that can occur in any domain of linguistic enquiry (see Goldberg, 2006, for a more detailed definition). Such domains include the following: the lexical domain (cf. Chang et al., 2012); predicate-argument relationships (e.g. the ditransitive construction, as exemplified by *Pat gave Mary a letter*; see Van Trijp, 2011); and form-meaning patterns containing fixed elements, as is the case of *What’s X Doing Y?* (e.g. *What’s he doing with our cattle on his truck?*), which conveys the subjective meaning that the state of affairs designated by the Y element bothers the speaker (cf. Kay and Fillmore, 1999; Sag, 2011). In addition, it is believed that, like lexical items, constructions are related to one another in the form of families. Second, the computational implementation of the constructional analysis put forward here is carried out within a multipurpose lexico-conceptual knowledge base for NLP systems known as *FunGramKB* (Periñán and Arcas, 2010a, 2010b, 2014; Periñán, 2013; see also Butler, 2012). *FunGramKB*, which formally describes the conceptual content of linguistic units, takes sides with the symbolic position. Although there is a body of work dealing with how knowledge bases like *FrameNet* can be used for NLP (e.g. Agarwal et al., 2014; Baker, 2014; Narayanan, 2014), *FunGramKB* is currently the only knowledge base which provides an environment for the computational management of constructional characterizations at all major levels of meaning construction (cf. section 3).

Thus, with a view to the computational implementation of constructions in the context of NLP, the present paper formalizes the two broad types of non-lexical linguistic constructions mentioned above, which are respectively referred to as *argument-structure* constructions, following commonly accepted terminology, and *implicational* constructions, a label introduced by the *Lexical Constructional Model* (LCM, cf. Ruiz de Mendoza, 2013; Butler, 2009b, for a critical overview), which is the constructionist model on which part of *FunGramKB* is

based. These construction types are very different. While argument-structure characterizations code participant roles and their relations within a state, situation, or event, implicational constructions put argument-structure representations within the scope of the speaker's emotional sphere. The former are based on event structure components (e.g. causes, actions, results, etc.) ranging over variables. For example, the ditransitive takes the form of 'X CAUSES Y TO RECEIVE Z', as illustrated by the sentence *Pat gave Mary a letter* ('Pat caused Mary to receive a letter'). By contrast, implicational constructions contain bundles of fixed grammatical markers that are bound to one another non-compositionally (i.e. the meaning of the whole does not arise from the mere combination of the parts). Thus, in *What's she doing knowing the answer?* there is no action involved, despite the use of *doing*, but a state of affairs that either displeases or amazes the speaker. These formal and functional differences pose a problem for computational tractability, which we argue can be sorted out by making use of the computational resources provided by FunGramKB.

We illustrate our discussion of computational implementation with reference to two families of constructions. The first is the family of the English *resultative*, which consists in argument-structure constructions expressing changes of state or of location. The second is, at the level of implicational structure, a network of constructions codifying the speaker's negative reaction (usually annoyance) at a state of affairs, which we have labeled *Wh-attitudinal* constructions. The study of these two families will unveil the specific requirements of each constructional type. It will be evident that the nature of such requirements precludes a unified analysis. In addition, our proposal strives to strike a delicate balance between linguistic explanation and computational implementation. It thus reduces to a minimum the amount of linguistic detail that is to be sacrificed for the sake of computational tractability. This will be possible through a careful examination of the meaning conveyed by each constructional family, which will allow us to determine in what ways such meaning can be translated into a computer-readable format.

With this in mind, the structure of the rest of this paper is as follows. Section 2 offers a brief overview of the architecture of FunGramKB. Section 3 gives an outline of the Grammaticon, which contains networks of constructions of all kinds, and its relation with the LCM. Section 4 is devoted to the analysis of the two types of constructional network mentioned above. While the resultative family has been studied in depth from a linguistic perspective (cf. Broccias, 2003; Goldberg and Jackendoff, 2004), its computational layout is here spelled out for the first time in the constructionist literature. In the case of the *Wh-attitudinal*, only *What's X Doing Y* has received attention (Kay and Fillmore, 1999). Other members of the family and their relationships are discussed for the first time here both from the linguistic and computational perspectives. Section 5 summarizes the main points made in the paper. Following the usage-based approach to linguistic analysis, the examples in this paper have been sampled from systematic searches within the Google Books American Corpus (GBAC) available at <http://googlebooks.byu.edu/#>.

## 2. FunGramKB: A thumbnail sketch

FunGramKB (at [www.fungramkb.com](http://www.fungramkb.com)) is defined as a user-friendly online environment for the semiautomatic construction of a multipurpose lexico-conceptual knowledge base for NLP systems. Its multipurpose nature stems from its multifunctional and multilingual approach. Thus, FunGramKB has been designed to be reused in other NLP tasks, in particular in those that focus on language understanding (e.g. machine translation, dialogue based-systems). As a multilingual environment, FunGramKB supports various western languages like Spanish, English, Italian, and French.

The architecture of FunGramKB is made up of three knowledge levels. Unlike the ‘lexical’ and ‘grammatical’ levels, which are language-specific, the ‘conceptual’ level is language-independent and is therefore shared by all the languages currently included in the knowledge base. Each of these levels, in turn, consists of several self-standing, yet interconnected, modules:

- The lexical level comprises a Lexicon, which is based on the Aktionsart categories put forward within Role and Reference Grammar (RRG; Van Valin and LaPolla, 1997; Van Valin, 2005), and a Morphicon. While the former stores morphosyntactic and collocational information about lexical units, the latter deals with inflectional morphology. This level is described in detail in Mairal and Perriñán (2009).
- Knowledge on grammatical constructions or ‘constructional schemata’, i.e. machine tractable representations of constructions, is stored in the Grammaticon. Such schemas help RRG to build the syntax-semantics linking algorithm<sup>1</sup>. This component is described further in the following sections.
- The conceptual level is made up of three sub-modules, all of which employ the same formal language (i.e. COREL, cf. Perriñán and Mairal, 2010) to codify knowledge. The Onomasicon stores information about instances of entities and events (e.g. 9/11, Johnny Cash). In turn the Cognicon contains procedural knowledge in the form of scripts (e.g. ‘going to a restaurant’). The third sub-module, the Ontology, is a hierarchical catalogue of the concepts that a person has in mind. Since the Ontology is the pivot around which the whole knowledge base revolves, FunGramKB clearly qualifies as a conceptualist approach to NLP.

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1 As is obvious from this discussion, FunGramKB is grounded in two largely compatible linguistic theories (i.e. RRG and the LCM) (cf. Nolan and Perriñán, 2014). It should be noted that RRG-based approaches to grammatical constructions are still fairly underdeveloped (see Nolan and Diedrichsen, 2013; Nolan, 2011, 2014; Jiménez and Luzondo, 2013). The adequate treatment of meaning construction at all levels underlies the use of the LCM constructional architecture for the FunGramKB Grammaticon.

### 3. Linking linguistic theory with FunGramKB: The Grammaticon

In FunGramKB, the Grammaticon is a repository of constructional schemata (cf. Perriñán, 2013). The linguistic basis for the Grammaticon is found in the LCM, which, for reasons of space, shall be outlined briefly (see Butler and González-García, 2014).

Each layer of the architecture of the LCM rests on a different idealized cognitive model (ICM) type. An ICM is understood as a conceptual schematization of experience, as originally postulated by Lakoff (1987). This means that the LCM, like FunGramKB, is a conceptualist model in nature. Thus, the LCM postulates four basic ICM types: ‘low-level’, ‘high-level’, ‘non-situational/propositional’, and ‘situational’ (cf. Ruiz de Mendoza, 2007). Low-level ICMs are defined as “non-generic semantic structures that result from the principled linkage of elements that belong to our encyclopedic knowledge store” (Ruiz de Mendoza and Galera, 2014: 64). Concepts like ‘pencil’, ‘vulture’, or scenarios such as ‘going on a date’, fall within this category. In turn, high-level ICMs arise from processes of generalization. For example, abstracting away common material shared by low-level ICMs, like ‘kicking’, ‘drinking’, or ‘walking’, gives rise to the higher-level notion of ‘action’. Non-situational (or propositional) ICMs designate entities, their properties, and their relations in non-situational contexts. Finally, situational ICMs capture scripted sequences of events (Ruiz de Mendoza, 2013: 245).

This classification finds its place in the architecture of FunGramKB. As such, the L1 or level-1 Constructicon of FunGramKB corresponds to the argument-structure layer (or level 1) of the LCM, which makes use of low-level and high-level non-situational ICMs. More concretely, lexical structure in the FunGramKB Lexica is grounded in low-level propositional ICMs<sup>2</sup>. In a process that will be spelled out later on, lexical items in the Lexica are integrated into argument-structure constructions in the L1-Constructicon. Because argument-structure configurations, like the ditransitive, caused-motion, etc., emerge from the abstraction of properties common to various lexical predicates, the ICM type that lies at their basis is a high-level non-situational one. The L2-Constructicon, which deals with level-2 or implicational constructions in the LCM, exploits low-level situational models. The L3-Constructicon of FunGramKB handles what the LCM refers to as illocutionary or level-3 constructions. These are similar to level-2 structures, except for the fact that illocutionary configurations are based on high-level situational models (e.g. ‘requesting’, ‘offering’, ‘apologizing’). Illocutionary constructions, like their level-2 counterparts, contain fixed and variable elements, as in *Can you X?*, *Would you mind X?*, etc. To conclude, relations of the type ‘cause-effect’, ‘action-result’, etc., which hold

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2 Although the Cognicon and the Onomasticon are beyond the scope of the present paper, it is worth noting that low-level ICMs are also present in these conceptual sub-modules. See Perriñán (2012) for more information on how conceptualization in FunGramKB is consistent with the notion of ICM, which the LCM has developed further.

among non-situational high-level ICMs, are treated in the LCM at its discourse layer or level 4. This discourse layer is addressed in the L4-Constructicon of FunGramKB.

#### 4. A computational approach to constructional families

In the constructionist view of language, grammar is conceived of as the structured repertory or “network of constructions, related through shared properties” (Fried, 2007: 727), i.e. the *constructicon*. Over the last three decades, many linguists have produced detailed accounts of individual constructions in different languages along the lines of seminal studies like Fillmore et al. (1988) on *Let Alone*. More recently, some linguists have begun exploring constructional families rather than just individual constructions, among them Goldberg and Jackendoff (2004), Bergen and Plauché (2005), Goldberg and Del Giudice (2005), González-García (2009), and Barðdal et al. (2011). The study of such families can be carried out from the point of view of *family resemblance* relations (i.e. relations based on overlapping similarities; cf. Wittgenstein, 1958) among their members, or via *constructional polysemy* (i.e. when one constructional form affords access to different but related senses). Since FunGramKB is concerned with conceptualization, we shall pay attention to the semantic properties shared by constructions connected on the basis of family resemblance criteria. As was mentioned in the introduction, the present paper deals with two families, the *resultative*, which belongs to the L1-Constructicon, and the *Wh-attitudinal*, which belongs to the L2-Constructicon. Each of these two families is highly representative of its constructional type (argument-structure and implicational, respectively) and each requires markedly different treatment.

##### 4.1. The L1-Constructicon

This section explores the family of the English *resultative* (cf. Goldberg and Jackendoff, 2004; Luzondo, 2014; Ruiz de Mendoza and Luzondo, 2014), whose members codify changes of state or location as the result of verbal action. A non-exhaustive list of the transitive members of this family is given in (1)-(6):

- (1) a. I painted the walls white (GBAC, 2008).  
b. They ate themselves sick (GBAC, 2000).  
c. The joggers ran their Nikes threadbare (Boas, 2003: 43).
- (2) a. Take this and cut the body to pieces (GBAC, 2000).  
b. Beryl painted the brush to pieces (Boas, 2003: 121).
- (3) a. Delaney kicked the ball into the goal (GBAC, 2004).  
b. They laughed him out of the office (GBAC, 2003).



- (4) a. I fought my way to the surface (GBAC, 2014).  
b. Knox fought his way free/to freedom (GBAC, 2009/2006).
- (5) I broke the twig and the branch apart (Levin, 1993: 62).
- (6) a. Martha carved a piece of wood into a toy (Levin, 1993: 56).  
b. She turned him into a bird (GBAC, 1999).  
c. The witch turned him from a prince into a frog (Levin, 1993: 57).

The examples in (1) convey changes of state through an Adjectival Phrase (AP). (1a) displays a non-figurative change of state where the verbal object is also the object of change. Similar instances make use of metonymic objects, as in *He also painted the house red* (GBAC, 2004), where ‘house’ stands for ‘walls’, which are the relevant paintable parts of a house, while the resultative ingredient applies to the whole (cf. the house becomes red). In (1b) the change of state holds true of the clausal subject via a fake reflexive object. Other realizations, such as the one in (1c), incorporate non-subcategorized objects (cf. ‘their Nikes’), which, as in the case of fake-reflexive resultatives, yield figurative readings of the whole utterance. For LCM proponents many of the examples in (1)-(6) are licensed by means of high-level metaphors and/or metonymies, or a combination of both<sup>3</sup>. For example, the high-level metaphor AN ACTIVITY IS AN EFFECTUAL ACTION, which is operational in (1c), allows speakers to re-construe an atelic activity predicate (‘running’) as if it were an effectual action with an impact on the object. The resultative component in (2) takes the form of a Prepositional Phrase (PP). As opposed to AP resultatives, the PP variant codifies changes of state as metaphorical changes of locations. In this metaphor, which was initially discussed in Lakoff (1993), high-level concepts like states and changes of state are seen in terms of locations and changes of location, which are generally considered in Cognitive Linguistics to be primary concepts rooted in our experience (Lakoff and Johnson, 1999; see also Ruiz de Mendoza and Galera, 2014: 64-65). But, in this family, pure changes of location also form a sub-class of their own, as shown in (3ab), which are two different realizations of the caused-motion construction. In (3a), we have a non-figurative change of location, whereas (3b) conveys a self-instigated change of location figuratively expressed as the result of caused motion. The outcome event in the way construction in (4) may either be a change of location (cf. (4a)), or a (figurative) change of state, as in (4b). In all cases, the whole utterance is to be interpreted figuratively due to the presence of the fixed element (“X’s way”) filling the object slot (i.e. one does not literally “fight his/her way”). Sentence (5) exemplifies the ‘apart reciprocal’ configuration, where the element ‘apart’ functions as a resultative adverb by virtue of its secondary-predication nature. To conclude, the utterances in (6), which Levin (1993) groups under the broad label of ‘creation and transformation’ construc-

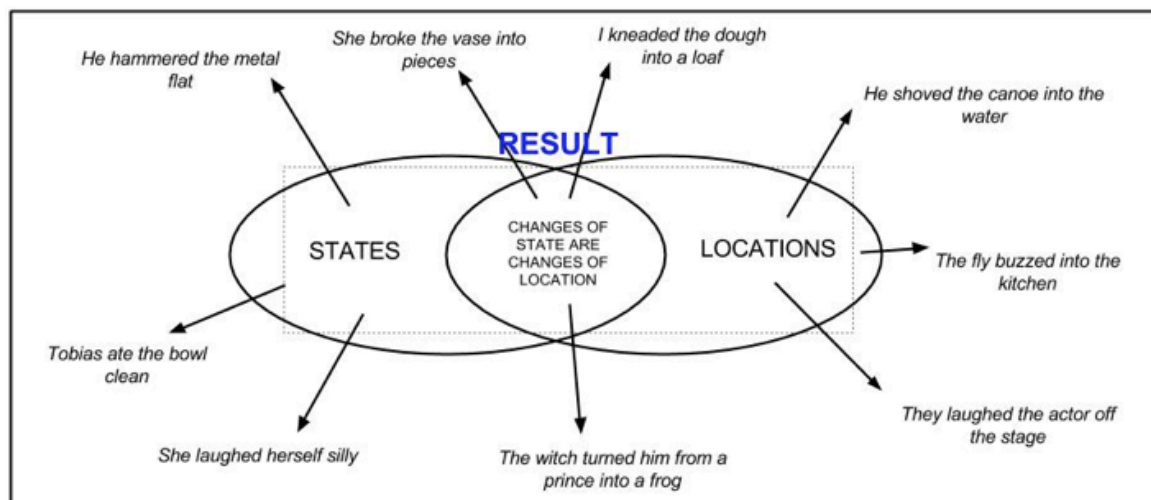
3 These cognitive operations are termed high-level since they involve generic cognitive models (e.g. ‘action’, ‘process’, ‘result’, ‘cause’, etc.) and thus work at higher levels of abstraction. See Ruiz de Mendoza and Pérez (2001) and Peña (2009) for more examples of high-level metaphor and metonymy.

tions, also exploit figurative motion to designate changes of state, as those in (2ab). Note that in (6c), the whole figurative path of motion is expressed: the initial point of the path maps onto the original state and the goal or destination of motion maps onto the resulting state. Following up on this logic, if the source of the figurative path is specified, then the end of the path must also be present (e.g. *\*She turned from a prince*), although it is possible to avoid mentioning the figurative initial location and only make reference to the destination of motion, as in *His rash attack on the Egyptian taskmaster turned him (from a prince of Egypt) into a fugitive from justice*<sup>4</sup>.

As may be apparent to the reader by now, the common denominator of this family of constructions is the high-level ICM of ‘result’, which may either be a change of state or a change of location, or a metaphorical interpretation of the latter to construe the former type of outcome event. The reason why changes of state can be conceptualized as changes of location arises from a conflation process based on experiential co-occurrence. We tend to associate certain kinds of locations with certain states (e.g. being cool in the shade, warm in bed, etc.; cf. Grady, 1997; Hampe, 2010). Thus, from the analytical perspective of the LCM, the various members of the resultative family gravitate around the following elements: i) the high-level concept of state, ii) the primary concept of location, and iii) the event-structure metaphor A CHANGE OF STATE IS A CHANGE OF LOCATION, which puts into correspondence the conceptual constructs (i) and (ii) (see figure 1). These are essential features that need to be captured in the computational implementation of this family, to which we turn now.

### FIGURE 1

Simplified representation of the family of the resultative



4 Example taken from Google Books: *Moses: A life*, by Jonathan Kirsch (2009). Accessed on January 28, 2015.

In order to see how these shared semantic components are managed computationally, we first need to address the Ontology and the Lexicon, to finally move to the L1-Constructicon.

Ontological concepts are provided with semantic properties, which in FunGramKB take the form of *thematic frames* (TFs) and *meaning postulates* (MPs). TFs are defined as “conceptual constructs which state the number and type of participants involved in the prototypical cognitive situation portrayed by the event” (Periñán, 2013: 210). Meaning postulates are sets of one or more logically connected predications ( $e_1, e_2 \dots e_n$ ), i.e. conceptual constructs carrying the generic features of concepts (Mairal and Periñán, 2009: 224). The formal language that allows the analyst to spell out a machine-readable representation of TFs and MPs is called COREL. Like its natural-language counterparts, COREL has its own syntax and semantics, which, for reasons of space, can only be outlined here (see Periñán and Mairal, 2010 for a detailed account). In FunGramKB, ontological concepts are organized hierarchically, which means that subordinate concepts (e.g. ‘sweep’, i.e. +SWEEP\_00 in formal language) inherit information from superordinate concepts (e.g. +CLEAN\_01). There are three conceptual levels in this hierarchy: *metaconcepts* (e.g. #MOTION\_00), *basic concepts* (e.g. +DANCE\_00, +BAD\_00, +BOY\_00) and *terminal concepts* (e.g. \$MOP\_00). Basic concepts are the building blocks used to define the meaning of other basic and/or terminal concepts via the MP (together with the TF). It is important to note that concepts in FunGramKB belong to different cognitive dimensions or metaconcepts (e.g. +SWEEP\_00 is located within the metaconcept #TRANSFORMATION\_00). Each metaconcept displays a fixed list of *thematic roles*. These are expressed through indexed variables (e.g. (x1), (x2), etc.) and their amount and definition varies from one cognitive dimension to another. To illustrate, in the Ontology of #EVENTS (verbs), the metaconcepts #TRANSFORMATION\_00 and #PERCEPTION\_00 contain two thematic roles, namely, Theme (x1) and Referent (x2). Their definition, however, is the following: in the former dimension the Theme is the entity that transforms another entity, while in the latter, the Theme is defined as the entity that perceives another entity through its senses. Finally, because the MPs of subordinate concepts must contain a distinguishing feature that is not present in the MP of the superordinate, FunGramKB also provides a list of Satellites (e.g. Manner, Scene, Purpose, Result, Instrument, etc.), through which semantic distinctions are codified. Thus, whenever we define concepts, or the semantics of constructions in COREL, we need to take into account the cognitive dimension in which a given concept is located and, therefore, its participant roles, the list of basic concepts currently stored in the Ontology, and the available satellites. This means that sometimes, the flexibility of the metalanguage will be constrained by such factors or elements as whether there is a basic concept, already defined in the Ontology, which can be employed to code the semantics of another concept. To exemplify this discussion, the TF and MP of the concept +SWEEP\_00 are given in (7):

(7) +SWEEP\_00

TF: (x1: +HUMAN\_00)Theme (x2: +FLOOR\_00)Referent

MP: +(e1: +CLEAN\_01 (x1)Theme (x2)Referent (f1: +BRUSH\_00)Instrument)

In the COREL notation, +SWEEP\_00 is defined as: ‘a human (x<sub>1</sub>) cleans the floor (x<sub>2</sub>) using a brush/broom (satellite f<sub>1</sub>). The basic concepts +HUMAN\_00, +CLEAN\_01, +FLOOR\_00 and +BRUSH\_00 are also described by means of COREL and, thanks to the two reasoning mechanisms employed in FunGramKB, i.e. inheritance and inference, a growing web of encyclopedic knowledge is obtained (see Perriñán and Mairal, 2010). In turn, each concept in the Ontology is realized by one of the senses of a lexical unit stored in the Lexicon, in this case, the English verbs *sweep* and *brush*, Spanish *barrer* and *escobar*, Italian *spazzare* and *scopare*, French *balayer* and *brosser*, etc., all of which share the conceptual knowledge in (7). Additionally, each of the lexical units that depend on this concept is individually defined at the lexical level (cf. Luzondo and Jiménez, 2014: 201-216). In the Lexicon, the most important component in the case of verbal predicates is called the *core grammar*. This component displays a list of “attributes whose values allow the system to build the basic logical structure of verbs automatically” (Perriñán, 2013: 212). What follows is a brief description of the attributes in the core grammar, which is largely inspired in related proposals in RRG. Values are exemplified through the verb *sweep*:

- (8) a. Aktionsart: the basic RRG verb class in which a given verb participates. *Sweep* is an activity predicate.
- b. The lexical template covers: (i) the number of verb variables; (ii) the thematic-frame mapping thorough which the prototypical arguments of the verb are bound to some of the participants in the TF of the concept to which the verb is linked; (iii) the idiosyncratic features or macroroles assigned to the verb, to wit, Actor and Undergoer (see Van Valin, 2005: 60). *Sweep* displays two variables, *x* and *y*. These are correspondingly mapped onto ‘Theme’ and ‘Referent’ (cf. (7) above). In turn, *x* is assigned the macrorole Actor, whereas *y* is the Undergoer.
- c. Constructions: lexical units in the Lexicon are linked by means of pointers to the range of constructions in which they may be embedded. *Sweep*, for example, can be fused with the resultative (e.g. *He swept the floor clean*, GBAC 2006), the caused-motion (e.g. *He swept the ashes into the dustpan*, GBAC 2013), or the way construction (e.g. *Headphones on, he swept his way through the store*, GBAC 2005).

We will now focus our attention on the L1-Constructicon of FunGramKB, whose interface is provided in figure 2. The transitive resultative construction has been selected to exemplify the different components (or ‘descriptors’ and ‘constraints’) of this figure.

As with lexical units, constructional schemas select one Aktionsart type, which, in the case of the transitive resultative, is a causative accomplishment (CACC). This construction comprises three variables, *x*, *y* and *z*, the third of which, *z*, finds no match in a two-place transitive verb. For this new variable, which is directly contributed by the construction, as in *He swept the floor **clean***, one must manually specify:

**FIGURE 2**

The interface of the L1-Constructicon

**Example:**  
Raid kills bugs. >>> Raid kills bugs dead.

FunGramKB words

**a) CLS:**

**Aktionsart:** CACC [help]      **Variables:** x,y,z

**Variable:** z

**Thematic role:** Result

**Macrorole:**

**Phrases:** ADJP, PP [help]

**Syntax:** Nucleus

**Prepositions:** into, to

**Preferences:** +STATE\_00

Assign      Clear

**b) COREL scheme:**

```
+(e1: <EVENT> (f1: (e2: +DO_00 (x1: x)Theme (x2: (e3: +BECOME_00 (x3: y)Theme (x4: z)Attribute))Referent))Result)
```

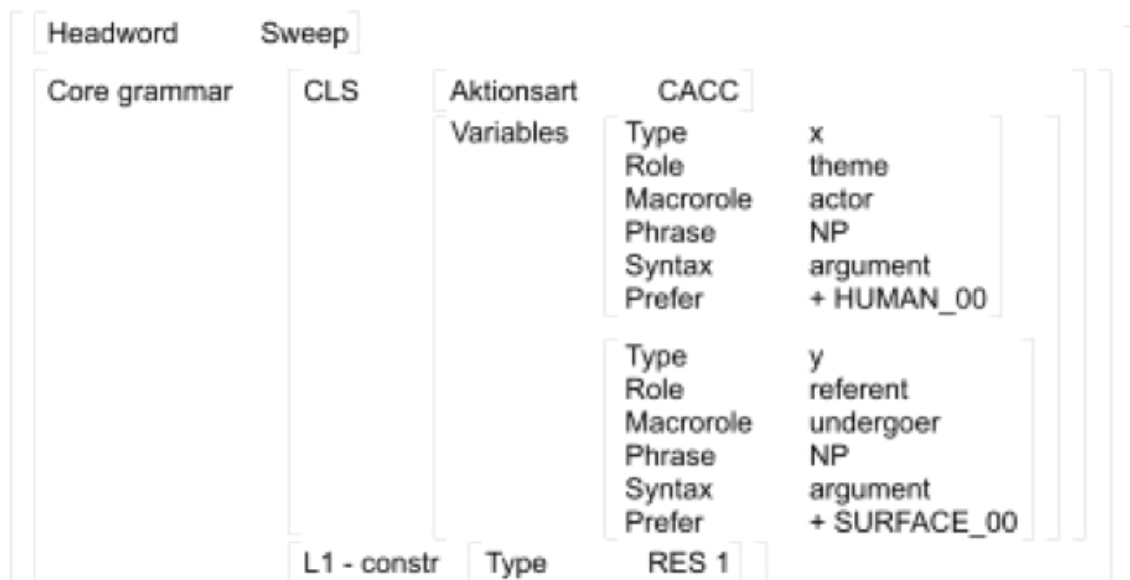
- (a) Its thematic role: z takes the conceptual role ‘result’.
- (b) The macrorole (if any) assigned to the new variable.
- (c) The categorial information of the variable: in the resultative, z can take the form of an AP or a PP.
- (d) The syntactic specification. Syntax accounts for the status of the variables of the construction as argument or as nucleus (see Van Valin, 2005: 4-5). Z functions as nucleus in the transitive resultative.
- (e) The selectional preferences (cf. +STATE\_00). These work as conceptual constraints prototypically related to a cognitive situation.

- (f) The COREL schema. This representation captures the cognitive content of the construction by means of the same formal language employed in the conceptual module. It makes use of ontological concepts together with their corresponding MP, which in turn contains the TF. The difference between the MP of +SWEEP\_00 in (7) and the COREL schema of the resultative is that in the latter, constructional variables are mapped onto participant roles (cf. (x1: x)Theme, (x3: y)Theme, (x4: z)Attribute)). Hence, the semantics contributed by the transitive resultative expressed through COREL can be translated as: ‘there is an event in which x causes y to become z as a result’.

At this point it is important to emphasize that FunGramKB follows the paradigm of constraint-based grammars or unification grammars (see Michaelis, 2013). As pointed out by Periñán and Arcas (2014: 179), the key component of constraint-based grammars lies in the complex formal description of grammatical units as Attribute-Value Matrices (AVMs), which describe features that can be merged via unification operations. For example, the AVM of the lexical entry *sweep* in figure 3, which captures the core grammar information in (8), can be merged with several members of the family of the resultative in figure 4, i.e. the transitive resultative, the caused-motion configuration, and the way construction. To be more precise, when the AVM for *sweep* merges with, say, the AVM of the transitive resultative (e.g. *He swept the floor clean*), the construction inherits monotonically the AVMs of the *x* and *y* variables from the lexical entry (i.e. **sweep'**(*x*, *y*)), whereas the AVM of the *z* variable is supplied by the construction. Similarly, the Aktionsart value in the lexical entry is overridden by that of the construction (see Periñán and Arcas, 2014: 180-181).

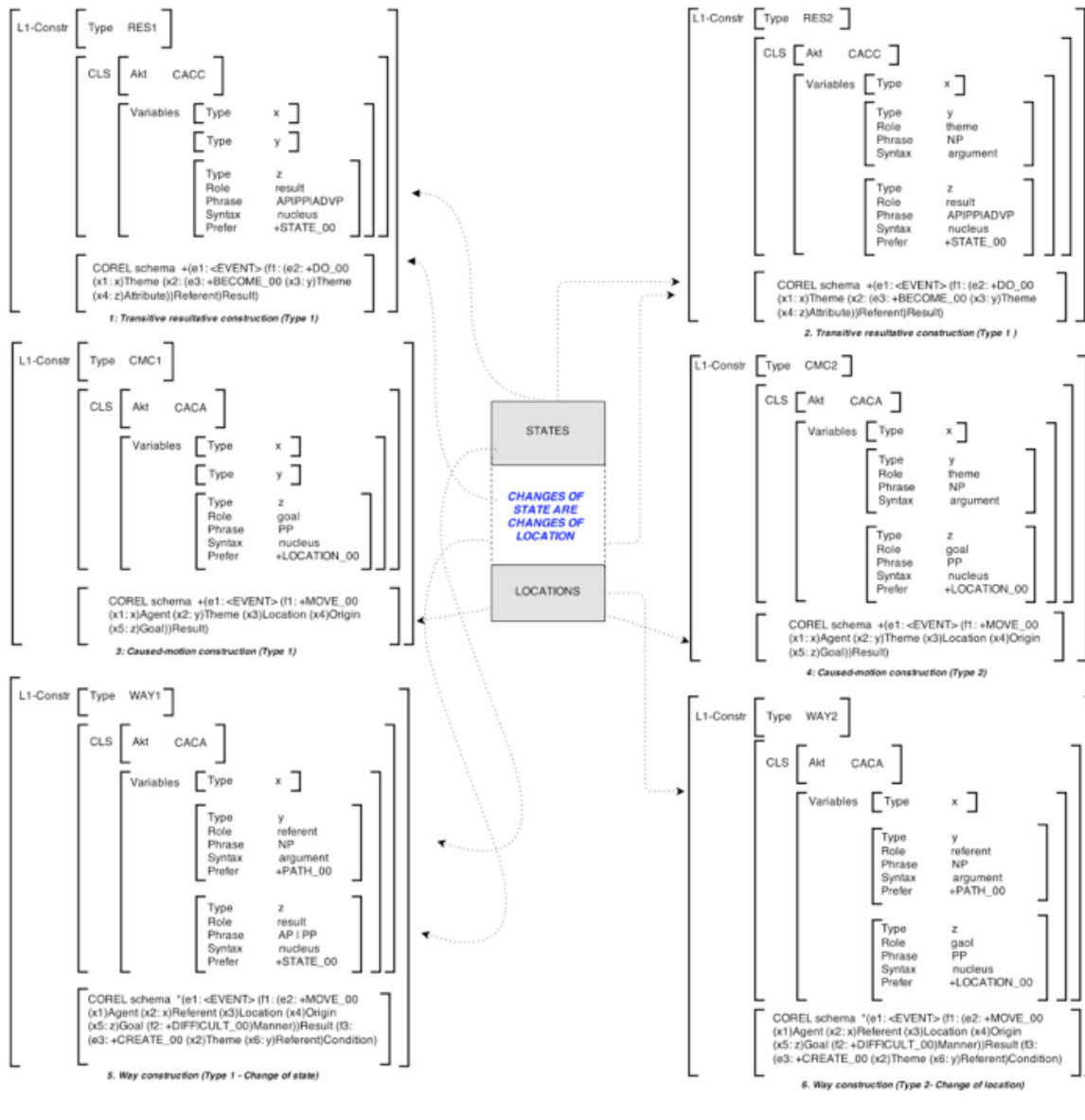
### FIGURE 3

The core grammar of *sweep* (English lexicon)



**FIGURE 4**

The family of the English resultative



As is evident from figure 4, the computational approach provided here captures the idea supplied by linguistic analysis that resultatives form “a sort of ‘family’ of constructions [...] sharing important properties but differing in certain specifics” (Goldberg and Jackendoff, 2004: 535). In figure 4, the properties shared by the members of this family are the following: i) the Aktionsart adscription (either a causative accomplishment or a causative active accomplishment), ii) the high-level ICM of result, which is expressed as a satellite in the COREL schema (f1 = Result), iii) and the selectional preferences +STATE\_00 or +LOCATION\_00, which work

by constraining the nature of the variable contributed by the construction. It is important to note that, although the ubiquitous metaphor A CHANGE OF STATE IS A CHANGE OF LOCATION has not been operationalized in FunGramKB, the machine will be able to process figurative changes of location as changes of state, since the selectional preference of the z variable in the transitive resultative (types 1 and 2), for example, is delimited by the concept +STATE\_00. This means that even if the outcome event is formally realized by a PP, the result must be interpreted as a change of state. Finally, there are certain functional and formal aspects in which these related constructions differ. Among them we may highlight the fact that the way construction introduces a fixed element, or the fact that, in this specific construction, motion occurs despite some external impediment (Goldberg, 1995), as indicated by the Manner satellite +DIFFICULT\_00.

It is important to note that our approach handles the mismatches that result from lexical-constructional fusion in resultative constructions. To illustrate this, take again the case of the transitive resultative and consider how this configuration interacts with the verb *sweep* in *He swept the floor clean*, which corresponds to AVM 1 in figure 4. Here, the construction supplies the result ingredient, whereas both Agent and Patient arise from lexical projection (cf. *He swept the floor*). By contrast, in the sentence *He swept the broom to pieces* (Boas, 2003: 7), which would be processed through AVM 2 in figure 4, it is the object and the resultative phrase that are contributed by the construction (cf. *\*He swept the broom*). If we go back to AVM 1 in figure 4, we note that the y variable is underspecified, which means that the machine will understand that both x and y are to be inherited from the lexical entry. In such a case, the construction is taken to be responsible for the addition of z. Thus, in order for the machine to be able to process sentences like *He swept the broom to pieces*, a distinct, yet related, sub-construction of the transitive resultative (i.e. ‘transitive resultative (type 2)’) needs to be added to the Grammaticon (see Luzondo and Ruiz de Mendoza, 2015, for more details). This sub-AVM must specify the thematic role, phrase, syntax and preferences of y, while x will be the only argument inherited from the Lexicon. The same rationale applies to the rest of constructions in figure 4.

What this situation shows is that, from a computational perspective, given the design of the L1-Construction, a solution based on fine-grained specifications (despite potential descriptive redundancy) rather than on broad-scale generalizations is required in order to handle the intricacies of lexical-constructional interaction. The former approach, labeled ‘mini-constructionist’ postulates the need to produce as many low-level constructional schemas (i.e. mini-constructions) as necessary to capture all possible ways of interaction between verbal predicates and constructions to yield specific input texts (cf. Boas, 2014). The latter approach, by contrast, posits macro-constructions that group different formal variants under one general conceptual schema. As we will see in the following section, this latter approach, typical of work by Goldberg (1995, 2006), is the one to be adopted for the L2 Constructicon.



## 4.2. The L2-Constructicon

In FunGramKB the L2-Constructicon deals with implicational constructions. These constructions have been studied in the LCM as originating in entrenched meaning implications of an attitudinal kind arising from premise-conclusion reasoning schemas exploiting low-level situational ICMs or, put simply, low-level scenarios. A case in point is the *What's X Doing Y?* construction, originally discussed, mainly from the perspective of its formal properties, by Kay and Fillmore (1999). These authors pointed out that this construction conveys meaning that is not produced compositionally from its constitutive elements: it conveys the idea that the situation that it questions about, which is already known to speaker and hearer, somehow concerns or bothers the speaker. So, rather than a question, it is a way of drawing attention to an undesirable situation. The LCM analysis investigates the reasoning process involved in this meaning implication (see Ruiz de Mendoza, 2015). Let us consider the sentence *What's she doing playing the trumpet?*<sup>5</sup> This sentence is not a question about what the protagonist (the X variable of the construction) is doing, since this information is clearly specified by the phrase *playing the trumpet* (the Y variable). This apparent inconsistency leads the hearer to look for an alternative interpretation along non-descriptive (i.e. interpretive) lines. This takes place through the application of a complex premise-conclusion reasoning schema that exploits elements of the “playing the trumpet” scenario. In an informal way, it can be spelled out as follows:

**Premise 1** (implicit assumption): When people ask for information that they already have, they are probably drawing our attention to such information.

**Explicit assumption:** S asks about X's behavior but then specifies the nature of X's behavior, i.e. playing the trumpet.

**Conclusion 1** (implicated assumption): S is not asking about X's behavior but drawing attention to the fact that X is playing the trumpet.

**Premise 2** (implicit assumption): People draw attention to other people's behavior when they want to express their attitude about it.

**Previous implicated assumption:** S is drawing H's attention to X's playing the trumpet.

**Conclusion 2** (implicated assumption): S is expressing an attitude about X's playing the trumpet.

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5 Example taken from Google Books: *Suffering and Sickness: The Mystic Knowledge Series*, by Marilyn Hughes (2004). Accessed on April 3, 2015.

**Premise 3** (implicit assumption): Playing the trumpet can bother people.

**Previous implicated assumption:** S is expressing an attitude about X's playing the trumpet.

**Conclusion 3** (implicated assumption): S is bothered about X's playing the trumpet.

Obviously, the third part of this reasoning schema could have been different since there is no *a priori* reason why we should expect the speaker's attitude to be negative about X playing the trumpet. The negative implication is just one possible interpretive pathway, but in fact it is the one that has been coded by the construction. This is probably the result of its frequent use in situations where speakers—at one further interpretive level of an illocutionary kind—need to express dissatisfaction in order to get hearers to deal with whatever the problem is.

In the LCM, the *What's X Doing Y?* construction is identified as a member of the family of Wh-attitudinal constructions. The members of this family share with *What's X Doing Y?* the same basic speaker's attitude about a state of affairs that s/he already knows about. These constructions are based on information questions that do not seek information, but point to the undesirable or otherwise surprising nature of the state of affairs that they apparently ask about. They vary in some of their formal and functional aspects, and in their degree of entrenchment, but they all preserve the same central meaning implications. Here are some of their formal specifications:

- (9) What Has/Have X Been Doing V-ing Y?: *What have we been doing wasting our lives with all this nonsense?* (GBAC, 1989).
- (10) Who's Been V-ing X?: *Who's been using my pool?* (GBAC, 2008).
- (11) What Has/Have X Been V-ing Y?: *What's she been doing down there?* (GBAC, 2003).
- (12) Why Has/Have X Been V-ing Y?: *Why have you been calling her so much?* (GBAC, 2013).
- (13) Where Has/Have X Been (V-ing) Y?: *Where have you been hiding all day?* (GBAC, 2003).
- (14) When Has/Have X Been V-ing Y?: *When has he been thoughtful at all?* (GBAC, 2009).

The *What's X Doing Y?* construction makes use of the present progressive, which points to an ongoing situation or event. The constructions in (9)-(14) use the present perfect continuous to denote a state of affairs that started in the past but is still active or at least relevant at present. This present relevance is essential for the construction to be able to direct the hearer's attention to whatever is happening. In turn, the Y element is essential in determining the status of the construction as a member of the same family, especially in those cases where the *wh-* component expresses reason, place, or time. In general, when the Y element, which serves the function of supplying circumstantial information, is highly detailed, it gives hearers reasons to suspect that the speaker is aware of the exact nature of the situation in question. This is also the case for *Who's Been V-ing Y?* Compare:

- (15)a. What's your kid doing?  
 b. What's your kid doing in the kitchen?  
 c. What's your kid doing in the kitchen with the oven turned on?
- (16)a. Who's been playing the guitar?  
 b. Who's been playing the guitar for hours?  
 c. Who's been playing the guitar for hours while your mom wanted to get some sleep?

The (b) and (c) examples are more clearly members of the *Wh-attitudinal* family than the (a) examples and, as a result, they are less likely to give rise to interpretive ambiguity. Then, in the case of constructions based on a *wh-* element expressing reason, place, and time, there is a strong tendency to interpret them as mere information questions, because of the satellital nature of these parameters, which fall outside the basic relationship between a predicate and its arguments. But this tendency can be overridden by an over-specification of the Y element:

- (17)a. Where have you been spending the day?  
 b. Where have you been spending the day while your father was working?  
 c. Where have you been spending the day while your father was working and your brother was making home repairs?

These observations have important implications for computational implementation. FunGramKB can list (9)-(14) as formal variants of one *same* constructional domain, with a common core meaning (or COREL schema), thus reflecting the linguistic evidence that they belong to the same family. In consonance with this, we have reduced the analysis provided above to a set of core assumption that can in fact be translated into COREL. These are the following:

- a. The speaker is aware that there is a situation or an event that is the case in the world.
- b. The speaker believes that such a situation or event is wrong.
- c. Because of (b) the speaker dislikes the situation or event.
- d. The speaker believes that the hearer either shares assumptions (b) and (c) or should share them with him.
- e. The hearer believes assumptions (a)-(d) to be the case.

In FunGramKB implicational configurations go beyond the logical structure of argument-structure constructions associated with verbal predicates. Because of this, implicational constructions can only extend the COREL schema (Periñán, 2013: 217). The COREL representation capturing the semantics of the *Wh-attitudinal* family is provided in (18):

- (18)+(e1: +FEEL\_00 (x1: <EVENT>)Agent (x2: <SPEAKER>)Theme (x3: +UPSET\_00 | +BOTHERED\_00) Attribute)

+(e2: +DO\_00 (x2)Theme (x4: (e3: +PERCEIVE\_00 (x5: <HEARER>)Theme (x6: (e4: +BE\_01 (x1) Theme (x7: +BAD\_00 | +WRONG\_00)Attribute))Referent))Referent (f1: (e5: nfut +CHANGE\_00 (x8)Theme (x1)Referent))Purpose)

Predication ‘e1’ states that ‘there is a situation/event which causes the speaker to feel upset and/or bothered’. In turn, ‘e2’-‘e5’ convey that ‘the speaker makes the hearer aware that such a situation is bad and/or wrong so that (f1 = Purpose) somebody will fix it in the immediate future’. As is obvious from (18), although the central meaning implications of the formal variants in (9)-(14) may be successfully represented on the basis of COREL, the individual meaning nuances of each of these related configurations exceeds its syntactic and semantic layout. For example, in *What Has/Have X Been Doing V-ing Y?* the speaker is bothered about the possible consequences of something that someone has done and wishes that this situation will not take place again. *What Has/Have X Been V-ing Y?* displays similar meaning implications, but in this construction, the speaker focuses on the object of an action rather than on the action itself. Unfortunately, COREL is not flexible enough to capture such fine-grained meaning implications. As a result, the approach adopted for the formal description of the semantics of level-2 constructions requires broader conceptual definitions à la Goldberg (1995), to which different formal variants of a given constructional family are connected.

## 5. Conclusions

This paper has aimed to contribute to the reconciliation of NLP and linguistic theory by providing formalized, machine-tractable representations of constructions that build on a previous linguistic analysis. From our discussion, we can conclude that FunGramKB benefits from the incorporation of the LCM into its design in two ways. First, individual constructions, as well as constructional families that belong to different levels of linguistic description and explanation, are included within a single architecture. Second, semantic processing is enhanced thanks to the incorporation of the fine-nuanced constructional schemata from the LCM, which go beyond the descriptive and explanatory scope of RRG, the other linguistic model in which FunGramKB is grounded (cf. footnote 3). In turn, FunGramKB has helped to prove the implementability of the LCM within an NLP environment, thereby contributing to its computational adequacy (Butler, 2009a). In this paper, the feasibility of this feedback has been demonstrated by conducting an analysis of two constructional families. Our goal was to examine how a non-compartmentalized approach to argument-structure and implicational constructions can be handled in a knowledge base for NLP systems. Needless to say, this collaborative effort is not without hurdles. Many of the explanatory tools put forward by the LCM (e.g. high-level metaphor and metonymy), which are essential to adequately motivate linguistic phenomena, cannot yet be operationalized in FunGramKB or in any other computational approach. By the same token, our analysis indicates that the properties shared by

the members of the constructional families under scrutiny cannot be formalized on the basis of the same methodology, as would be the case in the LCM. In order to comply with computational requirements, some of the members of the family of the resultative need to be split into mini-constructions, while the complexity of implicational configurations requires that different formal variants be lumped under one single COREL schema. We suspect that this will also be the case with constructional families from level-3. Finally, with regard to implicational constructions, for example, it is not possible as yet to transduce into FunGramKB the meaning consequences of making the Y element of *Wh-attitudinal* constructions more complex.

## 6. Acknowledgements

The research on which this paper is based has received financial support from the Spanish Ministry of Economy and Competitiveness, grants no. FFI2014-53788-C3-1-P and FFI2013-43593-P.

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