Design of an Explicative Combinatory Dictionary for Spanish Verbs

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Abstract. Several lexical resources have been proposed in the literature. However, the main problems of Natural Language Processing (NLP), such as ambiguity resolution and parsing, require a more integrated version of the different approaches, i.e. an organized, theoretically well-motivated form of lexical, syntactic and semantic information for each entry. In this paper we present the design of a dictionary based on a proposal by Apresjan. We describe the definition zones of entries in the lexicon, the methodology followed to obtain the content of this zones and we give an example in the semantic domain of creation verbs. We also discuss the complexity of carrying out this task.

1 Introduction

Assignment of senses to verbs is not a trivial matter. In modern linguistics and computational linguistics most studies have concentrated on identifying the thematic roles of verbs in order to characterize semantic frames. They also describe how semantic roles can be mapped onto syntax in a predictable way. Likewise, an Explanatory Combinatorial Dictionary (ECD) describes the logical arguments of verbs and the correspondences between semantic and syntactic arguments very adequately, identifying different senses of verbs by enumerating them as $sense_1, \ldots, sense_n$. We know very little about, among other things, what characterizes $sense_1$ as distinct from the others and what are the differences and similarities between sense1 and the other senses.

It is not sufficient to enumerate the different senses that a verb can have and acquire based only on semantic features (semantic structure). More important, the semantic structure only deals with the logical meaning of a sentence. Because of this fact, we must also attempt to classify senses according to their cognitive aspects, logical emphasis, presuposedness, social associations which are considered as part of the communicative structure of a sentence within its semantic representation structure. Thus, in this paper the meaning of a sentence

is based on Mel'čuk sentence representation structures [9]. That is, a sentence representation is conformed by a semantic structure, syntactic structure and a communicative structure. Nonetheless, due to some specific phenomena observed within sentences, we also think that it is necessary to include a referential structure to achieve an even broader sentence meaning representation. In order to realize this goal, we have implemented some criteria for establishing senses from a referential view point. Here, a referential structure is considered as specifying the referent of a semanteme configuration. That is, it indicates the links between semantic chunks and the corresponding entities and facts in the universe to which these chunks refer (Mel'čuk, 2001). Then, in order to deal with the referential structure, we assign different tags to different senses to set up the categories in which they participate.

In this proposal, therefore, a standard entry is organized basically into four definition zones:(1) the lemma zone; (2) the explanation and meaning zone; (3) syntax; and (4) the co-occurrence restrictions zone. Since referential structure is one important characteristic of this proposal when classifying senses, it is intended mainly to establish a methodology capable of, on the one hand, identifying all possible senses that a verb can have and, on the other hand, classifying senses into categories by tagging them in a reasonable manner. This will be done by the identification and classification of all different possible senses. This is based primarily on two criteria: (a) the participants (actants) of the verb and (b) the proper features of the verb. Consider the following sentences:

(1) a. Maria rompió la ventana.   *Maria broke the window.*
    b. El martillo rompió la ventana. *The hammer broke the window.*
    c. La ventana se rompió.   *The window broke.*

According to Case Grammar [4] [13] and from a communicative point of view these sentences express different senses since sentence (1a) expresses the subject who carries out the action; sentence (1b), however, it expresses the instrument with which the action was carried out; and finally, sentence (1c) shows the object affected by the action of *romper* (break). That is, thematically each one expresses a different theme and rheme due to well-known meaning communicative organization rules. Consequently, these sentences, (1a), (1b) and (1c), should be interpreted differently since they evoke different senses. As we can see, they clearly express different states of affairs in the world. That is the message is communicatively organized in such a way that it is making reference to different things in the world. On the other side, it seems syntactically that the above sentences are composed according to the grammatical constructions SVO (1a and 1b) or SV (1c). However, their semantic meaning has been strongly affected by the communicative structure of the sentences, proving that communicative structure has a great influence in the semantic interpretation. It is quite clear that they do not mean the same thing, since their interpretation depends too on what kind of argument the verb is interacting with, that is, whatever each participant denotes affects the possible meaning that a verb can acquire syntagmatically and paradigmatically.

Based on these considerations and the two criteria mentioned above, it is therefore assumed that identification of what each participant denotes is of great importance in the task of identifying and classifying the different senses of a given verb and arranging senses in different categories. For instance, in the case of the sentences mentioned previously, the meaning of sentence (1b) would be classified under the tag Instrument, Operative Part. Similarly, sentences (1a) and (1b) will be placed under the tag Object/Content, making it clear that (1a) is intended to describe the subject of the sentence, whereas (1c) is making reference to the direct object of the sentence which turns out to be the actant to be affected by the action of the verb. The other important criterion for identifying and eventually classifying all possible senses of a verb is the proper features of the verb examined. As an example, the verbs *comer* (eat) and *devorar* (devour), which are normally considered instances of the verb *ingerir* (ingest). From this perspective the purpose is to graduate the meaning of comer and devorar as two distinct manners of ingesting something. Although gradient distinctions are important for semantics, aspect features must be included in order to identify senses more accurately and classify them broadly. Let us consider the following sentences which contain the verbs *comer* (eat) and *devorar* (devour):

(1) d. María comió su torta ayer. *Maria ate her sandwich yesterday.*
  e. María comió ayer. *Maria ate yesterday.*
  f. María devoró su torta ayer. *Maria devoured her sandwich yesterday.*
  g. *María devoró ayer. **Maria devoured yesterday.*

In sentence (1d) and (1e), comer denotes an action of unbounded duration, that is, the sentence does not provide information about the duration of the action, although we know that it has finished, at least deictically, at some time in the past. However, sentences (1f) and (1g), in contrast to (1d) and (1e), make reference to a change of state. This change of state seems to be absent in comer; in other words, in devorar there is a completive implication which is absent in comer. This distinction seems to help us explain the syntactic behavior of these verbs, that is, why comer accepts the dropping of the direct object while devorar does not.

Once all possible senses of a verb have been established and assigned according to its participants and proper features, we determine in which semantic frames verbs participate. Thus we are trying to explain syntagmatically why verb classes behave as they do, and what consequences these distinctions have for the rest of the lexicon and grammar. Consequently, the aim of this research project is to identify compositionally the similarities and differences between verbs, whether or not they are semantic.

The article will be organized in the following manner, we explain in section 2 the organization of semantic classes. In section 3 the structure and composition of verb descriptions are reviewed. Finally, in section four we describe the methodology used and in section five we show what an actual (partial) dictionary entry looks like.

2   Semantic Classes

This project is based on one of the oldest semantic classifications of verbs, their aspectual class or Aktionsart. This classification considers that verbs and verbal phrases differ in the types of events that they denote in the world. In other words, in the kind of action verbs denote. It is normally assumed that there are at least three aspectual types: state, activity, and event, where the last sometimes is divided into accomplishment and achievement events.

Some examples will show what we mean by aspectual class. The verb *caminar* 'walk' in sentence (2) denotes an activity of unbounded duration; that is, the sentence itself does not carry information about the temporal extension of the activity, although deictically it is an event that finished in the past.

(2) María caminó ayer.   *Maria walked yesterday.*
(3) María caminó a su casa ayer. *Maria walked home yesterday.*

Thus sentence (2) denotes an activity or an achievement. Other examples of this class of verbs are: *dormir* 'sleep', *correr* 'run', *trabajar* 'work', *beber* 'drink', etc. On the other hand, sentence (3) conveys the same information as (2), except that (3) is constrained by the fact that María finished walking when she arrived home. Although there is no explicit reference to the duration of the activity, this sentence states that the process has a logical culmination, since it finishes when María gets home. It is said that this kind of sentence denotes an accomplishment.

Just as the verb *caminar* seems by default to be an activity in lexical terms, there are verbs that seem to denote accomplishments lexically. For example, the verbs *construir* 'build' and *destruir* 'destroy', in their typical transitive use, denote accomplishment events since there is a logical culmination to the activity performed.

(4) María construyó una casa. *Maria built a house.*
(5) María destruyó la mesa.   *Maria destroyed the table.*

In sentence (4) the coming into existence of the house is the culmination of Marías action, while in (5) the nonexistence of something referred to as a table is the direct culmination or consequence of the action of the verb. Verbs of creation are the best examples of accomplishment events.

An achievement, on the other hand, is an event where something undergoes a change of state, as in the case of an accomplishment event, but where the change is conceived of as occurring instantaneously. For example, in sentences (6), (7) and (8) the change is not gradual, but something that has a point-like characteristic to it. Therefore, modification with punctual adverbials such as *a las 3 en punto* suggests that the sentence denotes an achievement event.

(6) Juan murió a las 3 en punto.   *Juan died at 3 o'clock sharp.*
(7) Juan encontró su cartera a las 3   *Juan found his wallet at 3*
    en punto.   *o'clock sharp.*
(8) Maria llegó a la media noche.   *Maria arrived at midnight.*

It seems that some lexical properties of verbs may be affected by the sort of complement with which they interact.

As we can see from the examples so far discussed, the kind of event that a verb denotes may vary from a compositional perspective. Therefore, co-occurrence meaning as well as compositionality should be considered when describing a lexical item. A shift of meaning in the verb arises as a result of syntagmatic interactions and the semantic and syntactic relationship of the verb with the rest of the items in the sentence.

3   The Structure and Composition of Verb Descriptions

As mentioned in the Introduction, the aim of this research project is to identify similarities and differences between verbs, whether or not they are semantic. In this study we use Apresjan's [1] criteria for the elaboration of the *New explanatory dictionary of Russian synonyms*. Here a complete semantic description of a word or collocation consists in an explanation of the meaning of the word (verb, noun, etc.) or collocation (*dar inicio* 'begin') and its meaning. The meaning is also divided into three different categories, namely, purely denotative differences, connotations and, finally, information about its logical emphasis. Thus the composition of a standard entry for a verb is organized in the following definition zones: (1) lemma, (2) explanation and meaning, (3) syntax and (4) combinations and their co-occurrence restrictions (collocations).

3.1   The Lemma

The lemma includes a description of the type of category for each verb. That is, here we mention which category such and such a verb belongs to, the gender, number, etc., of its arguments, etc.

3.2   Explanation and Meaning

Explanation In this study, the explanation of the meaning of a word has two components: (1) the concept that corresponds to the thing, to the situation, to some property, to a state or a process, etc.; that is, what the word denotes. So the concept is described as the frame of the event, which at the same time constitutes an event structure, as well as a sub-event structure. Here also it is important to mention that the concept of a situation (that is, the participants, their characteristics, the relationships among them) can include details about the role which the observer plays. There are also some meanings (and, in consequence, some explanations) which have two different components, namely, presuppositions and assertions. Presuppositions are the elements in an explanation which are not affected by negation. As an example, in the word *soltero* (='bachelor', an unmarried male person who is old enough to marry), the definition element 'person' is a presupposition of *soltero*, while 'unmarried' is an assertion, that is, it is a semantic component which is affected by negation. And (2) the evaluation or

valuation, that is, the opinion of the interlocutors, the speaker or the hearer(s), about the thing, the situation, etc., as good or bad, credible or not, desirable or undesirable, etc. This component makes up the so-called modal framework of the explanation. The description of the concept is the central part of the explanation and the description of the evaluation is its modal framework.

Meaning A rational approach to the different types of meanings of a verbal lexeme is based on the fact that the different lexical entries for the verbs in the dictionary principally denote actions, situations, events, processes, states and properties. The different senses which a verb has may be distinguished both (a) by its participants (subject, object, recipient, instrument, means or vehicle) and (b) by its syntactic-semantic features (cause, effect, purpose, motivation, place, beginning point, end point, time, method of execution, nature, degree, form of manifestation, etc.) Apresjan [1] notes something very important about synonym dictionaries when he says that the types of participants and the generalized features of verbs are what in the majority of cases give us the distinctive features of each verbal lexical item. Thus there have been established purely semantic distinctions, distinctions in logical emphasis and their cultural associations or connotations in order to assign the different senses of a verb.

3.3 Syntax

Verb Alternations We also employ a recently-developed methodology to group the meaning of verbs in semantic classes through the analysis of the syntactic frames in which they participate; that is, common grammatical verb alternations. Here, as an example of similar works, we can mention the MIT Lexicon Project [7], which outlines a large classification of argument-verb alternations in English in order to classify verbs into semantically unique classes.

Let us consider the following examples, the verbs *hundir* 'sink', *rodar* 'roll', and *romper* 'break' all have transitive and intransitive forms when their lexical senses are related to the interpretative characteristic of causation[3].

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[3] In (9a), the pragmatically unmarked supposition is that the weather caused the sinking, while in (9b) the cause of the sinking is explicitly specified, the weather being only a commentary on the event.

(9) a. El bote se hundió en un clima *The boat sank in a storm.*
        tormentoso.
     b. El avión hundió el bote en un clima *The airplane sank the boat in a*
        tormentoso. *storm.*
(10) a. La pelota rodó por la colina. *The ball rolled down the hill.*
     b. Bill rodó la pelota por la colina. *Bill rolled the ball down the hill.*
(11) a. Súbitamente, la botella se *Suddenly, the bottle broke.*
        rompió.
     b. Súbitamente, Maria rompió la *Suddenly, Maria broke the bottle.*
        botella.
(12) a. La carta llegó a tiempo. *The letter arrived on time.*
     b. *El cartero llegó la carta a tiempo. **The mailman arrived the*
          letter on time.
(13) a. Mi terminal murió anoche. *My terminal died last night.*
     b. *La tormenta murió mi terminal **The storm died my terminal last*
        anoche. *night.*
(14) a. La torre de bloc cayó. *The block tower fell.*
     b. *Zacarías cayó la torre de bloc. **Zachary felled the block tower.*

Although sentences (12b), (13b), and (14b) are ill-formed, they are certainly understandable. A lexical semantic theory should specify what these classes share: for example, both have intransitive grammatical forms. Thus, it is important to identify similarities among verbs for establishing a domain where lexical items are somehow unified (unification), but equally important is the characterization of how verbs differ (individualization). For example, the latter group (the b. sentences) does not allow the transitive form of the sentence. The question is whether it is possible to identify the linguistically relevant features that lead to the distinct behavior of the transitive verbs above. However, as Pustejosvky [13] claimed, we must realize that explaining the behavior of a verb's semantic class can come about only by acknowledging that the syntactic patterns in an alternation are not independent of the information carried by the arguments characterized in those very patterns. In other words, the diversity of complement types that a verb or other category may take is in large part also determined by the semantics of its complements.

3.4   Collocations

It is worth pointing out that in this work collocations or semi-phrasemes are very important, since they contain a great deal of subjective communicative information. A collocation is a more or less fixed expression which is composed of (at least) two constituents. The meaning of the whole collocation includes the meaning of one of its components but not the other, at least not wholly. For example, *sostener una tesis* 'maintain a thesis', where the phrase is about a thesis but *sostener* 'maintain' does not convey its usual meaning (taken from [10]:269). In addition, Mel'čuk, Clas & Polguère [11] present the Lexical Functions (LF) in their Meaning-Text Theory. According to Corpas Pastor [14] the LF were

proposed as an attempt to systematize all the semantic links that could be established within word combinations, that is, between the base and the collocate. In other words, the lexical functions describe the co-occurrence restrictions of words, as well as the phenomena of derivation. Therefore, the notions of base and collocate are similar to the concepts of key (the word which is applied to determine a lexical function) and the value (the resulting word(s)). For example, applying the lexical function **Realization** to the key *promesa* 'promise' we obtain the value *cumplir* 'fulfill'.

4 Methodology

We used three different linguistic resources (dictionaries) to determine the lemma zone, as well as the explanation and meaning zones. These were: the *Diccionario enciclopédico Larrousse* [8], the *Diccionario Enciclopédico Océano* [12], and the Davies corpus for Spanish [3]. Dictionaries are valuable sources of useful information since they list all senses that a verb can have (or all considered necessary by the lexicographers). This knowledge can be verified using a corpus in order to corroborate the senses described in the dictionaries or to find another possible context in which it is employed in a new way which the listed senses do not cover and which consequently is indicative of a new sense[4].

The next step was, for each verb, to examine the dictionaries in order to ascertain its distinct senses. We then analyzed the Spanish corpus of Davies [3] to match each occurrence of the verb with the different senses of the term described in both dictionaries. Different contexts and participants were considered to match the distinct senses of a given verb in the dictionaries when the use of the examples in the corpus assumes such situations.

In our proposal, different senses that a term can have are not arranged in the traditional way of listing the various senses as $sense_1 \ldots, sense_n$; we rather seek an arrangement in accordance with what each different semantic argument or semantic actant denotes. In other words, what type of argument a verb can combine with and what each argument makes reference to are of great importance for compositional interpretation, on the one hand, and for the understanding of co-occurrence phenomena, on the other. In addition, the contribution of the arguments of a verb to its meaning and interpretation is regarded as another important characteristic which distinguishes this proposal.

The steps we have sketched for the procedure of constructing an entry in the ECD, apart from enriching our conception of the content and description of the ECD, permit us to have a better idea of the complexity of this task. It requires the use of linguistic resources (for example, machine readable dictionaries), the tools of NLP must be well-used [2][5][6], and a team of various specialists is needed. The procedures implicit in the construction of an ECD are variegated

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[4] Note that not all new collocations imply new senses: in about 1950 we would have found the collocation *prendí/encendí/conecté el radio/la televisión* but hardly the first element with *la computadora*, since the latter was not yet in widespread use; by 1995, all these collocations would have been found in large numbers.

and complex; just to mention a few, we need to make use of parsing, semantic tagging, word sense disambiguation, the identification of collocations and their collocates, and sense clustering.

5   Example Entry

In this work, it was decided to take a specific domain to demonstrate the dictionary entries: verbs of creation. These fall into the more general category of verbs which denote actions and events.

As a rule, both of the dictionaries we used coincided in the number and the description of the different senses of a term; nevertheless, the Larousse dictionary [8] is characterized by its richer lexical semantic descriptions, since it considers a greater number of different contexts for some terms.

The systematic lexicographic description of each verb was organized in the following way. On the one hand, the component of the explanation in which what each verb denotes is established and described, along with the presuppositions and assertions which can accompany certain explanations, and likewise the evaluative frame (evaluation) for each verb. On the other hand, we have the component of the meaning of a verb, in which the different senses which a verb may have are explained, placing these different senses in three separate definition zones: a) their purely semantic distinctions, b) their connotations and c) their logical emphasis. In Figure 1[5] appear each one of the components which are found, for the verb *construir*. Here we must remark that not all the definition zones will always occur for every verb, for example, *edificar* would have the connotation zone filled, while for the verb *construir* is not present. The two components, together with their respective frames and zones, are an attempt to achieve a perspicuous description of the semantic and conceptual organization of Spanish verbs.

Figure 1 shows an example (in part) of what the previous descriptions of our approach lead to.

6   Conclusions

We hope to have presented a cogent case for the usefulness and theoretical desirability of an Explanatory Combinatorial Dictionary for Spanish, as well as an actual partial entry in this dictionary for a member of a certain class of verbs (verbs of creation) in Spanish.

In the example entry, we experimented with a part of the process required for producing entries in the Explicative Combinatory Dictionary of Spanish verbs. Some important points are: (1) the conception of the situation (that is, the participants, their characteristics and the relationships between them) may include details about the role which the observer plays and (2) distinct senses emerge, depending on the combinations of the verbs with their possible arguments within a particular context. With respect to the computational assistance

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[5] GL stands for Generative Lexicon [13].

Fig. 1. Combined CED and GL.

Construir. (*Construct*)	v. tr. Del latín *construire*.
Explanation	Acomplishment event
Evento substructure:	E1 < Process
	E2 < State
Presupositions y assertions:	• Presupposes the termination of something.
	• Presupposes a plan.
	• Presupposes grouping the parts to form a whole.
Evaluation:	(+) desirable, (+) Aesthetics (pretty) (+) Ethics (well done)

Meaning
Construir. Hacer una cosa material o inmaterial ordenando y juntando sus partes de acuerdo a un plan.

Object
El objeto sintáctico de construir puede combinar con objetos físicos. Los sujetos por su parte refieren a seres animados y abstracciones de organizaciones sociales (compañías, instituciones). El verbo refiere la existencia de un bien material.
- Juan construyó la casa.
- La compañía construyó el puente después de la guerra.

Content
El objeto de *construir* también denota objetos abstractos. Aquí los sujetos refieren a seres humanos primordialmente. El verbo denota el orden y relaciones del objeto.
- Juan construyó una teoría.
- Construyeron su idea a partir de una fotografía.

Pseudo-passive with *se*[6]
En la cadena comunicativa el verbo *construir* hace referencia a la importancia, relevancia o interés que el objeto tiene sobre el sujeto lo que provoca que aparezca como sujeto gramatical, el sujeto semántico ('subyacente') queda sin especificar. Los sujetos gramaticales son bienes materiales o pueden ser abstracciones.
- El edificio se construyó en 1991.

Instrument
El verbo *construir* puede expresar también el instrumento con el cual se lleva a cabo la construcción de la obra como el sujeto gramatical. En este caso los argumentos con los que interactúa señalan herramientas tales como maquinaria y distintos dispositivos tecnológicos.
- La máquina construyó la carretera.

Definition zones of the verb *construir*.

$$
\text{Construir} \qquad\qquad\qquad\qquad\qquad [Construct]
$$

$$
\text{EVENTRSTR} = \begin{bmatrix} E1= & \text{process} \\ E2= & \text{state} \\ REST= & \leftarrow \\ HEAD= & e_1 \end{bmatrix}
$$

$$
\text{ARGSTR} = \begin{bmatrix}
ARG1= & 1\begin{bmatrix} \text{animate/inanimate-individual} \\ \text{FORMAL=physobj/absobj} \end{bmatrix} \\
X=1; & \text{who constructs?} \\
\%\ Juan \sim & [\%\ John \sim] \\
ARG2= & 2\begin{bmatrix} \text{entity} \\ \text{CONST=}\quad 3 \\ \text{FORMAL= physobj/absobj} \end{bmatrix} \\
Y=2; & \text{what?} \\
\% \sim una\ silla \simeq & [\% \sim a\ chair \simeq] \\
\% \sim una\ teoría \simeq & [\% \sim a\ theory \simeq \\
\text{D-ARG1} & 3\begin{bmatrix} \text{material} \\ \text{FORMAL= mass} \end{bmatrix} \\
Z=3; & \text{from what?} \\
\% \simeq de\ madera & [\% \simeq of\ wood] \\
\% \simeq sobre\ el\ clima & [\% \simeq about\ the\ climate]
\end{bmatrix}
$$

$$
\text{QUALIA} = \begin{bmatrix} \text{create-lcp} \\ \text{FORMAL=} \quad \text{exist}(e_2, 2) \\ \text{AGENTIVE= build-act}(e_1, 1, 3) \end{bmatrix}
$$

for the development of this project, we think that, at this stage of the project, the identification of verbal arguments, through the use of concordances, and their semantic classification would be of great assistance to the lexicographer.

Compiling the dictionary following the methodology proposed, we observed that apparently differences and similarities among verb senses do not depend exclusively on prototypical aspects; rather an schemata seems to arise which describes what senses are shared or not by two verbs considered synonyms. That is, two verbs may vary in accordance with their differences and similarities but within a schema. Though at the moment this proposal of dictionary is oriented for humans use, we think that the different zones can be codified in such a way that an automatic system can easily manage them and exploit them in NLP tasks. In addition, in future works the matrix for each verb description will include transformations (transmutations) so that each definition zone (consequently, meaning) is mapped onto its corresponding syntax representation.

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