

Semantic interpretations of postpositions and prepositions: a multilingual inventory for Basque, English and Spanish

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Abstract

This article describes a common inventory of interpretations for postpositions (Basque) and prepositions (English and Spanish). The inventory is a flat list of tags, based mainly on thematic roles. Using the same inventory allows to know for each postposition or preposition, which are the translations for each possible interpretation. We think this resource will be useful for studies on machine translation, but also on lexical acquisition experiments on the syntax-semantic interface that make use of multilingual data.

The method to derive the inventory and the list of interpretations for Basque postpositions and Spanish and English prepositions has tried to be systematic, and is based on [Aldezabal, forthcoming and [Dorr, 1993].

1 INTRODUCTION

This article describes an inventory of interpretations for postpositions (Basque) and prepositions (English and Spanish). Basque is an agglutinative language, and its postpositions are more or less equivalent to prepositions, but they are also used to mark the subject and objects of verbs. The interpretations are given for both arguments and modifiers, in a generic form. As the list of interpretations is common for all languages, a by-product is that it is possible to know which are the possible translations for a given postposition or preposition into the other languages. The table of interpretations is a generic knowledge resource that will help in the acquisition of complex multilingual structure in the framework of the MEANING project [Rigau et. al., 2002]¹.

For instance, [Agirre and Lersundi, 2002] describe a method based on such a multilingual table to link the syntactic function of an argument or adjunct to the semantic function of the argument or adjunct. The method is shown to be effective disambiguating occurrences of the Basque postposition *-z* (instrumental case) in dictionaries definitions, using parallel Spanish and English definitions. We plan to apply the method to the multilingual table described in this paper.

Our inventory of interpretations is based on [Aldezabal, forthcoming] and [Dorr, 1993]. Our goal is to deliver a flat list of interpretations in the form of tags. The tags are derived mainly from thematic role tags, but also cover adjuncts and other phenomena. In order to have a common inventory of interpretations, we have to fix first which are the interpretations that we are interested in. This is not an easy task, and we decided to fix the inventory as we were building the table of interpretations.

¹ <http://www.lsi.upc.es/~nlp/meaning/meaning.html>

This article is organized as follows. Section 2 presents previous work, followed by Section 3, which presents the method used to build the table and the inventory of interpretations. Section 4 illustrates the method with an in-depth study of the instrumental case (-z). Section 5 presents the analysis of the results. Section 6 reviews some remaining problems. Finally, Section 7 draws the conclusions.

2 PREVIOUS WORK

As we can read in [EAGLES, 1998], semantic relations were introduced in generative grammar during the mid-1960s and early 1970s [Fillmore, 1968; Jackendoff, 1972; Gruber, 1967] as a way of classifying the arguments of natural language predicates into a closed set of participant types which were thought to have a special status in grammar. A list of the most popular roles and the properties usually associated with them is given below.

Agent: A participant which the meaning of the verb specifies as doing or causing something, possibly intentionally. Examples: subjects of *kill, eat, hit, smash, kick, watch*.

Patient: a participant which the verb characterizes as having something happen to it, and as being affected by what happens to it. Examples: objects of *kill, eat, smash* but not those of *watch, hear, love*.

Experiencer: A participant who is characterized as aware of something. Examples: subject of *love*, object of *annoy*.

Theme: A participant which is characterized as changing its position or condition, or as being in a state or position. Examples: objects of *give, hand*, subjects of *walk, die*.

Location: The thematic role associated with the NP expressing the location in a sentence with a verb of location. Examples: subjects of *keep, own, retain, know*, locative PPs.

Source: Object from which motion proceeds. Examples: subjects of *buy, promise*, objects of *deprive, free, cure*.

Goal: Object to which motion proceeds. Examples: subject of *receive, buy*, dative objects of *tell, give*. (adapted from [Dowty, 1989]).

In linguistic theory, thematic roles have traditionally been regarded as determinant in expressing generalizations about the syntactic realization of a predicate's arguments (see [EAGLES, 1996]). In many cases, the interpretations of the prepositions is linked to thematic roles.

[Aldezabal, forthcoming] presents an in-depth study of 100 Basque verbs, including their argument structure and also mentioning the semantic interpretation of elements. We have used the link between the argument structure and the semantic interpretation in order to extract possible interpretations for postpositions². This list of postpositions and their interpretation is the main source of our inventory for Basque, together with Dorr and Habash (see below).

Nevertheless, it has some shortcomings:

- Aldezabal's work focuses mainly on arguments, but she also mentions some modifiers. Therefore, her inventory of interpretations may miss interpretations for adjuncts. To get over this gap, we can check the inventory of interpretations from Dorr.
- For a given postposition, some interpretations might be missing. Aldezabal works only on the interpretations that arise during her study of the 100 verbs, and it could be the case that one interpretation for a given postposition does not appear in her data. We can try to cover those missing interpretations with bilingual dictionaries, and the interpretations on other languages.

² The syntactic function of Basque arguments is marked in the surface by postpositions, that is, each argument has a postposition that determines (ambiguously) the syntactic function of the argument.

- Some postpositions might be missing. We will take missing suffixes from Basque grammars. It will be future work to include complex postpositions (which are comparable to complex prepositions in English, e.g. “-en parean” which is equivalent to “in front of”).

Regarding English and Spanish prepositions, our main source is the Lexical Conceptual Structure (LCS) description from Dorr and Habash [Dorr, 1993; Dorr and Habash, 2002]. From the LCS we extract the thematic roles assigned to prepositions, either directly from the description of the prepositions or indirectly from the LCS describing verbs. We also got a table from [Habash, 2002] where each English preposition (plus the \emptyset preposition for subject and object positions) has a list of possible thematic roles.

Extracting interpretations for all prepositions from the LCS is not straightforward, as the interpretation of some prepositions are not always described in terms of thematic roles (e.g. it might need a primitive). Besides some interpretations for prepositions might be missing, specially for adjuncts. To our experience, the quality and coverage for English prepositions is very good, but the Spanish prepositions are not so well represented.

3 METHOD

First, we have to decide which kind of interpretation we will use in the description of postpositions, and use the same interpretation inventory for English and Spanish prepositions.

In order to get this interpretation inventory we have two main sources, but we also have used the examples from bilingual dictionaries:

- Izaskun Aldezabal’s semantic interpretation for some Basque postpositions [Aldezabal, forthcoming].
- Bonnie Dorr’s LCS for English and Spanish prepositions [Dorr, 1993].
- Bilingual English/Basque and Spanish/Basque dictionaries [Morris, 1998; Elhuyar, 1996].

A first approach to get the inventory list would be to map both Aldezabal’s and Dorr’s interpretations, and perhaps choose an inventory which is a combination of both. We compared both lists, and realized that sometimes Dorr’s interpretations are more specific than Aldezabal’s ones (this is the case of *perc* –*perceived item*–); but, overall, Aldezabal’s interpretations are more specific than Dorr’s (we have *touched theme*, *displaced theme*, and so on instead of a single *theme*).

There is another disagreement between what Aldezabal considers semantic interpretation and Dorr considers thematic role. For example Aldezabal considers as interpretation *cause* or *path*, and in the LCS representation done by Dorr, these appear as primitives and types. We also realized that *manner* is listed among Dorr’s thematic roles, but it is not linked to any preposition.

The problem is that it is very difficult to match interpretations without studying the examples to which they apply. This is specially the case when the interpretations have been given for different languages.

As a method to fix the inventory of interpretations and build the multilingual table, we start on Basque and jump into the other languages via a set of manually tagged bilingual examples from a bilingual dictionary. Previously, we decided to group some of Aldezabal interpretations (which are too granular) into a single interpretation. After this, the postpositions in the Basque examples are tagged using our interpretations and the tag is copied to the corresponding example in Spanish and English. Finally, we compare the interpretations of Spanish and English prepositions thus obtained with the thematic roles given by Dorr.

This is the method step by step for each postposition:

- a) Take a postposition.
- b) Extract examples for this suffix from bilingual dictionaries. In this way we will get good translations of this suffix into the other two languages: English and Spanish.
- c) Look for interpretations of this case [Aldezabal, forthcoming].

- d) Study her interpretations, and, when we think interpretations are very granular, join them, controlling that it is coherent with the other postpositions.
- e) Tag the Basque examples with the interpretations. Control gaps:
 - Study if there is any interpretation in the Basque examples that is missing from Aldezabal's list.
 - Find Basque examples and English translation for the interpretations that don't appear in the examples from the bilingual dictionary, but which appear at Aldezabal's work.
- f) At this stage we already have a list of interpretations for the Basque suffix, a list of examples for each interpretation and a list of English and Spanish translations for each interpretation.
- g) Each English preposition in the bilingual examples is assigned the Basque interpretation. This is compared with Dorr's interpretations for that preposition.
- h) At this stage we produce a list of 4-tuples: (postposition, Aldezabal's interpretation, Dorr's interpretation, preposition). From the study of the 4-tuples we derive the following:
 - A study of the mismatches between both interpretations, including gaps in the interpretation of English and Spanish prepositions. A qualitative and quantitative analysis of the mismatches is produced.
 - A unified interpretation tag that tries to solve the mismatches, based on Aldezabal's and Dorr's tags, thus yielding a list of triples: (postposition, unified interpretation, preposition).
 - A mapping from the unified interpretation to Aldezabal's and Dorr's inventories.

After applying this method to all postpositions, we get a unified inventory of interpretations that is applied to both postpositions and English and Spanish prepositions. We also get a mapping between our unified inventory and Dorr's and Aldezabal's inventory.

In the next section we present a case study of this method as applied to the instrumental suffix.

4 CASE STUDY WITH THE INSTRUMENTAL CASE

We will illustrate the methodology of our study using the instrumental postposition.

First we look for interpretations of this postposition in the Ph.D. of Aldezabal. It is important to take into account that the goal of Aldezabal's thesis is not the study of thematic roles. She determines the argument structure of some verbs, and arranges them into groups according to their syntactic behavior. During her study she mentions some semantic interpretations of Basque postpositions, but the goal is not an exhaustive list of semantic interpretations.

Sometimes the interpretations she gives to postpositions are very granular, and we have tried to do a list with more general interpretations, so we join some of her interpretations. Aldezabal gives 12 interpretations to the instrumental and we join them into 6.

After this, we look the examples we extracted from bilingual dictionaries (61 examples) and we check them in order to see if there is any new interpretation for the postposition. In the case of the instrumental, there appears one new interpretation. Table 1 shows the 7 interpretations for the Basque instrumental postposition:

| interpretation | Basque example | English translation |
|----------------|---------------------------|-------------------------------------|
| cause | beldurrez isildu ziren | they shut up out of fear |
| content | ontzia urez bete zuen | she filled the container with water |
| instrument | hirira autobusez joan zen | she went to the city by bus |
| manner | eskuz idatzi zuen | she write it by hand |
| path | lehorrez joan zen | she went by land |
| theme | zutaz asko daki | he knows a lot about you |
| time | hiru urtez egon ziren han | they were there for three years |

Table 1. Interpretations for the Basque instrumental postposition.

Once we have tagged the examples extracted from the bilingual dictionaries with the unified interpretations, we obtain the following triples from the translations (cf. Table 2):

Interpretation – Basque postposition – English (or Spanish) preposition.

| Interpretation | English-prepositions | Spanish-prepositions |
|-------------------|---|---|
| Theme | Æ, about, at, for, in, of, on | Ø, a, acerca de, con, de, en, sobre |
| Time | Ø, at, by, during, for, in, on | Æ, a, de, durante, en |
| Instrument | Æ, by, for, in, on, with | Æ, a, con, en, por |
| Cause | because of, due to, for, from, in, of, on account of, out of | Æ, a causa de, con, de, por |
| Content | in, of, with | con, de |
| Manner | Ø, at, by, in, on, with | a, de, en |
| Path | Ø, along, by, by way of, on, round, through | a través de, por, por delante de, por encima de, sobre |

Table 2. Interpretations for the instrumental postposition after apply the method to all Basque postpositions.³

Once we have this triplets database, we will compare the interpretations for English prepositions and for Spanish prepositions obtained so far with the ones we have from Dorr's work. During this comparison, we will be able to map Dorr's interpretations with the ones we have; and, at the same time we will build the 4-tuples we have mentioned on step "h)" of the method. After building the list, we are able to evaluate the mapping between the unified interpretations and Dorr's LCS (Table 3).

| | English | % | Spanish | % |
|--|---------|-------|---------|-------|
| 4-tuples: postposition - interpretation - preposition - LCS | 44 | | 33 | |
| Good map | 19 | 43.18 | 10 | 30.30 |
| Primitive-role problem | 14 | 31.82 | 7 | 21.21 |
| Missing interpretation | 10 | 22.73 | 7 | 21.21 |
| Missing preposition | 1 | 2.27 | 9 | 27.27 |

Table 3. Evaluation of mapping of instrumental case with Dorr's LCS.

There are 44 4-tuples between English prepositions and the Basque instrumental case, depending on the interpretations, and 33 between Spanish prepositions and the Basque instrumental. From these, we have 19 good links between English prepositions and Basque one, and 10 with Spanish one. We say the link is good when our interpretation is described by a thematic role in Dorr's LCS (cf. Table 4)

³ The prepositions in bold are the ones we get when we study the instrumental postposition (the ones we get directly from the examples extracted from bilingual dictionaries when we look for instrumental case entry).

| Our interpretations | Dorr's th-roles in the LCS |
|---------------------|----------------------------|
| theme ⁴ | perc |
| theme | th |
| theme | info |
| instrument | ins |
| content | poss |
| time | time |

Table 4. Mapping with Dorr thematic roles.

The primitive-role problem line in Table 3 relates to the case when Dorr represents what we call an “interpretation” with a primitive. We have 14 in the case of English, and 7 in the case of Spanish. In the case of the instrumental all triplets are caused by primitives *cause* (7 for English and 4 for Spanish) and *path* (7 for English and 3 for Spanish) (cf. Table 5).

| Our interpretations | Dorr's interpretations |
|---------------------|------------------------|
| cause | cause |
| path | path (TO, TOWARD, VIA) |

Table 5. Mapping with Dorr primitives

A special case is *manner*. Dorr's representation takes this one as a thematic role (they also have it as a type), but they haven't given it to any preposition. This may be because *manner* is not usually part of an argument, and their job focuses on arguments of verbs. We have counted this as a “missing interpretation”, and amounts to 6 (English) and 3 (Spanish) of the missing interpretations (10 for English, and 7 for Spanish).

Something similar happens with the *time* thematic role. This is one of the biggest gaps in their representation. 3 of the missing interpretations are *time* (\emptyset , by, in) and the other one is a *instrumental* (in); 3 of the missing interpretations in the Spanish part are *time* (a, de, en) and the other one is *instrumental* (a).

Regarding missing prepositions, “on account of” is missing for English, and \emptyset ⁵ (4 links), “a causa de”, “acerca de”, “durante”, “por delante de”, and “por encima de” are missing for Spanish.

The process is repeated for all postpositions (see section 5), and, after adding the information for all English (and Spanish) prepositions from Dorr (via mapping), the table for the instrumental is as shown in Table 6.

⁴ It is important to remark that our *theme* interpretation has always a *perc* interpretation between English and Spanish prepositions. This happens in the case of the instrumental postposition.

⁵ For the sake of this article, “ \emptyset ” corresponds to noun phrases without prepositions. In the future, we plan to split this “ \emptyset ” into “subject” and “object” syntactic functions.

| Interpretation for the instrumental | English-prepositions | Spanish-prepositions |
|-------------------------------------|---|---|
| Theme | ∅, about, after, against, around, at, before, for, from, in, into, of, on, over, that, through, to, with | ∅, a, acerca de, ante, con, contra, de, en, por, que, sobre |
| Time | ∅, about, after, ahead of, around, as, as of, at, back to, before, behind, between, beyond, by, close to, during, following, for, from, in, in relation to, near, on, per, previous to, prior to, pursuant to, related to, relative to, round, since, through, throughout, till, to, until, with respect to, within | ∅, a, de, durante, en |
| Instrument | ∅, as, by, for, from, in, of, on, out of, with, without | ∅, a, con, de, en, por |
| Cause | because of, due to, for, from, in, of, on account of, out of | ∅, a, a causa de, con, de, por |
| Content | ∅, about, between, by, for, from, in, of, on, out of, with | a, con, contra, de, en, encima de, por |
| Manner | ∅, at, by, in, on, with | a, de, en |
| Path | ∅, along, by, by way of, on, round, through | a través de, por, por delante de, por encima de, sobre |

Table 6. Overlap of the instrumental postposition after the mapping with all English and Spanish prepositions.

5 OVERALL RESULTS

After analyzing all postpositions, their intersection with English and Spanish prepositions, and the comparison with Dorr's thematic roles we get the following quantitative results:

| | English | % | Spanish | % |
|--|---------|-------|---------|-------|
| 4-tuples: postposition - interpretation - preposition - LCS | 272 | 100 | 207 | 100 |
| Good map | 161 | 59.19 | 81 | 39.13 |
| Primitive-role problem | 51 | 18.75 | 26 | 12.56 |
| Missing interpretation | 51 | 18.75 | 43 | 20.77 |
| Missing preposition | 9 | 3.31 | 57 | 27.54 |

Table 7. Evaluation of mapping with Dorr's thematic roles.

Regarding English, most of the mappings are correct. The percentage of missing interpretations is quite high, but most of them are caused by the *manner* and *time* interpretations not being present in the English data (30 and 9 times respectively).

Regarding Spanish, *manner* is also missing, but the main problem for Spanish is the lack of coverage of prepositions.

Once we have applied the method to all Basque postpositions, we have built the mapping between Dorr's LCS and the unified list of interpretations. Table 6 shows the definitive list of triplets for the instrumental postposition.

The complete set of interpretations and overlaps between postpositions and prepositions is accessible on the Internet⁶. Table 8 shows the main figures in relation with the number of postpositions and prepositions we have used, and the number of overlaps we get.

| | |
|---------------------------------|------|
| number of postpositions | 14 |
| number of English prepositions | 123 |
| number of Spanish prepositions | 25 |
| number of Basque-English links | 946 |
| number of Basque-Spanish links | 339 |
| number of English-Spanish links | 2796 |

Table 8. Main figures for the whole database.

⁶ <http://ixa.si.ehu.es/Ixa/local/casesuffixes>

6 REMAINING PROBLEMS

Once we have built the mapping between Dorr's classification and the one we are building, there may be some thematic roles without mapping. One example is Dorr's *purpose* thematic role. We have decided to exclude it for the time being, because in most of the cases this is a Verb-Verb relation, and we have focused on Verb-Noun relations.

There are some issues which we have not settled. The first issue is that we have created some complex interpretations which are based on *time* or *location* and *source* or *goal*. For now we think this distinction is important because sometimes there is a clear distinction between prepositions. For example "since" has an interpretation as a *source* but this *source* will be a *time source*. When we want to map these interpretations and Dorr's thematic roles, we say the relation is right if it has one of the two thematic roles related with our two interpretations. For example if the complex relation includes *time* and *source*, we will say the mapping is OK if between LCS representation we have a *time* or a *source* thematic role or both. We have as complex interpretations: *source-time*, *source-location*, *goal-time*, *goal-location*.

Regarding the amount of prepositions, the list of prepositions in English is quite comprehensive. According to our analysis we think that most of their interpretations are covered, as we have completed Dorr's interpretations with those which appeared in the bilingual examples. The situation is worse for Spanish, as we have a lot of missing interpretations and prepositions. Further work is needed in order to get a satisfactory status for Spanish. Regarding Basque we are very satisfied with the coverage, but we need to extend our work to complex Basque postpositions which were not included in this study.

7 CONCLUSIONS AND FUTURE WORK

We have produced an inventory of interpretations that has been used to describe Basque postpositions and English and Spanish prepositions (see Table 9). The whole database is accessible on the internet⁷. Using a simple inventory allows to know for each postposition or preposition which are its synonyms on the same language, as well as which are the translation for each possible interpretation. We think this resource will be useful for studies on machine translation, but also on lexical acquisition on the syntax-semantic interface which makes use of multilingual data.

⁷ <http://ixa.si.ehu.es/Ixa/local/casesuffixes>

| Basque name | English name |
|----------------------------|-----------------|
| agentea | agent |
| baliabidea | instrument |
| bidea | path |
| denbora | time |
| edukia | content |
| esperimentatzaile | experiencer |
| ezaugarria | attribute |
| gaia | theme |
| hasierako denbora-kokapena | source-time |
| hasierako leku-kokapena | source-location |
| helburua | goal |
| helburuko denbora-kokapena | goal-time |
| helburuko leku-kokapena | goal-location |
| iturria | source |
| jarduera | activity |
| kausa | cause |
| konpainia | company |
| lekua | location |
| modua | manner |
| noranzko | direction |

Table 9. Unified inventory of interpretations

The source of the unified inventory of interpretations has been Aldezabal's semantic interpretations [Aldezabal, forthcoming] and Dorr's thematic roles [Dorr, 1993; Dorr & Habash, 2002; Habash 2002]. We provide a mapping to both of them. Their work also provides the main source of interpretations for each postposition and preposition. We have to note that our interpretations try to cover all possible meanings of a preposition when acting as an argument or adjunct of a verb. Dorr's work is relevant because although her description focuses on argument structure of lexical verbs, she also gives importance to adjuncts. She has also analyzed a list of prepositions (including complex prepositions), and once we get the relation between her thematic roles and the list of interpretations we are building, we have been able to use all the English and Spanish prepositions she has studied.

The method to derive the inventory and the list of interpretations for Basque postpositions and Spanish and English prepositions tries to be systematic. We first extract the interpretation for Basque postpositions from Aldezabal's work on verbs. We complement this data with examples from bilingual dictionaries (Basque/Spanish and Basque/English), which also provide English translations. Checking Aldezabal's interpretations for each bilingual example against Dorr's interpretations, allows us to construct a systematic mapping. The main advantage of this method is that we are able to map different inventories of interpretations based on actual examples, rather than the sole intuition of the linguist. The results of this analysis are a database of triples (Basque postposition – interpretation – English or Spanish preposition) plus mappings between our interpretations and Dorr's and Aldezabal's interpretations.

Regarding future work, it is important to remark that the inventory of interpretations and the database is not in a final stage. Some further research needs to be done for a number of issues. Nevertheless, the use of three different sources and the work done extracting the relationship between them gives a strong basement to this approach.

We would like to treat properly the “∅” preposition, determine if there is a “subject” or an “object” relation. We will also need to go beyond verb-noun relationships, and cover all syntactic functions intermediated by prepositions or postpositions.

Regarding Basque we have a to incorporate to the database all complex postpositions with their interpretations. Spanish is without doubt the language with worse coverage: we have only 3.31% missing prepositions for English, while 27.54% are missing for Spanish in Dorr's description when we checked against a set of bilingual examples.

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