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This paper is the author's draft and has now been published officially as:

Beuls, Katrien (2012). Handling Scope in Fluid Construction Grammar: A Case Study for Spanish Modals. In Luc Steels (Ed.), *Computational Issues in Fluid Construction Grammar*, 123–142. Berlin: Springer.

BibTeX:

```
@incollection{beuls2012scopeFCG,  
  Author = {Beuls, Katrien},  
  Title = {Handling Scope in Fluid Construction Grammar: A Case Study for  
          Spanish Modals},  
  Pages = {123--142},  
  Editor = {Steels, Luc},  
  Booktitle = {Computational Issues in {Fluid Construction Grammar}},  
  Publisher = {Springer},  
  Series = {Lecture Notes in Computer Science},  
  Volume = {7249},  
  Address = {Berlin},  
  Year = {2012}}
```

Handling Scope in Fluid Construction Grammar: A Case Study for Spanish Modals

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Abstract. This paper demonstrates one way how the Spanish epistemic modal system can be implemented in Fluid Construction Grammar. Spanish is a Romance language with a rich morpho-phonological system that is characterized by paradigmatic stem changes, a considerable degree of syncretism in verbal suffixes and a sophisticated usage of modal markers. Because the choice of mood does not only depend on the linguistic expression that is used (e.g. "probablemente", "creo que ..."), but also on the position of such expression in the utterance and its scope, the processing engine needs to be flexible enough to capture these conditions. The formal implementation of the Spanish conjugational paradigm with special focus on syncretic markers forms a prerequisite for the processing of verbal mood and modal expressions.

1 Introduction

Language is a product of its users. Conversation partners usually do not hesitate to package their utterances in such a way that the interlocutor understands their attitude toward the proposition that is expressed. This strategy is operational in many language systems around the world and is mostly realized by means of mood and modal expressions that create different shades of meaning. Since these forms are inextricably tied to the field of (inter)subjective communication, the main question of this paper is concerned with the way in which such expressions can be captured by a formal representation of grammar. This paper shows one way in which a modal language system for (peninsular) Spanish¹ can be modeled in Fluid Construction Grammar (hereafter: FCG) [3, 8, 12]. Linguists traditionally make the distinction between *propositional modality* and *event modality* [7]. Since this paper reports on a first case study of the implementation of a modal system in FCG, only propositional modality has been considered, with special focus on epistemic modality.

The following requirements are specific to this FCG grammar and make this case study an interesting workbench for grammar formalizations:

1. Since the Spanish language is characterized by frequent *stem changes* in the verbal conjugational paradigm and *syncretic suffixes* (single form for

¹ Modal expressions are often dependent on the geographical and social situation of the language community.

- multiple functions), the formalization needs to be robust enough to handle such morpho-phonological incongruencies.
2. Multiple modal constructions are needed to actualize differences in meaning and form (e.g. mood suffixes). The *organization* of such a series of constructions poses an interesting challenge: The moment in the processing pipeline when the modal constructions apply is crucial for their success.
 3. A modal grammar requires the use of subclauses and therefore launches the handling of *scoping* and the start of possible long distance dependencies between clauses.
 4. Flexible processing allows the grammar to come up with multiple solutions for one meaning, influenced by the *discourse context*. The constructions themselves are thus not the only decision makers in the production process.

After the introduction of some basic linguistic facts about the language system that forms the subject of this case study in Section 2, the paper addresses the four requirements listed above in their order of appearance. Section 3 demonstrates the processing of syncretic forms in FCG and introduces a template that handles verbal stem changes. Modal constructions form the subject of Section 4: their functionality as well as their role in the processing pipeline are discussed. Section 5 launches the use of modal subclauses and the presence of a scoping relation between the main clause and the subordinated clause. Section 6 discusses deviant uses of modal expressions and their implications for the processing engine. Finally, Section 7 concludes the paper and gives directions for further research on the topic.

2 Linguistic Facts

Since this paper is concerned with a case study on the implementation of epistemic modality in Spanish, some basic linguistic background information is required in order to fully grasp its computational complexity and relevance for theories of grammar formalization. Section 2.1 addresses the meaning of the term epistemic modality; Section 2.2 concentrates on the building blocks of the verbal conjugational paradigm in Spanish. Section 2.3 briefly discusses the use of the subjunctive mood in Spanish.

2.1 Epistemic Modality

Modality typically encodes the speaker's attitude towards the proposition that is expressed. In the case of epistemic modality, the speaker forms his or her modal "judgement" based on the kind of knowledge (< Gr. *epistēmē*) he or she has acquired about the proposition (truth, probability, certainty, belief, evidence). The use of the term epistemic is relatively straightforward, with *possibility* and *probability* as two major epistemic meaning predicates. Another epistemic category is *certainty*, which is used when the speaker has good reason to believe that the statement is true (e.g. 'There must be some way to get from New York to

San Francisco for less than \$600.’). Consider the clear contrast in the notional features involved in the following pairs of examples (adopted from [7]):

- (1) Kate may be at home now.
Kate must be at home now.
- (2) Kate may come in now.
Kate must come in now.

The distinction between (1) and (2) is usually made in terms of propositional modality and event modality. This is illustrated by the use of paraphrases using ‘possible’ and ‘necessary’:

- (3) It is possibly the case that Kate is at home now.
It is necessarily the case that Kate is at home now.
- (4) It is possible for Kate to come in now.
It is necessary for Kate to come in now.

In Example (4), the speaker expresses his personal attitude toward a potential future event, that of Kate coming in. Example (3) is concerned with the speaker’s judgement of the proposition that Kate is at home.

2.2 Spanish Verbal Paradigm

Spanish is a member of the Indo-European language family and belongs to the branch of Romance languages. This branch comprises all languages that descend from vulgar Latin, the language of Ancient Rome. Today, Spanish is the third most spoken language in the world with about 500 million native speakers.

A defining feature of Spanish phonology is its diphthongization of the Latin short vowels *e* and *o* into *ie* and *ue*, respectively, in stressed contexts (e.g. Lat. *petram* > Sp. *pedra*). This difference in stress pattern has been preserved in the current stem morphology, which has led to four main cases that a language user has to account for when conjugating a verb in Spanish:

1. Regular stem, regular endings: ‘cortar’, ‘deber’, ‘vivir’, etc. (see Table 1)
2. Irregular stem, regular endings: e.g. ‘empezar’ > ‘empiezo’ (*begin.inf* > *begin.1sg.present*), ‘volver’ > ‘vuelvo’ (*return.inf* > *return.1sg.present*)
3. Regular stem, irregular endings: e.g. ‘andar’ > ‘and-uve’ (*walk.inf* > *walk.1sg.past.pf*)
4. Irregular stem, irregular endings: ‘hacer’ > ‘hic-e’ (*do.inf* > *do.1sg.past.pf*)

Irregular uses do not always show a deviant conjugation over the full paradigm². Depending on the class a verb belongs to and the verb tense and mood that is required, verbs may or may not be conjugated in an irregular manner. There

² The term paradigm is used here to refer to one column in the conjugational table; e.g. 1st verb class indicative present.

are three verb classes in Spanish: verbs ending on *-ar*, *-er* and *-ir*. Without taking into account the compound tenses (auxiliary *haber* + past participle), there are five different tenses in the indicative mood: present, past imperfect, past perfect, future and conditional. The subjunctive mood only occurs with three tenses: present, past imperfect and future. Table 1 presents parts of the (regular) Spanish conjugational paradigm that have been implemented for the current case study: indicative present, indicative past perfect and subjunctive present. All forms for the three regular verb classes have been included.

Table 1. Indicative present, past perfect and subjunctive present conjugation paradigms for regular verbs of the three main verb classes: ‘cortar’ (‘to cut’), ‘deber’ (‘have to’), ‘vivir’ (‘to live’).

	-ar		-er			-ir		
	ind.	subj.	ind.	subj.	ind.	subj.	ind.	subj.
pres.	past pf.	pres.	pres.	past pf.	pres.	pres.	past pf.	pres.
cort- o	cort- é	cort- e	deb- o	deb- í	deb- a	viv- o	viv- í	viv- a
cort- as	cort- aste	cort- es	deb- es	deb- iste	deb- as	viv- es	viv- iste	viv- as
cort- a	cort- ó	cort- e	deb- e	deb- ió	deb- a	viv- e	viv- ió	viv- a
cort- amos	cort- amos	cort- emos	deb- emos	deb- imos	deb- amos	viv- imos	viv- imos	viv- amos
cort- áis	cort- asteis	cort- éis	deb- éis	deb- isteis	deb- áis	viv- ís	viv- isteis	viv- áis
cort- an	cort- aron	cort- en	deb- en	deb- ieron	deb- an	viv- en	viv- ieron	viv- an

There is a considerable number of syncretic forms present in Table 1. Syncretism occurs where two or more distinct morphosyntactic values are collapsed in a single inflected word form [1]. Table 1 contains three main instances of syncretic forms:

1. indicative present and past suffixes for 1st person plural are equal in form, e.g. ‘cort-amos’ (present/past);
2. 1st person indicative present and past forms are the same in writing but receive a different emphasis (*o* vs. *ó*), e.g. ‘cort-o’ (1sg) vs. ‘cort-ó’ (3sg);
3. subjunctive present suffixes of the first verb class and indicative present suffixes of the second and third verb classes are shared across all persons except 1st person singular: e.g. ‘cort-es’ (subjunctive) vs. ‘viv-es’/‘deb-es’ (indicative).

2.3 Subjunctive

The difference between the indicative and the subjunctive mood is linked to the degree of affirmation of an utterance. When the speaker is confirming that what he or she is saying is valid at the moment of speaking, the indicative is used. In the contrary case, the subjunctive shows up to mark the non-affirmative stance of the speaker towards his or her proposition. The following sentences illustrate the use of the two moods in a conditional subordinated clause:

- (5) *Aunque llueve, vamos a la playa.*
 although rain-(3sg.ind.pres), go-(1sg.ind.pres) to the beach.

Although it is raining, we are going to the beach.

- (6) *Aunque llueva, vamos a la playa.*
 although rain-(3sg.subj.pres), go-(1sg.ind.pres) to the beach.

Even if it rains, we are going to the beach.

The indicative ending in (5) expresses the fact that it is raining right now, imposing an ‘although’ meaning onto the conditional adverb *aunque*. The subjunctive verb form in (6) signals a rather hypothetical statement: ‘even if’ it is raining now, we will go to the beach. The speaker indicates that the condition of the weather cannot be confirmed at the moment of the utterance.

3 Capturing Syncretism

The previous section has already pointed at the presence of syncretic forms in the conjugational paradigm of verbs in Spanish. There are two main elements of processing complexity when multiple values are conflated into one morpho-phonological form: First, all values of the single form need to be learned to lead to successful parsing. When the suffix ‘-amos’ is encountered, three alternative values will usually be activated: 1st person plural indicative present, indicative past perfect or subjunctive present. According to the morphological verb form and the semantics of the verbal clause, one of these gets selected. Second, in production, a language user needs to know which forms go together with which meaning. This second element is thus an additional (syntactic) operation one needs to perform in order to find the right form. In order to express the indicative present first person plural form of the verb ‘cantar’ (‘to sing’), a speaker of Spanish needs to have access to the fact that there are three suffixes that can fill this slot (‘-amos’, ‘-emos’ and ‘-imos’) so he can select the appropriate form matching the verb class of the verb (‘-amos’).

Section 3.1 illustrates how such syncretic forms can be implemented in FCG to assure optimal processing in parsing as well as production. Section 3.2 discusses one way for dealing with morpho-phonological elements that share the same function but are used with different forms. Stem changes form the main focus of the discussion.

3.1 Morpho-phonological Constructions

The standard way of dealing with morphological variation in FCG is through morphological constructions. There have been many case studies on this issue ranging from Russian aspectual affixes [4], over German case markers [11], to Hungarian verbal agreement markers [2]. The general FCG template that instantiates a morphological construction has two main slots (apart from the obligatory construction name): **suffix** and **stem**. The suffix slot contains the marker string;

its grammatical function is specified in the stem slot. The function of a marker is usually implemented as a list of syntactic categories that a verb stem must have in order to license the presence of the marker string.

By definition, syncretic markers share the same marker string. The following lines of code show how such markers can be instantiated by means of the morphological template `def-morph-cxn`. The suffix `"-e"` is syncretic since it is used for the 3rd person singular present indicative (2nd and 3rd conjugation) and the 3rd person singular present subjunctive (1st conjugation). The only difference in functional use is the verbal mood.

```
(def-morph-cxn present-ind-3sg-2/3-morph-cxn
  :suffix "e"
  :stem (?stem-unit
    :syn-cat (==1! (verb-class (==1 (1 -) (2 ?vc2) (3 ?vc3)))
      (agreement (==1 (singular + - - +)
        (plural - - - -)))
      (tam (==1 (indicative + - + -)
        (subjunctive - - - -))))))
```

```
(def-morph-cxn present-subj-1sg/3sg-1-morph-cxn
  :suffix "e"
  :stem (?stem-unit
    :syn-cat (==1! (verb-class (==1 (1 +) (2 -) (3 -)))
      (agreement (==1 (singular ?sg ?1sg ?2sg ?3sg)
        (plural - - - -)))
      (tam (==1 (indicative - - - -)
        (subjunctive + - + -))))))
```

The syntactic categories³ that constitute the grammatical function of these markers contain three elements: the verb class (`verb-class`), subject-verb agreement information (`agreement`) and values for tense, aspect and mood categories (`tam`). Each of these is implemented as a so-called feature matrix, which contains the actual and potential functional values (see also [13]). The actual values are indicated by a '+' or a '-' sign, the potential values by variables: e.g. the verb class value of the first construction (`(==1 (1 -) (2 ?vc2) (3 ?vc3))`) is 2 or 3 but never 1. Agreement values are read as follows: (`singular ?sg ?1sg ?2sg ?3sg`) and (`plural ?pl ?1pl ?2pl ?3pl`). Third person singular is thus formalized as (`(==1 (singular + - - +) (plural - - - -))`). Tense and mood are specified as (`indicative ?ind ?ind-past ?ind-present ?ind-future`) and (`subjunctive ?subj ?subj-past ?subj-present ?subj-future`), resulting in (`(==1 (indicative + - + -) (subjunctive - - - -)`) for present indicative. A more detailed example that discusses the functioning of feature matrices can be found elsewhere in this Volume [5].

³ The special operator `==1!` needs to be interpreted as follows: The elements that follow it should occur only once in the list in any order (regular `==1`) and they should always be matched to the transient structure, even in merging (!). This operator avoids merging the wrong feature values into a unit in parsing.

Syncretism can also occur across lexical class boundaries. Remember the Spanish "-o" and "-a" suffixes to mark agreement in gender (masculine, feminine) between nouns and adjectives: 'una torta delicios-a', 'a delicious cake'. These cases are captured through the grammatical function that is expressed by these markers. A verbal marker "-a" will never conflate with an adjectival marker "-a" since they differ on substantial syntactic categories such as agreement (person, number vs. gender, number) and lexical category (verb vs. adjective).

Even though underspecification costs something in terms of ambiguity, it also facilitates processing. Having a construction inventory with less markers can reduce the storage cost considerably. Within the same verb class, the "-e" marker can be used for 1st and 3rd person singular subjunctive present. The final decision on whether the person value is 1 or 3 does not have to be stored in the inventory but can be delayed toward the moment of processing. It is then the grammar that fills in the person slot as soon as it is needed. However, such a reduction only works within one verb class.

3.2 Stem Changes

The previous section has shown that, in production, the decision of which form goes with which meaning can be guided by morpho-syntactic categories such as the verb class of the stem. There is one more aspect that plays a role in choosing the right form: phonology. Examples (7) and (8) illustrate a difference in stem vowel between the 1st person singular and plural of the indicative present paradigm.

(7) *Vuelv-o* *mañana*.
 return-(1sg.ind.pres) tomorrow.
 I will return tomorrow.

(8) *Volv-emos* *mañana*.
 return-(1pl.ind.pres) tomorrow.
 We will return tomorrow.

How does one represent such stem changes in a formal grammar? Generally, there are two possible approaches:

- A series of lexical entries can be created for to cover all different forms that might be encountered (e.g. 'vuelv-', 'volv-', etc.). However, this approach would lead to a processing overload in the lexical construction set (subset in the construction inventory containing all lexical constructions), since not only lexical but also morpho-phonological decisions would have to be made within this single processing step.
- By separating multiple concerns, the alternative option divides the work over three types of constructions: lexical, stem and morpho-phonetic. The lexical constructions contain the verb infinitive (e.g. 'volver'), the stem constructions instantiate the infinitive so it becomes a morphological stem (e.g. 'vuelv-', 'volv-') and the morpho-phonetic constructions match a stem with a suffix.

This case study follows the second approach. Separation of concerns implies that processing is separated into distinct modules that overlap in functionality as little as possible. Organizing constructions into construction sets fulfills this requirement (see also [2]). Figure 1 shows how two different verb forms of the verb ‘volver’ (‘return’), see (7) and (8) can be rendered in a production process. The constructional application order is set to: lexical, (functional, grammatical,) stem, morpho-syntactic. The role of the functional and grammatical construction sets can currently be ignored. Section 4 addresses their functional use.

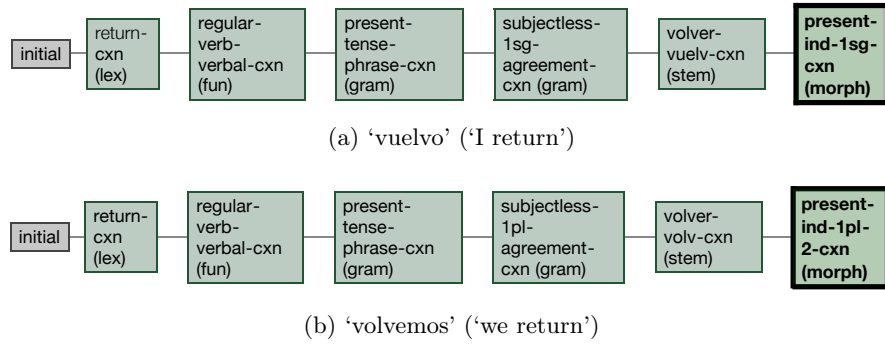


Fig. 1. Resulting application processes in production for ‘vuelvo’ (a) and ‘volvemos’ (b). The lexical construction for the verb (**return-cxn**) is shared, the stem and morpho-syntactic constructions differ.

The only difference that is visible in the processing pipelines of both verb forms is the application of the stem and morpho-syntactic constructions: **volver-vuelv-cxn** vs. **volver-volv-cxn** and **present-ind-1sg-cxn** vs. **present-ind-1pl-2-cxn**. In order to better understand how the production of a single verb form proceeds, we run step by step through the application of ‘vuelvo’, ignoring functional and grammatical constructions (responsible for subject-verb agreement and time).

- The initial transient structure contains the following semantic representation:

```
((1sg-agent indiv-1 context) (return event-1 context)
 (return-returner event-1 indiv-1) (event-overlaps event-1 now)
 (current-time-point now))
```

- First, the lexical construction **return-cxn** triggers on the presence of **(return event-1 context) (return-returner event-1 indiv-1)** in the initial structure. The lexical template that creates this construction consists of a skeleton covering its meaning and form (infinitive) and a lexical categorization which specifies its semantic class, lexical category and syntactic verb class.

```
(def-lex-cxn return-cxn
  (def-verb-skeleton return-cxn
    :meaning (== (return ?event ?base-set)
                 (return-returner ?event ?agent))
    :args (?event ?base-set)
    :string "volver")
  (def-lex-cat return-cxn
    :syn-cat (==1 (lex-cat (regular verb))
                 (verb-class (==1 (1 -) (2 +) (3 -))))
    :sem-cat (==1 (class event))))
```

- Second, after grammatical constructions have done their work and added the necessary syntactic information for agreement (covering meaning predicate (1sg-agent indiv-1 context)) and tense and mood (covering meaning predicates (event-overlaps event-1 now) (current-time-point now)), the stem construction `volver-vuelv-cxn` translates the infinitive "volver" into "vuelv-". This happens only when the verb form is specified as indicated by the syntactic slots `agreement` and `tam`, that is in the present tense indicative or subjunctive with all a singular person or the third person plural.

```
(def-stem-cxn volver-vuelv-cxn
  :infinitive "volver"
  :string "vuelv-"
  :syn-cat (==1 (agreement
                 (==1 (singular ?sg ?1sg ?2sg ?3sg)
                      (plural ?3pl - - ?3pl)))
              (tam
                 (==1 (indicative ?ind-pres - ?ind-pres -)
                      (subjunctive ?subj-pres - ?subj-pres -))))))
```

- Finally, the morpho-syntactic construction that adds the matching suffix to the stem form "vuelv-" can apply. According to the morpho-syntactic template included below, the "o" suffix triggers when the subject is first person singular and the tense is present indicative. All three verb classes take this suffix.

```
(def-morph-cxn present-ind-1sg-cxn
  :suffix "o"
  :stem
  (?stem-unit
   :syn-cat (==1 (agreement
                  (==1 (singular + + - -)
                       (plural - - - -)))
              (tam
                 (==1 (indicative + - + -)
                      (subjunctive - - - -)))
              (verb-class (==1 (1 ?vc1) (2 ?vc2) (3 ?vc3))))))
```

In parsing, the processing pipeline is traversed in almost the opposite direction: morpho-syntactic constructions trigger before grammatical constructions and stem constructions before lexical ones.

4 Formalizing Modal Constructions

Now that all morpho-phonological machinery for dealing with the Spanish conjugational paradigm has been introduced, it is time to move on to the real topic of this paper: modals in FCG. Modal expressions typically belong to one of the following three classes of modal assessment:

1. **Mental expressions** including cognition verbs such as *believe* and *doubt* and complex expressions such as *have the impression*, etc.
2. **Modal adjuncts** such as adverbs like *perhaps*, prepositional phrases like *in all likelihood* and clauses such as *there is a good chance that*, etc.
3. **Modal auxiliaries** such as *may*, *can* and *must*.

Each of these classes is related to a different subjective position a speaker can take according to a proposition. Take the proposition "Anna is pregnant". There are many possible sentences a speaker could utter when he or she forms a modal assessment of this proposition: e.g. '*I believe that Anna is pregnant*', '*Anna is probably pregnant*', '*Anna may be pregnant*', etc. Each of these utterances is characterized by a certain degree of belief the speaker has about the proposition that Anna is pregnant.

This section only concentrates on the FCG processing of modal adjuncts (adverbs) and modal auxiliaries. Apart from introducing a new range of constructions needed to operationalize main clauses that contain these modal expressions (Section 4.1), the remainder of the current section zooms in on the organization of the application process of these modal clauses (Section 4.2). Section 5 deals with cognition verbs, and consequently with subclauses and modal scoping.

4.1 Expanding the Construction Inventory

Lexical Constructions Lexical constructions map meaning to form and reversely. While the form part of modal adjuncts and auxiliaries is straightforward to implement, more questions arise when the meaning is considered. Is it possible to attribute a particular semantic representation to them? And moreover, how does one capture the semantic difference between modal adjuncts and auxiliaries in predicate logic terms? According to Nuyts [6], modal auxiliaries show the same functional position as the modal adverbs. Both adverbs and auxiliaries are neutral with respect to all functional factors in his model. He argues that an illustration of this is that they only very rarely occur in a focus position (as opposed to modal adjectives ('it is possible that') and mental state predicates ('I think that')).

The current case study follows this finding and does not distinguish between modal auxiliaries and adverbs in terms of their semantic representation. Spanish has three main modal auxiliaries that differ in the epistemic strength they express: ‘puede’, ‘debe’ and ‘tiene que’. Three "corresponding" modal adverbs are, respectively: ‘posiblemente’, ‘probablemente’ and ‘seguramente’. The meaning predicates that have been implemented for these modals look as follows:

```
(speaker ?speaker ?base-set)
(judgement ?evaluation ?speaker ?proposition)
(proposition ?proposition ?event)
(qual-strength ?evaluation [possibility|probability|certainty])
```

By using a modal expression, a *speaker* makes a *judgement* about a *proposition* concerning a particular event. Such an evaluation is characterized by a certain *qualitative strength*, which ranges from possibility over probability to certainty, depending on the modal expression that is used. Note that only the speaker predicate is linked to the physical context (**?base-set**). This implementation illustrates the fact that modal meaning is not directly observable from the context but that it needs to be constructed by a speaker.

Modal Constructions Apart from its presence in the lexicon of a construction inventory, the modal meaning also needs to be propagated to the rest of the utterance that a modal expression occurs in. This is the task of the modal constructions. For the modal auxiliaries, this means that a verbal complex (auxiliary + main verb) is created, and it is marked as a modal verb. Embedded modal adverbs are processed similarly.

The template for creating a modal auxiliary-verb construction is included here for the purpose of illustration. It comprises three main modules: a template skeleton, percolation of agreement features and percolation of variables for semantic linking. The template used here is the standard FCG template for creating phrasal constructions [9].

- The skeleton contains three main slots: **:cxn-set**, **:phrase** and **:constituents**. The phrasal unit that this template creates is a modal verb phrase that has a modal auxiliary and a verb as its constituents. The modal features of the auxiliary unit (provided by the lexicon) are percolated upwards so that the complete verbal complex gets marked for modality. The **:cxn-form** slot within the **?modal-verb-complex** sets the word order of the constituents.

```

(def-phrasal-skeleton modal-auxiliary-verb-cxn
  :cxn-set modal
  :phrase
  (?modal-verb-complex
    :sem-function predictor
    :cxn-form (== (meets ?modal-aux ?verb))
    :phrase-type (modal verbal-phrase))
  :constituents
  ((?verb
    :sem-function predictor
    :syn-cat (==1 (lex-cat (?type verb))))
    (?modal-aux
      :sem-cat (==1 (class (epistemic evaluation)))
      :phrase-type (modal verbal-phrase))))

```

- The phrasal agreement template percolates some values from the constituents to the newly created phrasal unit. Valency information is provided by the verb unit, while the auxiliary unit contributes the agreement information. The mood value is here merged into the syntactic category of the modal auxiliary. The indicative is the default mood but can be overridden by additional constructions that have scope over the `modal-auxiliary-verb-cxn`. An example of this is included in Section 5.

```

(def-phrasal-agreement modal-auxiliary-verb-cxn
  (?modal-verb-complex
    :sem-cat (==1 (sem-val ?sem-val))
    :syn-cat (==1 (syn-val ?syn-val)
                (agreement ?agreement)))
  (?verb
    :sem-cat (==1 (sem-val ?sem-val))
    :syn-cat (==1 (syn-val ?syn-val)))
  (?modal-aux
    :syn-cat
    (==1 (agreement ?agreement)
          (tam
            (==1 (indicative ?ind ?ind-past ?ind-present ?ind-future)
                  (subjunctive - - - -))))))

```

- Finally, the phrasal linking template percolates the values from the verb unit to the new modal verb unit so they can be accessed in later grammatical processing (agreement constructions, argument structure constructions). Note also that it is secured that the `?event` variable is shared across all units.

```
(def-phrasal-linking modal-auxiliary-verb-cxn
  (?modal-verb-complex
   :args (?event ?context))
  (?verb
   :args (?event ?context))
  (?modal-aux
   :args (?speaker ?event ?context)))
```

The template for the adverbial modal construction functions analogously. The slot of the modal auxiliary is filled in by a modal adverb and the agreement and mood information is provided by the main verb unit this time. Also here, the default mood is the indicative. Examples of a change in mood that is guided by the adverbial's position in the clause are included in Section 5.

4.2 Processing Modals

This section demonstrates the bi-directional processing of the previously introduced modal constructions. The following example sentences accompany this demonstration.

- (9) *Ana puede estar embarazada.*
 Anna could-(3sg.ind.pres) be.temp(inf) pregnant.
 Anna could be pregnant.

- (10) *Ana está posiblemente embarazada.*
 Anna be.temp(3sg.ind.pres) possibly pregnant.
 Anna is possibly pregnant.

Let us first concentrate on Sentence (9). The sentence contains one modal auxiliary ('puede'), which expresses a weak epistemic assessment of the proposition 'Ann is pregnant'. Figure 2 contains its production process (a) and the resulting linguistic structure (b). The application order is guided by construction sets that group constructions that share a certain functionality. Figure 2a illustrates this processing chain of construction sets, which starts off with the lexical construction set and reaches its goal (cf. the bold search node) when the last morpho-syntactic construction could apply. In order for the modal meaning to propagate, it is important that the modal construction set precedes other grammatical constructions (argument structure, agreement, word order) in both processing directions. Since the modal construction first groups modal auxiliary and main verb, argument structure and agreement constructions can then use the values of the modal verb phrase as its input and propagate them further in the clause.

Note that the order of application of the argument structure and agreement constructions is reversed in parsing. This is a consequence of the fact that in

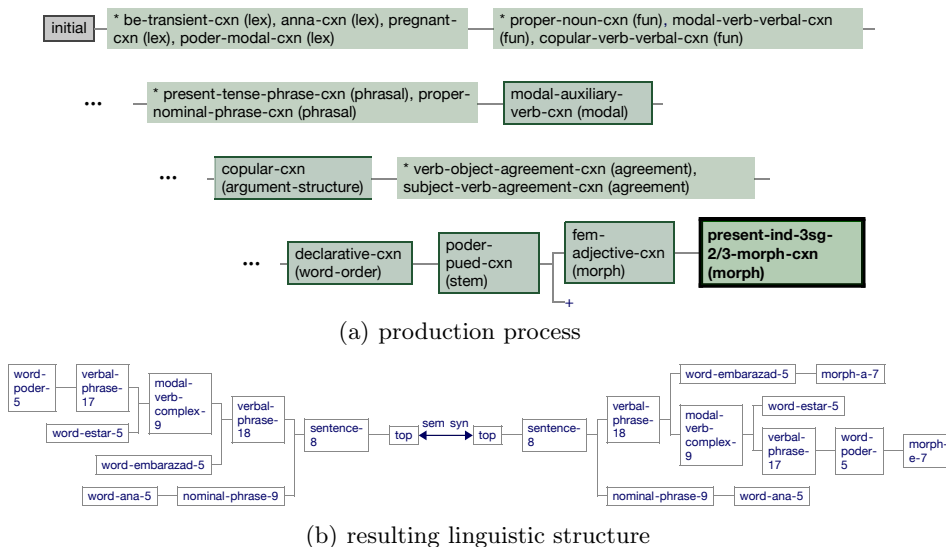


Fig. 2. Search process and resulting linguistic structure for the production of Sentence (9). 18 different constructions applied to build the resulting linguistic structure that contains the utterance: "Ana puede estar embarazada".

production, the argument structure relations are provided by the semantic representation and need to be translated into agreement feature matrices in order to express the appropriate form. In parsing, the process starts from the form side, so that the available agreement information needs to be converted into argument structure relations.

Figure 2b shows the final linguistic structure that has been built during the production process. The semantic and syntactic pole are symmetric with each a sentence unit directly under the top unit, which has a nominal phrase (subject: ‘Ana’) and a verbal phrase as its constituents (predicate: ‘puede estar embarazada’). The verbal phrase unit then comprises the main verbal complex (‘puede estar’) and its complement (‘embarazada’). It is through feature percolation that the agreement values (number and gender) of the adjectival complement are synchronized with the subject’s. The same goes for the agreement information needed for conjugation of the verb (person and number).

The processing of Sentence (10) proceeds in a similar fashion. Since the modal is an adverb and not an auxiliary anymore, it is the main verb ‘estar’ that receives the conjugational ending this time. The following slight difference in the meaning representations of Sentences (9) and (10) is responsible for this processing effect: (event-overlaps speaker-1 time-1) vs. (event-overlaps event-1 time-1). In the sentence with the modal auxiliary, it is the speaker constant that is linked

to the present time span. Since the modal auxiliary construction *poder-modal-cxn* also guarantees such a speaker link (see above) while the *be-transient-cxn* does not, it is assured that the present tense construction inserts conjugational information to the appropriate unit. Since the semantic difference between the use of a modal auxiliary and a modal adverb only becomes visible in the phrasal constructions, that is, after the lexical constructions have been processed, there are always two main branches in the search tree. One branch will finally fail in re-entrance, because the *event-overlaps* variables do not correspond.

5 Modal Scope

Section 4 has shown that the indicative is the default mood that modal constructions assign to the finite verb form of a clause. The current section shows how this default can be overridden through the application of an additional modal construction that has *scope* over the indicative verb form. The sentence that illustrates this scoping process builds further on Example Sentence (9):

- (11) *Dudo* *que* *Ana* ***pueda*** *estar*
 doubt-(1sg.ind.pres) that anna could-(3sg.subj.pres) be.temp(inf)
embarazada.
 pregnant.
 I doubt that Anna could be pregnant.

This sentence demonstrates the use of the third most common linguistic expression of modality (see Section 4): *mental state predicates*. A mental state predicate ('dudo' in (11)) is a cognition verb in the first person singular present that expresses the speaker's degree of certainty toward the realization of the proposition (following or preceding this predicate). In the first position of a sentence, mental state predicates are always followed by a complementizer such as "that" in English or "que" in Spanish.

First, we update the construction inventory with two new constructions: a lexical construction for the cognition verb 'dudar' and a grammatical construction that takes care of the scoping relation. The lexical construction takes the verbal infinitive (without 'que') as its form. Its meaning representation includes two additional predicates compared to the previous modal meanings:

```
(speaker ?speaker ?base-set)
(judgement ?evaluation ?speaker ?proposition)
(proposition ?proposition ?event))
(qual-strength ?evaluation unlikelihood)
(evidence ?proposition personal-knowledge)
(responsibility ?speaker ?evaluation)
```

The *evidence* predicate indicates the evidential source the speaker used to make his evaluation of the proposition 'Ann is pregnant'. In the case of 'dudar' ('to doubt'), this evidence stems from personal knowledge of the speaker. The

last predicate relates the responsibility of the evaluation and its impact to the realm of the speaker.

The grammatical construction that regulates the use of a subjunctive mood in the subordinated clause that depends on a mental state predicate is characterized by three main tasks:

- guaranteeing a scoping relation between the evaluation of the mental state predicate ‘dudo’ and the modal subordinated clause ‘ana pueda estar embarazada’
- adding agreement and valency features for a 1st person singular agent (speaker)
- providing the complementizer ‘que’.

Scoping has an effect on both structural poles of the transient structure. On the semantic side, this construction is responsible for the variable linking of speaker, event, proposition, context and time variables in the subordinated clause and the mental state predicate. The evaluation variables are kept different, since we are dealing with a second evaluation (‘dudo que’) of an earlier evaluation (‘puede estar’). On the syntactic side, the clausal mood feature (`tam`) is set to subjunctive mood. Since the mood feature already had a specified value, this value needs to be "overridden". This is done with help of the `->` operator:

```
(tam (=1 (-> (subjunctive - - - -)
              (subjunctive + ?subj-past ?subj-present ?subj-fut))
      (-> (indicative + ?ind-past ?ind-present ?ind-fut)
          (indicative - - - -)))
```

The semantics of the overrides operator are specified as follows: (`-> original-value new-value`). The subjunctive value was already set to – by the modal construction that operated in the subordinated clause, but it is now replaced by the subjunctive mood (any tense). The indicative feature receives the previous value of the subjunctive feature.

The syntactic pole of the resulting linguistic structure of parsing sentence (11) is visualized by Figure 3. Processing the mental state predicate has led to a considerable increase in structural complexity. A sentence unit now unites the subordinated clause (`clause-489`) and the mental state predicate (`verbal-phrase-2927`). The complementizer ‘que’ is present in the structure as a subunit of the `verbal-phrase-2927` unit. The scoping construction only changes the mood feature values in the `clause-489`, since they are automatically percolated among all children that carry such a feature. Eventually, this results in the presence of the subjunctive ‘-a’ marker that the stem ‘pued’ receives, as opposed to a default indicative ‘-e’ marker.

Another frequent example of overriding the default mood feature is the fronting of a modal auxiliary such as in:

- (12) *Posiblemente Ana esté embarazada.*
 possibly anna be.temp(3sg.subj.pres) pregnant.
 Possibly Anna is pregnant.

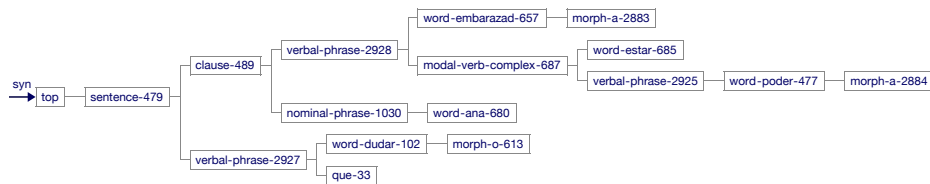


Fig. 3. The syntactic pole of the final transient structure after parsing "Dudo que Ana está embarazada".

Also here, the modal is not part of the clause that expresses the proposition but precedes it and can thereby influence the use of the subjunctive mood. Note that in this case, the modal has a direct influence on the presentation of the proposition itself, whereas the example of the mental state predicate ‘dudo que’ showed that there can also be an influence on another modal expression.

6 Robustness

Modality is generally a domain that has not been explored very much in implementations of grammar formalizations. This is probably due to the fact that it is an extreme example of an open-ended system, which has a negative effect on the robustness of the formalization. There are two main issues to consider when making a modal grammar more solid toward internal and external incongruencies:

1. The exact semantic representation of a modal expression can vary across speakers and between linguistic communities, since modality concerns personal judgements of individual language users. Moreover, depending on the situation, the choice of verbal mood for a particular proposition might differ.
2. Due to deviating meanings, the modal forms that are parsed by a hearer do not always conform to his or her constructional knowledge. This happens when the speaker is being innovative, when he belongs to a different linguistic community or when he speaks carelessly.

In terms of semantic robustness, a single user grammar does not really encounter the issue of variable semantic representations across speakers. There is only one speaker, which is the system itself. It is only in multi-agent experiments that make use of FCG, where semantic representations are built by every agent individually. Nevertheless, once semantic representations are constructed from grounded scenes, discrete modal categories such as qualitative strength, have to be replaced by continuous values.

Syntactic robustness is a different issue. Previous FCG research on robust parsing has focused on unknown words and coercion (for an overview see [10]).

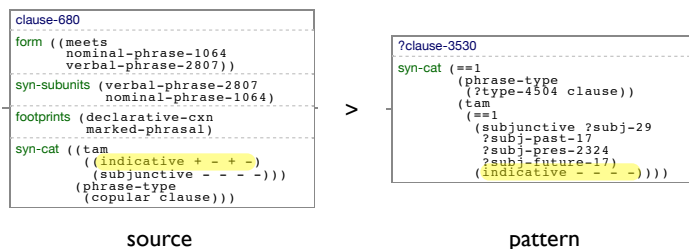


Fig. 4. In parsing the marked sentence "Dudo que Ana está embarazada", the source unit of the transient structure (left) is matched with the pattern unit of the **mental-state-predicate-cxn** (right). The match fails since the values of the indicative feature do not correspond: the source unit contains a present indicative mood, while the pattern expects a subjunctive mood.

The most straightforward deviating use of a modal expression, is an unexpected mood marker: the subjunctive instead of the indicative or reversed. Take the following mood alternation:

- (13) *Dudo que Ana esté embarazada.*
 doubt-(1sg.ind.pres) that anna be.temp-(3sg.subj.pres) pregnant.
 I doubt that Anna is pregnant. (default reading)
- (14) *Dudo que Ana está embarazada.*
 doubt-(1sg.ind.pres) that anna be.temp-(3sg.ind.pres) pregnant.
 I doubt that Anna is pregnant. (marked reading)

Sentence (13) illustrates the default use of the mood marker that follows a mental state predicate which expresses a high degree of uncertainty: the subjunctive ("-e" in "esté"). Parsing this sentence with the construction inventory that supports this case study, leads to a successful parsing process with 20 search nodes and a single search branch, the goal node being the scope construction **mental-state-predicate-cxn**. Now, parsing the marked mood marker in the subordinate clause, that is the indicative "-a", results in an explosion of the search space: 18 search branches with each 19 nodes and no correct solution found. The reason for this is the lacking of the twentieth node, namely that of the scope construction.

The FCG inspector tells us that there was no match between the transient structure after the 19th construction has applied and the scope construction. Figure 4 shows that the match failed exactly because of the presence of the indicative mood feature in the transient structure (source), whereas the scope construction (pattern) requires a subjunctive feature (of any tense).

The traditional FCG solution to such a problem in processing, is to create a diagnostic that notifies the mismatch in mood and then instantiate a repair process that adjusts the mood in the clausal unit. The diagnostics and repairs form part of the so-called ‘meta-layer’ in processing. On top of the routine processing layer, diagnostics check whether there has been some unexpected processing result, and if so, they call on a series of repair methods to solve the problem and continue regular processing.

7 Conclusion and Outlook

This paper has presented basic insights into the operationalization of modal constructions and their organization in terms of processing efficiency. Modal constructions are best processed before other grammatical constructions can apply so that the latter take over the modal values left in the verb unit by the former. Scope constructions (mental state predicates) are processed at the end of the grammatical construction batch. In production, this is right before morpho-syntactic constructions start to fill in the appropriate marker forms. A scope construction can thus modify a mood value left by the modal constructions and processed by the grammatical ones at the very last moment.

Since all the modal constructions that have been introduced in this paper work on verbal units, also the Spanish conjugational paradigm had to be captured in FCG constructions. A considerable degree of syncretism (same form shared across multiple functions) and variation in verbal stem morphology has been reported and covered by the current implementation. The use of the ==1 operator in the morpho-syntactic templates and the introduction of stem templates that translate infinitives into stems and reversely have been essential in this process.

The importance of building robust grammars has been pointed at through the incorporation of the parsing process of a sentence with an indicative subordinate clause where a subjunctive was expected. The FCG meta-layer has proved to be a valuable processing extension to capture unusual language use. By means of a repair strategy that modified the matching pattern of the modal construction, processing can be continued from the point where an earlier problem had been reported.

The goal of this paper has been to present a feasibility study on the implementation of modal expressions in FCG. The potential of such an implementation has become clear throughout the different sections. Nevertheless, an expansion of the current test grammar within the domain of epistemic modality (more modals, more sentences) as well as toward a wider application of modality (evidentials, event modality) is in order. The implementation of more modal systems that cover a number of different languages can offer a better understanding of the current Spanish test grammar.

Acknowledgements

This research was conducted at the Vrije Universiteit Brussel, financed by a strategic basic research grant (IWT-489) from the agency for Innovation by Science and Technology (IWT). Additional funding came from the European research project ALEAR (FP7, ICT-214856). Apart from the members of our team in Brussels and at the Sony CSL lab in Paris, I especially want to thank Johan van der Auwera (University of Antwerp) for his help in my quest for the right modal terminology.

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