Greek Topology: A Prosodic Generation System for Modern Greek

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Abstract

We propose to place the generation process of language in the Meaning-Text framework (Mel'cuk, 1988), replacing the usual 'morphological' level with a 'topological' structure as an interface between syntax and prosody (cf. Gerdes & Kahane, 2001). The topological structure allows computing the phonological (prosodical) structure of the sentence taking into account the communicative markup. We develop this generation system for Modern Greek, showing the rules that are implied for each step. The generation system has been implemented in a program called DepLin, where from a dependency structure, the possible linearizations accompanied by the different possible prosodic contours are computed.

1. Introduction

In this paper, we propose to place the generation process of language in a Meaning-Text framework (Mel'cuk, 1988), replacing the usual 'morphological' level with a 'topological' structure as an interface between syntax and prosody (cf. Gerdes & Kahane, 2001).

Usually, the prosodic structure of sentences is computed from the phrase structure, based on a GB or minimalist analysis (Selkirk, 1984 ; Hirst & DiCristo, 1998). This has two important drawbacks for language generation:

From a practical perspective, to our knowledge, no language generation system manages to actually compute a complete S-structure from their input (that is usually some semantic representation). Thus, the work based on these structures remains mainly theoretical.

From a theoretical viewpoint, it is difficult to base a prosodic structure on the S-structure, because the phrase structure encodes the whole transfer process from the logical form to the phonetic form, and its nodes can be of semantic, syntactic, or phonetic character. This is particularly problematic for languages with relatively free word order like German or Modern Greek.

We think it is necessary to separate different types of information into distinct representations, linearly ordered from meaning to sound: semantics->syntactic dependency->topology->prosody. The communicative markup (the information structure, Lambrecht, 1994, Mel'cuk, 2001) is passed on from level to level. We follow Vallduvi's (1992) idea that we should (at least) consider a tri-partition of communicative structure: topic (the prominent theme or *link*), focus (the rhematic part of the sentence), tail (non-prominent theme). We will present a generation system that obtains a linearized sentence with the correct word order and prosodic contours from an (unordered) syntactic dependency tree, taking into account the communicative markup. We will illustrate our purpose with the grammar of a "free word order language": Modern Greek.

2. The topological structure of Modern Greek

First of all, we assume that the different information about a sentence have to be separated into distinct representations that are ordered linearly from the level of meaning to the sound output. The Meaning-Text Theory developed by Mel'cuk is one of the rare theories where the levels of representations are clearly separated. The theory takes into account three intermediary levels between the meaning representation and the output, which are the syntactic, morphological and phonological levels. Each one of them is subdivided into a deep level (oriented toward the meaning) and surface level (oriented toward the output). We follow Gerdes & Kahane (2001) and Gerdes (2002) and we propose to replace the classical morphological level into a topological level, which corresponds to a morphological level to which a constituency tree has been added. This modification is very useful for the treatment of word order in languages such as German and Modern Greek. The topological structure allows also calculating the following step in the process of language generation: the phonological structure, i.e. a linear chain of phonemes added with a prosodic hierarchical structure. From the constructed phonological structure, we do the final computation of the output. For the moment, we leave aside the subdivision between deep and surface levels but it is not excluded that for more detailed analyses, we will have to take them into account. For the moment, this subdivision seems not necessary for the grammars we have tested in the implementation of the linearizer of a dependency tree called DepLin (http://talana.linguist.jussieu/~kim/depLin).

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The idea of a topological structure which is based on the idea of "fixed places", replacing the classical morphological level in the Meaning-Text framework, was developed for the description of German and was inspired by early traditional descriptions (Drach 1937). We adopt Gerdes & Kahane’s approach (2001) where a hierarchical structure of topological constituents is integrated in the process of linearization of the Meaning-Text theory. The resulting topological structure is taken as the interface between the syntactic and phonological levels. In fact, this topological structure makes the linearization rules easier as well as the computation of the prosodic structure in the next step of representation.
The constituents of the topological tree are called *domains*. A domain is a linear chain of fixed places, called *fields*. Each field has its own restriction indicating the number of domains it can accept in its field in order to obtain a well formed topological structure. It is important to say that fields are not constituents: As a consequence, two constituents that are in the same field do not obligatorily form a topological unit.
Starting from the surface syntactic dependency tree, linearization places the root of the latter in the initial field. Then, the *rules of domain construction* allow the root to open a domain, and to be paced in a specific field of this domain. The creation of a domain can be constrained by the communicative markup as well as by the nature of the field in which the element is placed. Then, we proceed to the placement of the verbal and nominal dependents following the *correspondence rules*. The correspondence rules indicate how a verbal or nominal dependent is placed in a field. This placement can depend on the field of the head, the syntactic relation between the head and its dependents or the communicative markup of the dependent. Depending on the studied language, some parameters can prevail more than others. Thus, in German, there is a strict syntactic restriction for the placement of the root of the dependency tree in the V2 position; in languages such as Russian or Modern Greek, the major parameter that is to be taken into account seems to be the nature of the communicative markup. In the following subsection, we will examine closely the topological structure of Modern Greek.

2.1 The topological rules

While in German the topological structure is conveyed by syntactic rules (the placement of the finite verb for example) as well as by informational rules (the placement of an element in the Vorfeld), the word order in Modern Greek is conveyed mainly by the information structure of the sentence (but syntactic rules may also intervene). For instance, Greek is said to be a “free word order” language because, if we take for instance a sentence which has two nominal arguments (an SVO sentence), all word orders are accepted (SVO, SOV, OSV, OVS, VSO, VOS) (Holton & al., 1997). However, if we take into account the prosodic variation each word order can take, we realize that the number of sentences we obtain goes up to 25 possibilities. On the other hand, if we take into account a specific communicative markup of the construction, we then obtain only one or very few possible realizations.
We consider that the topological structure of Greek consists of an initial field that opens a main domain. The main domain has three fields, the TopicField, the FocusField and the tailField, following the name of the three communicative markup, topic, focus and tail (Vallduvi). The FocusField must contain just one embedded domain while the two other fields have no restrictions on the number of constituents they can host.

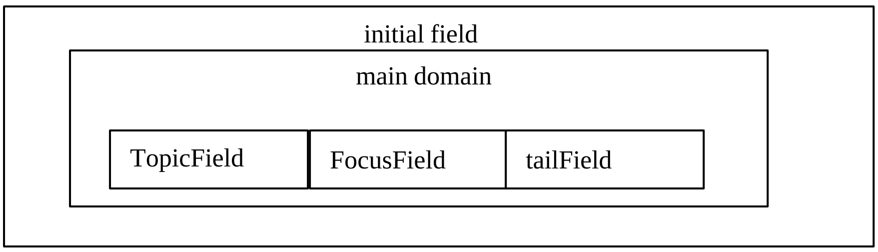

Figure 1: The fields of the main domain of the topological structure

The embedded domain contains five fields, the Vorfeld, the Na-Field, the ClitiqueField, the VerbField and the NachFeld. While the Vorfeld and the Nachfeld can contain as many elements as necessary, the box description rules set restrictions for the na-field, which may contain 0 or 1 element, and for the verbfield which has to contain just one element, the verb. The cliticfield is the place for the clitics[1].

[1] In Greek (like in French), the clitic order before the verb is strict. For a more detailed analysis, this field should be separated into subfields indicating the place of the different clitics.

embedded domain				
Vorfeld	Na-Field	CliticField	VerbField	Nachfeld

Figure 2: The fields of the embedded domain of the topological structure

The finite verb which is the head of the syntactic dependency structure is placed on of the main three fields following its communicative markup. Following the rules for the creation of emb edded domains, the finite verb opens an embedded domain in the field and it takes place in the VerbField. Then, the dependents of the verb can be placed. If the dependents share the same communicative markup, then they stay in the same domain, and are placed following the relation of the syntactic dependence or the grammatical nature. Thus, a clitic will be placed in the CliticField, the subject of the sentence will be placed in the Vorfeld or in the Nachfeld etc. Now if the dependents do not share the same communicative markup, then what will call “emancipation” occurs: the dependent emancipates from its original domain and goes to the field corresponding to its communicative markup. Notice that there are some restrictions of emancipation for the direct object and the verbal dependents.

2.2 Example

In this section, we give an illustration of the topological structure of Greek. The topological grammar of Greek has been implemented in a linearization program called DepLin (http://talana.linguist.jussieu.fr/~kim/depLin). DepLin allows the generation from the level of the surface syntactic structure (a dependency structure) into the topological structure, and then from the latter, the computation of the phonological structure and the phonetic output (the parame terization of the prosodic contours to the phonemic chain). In the remaining of the paper, we will present the Greek grammar we have developed in this program.

Take Figure 3 as an example of a syntactic dependency tree carrying a communicative markup. We start out with the unordered syntactic dependency tree carrying its inherited communicative markup. A syntactic dependency tree, following Tesnière 1959, encodes the syntactic subcategorization frame and other syntactic relations without the final ordering of the elements. Just as in X-bar based syntax, the finite verb is considered as the root of the tree.

Our task will be to linearize the element taking into account the syntactic and communicative information. We note an element that is a part of the prosodic group of its governor with the letter *N*.

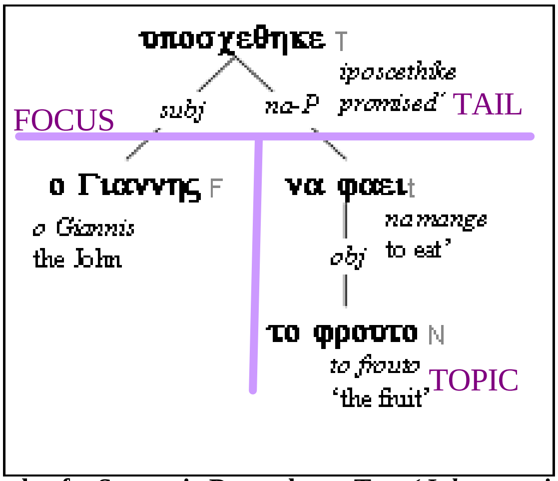

Figure 3 : Example of a Syntactic Dependency Tree ‘*John promised to eat the fruit*’.

Following our linearization rules, we start with the highest verb, which in this examp le is marked as the topic of the sentence. Thus, the verb ‘iposcethike’ goes to the TopicField where it opens an embedded domain and it is placed in the Verbfield. Since its syntactic dependants have a different communicative markup, they have to emancipate from their governor’s domain: the nominal argument ‘o Giannis’ which is the subject of the sentence is marked as the focus of the sentence. The dependent emancipates therefore from its governor’s domain and goes to the FocusField according to the communicative markup it bears. Finally, the verbal argument opens a new embedded domain in the tailField following again its communicative markup. We thus obtain the topological structure of Figure 4.

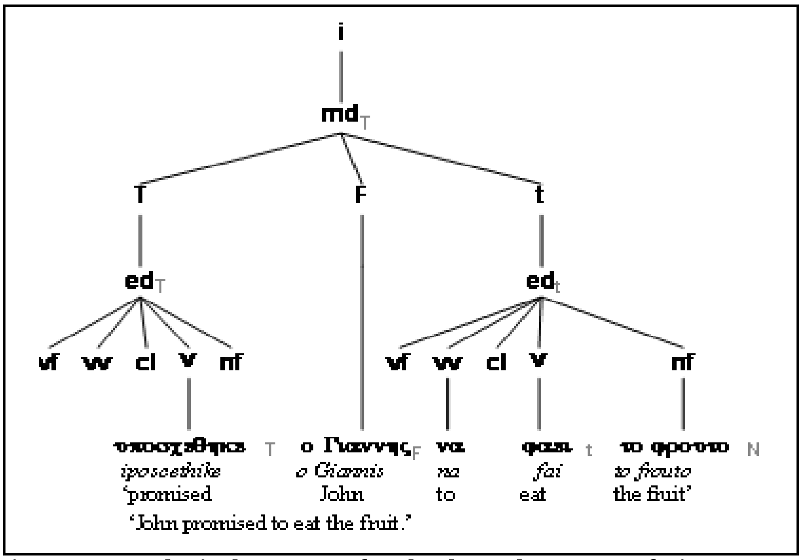

Figure 4: Topological structure for the dependency tree of Figure 3.

Notice that the linearized orders would have been different if the communicative structure was different.
The topological structure represents our interface between syntax and prosody, because we can easily derive from it the prosodic boundaries and contours.

3. Computation of the phonological structure and the output

From this topological structure, we compute the prosodic structure in the following separate step. We compute the correct prosodic groupings using exclusively the information contained in the topological structure. We assume that the phonological structure is a three-level tree, where the prosodic word is the lowest one, the prosodic group is the intermediary level and the prosodic sentence, the ultimate one. The prosodic word is the minimal prosodic unit containing minimally one accented word. It contains the lexical information, which is the information on the segmental level as well as on stress. The prosodic group is the intermediary level which contains at least one prosodic word. We assume that the prosodic groups correspond to communicative units and the prosodic patterns corresponding to the communicative units are directly associated at that level. Finally, the prosodic sentence gives the information on the general prosodic pattern of the sentence, which depends on the modality of the sentence (declarative, interrogative etc.).
In Modern Greek, almost every word has a lexical stress (except for some determinants, clitics and other functional words) on one of the last three syllables of the word (Garde, 1968). At this level, the computation of the phonological level from the topological level is quite simple, because it consists of a simplification of the topological structure. We assume there are two main rules. The *prosodic word rule* that is applied on the leaves of the topological tree, allows combining non stressed words with a stressed one in order to form a prosodic word. If the word is stressed, then it forms a prosodic word. If not, it has to join its adjacent word which is stressed. In the case of Greek, the non stressed words always join the stressed word on its right. The *prosodic group rule* is then applied to the domains of the topological structure. We have a rule of the type (D_1, C_1, F_1, D_2, C_2, GP) that says a prosodic group GP is formed by the contraction of the domains D_1 (which has the communicative markup C_1) and D_2 (which has the communicative markup C_2 and dominated by D_1 by the way of the field F). The domains that are not contracted form a prosodic group by their own. Once these two rules have been applied, we obtain the following phonological structure for the dependency tree of Figure 3:

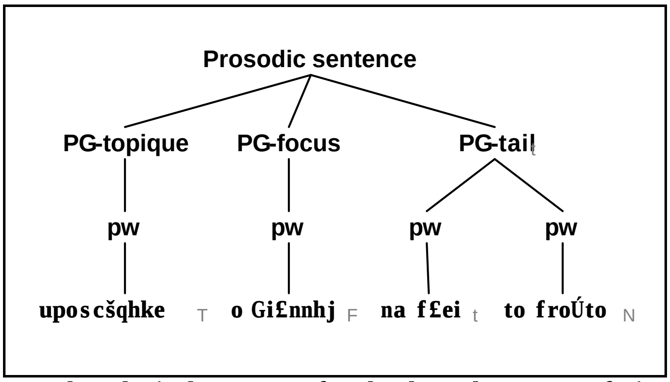

Figure 5: Phonological structure for the dependency tree of Figure 3

We synthesize the sentence from the given phonological structure which contains all the necessary information for this process. We apply the information about the sentence (declarative, interrogative sentence) to the prosodic contours of each prosodic group (cf. Le Gac & Yoo, 2000). In the present state of the work, we propose a synthesis by words where the melodic contours are associated to the prosodic words and where rules derive the intonative structure of the sentence. In the current state of the implementation, each prosodic word has been pre-recorded and synthesized with its corresponding contour (Yoo, 2001; Botinis 1988; Botinis 1998). We use five pre-recorded files per word that are then combined by Deplin, taking into account the boundaries of the topological structure. For the topological structure of our example, the prosodic step yields a sound output that we viewed with the Praat program (see Figure 6). The resulting sentences were tested by native speakers of Greek who accepted them as natural. Moreover, they were able to match the sentences with the corresponding context (that were presented in as questions, the generated sentence being a possible answer to one of the given sentences), showing that the communicative markup was correctly computed in the phonological structure. The generation system was also tested with more complicated sentences (with complementizers, verbal clusters etc.) and the results we obtained were satisfactory. The next step of the work is to make a better synthesizer, where we do not need pre-recorded files but we combine directly the correct prosodic contour to the phonological chain.

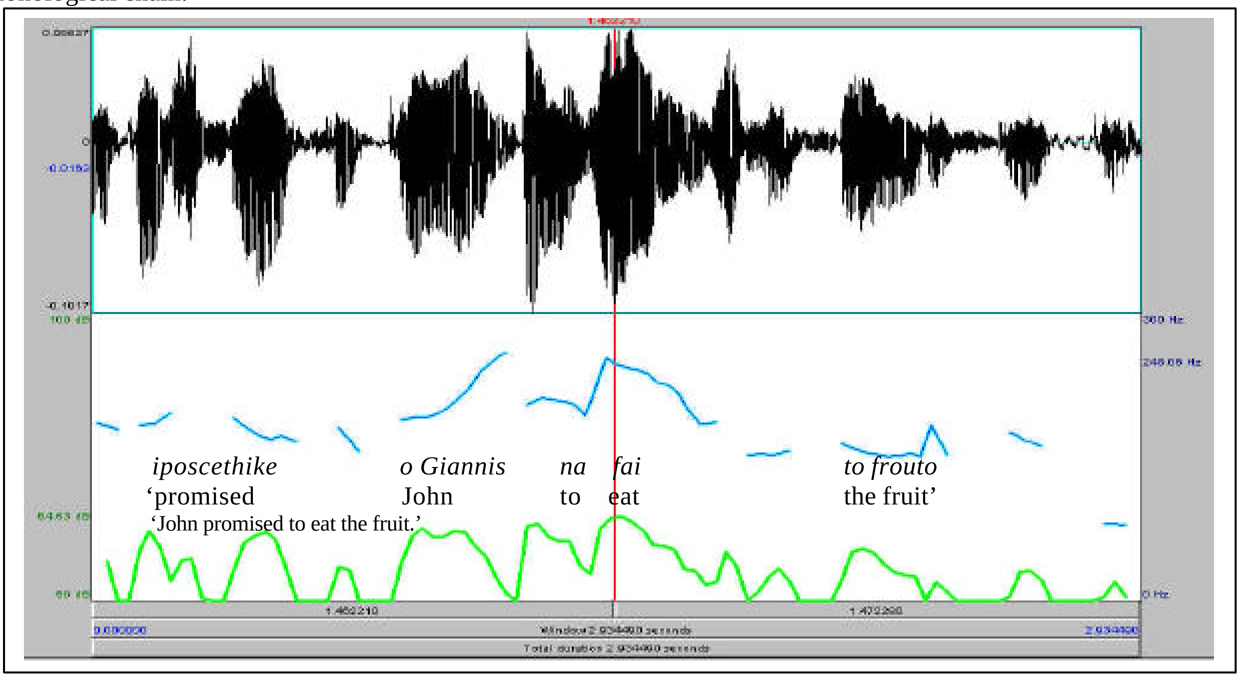

Figure 6 : Analysis of the sound output corresponding to Figure 4.

3. Conclusion

In this paper, we presented a modular generation system where a given surface syntactic dependency structure is computed in order to give the different possible linearizations (the different word orders for a non ordered syntactic structure) that we call topological structures. The topological structure, which is included in the modular Meaning-Text Model, represents an interface between syntax and prosody in the sense that the phonological structure (including the prosodic structure) will be computed from this level in order to give the correct output, which is a chain of phonemes where the correct prosodic contours corresponding to the communicative markup are added. At the current state of work, the output is obtained by combining pre-recorded files and the resulting sentences that have been tested by native speakers of Greek are very satisfactory. Further studies are at work in order to make a better synthesis of the output, our goal being to distinguish the segmental and the suprasegmental levels.

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