GRAMMATICAL COMPONENTS AND MACRO-PROSODY : QUANTITATIVE ANALYSIS TOWARD STATISTICAL CORRELATIONS

G. Caelen-Haumont

Laboratoire C.E.R.F.I.A., UA-Cnrs N°824
Université P. Sabatier
118 Route de Narbonne 31062 Toulouse Cedex France

ABSTRACT

This study fits within the scope of the natural understanding of texts. Already known, simplified grammatical (syntactic, semantic) models of linguistic analysis have been either adapted or elaborated upon, in order to verify the hypothesis according to which there exist actual traces of abstract grammatical levels within the prosodic continuum of speech.

A per-speaker statistical file was compiled, containing both (1-syntactic, 2-semantic, 3-pragmatic) parameters issuing from the above models, and phonetico-prosodic parameters that are specific to melodic, energetic and temporal (including pauses) registers. Such a file makes it possible, if we resort to correlation analysis, to secure a quantitative appreciation of variability in the strategies adopted by speakers.

While anticipating an analysis of statistical correlations, the present article states the contents of the various analytical levels involved in the segmentation and labelling of a prosodic data-base.

1. INTRODUCTION

The problem we turn to is very aptly described by Hirst (1983) : "A deeper reason [for the elusiveness of intonation] comes from the fact that an adequate description of intonation needs to take into account not simply the phonology of the language, but also the syntax and the semantics, as well as the interfaces between the grammar and 'the real world' constituted by phonetics and pragmatics." Initially touched upon by Kellenberger (1932), this domain has since often been explored; particularly, within the last few years, in generative phonology --viz., Chomsky and Halle (1968), Liberman (1975), Liberman and Prince (1977) in the United States, and by Hirst (1983 a,b), Dell (1984), Dell and Vergnaud (1984) in France.

The present paper does not deal at all with any theoretical excercise in generative phonology; instead, as a follow up on previously published preliminary work [Caelen-Haumont 1985], it reports on a linguistic analysis (for syntactic, semantic, pragmatic and prosodic components) that was run in an experimental attempt to relate text structures to prosodic ones, by means of a prosodic data-base. The categories yielded by this linguistic analysis are used as labels in the prosodic data-base; eventually, either they are symbols (alphabetic ones) involved in the computation of various averages, or they are the addresses of event-parameters (e.g., pause duration). Therefore, the parameters involved in correlation analysis issue either from computations run at those addresses, or from numerical categories involved in labelling.

2. LINGUISTIC ANALYSIS

2.1. Text Analysis

This involves three different components.

2.1.1. Pragmatic Component

The 3 successive reading instructions determine different relationships between the linguistic signs imbedded in the text and their human users (reader to human/computer listener); a three-grade scale being thus defined on the pragmatic axis : instructions 1 through 3.

2.1.2. Syntactic Component

The model text is limited to a set of sentences without subordinate clauses. The syntactic component is limited to a morphological analysis, as well as to an analysis of the syntactic complexity.

Through morphological analysis (1st level), a phonetic item (acoustical realization phase, phoneme, syllable or word) can be identified by locating it with respect to sentence boundaries, or to boundaries of groups (this term being, here, conceived of as designating a unit that pertains to the next deeper level, beyond the surface structure). Or again, a phonetic item can be identified by locating it within these groups. A further distinction (2nd level) is made by specifying whether a word is mono- or pluri-syllabled and, in this latter case, whether a syllable is initial, final or intermediate within a word. Words with a final /ə/ are in effect no problem, since the syllable that can actually be stressed can be counted as the real final syllable; provided the subsequent consonant, or consonantic group is also counted as part of it, and the /ə/ as a post-final phoneme. A third phase of analysis involves two facets : 1/ a description of how a word appertains grammatically --i.e., whether it is a "lexical" or a "grammatical" word, sometimes referred to as a "tool" word-- and 2/ an identification of 2 constituents having specific prosodic properties (coordinating conjunction and clitic).

All these different items of information can be recombined in such a way as to suggest 18 different 2-character codes. This code is illustrated on fig. 1.

At this stage of analysis, the depth-degree of a group within the constituent structure of a sentence, is not taken into account; major and minor groups being lumped together. This reinforced type of structure analysis tackles syntactic complexity.

Unlike morphological analysis, which proceeds by means of symbolic designation of elements, the coding procedure we describe here is quantitative. As is done with the semantic-complexity analytic model, quantification of syntactic complexity is performed by means of a procedural graph.

In its present stage, the syntactic model emphasizes deep structure at the expense of surface structure : despite their actual diversity, relations among the infra-syntagmatic units that make up the group have all been given the same weight (i.e., +1).

The kind of analysis, herein described, has no claim to being exhaustive. It purports, instead, to recognize and quantify more or less complex constituents or processes of syntax; whether, in the process of either coding or decoding linguistic units, such complexity is a matter for grammatical theory or for psycho-linguistics. In any event, this complexity is to be perceived at different levels of analysis. At the level of structure , the deeper a constituent is thought to be --and subsequently the more extent the sentence-- the more weight is ascribed to it : the heaviest weight, in the sentence, being ascribed to the P-level constituent --i.e., the final one-- while the skipping rate, from one hierarchical level to the next, is taken to be equal to 1.

The syntagmatic-relation module describes relations among constituents, in three different locations : definite end of syntagma, relative end of syntagma followed by a coordinated or a subordinated syntagma (respective weights for this three situations : +3, +2, +1). Finally, the model is sensitive to constituent order, and displacement within the structure is ascribed a +2 weight. Figure 1 shows an example of syntactic-complexity

quantification that is obtained through adding the module weights, described above, to eachother.

2.1.3. Semantic Component

This study also attempted to quantify the semantic complexity of the lexical items in text, by means of a new analytic model. This complexity is analysed from the point of view of any person insofar as he is considered outside his own speciality domain. This model is otherwise explained [Caelen-Haumont, 1986] and applied to textual analysis.

The model sought to describe the semantic effect, not the means of achieving it. In this matter, although they participate to the elaboration of meaning, the syntactic structuration processes have not been made explicit. The actual application range of this model is not the sentence but the text. The method, used, assumes both the intra- and inter-lexical components to be textwide dimensions; two dialectical poles in between which meaning is generated, in the course either of writing, reading, listening, or of analyzing the text for meaning. The analytic model consists of three modules :

1- intra-lexical analytic module :

a/ lexical-item register : fundamental, standard or specialized but vulgarized, specialized (respective weights : +1, +4 and +7)

b/ referent : concrete, concrete/abstract for items with two different acceptations (e.g., "combination"), abstract or imaginary (weights 0, +2, +4).

c/ specifying an essence : 1/ "state" or spatial notion of structure, 2/ relational link between concrete or abstract objects, 3/ "process" or temporal notion of evolution, 4/ combination of both (example: the lexeme "addition") with respective weights : 0, +1, +1, +1. These notions are independent from syntactic categories.

d/ designating of something in nature: "substance" or nature of the designated object and "attribute," quality of the latter. In turn, substance is subdivided into either spatial or temporal type categories (example : perfective vs. imperfective for "process"); these two notions possibly neutralizing eachother or combining together.

The "attribute" category covers the distinction between intrinsic and extrinsic attribute, and it applies to both types of substance, contemplated in their own pecularity.

At the outcome of this analytic level, quantification is obtained through repeatingly adding 0 or +1 weights.

2- transition module

This causes a lexeme to change category according to context; it either simplifies or complexifies (respective weights : +1 and +2, example : abstract to concrete (+1)).

3- inter-lexical analytic module

It encompasses various lexical networks both of form and of content. Form : repeating the term commands either -1 or -3 weight, depending on its register, as defined above. Content :

a/ use in the figurate possible (no figurate or cliché, lexicalized figurate, living figurate --respective weights : 0, +3, +5).

b/ occurrence of a lexical field (belonging to the field or initiating it, changing field, weights : 0, +2).

At the outcome of the procedural graph, each lexical item is given a weight (in the range : 1 to 25) which is held to be a quantitative (though subjective) assessment of its complexity of meaning and, followingly, part of the complexity of meaning of the whole text. Example on figure 1.

2.2. Prosodic Analysis

2.2.1. Phonetic Aspect

Concerning this aspect, two dimensions are considered : the phonemic and the infra-phonemic.

On the phonemic level, 43 labels are made available; beside the pause, various allophones. On the infra-phonemic level, the notions of realization phase and of "intonemes" are combined to yield 9 one-character codes. These structure up the phonemic space that has already been pre-segmented into "phones" (see 1., above); on the one hand, in terms of realization phases --set-in, sustained, caudal-- based on acoustic-cue behavior and, on the other hand, in terms of beginning and end of specific intonemes, spotted on the melody curve. In the present work, only continuity-intonemes have been retained and, for the sake of generalization, both maxima and minima of all final vowels of lexical words (as well as adjacent phonemes within the syllable, whenever necessary) have been coded, even in the case of weak or zero tonal variations.

2.2.2. Prosodic Relief-Map

The tonic-stress structure is analyzed according to the traditional key-points, based on position and quantity criteria : onset, pre-tonic, tonic and post-tonic vowels. With an aim to testing the influence of stressed-vowel position upon prosodic quantity (cf. notion of metrical structure in generative phonology), both types of vowels located between attack and stress have been numerically coded in decreasing order, down to the pre-tonic --coded 1. An illustration of phonetic labelling (phonemic, infra-phonemic and prosodical levels) is given figure 1.

3. CONCLUSION

The syntactic, semantic, pragmatic and prosodic components supplied a set of alphabetic and numerical labels. These were used to code the linguistic units (infra-phonemic items to sentences) or events of a prosodic data-base. A base containing prosodic data was set up on LSI 11-73 from a corpus handled as follows : 10 speakers reading a 45-word text, under 3 successive, increasingly demanding sets of instructions --i.e., 1/ natural and intelligible reading, 2/ very intelligible reading, and 3/ very very intelligible reading for the computer. This made for 30 uttered texts. Once segmented and labeled the 30 data-files were fed into other stastitical files that were set up through automated extraction of parameters deemed relevant --e.g., items of syntactic complexity, pragmatic situations, prosodic values (Fo, energy, duration) at certain points of the statement that are localized through the linguistic item addresses. By facilitating various types of data-analysis --e.g., of correlations [Caelen et alii,1985 a,b]-- this prosodic data-base opens up a possibility of working on the verification of various hypotheses concerning the presence, within speech and more specifically within loud reading, of grammatical-structure cues of a syntactic, semantic and pragmatic type.

Acknowledgment: I wish to thank J.F. Malet (of California State University, Sacramento) for meticulously translating this text from French.

BIBLIOGRAPHIC REFERENCES

[Caelen-Haumont,85] G. Caelen-Haumont. Dialogue homme /machine et aspects temporels des stratégies de locuteurs de type phonétique, syntaxique et sémantique,, Paris, 1985, pp. 183-187.

[Caelen-Haumont,85] G. Caelen-Haumont, Propositions

pour un modèle d'analyse sémantique simplifiée de la complexité des signifiés, Galf-Cnrs XVèmes JEP Proceedings, Paris, 1986.
[Caelen et alii, 85] J. Caelen et N. Vigouroux, A multi-level acoustic and phonetic base : from facts to knowledge, Symposium Franco-suédois Proceedings, Grenoble, 1985.
[Caelen et alii, 85] J. Caelen et N. Vigouroux, Segmentation automatique de la parole, Galf-Cnrs XIVèmes JEP Proceedings, Paris, 1985, pp. 152-155.
[Chomsky et alii, 68] N. Chomsky et M. Halle, The sound pattern of English, Harper and Row, New-York, 1968.
[Dell et alii, 84] F. Dell, D.J. Hirst, J-R. Vergnaud, La forme sonore du langage : la nature des représentations en phonologie, Hermann, Paris, 1984, p.95-116.
[Hirst, 83] D. Hirst, Structures and Categories in Prosodic Representations, in A. Cutler & D.R. Ladd (eds), Prosody : Models and Measurements, Springer, Berlin, 1983, pp. 93-109.
[Hirst, 83] D. Hirst, Interpreting intonation : a modular approach, Journal of Semantics 2: 2, 1983, pp. 171-181.
[Kellenberger, 32] H. Kellenberger, The influence of Accentuation on French Word Order, Princeton, 1932.
[Liberman,75] M. Liberman, The Intonational system of English, PH. D., Massachussetts Institute of Technology, distribué par Indiana University Linguistics Club, Bloomington, Indiana, 1975.
[Liberman et alii,77] M. Liberman and A. Prince, On stress and linguistic rhythm, Linguistic Inquiry 8.2, 1977, pp. 249-336.

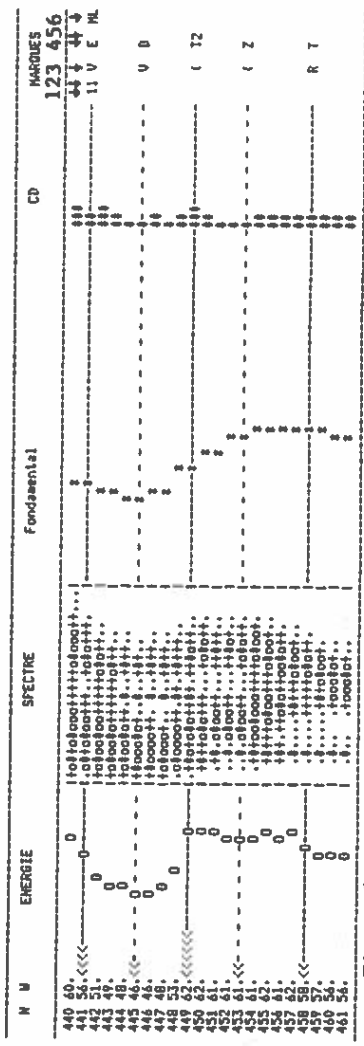

Figure 1 : An illustration of the prosodic data-base labels
1 : Semantic complexity
quantification of lexical items
3 : Phonemic labels
V —> /v/
(—> / /
R —> /R/
5 : tonic-stressed structure
2 second vowel before the tonic vowel
6 : sentence morphological structure
ML monosyllabled lexical word within a syntagma
2 : Syntactic complexity
quantification of lexical items
4 : Acoustical realization phase
+ Intoneme
E set-in phase
T sustained phase
Q caudal phase
D beginning of intoneme on Q
Z end of intoneme on Q