



IS SYNTACTIC STRUCTURE PROSODICALLY RETRIEVABLE?

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ABSTRACT

Syntactic structure is defined in its three components. A survey of prosodist's studies on the relationship between prosody and syntax brings out two major trends: those who think that syntactic structure is immaterial for intonation and those who argue for matching rules between syntax and prosody. The recent studies presented here lend weight to a syntactic-based approach to accounting for intonational phrasing and boundary strength. A three-level model consisting of three modules, pragmatic, syntactic and rhythmic, is discussed. The flexibility of the higher units of prosodic structure is explained and predicted. The extent to which syntactic structure can be retrieved from prosodic markers is demonstrated.

1. INTRODUCTION

Syntactic structure, as it is understood in this paper, is the linear organisation and hierarchy of syntactic constituents and the relations by which syntactic functions are defined. If syntactic structure could be retrieved by prosody, be it intonation, stress or rhythm, automatic speech understanding would be substantially improved. Some recent experiments have already proven the reliability of models using syntactic labelling for training (5,37).

A great deal of work has been published on the topic of the relationship between prosody and syntax. It is commonly acknowledged that intonational chunking, which is related to the well-formedness of the syntactic constituents of a given level, is more or less constrained by syntax. In this vein, many papers have recently been devoted to identifying the demarcative prosodic features, such as pre-boundary lengthening, *F₀* rising, and other cues.

Studies dealing with the representation of the hierarchy of the syntactic constituents in the prosodic

structure are more questionable; in the wake of generative grammar, some scholars argued years ago that the hierarchy of the syntagmatic tree was in some way reflected by prosody (45, 46, 3, 22, 23, 9, 10). This trend, whose premises were loosely confirmed by empirical facts, yielded to the criticism that if prosody were a mere bearer of syntax, it would be a superfluous burden (25). In contrast with this trend a novel approach gave way to seminal research on the prosodic structure considered as an autonomous phonological level equipped with its own rules and units. But the belief of the first syntactic prosodists -- that for the syntactic function of prosody to be accredited, the hierarchy of the syntagmatic tree should be reflected by prosody -- is still viewed by modern intonational phonologists as a counter-argument against the presence of matching rules between syntax and prosody. We shall discuss this point later.

Concerning the third point in the definition, the relations by which syntactic functions are embodied, I don't know of any study specifically devoted to this topic. Traditionally, scholars have been convinced that syntactic functions, which in generative syntax are represented by a geometric mapping in the syntagmatic tree, cannot be retrieved via prosody.

Today, we can summarise the state of affairs concerning the relationship between syntax and prosody as follows. Ladd (1996, 236) thinks that intonation does not have a privileged status in signalling syntactic structure. The general practice of intonational phonologists, following in Pierrehumbert's (1980) footsteps, has been guided by the belief that intonational data are autonomous «in the sense that dependence on segmental linguistic structure (syntax/lexis and segmental phonology) should have no place in the description» (12). The syntactic structure being immaterial for intonation, most of the intonational phonologists have never tried to associate specific intonation contours with specific grammatical structures, or, in other words, as Grønnum (1992, 79) said, they have never tried «to make a grammar code intonation», although none of them deny that there are some dependencies of intonation on syntax.

However the major advocates of prosodic phonology, such as Selkirk, and Nespor and Vogel, who propose a layered model of prosodic structure that goes from the syllable to the utterance, claim that «an adequate theory of phonology must provide a way of making reference not only to the morpho-syntactic bracketing of the surface syntactic structure, but also to other syntactic as well semantic notions» (29). In the layered prosodic model, Selkirk (1984) and Nespor and Vogel (1986) showed how the prosodic phonological units, although identified as the domains of specific phonological rules, are constrained by syntax, and Selkirk (1984) herself considered the intonational phrase, (the basic unit of the intonational phonologists), to be an «honorary constituent of the syntax»! Going further, Hirst (1993, 787) claims that «the correspondence between syntax and intonational phrasing, though less rigid than was assumed...is perhaps still somewhat stronger than has been suggested recently».

I go along with this assumption that a syntactically constrained structure theory partially accounts for prosodic facts (including intonational phrases). I shall try to show to what extent prosody is constrained by the linear organisation and hierarchy of the syntactic phrases, and just how much syntactic structure can potentially be retrieved.

2. LINEAR ORGANIZATION

Following a universal assumption, Ladd (1996, 235) stated that one of the functions of prosody is «to divide up the stream of speech into chunks or phrases of one sort or another» and that boundaries «are demonstrably not difficult to identify». Conversely, prosody has a grouping function. This assumption, according to Pierrehumbert's model, implies the presence of edge tones and boundary tones in intonational phrases, these boundaries occurring after the last pitch accent as in English and in Italian or being merged with the last pitch accent as in French and in German. A great deal of work has been devoted over the years to the study of the correlates of prosodic boundaries. These correlates are of two types: prosodic contours and timing, which includes lengthening and pauses (we shall discuss pauses later). Klatt (1975) found that systematic duration increases marked syntactic unit boundaries, and described the nature of the syntactic units delimited by lengthening. Beckman (1990) investigated the origin of significant pre-boundary lengthening at the end of prosodic and intonational phrases. She argued against Lehiste (1973), Klatt (1975), and Cooper and Paccia Cooper (1980) that substantial phrase-final lengthening is not constrained by syntactic but rather by phonological boundary strength. Contesting the findings of Beckman's experiments (1990),

Selkirk (1990, 195) concluded with convincing arguments that two theories can accommodate these data: the syntactic structure theory and the syntactically constrained structure theory. Price et al. (1991, 2967) found that prosodic cues, namely lengthening, play a crucial role in syntactic disambiguation, and claimed that their results provided «evidence for some systematic relationships between prosody and syntax that should be explored.». Campbell (1993) proposed a method for normalising segmental duration and calculating the relative lengthening of syllables. Significant syllabic lengthening was reported in two contexts: accentual prominence and pre-boundary position at the end of a phrase, which coincides with a syntactic break. He found that the lengthening of syllables tends to be more pronounced on initial onset segments in prominent syllables, and on later coda segments in pre-boundary syllables; this finding was used in an algorithm for distinguishing the two kinds of lengthening.

Pierrehumbert (1980) and Selkirk (1984, 288f) insisted on the importance of final contours (rise or deep fall) in structuring intonational phrase sequences. In a model using Fujisaki's algorithm, Möbius (1995) found that in order to account for German intonation, phrase commands must be provided at major syntactic boundaries along with the resetting of the declination line. He added that accent groups are sensitive to major syntactic boundaries, where they tend to be higher than in other positions. Mixdorff and Fujisaki (1995) reported an interesting feature of the final accent rise: they found that the continuation rise is mostly dependent on the accent command offset time, implying significant trailing of the rising tone.

One can wonder whether these two main pre-boundary parameters play a different role in phrasing. Hunt (1997), after Wightman et al. (1992), found that in English pause and rhyme durations were the most important acoustic feature in identifying syntactic breaks. For other languages, such as French and German, pitch features certainly play a greater role than in English in identifying boundaries (48). In experiments applied to French, Rossi (1981, 54ff) assumed that lengthening is a necessary condition for perceiving pitch and loudness glissandos, which are the main features of contours for phrasing in French, as proved by Di Cristo (1985) in his study on French intonation. In their synthetic and perceptual experiments for disambiguating an utterance by phrasing, Bruce et al. (1992) showed that Fo and duration cues interact, and in a complementary fashion: «they mutually contribute to the perception of phrasing rather than comprising a primary and a secondary cue». All these experiments confirm Swerts' view (1997) prosody is a helpful way of structuring discourse because of its great

redundancy manifested by register, range, contour type, timing, and declination reset.

According to Selkirk (1984) and Nespor and Vogel (1986), the basic principles delimiting the strings of prosodic hierarchy are domain-like principles: the intonational phrase (IP) is the domain of an intonational contour (including a boundary) and of specific phonological rules (28). If so, the boundaries of intonational phrases are sensitive to pragmatic and performance factors which explain their great variability, and hence the non-isomorphism observed in some cases between intonational and syntactic constituents, as in:

(1) *IP*[*I would never have believed the children of John and Mary*]*IP*

IP[*to be able to become so ill-mannered*]*IP*

where, as argued by Nespor and Vogel (1986, 198), given that the first IP does not represent a syntactic constituent, «it is clear that in this case, and in cases like it, the prosodic structure must be different from the syntactic structure».

I agree with the assumption that the pragmatic and performance factors account for the variability of prosodic units, but I think that the observed flexibility doesn't necessarily entail the violation of syntactic criteria, contrary to what one might infer from a superficial glance at the previous example. The chief constraints at stake are the ones that embody intonational phrases. Whereas all other categories of the Strict Layer Hypothesis, from the syllable to the phonological phrase, are strictly identified as domains of phonological rules and are syntactically defined, intonational phrases are not. What is striking is the elusiveness of the matching rules between this category and the other structural levels. Indeed (i) the intonational phrase as a domain of phonological rules is not convincing, since the rules adduced as a proof may be explained in a different way; and (ii) the intonational phrase is sometimes presented as a sense-unit, sometimes as a syntactic unit encompassed by a «designed category», and sometimes as a unit of performance.

3. HIERARCHY OF INTONATIONAL PHRASES

Generally, intonational phonologists deal with linear phrasing by disregarding the hierarchy among the intonational phrases (IP). They are mostly concerned with the hierarchy of the categories in the Strict Layer Hypothesis and that of the prominence of words in intonational phrases. For database labelling, four hierarchy levels (break indices) are identified by Price et al. 1991 and by Wightman et al. 1991), which correspond to the four levels found by Ladd and Campbell (1991), although with a different conception of the depth of structure. The levels identified by the former are related

not to the sole IPs, but to the different strings of prosodic hierarchy (utterance, IP, intermediate phrase, and so forth), those defined by the latter refer to domains, such as IP, and to «superdomains» which are compounds of domains of a given type (e.g. IP). Interestingly, this conception of the depth of structure is tantamount to recognise a hierarchy among IPs. In discussing the distribution of pauses relative to lengthening, Selkirk (1984, 312f) already identified stronger and smaller syntactic breaks, the latter being where only lengthening appears and the former, where both lengthening and pauses occur. Recent work on discourse and dialogue have argued in favour of the search for the prosodic features that signal the hierarchy of the discourse structure. In his studies on German intonation, Kohler (1997) proved that the intonational boundaries are hierarchically organised. In an analysis of discourse boundaries of different strengths, Swerts (1997) found six significant pause duration categories, two pitch resetting groups, and two boundary tone classes signalling the degree of «embeddedness» of phrases in the discourse. And in a study aimed at implementing phrase boundaries in synthetic speech essentially on the basis of pitch contours, Sanderman and Collier (1996, 3396) «adduced empirical evidence that listeners are sensitive to a five-level hierarchy».

A glance at certain corpora in the above studies shows that in most cases, boundary levels are determined by the syntactic hierarchy. So studies on boundary strength, as well as research on prosodic phrasing, argue for syntactic constraints on prosody and for matching rules between prosody and syntax. Yet can we be satisfied with the informal observation that there is a rather close relationship between semantic and syntactic structures, and that prosody is sensitive to major syntactic boundaries like clauses and major phrases? We need a suitable model to handle linguistic structures that constrain prosodic boundaries. I shall now briefly present a model that was designed for French but could be adapted to other languages.

4. A MODEL

An intonational phrase, being the domain «over which an intonational contour is spread» (Selkirk 1978, 130), necessarily contains boundary features. The issue is to identify the constraints that force boundary, and a given boundary strength, precisely at that point in the speech sequence. I presented a tentative model aimed at resolving this issue. It was designed to predict and interpret the prosodic organisation of spontaneous speech utterances (35). The model discussed here is a principle-based view of prosodic structure embodied in a three-level device consisting of (i) a pragmatic-prosodic module (PPM), (ii)

a syntactic-prosodic module (SPM), and (iii) a rhythmic module (RM). This hierarchy reflects the order of processing in the predicting model, not necessarily at the production stage or at the ideation or speaker programming levels. However this may be, the fact that the edges of the pragmatic units are in most cases coterminous with surface syntactic boundaries, seems to mean that the pragmatic level gets the output of the syntactic structure. We are faced with a paradox: on the one hand the pragmatic module seems to receive information from the output of syntax, and on the other hand, it is well established ontogenetically that the first grammar is a pragmatic intonation-based device, and that syntax comes later; hence we must assume that the pragmatic module is parallel to syntax, from which it receives information on surface phrasing, and that it is strong enough to override the syntactic hierarchy structure.

4.1 The pragmatic-prosodic module (PPM)

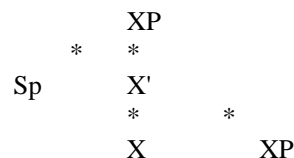
PPM was presented in Rossi (1995), so the discussion here will be restricted to the chief points. The main fundamental operations of this module, topicalisation, thematisation and focalisation, are aimed at organising foreground and background semantic information (44). Because such an organisation overrides the syntactic hierarchy, a preliminary identification of it is mandatory if we want to define syntactic constraints correctly; this requirement explains the operational «first place» of PPM in the model. This preliminary identification is made easier insofar as the pragmatic units (topic (TOP), parenthesis or internal theme (IT), and focus (F)) are predominantly realised by marked prosodic means. As I have already quoted, Campbell (1993) and Beckman (1997) found that lengthening under F-prominence in English is markedly different from phrase final lengthening; it was shown by Rossi (1995) that in French, F does not imply any lengthening, only expressive content (emphasis) on a nuclear tone being lengthened. Mixdorff and Fujisaki (1995) argued for different pitch contours defining continuation and F in German. ITs are systematically said on a nearly flat contour with a pitch level lower than that of the context, implying a prosodic break. Whereas ITs are isomorphic to syntactic constituents, they are not, as a consequence of the relationship between the pragmatic and syntactic modules, «structurally attached to the sentence tree» (29). Moreover they take the opportunity to incise syntactic constituents, which are candidates for intonational phrases, in such a way that the resultant strings are no longer in a one-to-one relationship with any syntactic constituent. For example (ibid.):

(2) *Charles wouldn't, I imagine, have done such a thing*

Yet, if clear prosodic markers are available for IT identification, then the underlying syntactic constituent and the domain of the involved intonational phrase should easily be retrieved. Other examples on the relationship between pragmatic and syntactic constituents and the possible retrievability of the latter will be adduced later at the Conference.

4.2 The syntactic-prosodic module (SPM)

In this paper a skeleton of the module is presented and only two principles will be discussed. SPM is based on the state of the X-bar theory described by Haegeman (14). The worthiness of this theory is due to its powerful generalisation capabilities, cross-categorical symmetry, representation level symmetry, and projection principle. The basic representation of any category:



shows that all categorical rules must be formulated entirely in terms of category variables. Thus, cross-categorical symmetry is a basic principle of the theory. In early generative grammar, the rules relied on categorical constants rather than variables, a situation which masked the structural symmetry of the categories. Logically, then, prosodic boundaries were assigned levels that depended on the hierarchy of the constituents in the syntagmatic tree. This led to the assignment of different boundary levels for identical structural relations, as in the subject/predicate relation in the matrix (0-level) and in the embedded (-3-level) sentences:

(3) *(Le gouvernement Juppé) vendra la société*
0

que (le gouvernement socialiste) avait nationalisée
-3

(The Juppe's government will sell the Company that the socialist government had nationalised)

Yet -- and this will be our basic principle here -- boundary levels appear to be essentially linked to the structural relations within the cross-categorical structure.

Another principle of X-bar theory, structural symmetry across representation levels, stipulates that the D-structure (Deep Structure) be saved in the S-structure (Shallow Structure). The categories assumed to be in the D-structure should be found in the S-structure. The structural symmetry across representation levels leads me to define a basic principle:

OP5 *Prosodic boundary levels depend on structural relations in the D-structure*

These same levels should also be found in the S-structure. Hence, moving a constituent does not change the prosodic boundary organisation, since:

OP6 *The moved constituent is assigned the boundary of the landing site*

Another principle of X-bar theory is the projection principle, which stipulates that lexical information must be syntactically represented. The thematic theory (ϑ -theory) deals with lexical sub-categorisation derived from the projection principle. This semantic component of grammar defines the assignment of thematic roles, mainly the predicate/argument relations. ϑ -theory plays a crucial role in the interpretation of prosodic boundaries as well as in the definition of phonotactic constraints.

Two principles account for the syntactic-prosodic boundaries assigned at the D-structure level:

OP7 *Every XP dominated by a sentential category requires a CD dominant prosodic marker for its right category, in any matrix sentence*

where CD is an operating marker that is dominated by the topicalisation marker (CDo) but that dominates all other boundaries within the utterance; in embedded sentences, OP7 generates CT boundaries (see OP8 for definition).

OP8 *Every right-branched XP dominated either by a lexical XP or by a [+N] and/or [+V] node requires a boundary, CT_n, immediately following its left L-commanding sister*

where:

(i) CT is a prosodic boundary immediately below CD, and sensitive to phonotactic constraints; (ii) *n* is a ranking index equal to *i-j*, where *i* is the number of bars in the L-commanding sister of XP whose *j* = 2; (iii) L-commanding is a c-command by a lexical category

In OP7 and OP8, for an application to SOV languages like Japanese, we have to take the converse of the locality terms *right*, *left*, and *following*.

4.2.1 Sentential categories

OP7 claims that the immediate constituents of a sentence which are in a position to c-command the remainder of the utterance are followed by a dominant boundary. For instance, the external argument (subject) of the predicate and the left sentence adverb, whose scope covers the sentence, are followed by a dominating CD below the topic boundary (CDo) whose scope is the utterance. CD is not sensitive to phonotactic conditions; it is a potential that can be expressed under any phonotactic

conditions, but it may be deleted if, for instance, the subject is too short.

4.2.2 Phrasal Categories

OP8 reflects the basic category structure. It differs from the purely hierarchical OP7 essentially in that it is dependent upon the c-command and government principles, intended here to mean strict c-command and proper government, respectively.

Proper government takes place between a lexical head X and its L-marked lexical argument XP; the CT-2 boundary which by OP8 has to occur between X and XP is a low-order marker that is the prosodic image of the close relation between the two sister nodes. The CT-2 boundary will occur in this same structure no matter what its ranking is in the syntagmatic tree. The only right-branching XPs above the argument are necessarily adjuncts to an X_n projection of X (X' or XP). Adjuncts are preceded by a syntactic-prosodic boundary insofar as they are dominated by a lexical category :

		XP	
		* *	
		* *	
CT , (i-j = 0).....	XP.....		XP ₃ --ADJU
	* *		
	* *		
	Sp	X'	
		* *	
		* *	
CT ⁻¹ , (i-j = -1)	X'		XP ₂ --ADJU
		* *	
		* *	
CT ⁻² , (i-j = -2).....	X		XP ₁ --ARGU

(4) *Ils laisseront* CT-2 [*la place*] CT-1[*pour deux agricultures*] CT [*sur les marchés mondiaux*]
(*They will leave the place for two crops on the worldwide markt*)

The right-branching condition restricts boundaries to sites before internal arguments of the head and adjuncts. In the first case, the categories are tightly linked by the proper-government relation and by its prosodic counterpart CT-2; in the second case, the categories are loosely tied by the c-command relation and its prosodic counterparts CT-1, and CT. It is interesting to note that SPM, together with PPM, identify a five-level system of boundary strength (CDo, CD, CT, CT-1, CT-2) which is akin -- for the number of levels -- to that found by Sanderman and Collier (1996). The boundaries generated

by the model are abstract markers liable to be prosodically represented in different ways, depending on the language.

If these principles are applied to languages other than French, it must be emphasised that, except for rhythmic constraints, not all of the above boundaries will have to be expressed. In English and Italian, for example, unlike French, the CT-2 argument boundary is not a possible intonational break: in these languages, the head and its internal argument are strongly tied to each other in the same intonational phrase. In this case, we find the same kind of link as between adjectives and their head in most languages. It follows from OP8 indeed, that the leftward-branched positions, namely functional heads, specifiers and adjectives, are tightly bound with lexical heads by ϑ -binding and ϑ -identification, which merge two positions into one (43). Prosodic behaviour accounts for this semantic binding and merging by identification. Consequently, although prosody is not liable to convey information relative to functional relations, we have an indirect indication, in languages like English and Italian, that some functions act within the intonational phrase.

As it will be demonstrated at the Conference, these basic principles account for disturbing empirical facts adduced for denying the strength of syntactic constraints on prosody; they simply explain some facts described on other grounds in several languages.

4.3 The rhythmic module (RM)

RM is provided with principles, rules, and two algorithms. The latter consist of devices for main and secondary accent generation. Principles may be considered as universal constraints, whereas rules and algorithms are parametric implementations appropriate to a given language. An example of a principle is the *Phonotactic Filter* which states that:

The constraints of proximity and rhythmic timing must be satisfied everywhere

The constraint of proximity (i) precludes the adjacency of intonative boundaries and/or accents, and (ii) states that intonative units in an utterance have to be time balanced. The phonotactic filter is implemented by appropriate rules. The constraint of proximity has the effect of cancelling the involved boundaries and/or accents, depending on the number of syllables between the two prosodic markers. Boundary strength is modified in such a way by the timing constraint that the level of boundaries may be lowered below CT-2, in which case they are no longer valuable for implementation:

(5) *Mais j(e) veux dire* CT-2

[qu'il a encore] [des années] [de compétition] ...

SPM : CT-2 CT-2

Time Bal. : CT-1 CT-4

(But I mean he has even so years of racing...)

In the above example, the CT-4 boundary will be erased.

More details will be given later from several languages. For now, we need to emphasise that the time balance principle is syntactically constrained insofar as it never entails boundaries inside syntactic constituents and deals only with SPM-generated boundaries. Its only consequence is to upset the hierarchy of related boundaries generated by OP8 and to mask some syntactic breaks. Consequently the resulting boundaries, although representing syntactic breaks, do not exactly share the syntactic hierarchy generated by OP8; however the relative hierarchy among the boundaries, from OP8 and the dominant breaks derived from OP7 and PPM, is maintained, provided the phonotactic conditions allow for the latter to be implemented. If some lower virtual boundaries are not realised as such, for structural reasons (as in English and Italian), and/or if some others are erased by phonotactic constraints, intonational phrases may appear to be syntactic non-constituents. This is the case in example (2), where the CT-2 boundaries are not realised at the end of the heads *believed*, *able*, and *become*, before their internal arguments, the only boundary maintained being the high-level break at the end of the subject *Mary*. The discrepancy between syntax and prosody in (2) is only apparent: the prosodic boundary represents a high-level syntactic break, the first IP consists of the syntactic domain of a phonological phrase (V with its left extension) followed by the governed NP of the verbal head, and the second IP contains a predicate.

5. CONCLUSION

I have defined the notion of syntactic structure as the linear organisation and hierarchy of syntactic constituents, and the relations by which functions are defined. The core of the proposed model generates syntactic-based prosodic boundaries ordered by the hierarchy principle (OP7, immediate constituents) and by the government principle (OP8). The syntactic linear organisation can be disrupted by pragmatic units (IT), but is retrievable, the prosodic features of pragmatic units being markedly different from those of syntactic boundaries. The background and foreground organisation of semantic information overrides the syntactic structure, so that topic strength has scope over syntax. In turn, the rhythmic device modifies the boundaries generated inside lexical XPs. As a result, a fourfold hierarchy can be retrieved on reliable grounds by the break strength of intonational phrases. The involved boundaries occur: (i) after a pragmatic unit, (ii) between immediate constituents, (iii) before an adjunct, and (iv) between utterances. Yet we have to bear in mind that CDo-topic boundaries and CD-immediate constituent boundaries,

although they could be produced in any case, may be cancelled under certain phonotactic conditions. A finer syntactic structure can be recovered using the strength of subordinate strings such as phonological and accentual phrases encompassed by intonational phrases.

The flexibility of prosodic constituents is mainly accounted for by performance factors that come last in the model. The latter «explain the discrepancy between how things are and how things should be» (8, cited by 29, p.57). If the variability of intonational phrases can be explained and predicted, syntactic constituents are appropriate to defining the underlying phrasing available

REFERENCES

1. Beckman, M. E. and Cohen K.B.(1997), Modelling the articulatory dynamics of two levels of stress contrast, in Horne (forthcoming).
2. Beckman, M.E. and Edwards, J. (1990), Lengthenings and shortenings and the nature of prosodic constituency, in J. Kingston and M.E. Beckman (eds), *Papers in Laboratory Phonology I*, 152-178.
3. Bierwisch, M. (1966), Regeln für die Intonation deutscher Sätze, *Studia Grammatica*, 7, 92-102.
4. Bruce, G., Granström, B., Gustafson, K. and House, D. (1992), Interaction of Fo and duration in the perception of prosodic phrasing in Swedish, *Nordic Prosody*, VI, 7-22.
5. Caelen, G., (ed.), *Prosodie et reconnaissance*, C.C.A.I., (forthcoming).
6. Campbell, N., (1993), Automatic detection of prosodic boundaries in speech, *Speech Communication* 13, 3-4, 343-355.
7. Carbonnel, N., Haton, J.P., Lonchamp, F. et Pierrel, J.M.(1982), Indices prosodiques pour l'analyse syntaxico-sémantique dans Myrtille II, *Actes du Séminaire Prosodie et Reconnaissance*, Aix, 59-91.
8. Chomsky, N. and Halle, M. (1968), *The sound pattern of English*, Harper and Row, New York.
9. Cooper, W. and Paccia-Cooper, J. (1980), *Syntax and speech*, Harvard University Press, Cambridge, MA.
10. Di Cristo, A. (1981), L'intonation est congruente à la syntaxe, in M. Rossi et al.(1981), 272-289.
11. Di Cristo, A. (1985), Publications de l'Université de Provence.
12. Grønnum, N., (1992), *The ground-works of Danish intonation*, Museum Tusulanum Press, University of Copenhagen.
13. Gussenhoven, C. (1983), Focus, mode and the nucleus, *Journal of Linguistics*, 19, 377-417.
14. Haegeman, L. (1994), *Introduction to Government and Binding Theory*, Basil Blackwell, Oxford.
15. Hirst, D. (1993), Detaching intonational phrases from syntactic structure, *Linguistic Inquiry*, 24, 781-788.
16. Horne, M. (ed.), *Prosody : Theory and Experiment*, Kluwer, Dordrech, (forthcoming) ;
17. Hunt, A. (1997), Training prosody-syntax recognition models without prosodic labels, in Y. Sagisaka, et al. (eds.), 1119-1122.
18. Klatt, D.H. (1975), Vowel lengthening is syntactically determined in a connected discourse, *Journal of Phonetics*, 3, 3, 129-140.
19. Kohler, K. J., (1997), Modelling prosody in spontaneous speech, in Sagisaka et al., 187-210.
20. Ladd, B. and Campbell, D.R. (1991), Theories of prosodic structure : evidence from syllable duration, *Proc. ISPHS 1991*, 290-293.
21. Ladd, D.Robert (1996), *Intonational Phonology*, Cambridge University Press.
22. Lea, W.A. (1972), *Intonational cues to the constituent structure and phonemics of spoken English*, Ph. D. Dissertation, Purdue University.
23. Lea, W.A. (1980), Prosodic aids to speech recognition, in W.A. Lea (ed.), *Trends in speech recognition*, Prentice Hall, New Jersey.
24. Lehiste, I. (1973), Phonetic disambiguation of syntactic ambiguity, *Glossa*, 7, 2, 107-121.
25. Martin, Ph. (1981), L'intonation est-elle congruente à la syntaxe ?, in Rossi et al. (1981), 234ff.
26. Meloni, H. et Guizol, J. (1982), Utilisation de paramètres suprasegmentaux en reconnaissance automatique de la parole continue, *Actes du Séminaire Prosodie et Reconnaissance*, Aix, 93-119.
27. Mixdorff, H. and Fujisaki, H. (1995), Production and perception of statement, question, non-terminal intonation in German, *Proc. ICPHS 95*, II, 410-413.
28. Möbius, B. (1995), Components of a quantitative model of German intonation, *Proc. ICPHS 95*,
29. Nespor, M. and Vogel, I. (1986), *Prosodic Phonology*, Foris, Dordrecht.
30. Ostendorf, M. and Veilleux, N. (1991), A hierarchical stochastic model for automatic prediction of prosodic boundary location, *J.Acoust. Soc.Am.*, 90, 2275 (A).
31. Pierrehumbert, J., (1980), *The phonology and phonetics of English intonation*, PhD, (MIT), IULC (1988).

32. Pollock, J.Y. (1989), "Verb Movement, UG and the Structure of IP", *Linguistic Inquiry*, 20, 3, 365-424.
33. Price, P., Ostendorf, M., Shattuck-Hufnagel, S. and Fong, C. (1991), The use of prosody in syntactic disambiguation, *J. Acoust. Soc. Am.*, 90, 2956-2970.
34. Rossi, M., Di Cristo, A. Hirst, D., Martin, P., & Nishinuma, Y. (1981), *L'Intonation, de l'acoustique à la sémantique* (Klincksieck, Paris).
35. Rossi, M. (1993), A Model for Predicting the Prosody of Spontaneous Speech (PPSS Model), *Speech Communication*, 13, 87-107.
36. Rossi, M. (1995), A Principle-based Model for Predicting the Prosody of Speech, in *Levels in Speech Communication Relations and Interactions*, Elsevier, Amsterdam, 159-170.
37. Sagisaka, Y., Campbell, N. and Higuchi, N. (eds.), (1997), *Computing prosody*, Springer, Berlin,
38. Sanderman, A.A. and Collier, R. (1996), Prosodic rules for the implementation of phrase boundaries in synthetic speech, *J. Acous. Soc. Am.*, 100, 5, 3390-3397.
39. Selkirk, E. (1978), On prosodic structure and its relation to syntactic structure, published in T. Fretheim (ed.), *Nordic Prosody II*, TAPIR, Trondheim, 1981, 111-140.
40. Selkirk, E. (1990), On the nature of prosodic constituency: comments on Beckman and Edwards paper, in J. Kingston and M.E. Beckman, *Papers in Laboratory Phonology I*, 179-200.
41. Selkirk, E. (1997), The interaction of constraints on prosodic phrasing, in *Horne*, (forthcoming)
42. Selkirk, E., O. (1984), *Phonology and syntax: the relation between sound and structure*, MIT Press, Cambridge (Mass).
43. Speas, J.M. (1990), *Phrase Structure in Natural Language*, Kluwer, Dordrecht.
44. Sperber, D. and Wilson, D. (1986), *Relevance: communication and cognition*.
45. Stockwell, R.P. (1960), The place of intonation in a generative grammar of English, *Language*, 36, 360-367.
46. Stockwell, R.P. (1972), The role of intonation: reconsiderations and other considerations, in D.L. Bolinger (ed.), *Intonation*, Penguin Books, 87-109.
47. Swerts, M. (1997), Prosodic features at discourse boundaries of different strength, *J. Acoust. Soc. Am.*, 101, 1, 514-521.
48. Vaissière, J. (1983), Une composante suprasegmentale dans un système de reconnaissance: réduction du nombre d'hypothèses lexicales et détection des frontières majeures, *Recherches acoustiques*, CNET, VII, 109-124.
49. Vincent, M., Di Cristo, A. and Hirst, D. (1995), Prosody feature of finality for intonation units in French discourse, *Proc. ISPHS 95*, II, 718-721.
50. Waibel, A. (1987), Prosodic knowledge sources for word hypothesization in a continuous speech recognition, *Proc. ICASSP*, Dallas, 856-859.
51. Wightman, C. W., Shattuck-Hufnagel, S., Ostendorf, M. and Price, P. (1992), Segmental durations in the vicinity of prosodic phrase boundaries, *J. Acoust. Soc. Am.*, 91, 1707-1717.