

Gradient linguopalatal variations due to a 4-level prosodic hierarchy in French

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Abstract

Many studies on various languages (English, Korean, French, Taiwanese, Estonian, Tamil) have shown that the articulation of segments in initial and final positions of prosodic constituents is strengthened and more resistant to coarticulation as a function of the hierarchical level of the prosodic. In French, studies have mainly dealt with V or C articulations in initial and final positions (Fougeron 2001, Tabain 2003), and V#C cross-boundary coarticulation (Tabain 2003).

This study on French (Meynadier 2003, 2004) deals with the effects of a 4-level prosodic hierarchy on V and C articulations in initial and final positions, and on pre-boundary VC, post-boundary CV, cross-boundary CC, VC and CV coarticulation. Articulatory analysis is based on an EPG investigation of the spatio-temporal dynamics of linguopalatal gestures in aC#Ca sequences, where CC stands for /kl/, /lk/, /kt/ or /tk/. Prosodic boundaries (#) vary according to 4 increasing hierarchical levels: *unaccented* < *accented* < *continuative intonational* < *conclusive intonational*.

This poster focuses on the nature of supralaryngeal correlates of prosodic constituency, and on the number and the type of hierarchical levels they distinguish across speakers.

Articulatory results show that the higher the prosodic level, (i) the greater the duration and the openness of the pre-boundary vowel /a/; (ii) the tighter the temporal intergestural coordination inside the final rime aC#; (iii) the more reduced cross-boundary C#C coarticulation; (iv) the greater the C#_(C)V cross-boundary interval.

These prosodic-dependant articulatory correlates account for 3 main decreasing hierarchical distinctions between prosodic levels: (i) intonational levels > lower levels; (ii) accentual levels > syllable/word level; (iii) continuative intonational level > conclusive intonational level.

Background

- In speech, the hierarchical prosodic structure of utterances is signaled primarily by suprasegmental variation, but also by means of segmental articulatory modifications.
- Segment articulation shows a gradient strengthening and resistance at the edges of prosodic constituents which correlate with the level of these units in the prosodic hierarchy.
- In spite of strong intra- and inter-speaker variability with respect to the number of distinguished levels and the nature of the articulatory correlates, these phenomena are attested in several languages including English [1, 2, 3, 4, 5], Korean [5, 6], French [5, 7, 8], Tamil [9], Taiwanese [5, 10] and Estonian [11].
- In French, previous studies have mainly dealt with V or C articulations in initial and final positions and V#C cross-boundary coarticulation.

Aims

This study [12, 13, 14] on the articulatory effects of a 4-level prosodic hierarchy deals with C and V articulations in initial and final syllables, and coarticulation of initial CVs, final VCs and cross-boundary VCs, CCs and CVs.

We will compare our results with previous studies on French which have dealt with a subset of these correlates.

Our study focuses on the articulatory nature and the prosodic granularity of the prosodic-dependant articulatory correlates across speakers.

Speech Material

3 native French speakers, 12-15 repetitions of each item

4 segmental sequences: /ak#la/, /ak#ta/, /al#ka/, /at#ka/

4 hierarchical levels of prosodic boundary (#)

validated by statistical analyses of lengthening, F0 peak and slope of pre-boundary /a/

Unaccented [UNA]

syllable
or
word

Ma belle-sœur a gagné deux quatre-**quatre** noirs et une moto. (My sister-in-law won two four-wheel drive and a moto.)

Ma grand-mère utilise un **sac Tati** pour faire ses courses. (Ma grand-mother uses a Tati bag for shopping.)

Accented [ACC]

word-final accent in
syntagme-median
or -final positions

La fatigue affaiblit l'atta**que** laotienne de l'équipe. (Fatigue weakens the Laotian attack of the team.)

La merveilleuse nounou éta**le** Camélia sur le lit. (The wonderful nurse lays Camelia on the bed.)

Continuative Intonation [CTI]

subject or
left-dislocated
theme intonation

La réponse de la candida**te** catastrophe le jury. (The answer of the candidate stuns the jury.)

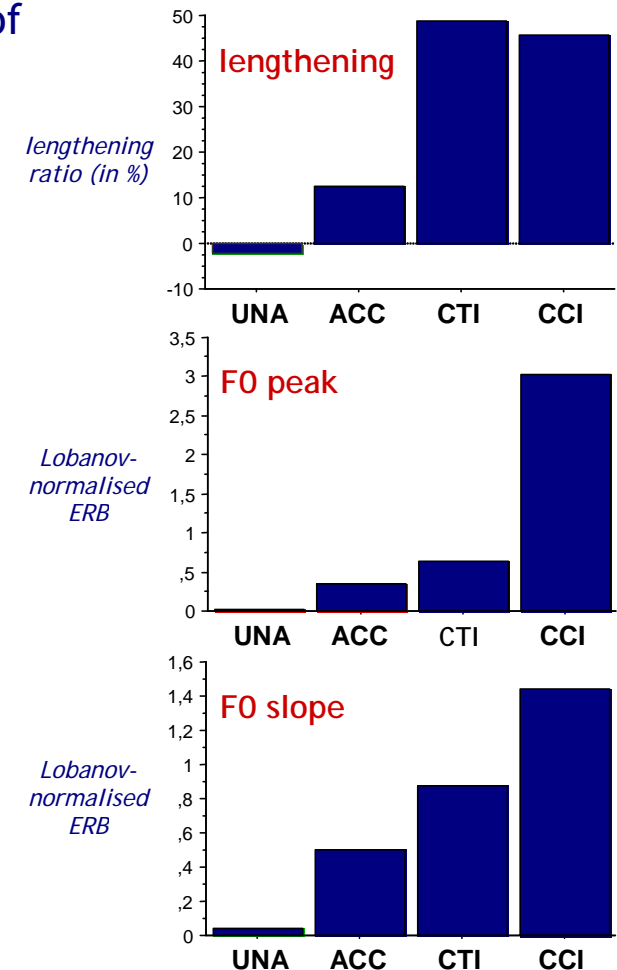
Ma mauvaise foi et mes atta**ques**, Tatiana les méprise. (My dishonesty and attacks, Tatiana scorns them.)

Conclusive Intonation [CCI]

right-dislocated theme
or utterance-final intonation

A force, elle les adore, les datta**tes**, Camélia, maintenant ? (Will she end up loving them, the dates, Camelia, now ?)

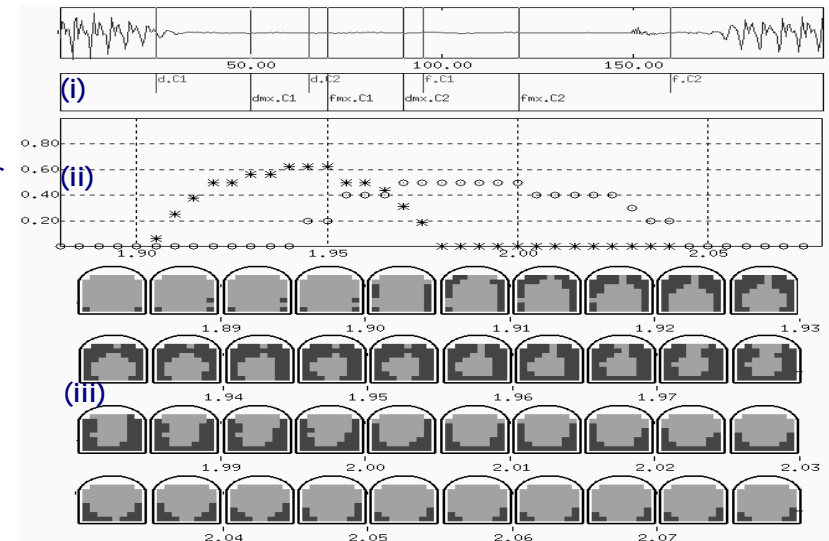
Ma belle-mère a trouvé l'éta**l** ? Camélia le cherchait. (Did my mother-in-law find the stall? Camelia looked for it.)



Articulatory Measurements

178 EPG measurements per token were extracted for C & V, and on VC, CC & CV coarticulation

- **Gestural timing:** duration and ratio of the onset, the occlusion, the maximal constriction and the release of Cs, duration of the maximal opening of Vs, etc.
- **Other gestural kinematics:** C and V amplitude, C anteriority, C posteriority, C centrality, EPG ratio difference between C and V, distance between C1 and C2 place of articulation, EPG contact ratio of C1 at the onset of C2, etc.
- **Inter-gestural timing:** absolute and relative temporal intervals between the different articulatory phases for CV, CC and VC, etc.



A token of at#ka (i) labeled articulatory points; (ii) EPG contact ratio over time for the anterior EPG area of /t/ (stars) and for the posterior EPG area for /k/ (circles); (iii) EPG frames (1/5ms)

Statistical Analysis

The inter-speaker gradient articulatory correlates of the prosodic hierarchy were extracted from the data by a statistical selection process based on 4 consecutive criteria:

- (1) Effect of prosodic level (*ANOVA, p < .05*)
- (2) Maximal correlation with hierarchical order (*Spearman rank correlation*)
- (3) First and second criteria (above) are true for at least 2 out of 3 speakers
- (4) Effect of prosodic level when data of included speakers are pooled (*ANOVA, p < .05*)

Gradient Articulatory Correlates #1

" constituent-final position "

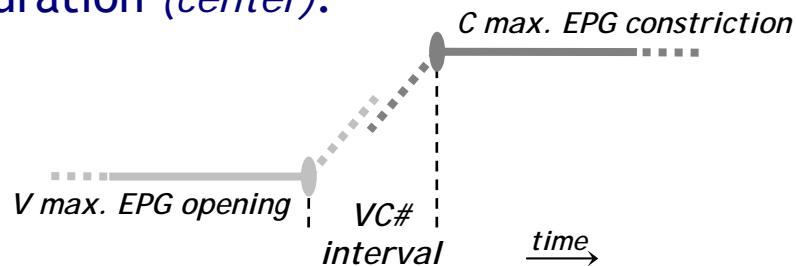
Pre-boundary V: aC#Ca

As a function of increasing prosodic boundary strength, the linguopalatal opening of the final /a/ is gradually

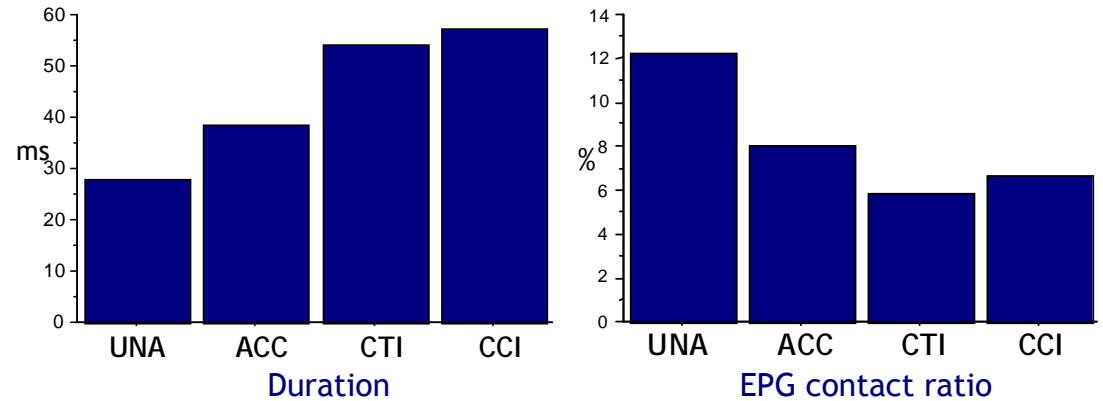
- longer (*left*)
- and larger (*right*)

Pre-boundary VC rime: aC#Ca

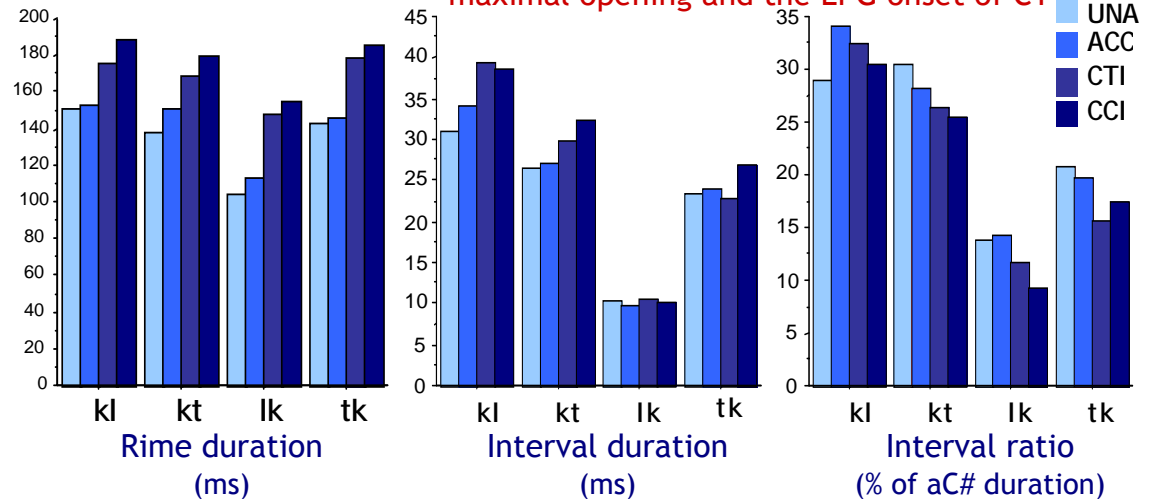
According to the prosodic hierarchy, the temporal interval between pre-boundary V and C decreases in proportion (*right*) as VC duration increases (*left*), even if this interval increases in duration (*center*).



maximal linguopalatal opening of a1



temporal interval between the offset of a1 maximal opening and the EPG onset of C1



Gradual Articulatory Correlates #2

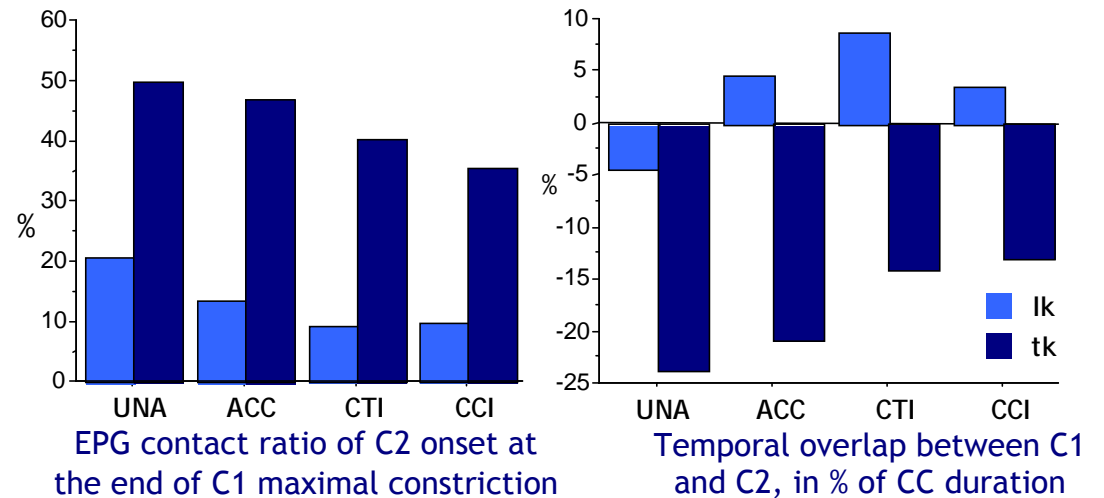
“ cross-boundary coarticulation ”

Cross-boundary CC coarticulation: aC#Ca

The higher the prosodic boundary, the less coarticulated the cross-boundary CC clusters,

- in the spatial dimension (*left*)
- as well as in the temporal dimension (*right*)

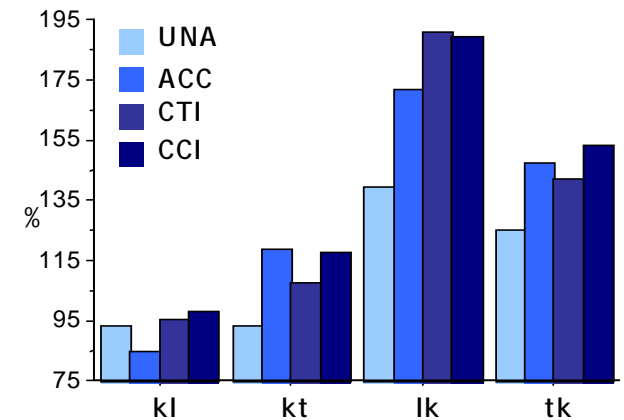
Only true for the anterior-posterior consonant clusters /lk/ and /tk/.



Cross-boundary CV timing: aC#Ca

As a function of the prosodic hierarchy, the temporal interval between the pre-boundary C and the non initial post-boundary V is gradually longer.

For example, the offset of the C1 maximal constriction is phased earlier relative to the acoustic onset of a2 (*right*, in % of a2 duration), as prosodic level increases.



Prosodic Granularity

“ inter-speaker prosodic granularity of supraglottic articulatory correlates ”

Percentage of significant distinctions and inversions between prosodic hierarchy levels

Calculated over the inter-speaker articulatory correlates of the prosodic hierarchy (N = 102), and from Fisher post-hoc tests (1 factor “prosodic levels”, *p < .05)

Prosodic levels	significant* distinctions	inversions	significant* inversions
CCI ≠ CTI	43	42	9
≠ ACC	87	-	-
≠ UNA	95	-	-
CTI ≠ ACC	77	3	0
≠ UNA	95	-	-
ACC ≠ UNA	52	7	1

When gradient articulatory variation is produced at the boundary of prosodic constituents and are correlated to the prosodic hierarchy, these show

- Most distinctions between intonative and non intonative levels (*CCI/CTI* > *ACC/UNA*: over 77 %)
- Fewer distinctions between accentual and unaccented levels (*ACC* > *UNA*: 52 %)
- Fewest distinctions between conclusive and continuative levels (*CCI* > *CTI*: 43 %)

The occurrences of hierarchical inversions confirm this scale, especially for the weaker hierarchical distinction between conclusive and continuative boundaries, where almost 50 % of cases show greater segmental strengthening for CTI than CCI.

Conclusion #1

**“ the most reliable articulatory correlates
of prosodic constituency ”**

Pre-boundary /a/ articulation

Apart from the well-known final vowel duration, this study on French shows that the more reliable segmental supralaryngeal correlates of hierarchical level of an inter-consonantal prosodic boundary (aC#Ca) are above all the gradient amplitude and duration of maximal linguopalatal opening of the final open vowel.

These correlates are the least variable according to speakers, phonotactic contexts and their prosodic granularity.

These results confirm the previous works by Tabain [8].

Coarticulatory variations

This study emphasizes too that although many various coarticulatory correlates exist, they cannot be considered as very good “predictors” of the hierarchical nature of prosodic constituent structure, because they appear to be largely both speaker and phonotactic context-specific.

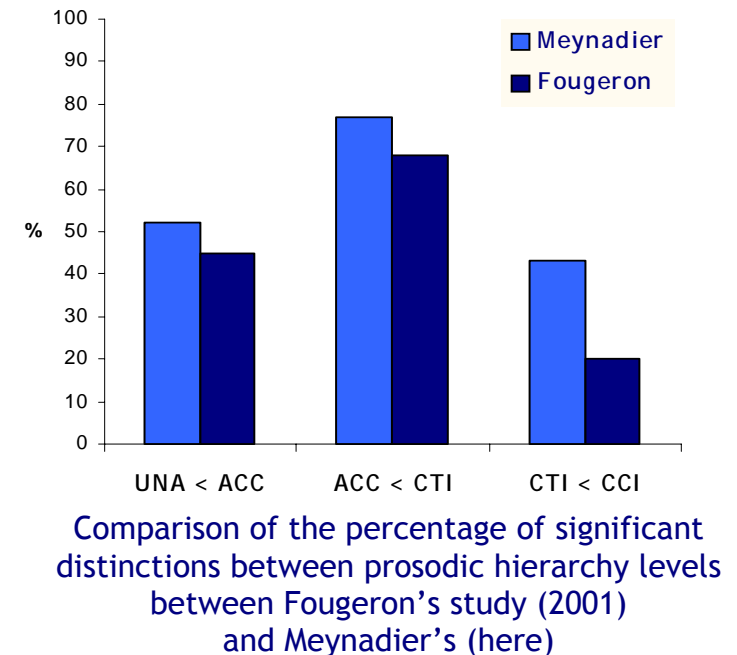
Conclusion #2

“ consistency of the prosodic granularity of articulatory variations in French ”

A comparison (Meynadier & Fougeron 2004) with a previous study on French (Fougeron 2001) shows a similar scale of hierarchical distinctions between prosodic levels, despite the fact that Fougeron investigated only post-boundary initial segment articulation, whereas the main results of our study come from pre- and cross-boundary (co)articulations.

This point provides strong evidence supporting prosodic-dependant segmental articulatory strengthening as a linguistic speaker-controlled process in speech, rather than a simple consequence of an intrinsic biomechanical response by speech motor production process.

If it so, we may expect, for example, reduced articulations at pre-boundary final position at the end of utterances due to articulatory declination, hence at the opposite that we found here, systematic hierarchical inversions between CTI and CCI levels (if we assume these levels are different and have hierarchical relationships). Nevertheless, the results of this study does not support this view.



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Acknowledgements

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