# INTERSEGMENTAL (VC & VCC) AND INTRASEGMENTAL (VOT & VTT) PHASINGS IN FRENCH

Rudolph SOCK Liisa OLLILA Christine DELATTRE Corinne ZILLIOX

Institut de Phonétique de Grenoble
Institut de la Communication Parlée
38031 Grenoble Cédex, FRANCE

ABSTRACT

The main thrust of this study is to examine on the acoustic level and across rate conditions, intersegmental and intrasegmental phasings in close phonetic classes : VC vs VCC. The psychomotoric recognition pattern paradigm adopted here is a means of inferring motor programs, separate or generalized, from the different types of phasing structures observed. We should also be able to compare our acoustic data with related results on movement studies, especially in the intrasegmental domain, for which lesser data is available.

## INTRODUCTION

Studies of timing in speech on the articulatory level postulate a relative constancy, across stress and rate for gestures associated with adjacent segments /1/ and also for gestures associated with events within one segment /2/. These results obtained for behaviours between oral articulators (intersegmentally) and between oral and laryngeal gestures (intrasegmentally) both suggest some motoric invariance.

In the light of this literature, we will investigate for French on the acoustic level intersegmental (VC & VCC) and intrasegmental (VOT & VTT) phasings across two rate conditions. The cyclic production activity in speech allowed us to determine, on the acoustic level, from reiterating events a release cycle and retain, within this cycle, four phases : VOT, Vocalic, VTT and Silence (cf. below). Our results will concentrate on the Vocalic, VTT and VOT ones. Adopting hence the psychomotoric recognition pattern paradigm borrowed from studies based on phasing, - e.g. those for human intralimb kinematics /3/, - we will try to show from our results that instead of simply advocating relative timing or phase invariance, we could search for clear-cut structural patterns (inferential of separate motor programs) and this for different - though linearly linked (as to cycle transformation) - linguistic tasks, like those found for the same gait pattern analysis in walking vs jogging /4/.

On the intrasegmental level, we will examine the behaviours of VOT /5/ and VTT (Voice Termination Time, see /6/ for measurements ; and /7/ for cue validation) in the VC domain since both are linked to the timing of the glottal gesture in relation to supraglottal release and closure respectively. If the intrasegmental timing for VOT is comparatively well known (for French see /8/), we do not dispose of enough information on the role that VTT plays in consonantal coordinations. Thus, we will attempt to situate our results in the perspective of glottal gesture control in relation to the two consonantal commands for closing and release responsible for producing the consonant hold. In recent research context, preoccupied with the phasing of these commands as revealing ultimate intersegmental motor programs /9/, this study should provide a comparison between the acoustic manifestations of our VTT with results obtained by /2/ examining the production of an intrasegmental coordination.

## LINGUISTIC MATERIAL

The linguistic material consisted of pairs derived from the following French verbs : empatter / empâter, téter / étêter, coter / écôter, égoutter / goûter. In certain contexts, these verbs become real minimal pairs permitting to test, in the VC domain, the effect of consonantal gemination on vowel length (pairs of the type : "nous l'empattons ? / nous l'empâtons ? vs "nous l'empatt't-on ? / nous l'empât't-on ?". See /10/ for a detailed description of this corpus). 12 repetitions were obtained for each item, amounting to 768 items for each speaker in two rate conditions :

normal and fast. To account for inter/intrasegmental phasings between VC and VCC classes, we will limit here our data to the first and last pairs in the series above (vowels /a/, /a:/, /u/, /u:/) and to preliminary results on 5 speakers from a larger data base. Our results will focus on three of them : speaker J.P. respects quantity contrasts (rare in present French) ; speaker R.L. is an example of representative results obtained in this study and elsewhere ; and Speaker C.F. has markedly different phasing structures from others.

After recordings, speech signals were digitalized and items extracted from their carrier sentences, segmented manually into acoustic events with the help of a speech editor /11/. A total of 44,490 events were detected.

The following parameters were retained in the VC domain : vocalic phase (VOT plus DVOC = clear vocalic formant structure), closure duration, VOT, VTT (from the beginning of closure to the end of voicing), the silent phase and the release cycle. For details on measurement procedures, cf. /12/.

## RESULTS AND DISCUSSIONS

### 1. <u>INTERSEGMENTAL PHASINGS</u>

Speaker J.P. (with vowel length)

In studying the effects of rate on the relative acoustic timing for our different phonetic classes, we observe in the release cycle a clear vocalic phase percentage difference (around 17%) between VC,V:C and VCC,V:CC classes. This distinction between the two categories, although highly significant (t=13.76) is not at all surprising since one is to expect a difference in ratio between a vowel followed by a single consonant and a vowel followed by a geminate one. What is interesting is that the vocalic phases for VC and VCC classes stay <u>relatively constant</u> in the release cycle, across quantity and rate conditions. The separation remains efficient in such a way that, for example, VCC classes in fast rate conditions are never confused with VC classes in normal rate conditions. We noted also that classes differed clearly along the cycle dimension. The outcome is two structural patterns for the two linguistic entities.

Speaker R.L.

Although this speaker has a different vowel system from speaker J.P., the overall consonantal phasing structure is the same. Figure 1 is a good illustration of the intersegmental strategy adopted also by the previous speaker. The relative stability across conditions evoked above is also evident here, with a phase percentage difference of around 20% (t=15.42). This mean phase percentage difference coupled with the obvious mean cycle difference (around 97 ms ; t=13.86) provides a maintenance of two well defined phasing patterns for different phonological tasks. Similar manoeuvres have been systematically reported by /13/ for 8 French vowels (/a/, /a:/, /E/, /E:/, /ɔ/, /O:/, /u/, /u:/) in an identical experimental paradigm for Savoie regional French.

Speaker C.F.

Examining this speaker's results, we noticed some sort of a linear transition between VC and VCC phases. Even though mean values are rather different between the two phonetic classes (around 10% ; t=6.50), the transition from VCC in fast speech to VC in normal speech is assumed without any striking phase rupture. This transition is due, to a great extent, to the phase change, within the VC class, from fast to normal speech. Phonetic classes are less distinct along the cycle dimension. It is interesting to note that this pattern is extended, for this speaker, to the other vowels, with the phase transition phenomenon being even more continuous in the case of the vowel /u/. This behaviour, deviating from those adopted by the other speakers, allows us to observe the notion of relative permanence in a difference between motor programs (which are very likely not based solely on phase relations). For a discussion on this phenomenon of phase transition, giving a revival to old experiences in motor phonetics /14/ in the new scope of synergetics, see /15/.

### 2. <u>INTRASEGMENTAL PHASINGS</u>

#### 2.1. VOT PHASINGS IN THE RELEASE CYCLE

The part that VOT plays in the release cycle seems to be quite different from both the vocalic and the VTT phase (see below). Like for the former, it is not surprising that quite similar dispersions between the two classes in absolute values give different percentages in such different cycles as VC and VCC. Note (e.g. for speaker R.L., Figure 2) that mean percentage differences are statistically significant (t=6.45). A more detailed examination of the two classes shows that : at first, the VOT phase diminishes abruptly as the release cycle increases and then the regression slope suddenly becomes relatively stable (around 240 ms) with further release cycle increase. So it seems that programming for longer cycles tends best to stability.

#### 2.2. VTT PHASINGS IN THE RELEASE CYCLE

The overall tendency is to reduce the VTT proportionnaly as the release cycle increases. Figure 3 plots, the duration of this release cycle against the VTT phase for the productions of the same Speaker R.L.. Correlation coefficients are significantly negative for both simple and geminate consonants (r=-.83 and -.61 respectively ; r=0.51, p=0.10), the falling regression slope being significantly steeper for simple than for geminate consonants. Between the two segmental classes the mean phase difference is small (just significant, t=2.90). On a whole, we can posit from these results that, as far as the VTT phase and the release cycle are concerned, the parameterization for this intrasegmental phasing is similar for both phonetic classes, thus implying a generalized motor program.

#### 2.3. VTT PHASINGS AND CLOSURE

Having in mind that /16/ recently reaffirmed the fact that the glottal opening phase remained relatively constant in relationship with consonantal closure/constriction across rate conditions, we examined the ratio of VTT to closure variations across normal and fast speaking rates. Our results are as follows : the VTT phase is negatively correlated with closure duration. An increase in closure duration for the geminate class, however, has less proportionnal reducing effects on the VTT phase, the regression slope for the single consonant class being generally more pronounced than for the geminate one. Figure 4 is an illustration of this strategy. It seems, in other words, that there is more tendency towards VTT phase constancy as closure duration increases. These results are similar to those obtained by /17/ in an interspeaker related study. Note that the VTT phase tends to increase rapidly as closure is reduced, and notwithstanding the fact that we are still far from complete voicing (with a maximum of 40% VTT for about 65 ms closure), the drift promises to be swift towards flaps for which prevoicing no longer participates in categorizing the feature.

## CONCLUSION

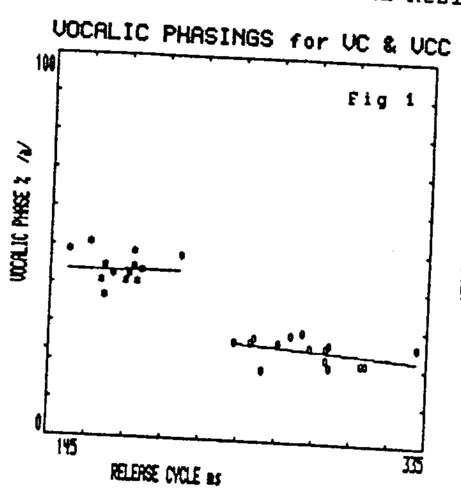
The very first question we raised in the beginning of this paper was in fact a reformulation of the invariance issue. Giving up research on relative timing invariance for a single phase in a cycle /18/, which appears to be quite problematic /19/, we looked at differences in multiphase patternings like those found for gait analysis /4/. Such data show clearly that re-patterning is a result of different types of behaviour within each phase. Some are constant (like E2 in the Philippson Cycle) ; some are slowly and smoothly changing (like E1) ; finally, a few give true discontinuities (like F). Likewise in speech, we found out that the only phase with such a decisive contribution to differences in patterning, related to close linguistic tasks, was the so called vocalic one. Contributions of VOT is of the E1 type, like for the silent phase (nearest to E3). This is true for our acoustic measurements. But it should be pointed out here that data in intrasegmental timing, considering the few available movement studies, will lead to similar results. Concerning VTT in particular, it is worth noting that /16/'s data could be situated in such research paradigms. Relative invariance of the peak glottal opening occurence in the closure/constriction time span is of course different from the acoustic VTT output, whose percentage varies inversely with closure increase (Figure 4). Movement results, when replaced in the total release cycle will give more differences than those found for our acoustic VTT : values around 50 to 60% for the peak glottal opening phase in closure will lead to quite different values in VC and VCC cycles (say 25% vs 40%). It seems therefore that this articulatory phasing is more discontinuous than for VTT, thus giving a more substantial contribution to differences in patterning. This remains to be quantified so as to evaluate the participation of intrasegmental phasings in speech cycles. The main question to ask now is : how can the dependency of laryngeal timing in its coordination with supralaryngeal gestures as a single programming be more evidently revealed ?

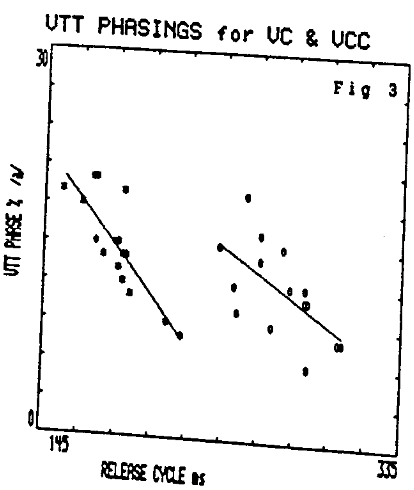
ACKNOWLEDGEMENTS : Special thanks to Christian ABRY, who followed this work closely, for his comments.

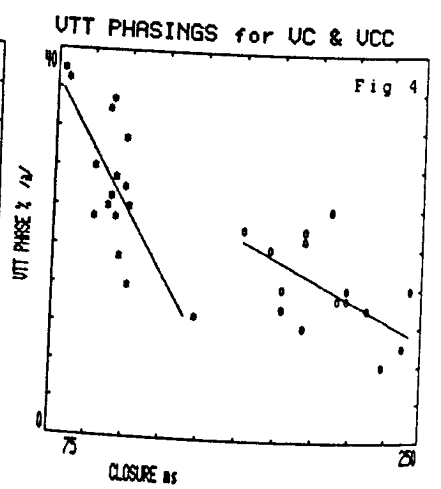
## REFERENCES

/1/ TULLER B. KELSO J.A.S. & HARRIS K.S. (1982) Interarticulator Phasing as an Index of Temporal Regularity in Speech. J. Exp. Psychol. HPP 8, 460-472.
/2/ LOFQVIST A. & YOSHIOKA H. (1981) Interarticulator Programming in Obstruent Production. Phonetica 38, 21-34.
/3/ PHILIPPSON M. (1905) L'Autonomie et la Centralisation dans le Système des Animaux.Trav. Inst. Solvay 7, 1-208.
/4/ SHAPIRO D.C. ZERNICKE R.F. GREGOR R.J. & DIESTEL J.D. (1981) Evidence for Generalized Motor Programs using Gait Pattern Analysis. J. Motor Behav. 13, 33-47.
/5/ KLATT D.H. (1975) Voice Onset Time, Frication and Aspiration in Word-Initial Consonant Clusters. J. Speech Hearing Res.18, 686-706.
/6/ AGNELLO J.G. (1975) Measurement and Analysis of Visible Speech. in : Measurement Procedures in Speech, Hearing and Language. S.SINGH ed. 379-397.

/7/ BERG van den R.J.H. (1986) The Effect of Varying Voice and Noise Parameters on the Perception of Voicing in Dutch Two-Obstruent Sequences. Speech Com. 5, 355-367.
/8/ WAJSKOP M. (1979) Segmental Durations of French Intervocalic Plosives. in : Frontiers of Speech Communication Research, LINDBLOM & OHMAN eds. 109-123.
/9/ FOWLER C. RUBIN P. REMEZ R.E. & M.T. TURVEY (1980) Implications for Speech Production of a General Theory of Action. in : Language Production 1, B. BUTTERWORTH ed., 373-420.
/10/ ABRY C. SOCK R. BOE L.J. OLILLA L. DOUBLIER D. DELATTRE C. & ZILLIOX C.(1986) L'Organisation Temporelle des Voyelles et des Consonnes du Français. Durée Phonologique et Vitesse d'Elocution. Rapport CNET LANNION.
/11/ BENOIT C. (1984) EDISIG : Encore un Editeur de Signal ?! 13èmes JEP du GCP du GALF, 211-213.
/12/ ABRY C. BENOIT C. BOE L.J. & SOCK R. (1985) Un Choix d'Evénements pour l'Organisation Temporelle du Signal de Parole. 14èmes JEP du GCP du GALF, 133-137.
/13/ DOUBLIER D. (1986) La Résistivité de l'Organisation Temporelle des Oppositions de Quantité dans le Français de la Chapelle d'Abondance (Hte-Savoie) face aux Variations de la Vitesse d'Elocution. TER de Sci. du Lang. Grenoble III, 87p. (dir. C. ABRY).
/14/ STETSON R.H. (1951)Motor Phonetics : a Study of Speech Movements in Action. Amsterdam:North Holland.
/15/ KELSO J.A.S. SALTZMAN E.L. & TULLER B. (1986)The Dynamical Perspective on Speech Production : Data and Theory. J. of Phonetics 14, 29-59.
/16/ LOFQVIST A. & YOSHIOKA H. (1984) Intrasegmental Timing:Laryngeal-Oral Coordination in Voiceless Consonant Production. Speech Com. 3, 279-289.
/17/ SOCK R. & BENOIT C. (1986) VOTs et VTT en Français.15èmes JEP du GCP du GALF, 307-310.
/18/ TULLER B. & KELSO J.A.S. (1984) The Timing of Articulatory Gestures: Evidence for Relational Invariants. J. Acoust. Soc. Am. 76, 1030-1036.
/19/ BENOIT C. & ABRY C. (1986) Vowel-Consonant Timing across Speakers. 12th Int. Congr. Acoust. A6-1.



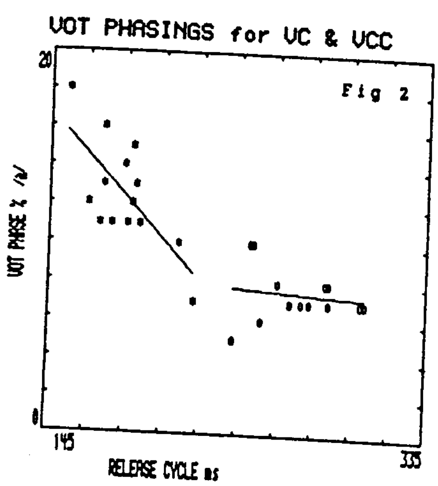




Fig. 1-3 Vocalic, VOT and VTT phasings in VC (*) and VCC (0) release cycles for "nous l'empattons ?" vs "nous l'empatt't-on ?" spoken at two rates, normal and fast (French Speaker R.L. without vocalic length contrast).

Fig. 4 : For the same utterances the VTT phase in the closure hold.