CONSONANT CLUSTERS: A COMPARISON BETWEEN WORD INTERNAL AND WORD JUNCTURE

Christine Meunier

Institut de Phonétique, Aix-en-Provence, France

ABSTRACT

We analyze the acoustic organisation of French consonant clusters (with two consonants) in three contexts: word internal position, word juncture provided with major boundary and word juncture provided with minor boundary. We use a specific classification of consonant clusters. Durations and acoustical transitions between both consonants are analysed in this paper.

1-INTRODUCTION

Some studies describe the acoustic and/or articulatory structure of the consonant structure[4] [5].The aim of our study is to evaluate the acoustic differences which can appear between a French word internal consonant cluster (two consonants) and the same cluster linking two words. We suppose that the acoustic features, we observed in word consonant clusters, may support modifications if we change the boundary between the two consonants.

2.CONSONANTS AND CONSONANT CLUSTERS

We classified the French consonants in order to draw up a consonant cluster (GC) classification.

2.1.Consonant classes [1]

-Stops: /p/ /t/ /k/ /b/ /d/ /g/

-Fricatives: /f/ /s/ /ʃ/ /v/ /z/ /ʒ/

-Vocalic consonants: glides /j/ /y/ /w/, liquids /l/ /ʁ/ and nasals /m/ /n/ /ɲ/.

2.2.Consonant clusters classification [2] [3]

We divided the GC into two groups:

Homogeneous consonant clusters (both consonants belong to the same consonant class), and *heterogeneous consonant clusters* (both consonants belong to different consonant classes). In these two groups, three types of GC can be deduced from the consonant classification:

Homogeneous GC:

- Ho1 ---> stops + stops
- Ho2 ---> fricatives + fricatives
- Ho3 --->voc.cons.+ voc. cons.

Heterogeneous GC:

- He1 ---> stops + fricatives
- He2 ---> fricatives + vocalic cons.
- He3 ---> stops + vocalic cons.

3-SPEECH MATERIAL

We selected two corpuses. In the first, the Word Corpus (CM, "Corpus Mots" in French), the GC are word internal; word initial for the heterogeneous groups (plat) and medial for the homogeneous ones (obtus). We took into account only the GC from French lexical words. All the words are included in the same sentence: "Ce n'est pas xxxx qu'il faut dire". In the second corpus, the Juncture Corpus (CJ, "Corpus Joncture" in French), we considered two levels of junctures: the first in a major boundary and the other in a minor boundary. In fact, the sentences of CJ follow the very simple syntactic structure: SN+SV. The first type of juncture (CJa) is between SN and SV (the major syntactic boundary), the second (CJb) is inside SV (between V and N, the minor boundary). We expected to obtain different acoustic effects with regard to the type of juncture which separate the first and the second consonant (C1 and C2). As a consequence, for each GC we analysed a triple comparison:

example:

CC: "ce n'est pas près qu'il faut dire"

CJa: "l'équipe ralentit son allure"

CJb: "ce retard handicape Robespierre"

We recorded two speakers (male) who read the three corpuses twice. The total number of recorded words is 336 (112 for each corpus).

4-ACOUSTICAL ANALYSIS

4.1.Duration

We observed the variations in duration between CM, CJa and CJb (means and coefficient of variation) for the consonant clusters (duration of C1, C2 and GC) and for each consonant class. In the same way we compared the correlations of the durations of CC/CJa, CC/CJb, CJa/CJb, for each class of GC and for all together.

4.2.Transition phase [2] [3]

An important point in the study of the consonant clusters is to observe the transition phase between C1 and C2. Two possibilities are considered:

The Direct Passage (PD): the GC is composed by C1 acoustical characteristics + C2 acoustical characteristics without any other segment.

The Transitory Segment (ST): a segment different from the acoustic characteristics of C1 or C2, appears toward the boundary; it can be either a transformation or an insertion. In order to evaluate the distribution of the Transitory Segments, we have to draw up the acoustical characteristics of each consonant class:

-*Stops* : silence (or voicing with regard to the phonological description) and burst.

-*Fricatives* : noise with a stable specific frequency (voiced or unvoiced).

-*Vocalic cons* : voiced formantic structure.

Any possible variations of these simple descriptions (with regard to the phonotypical transcription) will tell us if the transition phase is PD or ST realised.

5-HYPOTHESES

When we defined the Juncture Corpus we drew up hypotheses about the acoustical variations brought by the boundary degree between C1 and C2:

- the data of CJb would be closer to the data of CC (as long as we consider that the word boundaries disappear in continuous speech in French).
- the CJa clusters would be longer than the CJb ones (as long as the major boundary acoustic effect could be a duration increase of C1, C2 or both)
- the disappearance of ST in the CJa clusters (as long as the ST presence is a cue for strong coarticulation), and apparition of pauses between C1 and C2 (evidence of a major boundary).
- the increase of partial and total assimilation numbers in the CJb clusters, and decrease in CJa ones (comparing them to CC clusters).

The results of the acoustical analysis will confirm or not our hypothesis.

6-RESULTS

6.1.Mean duration :

Table 1: Mean duration (M) and coefficient of variation (C) of all the consonant clusters for the three corpuses:

		CM		CJA		CJB	
		M	C	M	C	M	C
ALL GC	C1	105	33	82	34	78	35
	C2	95	34	76	31	67	35
	GC	198	23	159	26	145	30

In the three contexts, C1 is always longer than C2, but the difference seems to decrease in the CJa context. The general means of CJa are slightly longer than those of CJb. We can explain the long durations of CC remaining that the CC clusters always belong to accented syllables.

Table 2: Mean duration (M) and coefficient of variation (C) of consonant classes in C1 position (C1), C2 position (C2) and in general (STOP, FRI, VOC) for the three corpuses:

		CM		CJA		CJB	
		M	C	M	C	M	C
STOP	C1	104	32	77	28	77	38
	C2	90	33	60	28	56	23
	STOP	101	32	73	30	73	38
FRI	C1	107	36	96	32	83	29
	C2	88	27	95	25	86	32
	FRI	101	35	96	30	84	30
VOC	C1	106	32	68	39	69	39
	C2	97	35	75	29	65	32
	VOC	99	34	74	31	66	31

We do not notice changes in the three corpuses for stops: stops are always longer in C1 than in C2 position. For fricatives, we see a difference between CC and CJ (a and b): CC fricatives are longer in first than in second position; in CJ (a and b) they tend to have the same duration whatever their position. Vocalic consonants are longer in first than in second position in CC; we notice the same

for CJb (but with a slighter difference), and the opposite for CJa. We must notice the strong stability of CC (whatever the consonant class), and the similarity between CJa and CJb with the exception of vocalic consonants. Consonants seem to be longer in CJa than in CJb.

6.2.Correlations :

Table 3: Correlation matrix of C1, C2 and consonant clusters for the three corpuses in general (number: 92)

		CM			CJA		
	↓	C1	C2	∝	C1	C2	∝
CJA	C1	0.31					
	C2		-0.18				
	∝			0.152			
CJB	C1	0.35			0.317		
	C2		0.255			0.322	
	∝			0.433			0.275

Significant correlations for 0,01 and 0,02 probability : CM/CJb, CJa/CJb, CM/CJa (only for C1).
Not significant: :CM/CJa (for C2,GC).

Table 4: idem table3: Ho1 (number: 16)

		CM			CJA		
	↓	C1	C2	∝	C1	C2	∝
CJA	C1	-0.152					
	C2		0.073				
	∝			0.385			
CJB	C1	0.182			-0.052		
	C2		0.476			0.212	
	∝			0.617			0.252

Significant correlations for 0,01 and 0,02 probability : CM/CJb (GC only).
Not significant: : CM/CJa, CM/CJb (for C1), CJa/CJb.

Table 5: idem table3: Ho3 (number: 20)

		CM			CJA		
	↓	C1	C2	∝	C1	C2	∝
CJA	C1	-0.028					
	C2		-0.133				
	∝			-0.203			
CJB	C1	0.091			0.201		
	C2		0.337			0.341	
	∝			0.25			0.228

Significant correlations for 0,01 and 0,02 probability : none.
Not significant: : all.

Table 6: idem table3: He2 (number: 28)

		CM			CJA		
	↓	C1	C2	∝	C1	C2	∝
CJA	C1	0.425					
	C2		-0.173				
	∝			0.103			
CJB	C1	0.666			0.617		
	C2		0.247			-0.014	
	∝			0.748			0.284

Significant correlations for 0,01 and 0,02 probability : CM/CJa (for C1), CM/CJb (for C1 and GC), CJa/CJb (for C1).
Not significant : CM/CJa (for C2, GC), CM/CJb (for C2, GC), CJa/CJb (for C2).

Table 7:idem table3: He3 (number: 32)

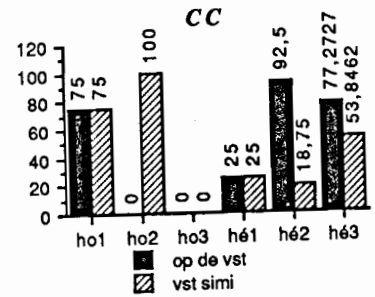
		CM			CJA		
	↓	C1	C2	∝	C1	C2	∝
CJA	C1	0.558					
	C2		0.143				
	∝			0.387			
CJB	C1	0.522			0.159		
	C2		0.288			0.339	
	∝			0.627			0.292

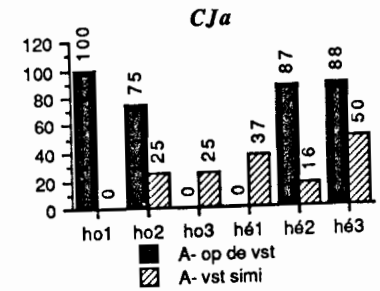
Significant correlations for 0,01 and 0,02 probability : CM/CJa (for C1), CM/CJb (for C1 and GC).
Not significant : CM/CJa (for C2), CM/CJb (for C2), CJa/CJb (for C1and GC).

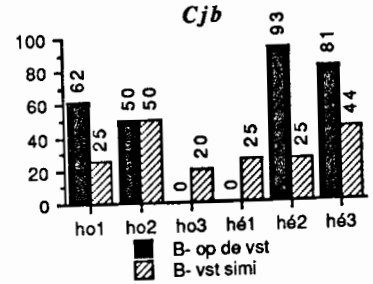
We do not give tables for Ho2 nor He1 because we have not enough values for the results to be relevant. In table 3, all the correlations are significant with the exception of CM/CJa (for C2 and GC); our hypotheses are partially confirmed: there is a better relation between CM/CJb than between CM/CJa. We observe very bad correlations in Ho1 and Ho3 (tables 4 and 5). For He1 and He2 (tables 6 and 7), the correlations are quite similar, with particulary good results for CM/CJb (C1 and C2) and CM/CJa (C1). C2 seems to support variability when we change the context, instead of C1 which is the stable consonant of the cluster in all contexts. But C2, in He2 and He3 is the vocalic consonant and this phoneme seems to be instable in all cases (see table 5).

6.3.Transition Phases

Table 8: Distribution of the Transitory Segments in the six consonant cluster classes for the three corpuses; voicing opposition (opp de vst) and similar voicing (vst simi) inside clusters are separated in each class:







Here our hypotheses are not confirmed: we do not notice a decrease of ST in the CJa realisation, nor an increase in CJb ones. In fact, the tables show stability in the distribution of ST whatever the context. These data confirm the correation results: strong stability for He2, He3; variation for Ho1, Ho3 (Ho2 and He1 values are not sufficient to be significant).

We observe a great proportion of ST when the two consonants are differently voiced: here the voiced consonant is in general partly (or, more rarely, completly) devoiced. When the consonants are not in voicing opposition, some ST are also present: it can be an insertion of a vocalic element (particulary in Ho1), or the "consonantification" of the vocalic consonant (/j/ following stops or fricatives). We did not note any pause in CJa context.

7.CONCLUSION

Some of our hypotheses seem to be partially confirmed by the results of the acoustical analysis: CJa clusters tend to be longer than CJb ones; the acoustic organisation of CJb clusters tends to look like CM one, instead of CJa. In fact, acoustic organisation seems to be more stable when clusters are inside a word; but we must specify that the sentence in CC was always the same, it could also stabilise the GC production. Stability also characterises stops and fricatives instead of vocalic consonants which are acoustically more heterogeneous.

REFERENCES

[1] AUTESSERRE, D., ROSSI, M. (1985), "Proposition pour une segmentation et un étiquetage hiérarchisé. Application à la base de données acoustique du GRECO Communication Parlée", *Actes des 14èmes Journées d'Etudes sur la Parole*, Paris, 147-152.
[2] MEUNIER, C. (1990), "Groupes consonantiques: premier inventaire des réalisations acoustiques des phases de transition", *Actes des 16èmes Journées d'Etudes sur la Parole*, Montréal, 69-73.
[3] MEUNIER, C. (1990), "L'analyse acoustique des groupes consonantiques: deux exemples de groupes hétérogènes" *Proceedings of the LP'90 Conference*, Prague, (in press).
[4] NISHINUMA, Y., et al. (1989), "Duration of Consonant Clusters in French: Automatic Detection Rules" *Proceedings of the European Conference on Speech Communication and Technology*, Paris, 260-264.
[5] ROCHETTE, C. (1973), *Les groupes de consonnes du français*, Québec: Klincksieck.