Acoustic cues of palatalisation in plosive + lateral onset clusters

Daniela Müller*, Sidney Martin Mota²
*Universitat de Tolosa & Universität Heidelberg, ²Escola Oficial d'Idiomes de Tarragona
*daniela.muller@univ-tlse2.fr, *smart47@xtec.cat

1. Background

• palatalisation of /l/ in complex onset clusters (obstruent + lateral) in the absence of a following palatal segment that could have triggered the change

• attested in a variety of Romance dialects, Thai dialects [1] and elsewhere

Examples:
Italian "piazza", "bianco", "fiore", "chiave", "ghiaccio"
< Vulgar Latin "platea", (germ.) "*blank", "flore", "clave", "glacie", respectively.

• Palatalisation of /l/ in /kl, gl/ is far more widespread than in /pl, bl, fl/.

• Dialects with dark /l/ realisations such as Eastern and Balearic Catalan and Val d'Anniviers Francoprovençal [2] are not affected by the phenomenon.

• On the other hand, labial + yod clusters develop an epenthetic /l/ in the history of Slavic [10] and sporadically in Romance dialects [11].

Traditional explanations:
articulatory explanation: palatalisation as place assimilation in /kl, gl/ clusters;

subsequently spread of palatalisation onto /bl, pl, fl/ through analogical change (e.g. [3]).

Sound change through misperception:
Erroneous (and non-corrected) perception of the speech signal leads to sound change ([4]).

→ /kl, gl/ should be acoustically more similar to /kj, gj/ than /pl, bl/ are to /pj, bj/.

2. Hypotheses

(a) the place of articulation of the preceding consonant has a significant influence on the palatalisation process, as predicted by the dialectological data;

(b) the degree of darkness/clearness of /l/ has an influence on this palatalisation process, more specifically dark laterals hinder palatalisation more than clear laterals do

3. Method

a) Subjects

• 2 male speakers of Lengadocian Occitan (clear /l/ dialect)

• 1 male speaker of Eastern Catalan and 1 male speaker of Western Catalan (dark /l/ dialects)

One-way ANOVA ($F(1,58) = 9,425$, $p < 0.01$) for F2-F1 distances (see below) showed that the intervocalic laterals in our Occitan tokens (mean = 8.16; SD = 1.87) were significantly clearer than the ones in our Catalan tokens (mean = 6.82; SD = 1.51).

b) Experiment design

Speakers read non-words (fig. 1) presented in random order. Each token occurred 8 times. The 5 best realisations were selected for further analysis.

Catalan		Occitan	
/Cl/	/Cj/	/Cl/	/Cj/
blata	biata	blata	biata
bluta	biuta	blota	biota
plata	piata	plata	piata
pluta	piuta	plota	piota
clata	quiata	clata	quiata
cluta	quiuta	clota	quiota
glata	guiata	glata	guiata
gluta	guiuta	glota	guiota

Fig. 1: tokens used in the experiment (in Catalan and Occitan orthography)

c) Analysis

a) The first **20 msec** starting from the onset of the /l/ and /j/ were selected.
b) Hz values were obtained for F1, F2, F3 and F4 at **0 msec**, **10 msec** and **20 msec** after onset of /l/ and /j/.
c) Hz values were converted to **Bark values** using the equation proposed by [5], assuming a similar transformation in the ear of the listener.
d) **F2 and F1 difference** (F2-F1) for **each of the three timesteps** was calculated in order to determine the degree of velarity/darkness-palatality/clearness of the lateral.
e) Data were analysed using **ANOVAs** ($p < 0.01$) with **F2-F1** as the **dependent variable** and **target consonant** (lateral vs. yod), **preceding consonant** (/k, g, p, b/) and **following vowel** (/a, u/) as **independent variables**.
f) Posthoc comparisons (**t-tests**, $p < 0.01$) were performed for the pairs /Cl/ vs /Cj/ .

4. Results

a) Summary of ANOVA table (4 subjects)

	Oc-XB			Oc-SC			Cat-MB			Cat-JM		
Factors/Timesteps	1	2	3	1	2	3	1	2	3	1	2	3
Target consonant	*	*	*	*	*	*	*	*	*	*	*	*
Preceding consonant	*	*	*	*	X	*	X	*	*	X	X	X
Following vowel	X	*	*	X	X	X	X	X	X	X	X	X

Fig. 2: Summary of the main effects in the four subjects at the three timesteps; significant effects (*), non-significant effects (X); $p < 0.01$. Significant interactions were obtained.

b) t-tests ($p < 0.01$)

pairs of clusters	Time steps	Oc - XB	Oc – SC	Cat-MB	Cat-JM
bla - bja	1	< 0.001	< 0.001	< 0.001	< 0.001
	2	< 0.001	< 0.001	< 0.001	< 0.001
	3	< 0.001	< 0.001	< 0.001	< 0.001
blu - bju	1	< 0.001	< 0.001	< 0.001	< 0.001
	2	< 0.001	< 0.001	< 0.001	< 0.001
	3	< 0.001	< 0.001	< 0.001	< 0.001
pla - pja	1	< 0.001	< 0.001	> 0.01	< 0.001
	2	< 0.001	< 0.001	< 0.001	< 0.001
	3	< 0.001	< 0.001	< 0.001	< 0.001
plu - pju	1	< 0.001	< 0.001	< 0.001	< 0.001
	2	< 0.001	< 0.001	< 0.01	< 0.001
	3	< 0.001	< 0.001	< 0.001	< 0.001
gla - gja	1	> 0.01	> 0.01	< 0.001	< 0.001
	2	< 0.01	< 0.01	< 0.001	< 0.001
	3	< 0.01	< 0.001	< 0.001	< 0.001
glu - gju	1	< 0.001	> 0.01	< 0.001	< 0.001
	2	< 0.001	< 0.001	< 0.001	< 0.001
	3	< 0.001	< 0.001	< 0.001	< 0.001
kla - kja	1	< 0.001	< 0.01	< 0.001	< 0.001
	2	> 0.01	< 0.001	< 0.001	< 0.001
	3	> 0.01	> 0.01	< 0.001	< 0.001
klu - kju	1	< 0.001	< 0.001	< 0.01	< 0.001
	2	< 0.001	< 0.01	< 0.001	< 0.001
	3	> 0.01	> 0.01	< 0.001	< 0.001

Fig. 3: results from pairwise comparisons (t-tests). Results falling short of the significance threshold ($p < 0.01$) are shaded in yellow. Results reaching a highly significant threshold ($p < 0.001$) are in white, results between $p < 0.01$ and $p < 0.001$ are shaded in peach.

5. Discussion

Hypothesis (a): *Velar plosives favour palatalisation of /l/ in onset clusters more than labial plosives do.*
As shown by the results in Fig. 3 and as suggested by dialectological evidence, velar + lateral and velar + yod clusters may resemble each other during the first few milliseconds of the sound for the Occitan subjects with clear /l/, with the consequence that listeners may easily confuse them.

This acoustic effect may have one of two causes:
(1)The velar stop is known to have a forward-directed looping articulation (e.g. [7]). Its tongue dorsum gesture is relatively unconstrained which allows coarticulation and possibly fronting when the tongue tip raises to the alveolar ridge for the lateral. However, no evidence for such a fronted articulation of the cluster has been found to date in the literature.
(2) A lateral fricative may develop during the transition from the velar stop to the lateral when the stop is laterally released. Such coarticulation has been observed in British English [8] and Greek [9]. Such an 'intrusive fricative' may bear resemblance to a palatal fricative.

Hypothesis (b): *Dark /l/ is less prone to palatalisation than clear /l/.*
This hypothesis is also accepted. It corroborates the assumption that the resistance for dark /l/ to undergo palatalisation (becoming clearer) is due to its being highly constrained in its tongue body configuration (DAC model: [6]). This coincides with the ANOVA results which show no significant influence of the vowel on F2-F1 distance for the Catalan speakers.
While lateral release may also be present in onset clusters with dark /l/, tongue body retraction and predorsum lowering may prevent a palatalised perception.

6. Conclusions

While acoustic evidence for the sound change of /l/ palatalisation in the complex onset could be provided, future research is needed to assess the two hypotheses about palatalisation of clear /l/ in the velar + lateral clusters from both an articulatory/aerodynamic and perceptual perspective.

7. References

[1] Li, F.-K., "Consonant clusters in Tai", Language 30 (3): 368-379, 1954.
[2] Haeberli, L., „Die Entwicklung der lateinischen Gruppen kl, gl, pl, bl, fl, im Franko-Provenzalischen", Zeitschrift für französische Sprache und Literatur 33: 1-43, 1908.
[3] Repetti, L. and Tuttle, E. F., "The evolution of Latin pl, bl, fl and cl, gl in Western Romance", Studi Mediolatini e Volgari 33: 53-115, 1987.
[4] Ohala, J. J., "The phonetics of sound change", in C. Jones [Ed], Historical Linguistics: Problems and Perspectives, 237-278, Longman, 1993.
[5] Traunmüller, H., "Analytical expressions for the tonotopic sensory scale", Journal of the Acoustical Society of America 88: 97-100, 1990.
[6] Recasens, D. and Espinosa, A., "Articulatory, positional and coarticulatory characteristics for clear /l/ and dark /l/: evidence from two Catalan dialects", Journal of the International Phonetic Association 35 (1): 1-25, 2005.
[7] Perrier, P., Payan, Y., Zandipour, M. and Perkell, J., "Influences of tongue biomechanics on speech movements during the production of velar stop consonants: A modelling study", Journal of the Acoustical Society of America 114 (3): 1582-1599, 2003.
[8] Hardcastle, W. J., "Some phonetic and syntactic constraints on lingual coarticulation during /kl/ sequences", Speech Communication 4: 247-263, 1985.
[9] Nicolaidis, K., "An electropalatographic study of Greek spontaneous speech", Journal of the International Phonetic Association 31 (1): 67-85, 2001.
[10] Carlton, T. R., *Introduction to the phonological history of the Slavic languages*. Columbus, OH: Slavica Publishers, 1991.
[11] Rohlfs, G., „Ein Problem der vergleichenden Lautgeschichte", Zeitschrift für romanische Philologie 42: 69-71, 1922.

Acknowledgments: This poster was made possible by a PhD scholarship of the State of Baden-Württemberg, Germany and a travel grant by the Exzellenzinitiative of Heidelberg University.