

Acoustic Characteristics of Velar Stops and Velar Softening in German, Polish and Catalan

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1. RESEARCH GOALS

a) To compare the two hypotheses on Velar Softening (VS), i.e., the sound change process by which /k/ > [tʃ] or [ts] before /j, i, e, ε/, but also before other vowels and word finally (e.g. Slavic, Romance and Bantu languages):

i) Articulatory hypothesis (ArthH): VS is triggered by particular anterior, (alveolo)palatal realizations of the velar stop in several contextual and positional conditions (Rousselot 1924).

ii) Acoustic equivalence hypothesis (AcouH): VS for a front velar stop, i.e., a velar stop before a front vowel or glide, is associated with the presence of a 2500-3500 Hz spectral peak for the stop burst and the /tʃ/ frication noise (Chang, Plauché & Ohala 2001).

b) To propose that VS of unaspirated stops is motivated articulatorily (ArthH), while VS of aspirated stops may be rooted in acoustic equivalence (AcouH).

2. PREVIOUS STUDIES

a) Recasens & Espinosa (submitted) → results support ArthH

The burst of the Majorcan Catalan unaspirated (alveolo)palatal stop allophone [c] of underlying /k/ could be perceived as [tʃ], more often when the stop precedes /a/ than when it precedes /i/ and fairly often word finally.

b) Guion (1998) → results support AcouH

Analogous stimuli with English aspirated front velar stops may be heard to some extent as [tʃ] only when mixed with high intensity white noise. A potential problem with the stimuli is the presence of their low signal-to-noise ratio.

A reason why front /k/ is better perceived as an affricate in English than in Majorcan Catalan may be because aspirated stops exhibit longer and more intense bursts than unaspirated stops.

3. PRESENT STUDY

3.1. MAIN HYPOTHESES

The acoustic factors causing front /k/ to be confused with front affricates were investigated in languages and dialects lacking [c] and exhibiting different degrees of stop burst aspiration:

- (i) German, where stops are strongly aspirated,
- (ii) Polish, where stops are slightly aspirated,
- (iii) Eastern Catalan, where stops are unaspirated.

It was predicted that the acoustic similarity between /k/ and [tʃ] should vary with the degree of stop burst aspiration in the progression aspirated > moderately unaspirated > unaspirated, and with the burst acoustic prominence in the progression /kj/ > /ki/ > /ke/ > /ka, kɔ, ku/ (cf. also Hall, Hamann & Zygis 2006).

3.2. DATA SAMPLE

The speech sample was composed of German, Polish, and Catalan bisyllabic words containing stressed, word-initial /kj, ki, ke, ka, kɔ, ku, tsa, tʃa/. The Polish CV sequence /tʃa/ was also included. The following frame sentences were used:

- (i) German: *Ich habe __ gesagt* 'I have __ said',
- (ii) Polish: *Powiedziała __ do niego* 'She said __ to him',
- (iii) Catalan: *Ell deia __ fort* 'He was saying __ loud'.

2 German, 2 Polish and 2 Catalan speakers recorded a set of sentences at 44 kHz (the acoustic signal was downsampled to 20 kHz for analysis).

3.3. ACOUSTIC ANALYSIS

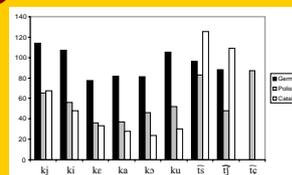
(i) Front-cavity dependent spectral peak frequency for the stop burst and the affricate frication noise.

(ii) VOT for the stop (burst spike + frication + aspiration if available) and frication period for the affricate (burst spike + frication).

(iii) Absolute intensity for the stop burst and the affricate frication period, and relative intensity with respect to the intensity level of the adjacent vowel for the stop burst.

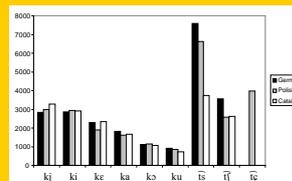
(iv) F2 and F3 vowel transition endpoints and ranges.

3.4. RESULTS



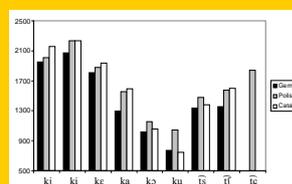
- /j, i/ > non-high vowels
- German > Polish > Catalan

Figure 1: VOT (ms)



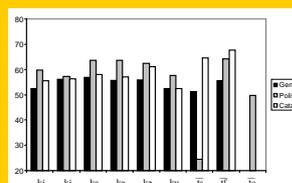
/j, i/ > /e/ > /a/ > /ɔ/ > /u/

Figure 2: Burst spectral peak (Hz)



/j, i/ > /e/ > /a/ > /ɔ/, u/

Figure 3: F2 transition endpoint (Hz)



/ε, a, ɔ/ > /j, i, u/

Figure 4: Absolute intensity (dB)

F2 transition range

/j/ > (/ε, a) > /i, ɔ, u/

4. CONCLUSIONS AND DISCUSSION

a) Findings for aspirated /k/ are in agreement with AcouH though perceptual testing is needed. VOT values render front velar stop bursts more prone to be integrated as affricates if aspirated than if moderately aspirated or unaspirated. Moreover, burst duration and spectral peak frequency, as well as the vowel transition endpoints and ranges, indicate that the replacement of /k/ by [tʃ] ought to take place mostly before /j/, more so before /i/ than before /ε/, and least often before low and back vowels as well as word finally.

b) Findings for unaspirated /k/ are in agreement with ArthH. Front velar unaspirated stops cannot be identified with affricates, which leads us to hypothesize that VS can only be triggered by (alveolo)palatal stop realizations. This finding is in accordance with data reported elsewhere showing that burst intensity and formant frequency ranges favour VS for unaspirated [c] before low vowels, and that much airflow passing through a narrow dorsopalatal constriction appears to be needed for VS for this consonant realization to apply before front vowels and glides (Recasens & Espinosa, submitted).

References

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