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Why final stop phonemes became unreleased stops? The cases of Vietnamese and Korean

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Production of stop consonants corresponds most of the time to a complete oral airflow obstruction followed by a rapid and sudden release of the closure that generates a short and audible noise (burst), due to rise in aero-acoustic pressure behind this closure (Stevens, 1993). However, in many Asian languages, allophones of these phonemes present very often no audible release burst in coda position, as in Vietnamese, Thai, Cantonese, Malaysian, Hokkien or Korean (Edmondson et al., 2010), and are termed unreleased stops in that case (Ladefoged & Maddieson, 1996). Furthermore, final consonants are frequently subject to articulatory and acoustic weakening or lenition (Kingston, 2008). Sometimes, lenition processes result in phonological neutralizations leading to a restriction of consonant inventories in syllable final position. This is the case in some of East or Southeast Asian languages independently of language families, such as in Korean or Vietnamese. In the latter, respectively, lenis /t/ vs fortis /t*/ vs aspirated /tʰ/ (Cho et al., 2002) or voiceless /t/ vs voiced /d/ (Kirby, 2011) could occur in syllable onset position whereas in syllable final position, these phonological distinctions are neutralized into one voiceless and unreleased coronal allophone [t̚]. Although this tendency is phonologically well identified, the explanation of the production process is not clear since the non-release implies a motor control of the closure stability and raises the question of the degree of complexity of this type of allophonic realization in non-fortis position. The purpose of the study presented here is to bring new insights on this issue.

Earlier investigations have aimed at characterizing the glottal activity of unreleased stops in East and Southeast Asian languages. Amongst these is the study of Iwata et al. (1990) which showed that in Cantonese and Thai an adductive movement of the ventricular bands occurred just after the oral closure of the stops and triggered glottalization as a reinforcement gesture. More recently, using a transnasal laryngoscope, Edmondson et al. (2011) investigated the production of final stops in Taiwanese and Hakka (a Chinese dialect). They found that the reinforcement gesture is the result of an adduction of the vocal folds and the ventricular bands (which are laryngeal structures located above and close to the glottis, cf. Bailly et al. 2014), and, in some cases, by an engagement of the aryepiglottic sphincter. They thus confirmed earlier results obtained for Cantonese, Taiwanese (Fukienese) and Thai (Edmondson et al., 2010). Unlike these languages, Vietnamese and Korean seem to not present such reinforcement of the glottis gesture accompanying the production of syllable final stops. In this way, Michaud (2004) showed that /p, t, k/ are not glottalized in Vietnamese and that there is no closure of the vocal folds at all in the production of these consonants. However, Edmondson et al. (2010) revealed that a lot of variability at the glottic level exists among different dialects of Vietnamese. Furthermore, Ladefoged & Maddieson (1996) pointed out that non-release of final stops is associated with a lowering of the velum causing a nasal leakage, especially in Vietnamese. On the other hand, Iwata et al. (1990) found that a very low degree of glottis opening accompanied the final stops in Korean.

We propose to examine the aerodynamic and glottographic characteristics of the syllable-final allophones of /p, t, k/ in two Asian languages, tonal (Vietnamese) and non-tonal (Korean). We address two hypotheses concerning the production of unreleased stops acoustically coupled with the absence of any burst: (1) as proposed by Ladefoged & Maddison (1996), a nasal leakage follows the mouth closure and (2) a lowering of the larynx accompanies the airflow obstruction in the mouth; both scenarios leading to a reduction of the pressure of the airflow behind the closure. To test the first hypothesis, we examined the presence of nasal airflow (NA) during the oral closure according to Ohala (1975) who provided evidence that maintaining a raised velum (i.e. no nasal airflow) during oral closure allows the oral pressure to reach a sufficient level for generating an audible noise (Ohala, 1975). To test the second hypothesis, we measured the larynx vertical position (LVP) and glottal contact area by means of electroglottography (EGG). It has been shown that LVP influences acoustic properties of speech signal as well as physiological characteristics of its production (Guzman et al., 2013). LVP is systematically

in a lower position during the production of unvoiced consonants whereas voiced consonants and vowels are produced with a high LVP (Shipp et al., 1987).

In our study, aerodynamic (oral and nasal airflows) and acoustic data were obtained using the EVA2 workstation (Computer Vocal Assessment, SQLab S_{ty}) for which a technical description is available in Teston (1993) and Ghio & Teston (2002). An auxiliary input-output of EVA2 were then connected to record the LVP and the signal of the vocal fold oscillations using the electroglottograph EG2-PCX2 (Glottal Enterprises Inc.). These synchronized multi-parametric data were recorded using Phonedit software.

For each language, a set of CV₁C₂ monosyllabic words and CV₁C₂.C₃V(C) disyllabic words in which C₂ corresponds to /p/, /t/, /k/, were selected considering both the tone for Vietnamese words and the segmental context (i.e. V₁ and C₃) of the target consonant for the two languages. The corpora consist of 12 monosyllabic words plus 24 disyllabic compound words for Vietnamese and 17 monosyllabic words plus 17 disyllabic words for Korean. Each was then inserted in a corresponding Vietnamese or Korean carrier sentence: respectively [dʒ] la tu _ dʒ] “*Here is the word _*” and [ja.ki.sa _ sak.fɛ.he] “*delete (the word) _ here*”. Each sentence was repeated three times in a random order. Twenty speakers per language (10 men, 10 women) were recruited for the experiment. The Vietnamese corpus was recorded in soundproof rooms at MICA, Polytechnic Institute of Hanoi (Vietnam), and the Korean corpus at SNU, Seoul National University (South Korea). We present here preliminary results obtained from eight speakers (4 Vietnamese and 4 Korean).

In both languages and for all speakers (1) no significant nasal leakage during the stop closure (Delvaux, 2000) that would provide a reduction of the oral pressure in the mouth was found and (2) a lowering of the larynx was systematically observed during the closure phase, even more when the stop was a syllable final consonant and consequently an unreleased stop. Both results was consistent for any place feature. As our first result indicates that a nasal leakage is not used as a compensatory mechanism to reduce the intra-oral pressure when an unreleased final stops is produced, it is inconsistent with the proposition of Ladefoged & Maddieson (1996). Furthermore, we found no EGG signal during the lowering movement of the larynx. This result suggests that the glottis remains open during the stop closure and that Vietnamese and Korean unreleased stops are not glottalized. This finding is consistent with those of previous works (among others Iwata et al., 1990; Edmondson et al., 2010, 2011; Michaud, 2004). Finally, the lowering movement of the larynx is in line with our second hypothesis that unreleased stops are realized with a glottal mechanism that reduces the oral pressure behind the closure and causes the absence of burst. This explanation leads us to suggest that the non-released allophones of the plosives are indeed part of a non-fortis process since the decrease in intraoral pressure generated by the lowering of the larynx, and consequently the increase in the volume of the oral cavity, allows for a decrease in the muscular stiffness of articulators involved in the formation of the occlusion.

Beyond the characterization of these stop consonants, our project is part of a broader scientific context of the second language phonological acquisition by Asian learners. The results obtained will provide solid answers to well-identified problems of the acquisition of final consonants and consonant clusters in French Foreign Language.

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