The identification of the place of articulation in coda stops as a function of the preceding vowel: a cross-linguistic study

Man-ni Chu^{1,2}, Carlos Gussenhoven² and Roeland van Hout²

¹Department of Linguistics, National Tsing-Hua University, Taiwan

²Department of Linguistics, Radboud Nijmegen University, the Netherlands

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Abstract

Three groups of listeners, one with a /p,t,k/ stop system in the syllable coda (Dutch), one with /p,k,ʔ/ (ChaoShan) and one with /p,t,k,ʔ/ (ZhangQuan) were asked to identify the final C in CVC-stimuli as one of the consonants [p,t,k,ʔ]. Identification was affected by the nature of the coda C and the V. The identification of the bilabial stop significantly increases after /i/, that of the velar stop after /-a/ and that of the alveolar stop after /u/.

Keywords: place of articulation, coda, Dutch, ChaoShan, ZhangQuan

Introduction

A number of studies (Delattre et al. 1955 and many) indicated that second formant transitions are crucial for coda consonant identification. In this study, we extend the research to three groups of subjects with different language backgrounds, ChaoShan with an unreleased [p,k,ʔ] coda system, Dutch with a released [p,t,k] system and ZhangQuan with an unreleased [p,t,k,ʔ] system.

Materials and Method

We used CVC stimuli, in which the onset C was varied over six consonants (p, t, k, p^h, t^h, k^h), the V over three vowels (i u a), and the unreleased coda C over four (p t k ʔ), which were spoken by a male speaker of Tainan. We manipulated the f₀ so that each stimulus occurred in a low-toned version (123Hz) and a high-toned version (164Hz). The level of noise (0db, -10db, and -20db) were varied in the two Chinese languages, while Dutch had only the first two noise levels. Because of lexical gaps in Tainan, we ended up with 48 original sound files, instead of 6*3*4=72. There were therefore 48 * 2 (tones) * 3 (noise levels) = 288 stimuli for the Chinese languages and 192 for Dutch, which were presented auditorily in a different random order to each subject. 54 (ChaoShan), 16 (Dutch) and 37 (ZhangQuan) participants were asked to identify the coda as one of [p,t,k,ʔ] by pressing one of the four.

Results

The cross-tabulations and the contingency coefficients indicated that the nature of the vowel and of the coda significantly affected subjects' identifications. Neither tone nor noise level had any effect on the responses. We applied two series of analyses, one with the overall coda response as the dependent variable, the other one on the correct responses per target coda. The repeated measures ANOVAs were done for the language groups separately, with vowel category as the independent variable. The vowel effect was tested by using the Huynh-Feldt adapted F values. The results of the post-hoc comparisons reported were adjusted by applying the Bonferroni procedure.

The overall coda response analyses showed that the coda /k/ was favored after /a/ in all three language groups ($F(1.73, 91.61)=66.05$; $F(1.54, 23.04)=56.61$; $F(1.89, 67.16)=34.17$; all $p<.05$), where the results are for the Chaoshan, Dutch and ZhangQuan listeners, respectively. The coda /p/ was favored when occurring after /i/ ($F(1.91, 101.39)=93.18$; $F(1.44, 21.65)=47.85$; $F(1.9, 68.0)=47.13$; all $p<.05$). The post-comparisons showed that the ZhangQuan listeners had a significant preference of /i/ and /a/ over /u/, but the difference between /i/ and /a/ was not significant ($p=.09$). Coda /t/ was favored after /u/ ($F(1.27, 67.31)=117.9$; $F(1.71, 25.62)=41.32$; $F(1.32, 47.58)=9.93$; all $p<.05$). The post-comparisons showed that the ZhangQuan listeners had a significant preference of /u/ and /i/ over /a/ but the difference between /u/ and /i/ was not significant ($p=1.0$). In addition, the /?/ was significantly least favored after /a/ in the Dutch group ($F(1.86, 27.9)=16.96$, $p<.05$), but it was favored by ZhangQuan listeners after /u/ ($F(1.54, 55.37)=17.59$; $p<.05$). The ChaoShan natives did not show any preference ($F(1.7, 89.9)=1.41$, $p>.05$). The conclusion for the /?/ is that there is no cross-linguistic pattern of preference. Figure 1 presents the mean responses for the four coda consonants as a function of preceding vowel for each language group.

The percentage correct analyses showed that the coda /t/ was favored when occurring after /u/ ($F(1.36, 72.04)=114.33$; $F(2, 30)=34.4$; $F(1.56, 55.92)=5.36$; all $p<.05$). The post-comparisons showed that the ZhangQuan listeners had a significant preference of /i/ and /u/ over /a/, but the difference between /i/ and /u/ was not significant ($p=1.0$). The coda /p/ was favored when occurring after /i/ by the ChaoShan and Dutch groups ($F(1, 53)=71.59$; $F(1, 15)=7.79$; all $p<.05$), while ZhangQuan listeners did not show any preference ($F(1, 36)=2.8$, $p>.05$). In addition, the /?/ after /a/ was significantly favored by the ChaoShan listeners ($F(1.95, 103.45)=11.96$) but it was not favored by Dutch listeners ($F(1.51, 22.66)=6.95$). The /?/ was favored after /u/ by the ZhangQuan listeners ($F(1.95, 70.14)=6.43$). The post-comparisons showed that they had a significant preference of /u/ over /i/, but

/a/ was not significantly different from /u/ or /i/ ($p=.25$ and $p=.14$). Figure 2 presents the mean percentage correct responses for the three codas for each language group. Overall, /p/ was mostly favored after /i/, /k/ was favored after /a/, /t/ was favored after /u/, and there is no clear pattern for /t/. The stimuli ended in /k/ only occurred in the /ak/ condition, due to lexical gaps in Tainan.

Figure 1: Identification of coda [p,k,t] as a function of the preceding vowel for ChaoShan, Dutch and ZhangQuan listeners.

Figure 2: Percentage correct identification of coda [p,t] as a function of preceding vowel for ChaoShan, Dutch and ZhangQuan listeners.

Discussion

Our results confirm those by Liberman et al. (1952) that coda stop identification varies with the spectral properties of the preceding vowel: /-p/ is preferred after /i/ and /-k/ after /-a/. The relatively high F2 of the high front vowel [i] causes a falling transition, which resembles the locus effect of

[-p], while the relatively low F2 of [a] causes a rising transition which resembles the locus effect of [-k]. In addition, the locus effect of [t] causes a rising transition when accompanied with the lowest F2 of the back vowel [u] (Delattre et al. 1955), which is a prominent feature compared to other consonants neighboring /u/. Formant transition and release bursts are two important cues for stop identification (Hall et al. 1956 and others). Since the identification of unreleased stops necessitates subjects to rely on formant transitions only, significant biases in the perception of final stops will be caused by vowel qualities that bring out those transitions. On the other hand, there is no consistent effect of the vowel in glottal stop identification, because there are no locus transitions.

Since the three language groups responded in very similar ways, we conclude that the biasing effects are language-independent. The absence of /t/ in ChaoShan, the absence of phonemic /ʔ/ in Dutch and the presence of the full four-way contrast in ZhangQuan had no interpretable effect on the perception of these consonants by the three groups of listeners.

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