

INVESTIGATING THE RELATION BETWEEN PLACE OF ARTICULATION MARKEDNESS AND PERCEPTUAL SALIENCE*

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1. Introduction

It has long been observed that segments having different places of articulation tend to exhibit different phonological behaviour (Paradis & Prunet 1991, Rice 1996, among others). These differences are manifested most clearly in place assimilation processes, where less marked segments often assume the place of articulation of the following more marked segments. For example, in Korean, coronals in consonant clusters assimilate to following dorsals and labials (1a); labials assimilate to following dorsals, but not to coronals (1b), and dorsals assimilate neither to labials nor to coronals (1c).

(1) Korean place assimilation (after Jun 1995:51–52; de Lacy 2002:350–351)

	<i>Input</i>	<i>Output</i>	<i>Gloss</i>
a.	/mit + ko/ /kot + palo/ /tʃinan + pam/	[mikko] [koppalo] [tʃinampam]	‘believe and’ ‘straight’ ‘last night’
b.	/ip + ko/ /nam + kik/ /ip + ta/ /sum + ta/	[ikko] [naŋkik] [ipta] *[itta] [sumta] *[sunta]	‘wear and’ ‘the South Pole’ ‘wear + SE’ ‘hide + SE’
c.	/ik + ta/ /tʃak + p ^h a/ /paŋ + pota/ /paŋ + to/	[ikta] *[itta] [tʃakp ^h a] *[tʃapp ^h a] [paŋpota] *[pampota] [paŋto] *[panto]	‘ripe + SE’ ‘destruction’ ‘(more) than room’ ‘room (as well)’

In Optimality Theory (Prince & Smolensky 1993), the relative markedness of places of articulation (POA) (2a) has been encoded as a universal POA hierarchy of faithfulness constraints to features (2b) (Jun 1995).¹ In this

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¹ The relative markedness of dorsals and the universality of the POA markedness hierarchy are issues of the current theoretical debate (see Rice 1996, 1999, Hume 2003).

hierarchy, a higher ranking of the constraint IDENT[DORSAL] captures the lesser susceptibility of dorsals to assimilation compared to labials and coronals; a lower ranking of the constraint IDENT[CORONAL] captures the greater susceptibility of coronals to assimilation compared to labials and dorsals. (See de Lacy 2002 on capturing the asymmetry using scale-referring faithfulness constraints).

- (2) a. coronal > labial > dorsal
- b. IDENT[DORSAL] » IDENT[LABIAL] » IDENT[CORONAL]

It has been proposed that the POA markedness scale and the corresponding faithfulness hierarchy are grounded in language-independent phonetic properties of POA (Jun 1995, 2004; Hamilton 1996, Hayes & Steriade 2004). Specifically, the coronals' higher susceptibility to place assimilation compared to labials and dorsals was argued to follow from poorer acoustic cues to syllable-final (unreleased) coronals (3a): relatively weak VC transitions resulting from the rapid tongue tip movement (Byrd 1992, Jun 1995). The dorsals' lesser susceptibility to place assimilation compared to labials was argued to follow from better acoustic cues to syllable-final (unreleased) dorsals: a clear convergence of F2 and F3 formants prior to the closure (Jun 1995, cf. Stevens 1989) (3b).

- (3) a. IDENT[DORSAL], IDENT[LABIAL] » IDENT[CORONAL]
 unreleased dorsal, unreleased labial > unreleased coronal
 more cues *fewer cues*
- b. IDENT[DORSAL] » IDENT[LABIAL]
 unreleased dorsal > unreleased labial
 more cues *fewer cues*

The relation between POA markedness and acoustic/perceptual salience has since been assumed by some phonologists (e.g. Steriade 2001, Hayes & Steriade 2004). Yet little cross-linguistic perceptual work has been done to directly verify the claimed POA salience relations and their language-independent status (cf. Hume et al. 1999, Wright 2001, Kingston & Shinya 2003, Winters 2003).

The goal of the current study is to explore the relation between POA markedness and salience by conducting a thoroughly controlled cross-linguistic experiment involving the perception of syllable-final stops /p t k/. The focus of the experiment will be the perception of Russian syllable-final stops by listeners of three languages: Russian, English, and Korean.

2. Method

2.1 Languages

The choice of Russian as the language of the stimuli for the experiment was motivated by the need to control for the lack of place assimilation in production. Russian is known to exhibit neither categorical, nor gradient major place assimilation (Jones & Ward 1969) (4a). Articulatory and acoustic investigations of Russian have established that place gestures of stops in clusters are not gradually reduced in amplitude and show relatively little gestural overlap (Kochetov & Goldstein 2001), as, for example, compared to English. The acoustic effect of this is the common audible release of syllable-final consonants in clusters (Zsiga 2000).

The advantage of employing Russian, English, and Korean listeners was to provide a control for differences in language-particular phonological knowledge of place assimilation. As mentioned above, Russian is a “non-assimilating” language. English is known to exhibit gradient coronal place assimilation (Browman & Goldstein 1990, among others) (4b). Korean is a language exhibiting (variable) coronal and labial place assimilation (Jun 1995, Son et al., to appear) (4c). Thus, a significant similarity between the three groups in perceptual performance can be attributed to factors independent from listeners’ language background. Differences between the three groups may be explained by listeners’ language-particular phonological (or phonetic) knowledge.

- | | | | | |
|-----|----|---|--|---|
| (4) | a. | Russian: no assimilation | | |
| | | ka[tk]a ‘tub’, o[t k]oški ‘from a cat’ | | no assimilation |
| | | ša[pk]a ‘hat’, lo[p k]oški ‘cat’s forehead’ | | no assimilation |
| | b. | English | | |
| | | si[tk]om, i[t k]omes | | gradient assimilation
(tongue tip reduction) |
| | | whi[pk]ream, to[p k]op | | no assimilation |
| | c. | Korean (see (1)) | | |
| | | /mit-ko/ [mikko] ‘believe and’ | | assimilation |
| | | /sip-ko/ [sikko] ‘go’, CON. | | assimilation |

2.2 Stimuli

The stimuli used in the experiment (5) were Russian syllable-final /p t k/ in nonsense utterances of the type taC1#C2ap. In each utterance, the target stop (C1 = coda) was followed by a hetero-organic stop (C2 = onset). The vowel context (/a/) and stress (both words stressed) were held constant. The stimuli, produced by two female speakers of Standard Russian, were taken from a production EMMA study (Kochetov & Goldstein 2001). An articulatory analysis

of the data showed that syllable-final stops in the data were fully produced and often audibly released.

- (5) Target stop is labial: ta[p] tap, ta[p] kap
 Target stop is coronal: ta[t] pap, ta[t] kap
 Target stop is dorsal: ta[k] pap, ta[k] tap

Two stimulus sets were created. The first set contained *unedited* utterances with target stops released (the ‘released condition’). The second set contained *edited* utterances where target stop releases were removed from the signal (the ‘unreleased condition’). Including the second set of stimuli was necessary, since the originally proposed POA salience scale was based on the acoustics of unreleased stops (Jun 1995).

2.2 Participants

The participants were 42 undergraduate Simon Fraser University students, native speakers of Russian, English, and Korean (14 listeners per language). None of the participants reported hearing problems.

2.3 Task

The task was forced choice phoneme identification: The participants were instructed to listen to utterances and to identify the last consonant of the first syllable (e.g. ta[p] tap) by pressing buttons labeled “p”, “t”, and “k” on a response box. They were instructed to respond as quickly as possible and to guess when they were in doubt. All the stimuli were presented in a randomized order with a four-second inter-stimulus interval. Each token was presented three times.

2.4 Analysis

All responses were analyzed using a measure of percent correct averaged across all listeners of each language group. There were a total 4032 responses (6 utterances * 2 speakers * 2 tokens * 2 repetitions * 2 conditions * 42 listeners).

3. Predictions

Assuming that place perceptibility correlates with phonological place markedness, we would expect that listeners, regardless of their language background, would identify dorsals and labials better than coronals; among the first two places, they would identify dorsals better than labials (i.e., dorsal > labial > coronal). This is expected for both released and unreleased conditions. However, since releases provide additional place information (Malécot 1958), we would expect listeners to have better results in the released condition compared to the unreleased condition. While predicting no substantial differences across the language groups in relative place perceptibility, we may

expect that language-particular knowledge of assimilation exerts some effect on listeners' performance. Thus, for instance, Korean listeners, accustomed to place assimilation in their language, may be less sensitive to place differences in the stimuli, compared to Russian and English listeners. Further, since Korean syllable-final stops are usually unreleased (Jun 1995), releases may not be as perceptually beneficial to Korean listeners as to Russian and English listeners, who are more accustomed to released stops.

4. Results

The results are summarized in Table 1, where percent correct values for each language given by the condition (released and unreleased) and consonant.

Table 1. Mean percent correct values for the released and unreleased /p t k/ by Russian, English, and Korean listeners (based on 2016 responses per group)

Conditions	Target Stops	Language Groups		
		Russian	English	Korean
Released	p	86.6%	77.4%	68.0%
	t	77.7%	74.1%	59.0%
	k	98.2%	92.4%	85.7%
Unreleased	p	75.5%	67.9%	60.7%
	t	47.3%	50.9%	52.2%
	k	50.0%	46.0%	39.7%

Overall, unreleased stops were identified considerably poorer than released stops. However, as shown in Figure 1, the effect of presence or absence of release was the most dramatic for the dorsal /k/; it was rather weak for the labial /p/, and of intermediate magnitude for the coronal /t/.

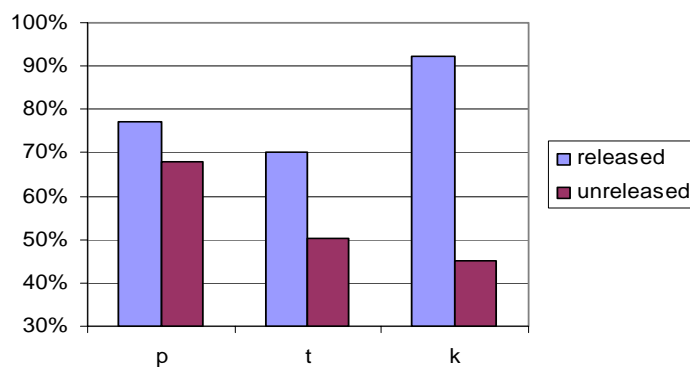


Figure 1. Mean percent correct values for released and unreleased /p/, /t/, and /k/, averaged across language groups

As seen in Figure 2, the effect of release was shown by all three language groups. However, it was somewhat stronger for Russian and English listeners compared to Korean listeners.

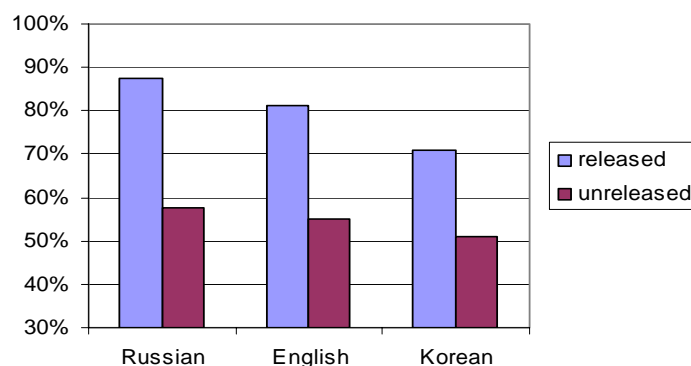


Figure 2. Mean percent correct values for released and unreleased stops (averaged by place) by language group

Data were submitted to two separated ANOVAs with Place (/p, t, k/) as the within subjects factor and the Language (Russian, English, and Korean) as the between subjects factor. The results are further discussed separately by condition, released and unreleased.

4.1 The released condition

The ANOVA results for the released condition showed that factors Place and Language group exerted significant effects on percent correct values [$F(2,78)=25.80$, $p<.001$, and $F(2,39)=0.784$, $p<.01$, respectively]. The interaction of the two factors was not significant.

As shown in Figure 3, the syllable-final dorsal /k/ was identified most reliably, followed by the labial /p/ and then by the coronal /t/. This pattern was quite consistent across the language groups. Among the language groups, Russian listeners showed overall the highest percent correct, and Korean listeners showed the lowest percent correct. The results for English listeners were intermediate.

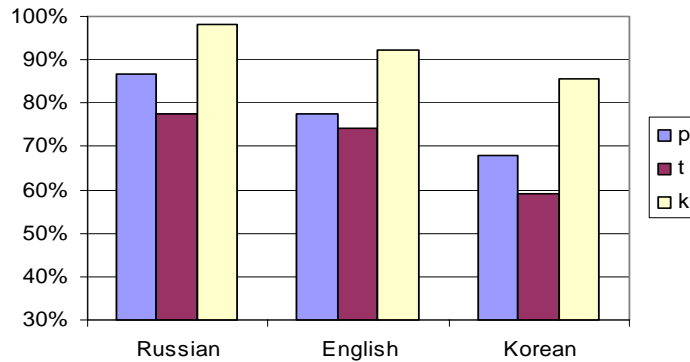


Figure 3. Mean percent correct values for *released* syllable-final /p/, /t/, and /k/ by language group

Post-hoc Tukey tests revealed that the place difference between /k/ and /t/ was significant for all language groups ($p < .05$), the difference between /k/ and /p/ was significant for Russian and Korean listeners ($p < .05$), and the difference between /p/ and /t/ was not significant for any of the groups. With respect to language groups, the difference between Russian and Korean listeners was significant ($p < .01$); the other differences were not significant, however, the difference between English and Korean listeners was close to the significance level ($p = .06$).

In sum, although not all of the place differences turned out to be statistically significant, the results can be interpreted as suggesting language-independent perceptibility scales, as shown in (6).

- (6) Perceptibility scales for released stops based on the results of the experiment
- a. dorsal > coronal
 - b. dorsal > labial
 - c. labial > coronal (limited evidence)

4.2 The unreleased condition

The ANOVA results for the unreleased condition showed that factor place exerted significant influence on percent correct values [$F(2,78) = 14.55, p < .001$]. The effect of the factor Language group was not significant, nor was the interaction of Place and Language.

As seen in Figure 4, the results are quite different from the released condition (Figure 3). When unreleased, the syllable-final labial /p/ was identified better than the dorsal /k/, and less consistently, identified better than the coronal /t/. The labial-dorsal asymmetry was consistent across the language groups. Language group differences were not consistent for all places, showing a pattern similar the released condition for the labial /p/ and dorsal /k/ (Russian > English

> Korean), but not for the coronal /t/. The identification of the dorsal /k/ was particularly low for Korean listeners, yet above the chance level (39.7% compared to the chance level 33.3%).

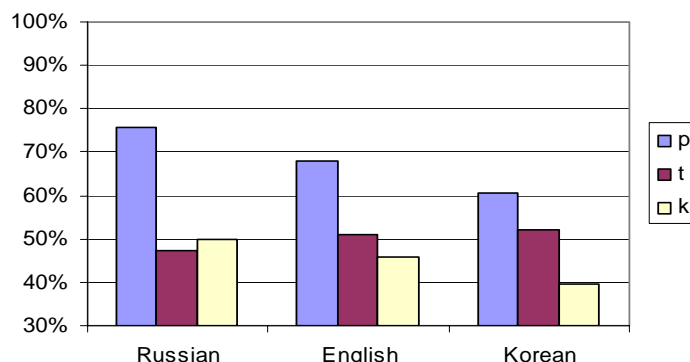


Figure 4. Mean percent correct values for *unreleased* syllable-final /p/, /t/, and /k/ by language group

Post-hoc Tukey tests revealed that the place difference between /p/ and /k/ was significant for all language groups ($p < .05$), the difference between /p/ and /t/ was significant for Russian listeners only ($p < .05$), and the difference between /k/ and /t/ was not significant for any of the groups. None of the differences between language groups were significant.

In sum, the results can be tentatively interpreted as providing evidence for the perceptibility scales for unreleased syllable-final stops, as shown in (7).

- (7) Perceptibility scales for unreleased stops based on the results of the experiment
- a. labial > dorsal
 - b. labial > coronal (limited evidence)
 - c. coronal > dorsal (limited evidence)

5. Discussion

The results of the study provide strong evidence for language-independent perceptual salience differences between places of articulation. However, these differences appear to be considerably affected by the presence or absence of stop releases. In general, syllable-final released dorsals are more salient than released labials and coronals; released labials are possibly more salient than released coronals (dorsal > labial > coronal). When stops are unreleased, syllable-final labials are more salient than dorsals and, possibly, coronals; coronals are possibly more salient than dorsals (labial > coronal > dorsal). Released stops, regardless of their place of articulation, are more salient than unreleased stops. The effect is greater for some places (dorsals) than other places (labials). Overall,

Russian listeners performed at the identification of Russian place contrasts better than Korean listeners; English listeners exhibited intermediate performance.

The results of the study are consistent with previous findings that releases provide important information about stop place of articulation (Malécot 1958) and that place salience may be different for released and unreleased stops (Winters 2003). Interestingly, the relative perceptual salience of place releases obtained in the current experiment (dorsal > coronal > labial) corresponds to the relative duration of stop releases: stops produced further back in the oral cavity tend to have longer and more acoustically robust releases (VOT; Cho & Ladefoged 1999). In the absence of such releases the ‘more back’ stops, such as dorsals, are much more perceptually vulnerable than the ‘more front’ stops, such as coronals and particularly labials.

The relatively high perceptual salience of the labial /p/ compared to the coronal /t/ (whether released or unreleased) is consistent with the perceptibility scale posited by Jun (1995) (unreleased labial > unreleased coronal; see (3)) as well as with previous perceptual studies (Byrd 1992, Kochetov 2004, among others). The labial vs. coronal asymmetry can be attributed to relatively slow movement of the lips resulting in more robust VC transitions, compared to the more rapid movement of the tongue resulting in weaker VC transitions (Byrd 1992). The low perceptual salience of the unreleased dorsal /k/ is inconsistent with Jun’s scale (unreleased dorsal > unreleased labial; see (3)). It should be mentioned that the presumed perceptual superiority of dorsals in this scale is deduced from acoustic observations (Stevens 1989) rather than from perceptual experiments. Some recent perceptual studies, however, provide evidence to the contrary (and consistent with the current results): unreleased dorsals tend to be less perceptually salient than other major places of articulation (Abramson & Tingsabadh 1999, Lisker 1999, Wright 2001, Winters 2003).

As expected, the results reflect some influence of listeners’ language-particular phonological and phonetic knowledge – patterns of assimilation and attunement to releases – on their perceptual performance. Thus, Korean listeners who have an active knowledge of place assimilation and a limited exposure to unreleased syllable-final stops in their native language, perform poorer than Russian and English listeners. The latter two groups presumably possess a limited knowledge of place assimilation (if any) and are more accustomed to released syllable-final stops (cf. Cho & McQueen 2004).

What do the results of the current experiment tell us about the relation between POA perceptual salience and phonological markedness? The results provide partial support for the relation between perceptual salience and phonological markedness. The lower perceptual salience of coronals, compared to labials (released or unreleased) and dorsals (released), corresponds to coronals’ relative unmarkedness (Paradis & Prunet 1991). The greater salience of released dorsals, compared to released labials and coronals, corresponds to dorsals’ relative markedness. Yet, the poorer salience of unreleased dorsals is at odds with their presumed marked status. The results contribute to previous findings that place perceptibility has a number of dimensions, or context-specific scales (cf. Hume et al. 1999). The POA salience may vary as a function

of syllable and word position, stop releases, vowel contexts, stress, etc.² Do all perceptual scales exert equal influence on the POA markedness? The current results suggest that whatever relation exists between specific perceptibility scales and the POA markedness, this relation is likely to be rather opaque and indirect, possibly mediated by other factors, both synchronic and diachronic (cf. Hume & Johnson 2001; Blevins 2004).

5. Conclusion

This paper addressed the question of the relation between place of articulation (POA) markedness and perceptual salience. Scales of POA perceptual salience were experimentally deduced based on the perception of Russian syllable-final stops by Russian, English, and Korean listeners. The results revealed some language-independent perceptual asymmetries in the identification of POA, strongly affected by presence or absence of stop releases. The obtained perceptibility scales partially correlated with POA markedness scales. This result was interpreted as evidence for an indirect relation between perceptibility and phonological markedness.

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² One limitation of the current study is that the vowel context in the stimuli was the low central vowel /a/. It is known, however, that VC (and CV) transitions to consonants show some variation depending on the quality of the preceding vowel and thus vowel contexts may influence place perceptibility (cf. Hume et al. 1999). Further research is needed to investigate the relative contribution of different vowel contexts on POA perceptibility.

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