

Cross-language Perception of Word-final Stops by Native Vietnamese Listeners: Preliminary Results on the Role of Specific, Non-native Phonetic Experience

Kimiko Tsukada¹ Thu T. A. Nguyen² Rungpat Roengpitya³

¹Department of East Asian
Languages and Literatures
University of Oregon
USA
ktsukada@uoregon.edu

²School of English, Media
Studies and Art History
University of Queensland
Australia
thunguyen@uq.edu.au

³ College of Religious Studies
Mahidol University
Thailand
rungpat@gmail.com

Abstract

This study examined the discrimination of word-final stop contrasts (/p/-/t/, /p/-/k/, /t/-/k/) in English and Thai by 12 listeners who speak Vietnamese as their first language (L1). Vietnamese shares specific phonetic realization of stops with Thai, i.e., unreleased final stop and differs from English which allows both released and unreleased final stops. These 12 native Vietnamese (NV) listeners' discrimination accuracy was compared to that of the two listener groups (Australian English (AE), native Thai (NT)) tested in previous studies. The NV group was less accurate than the native group in discriminating both English and Thai stop contrasts. In particular, for the Thai /t/-/k/ contrast, they were significantly less accurate than the AE listeners. The present findings suggest that experience with specific (i.e., unreleased) and native phonetic realization of sounds may be essential in accurate discrimination of final stop contrasts. The effect of L1 dialect on cross-language speech perception is discussed.

1. Introduction

There is the accepted wisdom that speech perception in adulthood is strongly shaped by individuals' linguistic experience. For instance, it is very well known that Japanese second language (L2) learners have considerable difficulty in producing and perceiving English /l/ and /r/ (see Aoyama, Flege, Guion, Akahane-Yamada, & Yamada, 2004 for a review).

However, not all foreign speech sound contrasts are equally resistant to change (e.g., voicing vs. place contrast in the Hindi language, Tees & Werker, 1984) or difficult to perceive and/or produce. Some non-native and exotic click contrasts in Zulu have been shown to be highly discriminable to native listeners of American English who were never exposed to click sounds even allophonically in their L1 speech (Best, McRoberts, & Sithole, 1988).

On the other hand, it has been shown that L1 phonology may overestimate listeners' responses to non-native sound categories (Hallé, Best, & Levitt, 1999). For instance, four English approximants /w j r l/ occur in French with varying degrees of similarity to the target sounds. If equivalence at the traditional phonological level predicts cross-linguistic perception patterns, French listeners would not be expected to have difficulties with these English sounds, since the equivalents of those sounds do occur in their L1 French. However, it was found that the French listeners had some perceptual difficulties with the English /r/. This finding was attributed to marked articulatory-phonetic differences between the English and French /r/ (i.e., phonetically realized

as a central approximant in English and a uvular fricative in French).

Theories of cross- and second language speech perception such as the Perceptual Assimilation Model (PAM) (Best, 1995) and Speech Learning Model (SLM) (Flege, 1995, 2003) posit that the perceived relationship between the sound system of L1 and that of the target language plays a crucial role in how those segments will be discriminated (Aoyama *et al.*, 2004).

With respect to the effect of previous linguistic experience, Werker (1986) investigated whether perceptual flexibility requires specific linguistic experience or whether broadened, but non-relevant linguistic experience is sufficient to enhance perceptual flexibility. Her findings indicated that broadened, non-specific linguistic experience or simply being able to speak more than one language did not give bilinguals/multilinguals an advantage over monolinguals in discriminating unfamiliar non-native contrasts.

In another study, Tees and Werker (1984) examined discrimination of Hindi contrasts by three groups of English-speaking listeners differing in the experience with Hindi (5 years or longer, 1 year study with or without early experience). Those listeners who had extensive experience (5 years or longer) or had exposure to Hindi in the first 1 or 2 years of their lives were able to discriminate both voicing and place contrasts in Hindi. The results from these two studies highlight the importance of early and specific linguistic experience for the maintenance of perceptual sensitivity.

The present study builds on previous studies (Tsukada, 2006; Tsukada & Ishihara, under review, Tsukada & Roengpitya, under review) and explores further the question

of the effect of linguistic experience on the discrimination of non-native place distinctions. The hypothesis tested in this study was that familiarity with specific but non-native phonetic realization (i.e., unreleased final stops) would generalize to non-native speech perception and enhance listeners' discrimination accuracy with stop contrasts in an unknown language.

In order to test the above hypothesis, 12 adult Vietnamese-speaking listeners were recruited in the present study. Vietnamese shares specific phonetic realization with Thai, i.e., unreleased final stop (Ingram & Pittam, 1987). Of the two main dialectal groups of Vietnamese, it is known that the speakers of the southern dialect have difficulty in producing and perceiving the distinction between the final /t/ and /k/. Thus, we were also interested in how this L1 dialectal difference might influence Vietnamese listeners' cross-language speech perception. Place substitution errors in final stops have been reported for English (Levitt, Stromberg, Smith, & Gold, 1980) and Cantonese (Law, Fung & Bauer, 2001).

2. Method

In this experiment, cross-language perception by adult native Vietnamese listeners was evaluated in comparison with the two groups of listeners examined in previous studies. The experimental stimuli and procedures were identical to those in earlier studies.

2.1. Stimuli

The AE and NT speakers read monosyllabic (CVC) words ending in /p t k/ in their L1s in the MARCS Auditory Laboratories recording studio at the University of Western Sydney, Australia. Test words (all real words in English or Thai) were presented to each speaker in randomized orders. Thai words were transcribed using Thai scripts and had either high or low tones. The recorded speech materials were digitized at 44.1 kHz using CoolEdit and amplitude of each sound file was normalized to 50% of the peak following the procedures used in previous research (e.g., Aoyama *et al.*, 2004; Flege & MacKay, 2004; Guion, Flege, Akahane-Yamada and Pruitt, 2000).

In order to minimize the speaker gender affecting listeners' responses, male and female voices were not presented together within a given trial, but instead, tokens from three female speakers were used for English stimuli and tokens from three male speakers were used for Thai stimuli. More than 90% (107 out of 117 unique waveforms) of the English final stops were produced with an audible release burst although speakers were not given specific instructions as to how the final stops should be pronounced¹.

¹The presence or absence of release burst was determined using a combination of auditory and acoustic information (i.e., inspection of wide-band spectrograms and time domain waveforms).

2.2. Listeners

2.2.1. This study

Twelve adult native Vietnamese (NV) listeners (3 male, 9 female) participated in this study. All were born outside Australia and had lived in Brisbane for a varying number of years (range: 4.5 months - 3.5 years) at the time of testing. The participants responded to a local advertisement and received payment for their participation.

None of the NV listeners had any knowledge of Thai. They all reported normal hearing and had no history of language problems in their L1 Vietnamese. Half of them were speakers of the Northern dialect and the other half were speakers of the Southern dialect. All participants were tested individually in the language lab in the School of English, Media Studies, Art History at the University of Queensland. Each session lasted about 45 minutes.

2.2.2. Previous studies

In previous research, 18 Australian English (AE) speakers and 18 native Thai (NT) speakers participated. All of them lived in Sydney at the time of testing and reported normal hearing and had no history of language problems in their L1 English and Thai. Their results were reported elsewhere (e.g., Tsukada, 2006).

2.3. Task

A categorial discrimination test (CDT) employed in previous L2 speech research (e.g., Flege, MacKay, & Meador, 1999, Guion, *et al.*, 2000, Flege, 2003, Flege & MacKay, 2004) was used. The stimuli (monosyllabic CVC words) were presented in triads via headphones at a self-selected comfortable level using a notebook computer. Each contrast was tested by change and no-change trials. The three stop tokens in all change and no-change trials were spoken by different talkers, and so were always physically, if not phonetically, different. Listeners were asked to choose an odd item out, if there was any.

The change trials contained an odd item out. For example, a change trial testing the /p/-/t/ contrast might consist of 'sip₂'-'sit₁'-'sip₃' (where the subscripts indicate different talkers). The correct response for change trials was the button ("1", "2", or "3") indicating the position of the odd item out, which occurred with near-equal frequency in all three possible serial positions. The change trials tested the participants' ability to respond appropriately to relevant phonetic differences between tokens and distinguish stops drawn from two different categories.

The correct response to no-change trials, which contained three different instances of a single category (e.g., /p₁ /p₃ /p₂ or /t₃ /t₁ /t₂), was a fourth button marked "NO". The no-change trials tested the participants' ability to ignore audible but phonetically irrelevant within-category variation (e.g., in voice quality). The participants were required to respond to each trial, and were told to guess if uncertain. A trial could be replayed as many times as they wished, but responses could not be changed once given. The inter-stimulus interval in all trials was 0.5 s. Two blocks of 58 trials were presented. A different randomization was used for each block. The first ten trials were for practice and were not analyzed. The 48 trials in each block consisted of 36 change trials testing three

contrasts (12 trials each for /p/-/t/, /p/-/k/, /t/-/k/) and 12 no-change trials (4 trials each for /p/-/p/, /t/-/t/, /k/-/k/). The English and Thai stimuli were presented in separate blocks and the listeners heard stop contrasts in English first and then Thai. This was to ensure that they understood the task.

Responses to the change and no-change trials were used to calculate A' scores (Snodgrass, Levy-Berger & Haydon, 1985), an index of discrimination accuracy. These scores were based on the proportion of 'hits (H)' obtained for each contrast and the proportion of 'false alarms (FA)'. If H equaled the proportion of FA, then A' was set to 0.5. If H exceeded FA, then $A' = 0.5 + ((H - FA) * (1 + H - FA)) / ((4 * H) * (1 - FA))$. However, if FA exceeded H, then $A' = 0.5 - ((FA - H) * (1 + FA - H)) / ((4 * FA) * (1 - H))$. A score of 1.0 indicated perfect sensitivity, whereas a score of 0.5 or lower indicated a lack of phonetic sensitivity.

3. Results

Figure 1 shows mean discrimination scores for English and Thai stimuli by the twelve NV listeners as a function of contrast types.

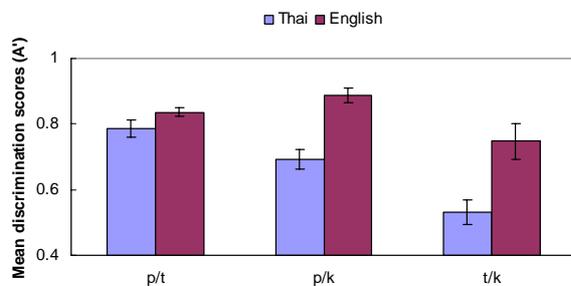


Figure 1: Mean discrimination scores for Thai and English stimuli by 12 NV listeners. The brackets enclose \pm one standard error.

A two-way ANOVA (analysis of variance) with Stimuli (English, Thai) and Contrast (/p/-/t/, /p/-/k/, /t/-/k/) as within-subjects factors was conducted. The dependent variable was the discrimination (A') scores obtained by each listener.

The main effects of Stimuli and Contrast reached significance [S: $F(1, 11) = 23.7, p < 0.001$, C: $F(2, 22) = 19.6, p < 0.001$] and so did the two-way interaction [$F(2, 22) = 4.8, p < 0.05$]. As shown in Figure 1, the listeners were more accurate in discriminating English than Thai stops for all three contrast types tested. The simple effect of Stimuli was significant for /p/-/k/ [$F(1, 11) = 38.3, p < 0.001$] and /t/-/k/ [$F(1, 11) = 10.4, p < 0.01$], but not for /p/-/t/.

The simple effect of Contrast was significant for both Thai [$F(2, 22) = 19.1, p < 0.001$] and English stimuli [$F(2, 22) = 5.8, p < 0.01$]. As for the Thai stimuli, the listeners' discrimination accuracy was significantly lower for /t/-/k/ (0.53) than /p/-/t/ (0.79) and /p/-/k/ (0.69), which did not differ from each other. As for the English stimuli, the only significant difference in discrimination accuracy was observed between /p/-/k/ (0.89) and /t/-/k/ (0.75).

Next, discrimination accuracy of the NV group was compared to that of AE and NT groups tested previously in order to assess the effect of listeners' L1 backgrounds. A three-way ANOVA with Group (AE, NT, NV) as a between-

subjects factor and Stimuli (English, Thai) and Contrast (/p/-/t/, /p/-/k/, /t/-/k/) as within-subjects factors was carried out.

All three main effects reached significance [Group: $F(2, 45) = 31.7, p < 0.001$, Stimuli: $F(1, 45) = 77.2, p < 0.001$, Contrast: $F(2, 90) = 41.5, p < 0.001$] and so did Group x Stimuli, Group x Contrast and Contrast x Stimuli interactions [G x S: $F(2, 45) = 27.1, p < 0.001$, G x C: $F(4, 90) = 11.1, p < 0.001$, C x S: $F(2, 90) = 24.3, p < 0.001$]. These results suggest that there is inter-dependence between each two of the three main factors. A three-way interaction was also significant [$F(4, 90) = 4.6, p < 0.01$], apparently because of different patterns of two-way interactions for the two stimulus languages as shown in Figures 2 and 3. Group x Contrast ANOVAs were therefore conducted for each language separately.

3.1. English stimuli

Figure 2 shows mean discrimination scores for English stimuli by three groups of listeners as a function of contrast types.

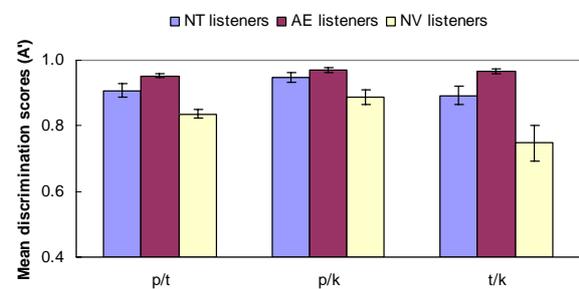


Figure 2: Mean discrimination scores for English stimuli by 3 groups of listeners. Native Thai (NT), Australian English (AE) and native Vietnamese (NV). The brackets enclose \pm one standard error.

The main effects of Group and Contrast reached significance [G: $F(2, 45) = 15.0, p < 0.001$, C: $F(2, 90) = 13.4, p < 0.001$] and so did the two-way interaction [$F(2, 90) = 4.6, p < 0.01$].

The simple effect of Contrast was significant only for the NT and NV groups [NT: $F(2, 34) = 4.8, p < 0.05$, NV: $F(2, 22) = 5.8, p < 0.01$]. All three groups discriminated the /p/-/k/ contrast most accurately and both non-native groups were significantly more accurate in discriminating /p/-/k/ than /t/-/k/.

The simple effect of Group was significant for all contrasts [/p/-/t/: $F(2, 45) = 14.3, p < 0.001$; /p/-/k/: $F(2, 45) = 7.1, p < 0.01$; /t/-/k/: $F(2, 45) = 11.6, p < 0.001$]. For all three contrasts, the significant difference was found only between the NV and other groups. The NT group did not differ significantly from the AE group for any of the contrasts.

3.2. Thai stimuli

Figure 3 shows mean discrimination scores for Thai stimuli by three groups of listeners as a function of contrast types.

For the Thai stimuli, there was a clear between-group difference in the discrimination accuracy. The advantage of the NT listeners over the AE and NV listeners is clearly seen in Figure 3. Although the NV listeners have experience hearing unreleased stops in their L1, such experience did not

appear to help them to discriminate Thai contrasts. On average, the NT group scored 0.91 as opposed to 0.73 and 0.67 for the AE and NV groups, respectively. The two non-native groups were also more variable than the NT group.

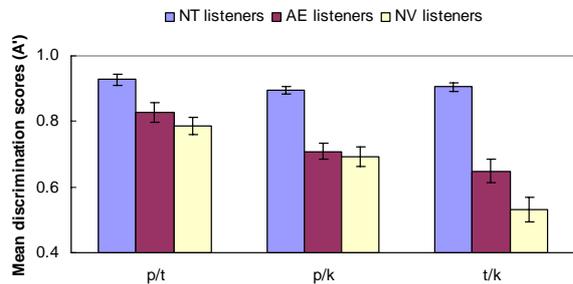


Figure 3: Mean discrimination scores for Thai stimuli by 3 groups of listeners. Native Thai (NT), Australian English (AE) and native Vietnamese (NV). The brackets enclose \pm one standard error.

The effect of listener groups can be clearly seen for all stop contrasts tested. The Group x Contrast ANOVA yielded significant main effects of Group [$F(2, 45) = 36.6, p < 0.001$] and Contrast [$F(2, 90) = 47.1, p < 0.001$]. A two-way interaction also reached significance [$F(4, 90) = 10.4, p < 0.001$] and was explored by simple effects tests.

The simple effect of Contrast was significant for all three groups [AE: $F(2, 34) = 21.4, p < 0.001$, NT: $F(2, 34) = 3.7, p < 0.05$, NV: $F(2, 22) = 19.1, p < 0.001$]. All three groups discriminated the /p-/t/ contrast most accurately, but they differed in their discrimination accuracy patterns. For the NV group, the discrimination accuracy was lower for /t-/k/ than for /p-/t/ and /p-/k/, which did not differ significantly. The AE listeners' discrimination was significantly more accurate for /p-/t/ than for /p-/k/ and /t-/k/, which did not differ from each other. Finally, for the NT group, the only significant difference was obtained between /p-/t/ and /p-/k/.

The simple effect of Group was significant for all contrasts [p-/t/: $F(2, 45) = 8.4, p < 0.001$; p-/k/: $F(2, 45) = 27.5, p < 0.001$; t-/k/: $F(2, 45) = 40.9, p < 0.001$] and the pattern of between-group difference was identical for all three contrasts: the discrimination accuracy was highest for the NT group, lowest for the VT group and intermediate for the AE group. For /p-/t/ and /p-/k/, the significant difference was found only between the NT and non-native groups. In other words, the AE and VT groups did not differ significantly from each other. For /t-/k/, however, the NV group was significantly less accurate than the AE group.

It appears that relatively high discriminability for the contrast involving /p/ is related to listeners' ability to accurately identify the final /p/ and this ease of identification for oral (and nasal) bilabial stops has also been reported in Cantonese (Law *et al.*, 2001). Further evidence for perceptual salience associated with bilabials comes from a study with Japanese L2 English learners (Aoyama, 2003). The Japanese listeners found it difficult to discriminate the /n-/ŋ/ contrast in word-final position, but not the /m-/n/ or /m-/ŋ/ contrast although none of these nasal contrasts occur word-finally in their L1.

3.3. The effect of L1 dialect in cross-language perception

We observed that despite their experience with unreleased final stops in their L1, the NV group did not discriminate the Thai contrasts more accurately than did the AE group. This may seem somewhat surprising, but a possible explanation may be sought in cross-language phonetic differences in how unreleased final stops are produced. It may be the case that the place cue is more strongly encoded in Thai than in Vietnamese unreleased final stops. We are currently conducting acoustic analyses of Vietnamese final stops to further investigate this issue.

As briefly mentioned in Introduction, it is known that the speakers of the southern dialect of Vietnamese have difficulties in producing and perceiving final stops. We therefore explored the effect of listeners' L1 dialect on their cross-language speech perception accuracy.

Figures 4 and 5 show mean discrimination scores for English and Thai stimuli by two dialect groups ($n = 6$ in each group) as a function of contrast types. The advantage of the Northern dialect group over the Southern dialect group can be clearly seen for the /t-/k/ contrast in both English and Thai stimuli.

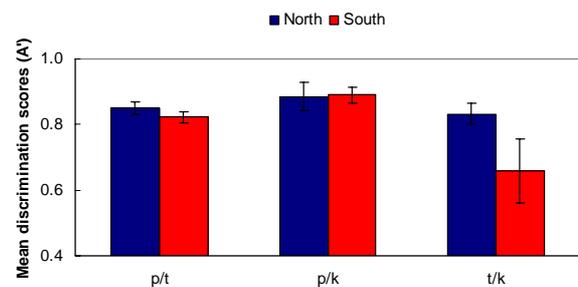


Figure 4: Mean discrimination scores for English stimuli by 2 groups of NV listeners (Northern vs. Southern dialect). The brackets enclose \pm one standard error.

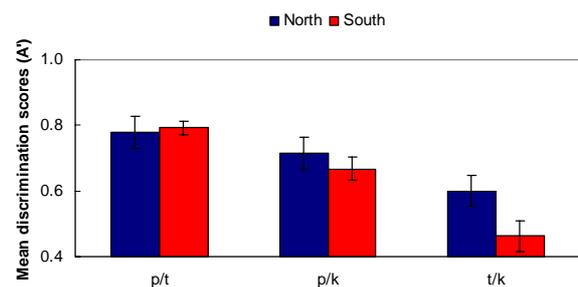


Figure 5: Mean discrimination scores for Thai stimuli by 2 groups of NV listeners (Northern vs. Southern dialect). The brackets enclose \pm one standard error.

A three-way ANOVA with Dialect (North, South) as a between-subjects factor and Stimuli (English, Thai) and Contrast (/p-/t/, /p-/k/, /t-/k/) as within-subjects factors was carried out.

Although there was a trend in the expected direction, the main effect of Dialect did not reach significance [$F(1, 10) = 3.9, p = 0.07$]. The main effects of Stimuli and Contrast reached significance [Stimuli: $F(1, 10) = 21.5, p < 0.001$, Contrast: $F(2, 20) = 27.1, p < 0.001$] and so did Dialect x Contrast and Contrast x Stimuli interactions [D x C: $F(4, 90) = 5.2, p < 0.05$, C x S: $F(2, 20) = 4.5, p < 0.05$]. Both dialect groups were more accurate in discriminating English than Thai stop contrasts.

Two-way ANOVAs (Dialect x Contrast) were carried out for each stimulus language. For both English and Thai stimuli, only the main effect of Contrast reached significance [English: $F(2, 20) = 6.9, p < 0.01$, Thai: $F(2, 20) = 20.5, p < 0.001$]. For the English stimuli, the significant difference was found only between /p/-/k/ (most accurate) and /t/-/k/ (least accurate). The two-way interaction approached, but did not reach significance [$F(2, 20) = 3.0, p = 0.07$]. For the Thai stimuli, listeners discriminated /p/-/t/ and /p/-/k/ contrasts significantly more accurately than /t/-/k/. Although the Northern dialect speakers were more accurate than the Southern dialect speakers in their discrimination of /t/-/k/ as predicted from acoustic characteristics of their L1 dialects, the statistical analyses did not yield significant results, possibly because of a small number of participants and relatively large variability of discrimination scores.

The bi-directional confusion between /t/ and /k/ in perception and production has been reported in Cantonese (Law *et al.*, 2001). Although it has been shown in an earlier study (Tsukada, 2006) that the discrimination accuracy of final stop contrasts depends on the identity of the preceding vowel, it may be the case that the alveolar and velar stops are generally confusable in final position, possibly for articulatory or physiological reasons.

4. Discussion

The present study demonstrated that adult native Vietnamese listeners discriminated final stop contrasts more accurately in English, a language they were familiar with than in Thai, a language unknown to them. While this finding may not be surprising, their results are revealing when compared to native listeners of each stimulus language, Australian English and Thai.

The NV listeners discriminated the Thai stop contrasts less accurately than did the NT listeners and did not differ significantly from the AE listeners with the exception of /t/-/k/. Although neither English nor Thai contrasts are considered phonemically novel to the NV listeners, hearing allophonic variation of unreleased stops in their L1 did not give them an advantage over the AE listeners in discriminating Thai stops.

In fact, the extent to which unreleased final stops are identified or discriminated appears to vary greatly even among native listeners of those 'unreleased' languages (Chen & Wang, 1975, Khouw & Ciocca, 2006, Law *et al.*, 2001 for Cantonese; Abramson & Tingsabadh, 1999 for Thai). If that is the case, it is not surprising that L1 listeners' attunement to such acoustic cues differing in robustness may influence their cross-language perception.

The present findings suggest that specific phonetic experience is not sufficient for accurate perceptual discrimination of certain speech contrasts in an unfamiliar language. Rather, our results seem to suggest that exposure to

native input is essential for maintaining perceptual capabilities.

5. Conclusions

Our tentative conclusion is that experience with specific but non-native phonetic realization of final stops may not be sufficient to ensure perceptual flexibility in an unfamiliar language. Although the participants in the present study are expected to have a much more active L1 than the native English-speaking Hindi students tested in Tees and Werker (1984), the present results are consistent with the view expressed in earlier studies. That is, an early exposure to specific *and* native phonetic contrasts that include detailed acoustic characteristics may be crucial in developing the capacity to discriminate subtle phonetic contrasts as truly native listeners. This highlights the importance of not only the amount but also the *kind* of input in the acquisition of speech sounds.

6. Acknowledgements

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