Perception of Korean stops and affricates by Mandarin learners of Korean: The role of the Korean language proficiency

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Introduction

• **L2 speech sound acquisition**: L2 categories are perceived according to their similarities and dissimilarities from native-language sounds.

  • **Japanese learners of English**: English /ɹ//-/l/ contrast
  
  • **Korean learners of English**: English tense/lax distinction
Goals

- To investigate how accurately Mandarin learners, whose native language has only a binary laryngeal contrast, perceive the Korean three-way laryngeal contrast, focusing on their Korean-language proficiency (L2).

AX discrimination task
(음소 구별 실험)

Identification task
(음소 확인 실험)
Phonological inventories of Mandarin and Korean

Different phonological inventories in the two languages
• Mandarin (L1): Two-way laryngeal contrast
  • aspirated(유기음), unaspirated(무기음)
• Korean (L2): Three-way laryngeal contrast
  • aspirated(격음), lenis(평음), fortis(경음)

Table1. Stops and affricates of Mandarin and Korean

<table>
<thead>
<tr>
<th></th>
<th>Mandarin (L1)</th>
<th>Korean (L2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aspirated</td>
<td>Unaspirated</td>
</tr>
<tr>
<td>Stop (파열음)</td>
<td>/pʰ/</td>
<td>/p/</td>
</tr>
<tr>
<td></td>
<td>/tʰ/</td>
<td>/t/</td>
</tr>
<tr>
<td></td>
<td>/kʰ/</td>
<td>/k/</td>
</tr>
<tr>
<td>Affricate (파찰음)</td>
<td>/ʨʰ/</td>
<td>/ʨ/</td>
</tr>
<tr>
<td></td>
<td>/ʦʰ/</td>
<td>/ʦ/</td>
</tr>
<tr>
<td></td>
<td>/tɕʰ/</td>
<td>/tɕ/</td>
</tr>
</tbody>
</table>
Previous studies

Phonological difference in the contrasts in the two languages
- **Mandarin**: Aspiration (기식성)
- **Korean**: Aspiration & tenseness (기식성 & 긴장도)

Different cue-weighting strategies for the contrasts in the two languages
- **Mandarin**: VOT (성대 진동 시작 시간)
- **Korean**: Both VOT and F0 (성대 진동 시작 시간 & 후행 모음 음높이)

Table 2. Dimension of the laryngeal contrast in word-initial stops in two languages

<table>
<thead>
<tr>
<th></th>
<th>Mandarin (L1)</th>
<th>Korean (L2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aspirated (유기음)</td>
<td>Unaspirated (무기음)</td>
</tr>
<tr>
<td>VOT</td>
<td>long</td>
<td>short</td>
</tr>
<tr>
<td>F0</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Research questions & Hypotheses

How accurately Mandarin learners of Korean perceive the Korean three-way contrasts in word-initial position?

• **L1 background**

  **Hypothesis 1**: Mandarin learners rely on VOT only, the primary cue in their native language, to distinguish the Korean contrasts.

• **L2 proficiency**

  **Hypothesis 2**: The higher the Mandarin learners’ proficiency in Korean, the better they perceive the Korean contrasts.
Experiments

- **Experiment 1: AX discrimination task** (음소 구별 실험)
  - To investigate how Mandarin learners discriminate the Korean three-way contrast.

- **Experiment 2: Identification task** (음소 인지 실험)
  - To test Mandarin learner’s ability to identify the Korean three-way contrast.

Order: The order of experiments was counterbalanced.
AX task: Participants

- **Target group:** 44 Mandarin learners of Korean at U of T
  - 37 females, 7 males, mean age: 20 years
- **Three Korean proficiency groups**
  - Based on course-level at University of Toronto
    - Beginner group: 20 (16 females, 4 males), Exposure to Korean: 19.3 hours
    - Intermediate group: 14 (13 females, 1 male), Exposure to Korean: 29.3 hours
    - Advanced group: 10 (8 females, 2 males), Exposure to Korean: 32.2 hours
- **Control group:** 13 native speakers of Seoul Korean
  - 7 females, 6 males, mean age: 29.3
  - The average stay period in Toronto: 2.46 years
AX task: Materials

- **Materials**: 48 Korean words, 16 minimal triplets beginning with stops and affricates in word-initial position.

  Table 3. Examples of target stimuli used in the AX task

<table>
<thead>
<tr>
<th></th>
<th>Aspirated</th>
<th>Lenis</th>
<th>Fortis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilabial</td>
<td>풀</td>
<td>볼</td>
<td>뿌</td>
</tr>
<tr>
<td>Alveolar</td>
<td>탈</td>
<td>달</td>
<td>딸</td>
</tr>
<tr>
<td>Velar</td>
<td>캐</td>
<td>개</td>
<td>깨</td>
</tr>
<tr>
<td>Palate-alveolar</td>
<td>차다</td>
<td>자다</td>
<td>짜다</td>
</tr>
</tbody>
</table>

- **Auditory stimuli**: natural recordings by a female and a male native speaker of Korean.
  - 96 tokens (48 words * 2 speakers)
AX task: Procedure

- 144 word-pairs were tested.

<table>
<thead>
<tr>
<th>Word-pairs</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three ‘different’ AB word-pairs</td>
<td>[풀-불], [불-뿔], [풀-뿔]</td>
</tr>
<tr>
<td>Three ‘different’ AB word-pairs in reversed order</td>
<td>[불-풀], [뿔-불], [뿔-풀]</td>
</tr>
<tr>
<td>Three ‘same’ AB word-pairs</td>
<td>[불-불], [풀-풀], [뿔-뿔]</td>
</tr>
</tbody>
</table>

- The inter-stimulus interval: 500 ms
- The inter-trial interval: 1000 ms
### AX task: Procedure

- **OpenSesame** (Mathôt, Schreij & Theeuwes 2012)

- Conducted individually in a sound attenuated booth in the U of T phonetics Laboratory.

- Participants listened to Korean pairs of stimuli over headphones and asked to determine whether the two stimuli they heard were the ‘same’, and ‘different’.

- Each participant completed a **practice session** to ensure familiarity with the task.

- All trials were pseudo-randomly presented for each participant.
AX: Example of instruction for Mandarin participants

If they thought Korean two sounds were the ‘same’, they were instructed to press q on the keyboard and p if ‘different’.

说明
你将听到两个语音，然后判断你听到的两个语音是否相同。
如果你认为这两个语音相同，键入 ‘Q’，
如果不同，键入 ‘P’。
请把注意力集中在每个单词开头部分的语音。
键入 ‘S’
AX: Statistical Analysis

- **Linear mixed effects model in R** (Baayen 2008, R CoreTeam, 2012)
  - The packages *lme4* (Bates et al., 2011), *lmerTest* (Kuznetsova et al., 2013), and *phia* (Helios et al., 2015) for post-hoc comparisons
- **Dependent variable**: d’
  - Sensitivity index: a measure of how discriminable two stimuli are for listeners 
- **Fixed effects**:
  - Korean proficiency level (beginner, intermediate, advanced, native Korean)
  - Condition (aspirated-fortis, fortis-lenis, aspirated-lenis)
  - Interaction between L2 proficiency and Condition
- **Random effects**: Speakers, words
AX task: Results of Proficiency

Adult learners’ Korean proficiency influences their perception of the contrast.

Discrimination accuracy (%) of Korean pairwise contrasts by Korean proficiency levels
AX task: Results of Condition

- **Same sound pairs**: least likely to correctly label [lenis-lenis] pairs.
- **Different sound pairs**: best at distinguishing [aspirated-fortis], worst at distinguishing [aspirated-lenis].

Discrimination accuracy of the Korean three-way contrast in word-initial position by Mandarin listeners.
AX task: Results of Interaction

- Significant main effects of both L2 proficiency and condition and their interaction.
- **L2 (Korean) Proficiency**: Higher the Mandarin learners’ the Korean language proficiency, the better their discriminate accuracy of the Korean contrast.
- **Condition**: L2 learners are most likely to perceive [aspirated-fortis] as different sound pairs regardless of proficiency level.

D-prime values for sound pairs of Korean stops and affricates by Korean proficiency levels.
ID task: Participants

- The participants in the AX task were the same in the identification task.
- Target group: 44 native speakers of Mandarin
- Control group: 13 native speakers of Seoul Korean
ID task: Materials

- 96 words
  - 48 real words, 16 minimal triplets used in the AX task
  - 48 nonce words, 16 minimal triplets

- Auditory stimuli: the same talkers used in the AX task
ID task: Procedure

- Participants were instructed to listen to a Korean stimulus and determine whether the stimulus was A, B, or C presented on a computer screen and press the corresponding numbers 1, 2 or 3 on the keyboard, respectively.
On a given trial, a participant might hear ‘pul[불]’. The task is then to choose from three visually presented stimuli, i.e., ‘phul[풀], pul[불], p’ul[뿔]’, by clicking on the corresponding number on the keyboard.
**ID: Statistical Analysis**

- **Mixed-effects logistic regression model in R**
  (Baayen et al. 2008, R Development Core Team 2012)
  - The *glmer* function in the *lme4* library (Bates et al., 2011) and *phia*
    (Helios et al., 2015) for post-hoc comparisons
- **Dependent variable**: Response pattern
  (correct response (1) vs. incorrect response (0))
- **Fixed effects**:
  - Korean proficiency level
  - Korean laryngeal category (aspirated, lenis, fortis)
  - Interaction between Korean proficiency and laryngeal category
- **Random effect**: subjects, words
ID task: Results of Proficiency

- Mandarin learners are more likely to **correctly identify real words than nonsense** words, but not statistically significant ($p$-value = 0.1012).

- **Mandarin learners’ identification accuracy** for the Korean three-way categories increases with **their Korean proficiency levels**.

![Identification accuracy of the Korean three-way categories by Korean proficiency levels]
Aspirated sounds are the most likely to be accurately identified (84.4%), whereas lenis sounds are the least likely to be accurately identified (68.5%).

Distribution of response patterns of the Korean three-way contrast in word-initial position by Mandarin learners.
ID task: Results of Interaction

- **Korean proficiency level**: Mandarin learners’ identification accuracy of the Korean three phonation types shows improvement along with their Korean proficiency.

Distribution of response patterns of the Korean three-way contrast by L2 proficiency
ID task: Statistical results

- **Only L2 (Korean) proficiency** plays a role in the perception of the contrasts.
- The laryngeal category does not play a role in the identification task.
- There were no interactions between the Korean proficiency and the laryngeal category

Table 4. The output of the mixed effects logistic regression model of the Korean three-way contrast

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std. Error</th>
<th>Z-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>5.01640</td>
<td>0.66885</td>
<td>7.500</td>
<td>6.38e-14 ***</td>
</tr>
<tr>
<td><strong>L2 Proficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beginner</td>
<td>-3.53067</td>
<td>0.74342</td>
<td>-4.749</td>
<td>2.04e-06 ***</td>
</tr>
<tr>
<td>Intermediate</td>
<td>-2.63642</td>
<td>0.78862</td>
<td>-3.343</td>
<td>0.000829 ***</td>
</tr>
<tr>
<td>Advanced</td>
<td>-1.33004</td>
<td>0.87529</td>
<td>-1.520</td>
<td>0.128625</td>
</tr>
<tr>
<td><strong>Condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fortis</td>
<td>0.07087</td>
<td>0.87758</td>
<td>0.081</td>
<td>0.935639</td>
</tr>
<tr>
<td>Lenis</td>
<td>-1.17507</td>
<td>0.77830</td>
<td>-1.510</td>
<td>0.131096</td>
</tr>
<tr>
<td><strong>Interaction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beginner:fortis</td>
<td>-0.56682</td>
<td>0.94946</td>
<td>-0.597</td>
<td>0.550510</td>
</tr>
<tr>
<td>Intermediate:fortis</td>
<td>-0.46208</td>
<td>0.99925</td>
<td>-0.462</td>
<td>0.643777</td>
</tr>
<tr>
<td>Advanced:fortis</td>
<td>-1.00636</td>
<td>1.09181</td>
<td>-0.922</td>
<td>0.356670</td>
</tr>
<tr>
<td>Beginner:lenis</td>
<td>-0.31547</td>
<td>0.86047</td>
<td>-0.367</td>
<td>0.713902</td>
</tr>
<tr>
<td>Intermediate:lenis</td>
<td>-0.32045</td>
<td>0.91058</td>
<td>-0.352</td>
<td>0.724901</td>
</tr>
<tr>
<td>Advanced:lenis</td>
<td>-1.28554</td>
<td>1.00158</td>
<td>-1.284</td>
<td>0.199310</td>
</tr>
</tbody>
</table>
ID task: Post-hoc interaction analysis

- **Beginning and intermediate Mandarin listeners** are significantly different from Korean native speakers, but **advanced listeners** are as good as Korean speakers.
- There is a significant difference between **beginning and advanced speakers**.
  - Mandarin advanced learners are better at identifying the Korean contrasts than the beginning learners.

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std. Error</th>
<th>Z-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginner-Native Korean</td>
<td>-3.5307</td>
<td>0.7434</td>
<td>-4.749</td>
<td>&lt; 0.001 ***</td>
</tr>
<tr>
<td>Intermediate-Native Korean</td>
<td>-2.6364</td>
<td>0.7886</td>
<td>-3.343</td>
<td>0.00449 **</td>
</tr>
<tr>
<td>Advanced-Native Korean</td>
<td>-1.3300</td>
<td>0.8753</td>
<td>-1.520</td>
<td>0.42076</td>
</tr>
<tr>
<td>Intermediate-Beginner</td>
<td>0.8943</td>
<td>0.5952</td>
<td>1.502</td>
<td>0.43109</td>
</tr>
<tr>
<td>Advanced-Beginner</td>
<td>2.2006</td>
<td>0.7195</td>
<td>3.058</td>
<td>0.01120 *</td>
</tr>
<tr>
<td>Advanced-Intermediate</td>
<td>1.3064</td>
<td>0.7683</td>
<td>1.700</td>
<td>0.31881</td>
</tr>
</tbody>
</table>
Conclusions

• All Mandarin groups of learners do not attain Korean native levels of perception accuracy for the Korean three-way contrast.

• Korean proficiency influences the listeners’ perception of non-native contrasts.
  • The advanced Mandarin learners are better at distinguishing the Korean three categories than the beginner learners.

• Both experiments provide empirical evidence of L1 influence on L2 perception with respect to cue-weighting strategies.
  • In the AX task, Mandarin listeners have difficulty discriminating [lenis-lenis] contrasts in the same pairs of sounds and [lenis-aspirated] contrasts in different pairs of sounds in word initial position, suggesting that they rely preliminary on the VOT difference for discriminating the Korean contrast.
  • In the identification task, lenis consonants are the least likely to be correctly identified. Mandarin learners tend to misidentify lenis tokens as aspirated, while aspirated consonants are most likely to be correctly identified.
Pedagogical Implications

• Mandarin learners should pay more attention to the \textit{f0 difference}, which is the most relevant cue to \textit{distinguish lenis from aspirated and fortis} for native speakers of Korean, in order to attain native-like perception patterns.
  • Once Mandarin learners of Korean catch on \textit{there is a tonal difference}, they can acquire f0 and use the cue to distinguish lenis consonants.

• There is individual variation in each proficiency group, implying that other factors such as \textit{L2 language exposure, type of instruction, age of acquisition, and hours of L2 use} should be considered in future research.
Further Study

• Production and perception of the Korean three-way contrast in stops and affricates by both Mandarin and English learners of Korean.
  • Effects of L1 background (English vs. Mandarin)
  • Effects of Korean language proficiency
  • Relationship between production and perception of the Korean laryngeal three-way contrast.
  • Subject individual difference between production and perception
Many thanks to

• Philip Monahan, Jessamyn Schertz and Yoonjung Kang for their valuable comments.

• Kyoungrok Ko and Yujeong Choi for their help recruiting participants.

• Mandarin and Korean subjects to participate experiments

• Patrick Murphy for help with OpenSeasame software.

• SSHRC Institutional Grant (SIG) for experiment participant costs.
Selected references


Summary of statistical results in the AX task

- **Significant main effects of both L2(Korean) proficiency and condition.**

- There are significant **interactions between the two factors**, indicating the effect of proficiency is different depending on condition.

- **Post-hoc comparisons:**

- Three groups of Mandarin learners do **not** reach the same level of discrimination accuracy as the native Korean speakers do.

  - **[aspirated-fortis (e.g 탈-딸)]: no L2 proficiency effect**
    - Accurately distinguishable for Mandarin learners due to the use of VOT, the primary cue in their L1.

  - **[aspirated-lenis(e.g 탈-달)]: significant L2 proficiency effect**
    - The higher their L2 proficiency level, the better their perception of the contrast.

  - **[fortis-lenis(e.g 딸-달)]: significant difference between the beginner and the advanced group**
    - Mandarin advanced learners are better at discriminating the contrast than the beginning learners.
Summary of statistical results in the ID task

• **Only L2 proficiency** plays a role in the perception of the contrasts.
  - There is a significant difference between beginning and advanced listeners.

• The laryngeal category does not play a role in the identification task.

• There are no interactions between L2 proficiency and the laryngeal category.
Previous studies

**Effects of L1 background**

- L1 affects L2 phonemic categorization (e.g., Flege’s (1995) Speech Learning Model)
- L1/L2 use influence L2 pronunciation (Piske, MacKay & Flege 2001)

**Effects of L2 proficiency**

- Larger instructional effects for beginners (Lee et al. 2014)
- Some evidence of differential instructional effects (e.g., Kissling 2014)
- Stabilization in L2 phonology after initial stages of learning/exposure (Derwing, Munro, & Thomson 2008, Flege, 1988)
ID task: statistical results

- **Mixed-effects logistic regression model** (Baayen et al. 2008)
  - Dependent variable: response (correct response (1) vs. incorrect response (0))
  - Fixed effects: L2 proficiency, Korean laryngeal category and their interaction
  - A random by-subjects slope of laryngeal category
  - **Exclude a random effect for word**

Table 5-2. The output of the mixed effects logistic regression model of the Korean three-way contrast

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std. Error</th>
<th>Z-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>4.68827</td>
<td>0.62170</td>
<td>7.541</td>
<td>4.66e-14 ***</td>
</tr>
<tr>
<td>Beginner</td>
<td>-3.25975</td>
<td>0.70355</td>
<td>-4.633</td>
<td>3.60e-06 ***</td>
</tr>
<tr>
<td>Intermediate</td>
<td>-2.45263</td>
<td>0.74839</td>
<td>-3.277</td>
<td>0.00105 **</td>
</tr>
<tr>
<td>Advanced</td>
<td>-1.30067</td>
<td>0.83245</td>
<td>-1.562</td>
<td>0.11818</td>
</tr>
<tr>
<td>Fortis</td>
<td>0.02816</td>
<td>0.80991</td>
<td>0.035</td>
<td>0.97226</td>
</tr>
<tr>
<td>Lenis</td>
<td>-1.42221</td>
<td>0.70130</td>
<td>-2.028</td>
<td>0.04256 *</td>
</tr>
<tr>
<td>Beginner:fortis</td>
<td>-0.54667</td>
<td>0.89706</td>
<td>-0.609</td>
<td>0.54226</td>
</tr>
<tr>
<td>Intermediate:fortis</td>
<td>-0.41910</td>
<td>0.94602</td>
<td>-0.443</td>
<td>0.65776</td>
</tr>
<tr>
<td>Advanced:fortis</td>
<td>-0.89339</td>
<td>1.03536</td>
<td>-0.863</td>
<td>0.38820</td>
</tr>
<tr>
<td>Beginner:lenis</td>
<td>0.01738</td>
<td>0.79652</td>
<td>0.022</td>
<td>0.98259</td>
</tr>
<tr>
<td>Intermediate:lenis</td>
<td>-0.03914</td>
<td>0.84550</td>
<td>-0.046</td>
<td>0.96308</td>
</tr>
<tr>
<td>Advanced:lenis</td>
<td>-0.90745</td>
<td>0.93298</td>
<td>-0.973</td>
<td>0.33074</td>
</tr>
</tbody>
</table>

- L2 proficiency plays a role in the perception of the Korean categories
- There is a significant difference between lenis and aspirated identification accuracy.
  - Lenis identification is worse than aspirated identification
AX task: statistical results

- **Linear mixed effects model** (Baayen 2008)
  - Dependent variable: d’
  - Fixed effects: L2 proficiency, condition and their interaction
  - Random effects: subject and word

Table 4. The output of the linear mixed effects model of the Korean three-way contrast in word initial stops and affricates.

<table>
<thead>
<tr>
<th></th>
<th>Sum Sq</th>
<th>Mean Sq</th>
<th>F-value</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2 proficiency</td>
<td>17.447</td>
<td>5.8156</td>
<td>36.345</td>
<td>6.709e-13 ***</td>
</tr>
<tr>
<td>Condition</td>
<td>46.538</td>
<td>23.2689</td>
<td>145.419</td>
<td>&lt; 2.2e-16 ***</td>
</tr>
<tr>
<td>L2 Proficiency: Condition</td>
<td>15.345</td>
<td>2.5575</td>
<td>15.983</td>
<td>5.154e-13 ***</td>
</tr>
</tbody>
</table>
AX: post-hoc interaction analysis

<table>
<thead>
<tr>
<th>Condition</th>
<th>Proficiency</th>
<th>Value</th>
<th>Df</th>
<th>Chisq</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>asp-for</td>
<td>native Korean-beginner</td>
<td>0.8321</td>
<td>1</td>
<td>14.4165</td>
<td>0.0003297 ***</td>
</tr>
<tr>
<td></td>
<td>native Korean-intermediate</td>
<td>0.6833</td>
<td>1</td>
<td>8.3187</td>
<td>0.0078480 **</td>
</tr>
<tr>
<td></td>
<td>native Korean-Advanced</td>
<td>0.5333</td>
<td>1</td>
<td>4.2491</td>
<td>0.0543756 .</td>
</tr>
<tr>
<td></td>
<td>beginner-intermediate</td>
<td>-0.1487</td>
<td>1</td>
<td>0.4815</td>
<td>0.5164330</td>
</tr>
<tr>
<td></td>
<td>beginner-advanced</td>
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