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

    (Miyawaki et al 1975, Mackain et al 1981, Yamada & Tohkura 1992, Iverson et al 2003)
  - **Korean learners of English**: English tense/lax distinction

    (Yang 1992, 1996, Flege et al 1997, Koo 2000)

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

	Mandarin (L1)		**Korean (L2)**		
	Aspirated	**Unaspirated**	**Aspirated**	**Lenis**	**Fortis**
Stop (파열음)	/pʰ/ /tʰ/ /kʰ/	/p/ /t/ /k/	ㅍ ㅌ ㅋ	ㅂ ㄷ ㄱ	ㅃ ㄸ ㄲ
Affricate (파찰음)	/tɕʰ/ /tsʰ/ /tʂʰ/	/tɕ/ /ts/ /tʂ/	ㅊ	ㅈ	ㅉ

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

	Mandarin (L1)		Korean (L2)		
	Aspirated (유기음)	Unaspirated (무기음)	Aspirated (격음)	Lenis (평음)	Fortis (경음)
VOT	**long**	**short**	**longest**	intermediate	**shortest**
F0	-	-	**highest**	**lowest**	intermediate

Rochet & Fei 1991, Chao & Chen 2008, 포건강, 2016 for Mandarin, Cho et al 2002, Kang & Guio 2008 for Korean

Research questions & Hypotheses

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

- **L1 background**

  Hypothesis1: Mandarin learners rely on VOT only, the primary cue in their native language, to distinguish the Korean contrasts.

- **L2 proficiency**

  Hypothesis2: The higher the Mandarin learners' proficiency in Korean, the better they perceive the Korean contrasts.

Experiments

- **Experiment1: 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.

[음소구별실험]
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, 2males), 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.

Table3. Examples of target stimuli used in the AX task

	Aspirated	Lenis	Fortis
Bilabial	풀	불	뿔
Alveolar	탈	달	딸
Velar	캐	개	깨
Palate-alveolar	차다	자다	짜다

- **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**.

Word-pairs	Examples
Three 'different' AB word-pairs	[풀–불],[불–뿔],[풀–뿔]
Three 'different' AB word-pairs in reversed order	[불–풀],[뿔–불], [뿔–풀]
Three 'same' AB word-pairs	[불–불], [풀–풀], [뿔–뿔]

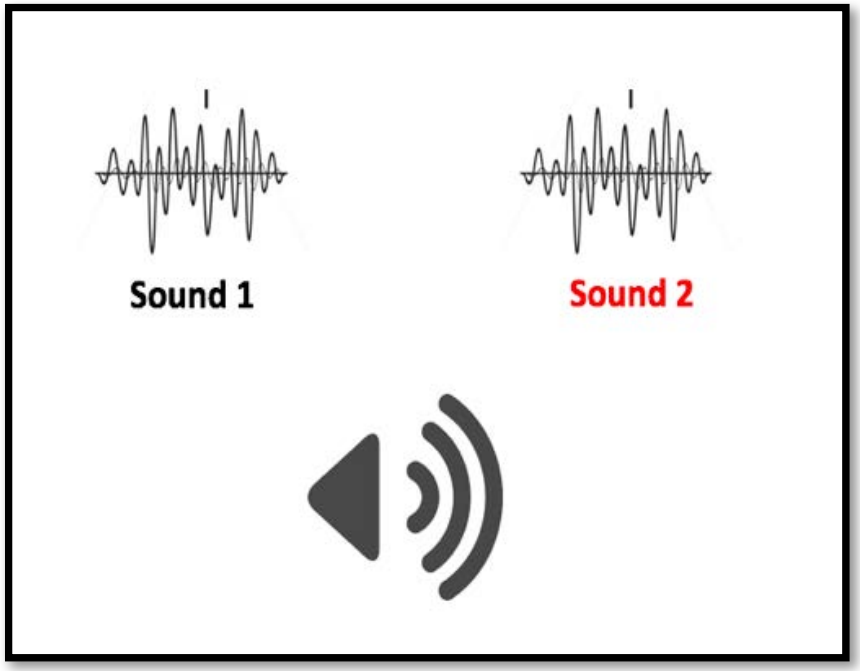
- The inter-stimulus interval: 500 ms
- The inter-trial interval: 1000 ms

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’

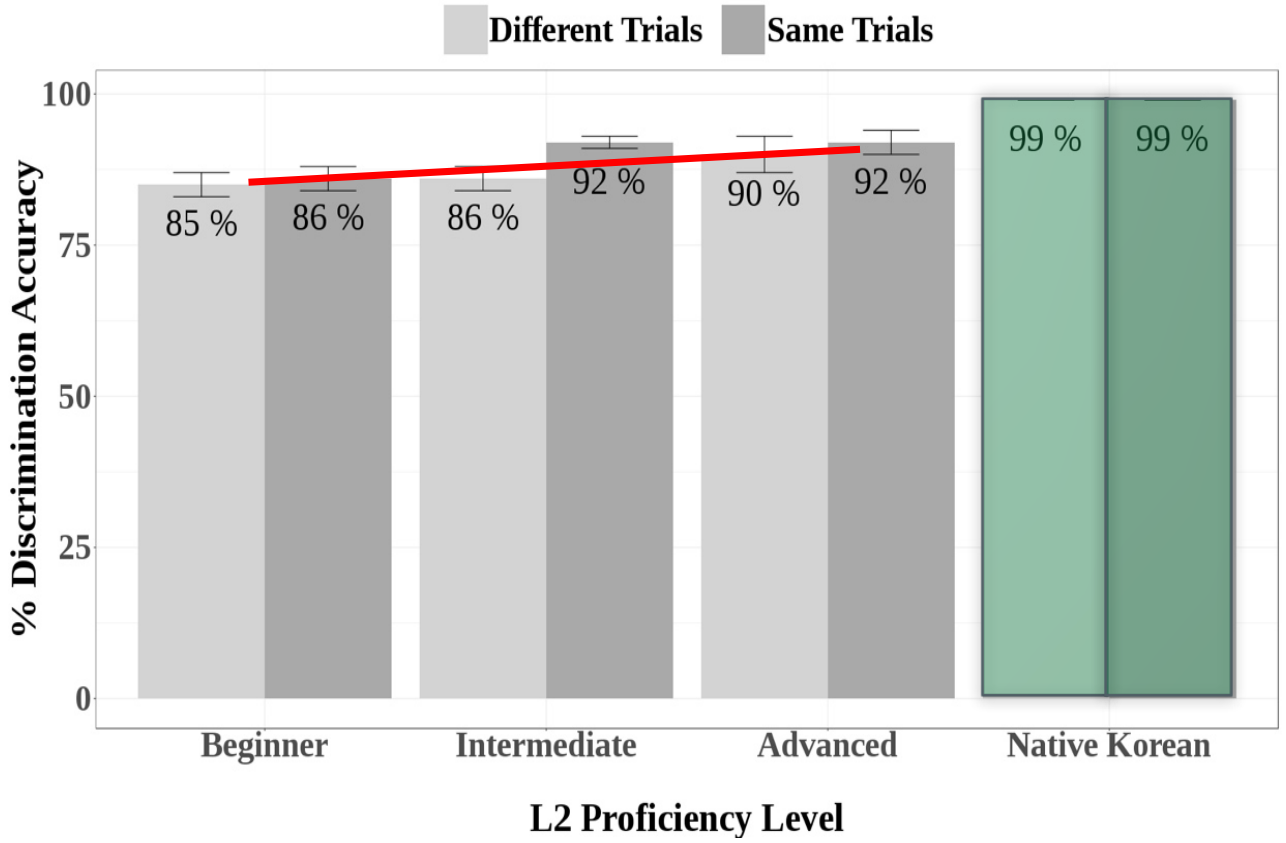


AX: Statistical Analysis

- **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 (Best et al 1981, Godfrey et al 1981, Francis & Ciocca 200)
  - **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

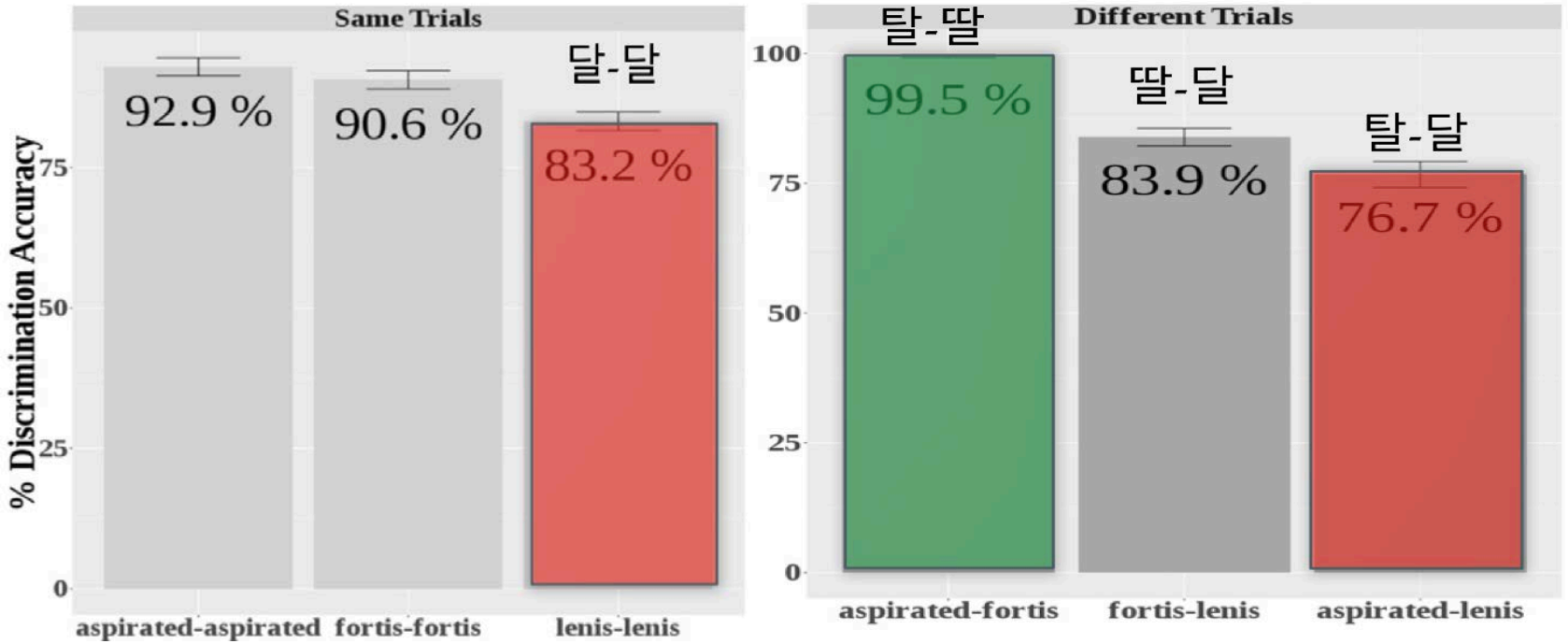
Adult learners' Korean proficiency influences their perception of the contrast.



Discrimination accuracy (%) of Korean pairwise contrasts by Korean proficiency levels

AX task: Results of Condition

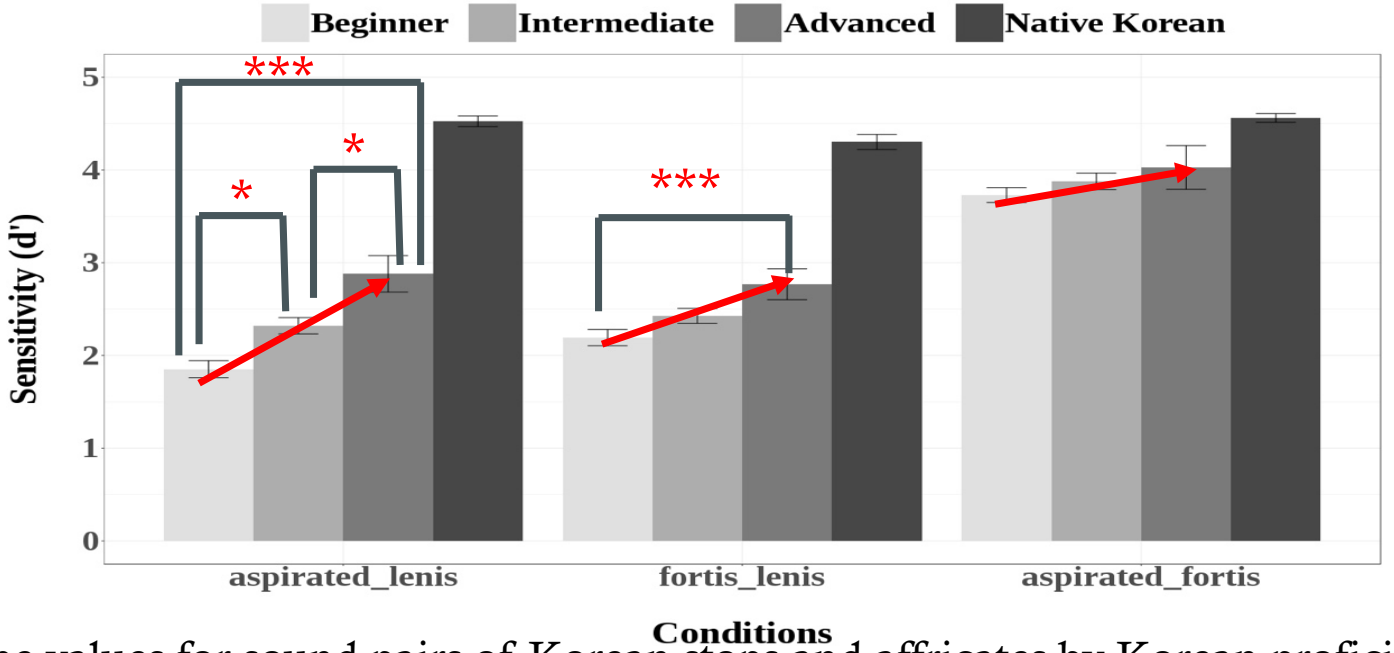
- **Same sound pairs**: least likely to correctly label **[lenis-lenis]** pairs.
- **Different sound pairs**: best at distinguishing **[aspirated-fortis]**, worst at distinguishing **[aspirated-lenis]**.



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.

[음소인지실험]
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.

ID: Example of instruction for Mandarin participants

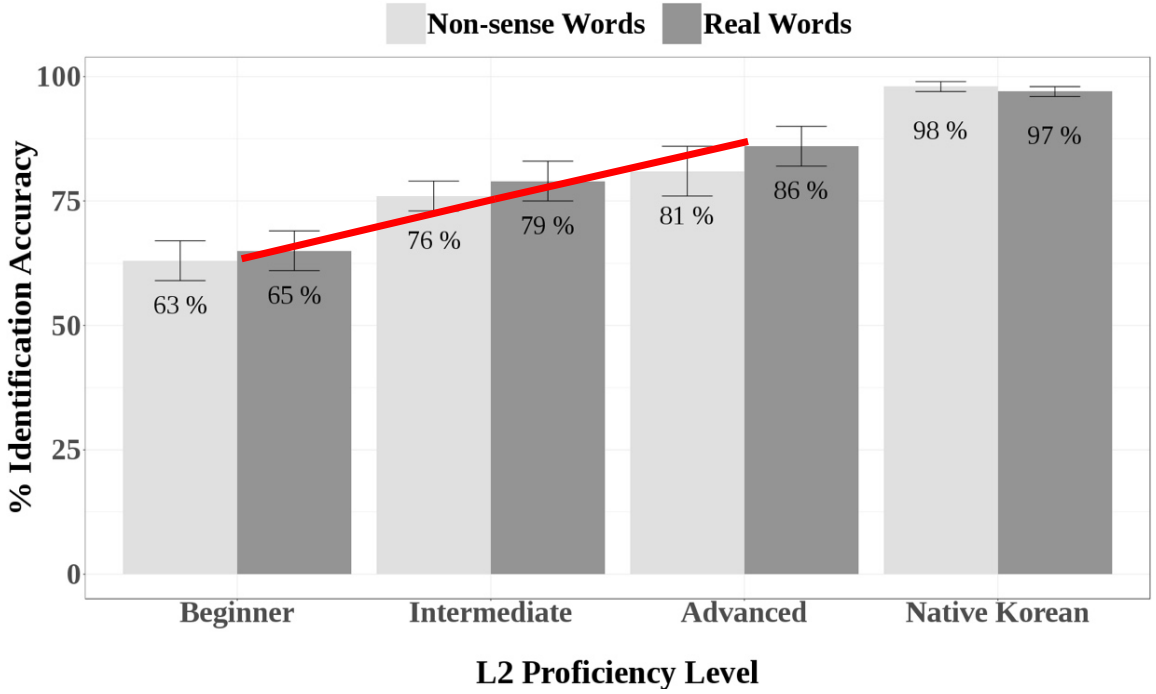
On a given trial, a participant might hear ‘pul[불]’.
The task is then to choose from three visually presented stimuli, i.e.,‘p^{h}ul[풀], pul[불], p’ul[뿔]’, by clicking on the corresponding number on the keyboard.

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

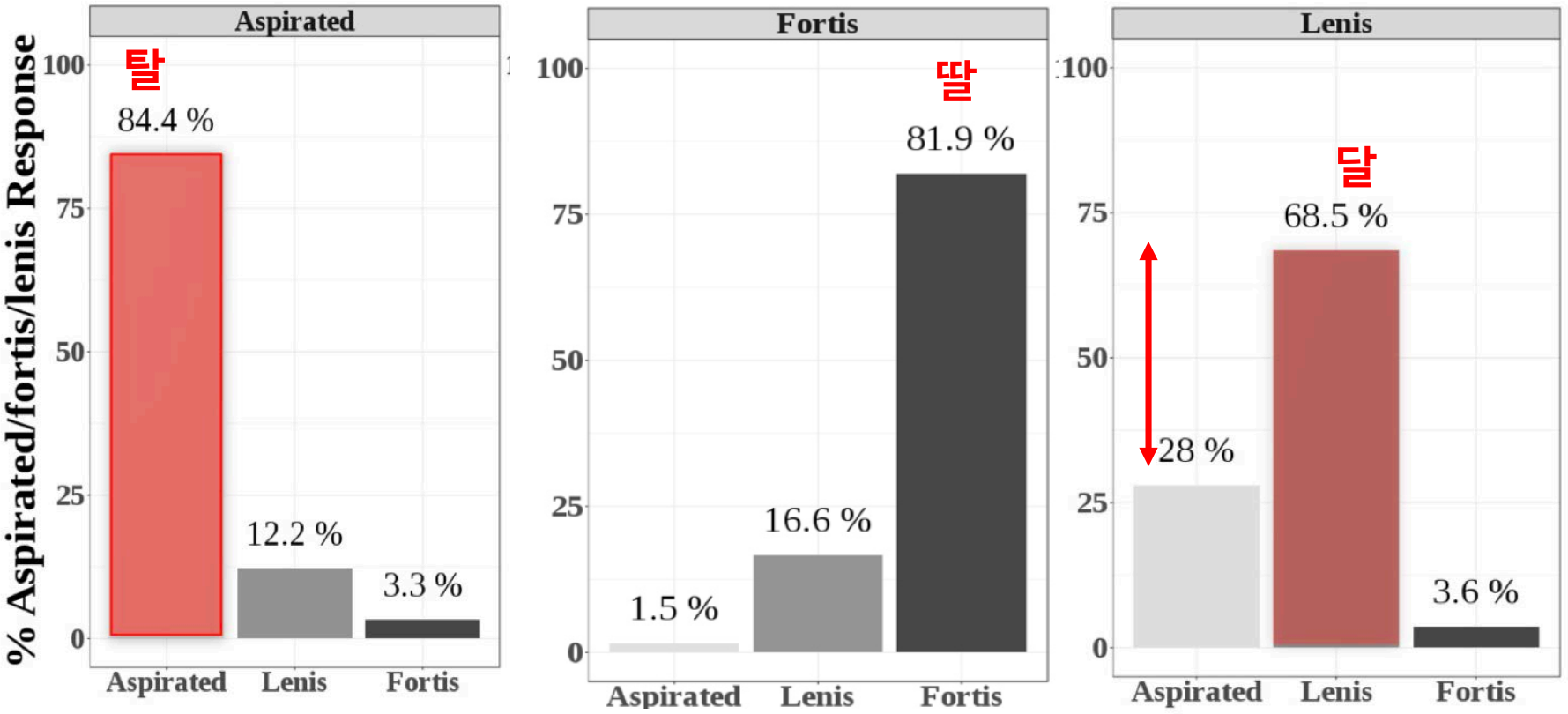
- Mandarin learners are more likely to **correctly identify real words than nonsense** words, but not statistically significant (*p*-value =0.1012).
- **Mandarin learners' identification accuracy** for the Korean three-way categories increases with **their Korean proficiency levels.**



Identification accuracy of the Korean three-way categories by Korean proficiency levels

ID task: Results of Condition

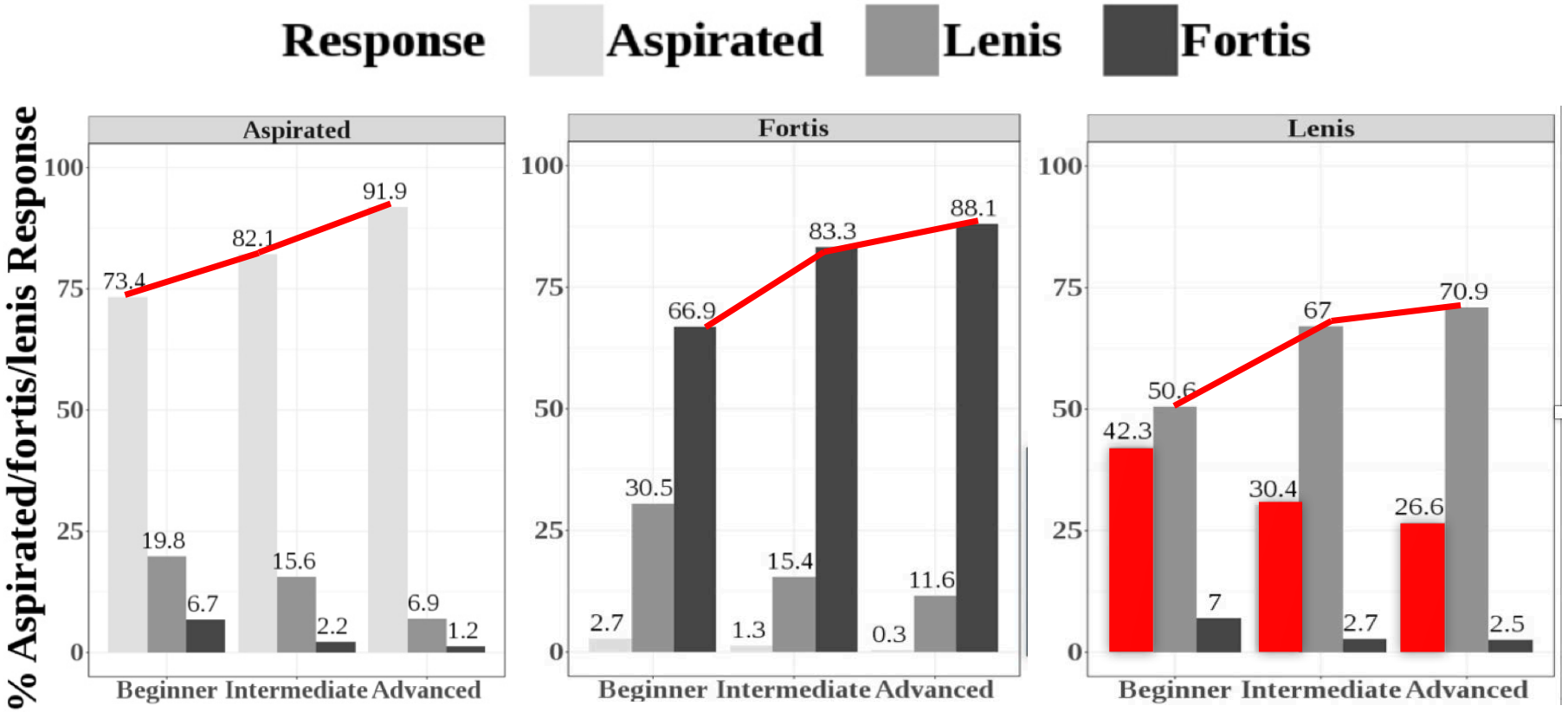
- **Aspirated sounds are the most likely to be accurately identified (84.4%), whereas lenis sounds are the least likely to be accurately identified (68.5%).**



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

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

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 5. Tukey's Post-Hoc Test: L2 proficiency level

	Estimate	Std. Error	*Z*-value	*P*-value
Beginner-Native Korean	-3.5307	0.7434	-4.749	< 0.001 ***
Intermediate-Native Korean	-2.6364	0.7886	-3.343	0.00449 **
Advanced-Native Korean	-1.3300	0.8753	-1.520	0.42076
Intermediate-Beginner	0.8943	0.5952	1.502	0.43109
Advanced-Beginner	2.2006	0.7195	3.058	0.01120 *
Advanced-Intermediate	1.3064	0.7683	1.700	0.31881

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 **f0 difference**, which is the most relevant cue to **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 **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 **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

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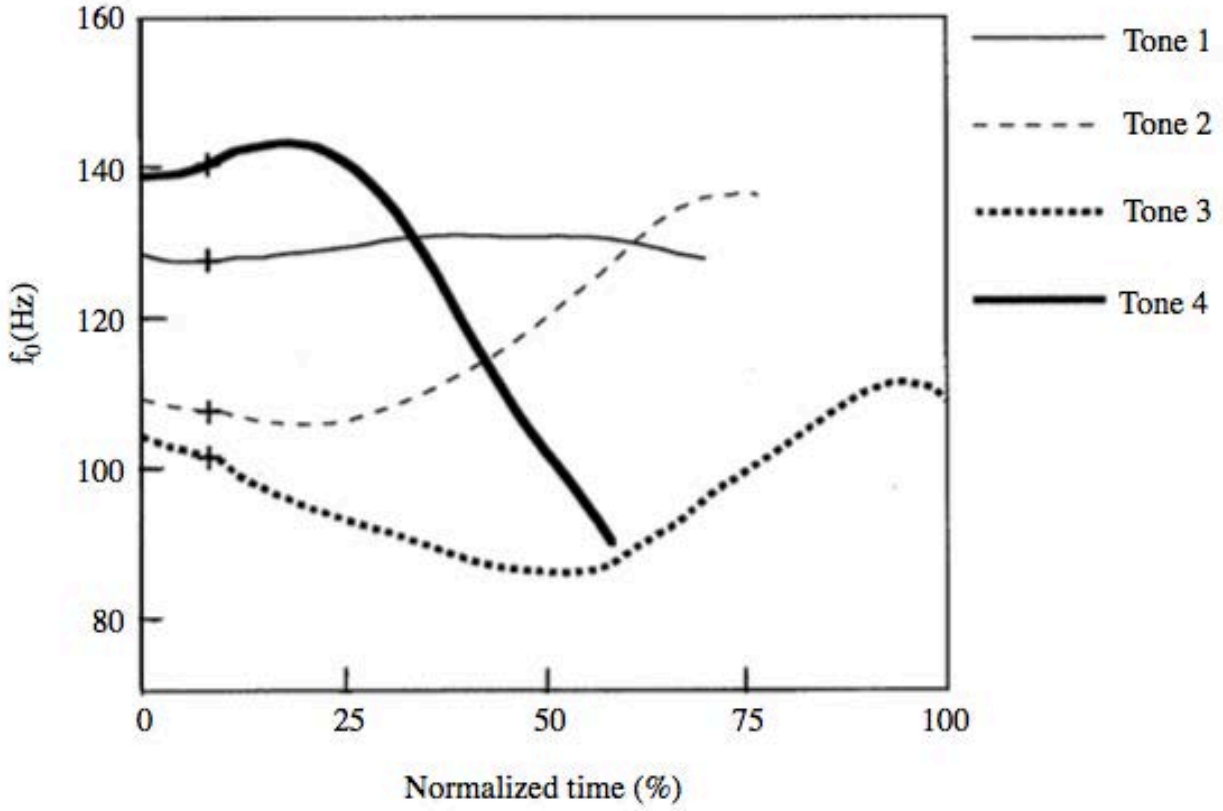
Summary of statistical results in the AX task

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


160
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f_0(Hz)
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50
75
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Normalized time (%)
Tone 1
Tone 2
Tone 3
Tone 4

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

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

- 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.

	Sum Sq	Mean Sq	*F*-value	*P*-value
L2 proficiency	17.447	5.8156	36.345	6.709e-13 ***
Condition	46.538	23.2689	145.419	< 2.2e-16 ***
L2 Proficiency: Condition	15.345	2.5575	15.983	5.154e-13 ***

AX: post-hoc interaction analysis

Condition	Proficiency	Value	Df	Chisq	*P*-value
asp-for	native Korean-beginner	0.83211	1	14.4165	0.0003297 ***
	native Korean-intermediate	0.68337	1	8.3187	0.0078480 **
	native Korean-Advanced	0.53336	1	4.2491	0.0543756 .
	beginner-intermediate	-0.14874	1	0.4815	0.5164330
	beginner-advanced	-0.29875	1	1.5724	0.2518305
	intermediate-advanced	-0.15001	1	0.3469	0.5558887
asp-len	native Korean-beginner	2.67316	1	148.7811	< 2.2e-16 ***
	native Korean-intermediate	2.20509	1	86.6162	< 2.2e-16 ***
	native Korean-Advanced	1.64597	1	40.4666	7.200e-10 ***
	beginner-intermediate	-0.46807	1	4.7680	0.0434898 *
	beginner-advanced	-1.02719	1	18.5888	4.170e-05 ***
	intermediate-advanced	-0.55912	1	4.8192	0.0434898 *
for-len	native Korean-beginner	2.10951	1	92.6529	< 2.2e-16 ***
	native Korean-intermediate	1.87498	1	62.6237	1.126e-14 ***
	native Korean-Advanced	1.53424	1	35.1592	9.115e-09 ***
	beginner-intermediate	-0.23453	1	1.1970	0.3081590
	beginner-advanced	-0.57527	1	5.8303	0.0283550 *
	intermediate-advanced	-0.34074	1	1.7898	0.2326489