Effects of cross-language acoustic similarity on non-native speakers' perception of Korean vowels

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Introduction

- Adult second language (L2) listeners have perceptual difficulty with some L2 vowels (Flege 1995; Best et al 1996; Levey & Strange 2002).

- Korean learners of English: English tense/lax distinction
  e.g. beat-bit (/i/-/ɪ/) (Yang 1992, 1996; Flege et al 1997; Koo 2000)

L2 speech sound acquisition

- **Speech Learning Model(SLM) & Perceptual Assimilation Model(PAM)**
  - L2 categories are perceived according to similarities and dissimilarities from native-language sounds (Flege 1995; Best 1995; Best and Tyler 2007)

- **L2 Linguistic Perception Model(L2LP)**
  - Acoustic comparisons should be quantitative measures of cross-linguistic similarity (Escudero 2005, 2006, 2009)
  - Linear discriminant analyses (LDA) models (Klecka 1980)

Goals

- **To investigate how adult Mandarin- and English- speaking learners of Korean perceive Korean vowels / ɨ, ʌ , o, u/.**

  e.g: Native Korean [ki.pun] 'feeling' > L2 learners [ki.pʌn]

(1) Effects of L1 vowel inventory size

Having a smaller L1 vowel inventory than L2 impedes L2 vowel perception, while having a larger one often facilities it. (Scholes 1968; Bradlow 1995; Fox et al 1995; Iverson and Evans 2007, 2009)

(2) Effects of cross-language acoustic similarity

L1/L2 acoustic relationship affects L2 sound perception.
(Vasiliev 2013; Elvin et al 2014; Escudero et al 2014).

(3) Effect of L2 experience/proficiency

The experienced L2 learners produce and perceive non-native sounds more accurately than do the relatively inexperienced L2 learners. (Flege 1997; Derwing et al 2008)

Research questions & Hypotheses (1)

- **The effect of L1 vowel inventory size on L2 vowel perception**

Mandarin	Korean	English
5 vowels /i, y, ə, u, ɑ/	7-8 vowels / a, (ɛ), e, i, o, u, ɨ, ʌ /	11 vowels / i, ɪ, æ, e, ɛ, ɑ, ʌ, ʊ, o, ɔ, u /

Research question1

Do L2 learners, who have different vowel inventory size, perform differently on non-native vowel perception?

Hypothesis1

English listeners with a large vowel inventory system are expected to have higher identification accuracy for all Korean vowels than Mandarin listeners with a small vowel inventory system.

Research questions & Hypotheses (2)

- **The effect of L1/L2 acoustic similarity and difference on L2 vowel perception.**

Research question2

Does L1-L2 acoustic relationship influence non-native sound perception?

Hypothesis2

Acoustic similarity between L1 and L2 vowels can accurately predict Mandarin and English listeners' Korean perceptual difficulty.

Research questions & Hypotheses (3)

- **The effect of L2 proficiency on L2 vowel perception**

Research question3

To what extent does a learner's L2 proficiency affect L2 vowel perception?

Hypothesis 3

The higher the proficiency English and Mandarin L2 learners have in Korean, the more likely they are to attain a Korean native-like performance in their perception.

Experiment 1:
A comparative acoustic study of Korean, English and Mandarin vowels

Experiment 2:
Perception of Korean vowels by Mandarin and English listeners

Experiment 1

Participants

- 68 female speakers of Mandarin, English and Korean
  - 37 female native Mandarin speakers (mean age = 21.1 years old)
  - 23 female native English speakers (mean age = 20.95 years old)
  - 8 female native Korean speakers (mean age = 23.46 years old)

Stimuli

- Mandarin: five vowels in the /hVdə/ context (Liao 2008)
- Korean: seven vowels in the /hVda/ context (Yang 1996)
- English: eleven vowels in the /hVd/ context (Hillenbrand et al 2001)

Experiment 1

Procedure

- Read words containing target vowels presented in their native language on a computer screen using PsycoPy (Pierce 2007).
- Each set of words appeared three times in isolation.

Acoustic measurements

- F1 and F2 values (mid 10%) in Praat (Boersma and Weenink 2011)
- 1,341 tokens (English tokens: 723, Mandarin tokens: 472, Korean tokens: 146) were acoustically analyzed.

Experiment 1

Linear discriminant analysis (Klecka 1980)

- To make L2 perceptual difficulty predictions, LDA has been used. (Strang et al 2004, 2005; Gilichinskaya and Strange 2010)
- A cross-language discriminant analysis was used to quantify the relationships between Koran-Mandarin, Korean-English vowels.
- Input parameters: F1, F2 bark values

Vowel space of Korean, English and Mandarin vowels

- Korean [u] and [o] overlap substantially (Chae 1999, Seong 2004, Kim et al 2006, Han and Kang 2013, Y. Kang 2015)

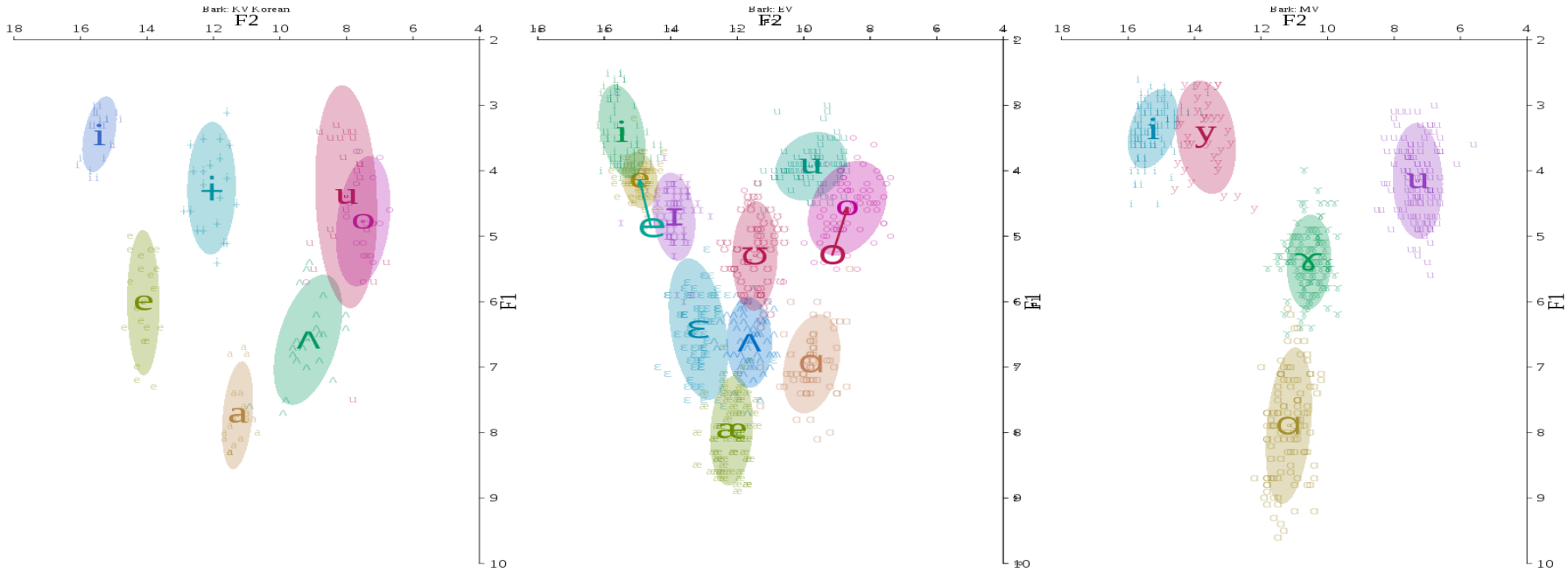

Figure 1. Average F1 and F2 values of Korean, English and Mandarin vowels
(The ellipses represent one standard deviation from the mean)

Acoustic comparison of Korean and Mandarin vowels

- Korean /i/ and /a/ are acoustically most similar to Mandarin /i/ and /ɑ/ respectively.
- Korean both /o/ and /u/ are acoustically very close to Mandarin /u/, which would lead to perceptual difficulty for Mandarin learners of Korean.

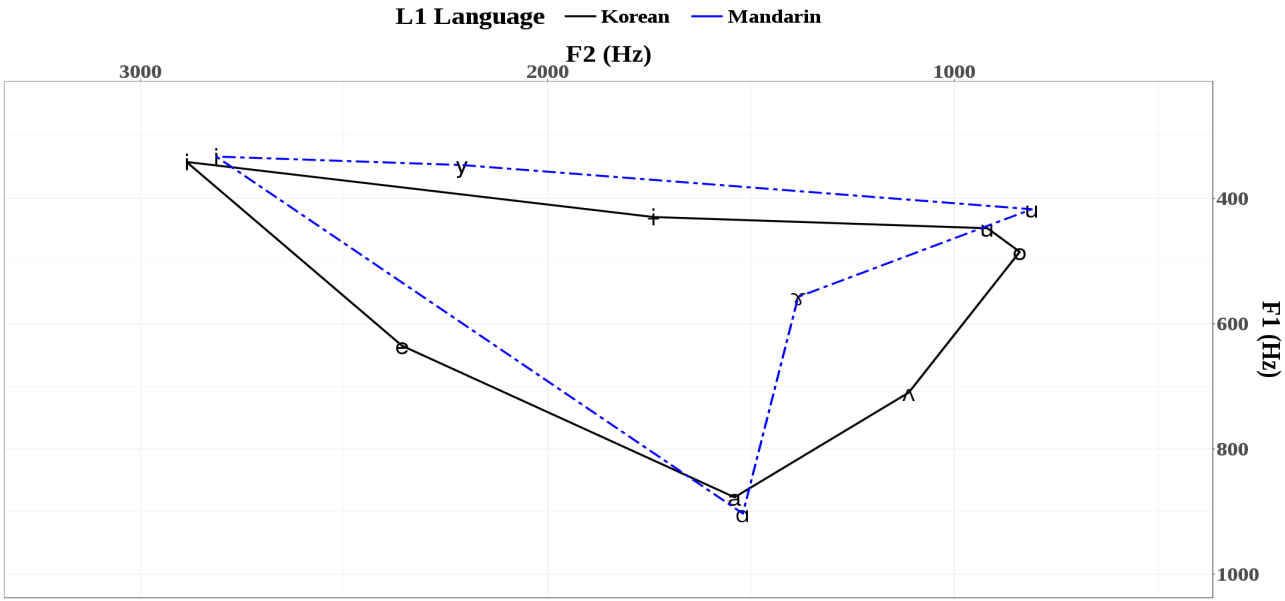

Figure 2. Average F1 and F2 values of Mandarin (blue) and Korean vowels (black) of adult speakers

Korean vowel tokens classified across Mandarin vowels using cross-language LDA

Prediction of perceptual difficulty ranking for Mandarin learners of Korean

: i, a, e, >> ɨ, ʌ, o,u (most difficulty)

vowel	ɑ	ɤ	i	u	y
a	19	0	0	0	0
e	1	0	0	0	20
i	0	0	22	0	0
ɨ	0	10	0	0	11
o	0	1	0	19	0
u	0	2	0	19	0
ʌ	4	14	0	4	0

Acoustic comparison of Korean and English vowels

- Korean /i/ is acoustically close to English /i/.
- Korean /u/ is higher in F1 values and lower in F2 values than English /u/, while Korean /o/ is lower both in F1 and F2 values than English /o/, which could lead to confusion and discrimination difficulty.

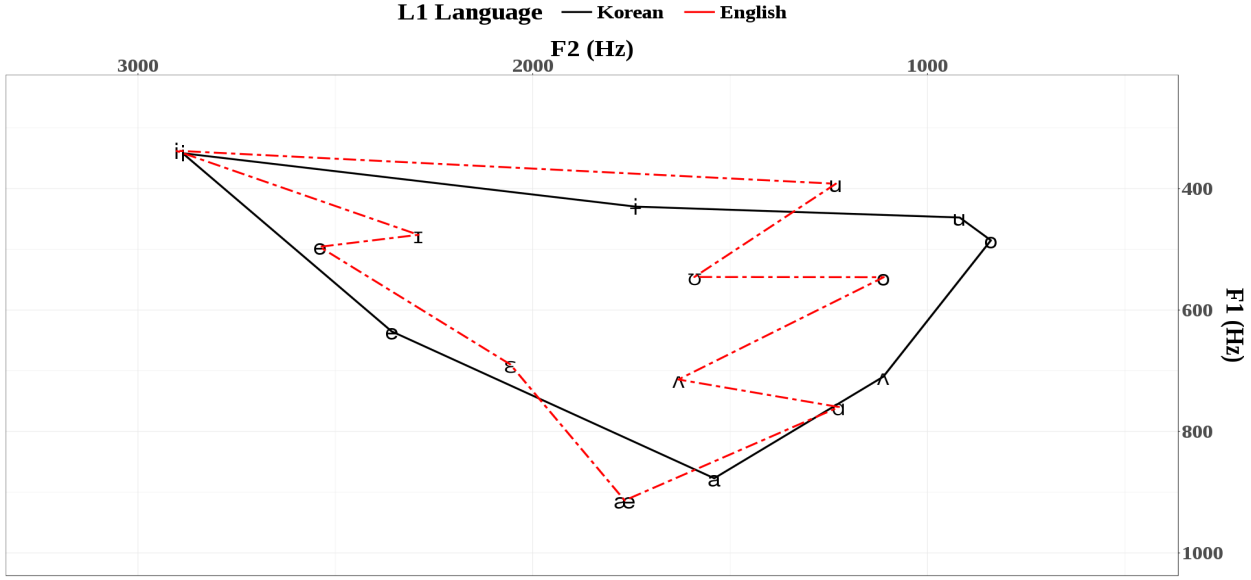

Figure3. Average F1 and F2 values of Canadian English (red) and Korean vowels (black)

Korean vowel tokens classified across English vowels using cross-language LDA

Prediction of perceptual difficulty ranking for English learners of Korean:
i, a, e, ɨ, ʌ >> o, u (most difficult)

vowel	æ	ɑ	e	ɛ	i	ɪ	o	ɔ	u	ʊ	ʌ
a	14	2	0	0	0	0	0	0	0	0	3
e	0	0	0	12	0	9	0	0	0	0	0
i	0	0	2	0	**20**	0	0	0	0	0	0
ɨ	0	0	0	0	0	6	0	0	1	14	0
o	0	0	0	0	0	0	19	1	0	0	0
u	0	1	0	0	0	0	19	0	1	0	0
ʌ	0	16	0	0	0	0	2	4	0	0	0

Experiment 2:
Perception of Korean vowels by Mandarin and English listeners

Experiment 2

Participants

- A total of 82 participants, 40 Mandarin and 29 English learners of Korean and 13 native speakers of Korean participated.
- Divided into two proficiency groups based on their years in Korean language programs at the University of Toronto.

	# of participants	Self-assessment Korean proficiency
Low proficiency learners (EAS110, EAS210)	English: 19 Mandarin: 20	English (3.33) Mandarin (3.09)
High proficiency learners (EAS310, EAS410)	English: 10 Mandarin: 20	English (3.57) Mandarin (4.08)
Native Korean (control group)	13	NA

Experiment 2

Stimuli

- **92 Korean nonsense words**, including the target four vowels /ɨ, o, u, ʌ/ which are relatively difficult to acquire for L2 learners (E. Kim 2009; J. Kim 2013)

Audio recording

- Recorded by a native male Korean speaker (46 years old)

Procedure

- Participants were asked to listen to a Korean stimulus and determine whether the stimulus was A, B, C or D presented on a computer screen by pressing the corresponding numbers 1, 2, 3, or 4 on the keyboard, respectively.
- It consisted of **92 trials** and all trials were randomly presented to each participant.

Experiment 2

Statistical analysis

- A mixed-effects logistic model in R (Baayen 2008; R CoreTeam 2012)
  - The package *lme4* (Bates et al 2011)
  - Dependent variable: response (correct:1, incorrect:0)
  - Fixed effects: L1 language, L2 proficiency
  - Random effect: speakers

Effects of L1 background

- Neither Mandarin nor English listeners reached the accuracy level of native speakers of Korean (P-value < 0.001)
- English listeners showed marginally higher identification accuracy for Korean vowels than Mandarin listeners (P- value < 0.061)

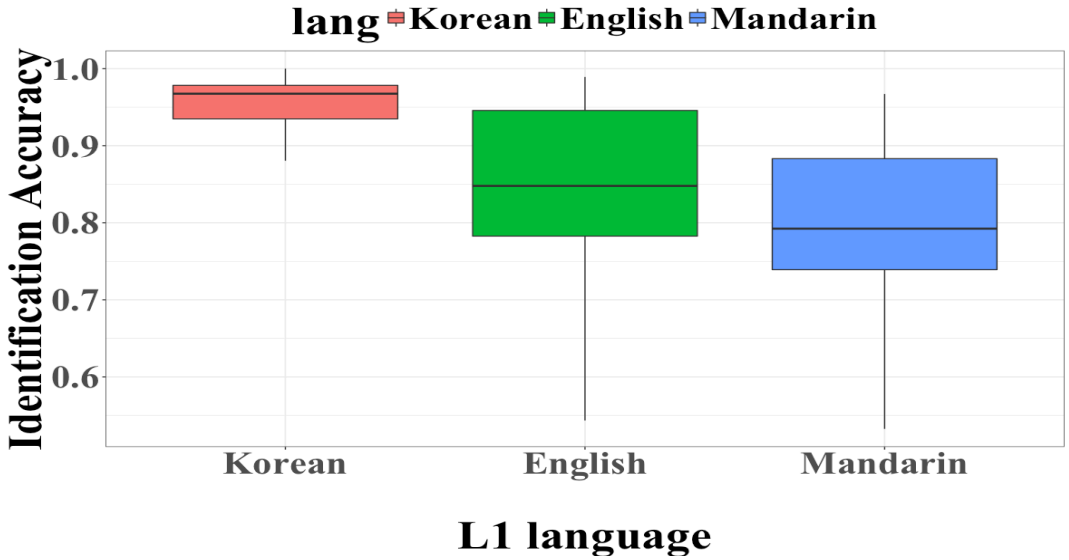

Figure 4. Identification accuracy of Korean vowels by L1 language

Response patterns of Korean vowels by L1 language

- Perceptual difficulty of L2 learners from least to most difficult: **ɨ > ʌ > u > o.**
- English listeners were more successful at identifying /ʌ , u, o/ than Mandarin listeners, while they were less accurate at identifying /ɨ/ than Mandarin listeners.

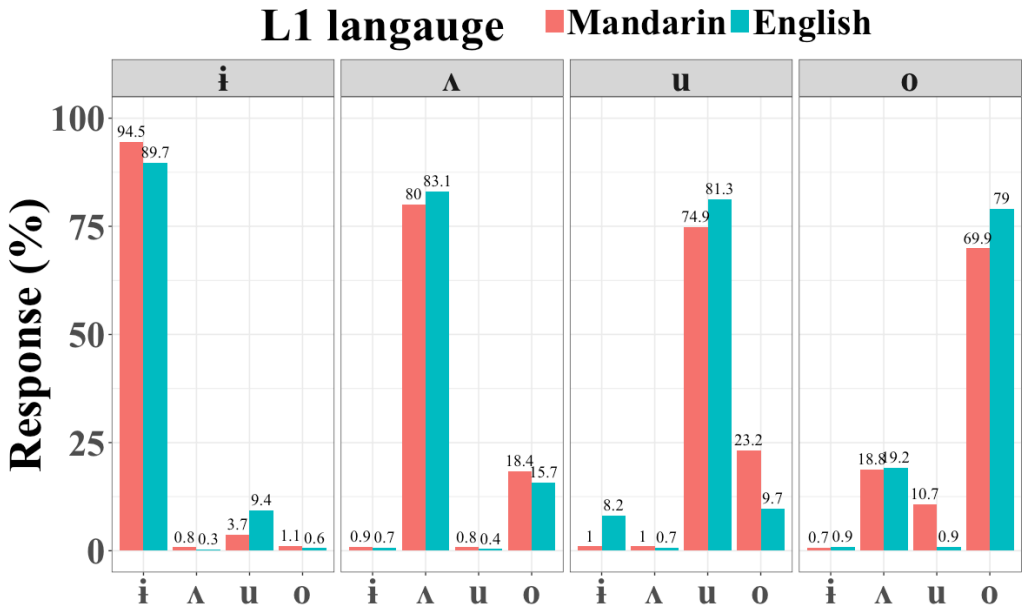

Figure 5. Distribution of response patterns of the Korean vowels by Mandarin and English listeners

Effects of L2 proficiency

- Neither high L2 proficiency nor low proficiency groups attained Korean native-like perception.
- Identification accuracy increases as L2 proficiency rises (P-value <0.018)

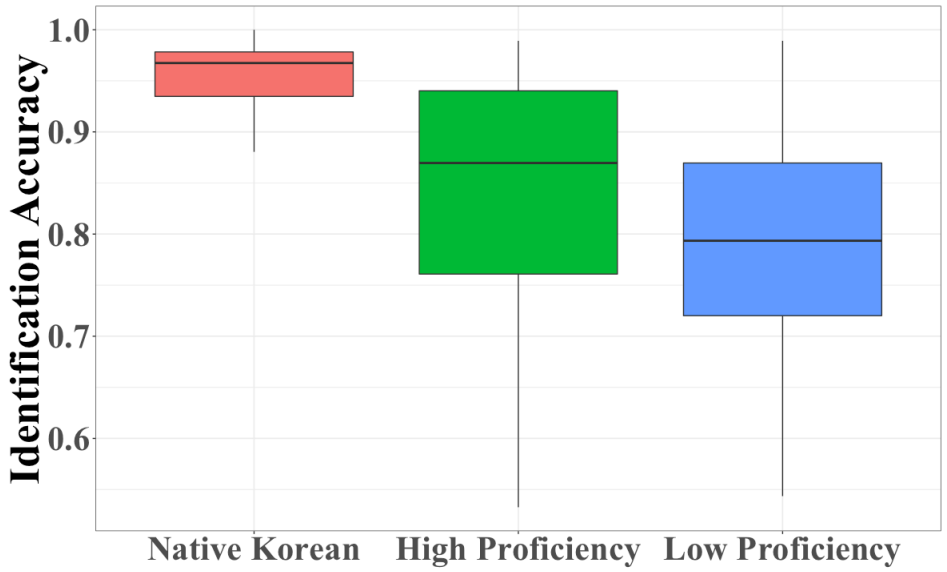

Figure 6. Identification accuracy of Korean vowels by L2 proficiency levels

Response patterns of Korean vowels by L2 proficiency

- Korean listeners were extremely good at identifying vowels except for Korean /u/, suggesting that Korean /o/ and /u/ are a merge in progress.
- Identification accuracy for all vowels increases as L2 proficiency rises.

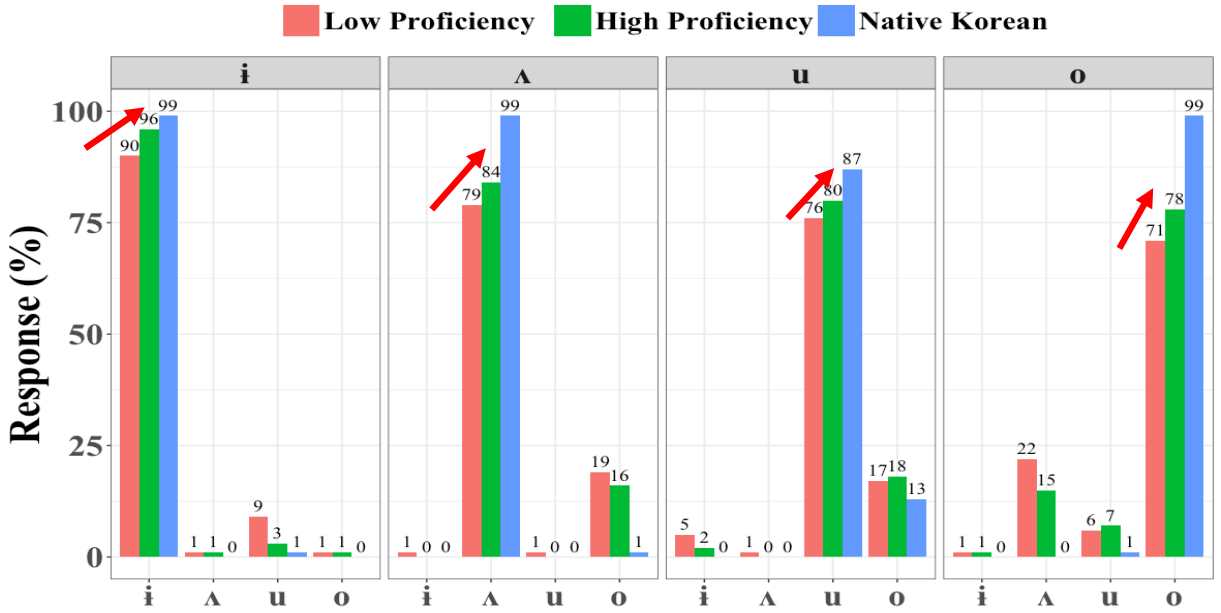

Figure 7. Distribution of response patterns of the Korean vowels by L2 proficiency levels

Effects of interaction between L1 background and L2 proficiency

- There is no interaction between L1 language and L2 proficiency, suggesting that identification accuracy of L2 vowels is higher as L2 proficiency increases regardless of their L1 background (P-value <0.14).

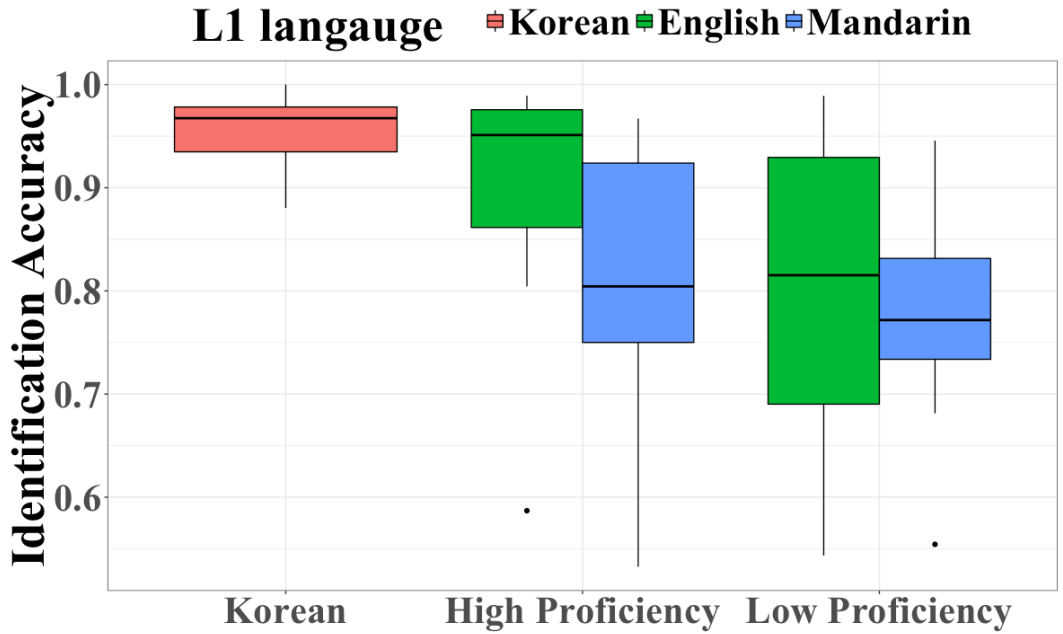

Figure 8. Identification accuracy of Korean vowels in the interaction of L1 background and L2 proficiency levels

Conclusion

- **The marginal effect of L1 vowel inventory size on L2 vowel perception**
  - There was a marginal effect of L1 language background (P <0.061).
  - English listeners were better than Mandarin listeners in their identification of /o, u, ʌ/, while Mandarin listeners had a higher accuracy than English listeners in only /ɨ/.

- **The effect of cross-language acoustic similarity on L2 vowel perception**
  - Prediction of perceptual difficulty for L2 listeners using LDA models was borne out.
    - Mandarin listeners (most difficult: ɨ, ʌ, o, u), English (most difficult: u , o)
  - Results of Korean vowel identification task found:
    - Perceptual difficulty for both Mandarin and English listeners: ɨ > ʌ > **u > o.**
  - Findings from the identification task are **partially** in line with acoustic predictions.

- **The effect of L2 proficiency on L2 vowel perception**
  - L2 proficient listeners had better identification accuracy than low proficient listeners (P<0.010).

Limitations

Why is perceptual difficulty not fully predicted by LDA?

- Allophones and Mandarin diphthongs are not taken into account.
- Audio stimuli was recorded by a male Korean 40 years of age, but participants for perception experiments were in their 20s.
- Production data: /hVd(a/ə)/ vs. Perception data: all contexts

Future studies

- Having a larger and more complex first-language vowel inventory **is not always a good predictor for L2 perceptual difficulties**, as reported in previous literature (Iverson and Evans 2009, 2009; Allispahic et al 2017).

- Further analyses should be undertaken to generate more accurate perception predictions based on quantitative measures of cross-linguistic similarity between L1 and L2, such as **Euclidean Distance.**

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