The Phonetic Space of Phonological Categories in Heritage Speakers of Mandarin

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Outline

1. Background and research questions
2. Methods
3. Experiment 1: vowel contrast
4. Experiment 2: laryngeal contrast
5. Discussion
6. Conclusions
This study examines production of Mandarin and English in heritage speakers of Mandarin, native Mandarin speakers, and native English speakers learning Mandarin as a foreign language.

Heritage speakers of Mandarin (narrow definition):

people who have had exposure to Mandarin in their family but have shifted to primarily using English
Background

- A few studies have examined the phonological competence of heritage speakers:
  - Au et al. (2002), Knightly et al. (2003): heritage speakers of Spanish have a phonological advantage over late learners (VOT, degree of lenition, and accent ratings).
  - Godson (2003): heritage speakers of Armenian show influence in their Armenian vowels from English, but only for Armenian vowels close to English vowels.
Research Questions

- Do heritage speakers maintain contrasts in both the heritage language and the dominant language? If so, do they realize the contrasts in the same way as native speakers?

- Do heritage speakers maintain contrasts between segments of the heritage language and “similar” segments of the dominant language?

- Do these categories undergo equivalence classification and interact with each other (cf. Flege 1987)?
In previous work on heritage speakers’ fricative production (Chang et al. 2008), we found:

- Native speakers and late learners fail to distinguish Mandarin /ʂ/ and English /ʃ/, while heritage speakers tend to keep the two sounds distinct.

- There is a correspondence between heritage speakers’ linguistic performance and amount of exposure to the heritage language.
In this study, we focus on vowel categories and stop consonant categories.

**Experiment 1:** five vowel categories
- English /u/, English /ou/
- Mandarin /u/, Mandarin /ou/
- Mandarin /y/

**Experiment 2:** four laryngeal categories
- English voiced (unaspirated) stops /b, d, g/
- English voiceless (aspirated) stops /p, t, k/
- Mandarin (voiceless) unaspirated stops /p, t, k/
- Mandarin (voiceless) aspirated stops /pʰ, tʰ, kʰ/
1. Background and research questions

2. Methods

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4. Experiment 2: laryngeal contrast

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Methods

- **Participants**
  - 18 speakers total
    - 5 native speakers of Mandarin
    - 8 heritage speakers of Mandarin
    - 5 late learners of Mandarin

- **Questionnaire**
  - Speakers’ status (and rank) determined based on a language background questionnaire regarding geographic history, past and current Mandarin use, formal language education, etc.

- **Recordings**
  - Made in a sound-attenuated room (at 48 kHz, 16 bps)
  - Marantz PMD660 / M-AUDIO pre-amp, AKG C420/C520 head-mounted condenser microphone
Methods

Stimuli

- **Experiment 1**
  - English: 11 /CuC/ words, 10 /CouC/ words
  - Mandarin: 10 /Cu/ words, 7 /Cou/ words, 3 /Cy/ words

- **Experiment 2**
  - English: 12 stop-initial CVC words (2 per place/laryngeal category)
  - Mandarin: 12 stop-initial CV words (2 per place/laryngeal category)

- **Experiments 1 and 2**
  - segmental context matched across language as much as possible
  - falling tones chosen for Mandarin words if possible (e.g. *tote* / tòu 透)
Methods

- **Stimulus presentation**
  - words read off of flashcards
    - English words written in English orthography
    - Mandarin words written in Mandarin orthography (traditional and simplified characters) and Romanization (pinyin and BoPoMoFo)
    - all words written and read in isolation
  - words produced in 8 blocks
    - 4 Mandarin blocks, 4 English blocks
    - one block consisted of all words from a given language
    - words randomized before each block
Methods

- **Acoustic measurements**
  - All measurements were taken by hand in Praat (Boersma & Weenink 2008).
  - *Experiment 1*: average values of F1, F2, and F3 were measured over the whole duration of the vowel.
  - *Experiment 2*: VOT values were measured for word-initial stops.

- **Analysis of data**
  - Statistical analyses were performed using the Wilcoxon matched pairs signed-rank test and Spearman’s nonparametric correlations.
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Experiment 1: Vowel Targets

- Mandarin back vowels (cf. Wu & Lin 1989)
  - /u/  
    - F1: 351 Hz (m.) / 411 Hz (f.)  
    - F2: 454 Hz (m.) / 639 Hz (f.)
  - /ou/  
    - F1: 554 Hz (m.) / 726 Hz (f.)
    - F2: 711 Hz (m.) / 917 Hz (f.)

- English back vowels (cf. *Hagiwara 1997, **Labov et al. 2006)
  - /u/  
    - F1: *323 Hz (m.) / *395 Hz (f.)
    - F2: *1417 Hz (m.) / *1700 Hz (f.) / **1520 Hz
  - /ou/  
    - F1: *437 Hz (m.) / *516 Hz (f.)
    - F2: *1188 Hz (m.) / *1391 Hz (f.) / **1233 Hz
Experiment 1: Results

Mean Formant Values of English /u/

![Graph showing mean formant values of English /u/ for different groups.](image)
Experiment 1: Results

Mean Formant Values of Mandarin /u/

Mean F2

Mean F1

- Mandarin Speakers - Mandarin /u/
- Heritage Speakers - Mandarin /u/
- English Speakers - Mandarin /u/
Experiment 1: Results

Mean Formant Values of Mandarin /y/

Mean F2

Mean F1

- Mandarin Speakers /y/
- Heritage Speakers /y/
- English Speakers /y/
Experiment 1: Results

Mean Formant Values of Mandarin /y/, Mandarin /u/, and English /u/
Experiment 1: Results

Mean Formant Values of English /ou/

- Mandarin Speakers - English /ou/
- Heritage Speakers - English /ou/
- English Speakers - English /ou/
Experiment 1: Results

Mean Formant Values of Mandarin /ou/
Experiment 1: Results

Mean Formant Values of Mandarin and English /ou/
Experiment 1: Results

- **Mean F2 for /u/+/y/, by speaker (L = f, R = m)**

![Graphs showing F2 frequency for different genders and vowels](image-url)
Experiment 1: Results

- Mean F2 for /ou/, by speaker (L = f, R = m)
The results of Experiment 1 show:

- Mandarin back vowels are produced with lower F2 values than English back vowels by all speakers.
- Native Mandarin speakers’ back vowels have lower F2 values than those of heritage speakers and late learners in both languages.
- Speaker rank (based on experience with Mandarin) is negatively correlated with F2 in the front vowel /y/ ($r = -0.149$, $p < 0.05$), but positively correlated with F2 in all back vowels ($r$’s from 0.309 to 0.528, all $p$’s < 0.0001).
1. Background and research questions
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4. **Experiment 2: laryngeal contrast**
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Experiment 2: VOT Targets

- Mandarin VOTs (in ms)

<table>
<thead>
<tr>
<th>/p/</th>
<th>/t/</th>
<th>/k/</th>
<th>/pʰ/</th>
<th>/tʰ/</th>
<th>/kʰ/</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>7</td>
<td>15</td>
<td>106</td>
<td>113</td>
<td>116</td>
</tr>
</tbody>
</table>

(Wu & Lin 1989)

- English VOTs (in ms)

<table>
<thead>
<tr>
<th>/b/</th>
<th>/d/</th>
<th>/g/</th>
<th>/p/</th>
<th>/t/</th>
<th>/k/</th>
</tr>
</thead>
<tbody>
<tr>
<td>18*</td>
<td>24*</td>
<td>27*</td>
<td>58**</td>
<td>70**</td>
<td>80**</td>
</tr>
</tbody>
</table>

(*Byrd 1993, **Lisker & Abramson 1964)
Experiment 2: Results

- Mean VOTs, by speaker (L = f, R = m)

![Graph showing mean voice onset times for different laryngeal categories with error bars]

Error bars: +/- 1 SE
Experiment 2: Discussion

The results of Experiment 2 show:

- All speakers distinguish English *voiced* vs. *voiceless*, and Mandarin *unaspirated* vs. *aspirated*.
- Most native Mandarin speakers and heritage speakers have longer VOTs for Mandarin aspirated than for English voiceless (aspirated).
- Most of the late learners fail to distinguish Mandarin aspirated and English voiceless.
- Speaker rank is negatively correlated with VOT for Mandarin aspirated ($r = -0.330, p < .0001$).
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Research questions revisited:

- Do heritage speakers maintain contrasts in both the heritage language and the dominant language?
  
  Yes.

- Do they realize the contrasts in the same way as native speakers?
  
  No, but they come closer than late learners.
Research questions revisited:

- Do heritage speakers maintain contrasts between segments of the heritage language and “similar” segments of the dominant language?
  
  *Yes, but other speakers do as well.*

- Do these categories undergo equivalence classification and interact with each other?
  
  *Not necessarily.*
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Conclusions

- Consistent with our previous findings, the current results suggest:
  - There is a correspondence between heritage speakers’ linguistic performance and amount of exposure to the heritage language.
  - Heritage speakers tend to be better at maintaining contrasts between “similar” categories in two languages.
Conclusions

Two possible explanations:

- **Hypothesis 1**: early exposure to both languages makes heritage speakers better at accurately hitting two close targets.

- **Hypothesis 2**: early-acquired categories interact and are dissimilated from each other (i.e. “polarization” occurs, cf. Laeufer 1997).
Re: Hypothesis 1 –

- What are the native targets, and how close do heritage speakers come to hitting these targets?
- Our current data are consistent with this hypothesis, but not conclusive.
- More data are required.
Re: Hypothesis 2 –

Do heritage speakers effect larger differences between categories than native speakers and late learners?

Our current data are insufficient to support/refute this hypothesis.

There may be floor effects and intrusion into the vowel space on the other side for /u/. 
Conclusions

Mean F2 Difference between English and Mandarin /u/ for
(1) Mandarin Speakers, (2) Heritage Speakers, and (3) Mandarin Learners
Thank you!

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