Acoustic and articulatory correlates of lexical-stress in Mandarin accented English

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INTRODUCTION

- L2 sound contrasts that do not exist in the L1 system are often explained in connection with the L1 system. However, this phenomenon has been largely discussed in segmental level rather than suprasegmental level (e.g., lexical stress).
- L2 speakers' articulatory realization of suprasegmental factor has been the focus of less research, and it is, therefore less well understood.
- In American English, both spectral and temporal cues are used to realize tense-lax contrasts [1-2] and lexical-stress [3-7].
- Mandarin L2 speakers exhibited limited use of spectral cues realizing tense-lax distinction [8-10], and lexical-stress [11-14].
- The current study combines these segmental (tense-lax contrasts) and suprasegmental (lexical-stress) factors to examine their interaction.
- It investigated how Mandarin L2 speakers resemble or differ from L1 speakers in using spectral and temporal cues, when tense-lax contrasts and lexical-stress are examined together.

Hypothesis
Mandarin L2 speaker retains the tense-lax contrast that are modulated by lexical stress in a temporal domain but not in spectral domain.

METHOD

- Subset of publicly available Mandarin Accented English Electromagnetic Articulography Corpus was used [24].
- A total 12 speakers' data was analyzed; 6 speakers (3 M; 3 W) from L1 and L2 groups, respectively.
- Target vowels were stressed and unstressed /i - ɪ/ and stressed /u - ʊ/, as unstressed /u - ʊ/ tokens did not occur in sufficient numbers to run statistics (total 3859 tokens).
- Vowel duration (ms) was calculated based on the start and the end of target vowels
- First two formants were extracted using seeding method [25].
- Tongue tip (TT) and tongue dorsum (TD) locations were extracted from the mid-point of each vowel.
- Outliers of both acoustic and articulatory data were removed using elbow method [26] and normalized within each speaker, using a z-score.
- To examine how well the tense-lax pair is separated in spectral domain, the proportion of the overlap area of the vowel ellipses was calculated.

BACKGROUND

Vowel system of Mandarin and English

English [1-2]

- English tense vowels are articulated in more peripheral locations of the vocal tract than lax vowels and feature longer durations than do lax vowels [1-2].

Mandarin [10]

- Mandarin consists of smaller vowel inventory, /a, i, u, y, ə/.
- Mandarin lacks tense-lax distinction.
- In previous studies, when realizing English tense-lax contrast, Mandarin L2 speakers relied more on temporal cue than spectral cues [8-10].

Lexical-stress in Mandarin and English

English

- Stressed syllables are produced with longer **durations**, increased intensities as well as clearer spectral information, relative to unstressed syllables [3-7].
- Articulatory movement becomes larger, longer and faster in prominent speech units by L1 speakers [15-19].
- **Vowel quality** (i.e., full vs reduced) plays crucial role to realize lexical-stress [3,7,12-13].

Mandarin [20]

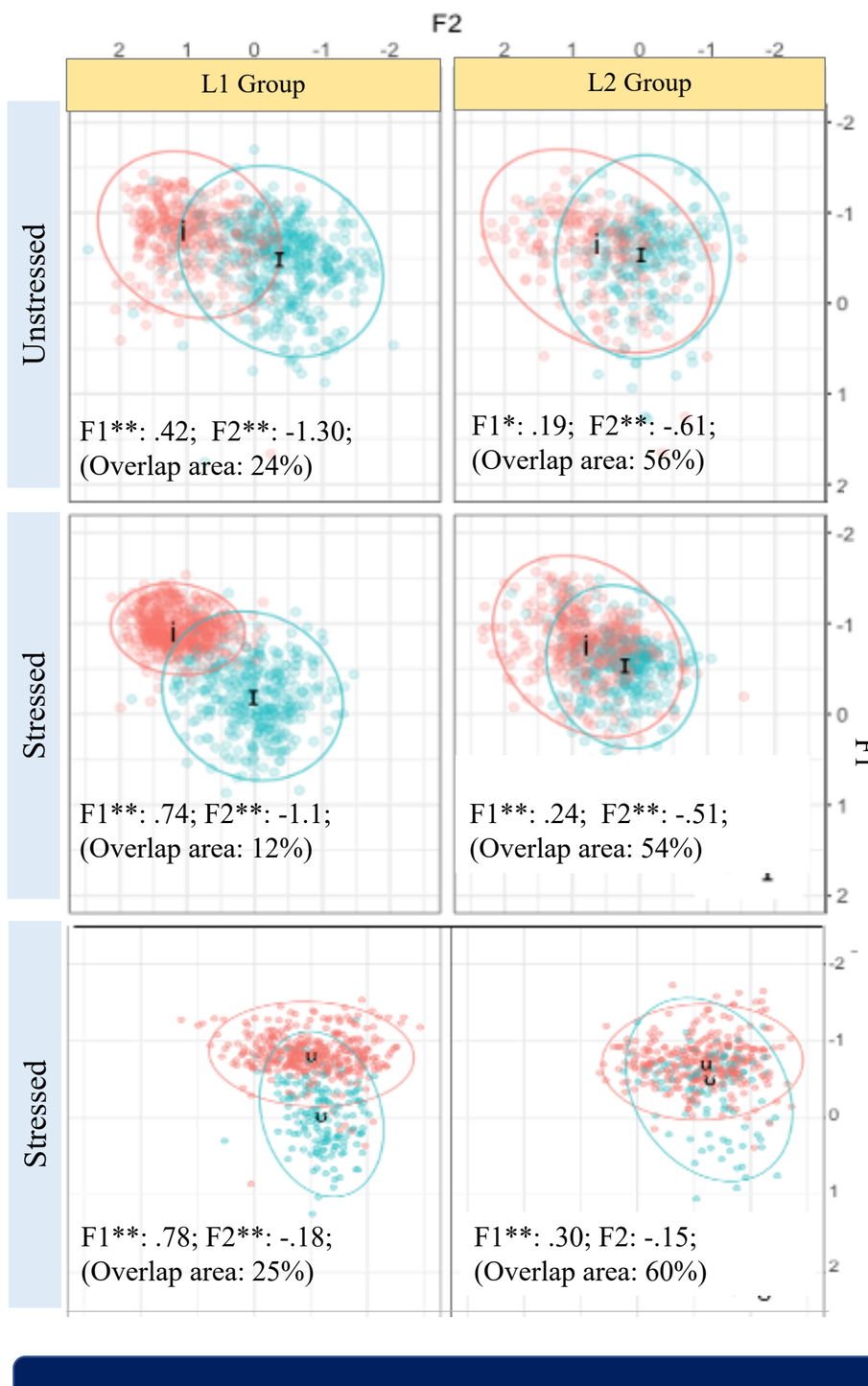
- Lexical tone: full tone *vs* neutral tone
- Stress in Mandarin is encoded in the lexical entry (e.g., *-zi*, *-le*).
- Unstressed morpheme is limited to the syllable that carries a neutral tone.
- Example of contrastive stress (the first syllable must be stressed)

东西	*dōngxī*	'east-west'	(stressed-stressed)
	dōngxi	'stuff'	(stressed-unstressed)

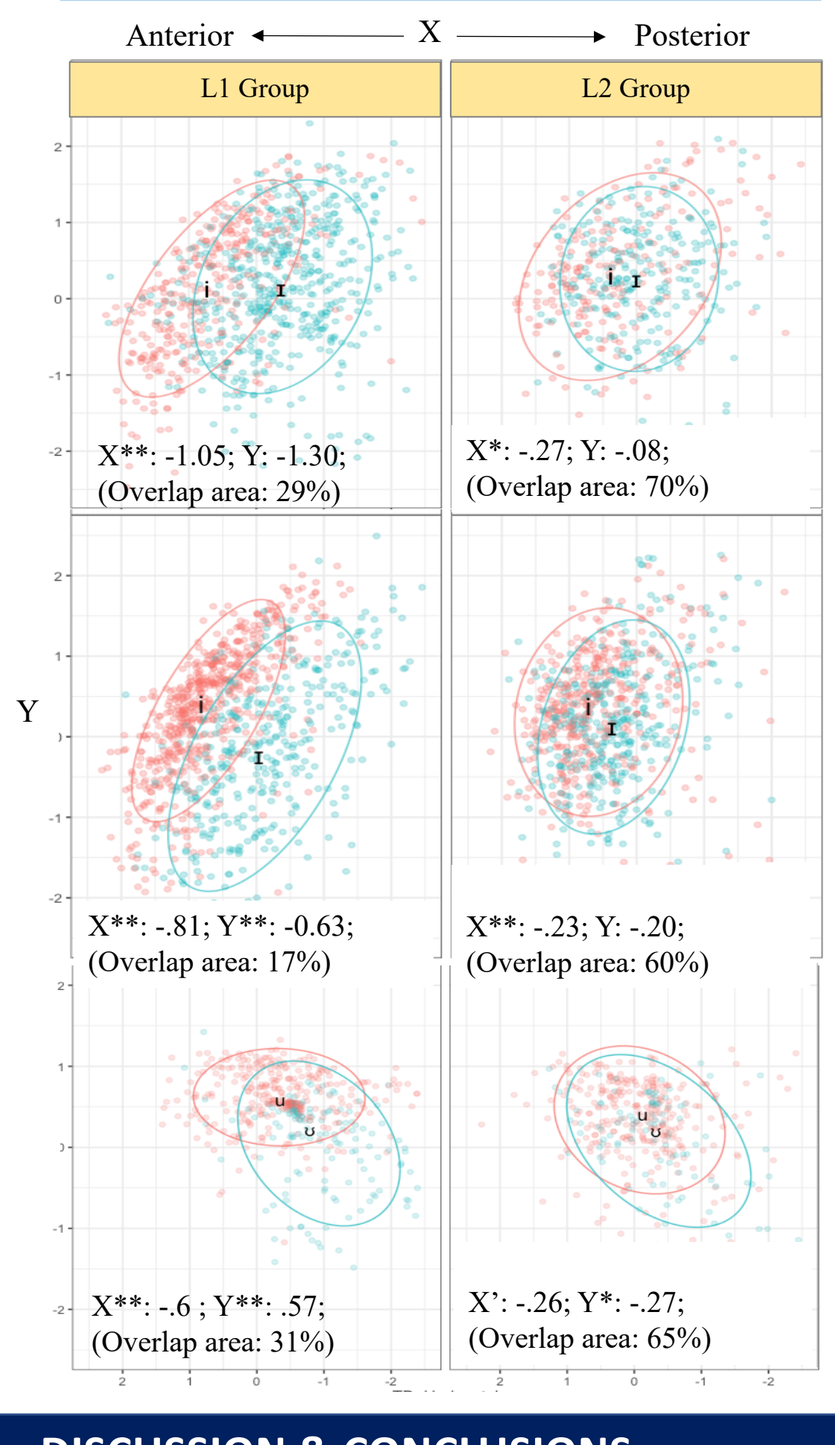
- **Duration** is the primary cue to the stress contrast [21-22].
- F0 is the secondary cue: F0 of an unstressed syllable carrying a neutral tone depends on the lexical tone of the preceding syllable.
- **Vowel quality** is not considered important as a cue to Mandarin stress, at least as compared to English stress [21,23].

RESULTS

Spectral domain: formants

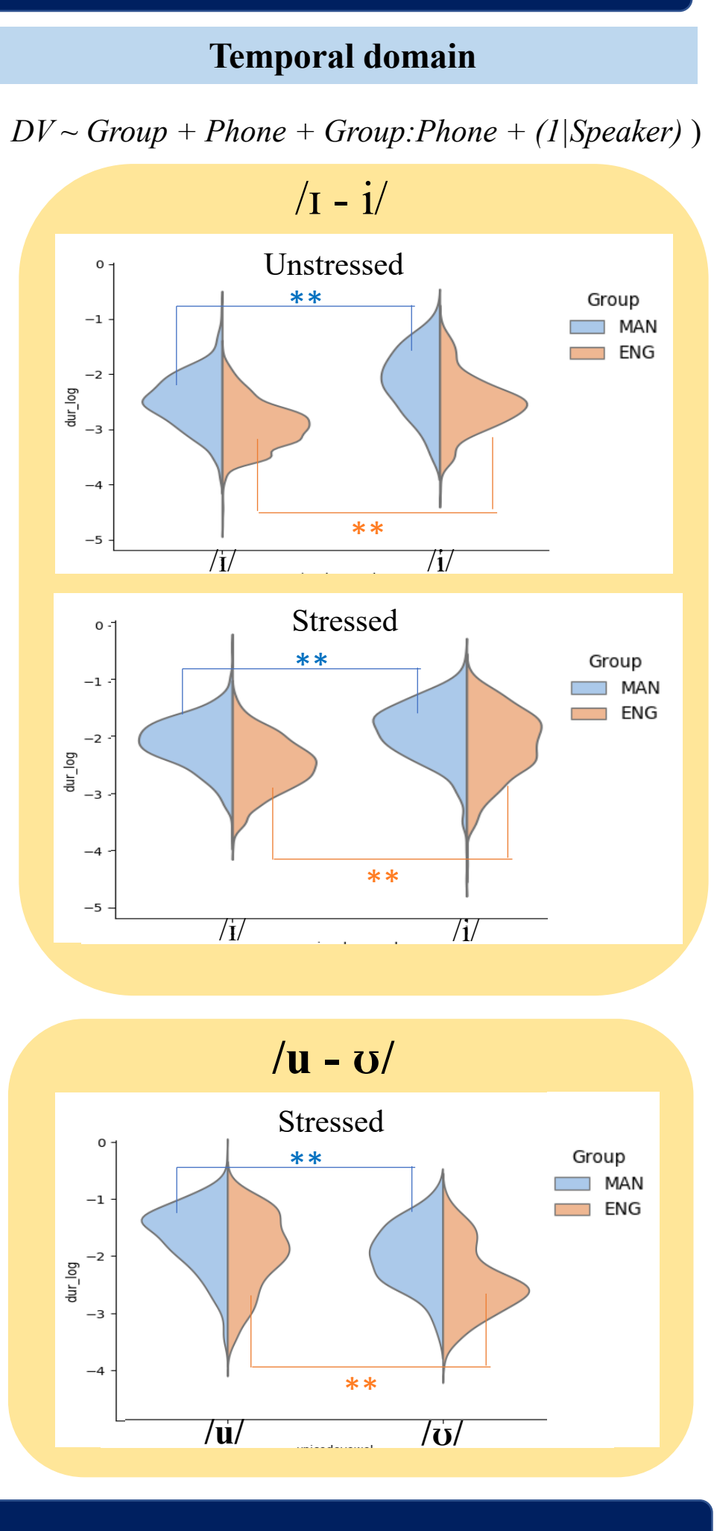


Spectral domain: TT (/i - ɪ/) and TD (/ʊ- u/)



Temporal domain

DV ~ Group + Phone + Group:Phone + (1|Speaker))



DISCUSSION & CONCLUSIONS

- Mandarin L2 speakers merged tense-lax contrasts in the spectral domains showing larger overlap in vowel ellipses, regardless of stress conditions.
- Mandarin L2 speakers retained the contrasts in temporal domain in both stressed and unstressed conditions.
- Examining F0 would be interesting as F0 is a secondary cue to Mandarin lexical-stress, while it is a cue to phrasal prominence (i.e., sentential stress) in English.
- Future study is needed to examine other articulatory gestures such as lips aperture, and/or jaw movements to better understand the articulatory correlates of lexical-stress and the kinematics of L2 vowel production.

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