Conditions on Adaptation to an Unfamiliar Lexical Tone System: The Role of Quantity and Quality of Exposure

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INTRODUCTION

The perceptual system routinely handles rich variation in speech and tends to accommodate such variation efficiently and effectively
(Munro & Derwing, 1995; Weil, 2001; Norris, McQueen, & Cutler, 2003; Clarke & Garrett, 2004b; Zheng et al., 2005; Bradlow & Bent, 2008; Best et al., 2015).

Adaptation to unfamiliar speech–e.g., from an unfamiliar accent–typically requires "adequate exposure" to the target speech

But what makes the exposure "adequate"?

Previous assumption: both **quality** and **quantity** of the spoken stimuli affect the adaptation outcome

Quality (source, structure & type of exposure):
Discrimination of a novel segmental contrast was significantly enhanced when lexical information was present (Norris et al. 2003; Hayes-Harb 2007)

Is adaptation to novel tones facilitated when clear tonemic contrasts (minimal pairs) are in the stimuli?

Quantity (amount of exposure):
Though adaptation often relies on explicit training for sufficient input, short-period incidental exposure also initiated successful adaptation to unfamiliar speech (Clarke & Garrett 2004; Bradlow & Bent 2008)

Does discrimination of unfamiliar tones improve with increased incidental exposure?

Previous study: Native Standard Mandarin listeners adapted to a novel lexical tone system from the Chengdu Mandarin dialect with less than two minutes of incidental exposure from sentential stimuli (Zhao, Sloggett, & Chodroff 2022)

- Tone systems: Chengdu Mandarin vs Standard Mandarin (Figure 1)
- Stimuli: 24 sentence pairs contrasting in semantic plausibility (high vs low surprisal) triggered by a mismatch tone (quality: with minimal pairs)
- Limited amount of exposure with no repetition (quantity: no repetition)

Current study: Would adaptation still occur with minimal pairs removed? Will it be facilitated with increased exposure through repetition?

- Stimuli: only one surprisal version of each sentence pair was presented (quality: no minimal pairs)
- Increased exposure over 3 repetition blocks (quantity: with repetition)

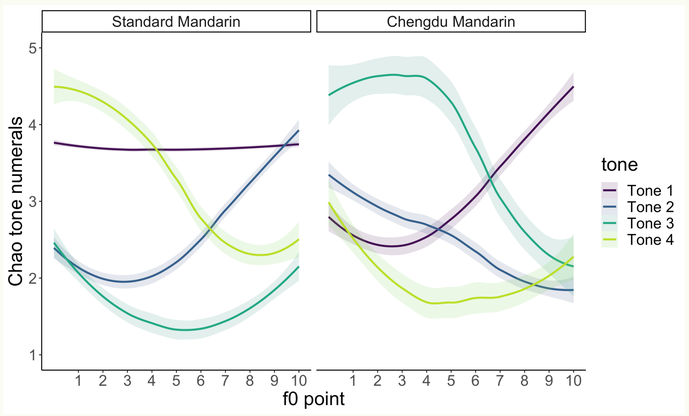

Figure 1: Smoothed lexical tone contours of Standard Mandarin and Chengdu Mandarin converted to Chao tone numerals. Ribbons reflect ±1 standard error of the mean.

CONCLUSION & DISCUSSION

Current study:
Adaptation to the novel tone system was persistent even when minimal-pair sentences were removed from the stimuli and only minimal incidental exposure was available

Effect of ***increased amount of exposure*** (quantity):
- Adaptation improved over repetition (accuracy and response time)
- Enhanced sensitivity to the surprisal manipulation (response time)
- About one-minute incidental was sufficient; repetition was more of a facilitating factor than a critical one

Effect of ***minimal-pair presentation*** (quality):
- Rapid adaptation to an unfamiliar tone system even without minimal pairs in the exposure
- Lexical contrast might direct more attention to the tone contrast and ease the process of adaptation or learning of the new tone system
- Minimal-pair presentation may have numerically facilitated adaptation, resulting in greater distinction between the surprisal manipulations; removal of the minimal pairs reduced, but did not obviate the effect of surprisal

Rapid adaptation to an unfamiliar tone system even in adverse conditions; one-minute natural speech seems adequate for significant discrimination between novel contrasts

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METHOD

Participants
13 native speakers of Standard Mandarin (little/no knowledge of Chengdu Mandarin)

Stimuli
24 pairs of low/high-surprisal spoken sentences manipulating Mandarin dialect (Standard vs. Chengdu Mandarin)

Experimental manipulation
24 trials × 2 dialects × 3 repetitions
Surprisal: high surprisal vs. low surprisal
Dialect: Chengdu Mandarin vs. Standard Mandarin
Repetition: block 1 ,2, 3

Comparison with the previous study
Design: with minimal pairs (previous) vs no minimal pairs (current)

Table 1: An example sentence item across surprisal conditions

low-surprisal sentence	a) 有 一只 鹰 在 天上 飞 You3 yi4 zhi1 ying1 zai4 tian1 shang4 fei1 There is an eagle in the sky flying "There is an eagle flying in the sky"
high-surprisal sentence	b)* 有 一只 鹰 在 天上 肥* You3 yi4 zhi1 ying1 zai4 tian1 shang4 fei2* There is an eagle in the sky gaining weight* "There is an eagle gaining weight in the sky"

Procedure
Online *Gorilla* Experiment builder (Anwyl-Irvine et al., 2018)

Familiarization phase:
- "***Does this sentence make sense***?" and clicked **"yes" or "no"** on the screen after hearing the whole sentence (stimuli: two pairs of sentences in Standard Mandarin)
- Immediate feedback on the correct answer and the sentence

Test phase:
- Identical to the familiarization phase, except no feedback was provided
- The presentation of trials was fully randomized

Data Analysis
Accuracy: expected judgment on sentence plausibility counted as correct
- "Yes" responses to low surprisal (i.e., plausible) sentences
- "No" responses to high surprisal (i.e., implausible) ones

Response times: the interval between the end of the audio file and the click registering a judgment

Comparison between the two designs:
All the data from the previous study (no repetition & with minimal pair) compared with data from the 1st block of the current study (no repetition & no minimal pairs)

RESULTS

Statistical models
Accuracy: Bayesian logistic mixed-effects regression
Response time: Bayesian log-normal mixed-effects regression
**both with weakly informative priors (Bürkner, 2018)*

Fixed effects:
surprisal, dialect, two repetition contrasts, and the full set of interactions
Random effects:
- For participant: an intercept and slopes for surprisal, dialect, repetition contrasts, and the interaction between surprisal and dialect
- For sentence frame: an intercept and random slope for dialect

Accuracy

Credible main effects of *surprisal*, *dialect* and *the interaction between surprisal and dialect*

Surprisal: low-surprisal >> high-surprisal condition
Dialect: Standard Mandarin >> Chengdu Mandarin
Surprisal × *dialect*: even less accurate in the high-surprisal Chengdu condition relative to average

Repetition: Block 2 >> Block 1
Repetition × *surprisal*: improvement in Block 2 for high surprisal sentences
Repetition × *dialect*: improvement in Block 2 for Chengdu sentences
No effect found for Block 3

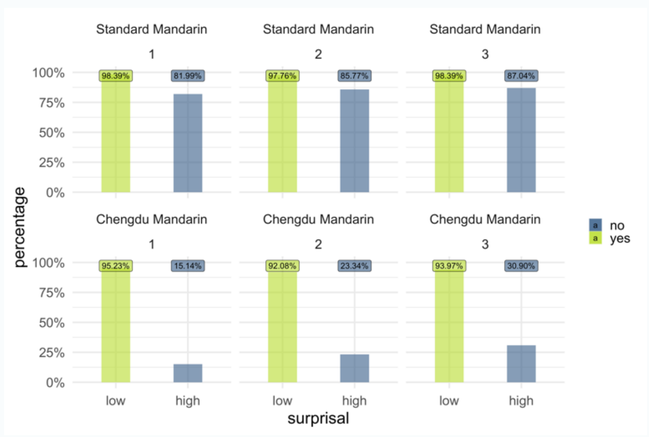

Figure 2: Percentage of *correct* responses across dialect, surprisal and repetition ("1, 2, 3" refer to the repetition blocks)

Response time – Finding 1

Credible main effects of all tested factors and their interactions, except for the interaction between surprisal and the second repetition contrast

Surprisal: high-surprisal >> low-surprisal condition
Dialect: Chengdu Mandarin >> Standard Mandarin
Difference between high- and low-surprisal:
Standard Mandarin >> Chengdu Mandarin

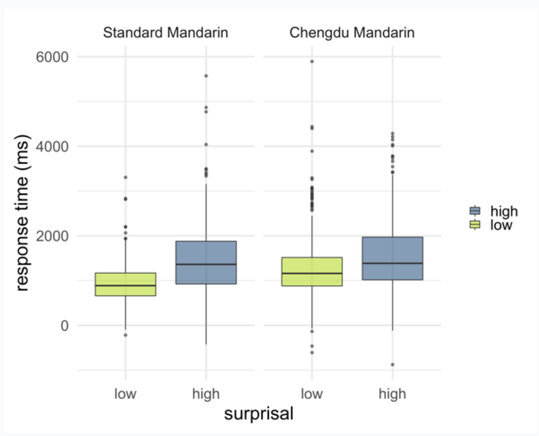

Figure 3: Response times across dialect and surprisal conditions.

Response time – Finding 2

For the effect of *repetition* (Figure 4), all responses generally accelerated block by block

Block 1 >> Block 2 >> Block 3

Repetition × *dialect:* slower responses for Chengdu sentences after each repetition

Repetition × *dialect* × *surprisal:* block-wise slowdown for Chengdu high-surprisal sentences, but block-wise speed-up for Standard Mandarin high-surprisal sentences

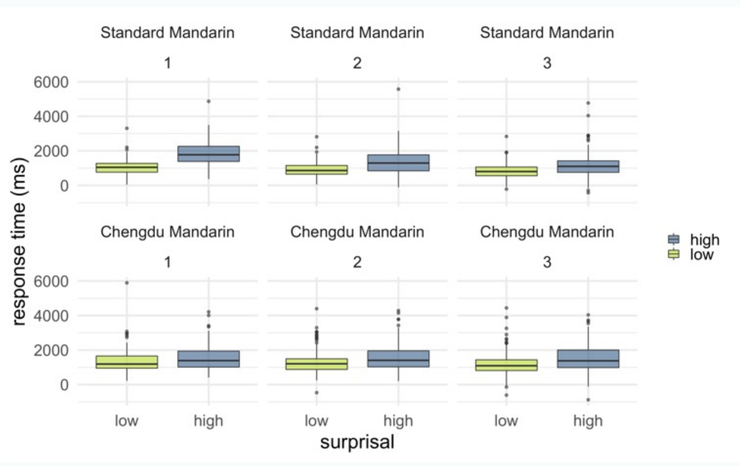

Figure 4: Response times across dialect, surprisal and repetition conditions ("1, 2, 3" refer to the repetition blocks)

Response time – Finding 3

For the comparation between the two designs (with minimal pairs vs no minimal pairs)

Design: no credible effect
Design × *surprisal*: no credible effect
Design × *surprisal* × *dialect:* no credible effect

Design × *dialect:* slower responses to Chengdu sentences when minimal pairs were present

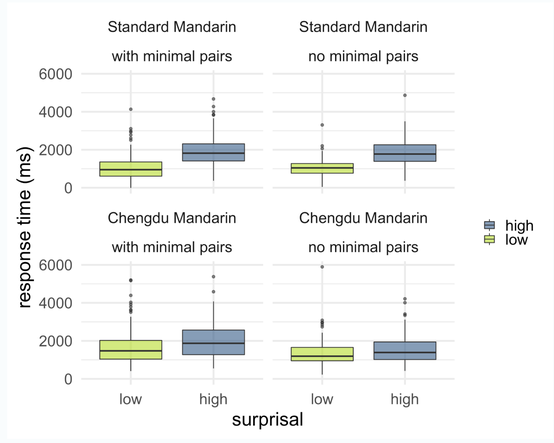

Figure 5: Response times across dialect, surprisal and presentation conditions in the previous (with-minimal-pair) and the new (no-minimal-pair) experiments