The influence of native intonational and tonal categories on nonnative tone learning

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As we age, it becomes increasingly difficult to acquire nonnative linguistic features. The native language influences how nonnative speech sounds and prosodic patterns are perceived. With training, however, perception of nonnative linguistic features can improve.

Lexical tone is a linguistic feature that distinguishes the meanings of words using pitch. Tone languages vary in the number of tones within their inventories, and individual tones may differ in height, direction and pitch trajectory. Tone language experience modulates perception of nonnative tone contrasts [1], [2], sometimes facilitating it, other times interfering with it [3]–[5]. Ease of tone learning may depend on how nonnative tones map onto L1 tonal or intonational categories [6]. But, it is not well understood how the *complexity* of the native tone system influences nonnative tone perception. Complexity has been defined as the number of tones within a tone system [7], but has also referred to similarity of pitch slopes and the presence of level, contour and/or checked tones.

Here, we examined if tone language experience facilitates nonnative tone learning, and whether experience with a more complex tone system confers additional benefit. We compared native speakers of nontonal (Australian English) and tonal languages (Mandarin Chinese and Vietnamese) in their ability to learn the tones of Meixian Hakka, a language with four regular and two checked tones [8]: Tone 1 (33) is a mid-level tone, tone 2 (11) is low-level, tone 3 (41) is mid-falling, and tone 4 (51) is high-falling [9]. The first checked tone (55) is high-level, and the second (41) is mid-falling. Permissible stop codas include /p/, /t/, /k/, and can appear in the VC or CVC syllable contexts [9].

Hakka differs from the tone languages of our participants. Mandarin has four tones: high-level (55), mid-rising (35), low-dipping (214) and high-falling (51) [10], and no checked tones. Southern Vietnamese has five tones: mid-level, low-falling, mid-rising, low falling-rising and falling-rising. Checked (mid-rising and low falling-rising) tones appear when a syllable ends in /p/, /t/ or /k/ [11].

Participants completed five sessions of tone word training, held on separate days. In session 1, participants completed a demographic questionnaire, a tone identification pre-test, and their first training session. Participants repeated the training task in sessions 2 to 4. In session 5, they completed their final training session, a generalisation task and a tone identification post-test.

The Mandarin (M_{Diff} = 21.8, 95% CI [12.1, 30.5], $p < .001$) and Vietnamese (M_{Diff} = 10.4, 95% CI [1.5, 19.3], $p = .017$) speakers identified Hakka tones more accurately than English speakers, and the Mandarin speakers also outperformed the Vietnamese speakers (M_{Diff} = 11.4, 95% CI [2.3, 20.5], $p = .009$). The interaction between test and language was not significant ($p = .632$).

In tone training, all groups improved across sessions. The Mandarin speakers outperformed the English speakers (M_{Diff} = 22.3, 95% CI [9.9, 34.7], $p < .001$), while the English and Vietnamese groups did not differ (M_{Diff} = 10.6, 95% CI [-2.1, 23.3], $p = .130$). The difference between the Mandarin and Vietnamese groups was only marginally significant (M_{Diff} = 11.7, 95% CI [-1.3, 24.7], $p = .09$). A similar pattern was observed for generalisation to a novel talker.

In identification, patterns of tone confusions revealed that all groups consistently identified the correct tone, but tonal language speakers were most accurate. For instance, English speakers identified level tones 2, 5 and 6 quite successfully, but struggled with other tones (63-69%). Mandarin speakers identified falling tones 3 and 4 slightly less accurately (79-84%), while Vietnamese speakers misidentified tones 2, 3, 4 more than other tones (70-79%). Accuracy decreased further for certain contrasts, and these contrasts differed across groups. For instance, English speakers identified tones 1 and 3 only 66% and 52% of the time when distinguishing between the two, and tones 1 and 4 63%

and 56% of the time. Mandarin speakers correctly identified tones 3 and 4 71% and 69% of the time, while Vietnamese speakers correctly identified tones 2 and 3 72% and 66% of the time.

The findings show that although native speakers of nontonal and tonal languages benefit from tone training, tonal language speakers showed an advantage from the commencement of training. Further, the learning of nonnative tones does not seem to depend on the complexity of the native tonal language, but rather how well the tones map onto native tonal or intonational categories.

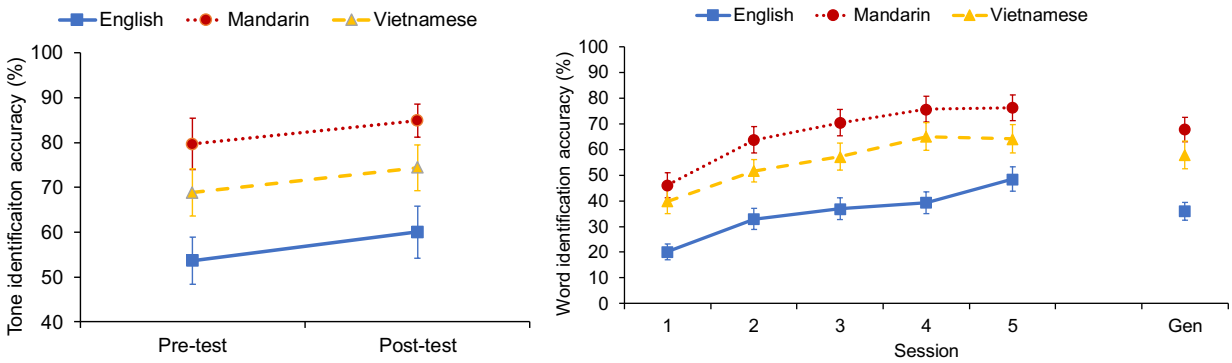

Figure 1. *Left panel: Tone identification accuracy (%) at pre- and post-test. Right panel: Tonal (Mandarin, Vietnamese) and nontonal (English) learners' word identification accuracy (%) across five training sessions and generalisation test (Gen). Error bars depict SEM.*

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