Cue weighting in Mandarin tone perception:
A comparison between native speakers and learners of Mandarin

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Introduction   Phonetic distinctions can be perceived with different cue weighting patterns in different languages [1, 2]. It has been widely discussed whether L2 listeners can adapt their perceptual cue weighting in response to different target languages that vary in the distribution of acoustic cues [2, 3, 4]. Mandarin tone perception is an interesting case, since native listeners heavily rely on contour shape, which is non-contrastive in most non-tonal languages. Turning point position (TP; [5, 6]), which shapes the pitch contour, and End f0 [5, 7], which is associated with the pitch height and the pitch slope, have been attested important cues in native Mandarin Tone 2 (T2)-Tone 3 (T3) perception. In the current study, we aim to investigate how TP and End f0 interact in L1 and L2 perception of Mandarin T2-T3 and if learning experience would influence learners' cue weighting patterns.

Participants   72 participants were recruited for the identification experiment, and consisted of the following three groups: native Mandarin speakers (MAN; $n = 26$), English learners of Mandarin (L2M; $n = 26$), and naïve English speakers (ENG; $n = 20$).

Stimuli   The syllable /i/ was synthesized with different f0 contours covarying in TP and End f0, resulting in a set of audio stimuli spanning a two-dimensional T2-T3 perception space (Figure 1; 7 TP steps × 9 End f0 steps = 63).

Figure 1 Stimulus space

Procedure   An online 2AFC task was conducted on Gorilla. Participants were first asked to complete the training phase (2 repetitions of canonical T2 and T3; 16 trials) with feedback. Then, they were asked to complete the testing phase (10 repetitions of the entire space; 630 trials) without feedback.
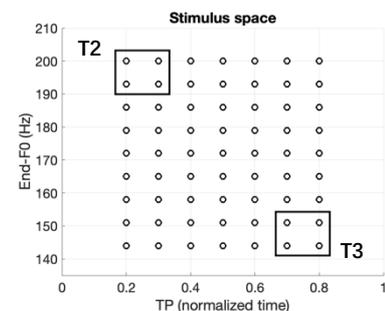
Results   As shown in Figure 2, the MAN group had a more vertical categorical boundary than the other two groups. L2M and ENG had similar boundary slopes. Generalized logistic regression was used to predict a linear boundary [8] for each individual. ANOVAs showed a significant effect of Group for boundary slopes ($F(2, 57) = 4.278$, $p = 0.018$). Tukey's HSD *post hoc* analyses revealed that the MAN group had significantly steeper boundary slopes (more reliance on TP) than the other two groups (MAN > L2M, $p = 0.041$; MAN > ENG, $p = 0.038$). No significant difference in boundary slopes was found between L2M and ENG.

| (a) MAN | (b) L2M | (c) ENG |
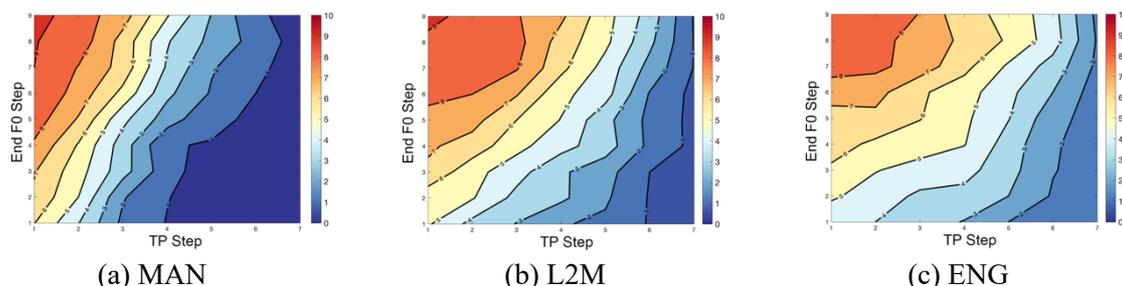
Figure 2 Contour maps of the average responses of each group (Numbers: counts of T2 responses)

Discussion   TP serves as a primary cue in T2-T3 perception for native listeners. However, learners and naïve English listeners tend to rely on both TP and End f0, regardless of learning experience. Shen and Froud (2016) proposed that advanced learners could have native-like categorical perception. However, our results show that changing the cue weighting seems not the strategy that learners use to achieve their goal in Mandarin tone perception.

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