Exploring Cross-Categorical Pitch Shift Effects on Mandarin Tone Production

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Introduction

The Dual Speech Coordination model suggests distinct cortical pathways for laryngeal (pitch) and supralaryngeal (articulation) control [1].

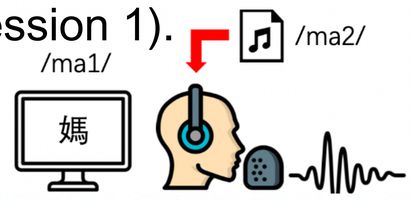
We hypothesize that a dorsal-lateral system coordinates pitch in speech, but it is unclear if dPCSA and higher-level areas (e.g., 55b) in the pathway are involved when pitch is linguistically contrastive, as in Mandarin tones.

Methodology

Prior studies' direct pitch shifts may not affect tone category perception [2]. We thus aimed to manipulate cross-categorical shifts with pre-recorded tokens from the participants as feedback, with full procedure implemented in Matlab.

Session1 participants are recorded for tokens while producing tones with normal auditory feedback.

Session2 participants hear normal or cross categorical pitch-shifted feedback token during production (e.g., produce /ma2/ but hear /ma1/ recorded from session 1).



Target	Auditory Feedback		
媽 ma1	Normal	麻 ma2	罵 ma4
麻 ma2	Normal	媽 ma1	罵 ma4
罵 ma4	Normal	媽 ma1	麻 ma2

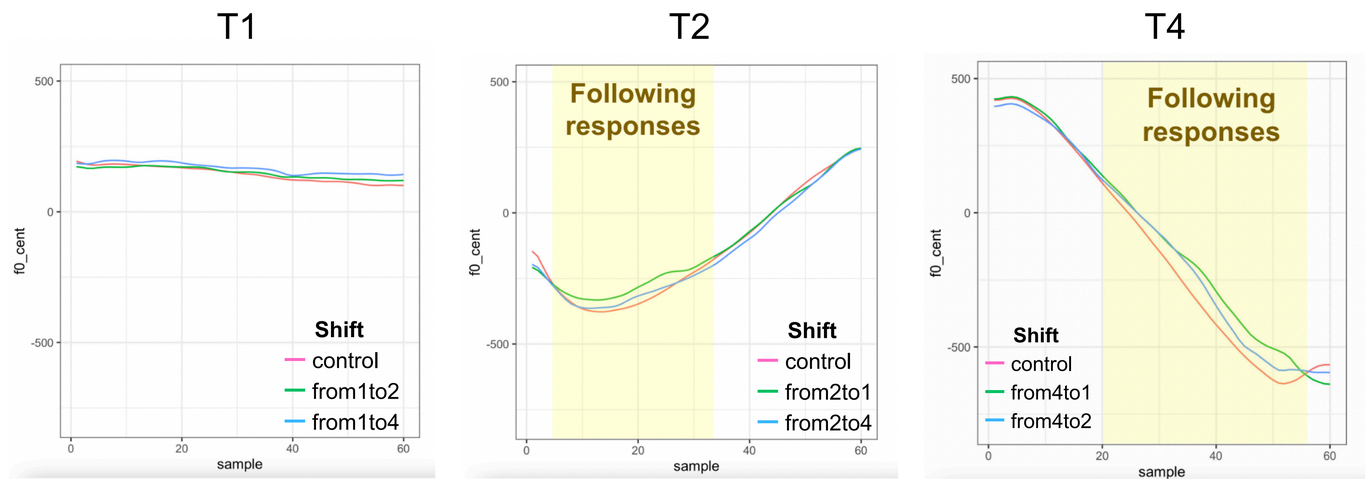
No-Shift Shift

Results

Pilot results (N=7) revealed that:

(1) Participants appear to adjust to pitch shifts in contour tones (Tone2 and Tone4) but not in the level tone (Tone1), see figures.

(2) All participants found the fact that the shifted tokens are pre-recorded from the very beginning, but still exhibited behavioral responses to perturbation.



Conclusion & Future direction

Our goal is to explore the cortical hierarchy underlying pitch control in linguistically contrastive contexts. Pilot results show participants adjusted to cross-categorical shifts in contour tones. Nonetheless, limitations remain:

1. The altered feedback may not sound natural enough to be perceived as self-voice, thus confounding responses.
2. The study lacks a non-linguistic pitch counterpart for comparison.

Future designs will compare normal feedback (**Control**), across-category shifts (**S1**), and within-category shifts (**S2**, e.g., "level tone" with a slight slope, but still perceived as tone1). By identifying the averaged contour slope of tones through a cross-category judgment test, real-time pitch shifting will be implemented and customized for each participant.

Moving forward, fMRI scanning will explore the neural basis of pitch control. We expect quantitative differences in the dorsal precentral speech area (dPCSA) and/or qualitative recruitment of area 55b between Control, S1, and S2 conditions.

References:
[1] Hickok, G., Venezia, J., & Teghipco, A. (2023). Beyond Broca: neural architecture and evolution of a dual motor speech coordination system. Brain : a journal of neurology, 146(5), 1775–1790.
[2] Tang, D. (2024). Using altered auditory feedback to study pitch compensation and adaptation in tonal language speakers. Frontiers in Human Neuroscience, 18.