Language experience dependent plasticity for pitch representation in the human brainstem

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Abstract

Brainstem frequencies following responses (FFR) were recorded from Chinese and English participants in response to Mandarin tonal patterns presented in a speech and a non-speech context. Results showed that the Chinese group exhibits stronger pitch representation and smoother pitch tracking than the English group. Moreover, the Chinese group exhibited relatively more robust pitch representation of rapidly-changing pitch segments. These findings support the view that at early preattentive stages of subcortical processing, neural mechanisms underlying pitch representation are shaped by particular features of the auditory stream rather than speech per se.

Index Terms: pitch representation, experience-dependent plasticity

1. Introduction

Language experience could shape the representation of pitch even at subcortical stages of processing in the rostral brainstem [1]. Here we examine the language, contour, and domain specificity of this experience dependent brainstem plasticity using the brainstem frequency following responses (FFR) elicited in response to Mandarin tones presented in speech, non-speech [2], and using linear versions of the original curvilinear pitch contours.

2. Methods

FFRs were recorded from twelve adult native speakers of Mandarin Chinese (5 male, 7 female) and ten adult, monolingual native speakers of English (5 male , 5 female) with normal hearing in response to Mandarin pitch contours (Figure 1) presented in either a speech or a non-speech context [2]. In addition, responses were recorded to stimuli with linear versions of tones 2 and 4. Pitch strength and accuracy of tracking and the spectrograms of the recorded FFRs were evaluated.

3. Results & Conclusions

In the first experiment, FFRs elicited by four Mandarin tones in a speech context showed greater pitch strength (Figure 2) and accuracy of pitch tracking (Figure 3) for the Mandarin speakers compared to the English speakers. These results suggest language experience induced neural plasticity in the brainstem that may be enhancing linguistically relevant features of the speech input. In the second experiment no differences were observed in pitch strength or tracking accuracy, indicating that stimuli with linear rising or falling ramps elicit similar pitch representations at the brainstem level (Figure 3). We conclude that pitch extraction at the brainstem is critically dependent on specific dimensions of pitch contours that native speakers have been exposed to in natural speech contexts. In the third experiment, using stimuli presented in a non-speech context, the Chinese group exhibited stronger pitch and smoother pitch tracking than the English speakers (Figure 4, left panel). Moreover, crosslanguage comparisons of pitch strength of individual segments revealed that the Chinese group exhibits relatively more robust pitch representation of those segments containing rapidly-changing pitch movements. The Chinese group also exhibited stronger representation of pitch harmonics (Figure 4, right panel). These findings support the view that at early preattentive stages of subcortical processing, neural mechanisms underlying pitch representation are shaped by particular features of the auditory stream rather than speech per se.

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5. References