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Cortical pitch representations of complex tones in musicians and non-musicians

Federica Bianchi1,2, Jens Hjortkjær1,2, Søbæt Santurette1, Hartwig Siebner2, Robert Zatorre3, Torsten Dau4
1 Hearing Systems, Technical University of Denmark, Ørestad Plads Building 382, 2800 Kongens Lyngby, Denmark
2 Danish Research Centre for Magnetic Resonance (DRCMR), Hvidovre Hospital, Denmark
3 Montreal Neurological Institute, McGill University, and BRAMS, Montreal, Canada

Introduction

Musicians have been shown to have an enhanced pitch-discrimination ability compared to non-musicians for complex tones with either resolved or unresolved harmonics (1, 2, 3, 4, 5). It is unclear whether this perceptual enhancement can be ascribed to an enhanced neural representation of pitch at central stages of the auditory system. The aim of this study was to clarify whether (i) cortical responses increase with harmonic resolvability, as suggested in previous studies (6, 7), and whether musicians show (ii) different neural activation in response to complex tones as compared to non-musicians and/or (iii) a finer fundamental frequency (FF) representation in the auditory cortex. Assuming that the right auditory cortex is specialized in processing fine spectral changes, we hypothesized that an enhanced FF representation in musicians would be associated with a stronger right-lateralized response to complex tones compared to non-musicians.

Method - Experiment I: Behavioral pitch discrimination

q 31 listeners (15 non-musicians and 16 musicians with more than 5 years of formal musical training) participated in Experiment I and II.

Stimuli

Low-frequency (LF): 0.3-1.5 kHz
High-frequency (HF): 1.5-3.5 kHz

Paradigm

"Which tone has the highest pitch?"

Conditions

The smallest detectable ΔF1 was measured at two points on the psychometric function (difficult ΔF1: 60%, easy ΔF1: 90%) for the HF complexes and at 75% for the LF complexes.

Method - Experiment II: fMRI

q Measure neural activation during a pitch-discrimination task
q 6 pitch conditions (same as in Experiment I, see Table 1) and 1 noise condition with TSN
q ΔF1, between reference and deviant individually set at the listener’s threshold (from Experiment I)
q Event-related paradigm with sparse sequence (TR = 10 s, TA = 2.5 s 38 isotropic slices of 3 mm3, 37 Philips Achieva). Data acquired at DRCMR:

Results - Experiment I: Behavioral pitch discrimination

A full-factorial ANOVA (3 levels of difficulty, 2 levels of resolvability) revealed

q A significant effect of musical training (musicians > non-musicians) even if task difficulty was adjusted across participants (Fig. 5)

Results - Experiment II: fMRI

A parametric analysis for the 3 levels of task difficulty (80%, 75% and 90%) revealed a significant increase of neural activation bilaterally in the auditory cortex, in the left inferior frontal gyrus and left thalamus (Fig. 7). Additionally, a decrease of behavioral performance (% correct deviant identification) was correlated with the increase of neural activation in the inferior frontal gyrus (Fig. 8).

Discussion

The 10% most activated voxels for the pitch-choice contrast were selected in the primary and non-primary AC (Te1.0, Te1.1, Te1.2 and Te2). No effect of harmonic resolvability was found (see Fig. 9), in contrast to previous studies (6, 7). This finding might be due to the fact that the level per harmonic (and not the overall level) was fixed, leading to the same SNR in all conditions. There was a significant effect of FO (100/500, see Fig. 10) in the right Hess/Cuneus, probably driven by the higher spectral density for the 100 Hz condition.

Conclusions

Overall, these findings suggest an involvement of a posterior-lateral region in both auditory cortices during a pitch-discrimination task with conditions of varying task difficulty. When the harmonic level was fixed above the noise, no effect of harmonic resolvability was observed. Cortical responses in musicians were larger in the right than in the left auditory cortex as compared to non-musicians and were predictive of individual pitch-discrimination abilities. These outcomes are consistent with the right auditory cortex being specialized in processing fine spectral changes.

References