

# Proficiency and gender effects on music processing in harmonic/discordant chords by using fMRI

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## Introduction

Former fMRI studies on musicians have revealed laterality of the brain function during imagined performance [1] and cross-cultural music comprehension [2]. The difference in music training between professionals and amateurs also showed a shifting of brain activation area [3]. Most of these studies were focused on primary auditory cortex activations. Here in this study, we employed an interlaced paradigm design to assess music cognitive function with relative suppression of the auditory activation signals. Furthermore, we used the more basic components, the harmonic chords, as the stimuli to explore the cognitive function of music processing in professional musicians and amateurs using fMRI. In addition to proficiency dependence [4], the gender effect was also investigated.

## Methods

Measurements were performed in 25 healthy right-handed subjects divided into 4 groups: amateur female (n = 10, 26.6±7.0 yr), amateur male (n = 7, 24.9±5.4 yr), professional female (n = 6, 23.4±3.0 yr), and professional male (n = 2, 22 and 45 yr). Auditory stimuli consisted of three-note C-major chords (C, Dm, Am, etc.) played sequentially, plus discordant ones composed of three neighboring semitones, interleaved in random order. The subjects were instructed to perform two types of tasks: chord distinguishing (harmonic vs. discordant) and chord naming (C, Dm, Am vs. discordant). Boxcar paradigm was used with passive listening of the same chords as control interlaced with the stimuli, and no chords were played in the resting state (Fig.1). All subjects performed the distinguishing task successfully, while six out of the 25 subjects were unable to perform the naming task because of amateur proficiency. Image acquisitions were performed on a 1.5T system (Siemens Vision plus), using T2\*-weighted EPI (TE=66ms) with scanning interval of 8 seconds. The image number for each session was 64, each with 12 slices for whole-brain coverage at a voxel size 3x3x7 (mm<sup>3</sup>). High-resolution whole-brain EPI and 3D T1 images were also collected for inter-subject coregistration and normalization to T1 template using Spm2.

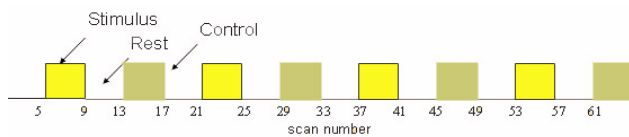


Fig 1. The paradigm designed for distinguishing and naming tasks where the stimulus and control conditions were interlaced.

## Results

The activation sites of the amateurs and professional musicians are shown in Figs.2 and 3, respectively. BA6 activation was observed bilaterally for the amateurs, but strongly lateralized toward the left hemisphere in professional musicians. The activation site of the distinguishing task in amateurs was similar in male and female, whereas for the naming task, BA40 showed gender-dependent lateralization in different hemispheres (Fig.2). Interestingly, BA40 activations in professional musicians were located on the left hemisphere irrespective of gender (Fig.3). Proficiency-independent activation was found in BA31 only for female subjects and in BA4 only for male, respectively. BA8 was right-side activated in professional cases but not in the amateurs. In distinguishing task, BA22 was activated bilaterally in the amateurs but only left-side-activated in the professionals. BA44 and BA45 were bilaterally activated in male subjects, but strongly lateralized in females, relatively irrespective of proficiency except minor differences.

## Discussion and Conclusion

The training of musicians and amateur music learners is believed to be completely different in terms of cognitive function. Our results suggested that the identification or differentiation of music chords may be a complicated process where inherent influence (e.g., gender) and training background (e.g., proficiency) both present apparent influences. BA6 may be closely related to the naming and distinguishing of music chords, whose strong lateralization in professional musicians is believed to be associated with difference in the educated expertise. BA8 activations were found exclusively for professional musicians, suggesting that it may likely be the outcome from formal musical training. Differences in the activation patterns between males and females in BA4, 31, 40, 44, and 45 further indicated that there exhibits prominent gender dependency in chord identification. BA22 showed gender and proficiency influences simultaneously. Results from our study may help unraveling the missing linkage between pure music listening and cognitive music processing.

## References

[1] M. Lotze *et al. NeuroImage* **20** (2003) 1817-1829. [2] S.J. Morrison *et al. NeuroImage* **20** (2003) 378-384. [3] Ohnishi *et al. Cerebral Cortex* **11** (2001) 754-760. [4] I.J. Huang *et al. Proc ISMRM* **11** (2003).

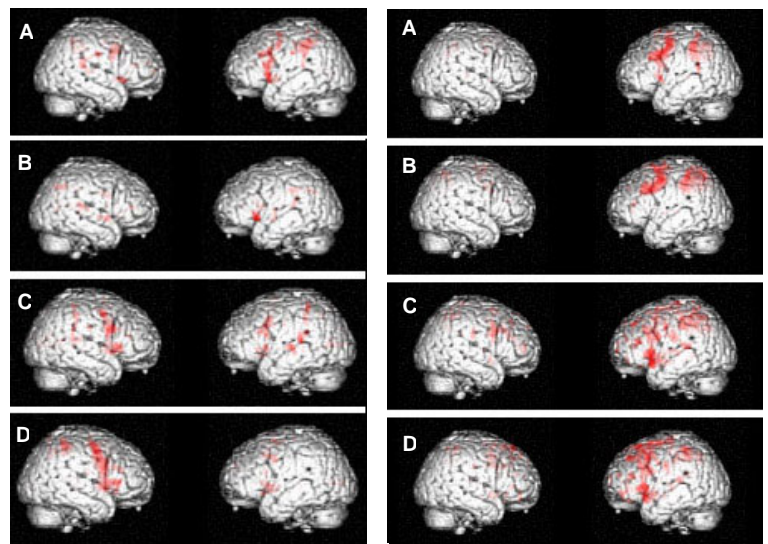


Fig.2 Activation sites of the amateurs. (A) Female distinguishing, corrected p<0.05. (B) Female naming, uncorrected p<0.001. (C) Male distinguishing, corrected p<0.01. (D) Male naming, corrected p<0.01.

Fig.3 Activation sites of the professional musicians. (A) Female distinguishing, corrected p<0.05. (B) Female naming, corrected p<0.001. (C) Male distinguishing, corrected p<0.05. (D) Male naming, corrected p<0.01.