Musicians Differ from Nonmusicians in Brain Activation despite Performance Matching

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ABSTRACT: Brain activation patterns in a group of musicians and a group of nonmusicians (matched in performance score to the musician group) were compared during a pitch memory task using a sparse-temporal sampling functional magnetic resonance imaging experiment. Both groups showed bilateral activaton (left more than right) of the superior temporal gyrus, supramarginal gyrus, posterior middle and inferior frontal gyrus, and superior parietal lobe. Musicians showed greater right posterior temporal and supramarginal activation, whereas nonmusicians had greater activation of the left secondary auditory cortex.

KEYWORDS: musicians; pitch memory; fMRI; planum temporale; performance

INTRODUCTION

Functional brain differences between musicians and nonmusicians have been found mainly in perisylvian brain regions using various perceptual tasks including just listening to music or performing pitch, harmony, melody, or rhythm tasks.[1–5] These studies speculated that musicians and nonmusicians might process music in a different way: increased musical sophistication would be associated with more lateralized (mostly left) activation. However, it is unclear if group differences in the actual performance of these tasks (e.g., percentage of correct answers), in cognitive strategies, in specialized musical abilities (e.g., absolute pitch), or even in anatomic differences between musicians and nonmusicians account for these between-group functional differences.

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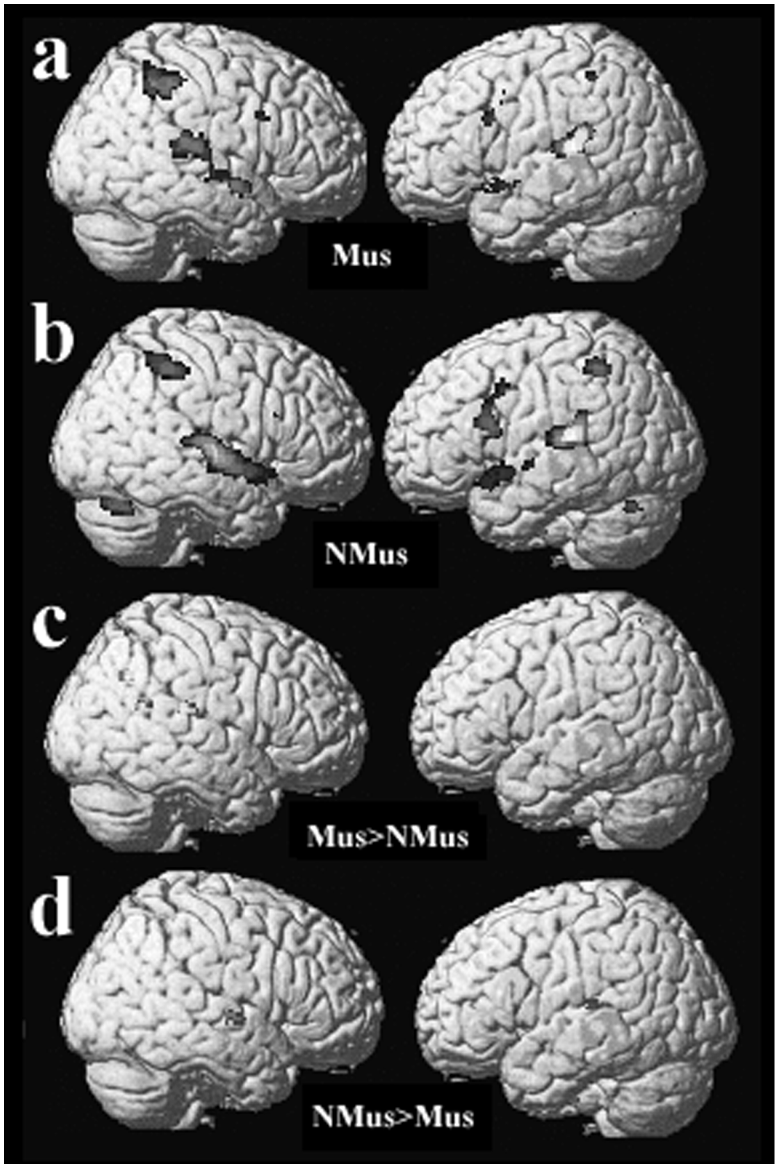

FIGURE 1. Group mean activation maps for musician (**a**) and nonmusician (**b**) groups (P <0.05, corrected for multiple comparisons); (**c**) the contrast "Musicians>Nonmusicians;" (**d**) the contrast Nonmusicians>Musicians. All activation maps are only for MR acquisitions obtained at 0–3 seconds after the end of auditory stimulation. Later time points (MR acquisitions obtained at 4–6 seconds after the end of auditory stimulation) are not shown.

METHODS

Ten right-handed musicians and 10 right-handed nonmusicians (age range 18–40 years; matched for age and gender) participated in this study. Subjects had to listen to a sequence of tones (6–7 tones with a total duration of 4.6 seconds) and were asked to decide if the last or second to the last tone (depending on a visual prompt) was the "same" as or "different" from the first tone, indicating the answer by a button press response. This task was contrasted with a motor control condition in which subjects pressed a right or left button, depending on a visual prompt. The nonmusicians were matched with the musician group in their performance score (% correct responses) in the pitch memory task. For this experiment, we defined musicians as those who had a formal music education and played a musical instrument regularly. A nonmusician was defined as someone who had never played a musical instrument and did not have a formal musical education.

MR Data Acquisition and Image Analysis. Functional magnetic resonance imaging (fMRI) was performed on a Siemens Vision 1.5 Tesla whole-body MR scanner. To avoid interference with the MR scanner noise as well as auditory masking effects, a sparse temporal sampling fMRI method with a long repetition time (TR) of 17 seconds was used. This ensured that the clustered volume MR acquisition (over 2.75 seconds) was always separated from the actual auditory task. In addition, the stimulus-to-imaging delay time was varied between 0 and 6 seconds in a jitter-like fashion to explore the time course of brain activation in response to the perceptual and cognitive demands of this pitch memory task. FMRI data were analyzed using the SPM99 software package (Institute of Neurology, London, UK). Planum temporale measurements were done as previously described.[6]

RESULTS

The musician group had a mean correct response rate of 78% (SD = 6), whereas the mean of the nonmusician group was 76% (SD = 6) ($P > 0.05$) after individually matching nonmusicians with musicians depending on task performance. Group mean activation images for musicians and nonmusicians showed involvement of the superior temporal gyrus, supramarginal gyrus, posterior middle and inferior frontal gyrus, and superior parietal lobe bilaterally in the pitch memory task (FIG. 1a and b). Contrasting both groups directly with each other for time points 0–3 (MR scan acquired 0–3 seconds after the end of auditory stimulation) revealed that musicians had more activation of the posterior planum temporale as well as the supramarginal gyrus on the right and the superior parietal lobe bilaterally compared to the nonmusicians (FIG. 1c). Nonmusicians differed from musicians by greater activation of a region in the anterior part of the planum temporale (immediately posterior to the HG) on the left (FIG. 1d). Analysis for later imaging time points (MR scans acquired 4–6 seconds after the end of auditory stimulation) revealed greater activation in the right inferior parietal lobe in musicians than in nonmusicians. Planum temporale measurements did not indicate significant differences in hemispheric asymmetry between both groups.

CONCLUSIONS

We interpret our results as indicating perceptual and cognitive processing differences between musicians and nonmusicians, because performance scores and measures of anatomic hemispheric asymmetry were similar between both groups. Although musicians seemed to use more short-term auditory storage centers (e.g., supramarginal gyrus), nonmusicians relied more on early perceptual brain regions (e.g., primary and early secondary auditory areas) within the superior temporal lobe to solve the pitch memory task with similar performance.

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