Function and Connectivity in Human Auditory Cortex: A Combined fMRI and DTI Study at 3T

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Introduction

The manner in which frequency information is processed in the auditory system, and the extent to which tonotopic organization is preserved in lower and higher level auditory brain regions has been shown in animal studies using electrophysiological techniques (1). In human studies, hemodynamic responses were found to vary in distinct primary auditory cortex (A1) regions upon presentation of specific frequency sounds; thus proving that tonotopic organization can be revealed using neuroimaging techniques such as functional MRI (fMRI) (2). In this study, fMRI and diffusion tensor imaging (DTI) is used to understand the functional connectivity that underlies low level auditory stimuli processing in healthy subjects.

Materials and Methods

All imaging was performed on a 3 Tesla Phillips Intera magnet. fMRI parameters: Pulse sequence = FE-EPI, TR/TE=25s/35ms, Imaging Resolutions=1.8x1.8x2.0 mm, Flip angle=90° DTI parameters: Pulse sequence = Single Shot SE-EPI, TR/TE= 3000ms/100ms, Imaging Resolutions=1.8x1.8x2.0 mm. Six right handed male subjects, ages 24-30 years old gave consent and participated in this study. Auditory stimuli consisted of six frequency-varying tones (0.3, 0.5, 0.8, 1, 2, and 3 kHz), each of which was presented binaurally for 2 seconds. Output intensity of all tones for all subjects was set to 70 dB SPL. Functional imaging was performed using a stroboscopic event-related design where each sound was presented in a pseudo randomized delayed manner. By utilizing a TR of 25 seconds and eight distinct sound presentation delays the hemodynamic response was sampled at 8 distinct time points (2, 3 4, 6, 7, 8, 9 and 12 seconds). An 11 second time interval in each epoch was allotted to allow for the full decay of the hemodynamic response elicited from gradient acoustic noise.

Results and Discussion

Blood oxygenation level-dependent (BOLD) activation maps within A1 were obtained in all subjects. Activation is predominately present along Heschel's Gyrus and the Sylvian Fissure in all subjects. fMRI data from a single subject are shown on echo-planar images (Fig. 1a) as well as an inflated anatomical representation in Talairach space (Fig. 1b). Activation maps shown below are in agreement with tonotopic maps obtained in a previous study that also utilized a stroboscopic event-related design (2). Using the activation maps in A1, grey matter ROI seeding points were created in DTI datasets to characterize axonal projections within the auditory cortex (Fig. 2). From DTI data, fibers originating in functionally activated areas are observed to extend laterally towards the Superior and Middle Temporal Gyri. The functional implication of this finding is not known at this time. However, upon further investigation detailed tonotopic maps will enable how and where frequency information is handled in the auditory processing stream. Furthermore, the functional connectivity underlying the processing of more complex auditory stimuli will be sought.

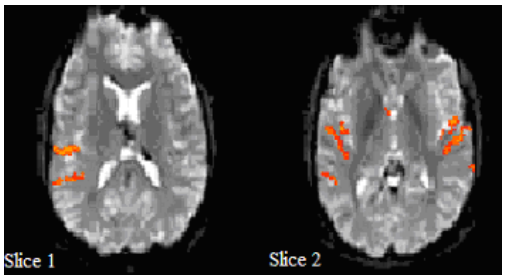
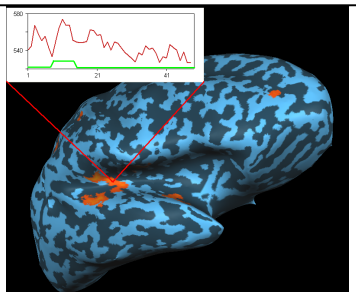


Fig 1a. BOLD response activation maps for all six frequency sounds superimposed on echo-planar images. Slice 1 is located superior to Slice 2.



Fig, 1b. Activation maps on inflated representation of the right cerebral hemisphere. Hemodynamic response shown for single ROI. Greatest % signal change in BOLD response (red trace) occurs for 0.3 kHz sound. Time course of stimulus condition is shown in green trace.

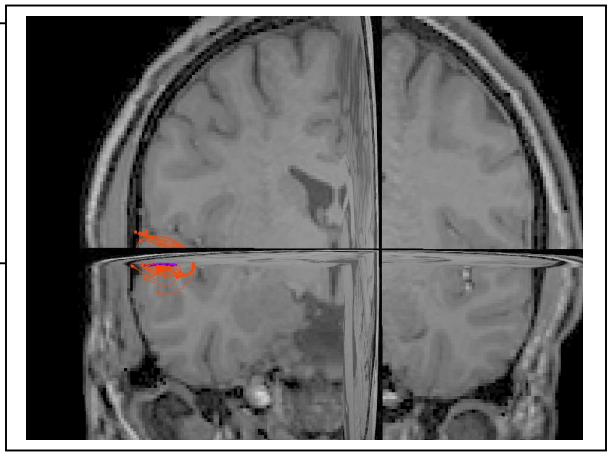


Fig. 2. DTI data showing axonal projections seeded from activated areas in A1. Axonal projections are shown in orange originate in A1 while terminating near the Temporal Gyri.

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References

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