MAPPING THE TONOTOPIC ORGANIZATION OF AUDITORY CORTEX IN AWAKE MARMOSET USING FMRI

Cecil Chern-Chyi Yen[1], Camille Toarmino[2], David A. Leopold[3], Cory T. Miller[2], and Afonso C. Silva[1]

[1]CMU/LFMI/NINDS, National Institues of Health, Bethesda, Maryland, United States, [2]Psychology, University of California San Diego, La Jolla, California, United States, [3]SCNI/LN/NIMH, National Institutes of Health, Bethesda, Maryland, United States

Target Audience:

Neuroscientists interested in the auditory system and MR scientists interested in mechanisms of fMRI in the awake non-human primate model.

Purpose:

The functional architecture of primate auditory cortex is of great interest to neuroscientists. The tonotopic organization of the auditory core, primary auditory cortex (A1), rostral area (R), and rostral-temporal area (RT), has been extensively studied for decades using electrophysiology (1,2). However, the uncertainty of the electrode position over time and limited number of single-point measurements has limited our understanding of how the auditory system operates within itself and with other functional brain systems. Recently, BOLD fMRI has been used as a non-invasive neuroimaging method complementing electrophysiological findings and has been applied to systematically investigate the tonotopic architecture in human and macaque auditory core (3,4), but not in the marmoset. The common marmoset (*Callithrix jacchus*), is a New World primate, and has proved to be an excellent animal model for auditory studies due to its high vocal activity in captivity (5) and the possibility of transgenic modification (6). In this proceeding, we report a novel fMRI experimental design, which could robustly detect stimulus-induced responses in the auditory cortex of awake marmosets and the first tonotopic map in A1, R, and RT of awake marmosets.

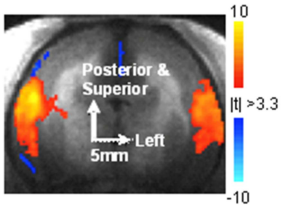

Fig. 1. BOLD activation map of auditory stimuli overlaid on T_1-weighted anatomical image

Methods:

Three adult marmosets were acclimated to body and head restraint inside a horizontal 7T/30cm MRI spectrometer (Bruker-Biospin Corp., Billerica, USA). The animals' heads were comfortably immobilized by custom-built helmets. Two surface coil arrays (16 mm inner diameter) placed above the auditory cortex bilaterally were used to receive the MR signal. BOLD functional images were obtained using a 2D gradient-recalled echo planar imaging (EPI) sequence from eight slices parallel to lateral sulcus with minimal inter-slice delay (TE/ TR= 26/ 3600ms; FOV/ thickness= 28.8×28.8/ 0.5mm; matrix= 96×96). T_1-weighted anatomical images were obtained using a 3D magnetization prepared rapid gradient echo sequence with the same plane of EPI (TE/ TR/ TI= 3/ 12.5/ 1200ms; FOV= 28.8×28.8x24 mm; matrix= 96×96x80). Auditory stimuli were presented in 50ms pulse train for 36 sec followed by 36 sec of silence as a conventional block design. Binaural tone stimuli and band-passed noise of three frequency ranges (high=4-16kHz, medium=1-4kHz, low=0.25-1kHz) were delivered in pseudo-random order via electrostatic headphones placed directly into the ear canal. Pre-processing, such as motion correction, outlier removal, spatial Gaussian smoothing, temporal bandpass filtering, and cross-session registration, was done using AFNI(7). General linear regression analysis was done after concatenating all pre-processed runs in AFNI. The final fMRI activation maps were co-registered to the anatomical T_1-weighted images and manually skull striped.

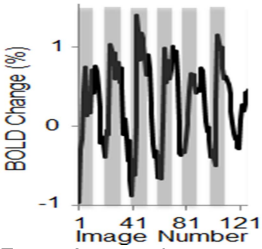

Fig. 2. Averaged time course of four scan from one session

Results:

As shown in Fig. 1, robust BOLD responses evoked by all stimuli were detected in one awake marmoset. According to the atlas, the responses roughly cover three auditory cortices, A1, R and RT. In Fig 2, BOLD percent change time course of bilateral auditory cortices were averaged over four scan in one session. The BOLD time course followed the auditory stimuli vigorously implying our paradigm effectively stimulate the auditory cortex. Fig. 3 depicts tonotopic mapping generated by a contrast between low versus high frequencies from one marmoset. The frequency reversal of the tonotopic mapping across auditory cortices can be observed from A1 to R whereas the transition from R to RT is from low frequency to middle frequency (data not shown).

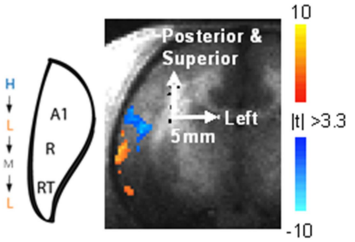

Fig. 3. Tonotopic map of the right hemisphere in one marmoset and the schematic drawing of the auditory areas

Discussion and Conclusion:

In the present study, we have demonstrated robust BOLD response in auditory cortex using a continuous sampling acquisition scheme. Although sparse sampling may reduce the influence of gradient noise to the evoked BOLD response in auditory cortex, fewer sampling points significantly lower the statistical power in the analysis (data not shown). We also showed the first tonotopic mapping in the awake marmoset using fMRI. Our preliminary data suggest the usefulness of fMRI in studying auditory processing. In addition, parcellating auditory cortex of the marmoset can potentially provide a novel platform to study the spatiotemporal characteristic of the BOLD response.

References:

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