Functional connectivity between structures in auditory pathway using fMRI technique

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INTRODUCTION

Auditory pathway consist of several subcortical structures such as medial genicualte body (MGB), inferior colliculi (IC), nuclei of lateral lemniscus (nuclei of LL), cochlear nuclei (CN) and superior olivary complex (SOC). So far few studies have demonstrated auditory pathway using *fMRI* [1]. However the connections between these structures are still topic to discussion. Analysis of functional connectivity can be useful tool which can describe the correlation between functionally related regions [2]. Checking the similarity of signal time course in the whole auditory pathway can improve the visualization of these structures. The purpose of the study was land the nuclei within the auditory pathway compare the time courses coming from central auditory system as well as combine standard SPM analysis with correlation analysis.

MATERIALS AND METHODS

This study was performed with seven right handed volunteers (five females and two males, age range 22-34 years). All of them were free of neurological disorder and did not report any major hearing problems. All imaging was performed on a whole body scanner *(3 T Trio Tim, Siemens, Erlangen, Germany)* using a cardiac gating method to improve the detection of brainstem nuclei. Neural activation was detected by BOLD differences using *T2**- weighted EPI(echo time (TE) of 30 ms, repetition time (TR) depended on the cardiac cycle ,measured with finger tip pulse oxymeter every second or third heartbeat. The volumes consisted of 10 slices with the slice thickness was 2.5mm, a base resolution 64. Using a MPRAGE sequence with parameters as a follows: TR= 2300ms, TE= 3.03ms, TI= 110ms, flip angle= 8 degrees, slice thickness= 1mm, FoV= 256mm, voxel size 1.0x1.0x1.0mm anatomical images were acquired after *fMRI* data. Auditory stimuli consisted of rock and classical music divided into 2 seconds parts. Paradigm consisted of 7 stimulation cycles of 10 scans duration "ON" epochs alternating with eight "OFF" epoch s (10 scans) of no stimulation. Length of music in each stimulation cycles depended of cardiac rhythm. Pre-processing, single subject and correlation analyses were carried out using SPM5 (http.//www.fil.ion.ucl.ac.uk). Statistical analysis was performed according to GLM. Regions of auditory cortex and brainstem were identified on the basis of the anatomical atlases using threshold P<0.001 uncorrected. Afterwards obtained time courses in MatLab (*The MathWorks, Inc. Natick, MA, USA*) corresponding local maximum in auditory cortex were used in correlation analysis. It showed functionally region related auditory cortex and brainstem. Nuclei of auditory pathway were identified with the threshold P<0.001 uncorrected.

RESULTS

In total of 10 sessions activation in auditory cortex and brainstem was detected in all individuals .Coordinates from all of the detectable structures in auditory pathway were used to obtain the time courses, examples are presented in the Fig.1. Coordinates were chosen in standard SPM analysis. Time courses from auditory cortex were used as references in correlation analysis in individual subject. Results of correlation analysis are demonstrated in T maps (Fig.2). In correlation analysis the percentage of detectability for brainstem structures (74%) was higher than in standard SPM analysis (30%). Inferior colliculi (IC) in right and left hemispheres was detected in 8 and 9 experiments respectively. Nuclei of lateral lemniscus (LL) found in 7 (right side) and 6 (left side) and super olivary complex (SOC) were found in 7 (right side) and 8 (left side) tests. Cochlear nucleus (CN) was detected in 6 (right) and 7 (left) experiments. The structure of medial geniculate body was identified bilaterally in 8 examinations.

DISCUSSION

The results demonstrate the capacity of *fMRI* to visualize auditory activation of human brainstem structures [3]. Presented time courses from auditory cortex and brainstem nuclei showed similar behavior. This similarity demonstrated the connection between structures in auditory pathway and gives the reason to applied correlation analysis. The differences between individual blocks are due to different response for each part of the paradigm. The correlation analysis was obtained using the reference time course from the coordinates corresponding areas of auditory cortex with the highest t parameter. Within this analysis was possible to create T maps between functionally related regions auditory cortex and the whole brain. Results demonstrate a tight functional relation between auditory cortex and brainstem in the human brain and provide an improvement in the t-test analysis about location of activated areas within the brainstem by correlation analysis [4].

Fig. 1. Time courses for the auditory cortex and cochlear nuclei found in SPM analysis.

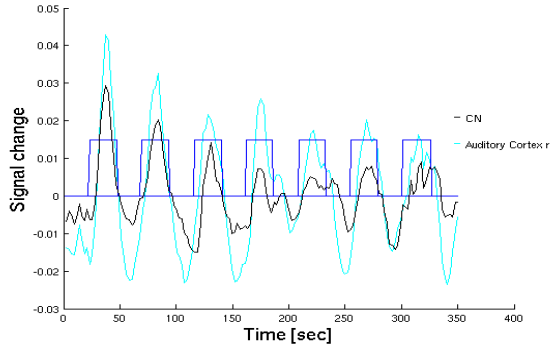
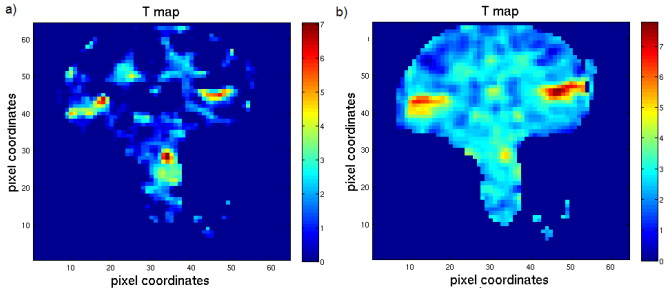


Fig. 2. T maps for: standard T test analysis (a) and correlation analysis (b).



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