A fMRI study of Temporary Hearing Threshold Shift

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1. Purpose:

Several empirical studies have shown that high level acoustic exposure in humans may cause an effect called Temporary Hearing Threshold Shift (TTS) [1]. A dB SPL TTS value expresses a subject specific hearing level shift caused by an acoustic overload. The main aim of this work was to study the effect of TTS and use fMRI to evaluate subject specific hearing levels measurements and high level acoustic exposures.

2. Material and Methods:

Fifteen healthy subjects participated in the study (aged 20-38 years, 10 male, 2 left-handed). For each of the subjects a specific TTS time characteristics for 1, 2, 3 6, 8 kHz was measured. Thereafter subjects participated in scanning sessions with the following protocol: 1) T1 structural brain imaging on a 3T scanner, 2) an fMRI run called 'pre' with clustered volume acquisition GE EPI scanning with block type auditory stimulation, 3) 15 min of 95 dB SPL narrow-band noise (centered around 4 kHz) exposure, 5) repeated step2 of protocol named 'post'. Stimulation was done with a piezoelectric Sound Delivery System (SDS)[2].

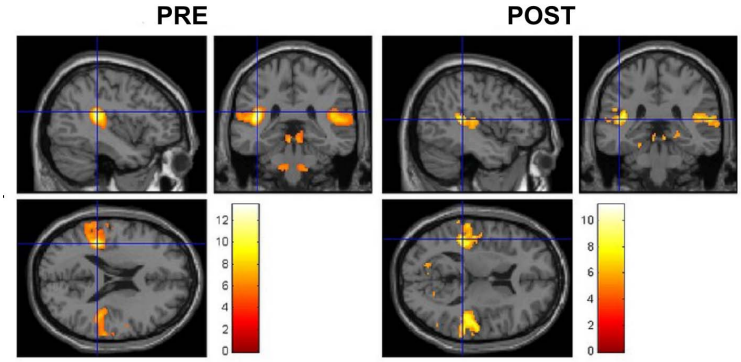

Fig. 1 Activations of Primary Auditory Cortex pre and post acoustic noise exposure.

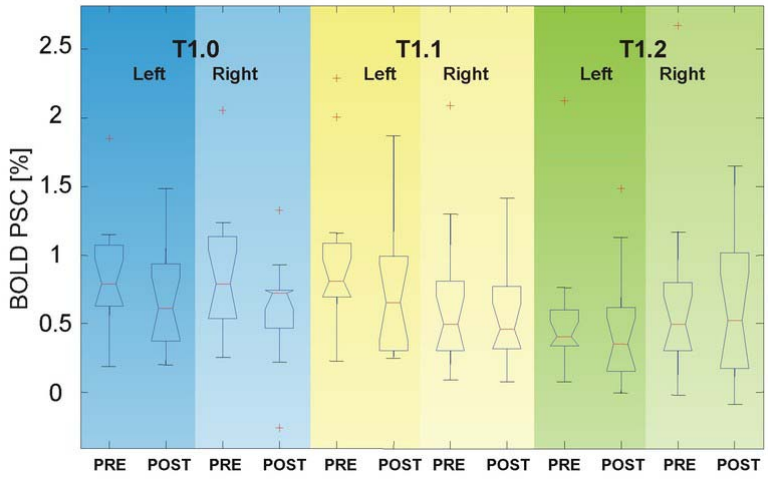

Fig.2 BOLD signal measures evaluated for Auditory areas.

	Cluster 1 (1728 vox): Before (T> 5.00)		Cluster 2 (577 vox): After (T> 5.00)	
	voxels	% of this area activated	voxels	% of this area activated
left TE 1.0	190.5	98.4	118.9	61.4
left TE 1.1	175.8	99.2	126.8	71.6
left TE 1.2	49.8	48.7	1.1	1.1

	Cluster 2 (1479 vox): Before (T> 5.00)		Cluster 1 (917 vox): After (T> 5.00)	
	voxels	% of this area activated	voxels	% of this area activated
right TE 1.0	233.0	95.7	173.4	71.8
right TE 1.1	125.3	74.9	110.1	66.4
right TE 1.2	18.1	18.2	39.7	40.2

Tab.1 and 2 A cluster size and localization in primary auditory cortex areas.

All sounds delivered to the subject are expressed in dB SPL after calibration of SDS on spectrum analyzer (Brüel & Kjær Type 2143) and artificial ear (Brüel & Kjær Type 4152). Statistical parametric maps were generated using SPM5. Single subject (mean and variance) and group analysis (one sample T-test, ANOVA) were calculated and BOLD signal changes in auditory areas TE1.0, TE1.1 and TE1.2 as defined in Anatomy SPM toolbox [3] were calculated and analyzed.

3. Results:

The fMRI results with a random effects analysis showed strong activations in different parts of the auditory cortex [Fig.1] (max. T-value was 13.3 in the left hemisphere and 10.45 in right hemisphere) for both functional runs (before and after noise exposure). The locations of activation clusters are summarized on [Tab1] for the left hemisphere (LH) and [Tab2] for the right hemisphere (RH). A two-sample T-test did not show any statistically significant results, however more specific ROI anaysis with the SPM anatomy toolbox shows differences in BOLD signal change measure in primary auditory areas [Fig.2]. An average over subject TTS was: 19 +/-5, 16 +/5.3, and 13 +/-4.9 after 1, 2 and 5 minutes after exposure, respectively.

4. Conclusion:

The experimental data showed that the proposed protocol can be used for quantitative analysis of the TTS effect. This study showed strong activations in auditory areas, and the effect of TTS was not detectable with current methodology. One of the reasons may be that the human auditory cortex has caused technical challenges in creating average maps for a subject population. However, direct auditory stimulation and hearing level measurements directly in the magnet bore may open new possibilities in this area. In the near future, we plan to include more studies to obtain a group effect, if any exists.

5. References

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[3] Morosan P, Rademacher J, Schleicher A, Amunts K, Schormann T, et al. (2001) Human primary auditory cortex: cytoarchitectonic subdivisions and mapping into a spatial reference system. Neuroimage 13: 684–701.