High resolution auditory fMRI at 7 T

W. van der Zwaag[1,2], E. Fornari[3], P. Maeder[3], and R. Gruetter[1,4]

[1]LIFMET, EPFL, Lausanne, VD, Switzerland, [2]Radiology, UNIL, Lausanne, VD, Switzerland, [3]Radiology, CHUV, Lausanne, VD, Switzerland, [4]Radiology, UNIL, UNIG, Lausanne, Geneva, Switzerland

Introduction Auditory fMRI at ultra high field is challenging because the extended stray field of the magnet forces the sound to be transported over relative long distances. An actively shielded short-bore magnet design contains the field lines close to the bore and allows the conversion of optical to electric signal to be relatively close to the subject. Increased acoustic sound from the gradients can also form a problem. The aim of this study was to demonstrate that high resolution fMRI with an auditory task is possible at 7T using an actively shielded head-only MR system, a gradient insert with torque balanced design and an auditory delivery system using earplugs extending only 2 cm from the subjects head , allowing the use of a tight-fitting rf-coil.

Methods Four subjects were scanned on an actively shielded 7T system with 2.2 m effective bore length (Siemens Medical solutions, Erlangen, Germany) with a gradient insert[1], an 8 channel rf-coil (RAPID Biomedical GmbH, Germany) and a commercially available audio delivery system (EarPlug, NNL, Norway).

A word-recognition task was used for auditory stimulation following a silent event-related design[2]. Five presentations of sentences were followed by 5 presentations of environmental noise and 5 acquisition of rest; this cycle was repeated 4 times. Subjects were asked to report grammatical or lexicological errors in the sentences via a button press (50% of sentences). A sparce sampling technique[3] was used for fMRI data acquisition. 50 ascending slices were acquired in such a way that the superior bank of the Sylvian fissure was sampled 6 seconds after the sound was played out. Other scan parameters: FOV = 192 mm, resolution = 1.5 x 1.5 x 2 mm, TE / TR / TRdelay / α = 25 ms/15 s/11.7 s/90^0. 6/8 k-space acquisition was used to optimise TE. MPRAGE data was acquired for anatomical registration. Pre-processing and single subject analysis were conducted on SPM5. Pre-processing included motion correction, coregistration with high resolution anatomical image and normalization to the standard MNI template. fMRI data were resampled to isotropic voxels of 2mm but not smoothed. Statistical analysis was performed according to GLM. All statistical maps were thresholded for peak height at $p<0.01$ (FDR corrected) and at $k>30$ for spatial extent.

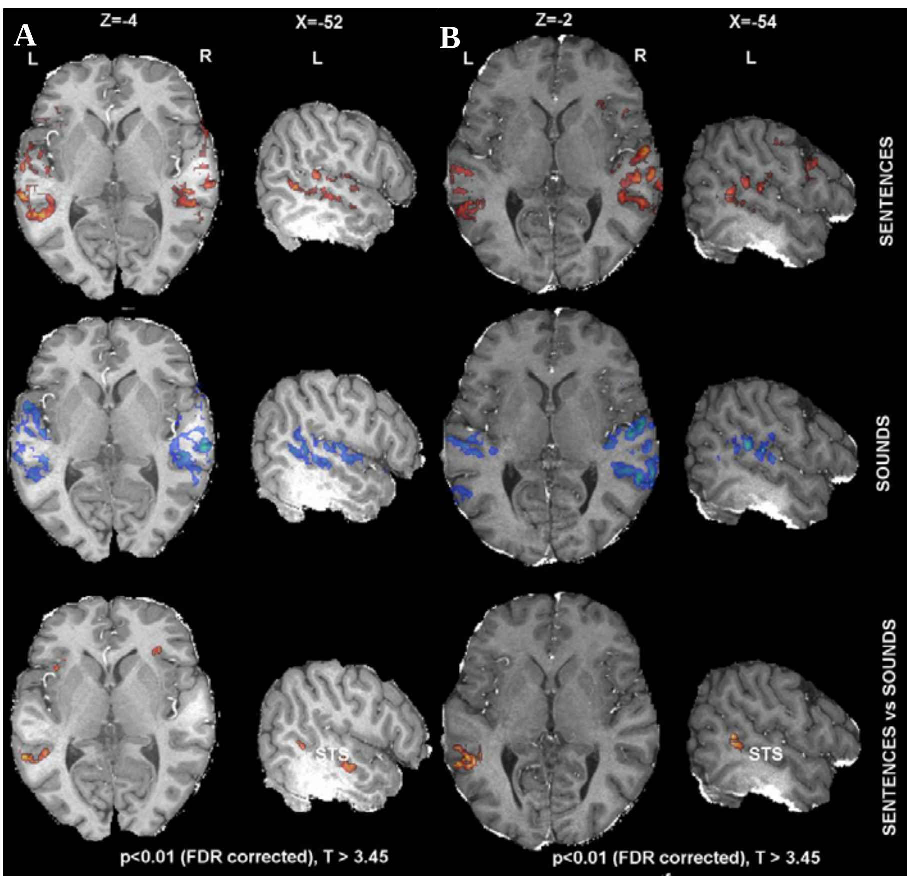

Figure 1. Activation maps of two representative subjects (panel A and B) shown overlaid on the anatomical data. Note the good spatial correlation of activation and grey matter in both subjects.

Results All subjects were able to hear and understand the phrases and correctly identified errors. For all subjects, activation was found in the primary auditory cortex (planum temporalis, Superior temporal gyrus, Heschl's gyrus) for both 'sound' and 'sentences' conditions (Fig 1, top and middle rows). The spatial extend of the active area in the primary auditory cortex did not change significantly between conditions. The comparison between sentences and environmental noise could precisely discriminate the involvement of the Superior Temporal Sulcus (STS) in the voice and sentence processing (Fig 1, bottom row). For subject A, 2 active regions were detected in the STS for the 'sentences vs sounds' condition, centred at -64, -48, 0 in MNI space and, more anterior, -54 -20 -12, spanning 42 and 35 voxels and with 2.4 and 3.0 % signal change at the centre voxel respectively. For subject B, a 132-voxel active region centred at -56 -52 -2 in MNI-space with 2.8% signal change in the centre was found.

Thanks to the high spatial resolution employed here, activation for all conditions was constricted to the grey matter areas, as expected from the physiology.

Discussion Padding around the ears was carefully adjusted to limit acoustic noise. All subjects reported good sound quality and activation of the auditory cortex was consistently found. Through-slice dephasing, which can be severe in the auditory cortex and frontal areas in 7T echo planar data, was limited by the use of a relatively thin slice thickness. The 'earplugs' did not cause added distortions in the echo planar images. Because of the high spatial resolution employed here, distortion of the EPI data in the areas of interest was limited, as can be seen by the excellent spatial correlation of the activation and the grey matter in the, not distorted, MPRAGE images.

Conclusion The high spatial resolution offered by 7T allows the acquisition of auditory fMRI with minor distortion, where activation is consistently found in individual subjects and constrained to the grey matter of the auditory areas.

References [1]A.vom Endt et. al, 00451, Proc. ISMRM 2006 [2]Meader et. al, 2001,NeuroImage 14, 802-816 [3]Meuli et. al. 2000, NeuroImage 11, S541