SE fMRI in human bilateral auditory cortex using B1 shimming

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INTRODUCTION. It has been shown that Spin Echo (SE) based BOLD fMRI in conjunction with Ultra High magnetic Field (UHF) allows for the detection of functional responses originating mostly at the microvasculature level, providing increased spatial specificity and contrast to noise ratio, while reducing sensitivity to large draining veins [1]. With this approach, robust SE-BOLD functional maps have been obtained at a sub-millimeter scale in the human brain at 7 T allowing detecting orientation columns [2] in the visual cortex. Our motivation is to use SE-fMRI to push further the investigation of conspicuous functional organization in the human auditory cortex, where mirroring tonotopy had previously been demonstrated in Gradient Echo BOLD fMRI at 7 T [3]. Successful SE-BOLD however, relies on refocusing RF pulses, requiring that transmit B1 (B1+) magnitude be sufficiently large and homogeneous in the structure of interest. This can be achieved in the visual cortex with a surface quadrature Transmit (Tx) coil covering the occipital lobe [2], but the latter coil cannot reach the auditory cortex. Single channel Transmit (1Tx) volume head coils, on the other hand, typically produce high |B1+| in the center of the brain at 7T, but with B1+ dropout in the auditory cortices, so that SE-BOLD fMRI with a reasonably short TR (≤ 3s) would be limited to a very small number of slices to not exceed SAR limits. Here we investigate the use of an RF coil that includes 8 Transceivers (8TCx), allowing for the use of B1 shimming over right *and* left auditory cortices, as well as 24 Receive only channels (24Rx), providing higher SNR.

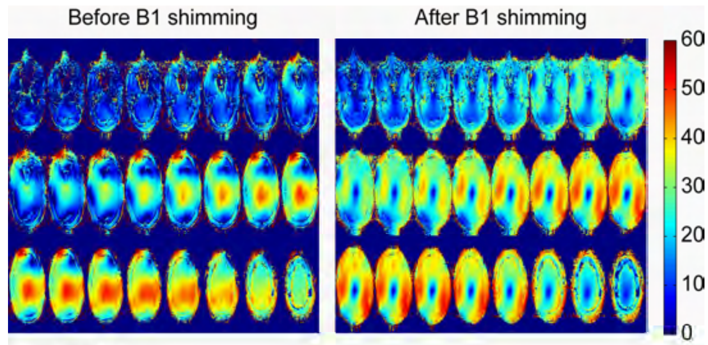

Figure 1

MATERIAL AND METHODS. Two healthy volunteers were imaged at 7T (Siemens, Germany) using a using a custom 8TCx24Rx RF coil (total of 24 + 8 = 32 Rx channels) powered by 8x1kW RFAmps (CPC, USA). 3D T1w MPRAGE anatomical data were acquired with initial B1 shimming settings close to CP-like mode to achieve whole brain excitation. Fast |B1+| mapping was obtained over the 8 channels in small flip angle regime in an oblique slice crossing both auditory cortices [4]. Prior to functional measurements, B1 efficiency was optimized by reducing destructive interferences within two ROIs manually drawn over bilateral auditory areas [5] and RF power was calibrated accordingly based on a 3D AFI maps [6]. Functional responses were measured with standard SE-EPI sequence (27 slices transversal oblique; TE = 37 ms; TR = 3000 ms; gap in TR = 1500 ms; resolution 1.5 x 1.5 x 1.5 mm^3). Stimuli consisted of 800 ms long amplitude-modulated (8 Hz; modulation depth of 1) tones (.45; .5; .55; 1.35; 1.5; 1.65; 2.25; 2.5; 2.75 KHz) presented grouped in blocks around three center frequencies (.5; .1.5; 2.5 KHz) together with blocks of natural sounds grouped in five categories (voice, speech, animals, tools, nature). All sounds were presented in silent gaps in between TRs. Six runs of ten minutes were acquired in each subject. All analyses (pre-processing motion correction spatial smoothing) were carried on in BrainVoyager (BrainInnovation, The Netherlands).

RESULTS. As can be seen in Fig. 1 on flip angle maps obtained before and after B1 shimming (24 axial views out of a 3D set), normalized to a same reference voltage, substantial increase in local |B1+| was obtained in right and left auditory cortex. The corresponding reduction in required RF power made it possible to acquire 27 slices with a 3s TR without exceeding maximum SAR limits, whereas in the CP-like mode only about 9 slices could have been sampled in the same TR. The SE-EPI fMRI images shown in Fig. 2 were obtained in a subject using this B1 shimming solution. Note the expected drop in sensitivity in centre regions, deliberately ignored in our B1 shimming target, corresponding to areas of minimum B1 efficiency (see Fig. 1). Figure 3 shows results of preliminary analysis carried at the slice level. Figure 3a shows the F-map resulting from a standard General Linear Model analysis, with clear bilateral auditory activation. Figure 3b shows the single subject results for a contrast between voices or speech against animals' tools and nature sounds, activating lateral (right) regions in the anterior

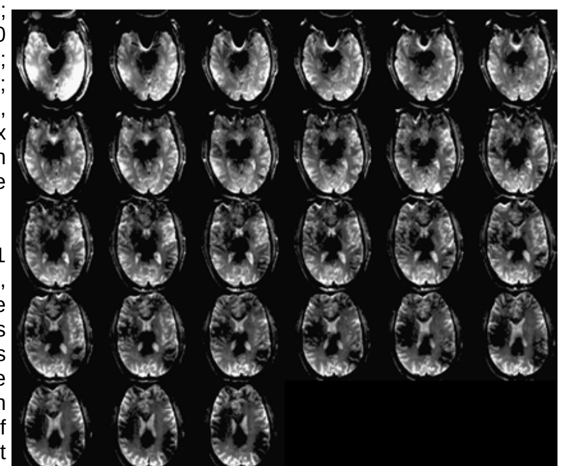

Figure 2

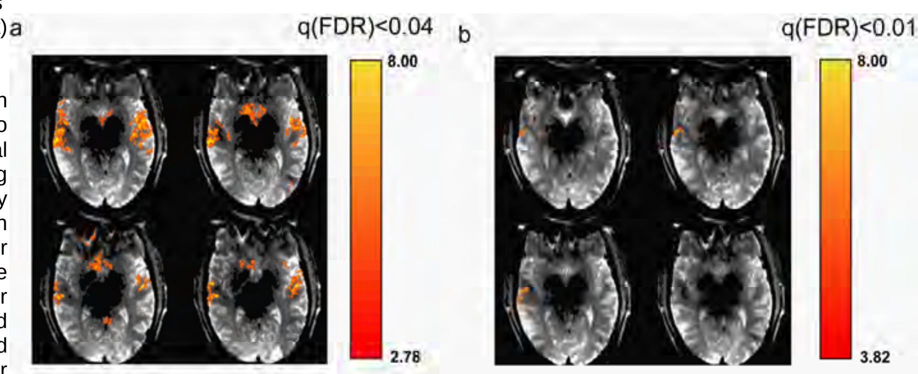

Figure 3

DISCUSSION. We demonstrate successful SE-fMRI in bilateral auditory cortex at 7T, using B1 shimming to preserve spatial resolution (1.5^3 mm^3) and spatial coverage (27 slices) at a TR of 3s without exceeding global SAR limits. With this approach, our preliminary results highlight significant differences between responses to voice vs. non-voice stimuli in anterior areas of the superior temporal sulcus and gyrus. These preliminary results are strongly supporting further investigation of acquisition techniques at ultra high field on large topographical responses such as tonotopy and the use of T2 weighted fMRI for the study of columnar responses in auditory regions.

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