An open 4ch. Transmit / 16 ch. Receive coil for High Resolution Occipital and Temporal Visual Cortex Imaging at 7T

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INTRODUCTION

Images of the human brain at ultra-high fields of 7T and above are often acquired using a cylindrical quadrature volume transmit (Tx) coil and whole head phased array receive coil. Though this allows for a high B_1^+ value at the center of the head, the Tx efficiency is much lower along the periphery and inferior extents of the brain, particularly along the occipital and inferotemporal visual cortex. In addition, receive (Rx) coil loop size optimized for whole brain coverage sacrifice SNR at the periphery in the cortex. This can be addressed by a) using a phased-array, semi-cylindrical Tx coil layout, where B_1^+ can be homogenised by phase and amplitude shimming in the region of interest [2], and by b) additionally utilizing arrays of small receive coils with closely attached preamplifiers [3]. Here we try to show the advantages of building an open, half-cylindrical Tx coil layout with a conformal small loop size Rx coil layout optimised for functional MRI of the occipital and inferior and middle temporal visual cortex at high spatial resolution.

METHODS

The coil housing was 3D printed using the Fused Deposition Modelling (FDM) method. The receive coils were built on a conformal former following the contours of the human head; the transmit array was laid out on a half-cylindrical former. The transmit array consists of 4 overlapped coils laid out using 1.2cm wide copper tape [1]. The transmit coils on either side are 12x12cm^2, with ten 12pF capacitors distributed along it while the two posterior coils are slightly larger at 12x14cm^2 and have four 12pF and six 10pF capacitors distributed along its length , thus providing an extended cerebellar coverage. An RF shield was placed concentric to the transmit array, 3 cm away from it, to minimize eddy current losses. [**Fig. 1 (L)]** High-power PIN diodes on each Tx loop were used for active detuning of the Tx array. The receiver section consists of 16 phased-array coils in a 8x2 grid, with each coil being 6cm in diameter, and built using 2mm diameter silver-coated copper wires. [**Fig. 1 (R)]** The placement and layout of the Rx array was optimised to ensure full coverage of the occipital and inferior and middle temporal visual cortex. Each Rx coil is matched using a balun circuit and contains active and passive detuning circuitry. They are connected to 16 low-noise preamplifiers using $\lambda/4$ length coaxial cables and lumped-element networks, which also help achieve preamplifier decoupling [4]. Experiments on a human volunteer were conducted in a Siemens MAGNETOM 7T actively shielded system with an SC72 70mT/m gradient coil using the actual flip angle (AFI) technique for absolute B_1^+ quantification and the University of Minnesota multi-band EPI package for GE BOLD EPI at 1.1mm (TE=19, PF=6/8, GRAPPA 3, BW= 1370 Hz) and 0.8mm (TE=19, PF=6/8, GRAPPA 3, BW= 1000 Hz) isotropic.

RESULTS

Individual Tx and Rx coil elements were tuned to 297.2MHz. The Rx coils were matched to better than -20dB at 50 Ohms, with preamplifier decoupling < -25dB. The phases of the transmit array where adjusted for optimal performance in the visual cortex. We were able to utilize a four way splitter with this fixed optimal phase setup for all our subjects. The B_1^+ map shows a homogeneous excitation in the visual cortex regions, with a slight asymmetry towards the right. [**Fig. 2 (L)]** An excitation voltage of 120-125 V was required to achieve a 90˚ flip angle in the occipital lobe. The receive loops achieved high SNR and relatively low noise correlation. [**Fig. 2 (R)]** Mean EPI images (over 100 volumes) at 0.8mm isotropic and 1.1mm isotropic confirm this result. [**Fig. 3**]

CONCLUSION AND DISCUSSION

The custom built 4 channel Tx / 16 channel Rx coil offers a significant advantage over standard cylindrical volume coils when imaging the human occipital and temporal visual cortex. The Tx array allows for high flexibility in terms of B_1^+ shimming, and provides a homogeneous excitation profile in the region of interest with a comparably lower excitation voltage (compared to a whole head coil). The Rx array allows for a high SNR value and has enough penetration depth to image the entire visual cortex region into sulcal depths. Future work would involve incorporating upto 32 receiver loops of smaller diameters and increasing the number of Tx coils in order to achieve more localised brain coverage, higher SNR and increased control over B_1^+ fields and B_0 shimming near the ear canals.

REFERENCES

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Fig. 1 (**Top**): *The assembled coil* **(L**): *The transmit array consisting of 4 phased-array loops and a power splitter at the bottom. The RF shield can be seen behind the Tx array (***R**): *The 16 receiver loops in a 8x2 grid, encapsulating the visual cortex*

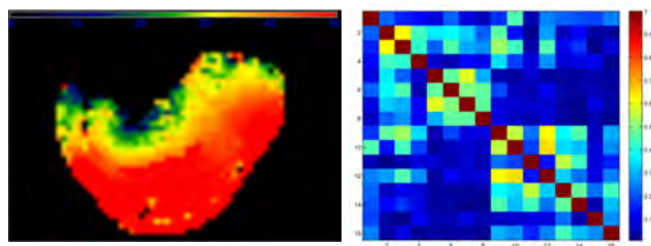

Fig. 2 (**L**): *B_1^+ map in the transverse plane with human subject with flip angles from 0˚ to 50˚* (**R**): *Noise correlation matrix for 16 ch Rx array with human subject*

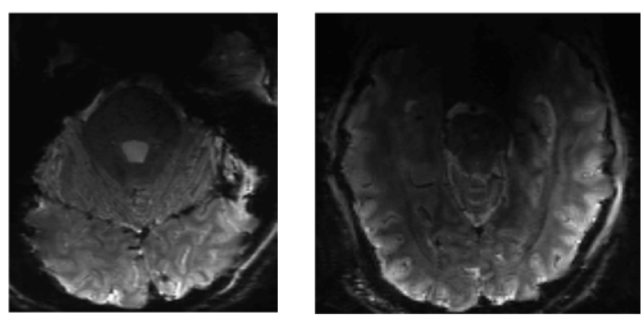

Fig. 3 (**L**): *0.8mm isotropic EPI, mean image, occipital pole* (**R**): *1.1mm isotropic EPI, mean image, occipital and middle temporal cortex*