A 12-element Receive Coil Array for the Rat Brain at 11.7T

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Introduction. In order to take advantage of the sensitivity that high fields offer we have developed and describe here a 12-element receive-only array design for parallel imaging optimized for the rat brain at 11.7 T. To achieve the necessary decoupling between array elements, small, low noise, low input impedance preamplifiers were designed with the limited diameter of small bore animal systems in mind.

Methods.

Preamplifiers. Small 35 x 12 mm preamplifiers were constructed using an earlier design (1), however a FET-bipolar transistor cascode was used instead of the dual FET design. The amplifiers were powered with a 10V supply fed onto the receive signal lines. The preamplifiers were able to achieve a gain of 28 dB with a noise figure of 0.8 dB and an input impedance of < 2 ohms. When stacked in a 4x3 formation, the total width of the preamplifier block was 65 mm, and the height was 40 mm (Figure 1).

Receive array. The coil pad layout was milled on copper-plated teflon (Polyflon Company, CT, USA) which becomes flexible after copper removal. The coils were arranged in three rows in a 5-5-2 configuration with coils overlapping in the z-direction and with a small gap (~ 1 mm) in the x-direction (Figure 1). The five element rows were optimized for the rat brain using a simulated annealing algorithm (2). This results in elements that become larger when moving to the side of the head to compensate for increased distance to the brain. Individual coil Q for the smallest coil (10 x 5 mm) was measured to be 270 unloaded and 150 when loaded with a 0.45% w/v saline phantom. For the largest coil (10 x 11 mm) Q was 330 unloaded and 130 loaded. A pin diode circuit was used to detune the receive coils during transmission. Decoupling of >15 dB was achieved through the preamplifier in bench experiments. In-line cable traps were placed between the coil and preamplifiers and on the preamplifier outputs (isolation ~10 dB). All images were acquired on a 31-cm 11.7 T magnet (Agilent) equipped with 12-cm i.d. gradients, a 90-mm i.d. quadrature transmit coil (Resonance Research Inc, Billerica, MA) and a Bruker Avance III console with twelve receivers.

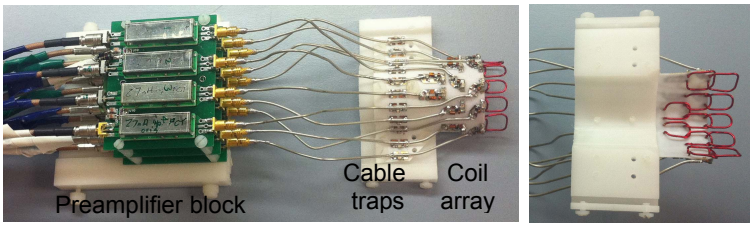

Figure 1. Preamplifier and coil layout for the 12-coil rat brain array.

Results. Spin-echo images were acquired on a 0.45% w/v saline phantom, and on a rat brain *in vivo*. Image parameters: FOV = 30 mm, slice thickness = 0.5 mm, matrix size = 256 x 256, TR/TE = 1.5s/12 ms, GRAPPA reconstruction for accelerated images. 3D gradient-echo images were also acquired with TR/TE=30/8 ms, 50 µm resolution, 512x512x256 matrix. Compared to a large 25-mm surface coil shaped to the rat head (non-quadrature) a factor of 3 improvement of was observed in the maximum SNR at the surface, and 1.3 at the position of the base of the rat brain (SNR was calculated in the phantom using method in ref 3). If the surface coil were replaced with a quadrature coil, an equivalent sensitivity at the base would be 0.9 (=1.3/sqrt(2)) which is consistent with significant noise contribution from small coil elements. *In vivo* rat brain images are shown in figure 2 and 3, demonstrating acceleration through each row of the array, and to show the coverage over the brain.

Conclusions. We have demonstrated the utility of a 12 element rat brain array providing high SNR at the cortex with only a minor penalty in deep regions. Although acceleration is shown in only one direction, it may be applied to each of the other directions up to a factor of 2. Although we currently only use the array for anatomical imaging, it is expected that it will be used for high speed imaging of the whole rat brain e.g. for fMRI.

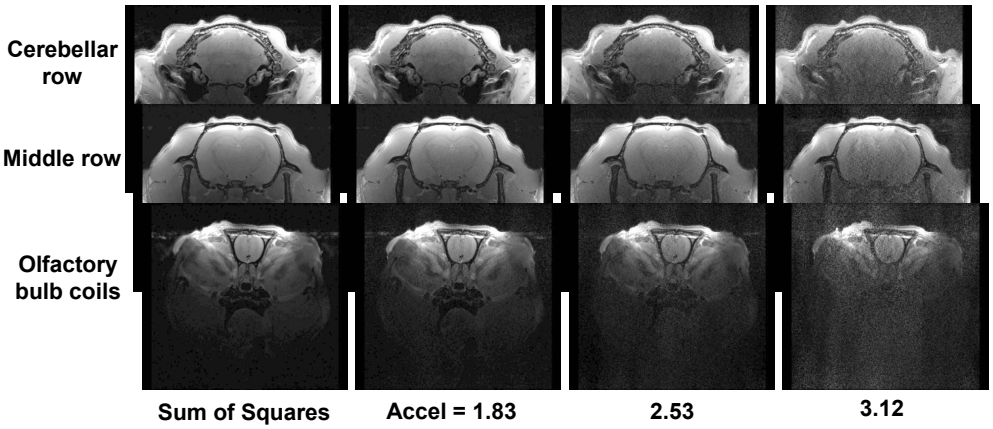

Figure 2. Spin-echo images from a rat brain *in vivo*. The images are taken from the approximate center of each coil row. The phase encode dimension for acceleration is from left to right. Image reconstruction uses the GRAPPA algorithm.

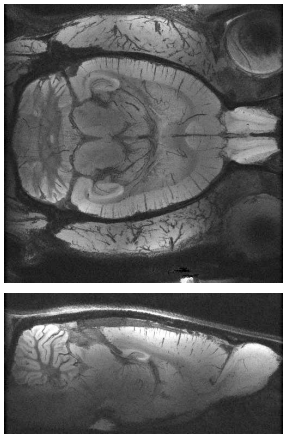

Figure 3. Coronal and sagittal images showing the coverage of the array. In this case the images are minimum intensity projections through 1 mm of tissue. The images are weighted for veins and for manganese enhancement. Resolution is 50 µm isotropic.

References.

1. Dodd S. et al, Proc 17th ISMRM, Honolulu, p3141, 2009
2. Dodd S. et al, Proc 13th ISMRM, Miami, p913, 2005
3. Kellman et al MRM. 54(6):1439. 2005