Parallel Transceive Array for 9.4 T Animal Studies

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Introduction

Parallel receive arrays provide a number of benefits for MR experiments. Measured SNR is improved over that provided by a larger volume coil due to the use of smaller surface coils to construct the array. Rapid imaging is also made possible by using methods such as SENSE to reduce scan time required during the imaging study. This helps to reduce blurring, distortion, and signal loss effects that degrade image quality as a result of B_0 inhomogeneity and susceptibility effects, prevalent for functional studies that use EPI. Such rapid techniques also enable greater flexibility in translating SNR into higher resolution. Recent efforts have extended parallel reception approaches into multi-channel transmission of the RF, with tailoring possible of the individual frequencies, phases, and shapes of the RF pulse delivered by each individual channel [1]. The added benefits of this customization include acceleration of the transmission for long pulses typically used for spatial selection, as well as for correction of B_1 inhomogeneity that worsens with field strength. In this abstract, we describe the modification of a parallel receive array to perform as a parallel transceive system for use in animal experiments at 9.4 T, with performance demonstrated in the rat brain.

Methods

Receive Array – As the basis for the transceive design, the parallel receive system described previously [2] was used (Figure 1). This consisted of four surface coils arranged orthogonally around a 38 mm cylinder. Each contained: balanced adjustable capacitive match, adjustable tuning, active detuning, overlap decoupling, and lattice and figure-eight loop baluns on inputs. Transmission was initially achieved using a detuneable linear volume coil.

Transceive Array –To configure this system for parallel transmit, the input RF was split using a four way 1kW RF divider custom built by Werlatone for 400 MHz. Each of its four outputs had an incremental 90° phase, increasing clockwise when connected to the multi-channel array, with each maintained in the active state and the volume coil detuned throughout the experiment.

Imaging Tests – To test the developed system, a deceased rat was imaged under the following configurations using a Varian 9.4T system with a DirectDrive console: 1.) parallel receive – use of volume coil for TX, parallel array for RX, 2.) transceive – array was used for parallel TX and RX, and 3.) volume coil –volume coil used only with array removed. For each case, 10 images were acquired using a gradient echo sequence, where: TR/TE = 250/4.7 ms, 256x256 points, 36x36x3mm FOV, 30° excitation, R = 1. For cases 1 and 2, all images were reconstructed using a SENSE algorithm with the first image of 10 used to calculate sensitivity maps. SNR maps were generated for all three cases by taking the mean over the standard deviation at each pixel across all 10 images. Mean SNR was computed within the rat brain for each map.

Results and Discussion

Good uniformity was observed for all three cases (Figure 2), with the transceive design producing the highest mean SNR in the defined rat brain ROI of 77.4, versus 54.1 for receive only, and 21.5 for the volume coil. This represents a 43% increase over the receive array, and a 3.6 fold improvement over the volume coil. The notable SNR improvement is believed to be in part due to more efficient transmission using the smaller surface coils in a circular polarized configuration versus the linear volume coil, whose performance suffered from cable current issues. Future work will focus on removing redundant components from the transceive array, such as active detuning circuitry, and characterizing transmit profiles. Additional rat brain functional and anatomical studies will be performed with the modified transceive design.

References [1] Katscher U, et al, MRM 49: 114-150 (2003)
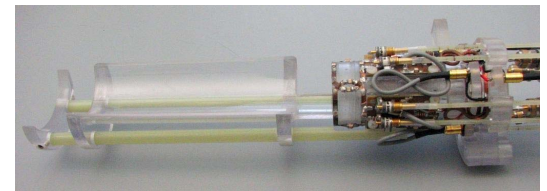[2] Wargo CJ, et al, ISMRM Toronto: 1102 (2008)

Figure 1 – Parallel receive array composed of four channels adapted for simultaneous RF transmission.
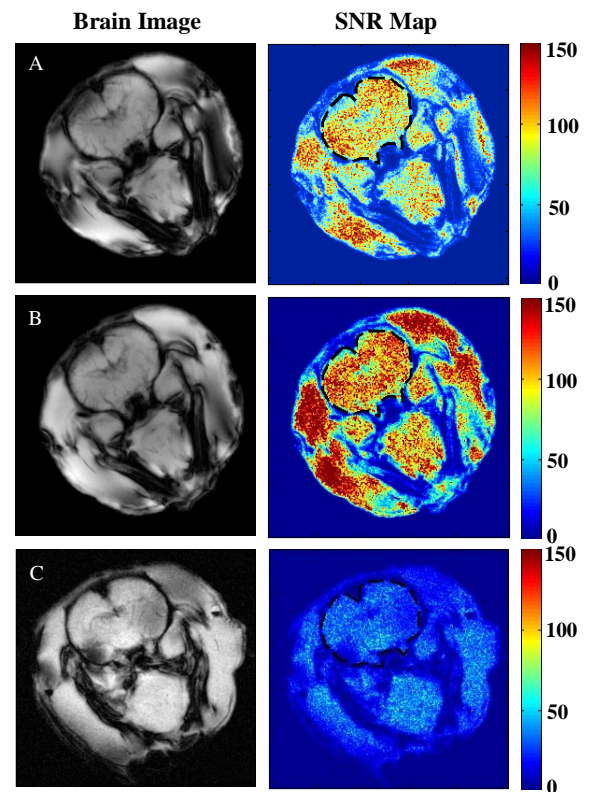

Figure 2 – Rat brain image and SNR map for A.) receive array, B.) transceive array, and C.) volume coil. Dashed lines define mean rat brain SNR ROI.