Phased Array Optimized for Simultaneous Reception with a Transmit Volume Coil for SNR Improvement of the Spectroscopic Imaging of the Hippocampus.

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Introduction: A common way to improve SNR for spectroscopic studies from restricted regions is by using a transmit-only volume coil with a receive-only surface coil phased array (1). Improved sensitivity in the medial temporal lobes is critical for the accurate measurement of low concentration neurotransmitters such as GABA. Although phased arrays have superior SNR near the array, it has not been possible to achieve substantial SNR increases in comparison to volume coils from the central regions of the brain such as the hippocampi (2). Substantial improvements of the SNR near the center of the head can be obtained if the volume transmit coil is also used for reception. Previously Hyde used a volume coil and a single surface coil for simultaneous reception demonstrating improved SNR (3). To avoid interactions between the two coils, a counter rotating current (CRC) surface coil consisting of two parallel rings carrying opposite currents (4) was used. Recently simultaneous reception for improved sensitivity in the center of the human brain has been reported using a volume coil and a CRC array (5). In this work we developed a 6-channel CRC phased array optimized for the hippocampus and capable of receiving simultaneously with a head-sized volume coil.

Methods: A 16-element quadrature TEM head volume coil (element id - 31.8 cm, shield diameter – 38 cm, length 23.9 cm) was constructed for 4 T (170 MHz - ^{1}H frequency) (6). No active detuning of the TEM was utilized. The CRC phased array consisted of six 8 x 5.5 cm CRC surface coils (Fig. 1) with three coils located on each side of a head. Each CRC coil contained two parallel loops separated by 12 mm and connected in series. To optimize SNR and increase contribution from adjacent coils in the hippocampus area (7-8 cm depth) CRC coils were overlapped. The length of the three coil set measured 12.5 cm. Each set was tilted from vertical direction to accommodate for the geometry of the hippocampus (Fig.1A). Intrinsic decoupling due to coil overlapping between adjacent surface coils loaded with a head or a phantom was -15 dB or better. Intrinsic isolation between coils located at the ends (1 & 3) measured -7 dB and was improved inductively to about -20 dB by using small (~5 mm) loops connected in series with the outside loops of these two CRC coils (Fig.1A). The intrinsic isolation between the loaded volume coil and the CRC coils was better than -20 dB. Ratio of Q_U/Q_L for CRC coils loaded with a human head was 2.5 or greater. All surface coils were actively detuned for preamplifier protection. Preamplifier decoupling using low input impedance preamplifiers (input impedance ~4 Ω) was utilized to optimize the system performance (5). Six preamplifiers and six T/R switches were mounted on the volume coil shell. Home-built T/R switches provided better than -50 dB isolation and ~0.15 dB insertion loss.

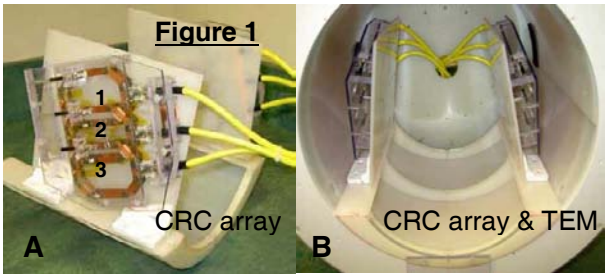

Figure 1

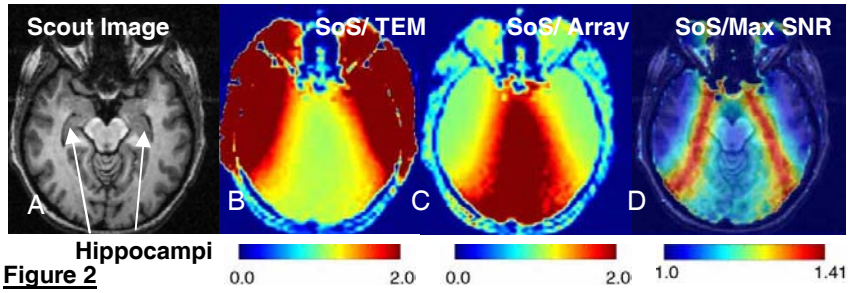

Figure 2

Results and Discussion: Simultaneous reception improves SNR in the areas where the volume coil and phased array produce similar sensitivities. Therefore, size and geometry of the phased array was optimized for the hippocampus. Fig. 2 shows maps demonstrating improvement of the SNR in the TEM/CRC sum-of-square (SoS) combined image (1) of a human head when using the CRC array and the TEM volume coil for simultaneous reception. The SoS-image provides more SNR than the volume coil image in the peripheral part of the brain (Fig.2B) and higher SNR than the phased array image in the center of the head (Fig.2C). Both coils have similar sensitivity at the depth of ~7-8 cm. As a result ~40 % SNR improvement was obtained in the hippocampi as compared to using TEM or phased array alone (Fig.2D).

Conclusion: A 6-channel CRC surface coil phased array was constructed for spectroscopic measurements in the human hippocampus. Due to intrinsic isolation between the CRC coil and the transmit volume coil, simultaneous reception with both the volume head coil and phased array is possible. A 40% SNR improvement was demonstrated for the hippocampi.

References: 1) Roemer PB, MRM 1990;16:192-225. 2) Wright SM et al NMR in Biomed 1997;10:394-410. 3) Hyde JS et al, MRM 1988:6:235-239. 4) Froncisz W et al, MRM 1986;3:590-603. 5) Avdievich NI et al, Proc ISMRM 13, 2005, p 327. 6) Vaughan JT et al, MRM 1994;32:206-218.