

# Variable Geometry Elliptical Transceiver Phased Array for Imaging of the Human Brain at 7 T

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**Introduction:** Despite the availability of 7T systems dating from late 1990s, their use in clinical applications has been slowed by technical hurdles associated with detector design. This limitation is due to increased power deposition and  $B_1$  inhomogeneity for conventional volume coils (1). To overcome this limitation substantial effort has focused on the use of transceiver phased arrays with independent amplitude and phase control (2-5). The performance of the phased array can be further optimized by adjusting the array's geometry to accommodate heads of various sizes. However, changes in coil coupling resulting from different loading conditions complicate its construction and use (5). We have developed an 8 element 7T transceiver split phased array with selectable geometry and a method for individualized optimization of the RF phases and amplitudes. This design allowed substantial improvement in coil's efficiency and homogeneity.

**Methods:** The transceiver phased array consisted of eight (9cm - length) evenly spaced rectangular surface coils circumscribing the head. All the adjacent coils were decoupled inductively to a level of at least -18-20 dB when loaded. The array was split in two parts with the bottom section having five surface coils and the top portion – three coils. Due to inductive decoupling no electrical connection between the parts of the array was required. To accommodate different head sizes we constructed three different array tops (Fig.1A), which when combined with the bottom (Fig.1B) allowed the coil's height to be varied (21, 23 and 25 cm). The width for all three combinations measured 19.5 cm. For comparison we also built a circular (25 cm - diameter) non-split phased array (Fig.1C) with eight surface coils of the same length as the elliptical array. The RF shimming procedure included the following. First,  $B_1$  maps (phase and amplitude) of the individual coils (single coil transmitting) or the combined array (all coils transmitting simultaneously) were acquired. The phases for the RF for each coil were chosen to maximize the  $B_1$  for the center of the brain (6cm ROI) (Fig.2A). Using these phases the amplitudes were optimized over a second ROI encompassing the majority of the brain within the slice using a least squares algorithm (Fig.2A). A second  $B_1$  map was then acquired with all coils transmitting simultaneously to verify the target performance was achieved (Fig.2B). Data was acquired on a Varian Direct Drive 7T human imaging system.

**Results and Discussion:** To demonstrate the importance of the elliptical geometry of the array we compared the performance of all four arrays on two subjects (Figs.3 & 4). While subject #1 (female) was able to fit in all four arrays, subject #2 (male) could not fit in the smallest array. Excellent  $B_1$  homogeneity ( $\sim 9\text{-}12\%$  SD over larger ROI (Fig.2A)) was obtained for all the coils. Fig.2B shows an example of  $B_1^+$  map. For larger coils the optimized  $B_1$  required substantially higher drive voltages for the upper surface coils (Fig.3) and thus increased RF power. Fig.4 presents a plot of RF power (summed over all 8 channels) required to produce a  $B_1$  of 1 kHz (averaged over larger ROI) for all array combinations. For both subjects the elliptical arrays with closest fit required  $\sim 40\%$  less power than the cylindrical array. With respect to the phase of the RF (across the two individuals and all coils) the mean phase shifts in comparison to the theoretical incremental  $45^\circ$  values varied from  $44^\circ$  to  $61^\circ$  depending upon the specific coil, with a maximal deviation of  $\sim 40^\circ$ . For the smallest configuration ( $19.5 \times 21\text{cm}^2$ ), the  $90^\circ$  pulse duration at 1 kW was 335  $\mu\text{s}$ . This is  $\sim 30\%$  shorter than a recently described 16 element transceiver array ( $18 \times 22\text{cm}^2$ ; length -15cm) as reported by Adriany (5).

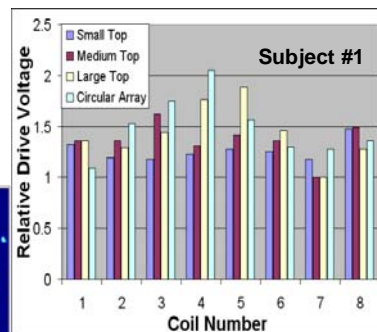
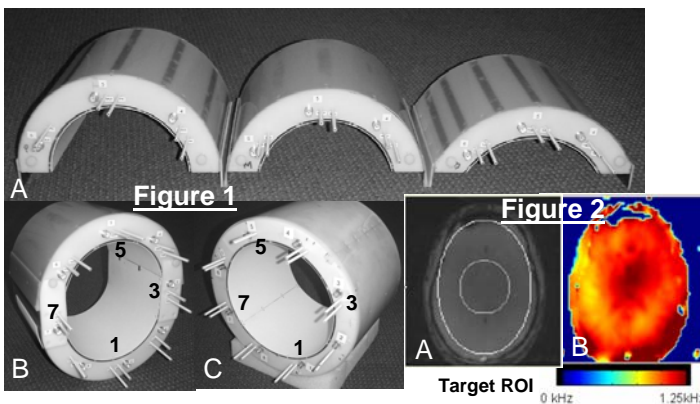


Figure 3

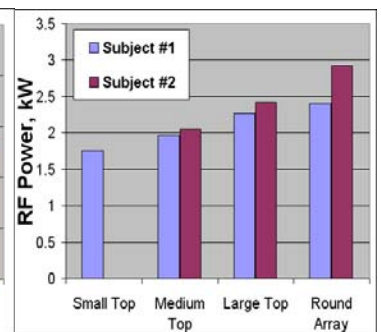


Figure 4

**Conclusion:** The combination of a transceiver array and RF shimming to optimize both the phase and amplitude provides for highly efficient generation of a relatively homogenous  $B_1$  field for human head at 7T. For the two volunteers, the respective optimal sizes achieved 1 kHz of  $B_1$  at powers of 1.76 and 2.04 kW,  $\sim 40\%$  less than the circular array.

**References:** 1) Vaughan JT et al, MRM 2001;46(1):24-30. 2) Adriany G, MRM 2005;53(2):434-445. 3) Collins CM et al, MRM 2005, 54: 1327-1332. 4) Mao W et al, MRM 2006;56:918-922. 5) Adriany G et al, MRM 2008;59:590-597.