Ink-Net: Safe 256 Channel EEG at 7T

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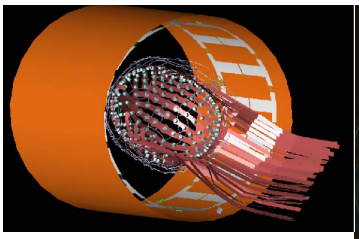
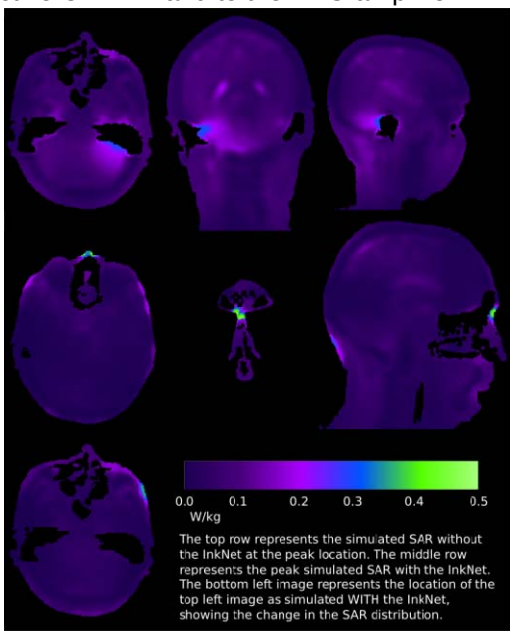
Target Audience:
MRI Compatibility Designers, MRI Safety Officers, RF Engineers, Neuroscientists

Purpose:
To show the safety of performing 256 channel Ink-Net EEG recordings simultaneously with MRI acquisition at 7T



Methods:
Previous studies have shown that high density EEG caps in high field MRI (3 & 7T) can generate high Specific Absorption Rates (SAR) above safety limits [1]: Food and Drug Administration (FDA) maximum whole head SAR of 3.2 W/kg and a 1g maximum of 8W/kg; International Electrotechnical Commission (IEC) 10 W/kg over a 10g average. In order to test the safety of using our new polymer thick film e-ink 256 channel EEG simultaneously with 7T MRI, we performed a combination of simulations and temperature measurements. Finite Difference Time Domain (FDTD) was used to simulate the electromagnetic field induced by the transmit coil and influenced by 31 phased array receive coils, an RF shield, the Ink-Net (EEG net), and a 49 tissue head and shoulders model [2], allowing us to estimate the Specific Absorption Rate (SAR) in our 49 tissue head model. We also constructed a CHEMA [3] and performed temperature measurements using 4 Neoptix Inc. (QC,Canada) temperature probes during a TSE sequence at 100% SAR for one hour to maximize any potential heating effect. These scans were performed both with and without the Ink-Net electrically connected to the conductive CHEMA and to the EEG amplifier.

Results:
Our FDTD simulations show that both the peak 1g and 10g SAR in the head shift from the border of the mastoid and inner table on the right hemisphere, to the nasion when the Ink-Net is added. Both with and without the InkNet the SAR levels were well below the FDA and IEC limits: the maximum value for the 1g SAR was estimated at 0.29 W/kg without the InkNet and 0.43 W/kg for all three different conductivities simulated in the Ink-Net traces. Our CHEMA temperature measurements displayed that the RF induced temperature changes were slightly higher with the InkNet and never exceeded 1 degree Celsius more than without the net over one hour of 100% SAR scanning.



Discussion:
The peak SAR in the nasion has not been found in previous 7T EEG simulations [1,3] suggesting that the EEG layout shifts the location of the peak.

Conclusions:
For each new EEG/device layout and electrical properties of the various materials, new simulations and temperature measurements must be performed to evaluate device safety.

References:
[1] Angelone, et al. Bioelectromagnetics, 25 285-295 (2004)
[2] Makris, et al. Med Biol Eng Comput, 46(12) 1239-1251 (2008)
[3] Angelone, et al. Magnetic Resonance Imaging, 24(6) 801-812 (2006)