



**Supporting Figure S1:** A) Experimentally measured  $B_1^+$  maps shown in the three orientations, and normalized to a  $90^\circ$  flip angle at the center of the brain for the in-house built 8Tx/32Rx coil array (upper row) and the commercial 1Tx/32Rx coil (bottom row). The total input voltages were 249V for the in-house built 8Tx/32Rx coil array and 187V for the commercial 1Tx/32Rx coil. For the in-house built 8Tx/32Rx coil array, the RF phases were optimized in transverse slice to cover the whole-brain. The same subject is shown for both coils. Nevertheless, the different fitting of the commercial 1Tx/32Rx coil on the head is responsible for the apparent differences on head's shape in sagittal slice. All measurements were performed within the SAR limits. B) Structural MP2RAGE image (0.6 mm-iso) masked to the brain tissues, and indicating the slices' positions shown in A) (white solid lines). The axial slice was oblique and oriented from the frontal to the occipital lobes.