Large-N Coil Arrays Decrease the Scantime Required to Accurately Identify Cortical Visual Areas

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Introduction: Using large N-array coils for MRI acquisition provides increased signal-to-noise ratio (SNR) in brain regions near the coils. We sought to quantify the benefit of higher SNR by measuring the effective reduction in acquisition time to accurately map neural representations using functional MRI. Mapping visual cortical area boundaries was chosen for this purpose because the neural organization of these areas is well understood and because quality of boundary estimation is not trivially related to the SNR of the fMRI acquisition, as opposed to estimating neural activation via measurement of BOLD-related signal changes. Visual area maps are useful as functional localizers, which simplify analysis and interpretation of functional imaging data (1). Decreased acquisition time devoted to functional localizers frees acquisition time for study of the brain function of primary interest in neuroimaging studies. In this study, we demonstrate an approximately four-fold decrease in acquisition time required to estimate the location of the boundary between visual cortical areas V1 and V2 using a 32-channel phased array head coil versus a 12-channel head matrix.

Methods: Two subjects were imaged twice each using a 3T Trio a TIM system (Siemens, Erlangen, Germany). Images were acquired using a prototype Siemens 32-channel phased-array head coil in the first session and with a standard TIM 12-channel head matrix coil in the second. A three-dimensional high resolution T1-weighted structural scan was acquired using an MP-RAGE pulse sequence with voxel size of 1x1x1 mm, flip angle of 7°, TE=3.48 ms, TI=1100 ms, and TR=2530 ms. Functional BOLD measurements were obtained using a single-shot, gradient echo EPI sequence with TR=2000 ms, TE=30 ms, flip angle=90°. Twenty-eight 2 mm thick slices were acquired with inter-slice gap of 0.2 mm and an in-plane resolution of 2x2 mm. During the second session a slightly modified fMRI protocol used with TE=31ms, twenty-five 2.3 mm thick slices, and an in-plane resolution of 2.1x2.1 mm. Standard phase-encoded visual stimuli (expanding and contracting rings, clockwise and counterclockwise rotating wedges) designed to localize visual area boundaries (2,3) were presented to the subject in runs lasting about 8 minutes each. A single run was performed with the 32-channel coil, while five runs were performed with the 12-channel matrix coil. The FSFAST software package was used to estimate the visual field representation for each functional voxel by estimating its preferred phase in the periodic visual stimulus. A surface representation of the interface between gray and white matter was constructed from the structural volume using the FREESURFER software package (4), then the visual field coordinates were projected onto the cortical surface for significant voxels. The sign of the determinant of the Jacobian of the visual field map provided an estimate of the handedness of the coordinate system of the local cortical visual field representation. Because this handedness is opposite in V1 and V2 the V1/V2 boundary can be identified as locations of fieldsign reversal. This analysis was repeated for each combination of between one and five runs acquired with the 12-channel coil and for the single run acquired with the 32-channel coil.

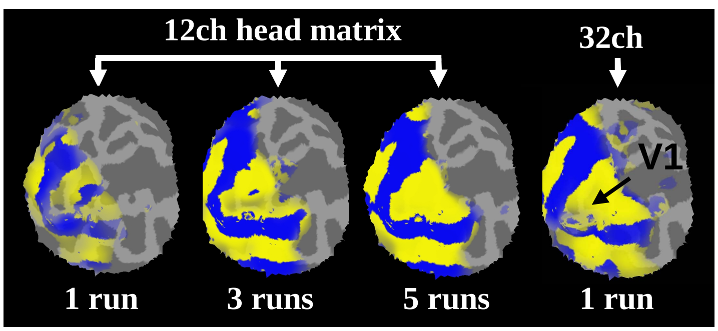

Figure 1: Comparison of the fieldsign estimate over the number of runs performed with the 12-channel head matrix coil (left three images) and the single run with the 32-channel coil (right).

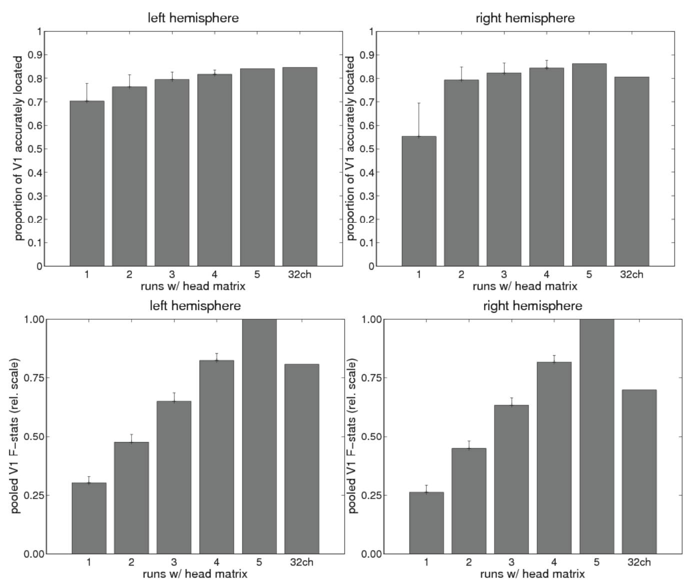

Figure 2: The proportion of V1 accurately identified for each hemisphere is shown on top for different numbers of runs with the 12-channel head matrix compared with a single run using the 32-channel coil. The bottom row shows the pooled F-statistics over V1 for the same runs and hemispheres.

Results: Figure 1 shows representative fieldsign estimates (opacity codes significance) derived from different numbers of runs with the 12-channel coil compared with a single run acquired with the prototype 32-channel coil (left hemisphere of subject one). V1 is the large yellow region in the center and V2 surrounds V1 in blue. Qualitatively, a single run with the 32-channel coil has similar accuracy and significance to three runs with the 12-channel. Figure 2 shows quantitative results; the top row illustrates the proportion of cortical surface vertices within V1 for which the fieldsign was correctly identified for each hemisphere. The bottom row shows the pooled F-statistics from within V1 over coils and number of runs. These measures indicate that images acquired in a single run using the 32-channel coil provide the same quality boundary estimation as three to five acquisitions with the 12-channel coil.

Conclusions: We have demonstrated an approximately four-fold decrease in acquisition time required for accurate estimation of the V1/V2 boundary location when using a 32-channel coil as opposed to a 12-channel coil. This shows that the increased SNR provided by high-N array coils in visual cortex provides substantial benefit for estimation of neural representation in cases where computing the expected benefit of increased SNR is not straightforward. Specifically, these results suggest that using large N-array coils decreases the scantime required for accurate functional localizers, which allows increased time for imaging brain function of primary interest.

References: 1) Saxe R., et al. Neuroimage, 30 (4) 1088–96, 2006, 2) Sereno M.I., et al. Science, 268 (5212):889–93, 1995, 3) Polimeni J., et al. HBM Meeting, (128), 2005, 4) Dale A.M., et al. Neuroimage, 9 (2):179–194, 1999.

Acknowledgments NCRR P41-RR14075, the MIND Institute, and NIH RMR U54-EB005149.