Bridging the gaps: High-Resolution Visual Field Mapping using Passband b-SSFP fMRI

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Introduction: Accurate visual field mapping using non-invasive BOLD fMRI is an important tool for elucidating the basic scaffold of the brain's functional architecture underlying visual information processing. It is hypothesized in this study that passband b-SSFP fMRI [1-11] can provide more accuracy due to its distortion-free, high-resolution and high-SNR [7, 11-12] characteristics.

Methods: All experiments were conducted using a GE 3 T whole-body Signa Excite system and an 8-channel post-head coil. *(1) Stimulus Design:*. Cyclic visual field mapping protocols with rotating wedges and log-scaled expanding rings of flickering color checks were presented on a small screen mounted on the head coil. Figure 1 depicts the stimuli which hadan extended fixation grid and a small flickering fixation dot and a color detection fixation task. Stimuli were optimized to maximize the likelihood for mapping pattern of activation that include foveal areas [14]. Cycle length was 30s with 12 cycles. *(2) Image Acquisition:* A stack-of-spirals acquisition was used to image an18 x 18 x 3.3 cm^3 FOV with 1.5 x 1.5 x 1.5 mm^3 spatial resolution and 3 s temporal resolution. An oblique plane through the occipital lobe was prescribed. Data from individual coils were first gridded and then combined through sum-of-squares for optimal SNR. *(3) Experiments* Total acquisition time was 372 s (12 s prep time + 360 acquisition time) per run. Four runs were repeated for signal averaging. *(4) Data Analysis:* Data was analyzed using mrVista software (http://white.stanford.edu).

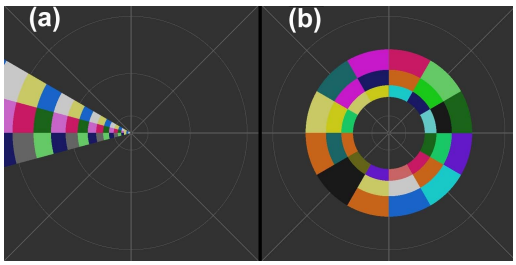

Figure 1 Visual Field Mapping stimuli design with extended fixation grid and flickering fixation dot. (a) Wedges and (b) Rings.

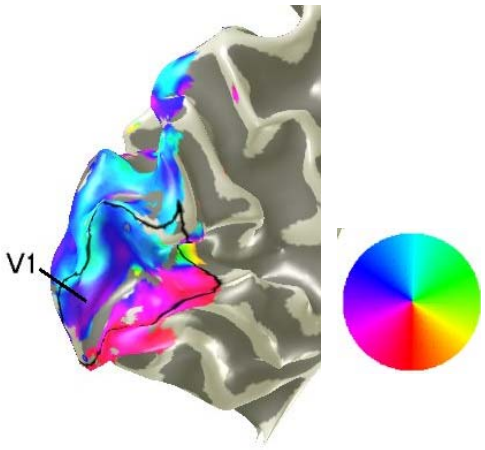

Figure 3 3d-Surface reconstruction of the occipital pole, with Area V1 labeled.

Results: *(1) Image Quality:* Distortion-free acquisitions were obtained demonstrating high-resolution images with little thermal noise For voxels in the brain, a mean signal intensity value of 21831 was estimated, while the standard deviation across time, averaged across voxels was 1804or 0.083%. Significant functional activity is visually restricted to subparts of the data images, matching the location of functionally active gray matter, while intermittent white matter shows no significant signal (Figure 2 top). Mean response amplitude of significant voxels was 2.2%. Repeated measurements show a high degree of repeatability across scans (Figure 2 bottom) demonstrating the stability of measurement protocols. *(2) Visual Field mapping:* Figure 3 shows a 3D reconstruction of occipital lobe from a single subject. Retinotopic field positions are color coded, such that horizontal meridian representations are signified by bluish purple colors, upper vertical meridian representations (i.e. the V1 V2v border) by red phases and finally lower vertical merdian representations (i.e. the V1 V2d border) by cyan phases. These features define the borders of V1 as marked in the figure.

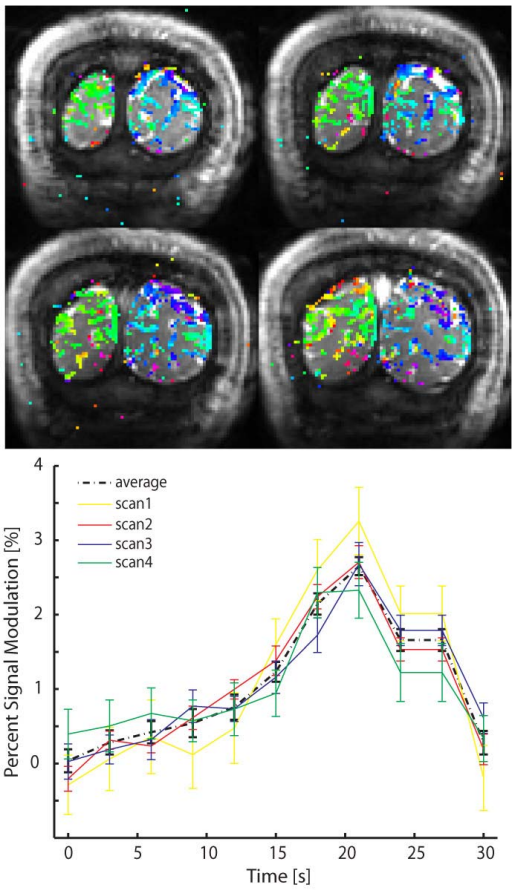

Figure 2 Cross-sectional color coded phase map with coherence threshold above 0.3. Top: Phase map is overlaid onto a raw inplane fMRI data. Note that significant activity is restricted to gray matter. Bottom: Single cycle response across runs and averaged across runs. Note the high degree of repeatability between measurements.

Conclusion: The results of our initial studies suggest that b-SSFP based fMRI will provide high resolution and high SNR maps of the human retinotopy with minimum spatial distortions, while demonstrating sufficient headroom in retinotopic signal to measurement noise ratio for allowing higher resolution in a standard 3T scanner. . .

Discussion: Stack-of-spirals acquisition provides excellent spatio-temporal resolution without parallel imaging. However, to further improve spatial resolution, combining with the stack-direction SENSE reconstruction would be highly desirable.

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