TWO-DIMENSIONAL MATHEMATICAL STRUCTURE OF THE HUMAN VISUOTOPIC MAP COMPLEX IN V1, V2, AND V3 MEASURED VIA FMRI AT 3 AND 7 TESLA*†

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Abstract

We describe an improved methodology for recording human visual topography in striate and extra-striate cortex via fMRI at 3 T and 7 T field strengths, as well as the first fit of a two-dimensional map function which jointly models the visuotopic structure within cortical areas V1, V2, and V3 to fMRI visual topography data. We discuss five methodological improvements for fMRI visual topography studies. (1) We constructed a custom multi-channel surface coil covering occipital cortex for an improvement in signal-to-noise ratio relative to standard head coil systems. (2) Real-time feedback to subjects, based on psychometrically established eye fixation performance for individual subjects, motivated subjects to maintain fixation. This enabled us to verify accurate long-term fixation and to discard trials where performance was poor. (3) We developed a phase encoding stimulus paradigm where the standard M-factor scaling of a black-and-white checkerboard pattern is replaced with a dynamic spatial noise pattern, in which the correlation length of the noise is matched to cortical magnification factor and thus scales with distance from the center of the visual field. (4) Least-squares optimal quasi-isometric brain flattening was used to obtain flat representations of the two-dimensional cortical surface without relaxation cuts through V1 or any other retinotopic area. (5) Finally, we fit a recently developed model of the structure of V1, V2, and V3 visual topography (Balasubramanian et al., *Neural Networks*, 15:1157–1163, 2002) to our data. This mathematical model allows for shear (i.e., anisotropy) in the cortical map and uses a small number of parameters (two global parameters and one additional parameter each for V1, V2, and V3 shear). Results of this new methodology and data analysis are presented on five human subjects, four collected at 3 T field strength and one collected at 7 T field strength.

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