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

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Abstract

Objective

Previous reports have described the layout of human visuotopic map in V1, V2, and V3 via fMRI, but characterized these data using simple one-dimensional logarithmic or power-law functions—an approach that is insufficient to accurately characterize these two-dimensional structures. This report demonstrates a quantitative fit to two-dimensional visuotopic maps obtained with fMRI. Our objectives are to provide better understanding of cortical receptotopic structure and to establish a body of data providing *in vivo* "ground truth" to be used for extending the accuracy of MRI measurement.

Methods

We present four incremental improvements to fMRI measurement in visual topography studies. (1) We constructed a custom multi-channel surface coil covering occipital cortex which produced improved SNR relative to standard head coil systems. (2) The use of real-time behavioral feedback, based on psychometrically established eye fixation performance for individual subjects, allowed us to monitor, and to motivate, compliance with the difficult long-term eye fixation required. This allowed us to collect uniformly high-quality data. (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. (4) A least-squares optimal quasi-isometric brain flattening algorithm generated flat representations of the two-dimensional cortical surface without relaxation cuts through V1 or any other retinotopic area, and provided a per-vertex flattening error measure (see Balasubramanian et al., this meeting).

Finally, we applied a recently developed model of V1–V2–V3 visuotopy [1] to modeling the fMRI visuotopy data. This model allows for shear (i.e., local 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). The proposed model is termed the *Wedge–Dipole* map, since it is the composition of constant azimuthal shear "wedge" map with a conformal "dipole" map that is an extension of the standard log-polar or complex logarithm mapping.

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Results and Discussion

Visuotopy data are presented on a population of five human subjects, four collected at 3T field strength and one at 7T field strength. Our preliminary results show that the model provides a good fit to the data and reveals that V1 exhibits less azimuthal shear than extra-striate areas V2 and V3.

Conclusions

The visuotopic structure of human striate and extra-striate cortex appears to be well-described by the quasiconformal map given by the Wedge–Dipole model. This model provides the basic scaffolding upon which the topography of all three visual areas is constructed: the visuotopy of the areas V1, V2, and V3 can be summarized in terms of a single mathematical function with a simple analytic form. Prospects for extending this analysis to more general quasiconformal mappings will be briefly discussed.

References and Acknowledgements

[1] M. Balasubramanian, J. Polimeni, and E.L. Schwartz. The V1–V2–V3 complex: quasiconformal dipole maps in primate striate and extra-striate cortex. *Neural Networks*, 15(10):1157–1163, 2002.

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