THE STRUCTURE OF SINGULAR REGIONS IN CORTICAL ORIENTATION MAPS: A FUNCTION OF SPATIAL BLUR*†

E.L. Schwartz‡
Cognitive and Neural Systems
Electrical Computer Engineering
Anatomy and Neurobiology
Boston University
Boston, MA 02215

J. Polimeni
Electrical Computer Engineering
Boston University
Boston, MA 02215

D. Granquist-Fraser
Cognitive and Neural Systems
Boston University
Boston, MA 02215

R.J. Wood
Cognitive and Neural Systems
Boston University
Boston, MA 02215

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Abstract

Orientation singularities in V1 arise from the topological impossibility of a continuous map (with a continuous inverse) of orientation to a planar region. As instrumental blur increases, they first approach and then annihilate in chiral pairs (Schwartz & Rojer, *ICPR-12*, 2:150–5, 1994). Blur causes *systematic* experimental error in their location. Womelsdorf et al. (*NeuroImage*, 13:1131–9, 2001) confirmed this by showing that orientation undersampling—in effect a spatial undersampling—produces significant singularity shift and annihilation of singularities. We have shown that the spatial blur in optical recording due to photon scatter and optics is roughly $300\mu\mathrm{m}$ (Gaussian) (Granquist-Fraser et al., *Soc Neuro Abs* 2003). Here, we show consequences of experimentally induced blur by computer animation. *Systematic* singularity offset is about $100\mu\mathrm{m}$, and annihilation is about 25%. Thus, electrode placement guided by optical recording is in error by more than the radius of a cytochrome oxidase (CO) blob in monkey. Claims that orientation singularities are not aligned with CO blobs and that orientation tuning is strong at singularities (Bartfeld & Grinvald, *PNAS*, 89:11905–9, 1992; Maldonado et al., *Science*, 276:1551–5, 1997) are called into question by this error analysis. *Point* singularities (in the range of $50\mu\mathrm{m}$) are an artifact of spatial interpolation of orientation maps caused by the use of pixels as small as $10\mu\mathrm{m}$—by sampling theory, 100–$150\mu\mathrm{m}$ pixels are sufficient. We suggest that the center of cortical hypercolumns is a *finite-area orientation vortex core*, much like the eye of a hurricane, aligned with the CO blob. Just as point singularities do not occur in physical vortex phenomena, they are unlikely to occur in the biological vortex phenomena observed in cortex. The question is: Are vortex cores "point-like" ($50\mu\mathrm{m}$) or are they "blob-like" ($150\mu\mathrm{m}$)?

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‡Contact info: Eric L. Schwartz, Computer Vision and Computational Neuroscience Lab, 677 Beacon St., Boston, MA, 02215.
Email: eric@bu.edu