

# THE STRUCTURE OF SINGULAR REGIONS IN CORTICAL ORIENTATION MAPS: A FUNCTION OF SPATIAL BLUR<sup>\*†</sup>

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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 $\mu\text{m}$  (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 $\mu\text{m}$ , 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 $\mu\text{m}$ ) are an artifact of spatial interpolation of orientation maps caused by the use of pixels as small as 10 $\mu\text{m}$ —by sampling theory, 100–150 $\mu\text{m}$  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 $\mu\text{m}$ ) or are they “blob-like” (150 $\mu\text{m}$ )?

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