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Quantitative universality and non-local interactions in neural pattern formation MATTHIAS KASCHUBE, Princeton University, MICHAEL SCHNABEL, MPI-DS, SIEGRID LOEWEL, University of Jena, DAVID COPPOLA, Randolph-Macon College, LEONARD WHITE, Duke University, FRED WOLF, MPI-DS — The occurrence of universal quantitative laws in a strongly interacting multi-component system indicates that its behavior can be elucidated through the identification of general mathematical principles rather than by the detailed characterization of its individual components. Here we demonstrate that universal quantitative laws govern the spatial layout of orientation selective neurons in the visual cortex in three mammalian species separated in evolution by more than 50 million years. Most suggestive of a mathematical structure underlying this universality, the average number of pinwheel centers per orientation hyper-column in all three species is statistically indistinguishable from the constant π. Mathematical models of neural pattern formation can reproduce all observed universal quantitative laws if non-local interactions are dominant, indicating that non-local interactions are constitutive in visual cortical development. The spatial layout adheres to these laws even if visual cortical organization exhibits marked overall inhomogeneities and when neuronal response properties are experimentally altered. These results demonstrate that mathematical principles can shape the organization of the brain as powerfully as an organism's genetic make-up.

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