The predominant pathway for "early" vision
Vision starts in the eye - and is largely mapped 1:1 across space (retinotopy)
Many output cells from the retina, i.e., retinal ganglion cells, have a $\nabla^2$ receptive field.
Visual information travels from retina to thalamus to cortex
Wandell, Dumoulin, Brewer (Neuron 2007)
Cortex synthesizes orientation preference from $\nabla^2$ receptive fields
Continuous coding variables, like orientation, in primate vision, are mapped.
The representation of continuous coding variables can be imaged across cortex.

These features are mapped across visual cortex in primates and cats, as seen by intrinsic optical imaging.
Nearby neurons have similar receptive field (but note discontinuities at spirals)

Grinvald, Lieke, Frostig, Gilbert, Wiesel (Nature 1986)
Clarification of maps

Bonhoeffer and Grinvald (J Neuroscience 1993)
Nearby neurons with similar receptive field have significant "noise" correlations

Figure 3. Correlograms obtained from two cell pairs. A, The cell pair had similar receptive fields: the first cell had an orientation preference of 120°, directional preference to the right and an ocular dominance group of 2, whereas the second cell had identical orientation and direction preference and an ocular dominance group of 3. B, The first cell was the same as the first cell in A. The second cell had different receptive field properties: an orientation preference of 20°, upward directionality, and an ocular dominance of 5.

Figure 4. Medial wall projection similar to Figure 3. Note tendancy for the electrodes through the posterior part of Medial Wall to project to the same recording sites. Arrowheads indicate the potential for afferent input.
Just a reminder - A mouse is not a monkey, and vice versa

Ohki, Chung, Ch’ng, Kara, Reid (Nature 2005)
A conundrum is that the width of tuning is independent of the contrast (input strength).

Sclar and Freeman (Experimental Brain Research 1962)

Ferster, Sooyoun, Wheat (Nature 1996)
Cortical interactions, as opposed to solely feedforward features, define the tuning width.

Crook, Kisvarday, Eysel (Visual Neuroscience 1997)
Beyond vision, normalization of input signals is seen in other systems, e.g., the coding of touch by the vibrissa system of rodents.

Chen-Bee, Zhou, Jacobs, Lim, Frostig (Frontiers of Neural Circuits 2012)
Chen-Bee, Zhou, Jacobs, Lim, Frostig (Frontiers of Neural Circuits 2012)
Unstable output

Homogeneous activity with orientation selectivity driven by input

Bump of activity with orientation selectivity pinned by (weak) input
$W_0 = -0.4$ and $W_2 = 4.0$

$\varepsilon = 0.09$
Figure 13.9
Evolution of the neuronal activity in response to a change in the stimulus orientation from an initial value \( \theta_1 = 0^\circ \) to \( \Theta_2 = 60^\circ \). The change occurs at \( t = 0 \). (A) Afferent mechanism with uniform inhibition. Parameters: \( J_0 = -15.5, C = 1.1, \epsilon = 0.5 \). Times (units of \( \tau_0 \)): 0, 0.5, 1, 2, 6 (lines 1–5, respectively). (B) Virtual rotation in the marginal phase. The activity profile is moving toward \( \theta_2 \). Parameters: \( J_0 = -17.2, J_2 = 11.2, \epsilon = 0.05, C = 2 \). Times (left to right): 0 to 35\( \tau_0 \) each 5\( \tau_0 \).
Bumps of activity in the heading direction system in rodent thalamus

Internally organized mechanisms of the head direction sense
Nature Neuroscience 2015
Adrien Peyrache, Marie M Lacroix, Peter C Petersen & György Buzsáki
Bumps of activity in the landmark heading system in the fly ellipsoid body of the central complex thalamus

Neural dynamics for landmark orientation and angular path integration
Nature
Johannes D. Seelig & Vivek Jayaraman
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