Fundamentals of area V1
Part 1: Receptive fields and maps

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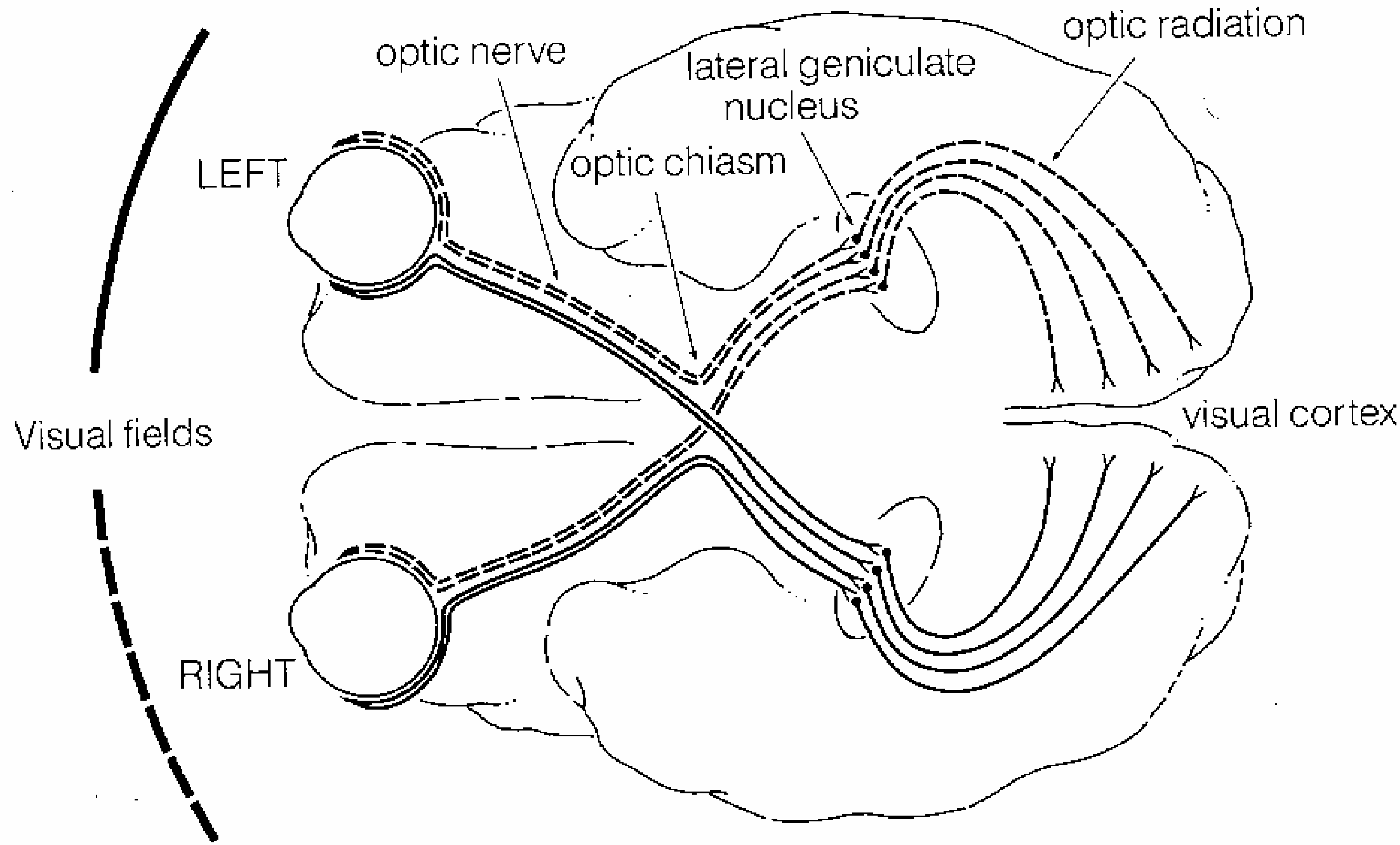
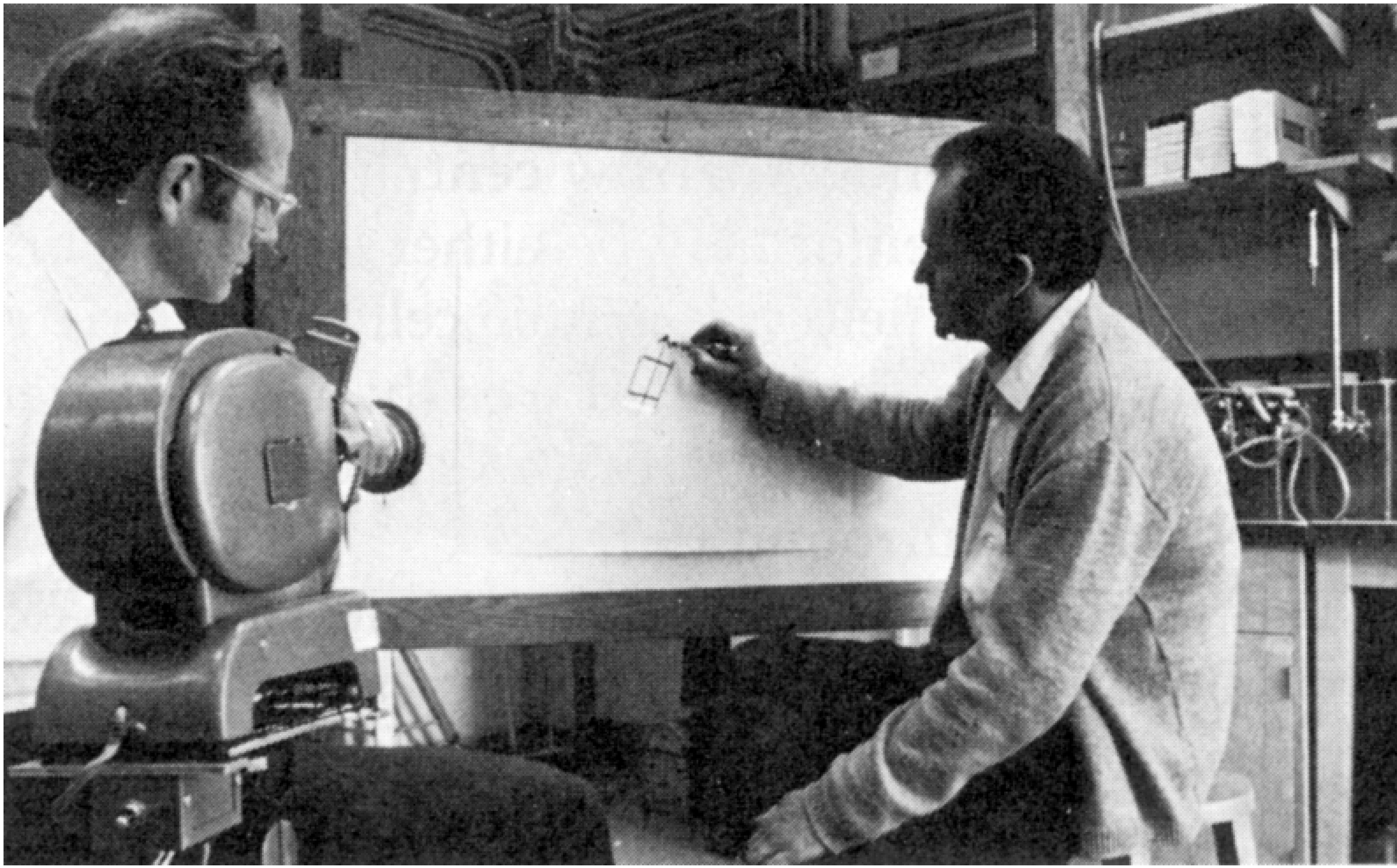


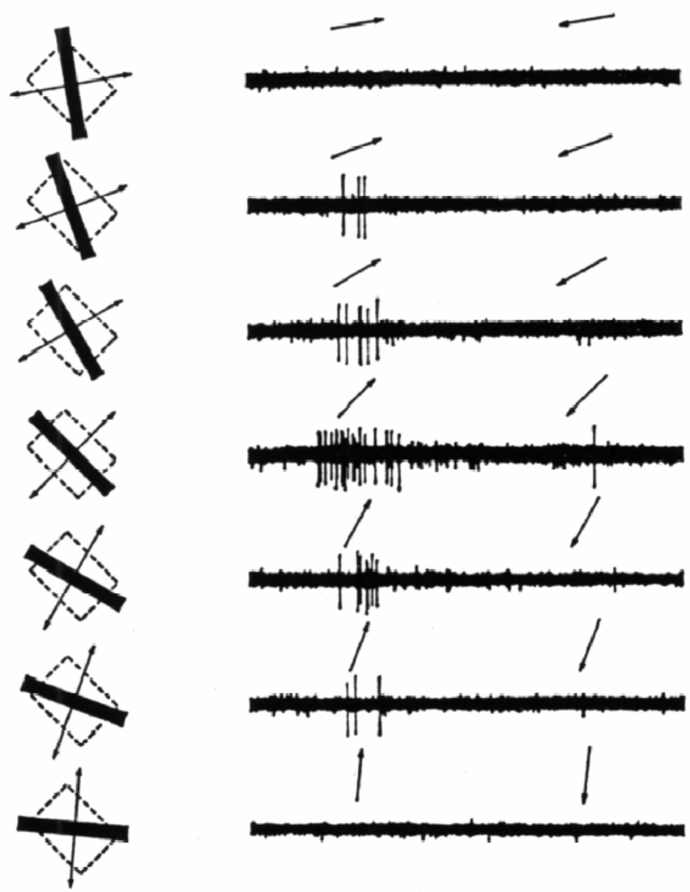
Dowling, 1987 (Fig 1.2)

Receptive fields in area V1



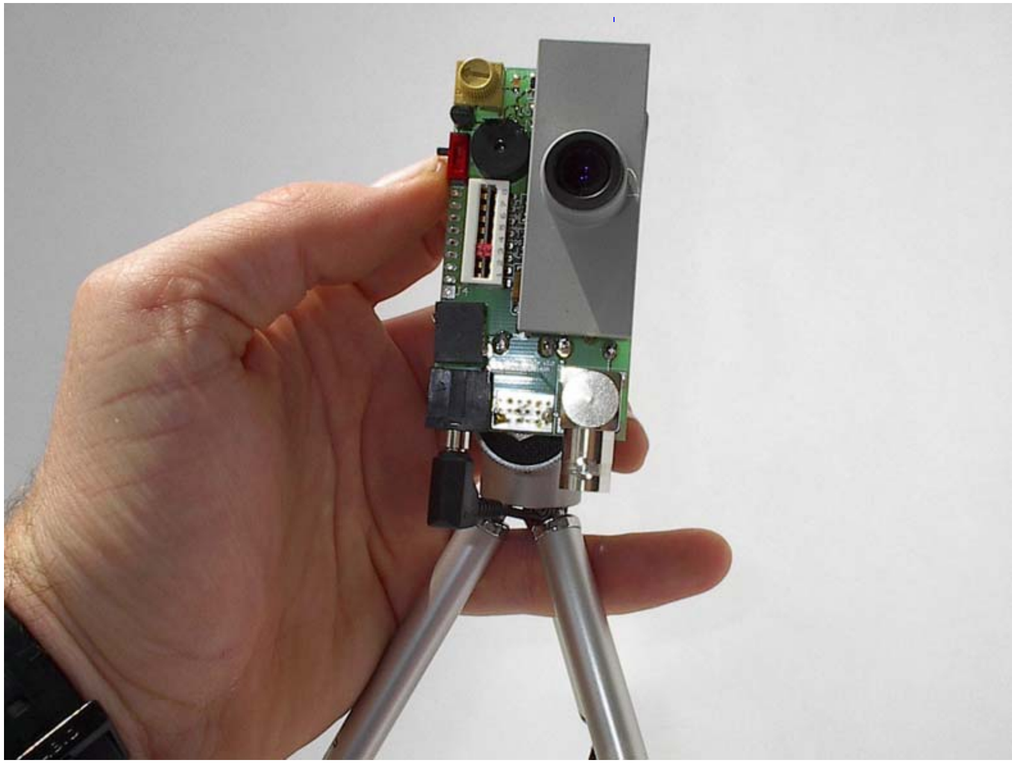
Hubel and Wiesel, circa 1969 (from Nicholls et al., 1992)

Responses of a V1 neuron



Hubel and Wiesel, 1959

Artificial early visual system

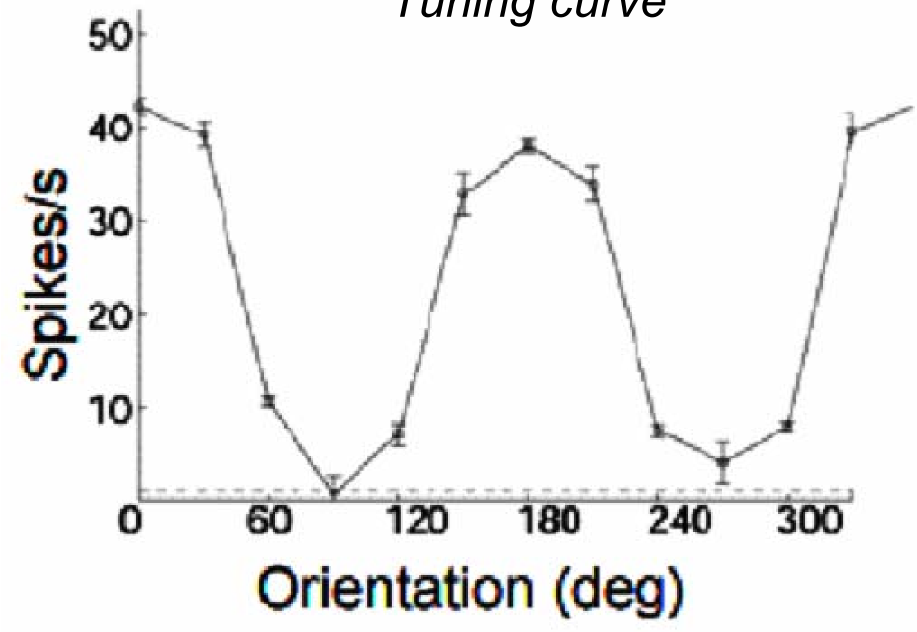


www.ini.unizh.ch/~tobi/friend/chip/

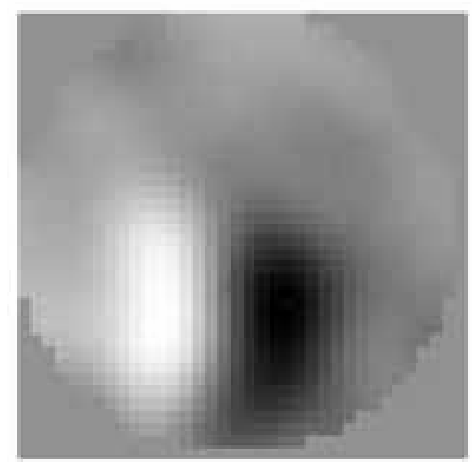
Delbruck & Liu, 2004

Responses of artificial simple cell

Tuning curve

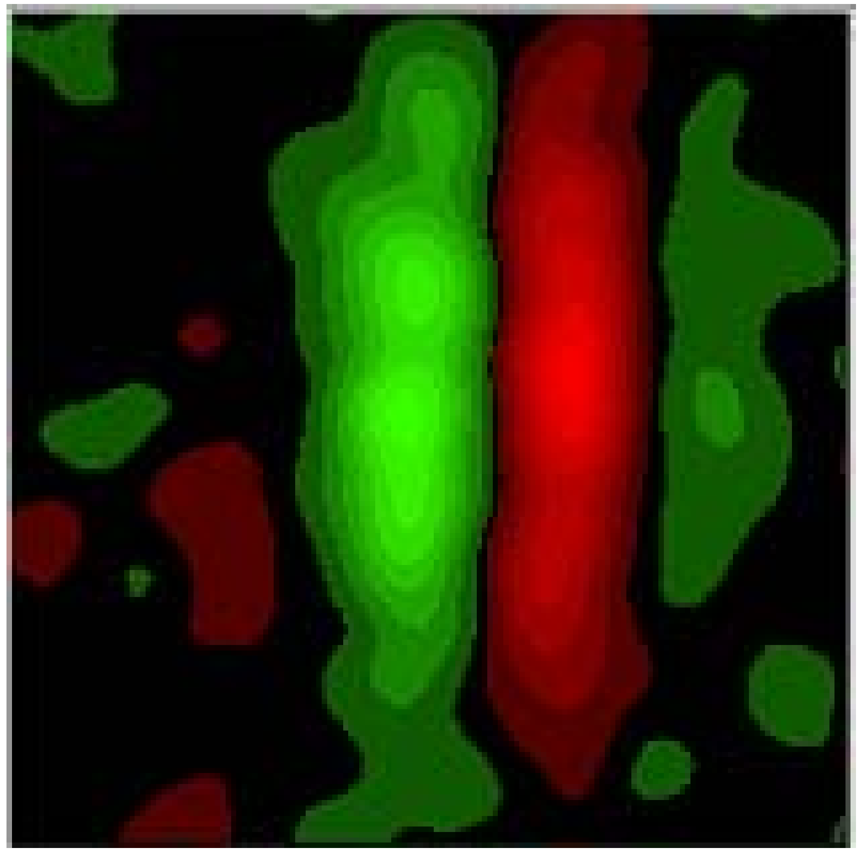


Receptive field



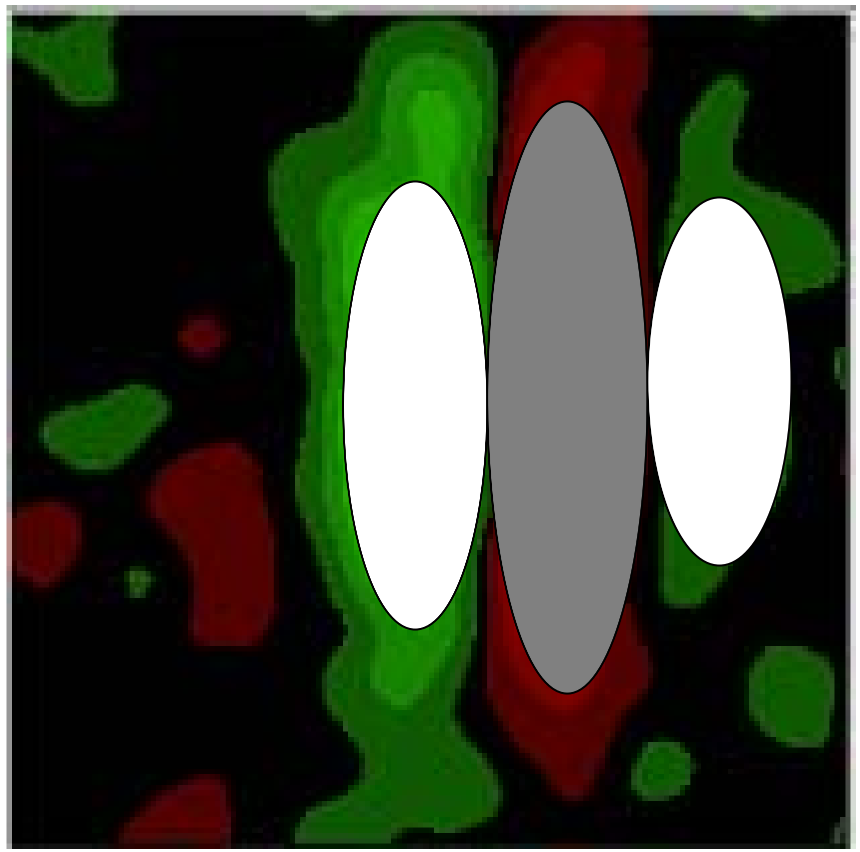
Delbruck & Liu, 2004

Receptive field of a V1 simple cell



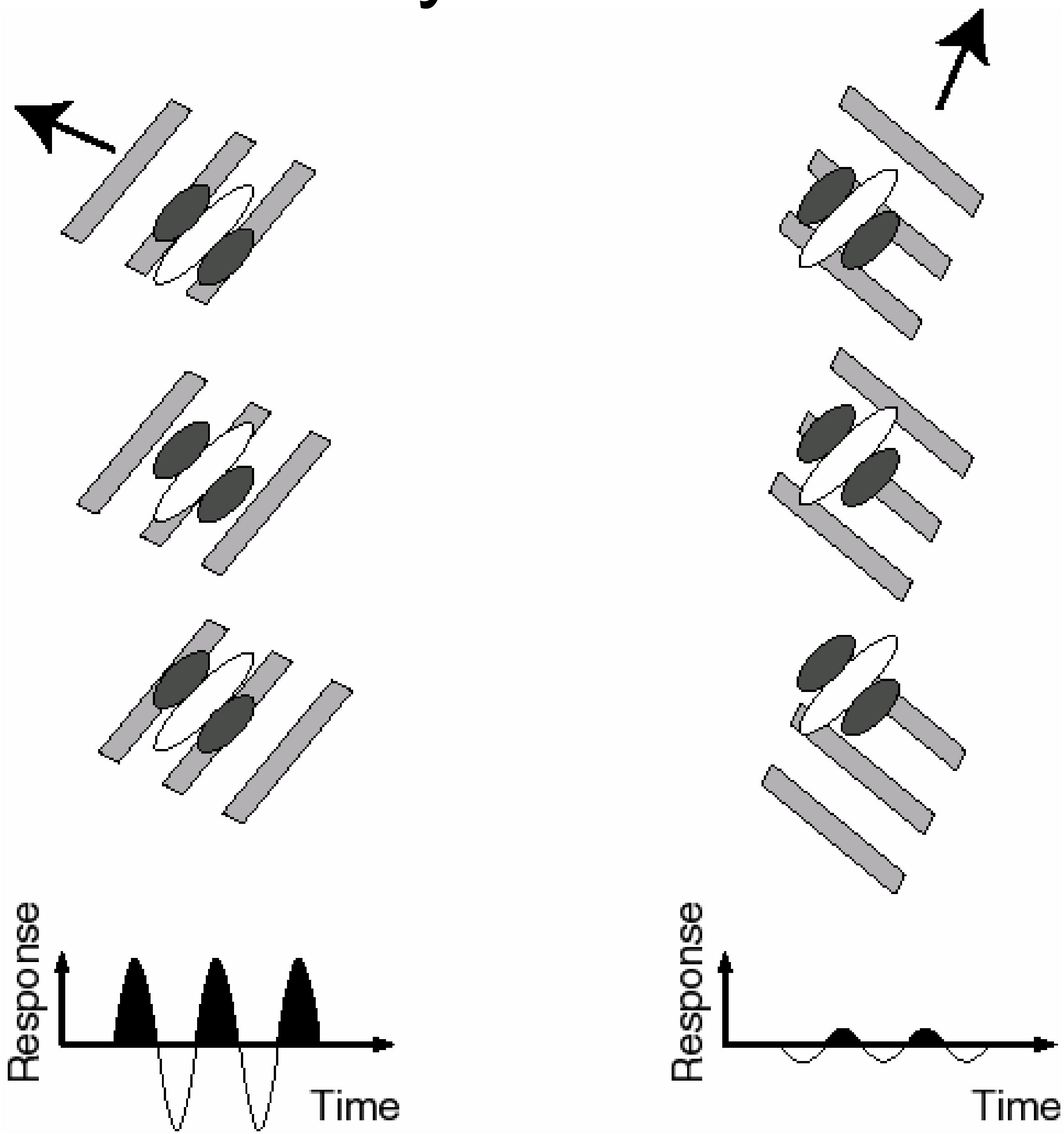
DeAngelis, Ohzawa & Freeman, 1995

Receptive field of a V1 simple cell

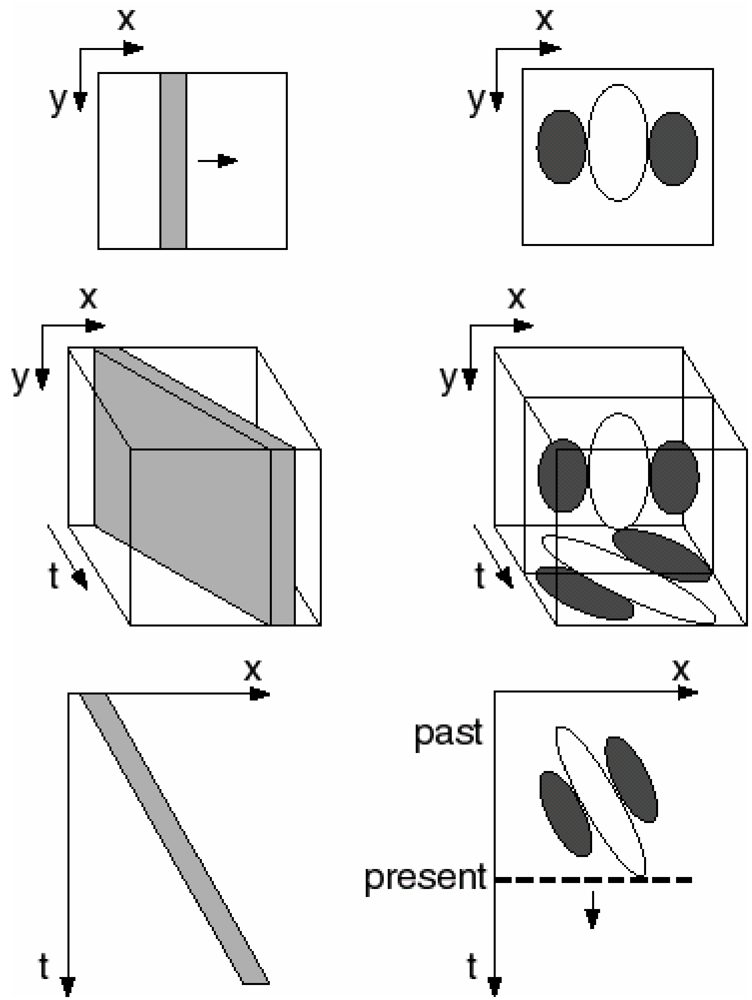


DeAngelis, Ohzawa & Freeman, 1995

Selectivity for orientation



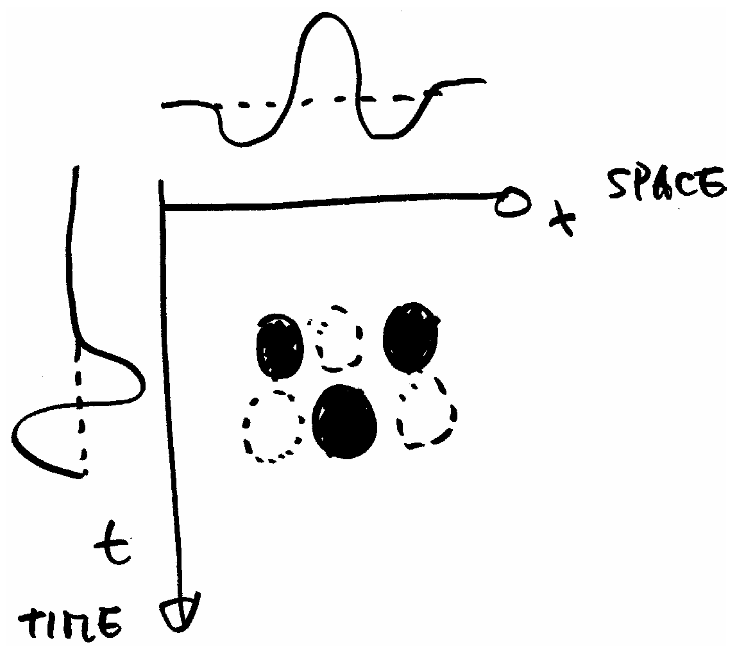
Stimuli and receptive fields in space-time

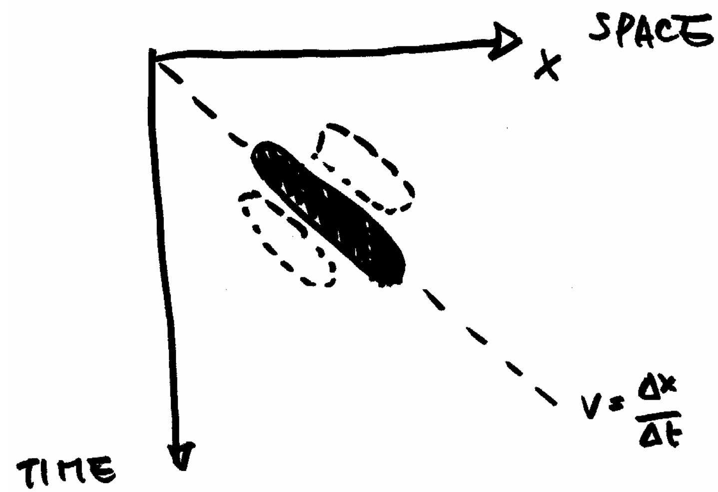


Adelson & Bergen, 1985

Carandini, Heeger & Movshon , 1999

Separability and direction selectivity

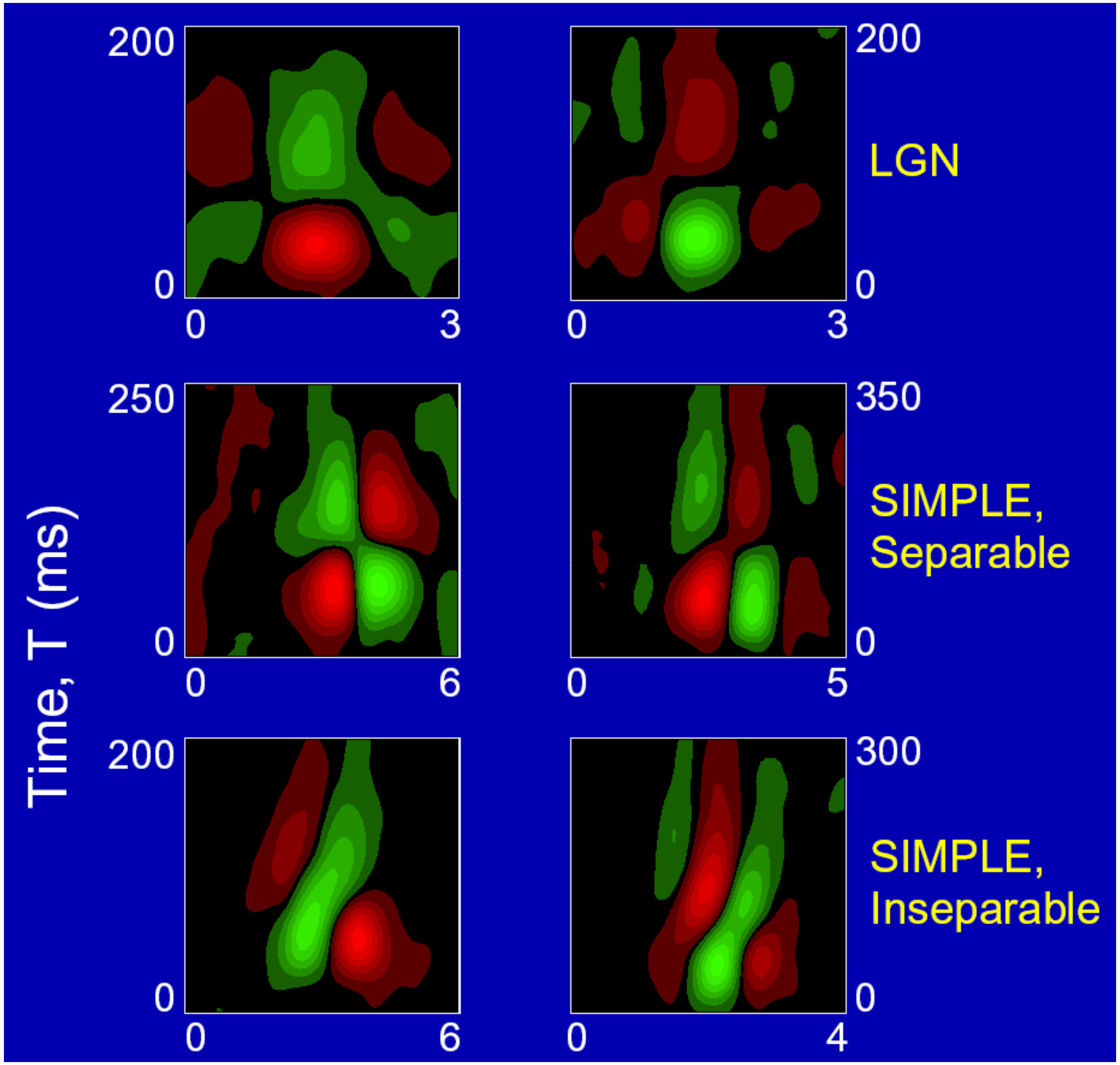




Separable,
not direction selective

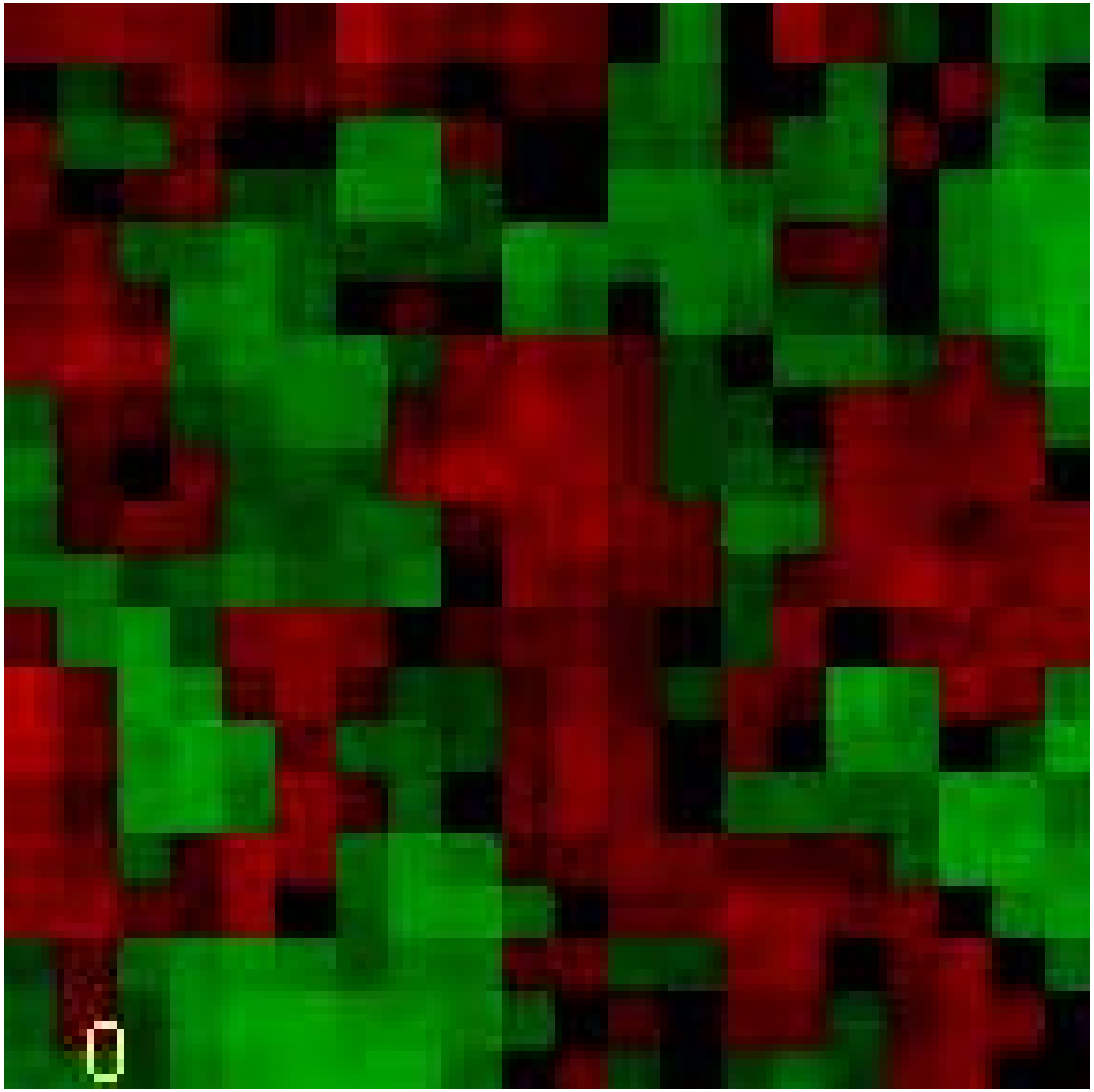
Inseparable,
direction selective

Space-time receptive fields



DeAngelis, Ohzawa & Freeman, 1995

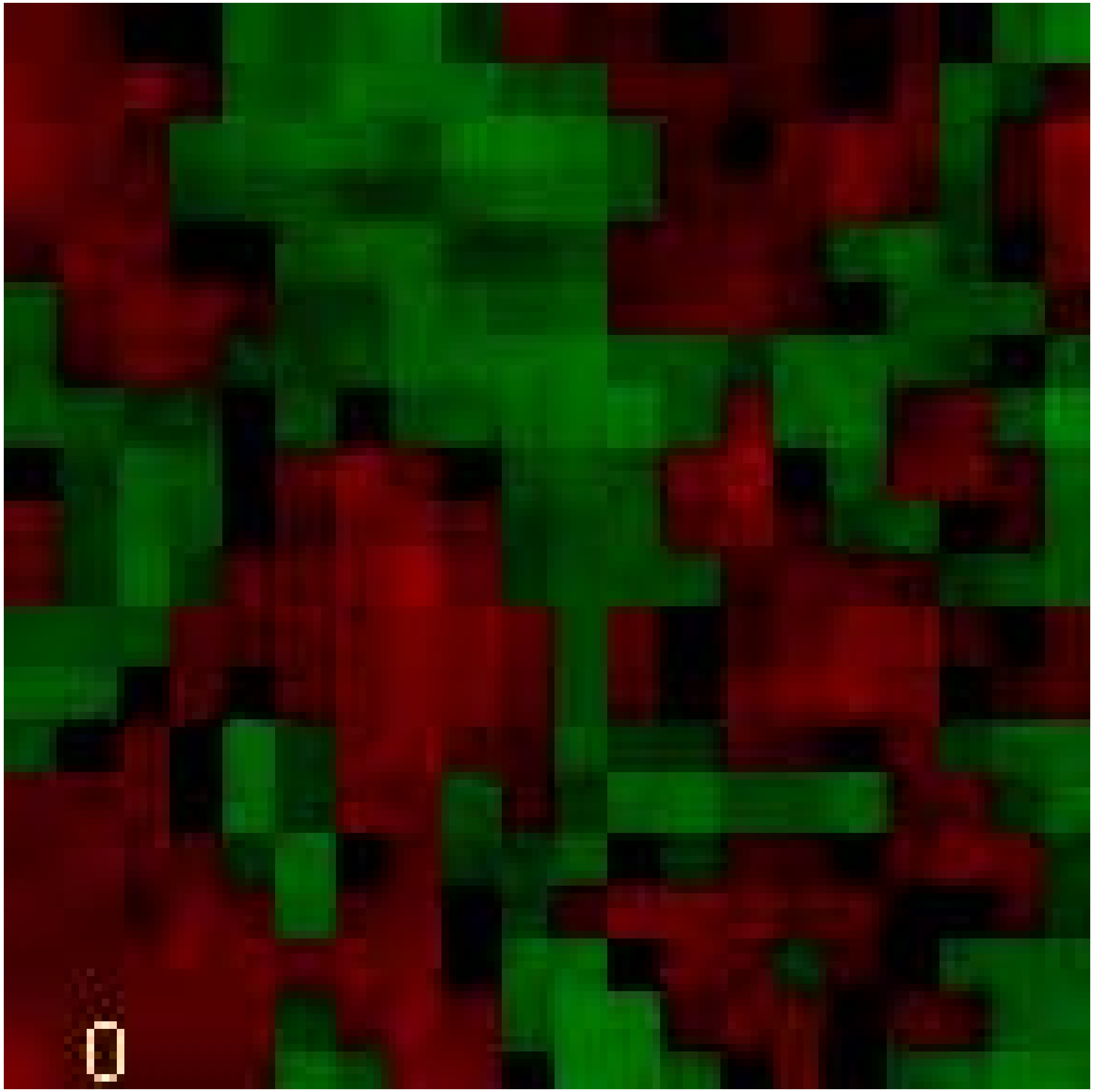
V1 simple cell, separable



www.bpe.es.osaka-u.ac.jp/ohzawa-lab/

Ohzawa, DeAngelis & Freeman, 1996

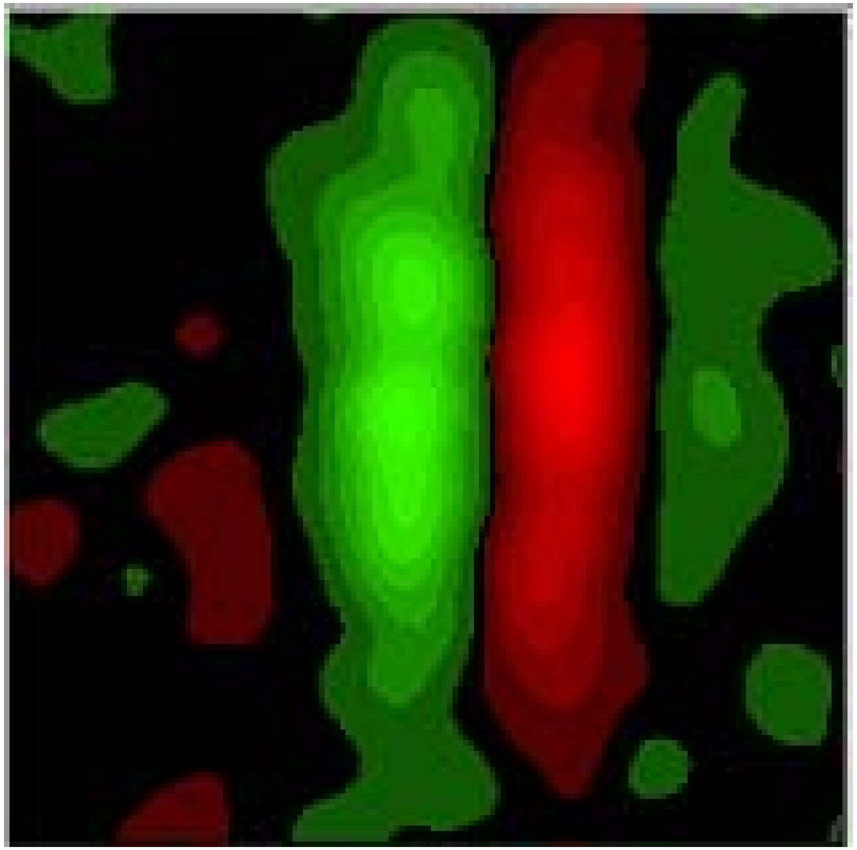
V1 simple cell, inseparable



www.bpe.es.osaka-u.ac.jp/ohzawa-lab/

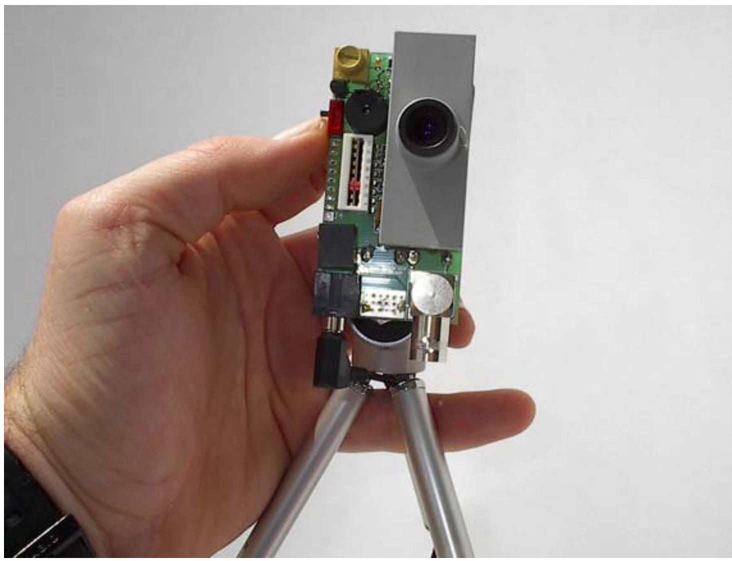
Ohzawa, DeAngelis & Freeman, 1996

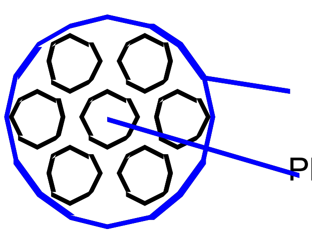
How are V1 receptive fields obtained?

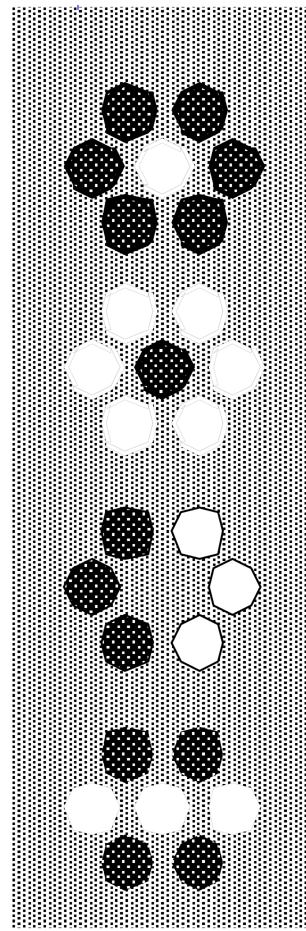


DeAngelis, Ohzawa & Freeman, 1995

Assembly of receptive fields in the artificial visual system



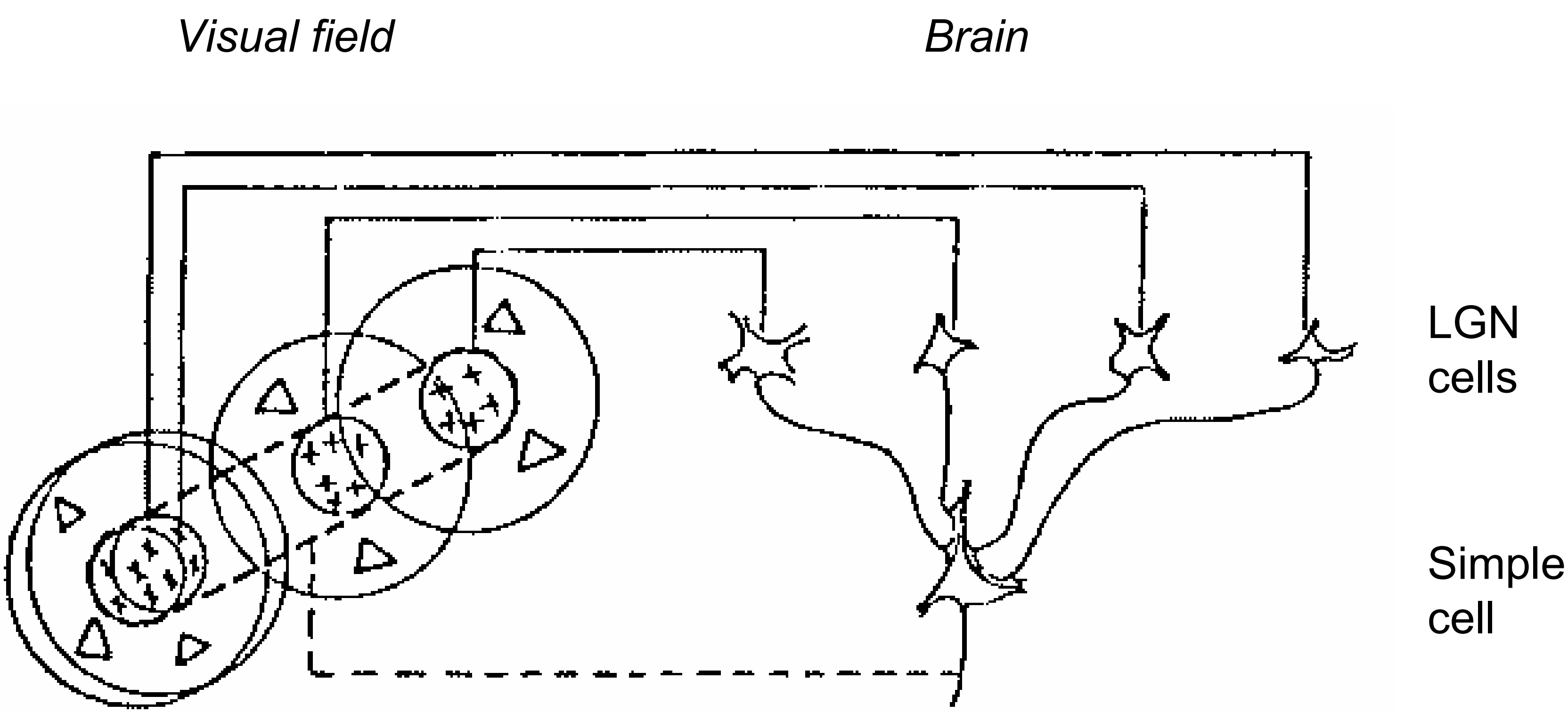




www.ini.unizh.ch/~tobi/friend/chip/

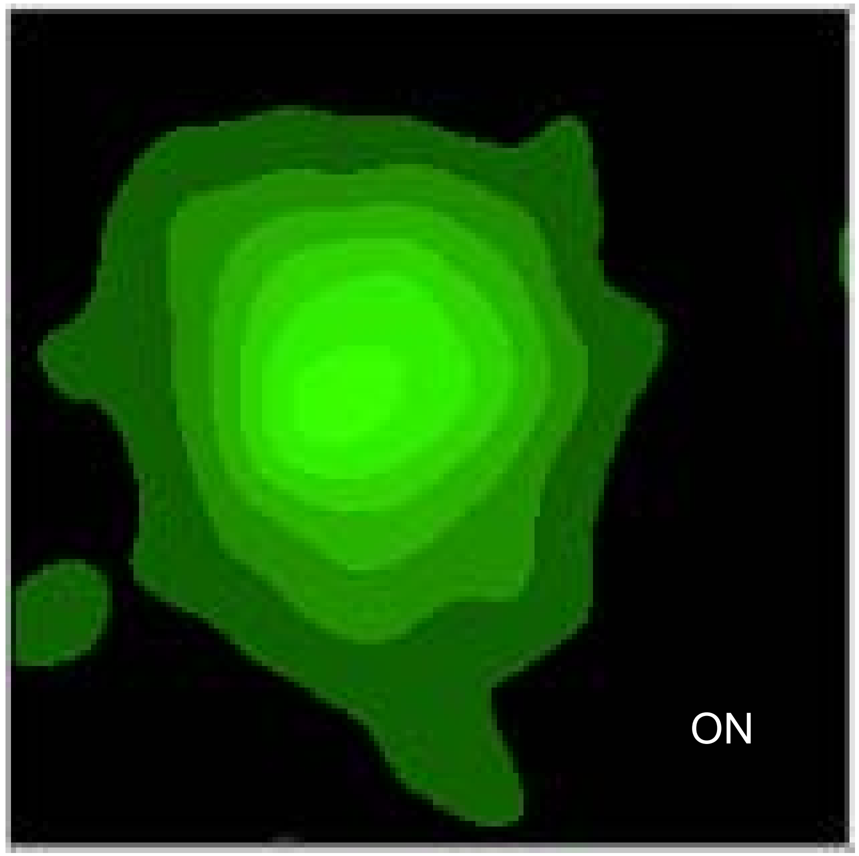
Delbruck & Liu, 2004

H & W's feedforward model of simple cells



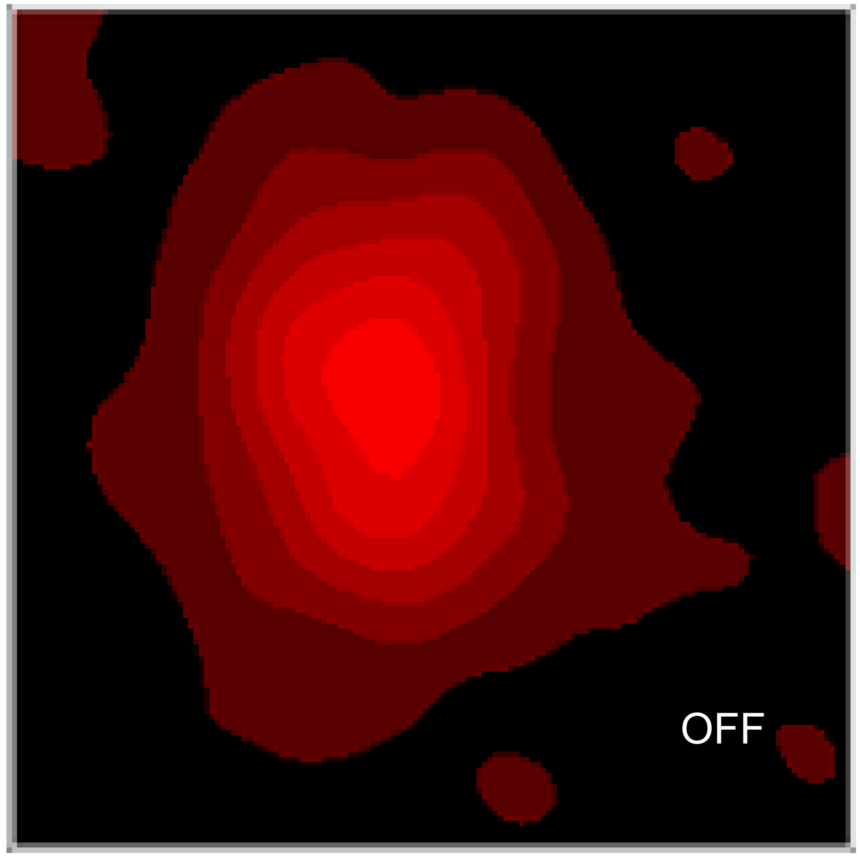
Hubel & Wiesel, 1963

Receptive field of a V1 complex cell



DeAngelis, Ohzawa & Freeman, 1995

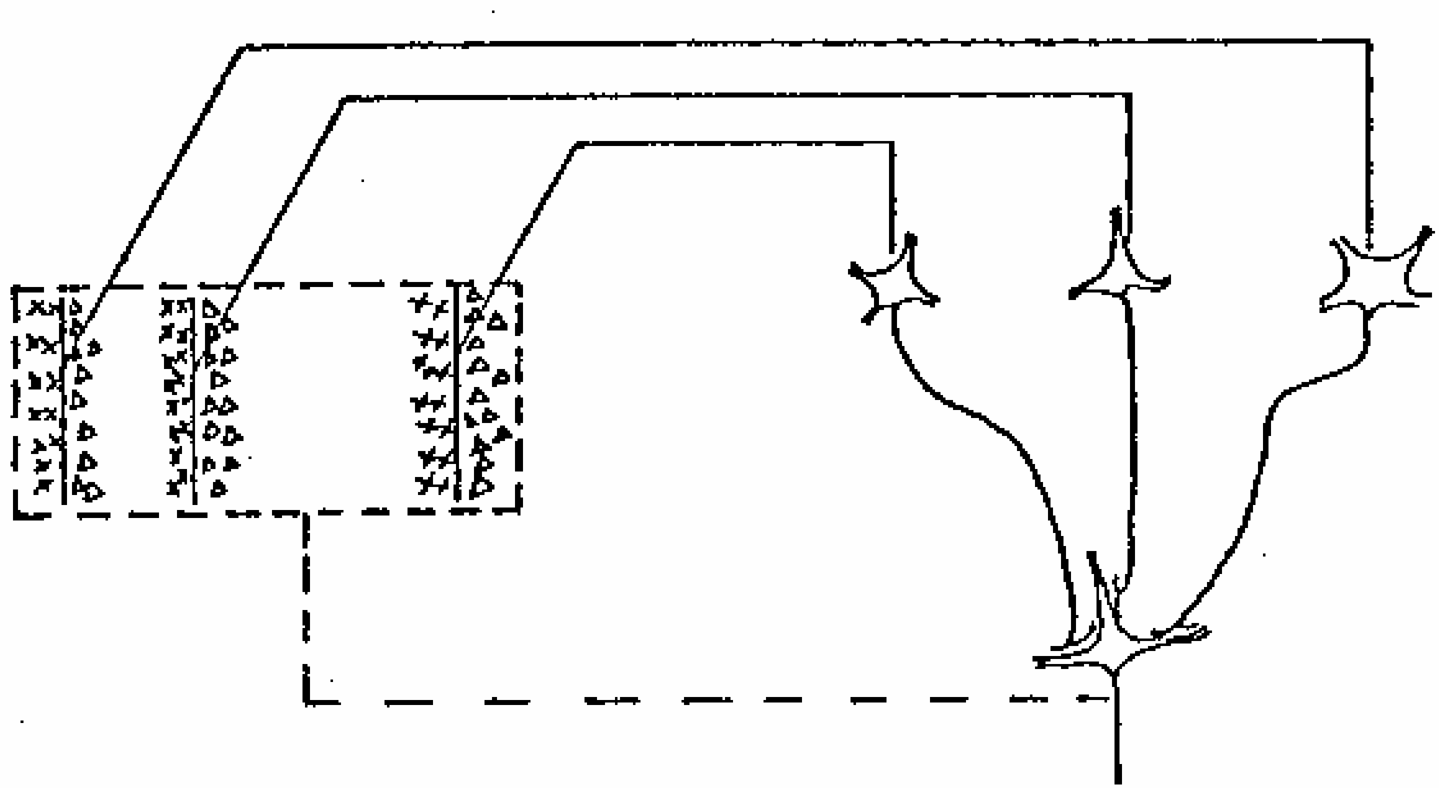
Receptive field of a V1 complex cell



DeAngelis, Ohzawa & Freeman, 1995

H & W’s feedforward model of complex cells

Visual field *Brain*

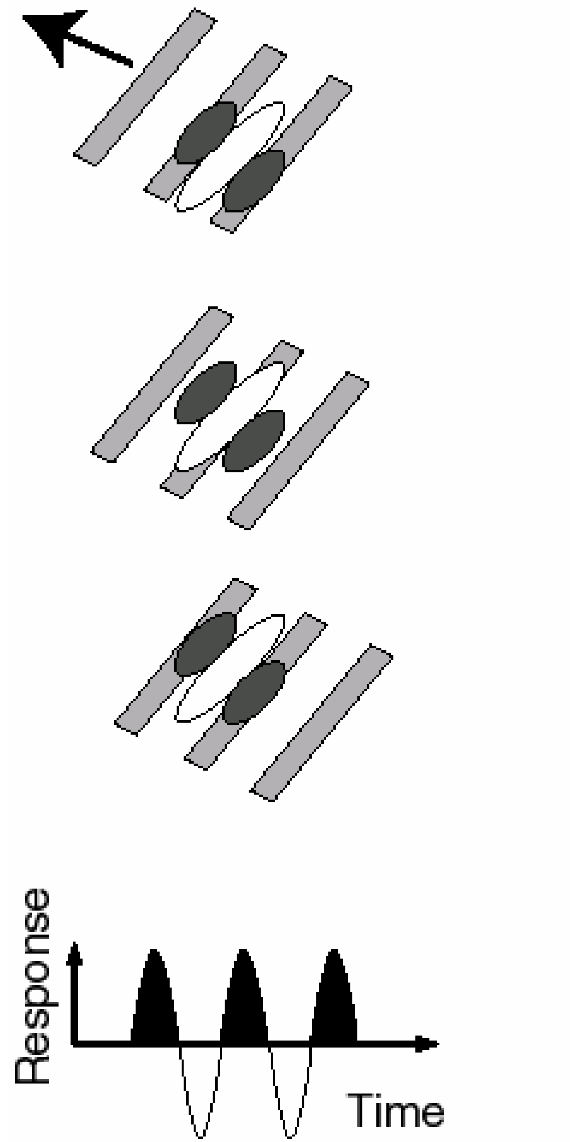


Simple cells

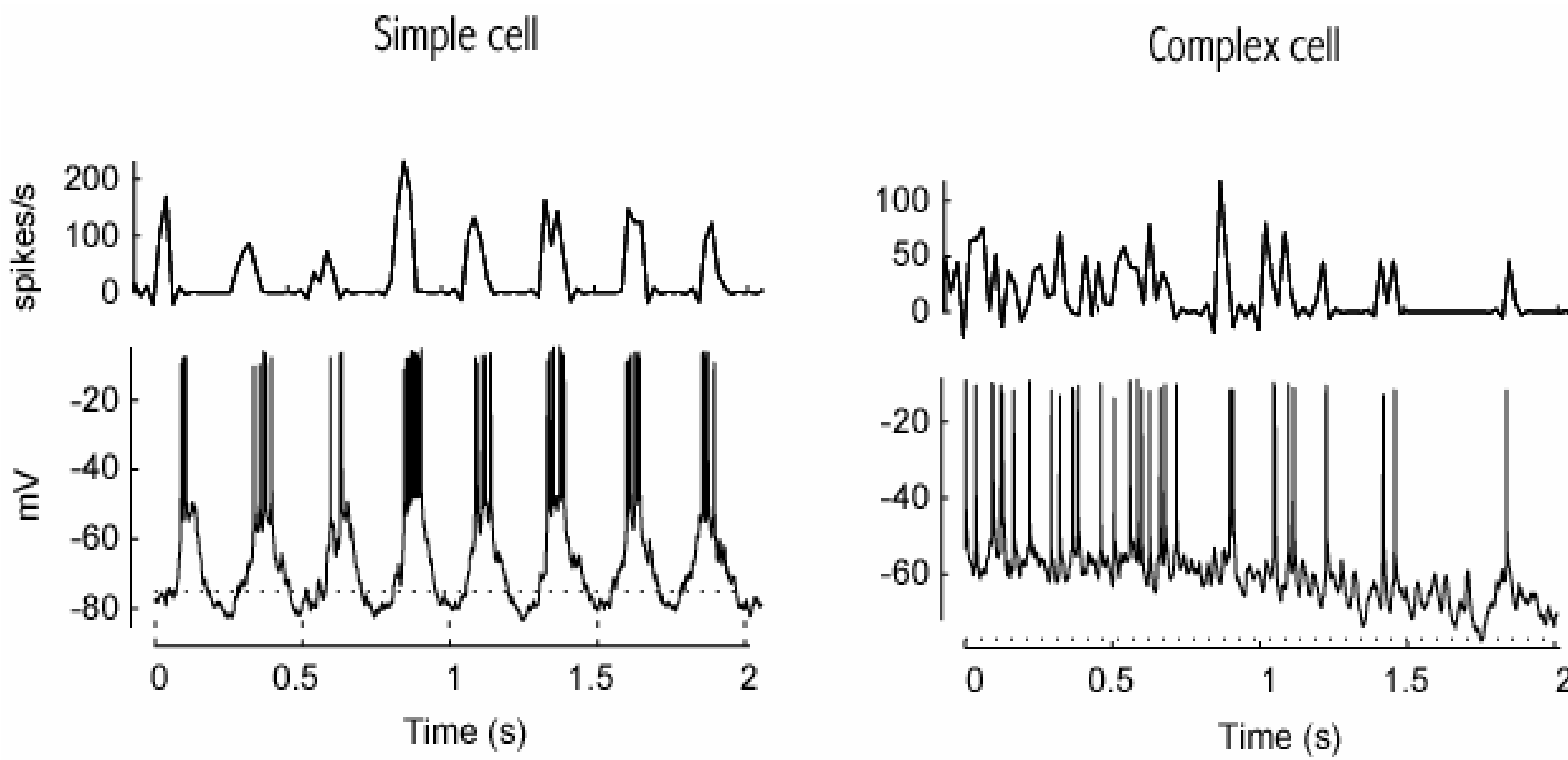
Complex cell

Hubel & Wiesel, 1963

Simple cell responses to a drifting grating

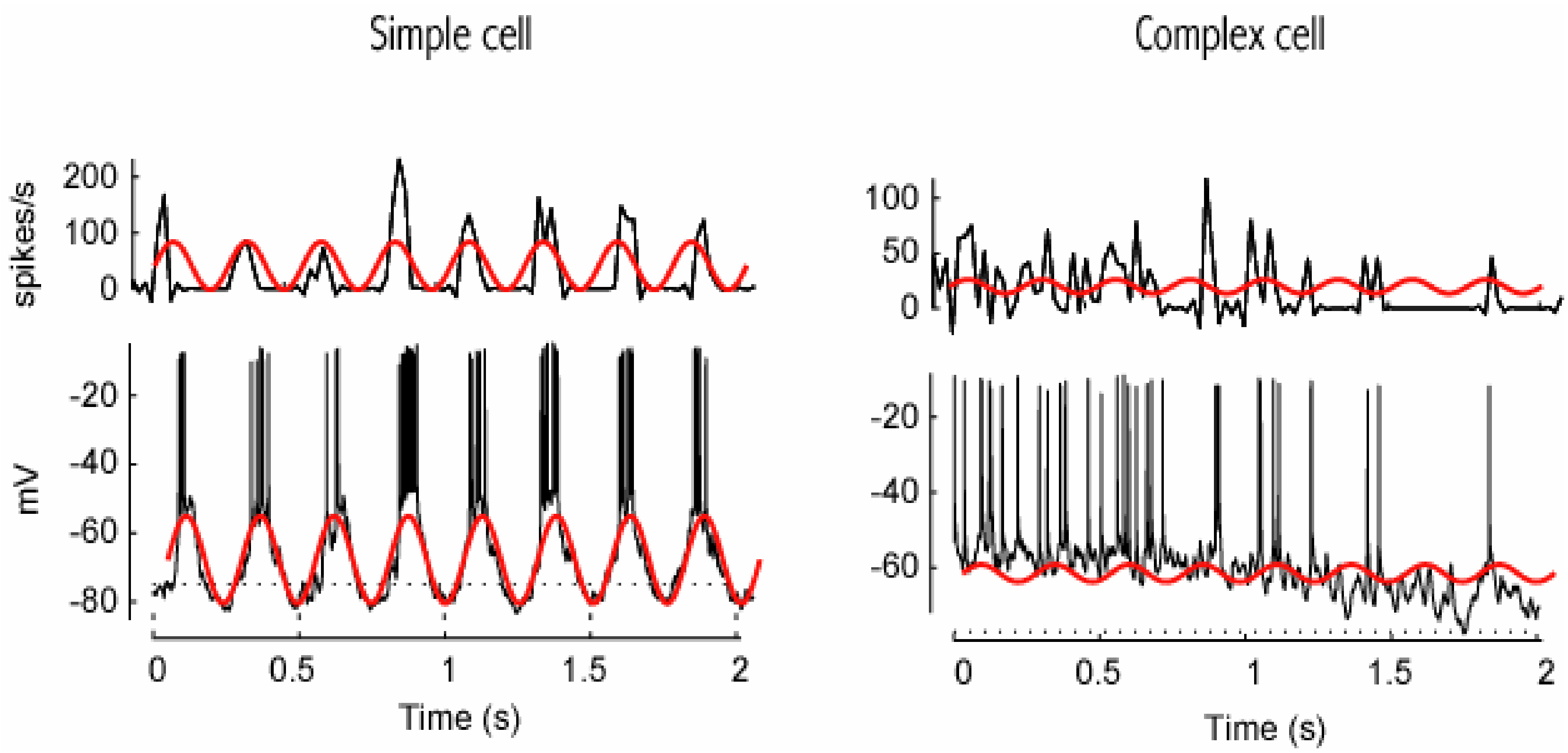


Responses to a drifting grating



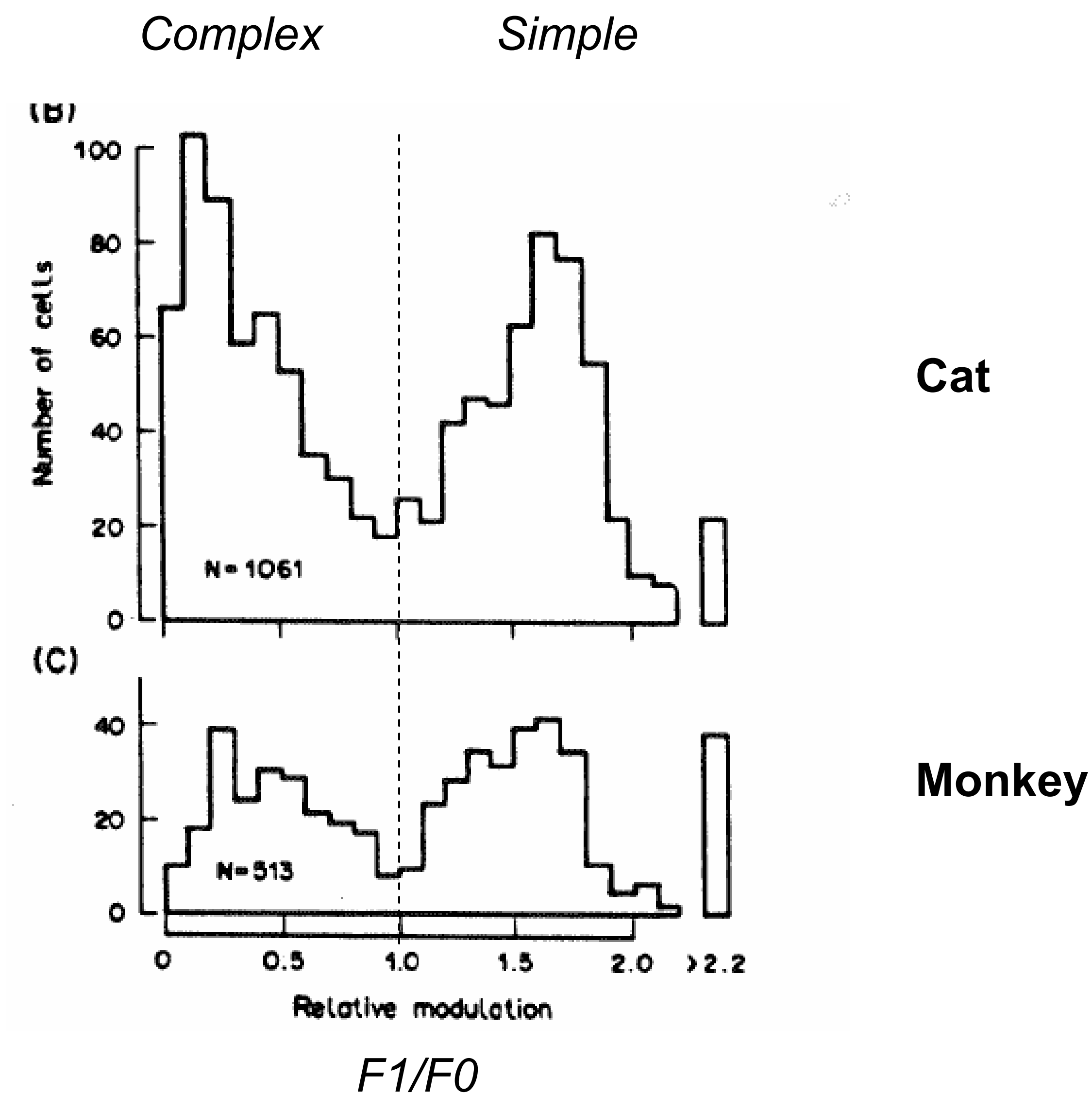
Carandini & Ferster, 2000

Responses to a drifting grating



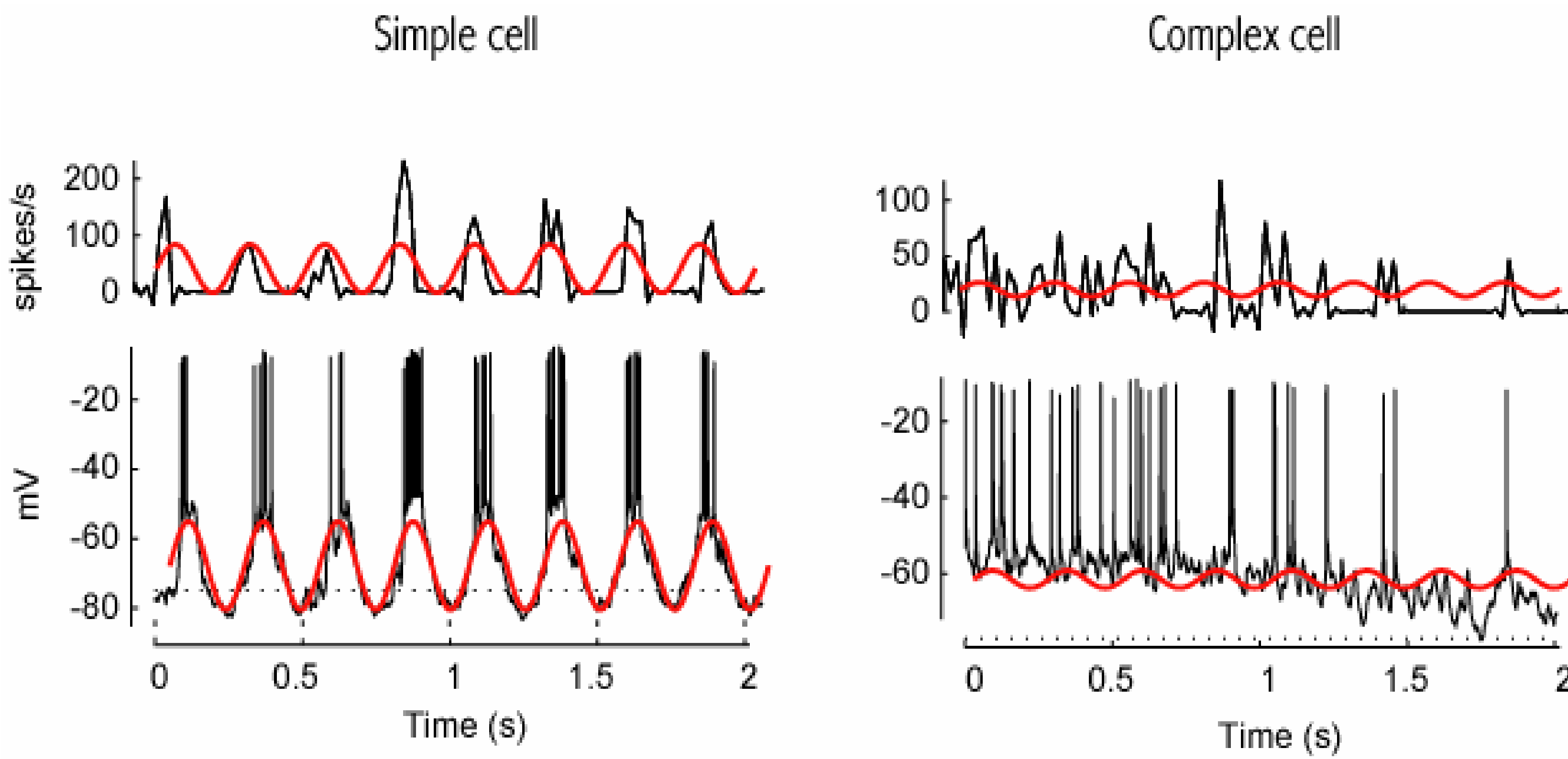
Carandini & Ferster, 2000

Dichotomy of simple and complex cells



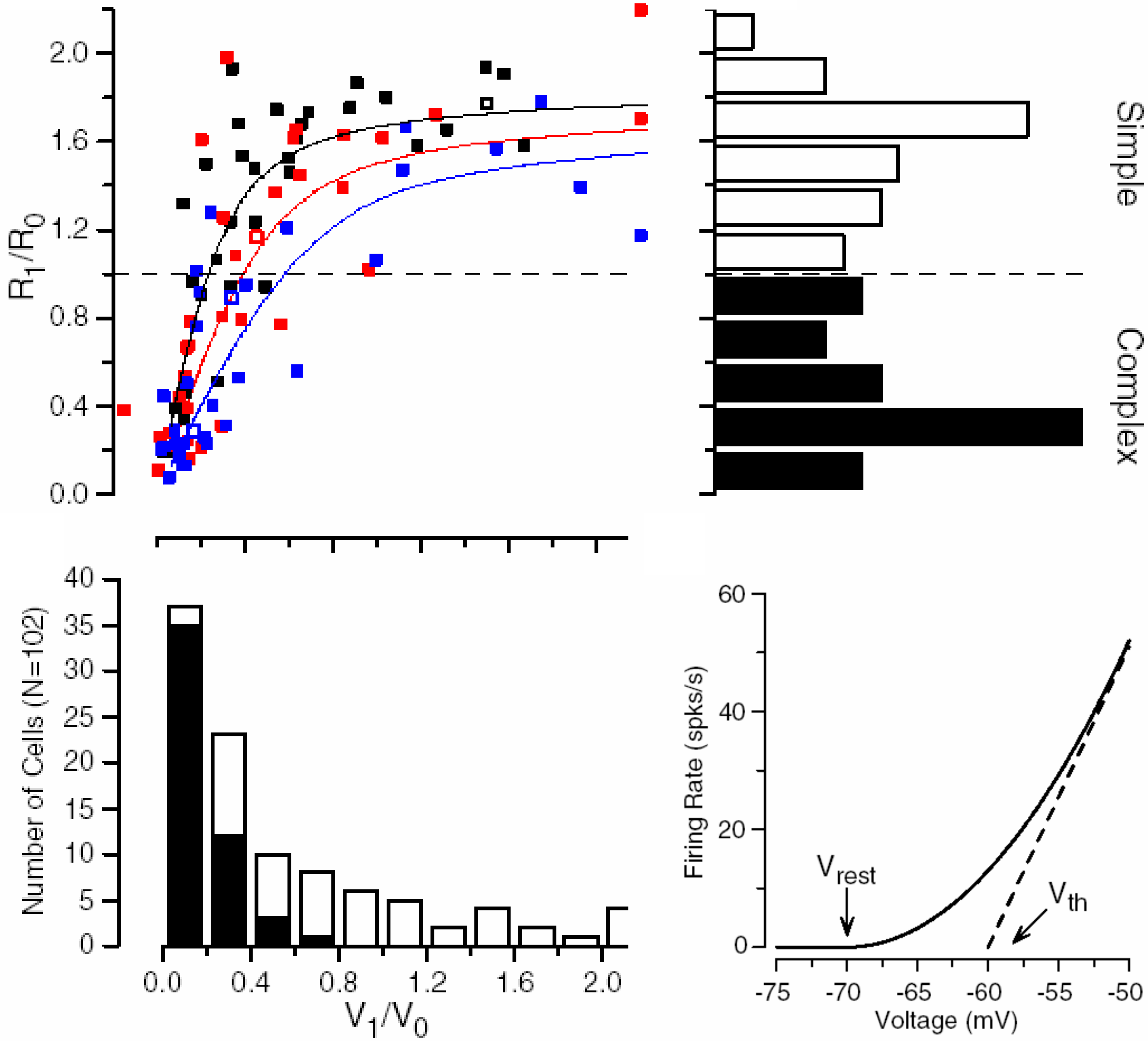
Skottun, DeValois, Grosof, Movshon, Albrecht & Bonds , 1991

Responses to a drifting grating



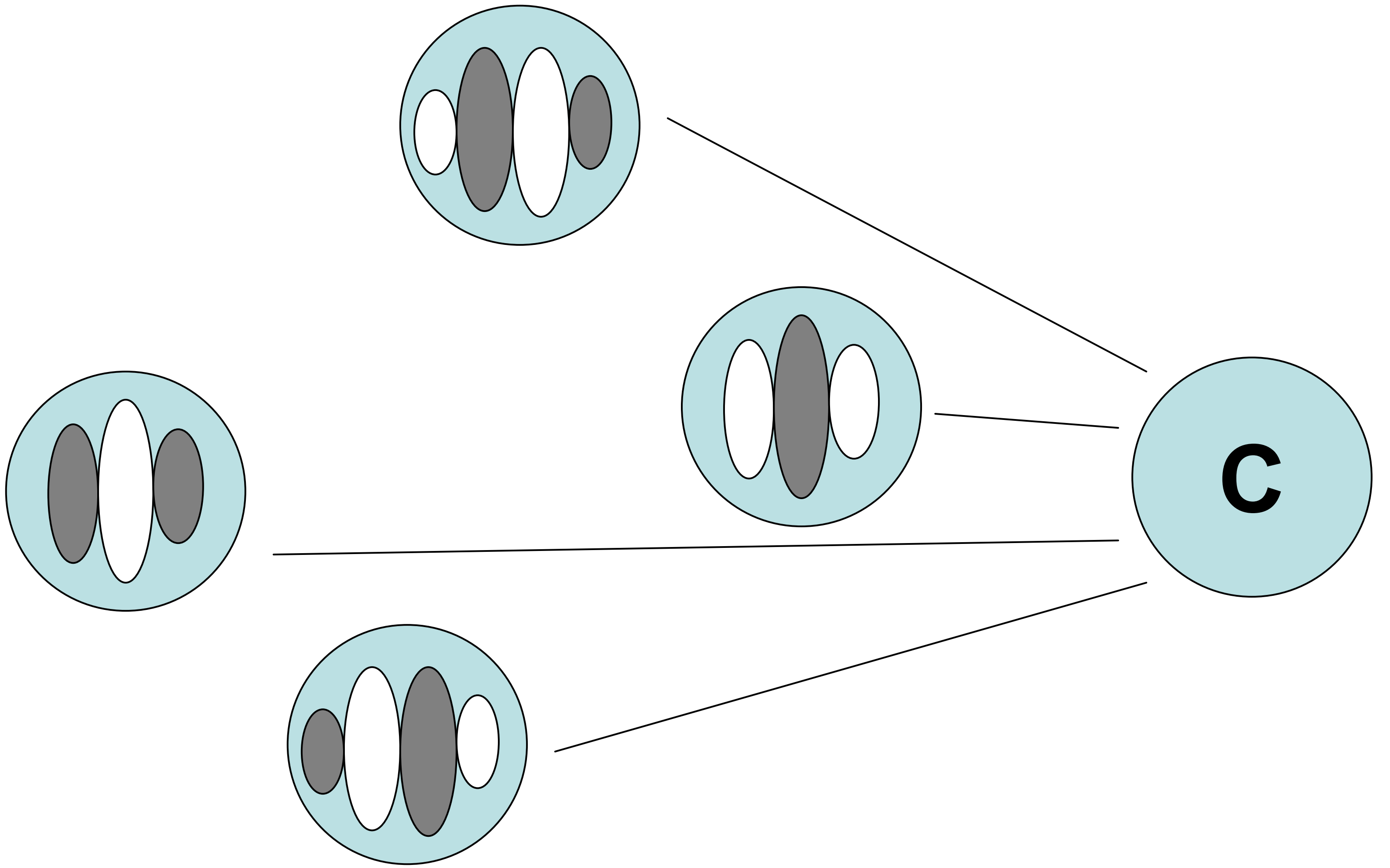
Carandini & Ferster, 2000

Dichotomy is created by threshold

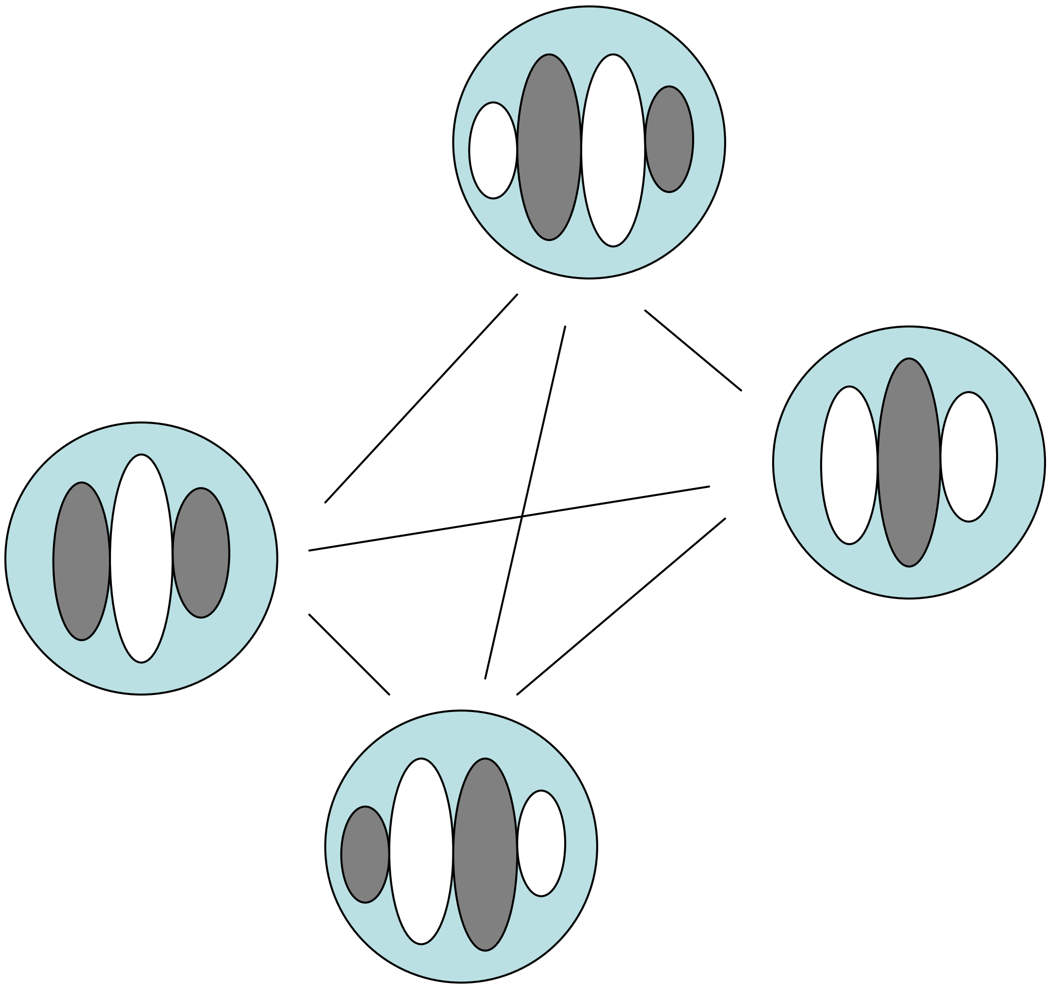


Priebe, Mechler, Carandini & Ferster, 2004

Feedforward model of complex cells



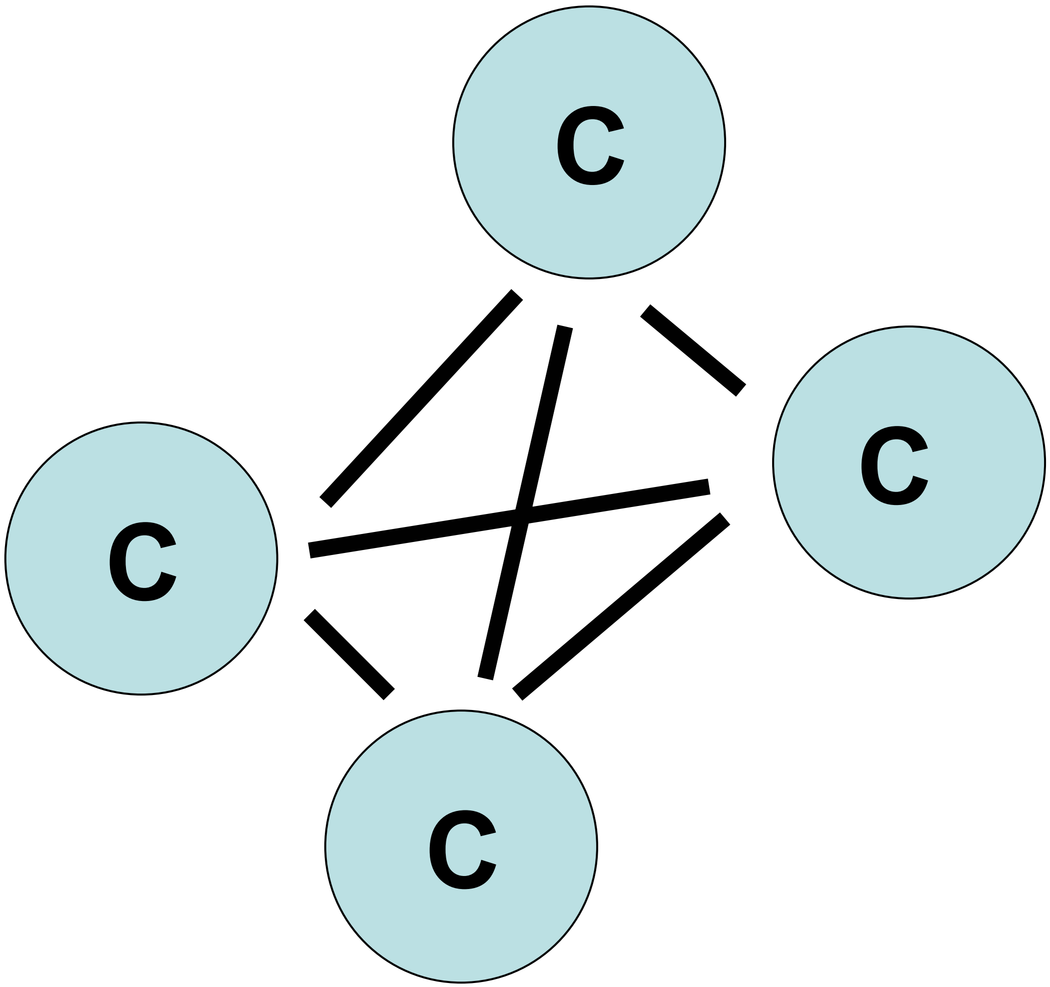
Complex cells as networked simple cells



Low gain

Chance, Nelson & Abbott, 1999

Complex cells as networked simple cells



High gain

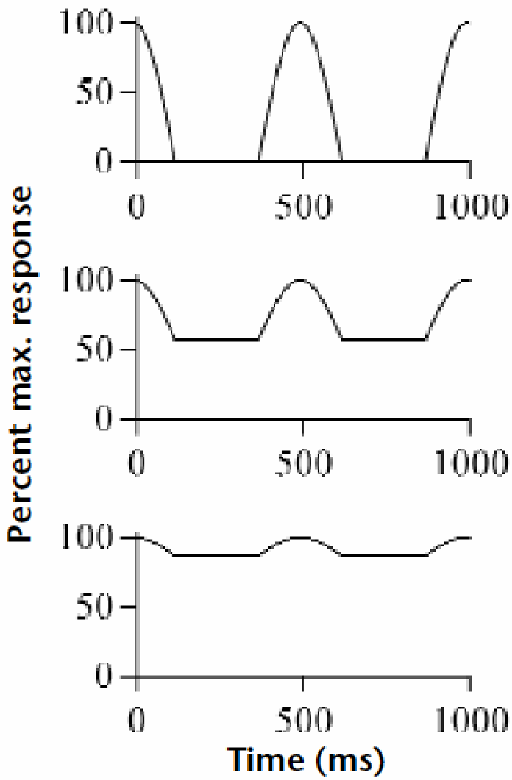
Chance, Nelson & Abbott, 1999

Complex cells as networked simple cells

Simple

Intermediate

Complex



Gain = 1

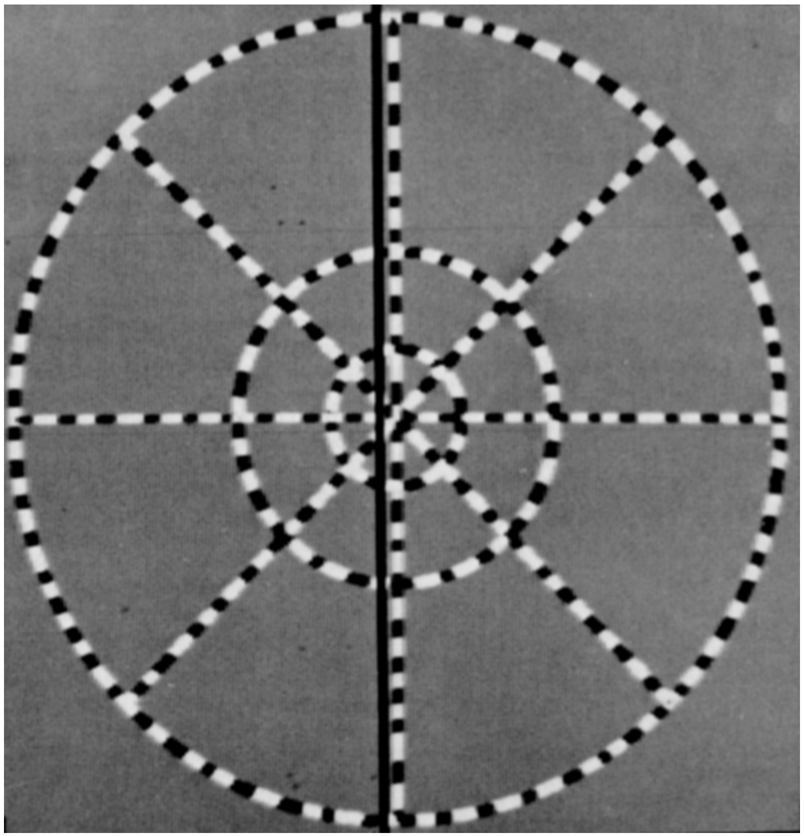
Gain = 5

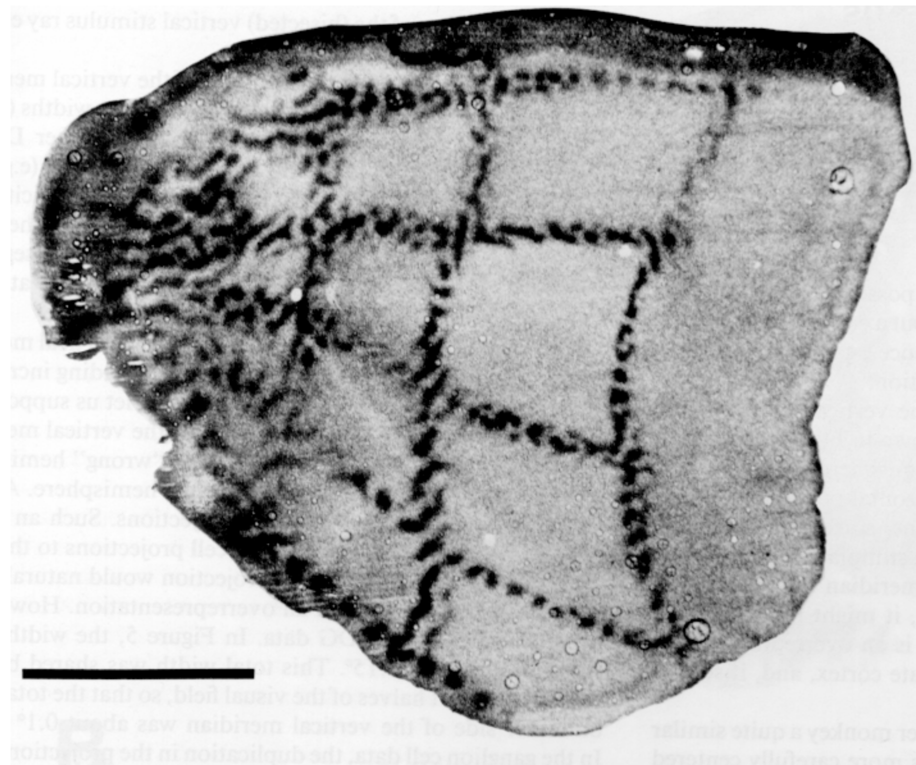
Gain = 20

Chance, Nelson & Abbott, 1999

Maps

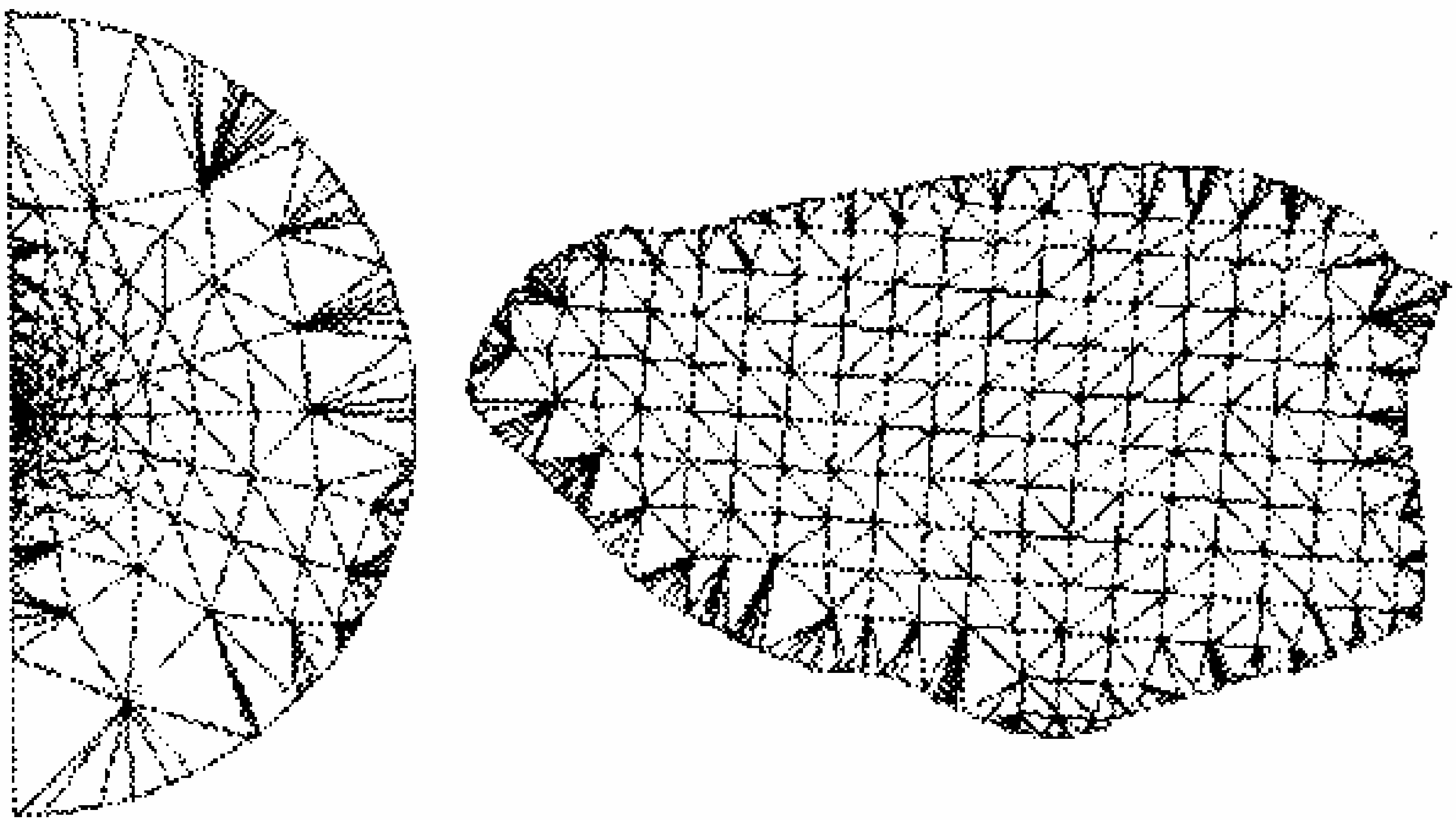
Cortical representation measured with 2-deoxy-glucose





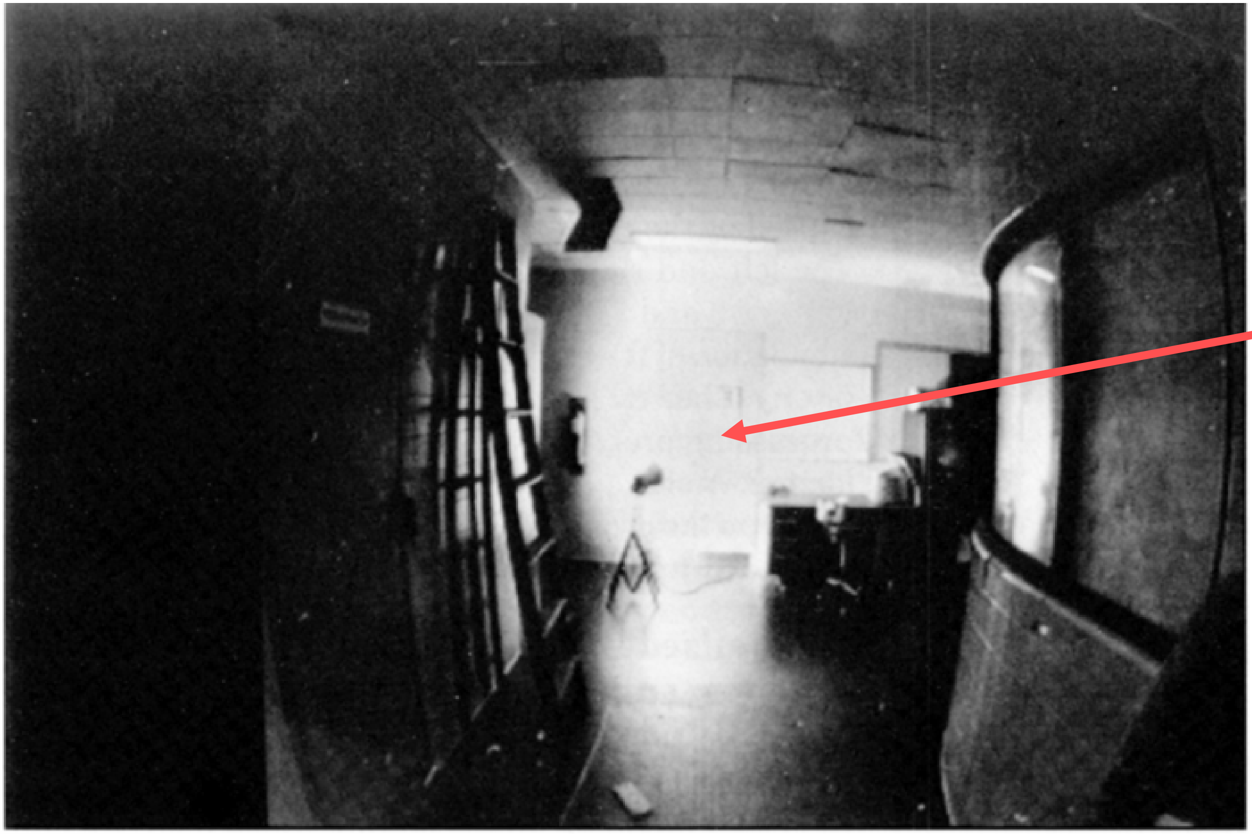
Tootell et al. (1988)

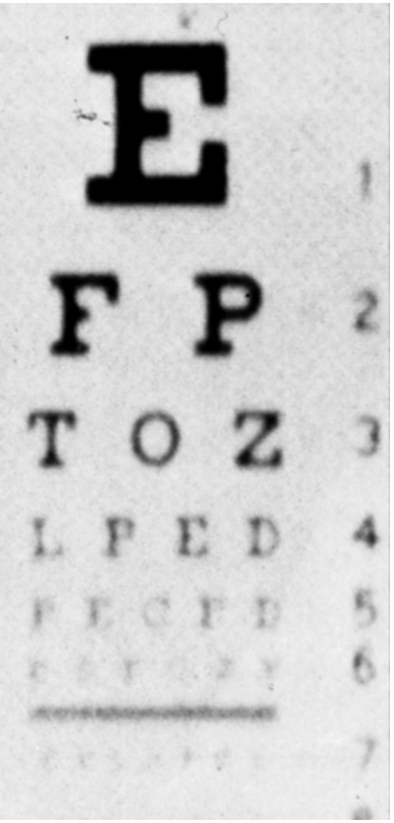
Complex-log model



Schwartz et al. (1988)
Frederick and Schwartz (1990)

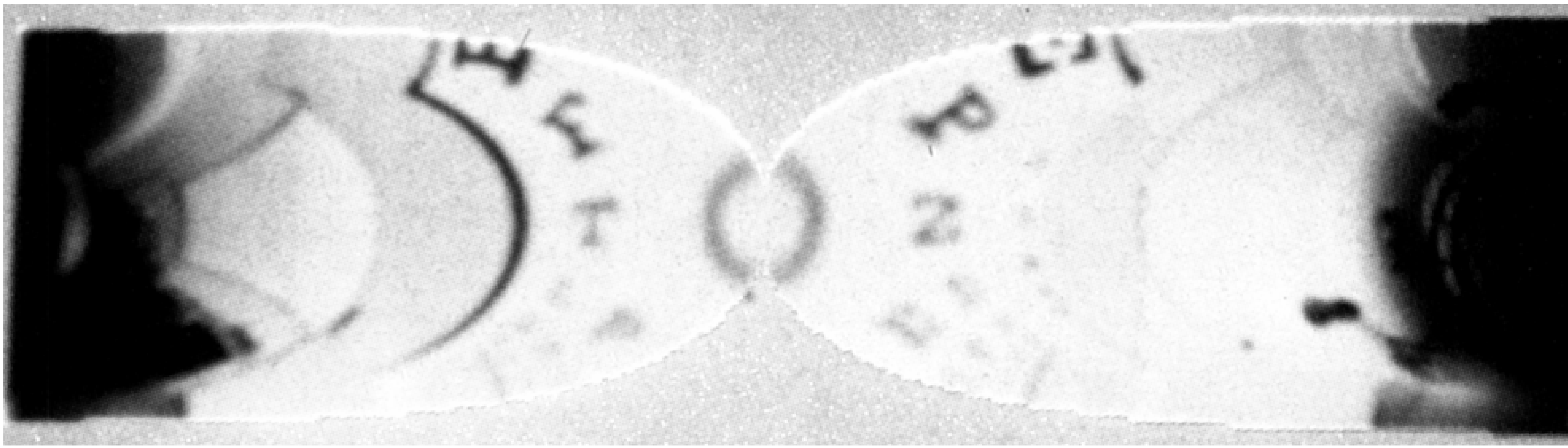
If your eyes see this…





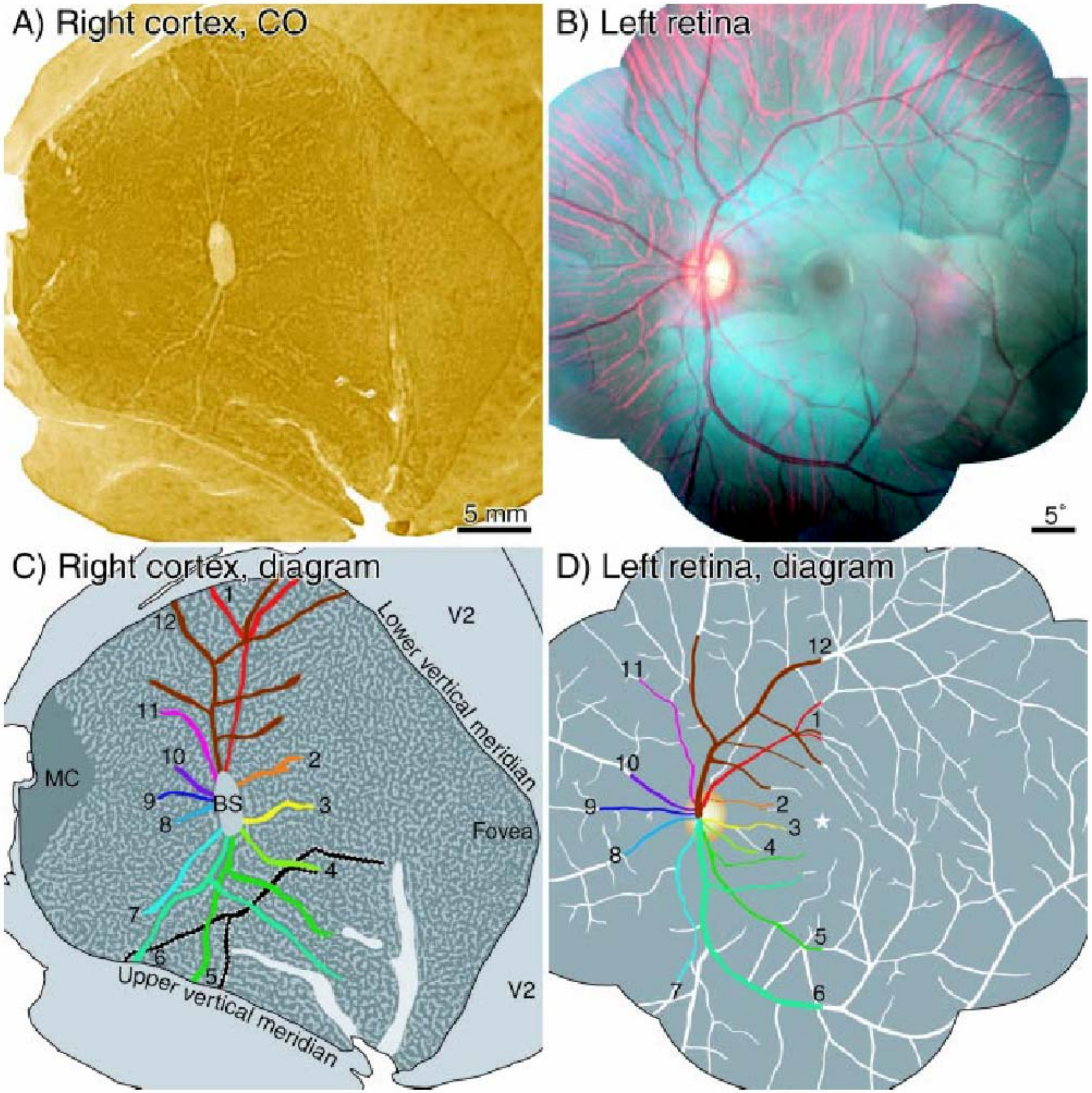
Schwartz et al. (1988)
Frederick and Schwartz (1990)

…your brain maps it to this



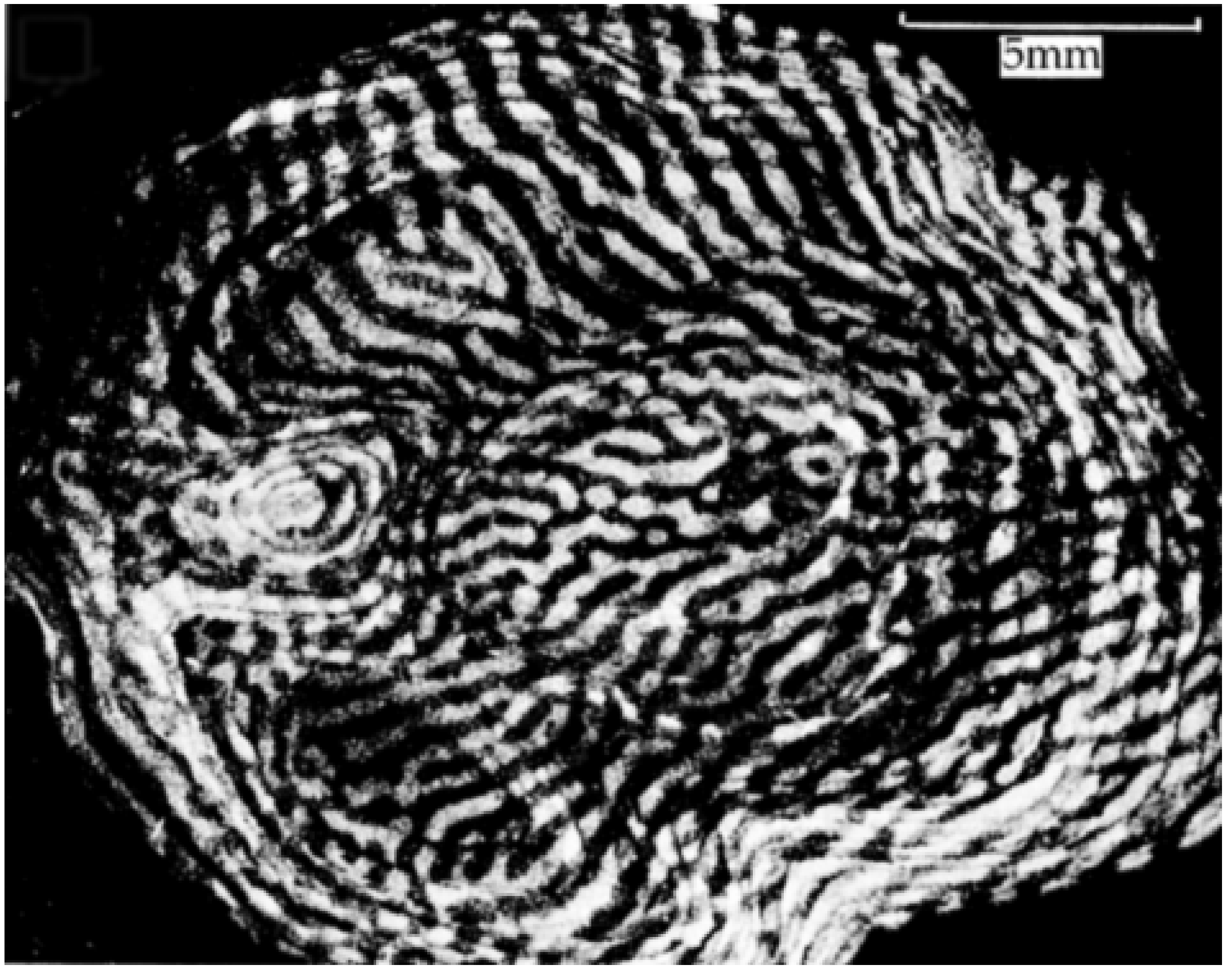
Schwartz et al. (1988)
Frederick and Schwartz (1990)

Retinotopy is very precise



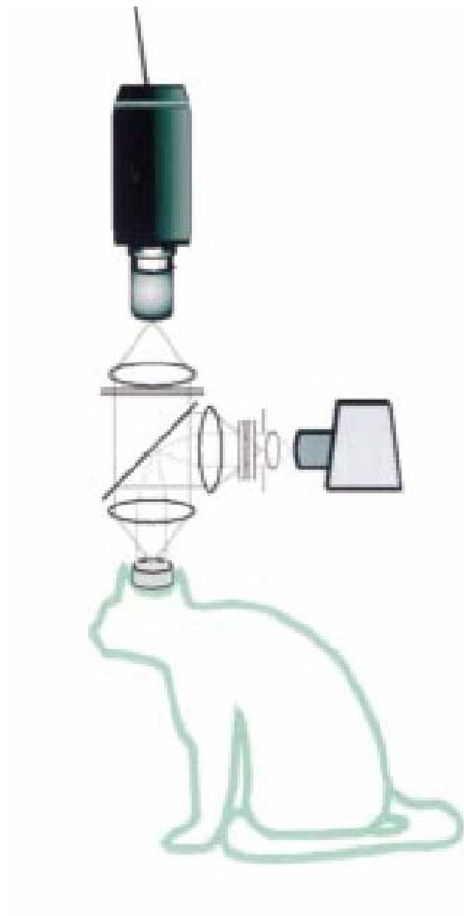
Adams & Horton (2003)

Map of ocular dominance measured with radioactive proline



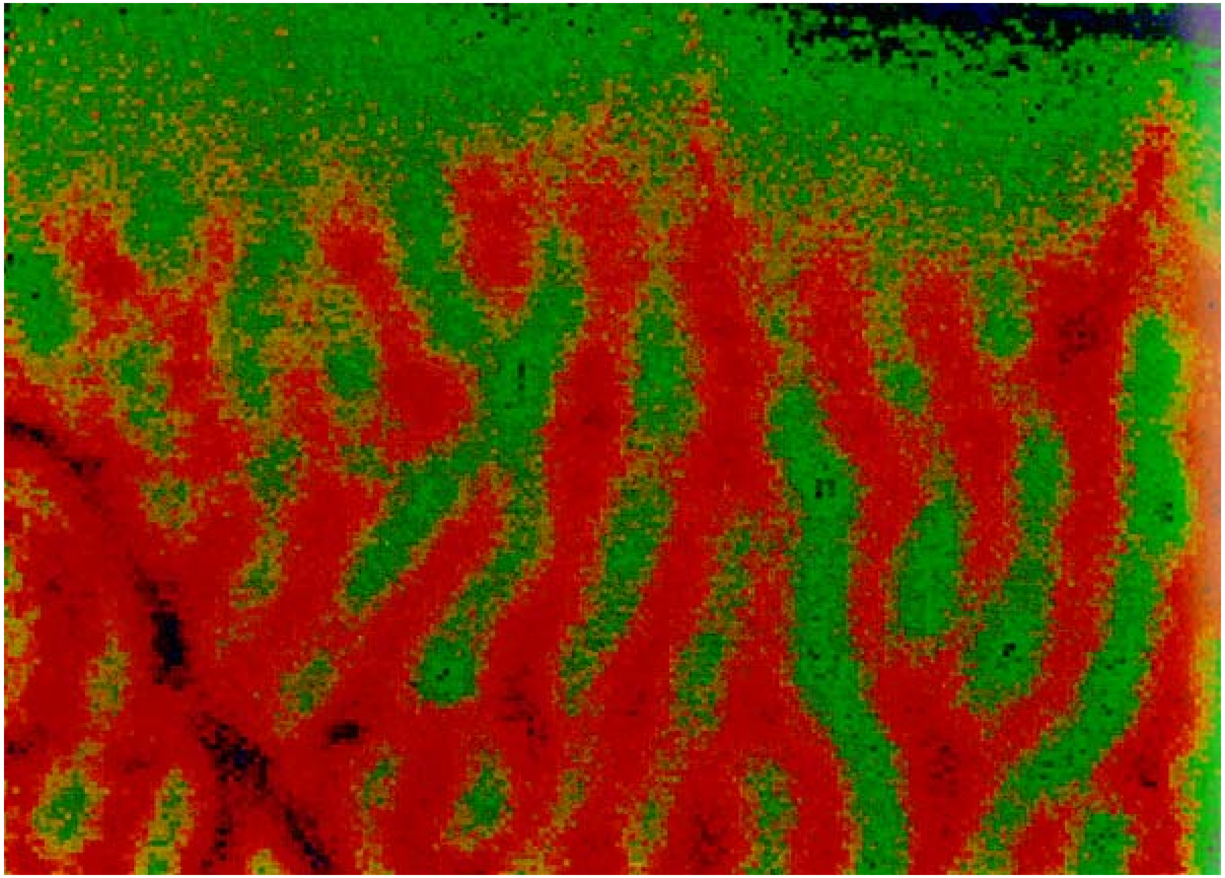
LeVay, Hubel and Wiesel (1975)
in Nicholls et al. (1992)

Optical imaging



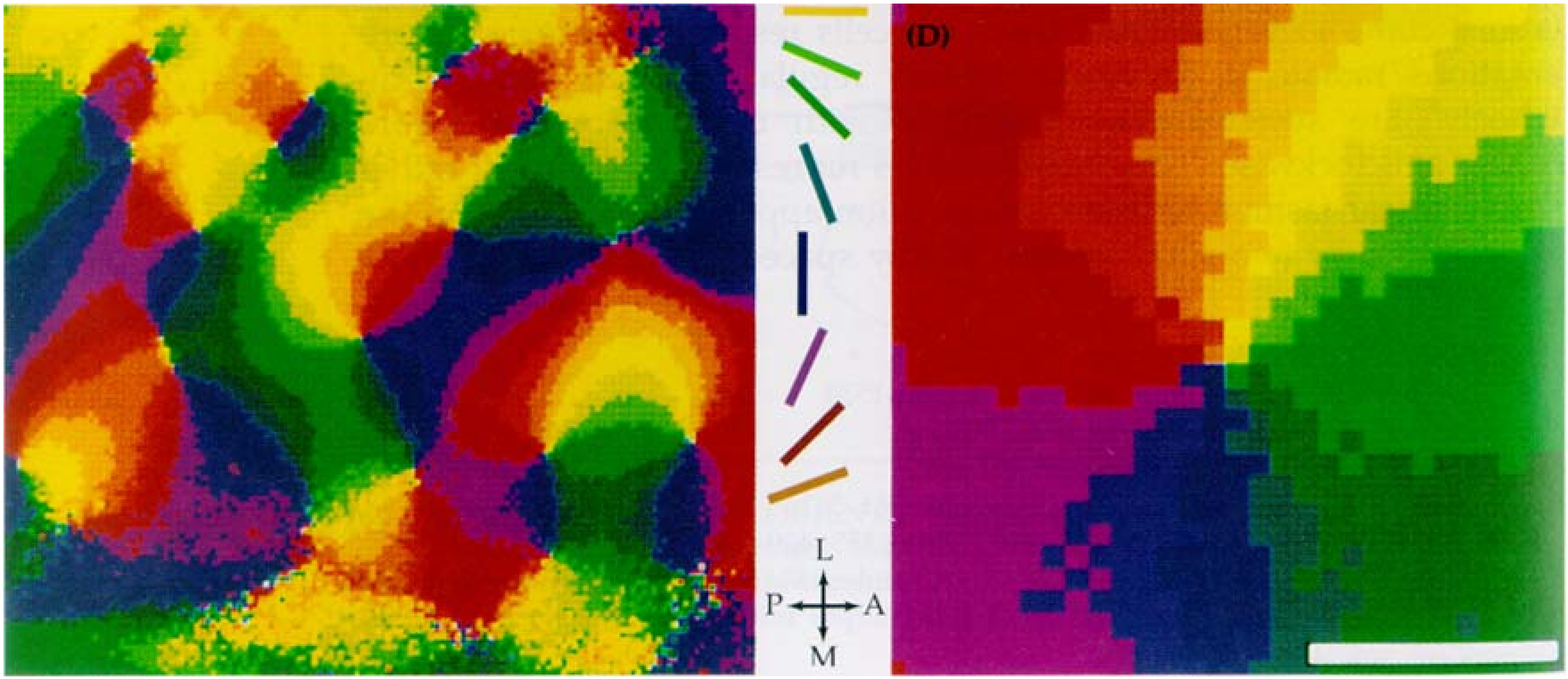
•Intrinsic signals
•Voltage-sensitive dye

Map of ocular dominance measured with optical imaging



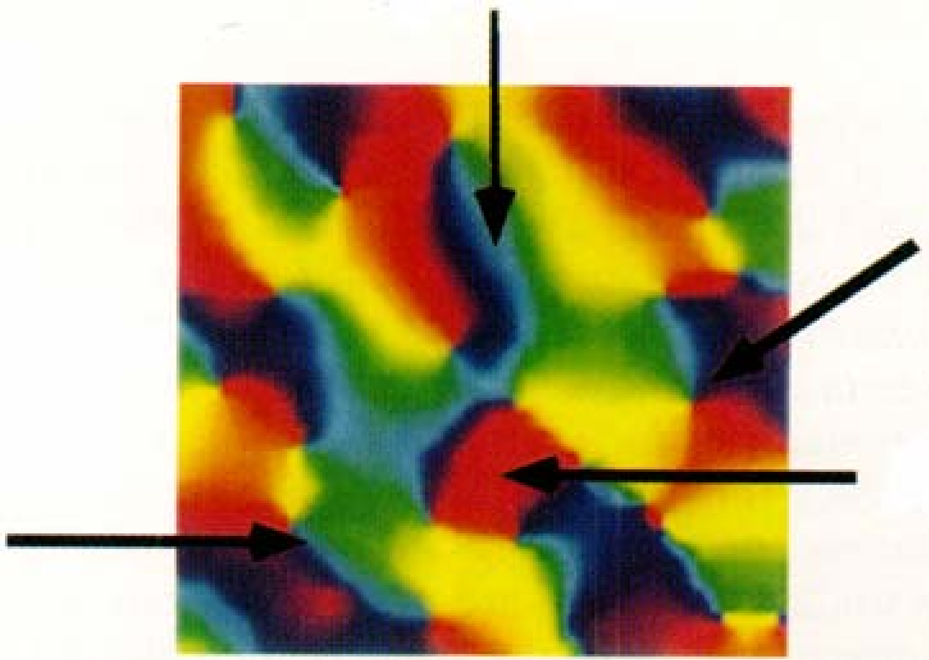
Bonhoeffer & Grinvald (1991)
in Nicholls et al. (1992)

Map of orientation preference measured with optical imaging



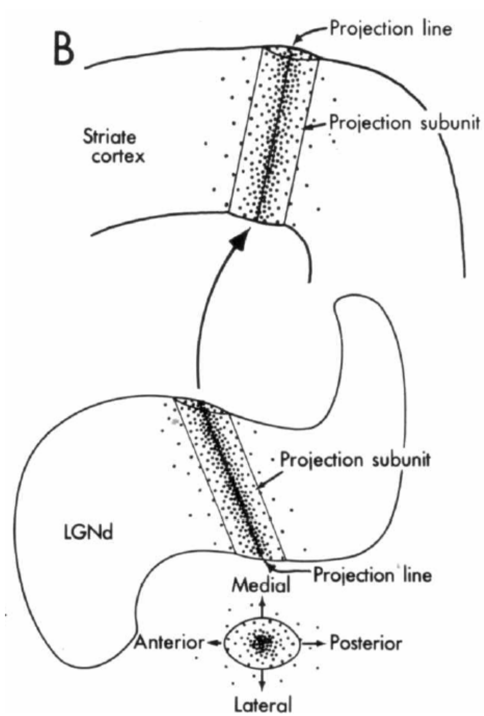
Bonhoeffer and Grinvald (1991)
in Nicholls et al. (1992)

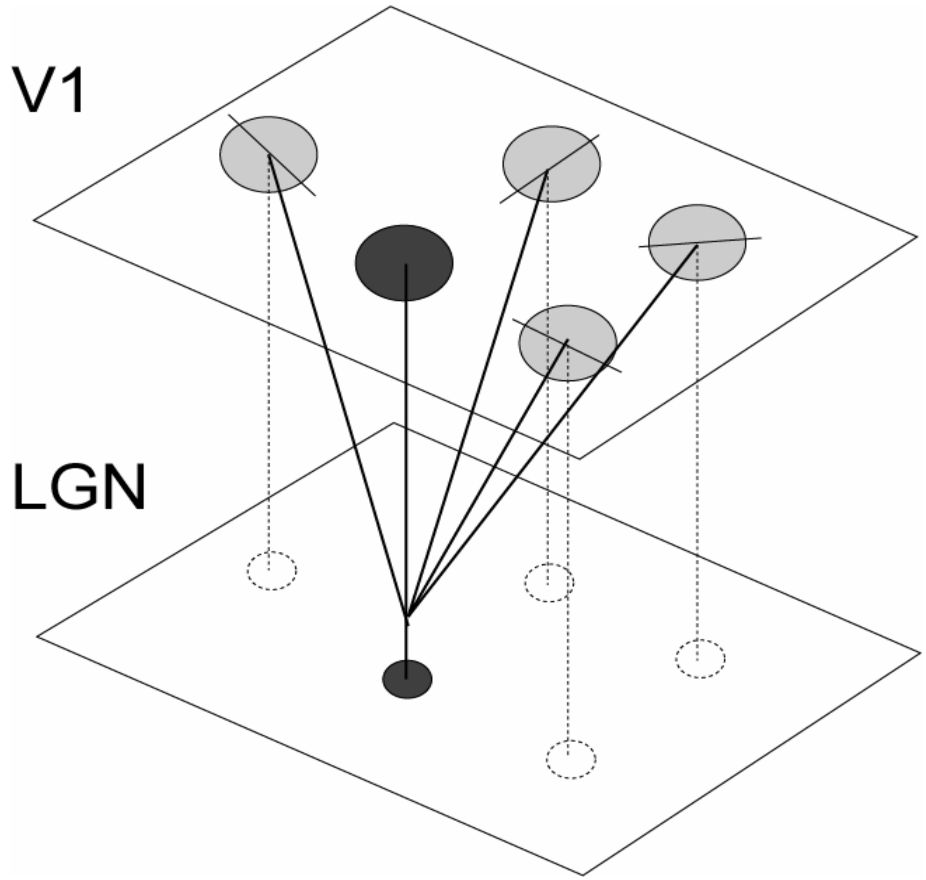
Relationship between ocular dominance and orientation preference



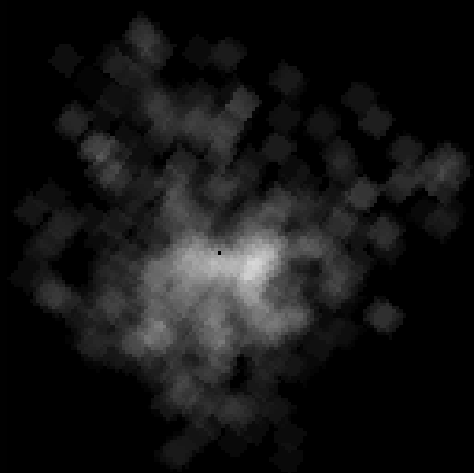
Obermayer & Blasdel (1993)

Connections from LGN may constrain the map of orientation preference

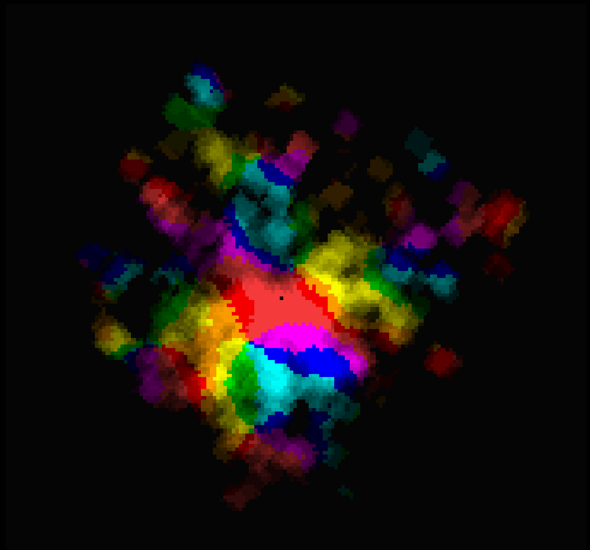




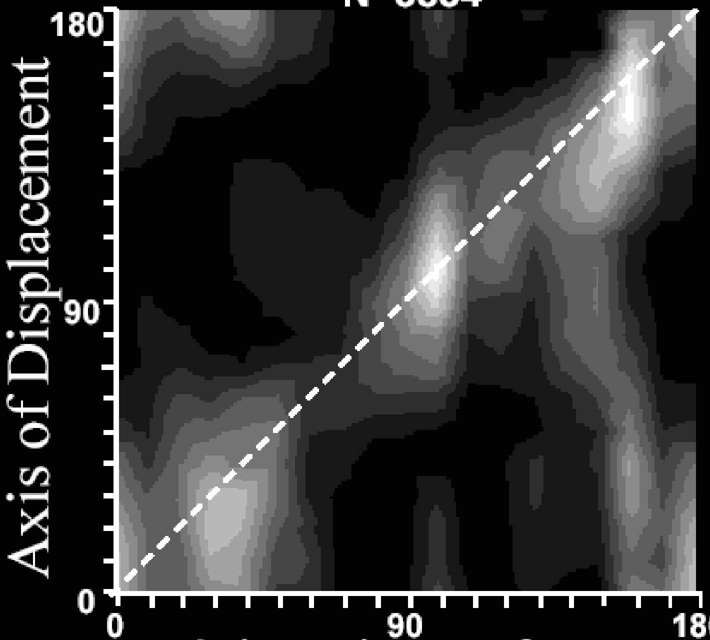
Preliminary evidence from tree shrew V1



Bouton Density

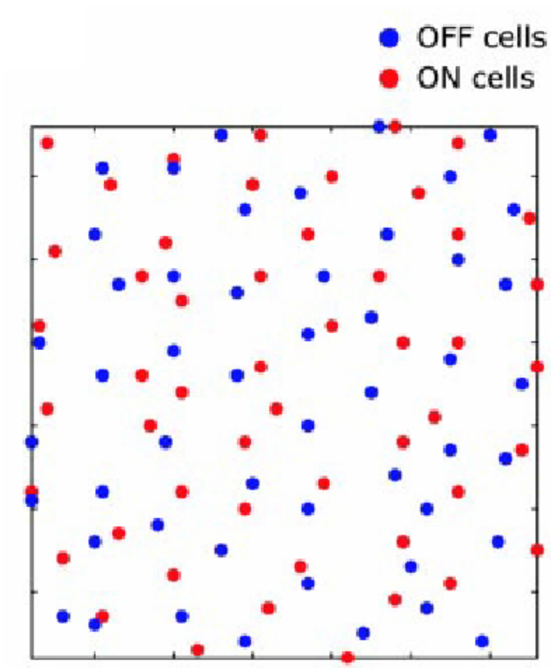


Bouton thresholded orientation map

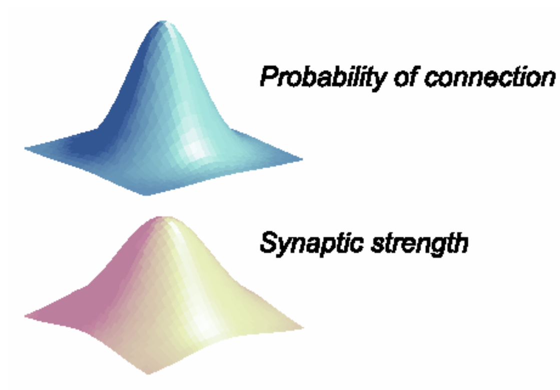


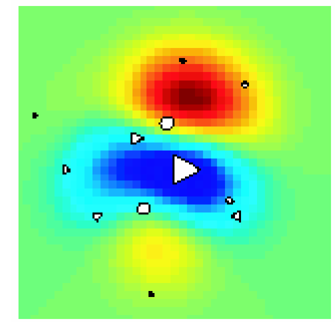
Mooser, Bosking & Fitzpatrick, *Soc Neurosci Abs* 2001

The retinal mosaic may determine orientation preference



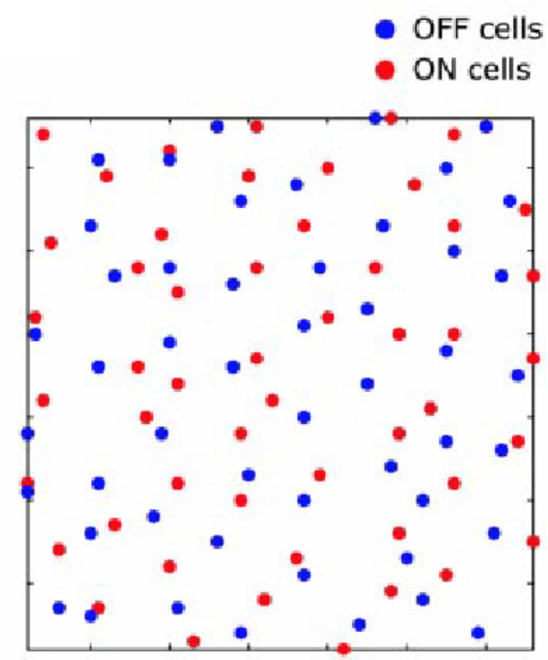
Retinal mosaic, X cells



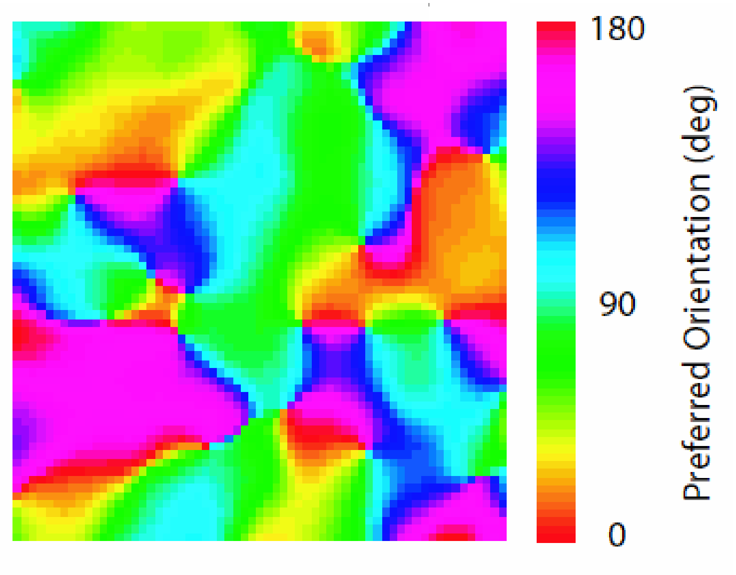


Ringach, 2004

The retinal mosaic may constrain the map of orientation preference



Retinal mosaic, X cells

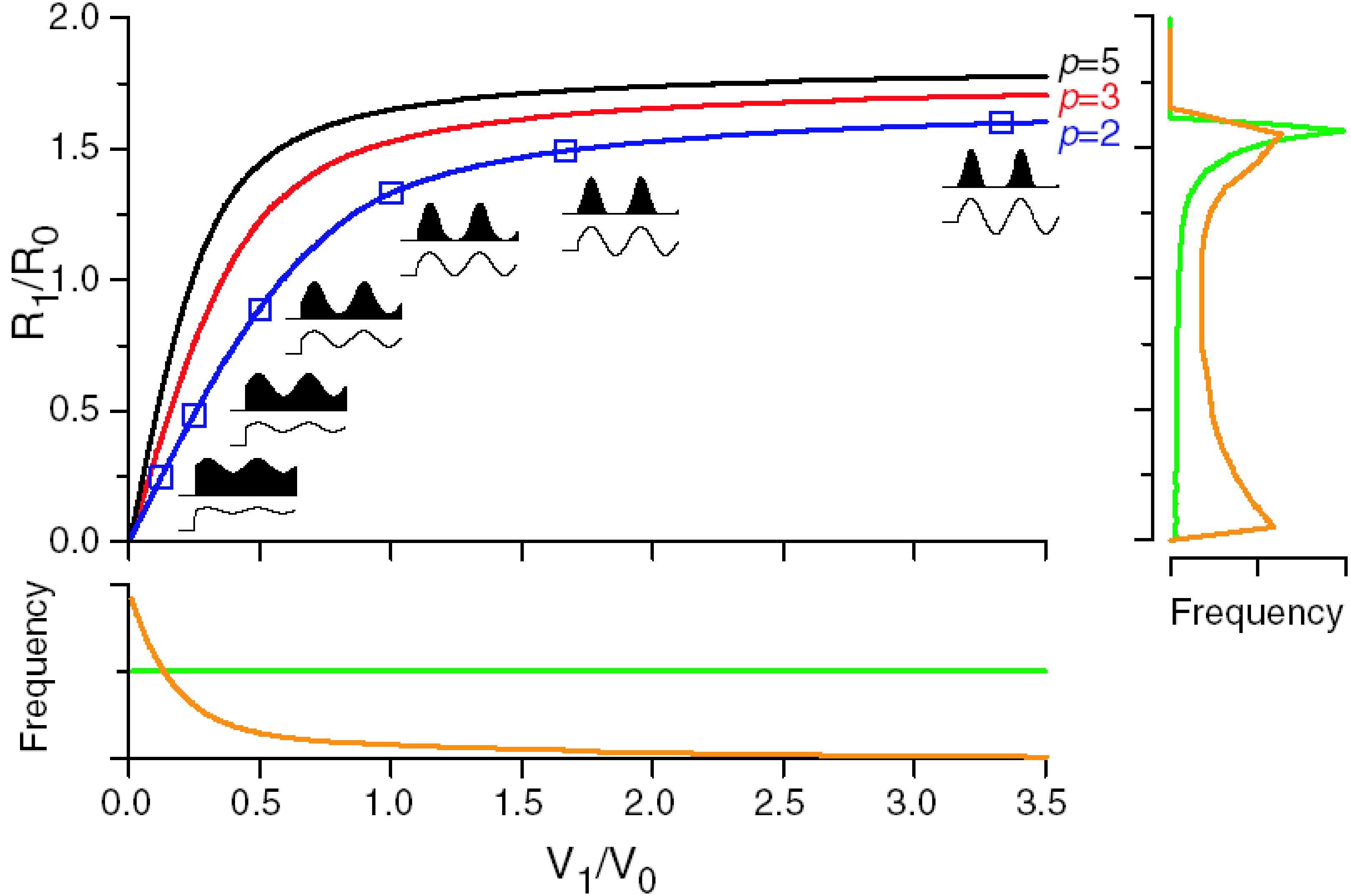


Ringach, 2004

Summary

- V1 receptive fields in space-time
- Wiring of simple cells and complex cells
- Maps of selectivity
- Constraints on orientation map

Power law creates dichotomy



Priebe, Mechler, Carandini & Ferster, 2004