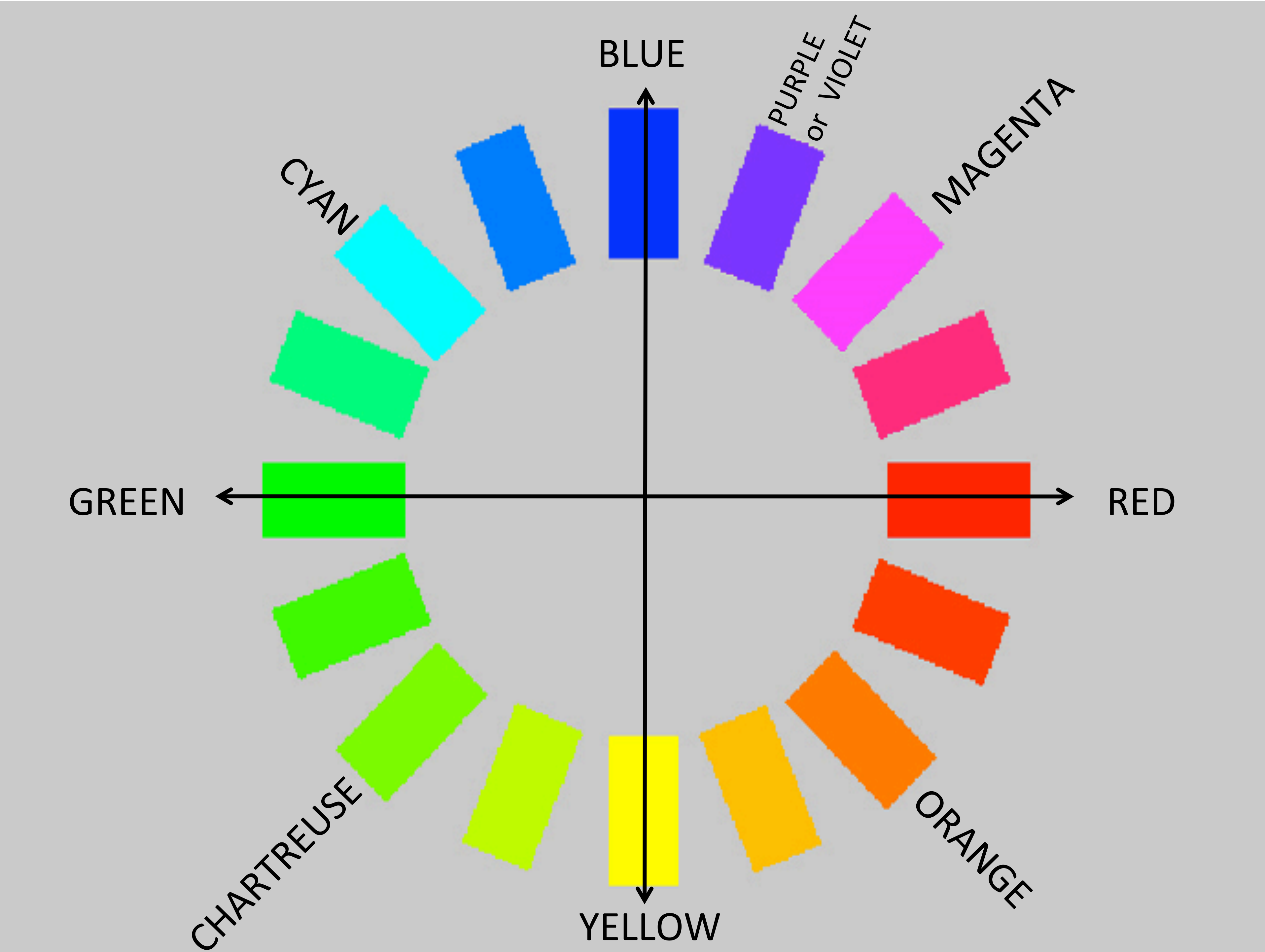

BLUE
PURPLE
or VIOLET
MAGENTA
CYAN
GREEN
RED
CHARTREUSE
YELLOW
ORANGE

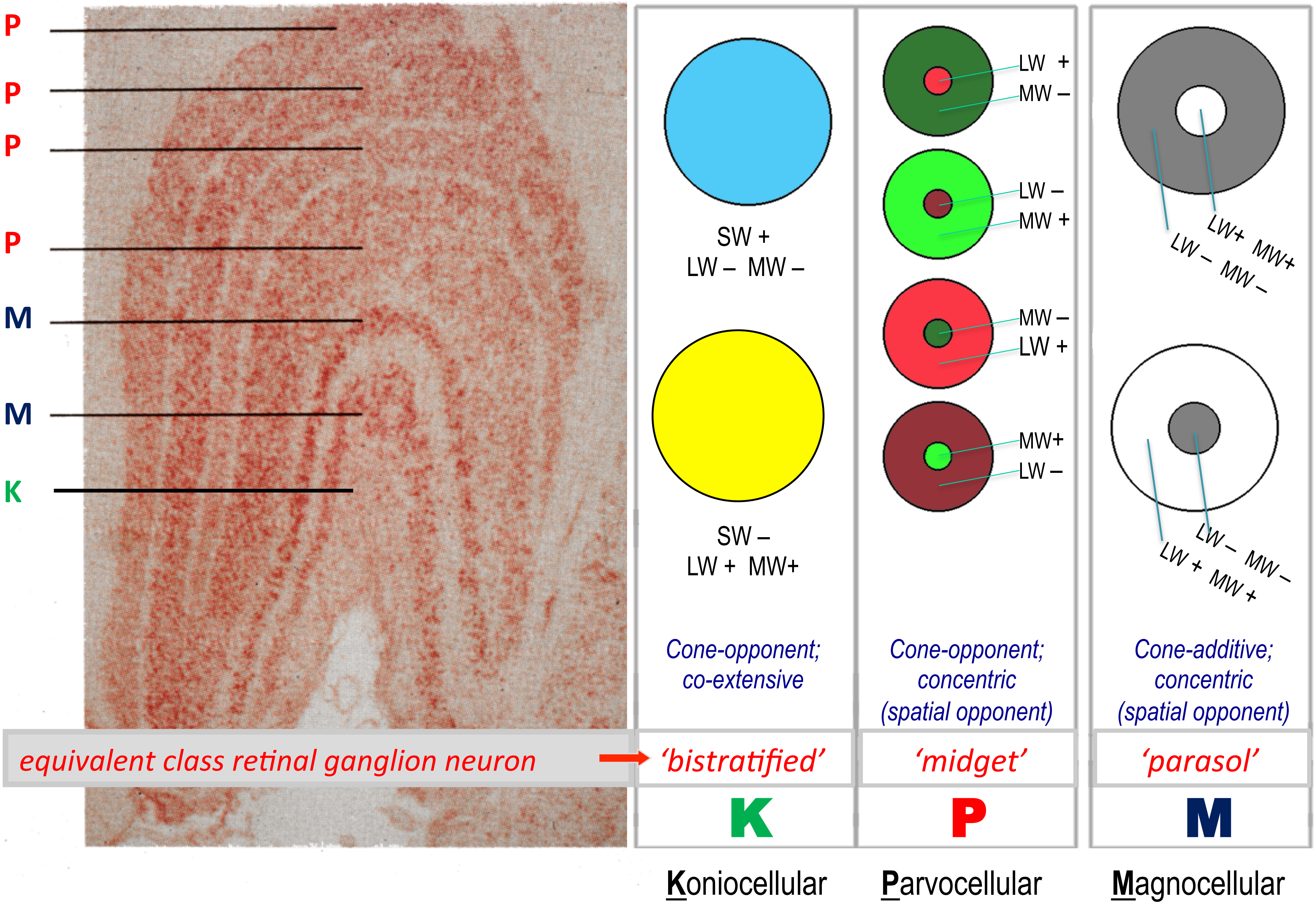
How similar are different
cultures' concepts of colour?

Do different languages share
equivalent basic colour terms ?

Basic Color Terms: Their Universality and Evolution
Berlin & Kay 1969.

1 & 2	Light and dark (i.e. 'black' & 'white')
3	Red
4 & 5	Green & Yellow
6	Blue
7	Brown
8-11	Purple Pink Orange Grey

LGN – receptive field properties of 3 different channels



NAMING SEQUENCE		WAVELENGTH
Red	R	668
Reddish-yellow	R Y	
Yellow	Y	580
Yellowish-green	G Y	
Green	G	520
Greenish-blue	G B	500
Blue	B	464
Bluish-red	R B	440

TRADITIONAL SPECTRUM

Red

Orange

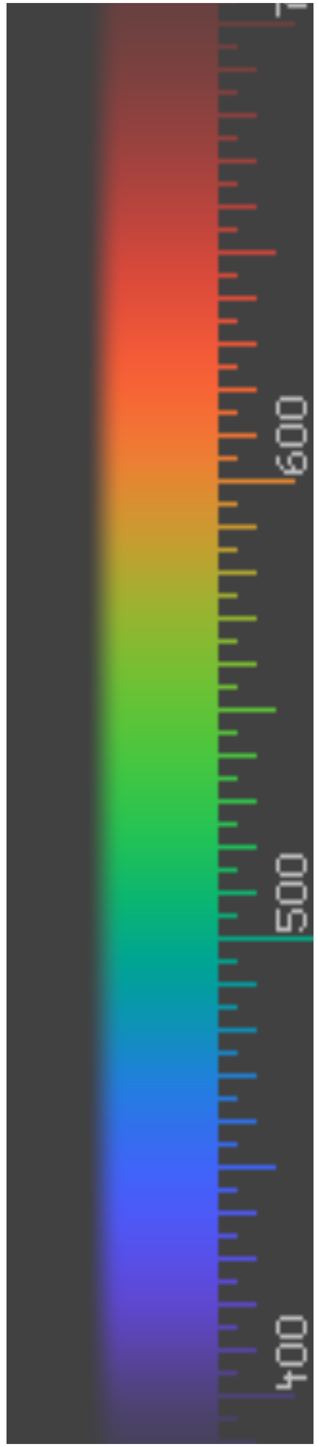
Yellow

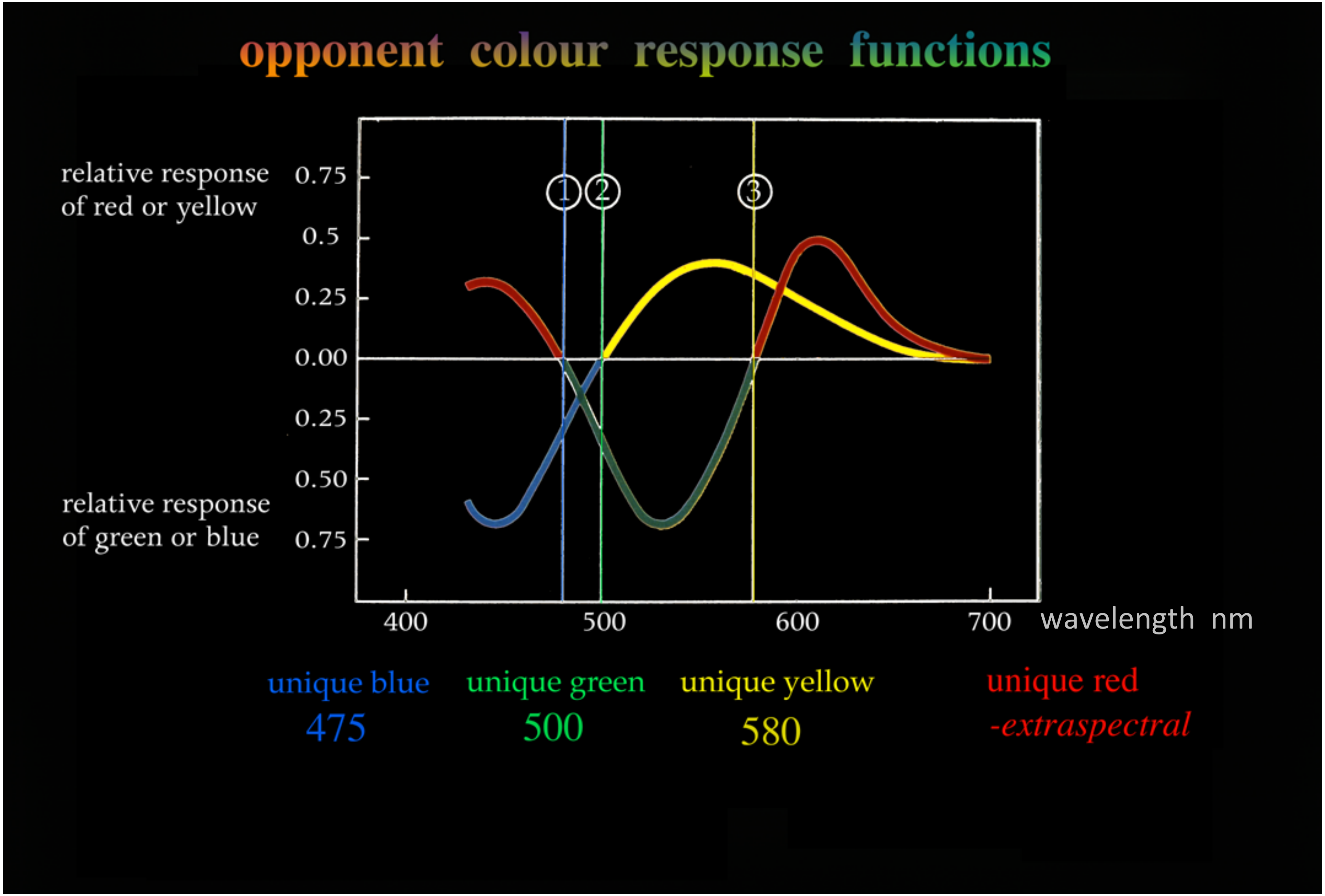
Green

Blue

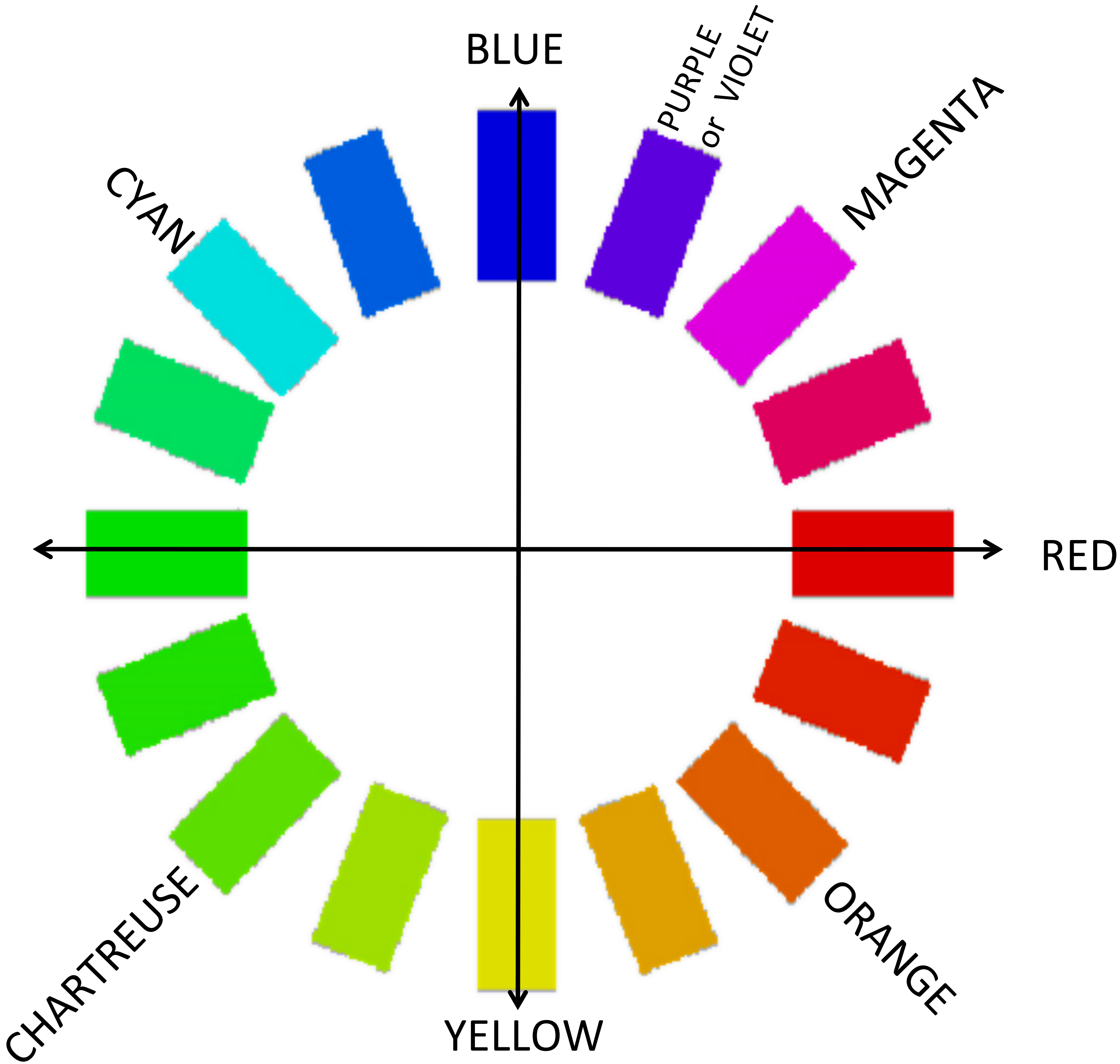
Indigo

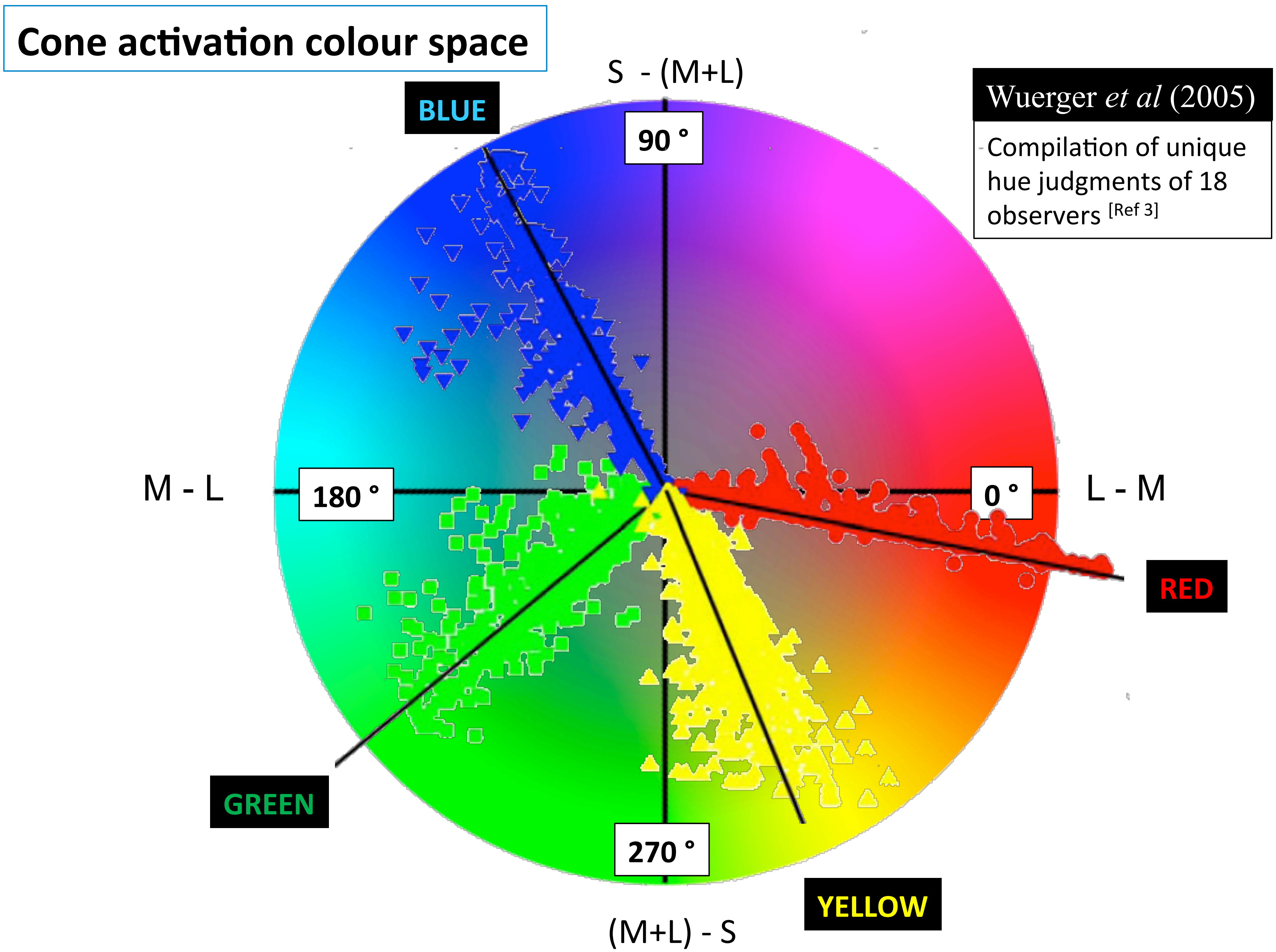
Violet





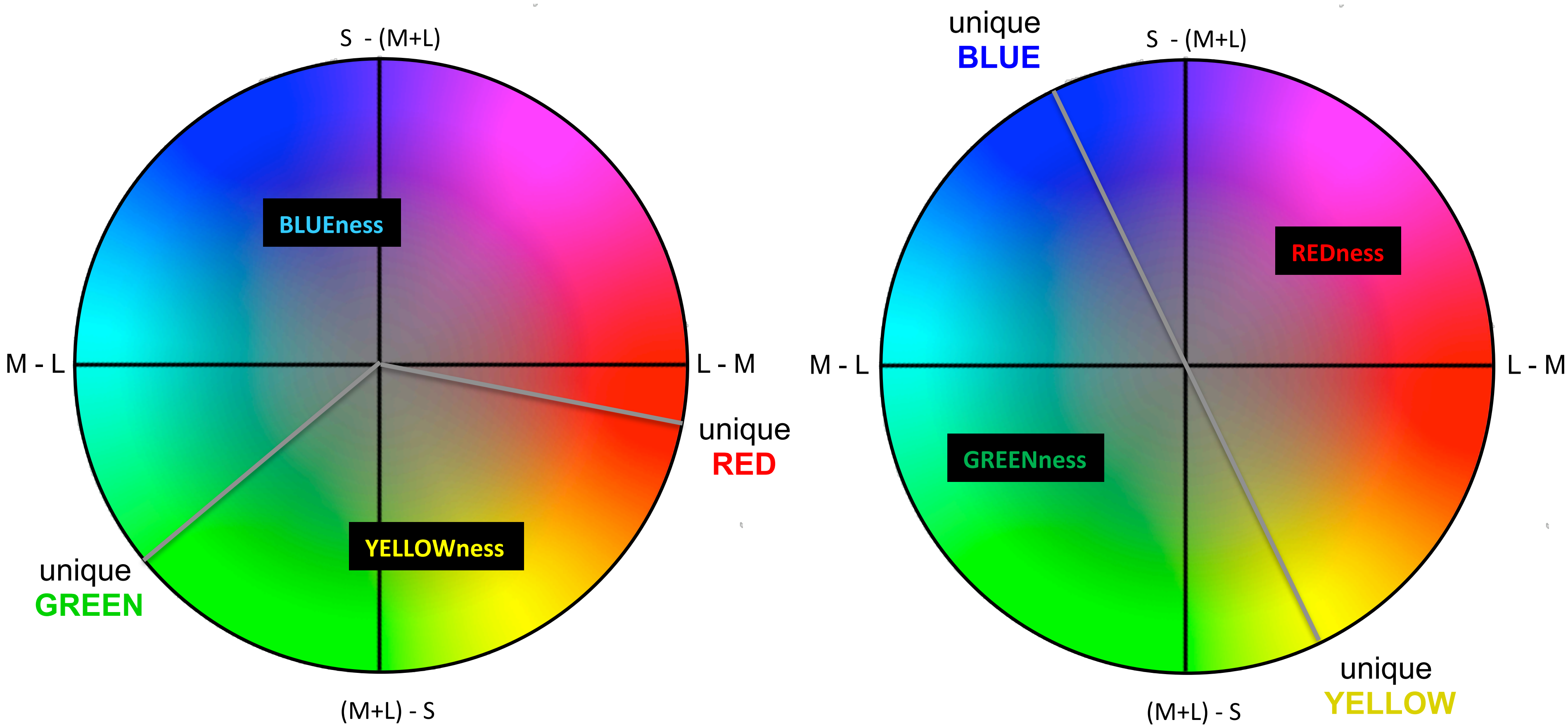
[Ewald Hering 1878 – opponent colours theory]


BLUE
PURPLE or VIOLET
MAGENTA
CYAN
RED
CHARTREUSE
YELLOW
ORANGE

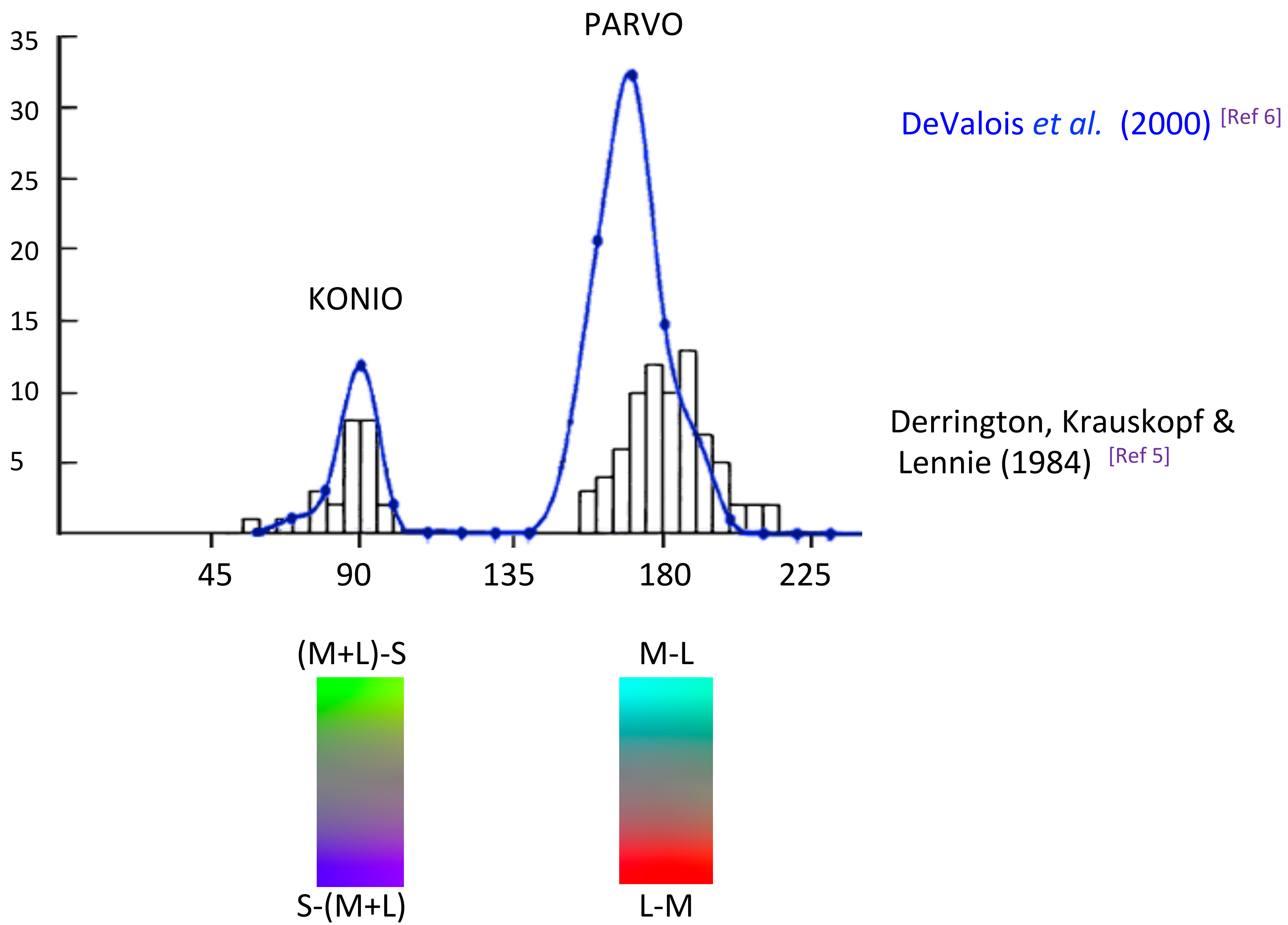


Cone activation colour space
S - (M+L)
BLUE
90 °
Wuerger et al (2005)
Compilation of unique hue judgments of 18 observers [Ref 3]
M - L
180 °
0 °
L - M
RED
GREEN
270 °
YELLOW
(M+L) - S

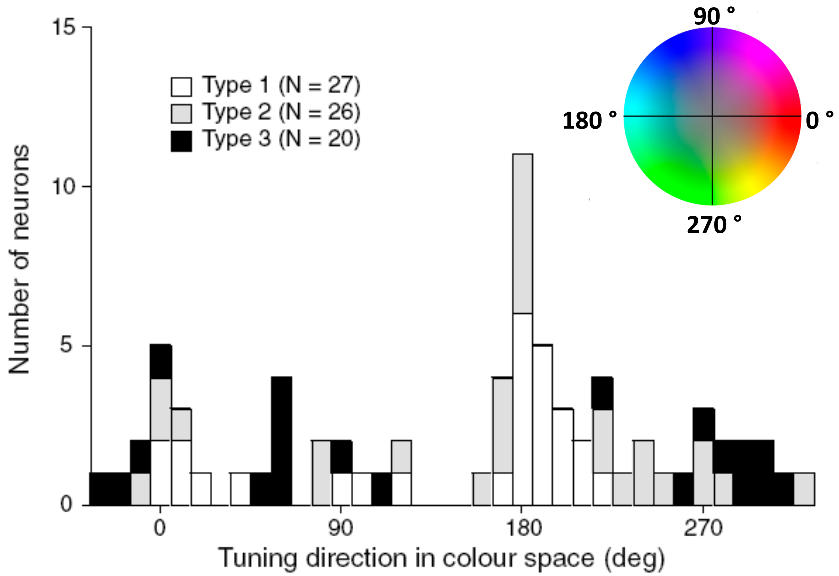
Cone activation colour space

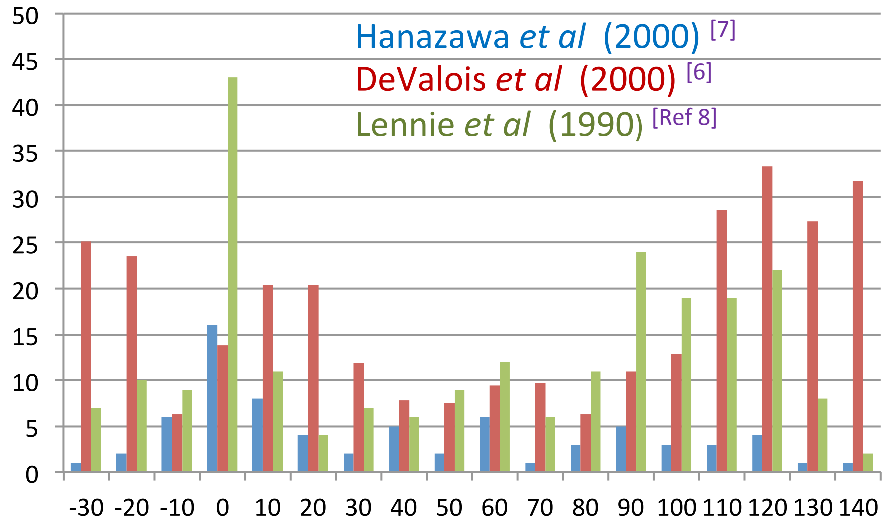


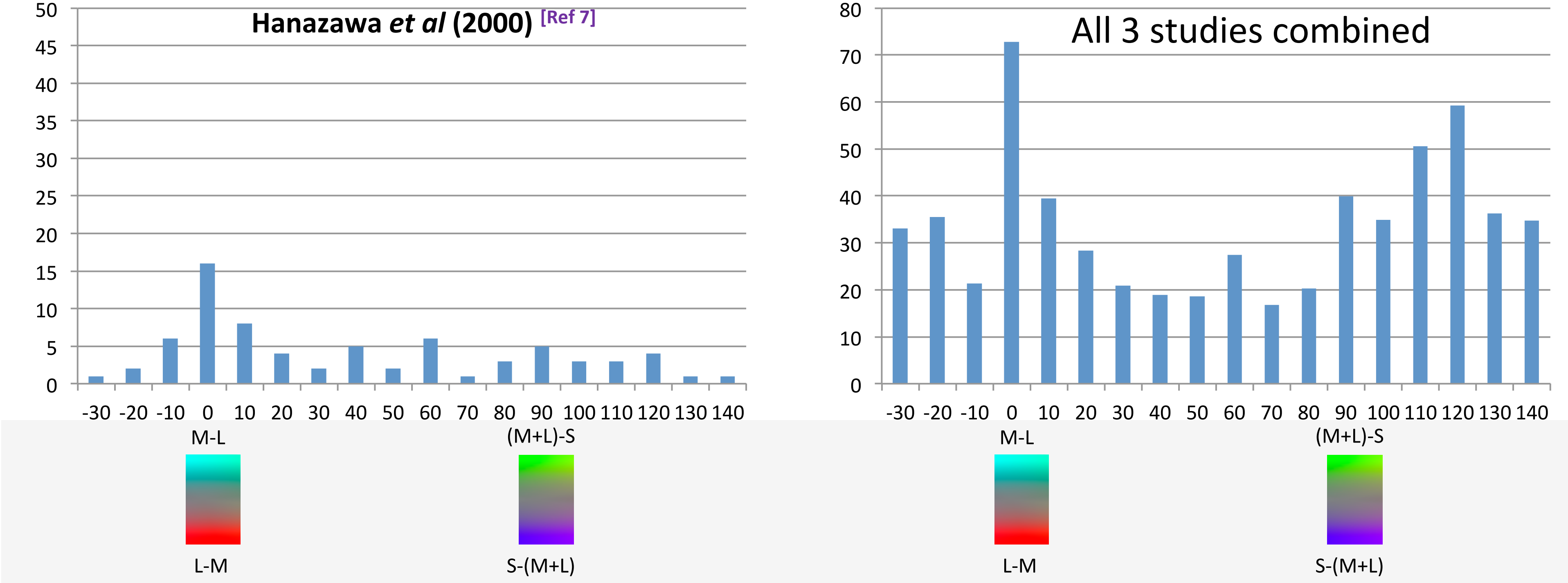
LGN - frequency distribution of chromatic tuning



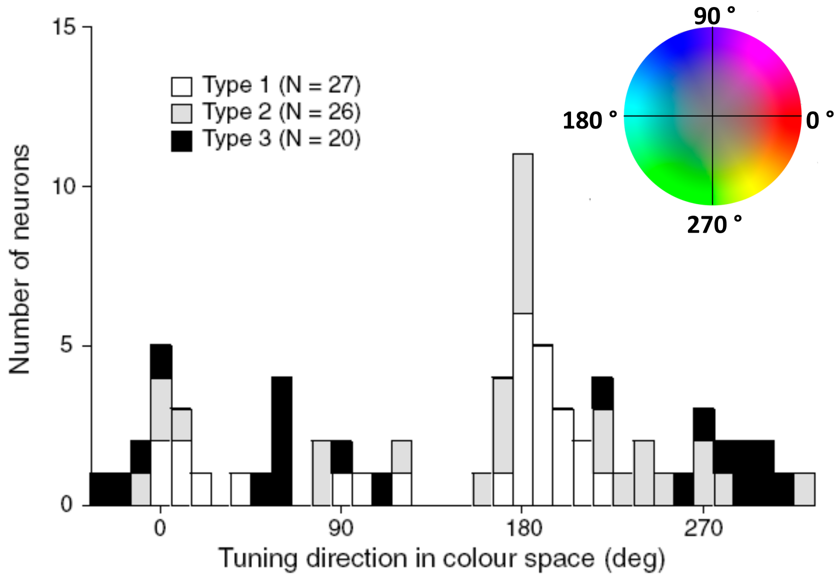
Neural colour axes in V1





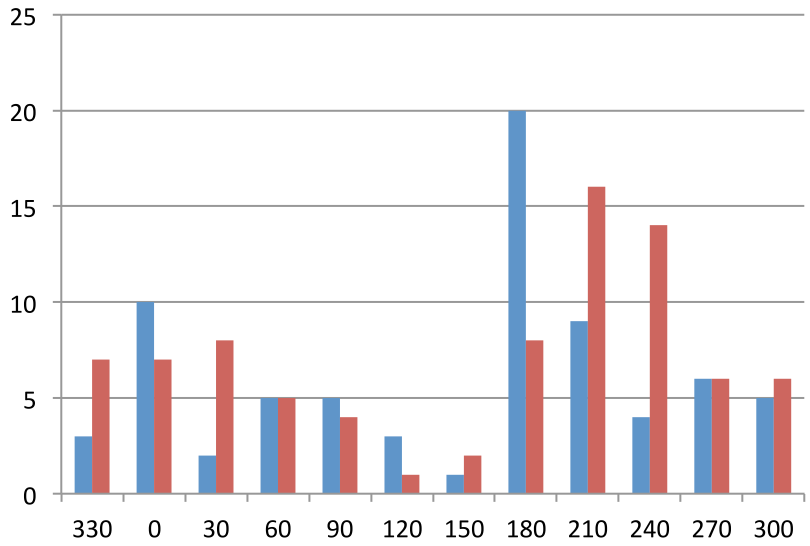


Neural colour axes in V1 & V2



V1: Hanazawa *et al* (2000) [Ref 7]

10 deg. histogram (360 scale)



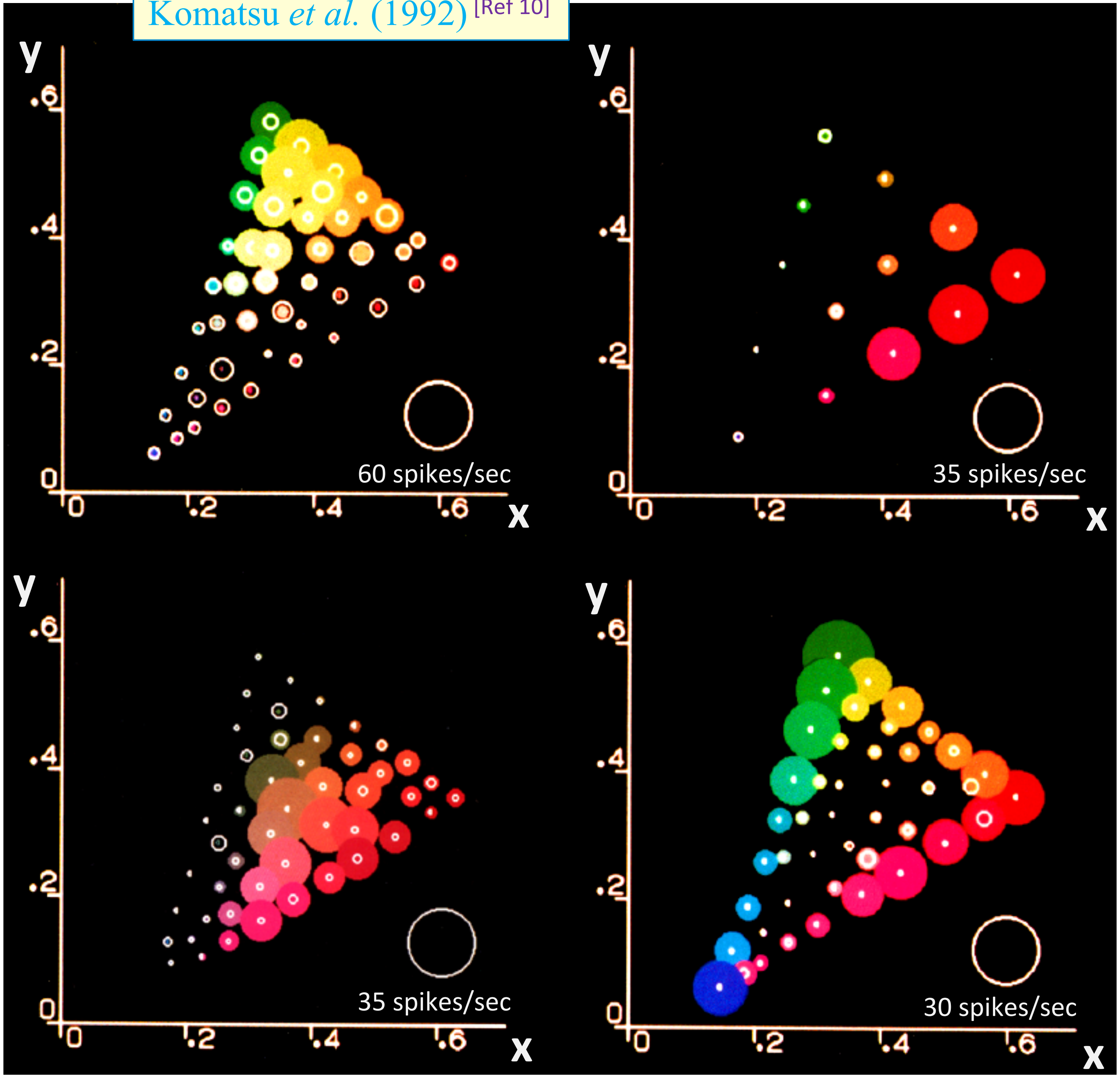
V1: Hanazawa *et al* (2000) [Ref 7]
V2: Kiper *et al* (1997) [Ref 9]

Similar looking?
- but correlation coefficient = 0.29, not significant

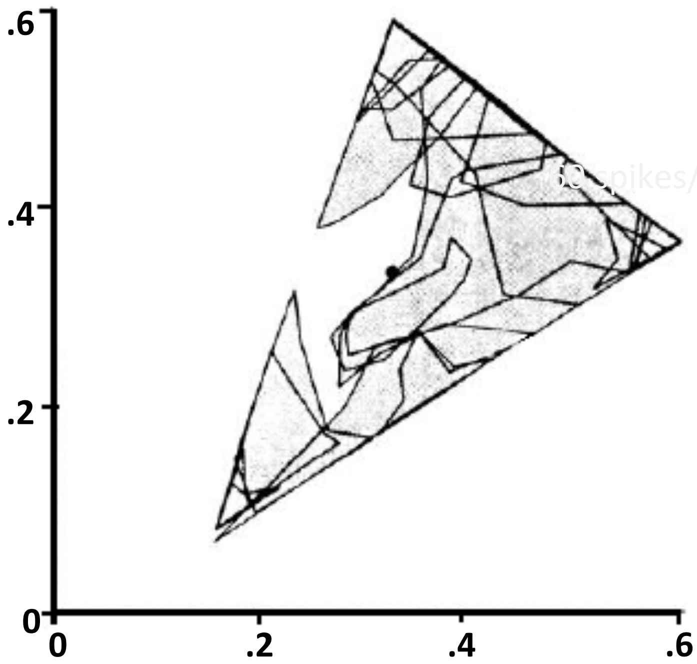
30 deg. histogram (360 scale)

And, at the far end of the ‘ventral’ visual pathway...

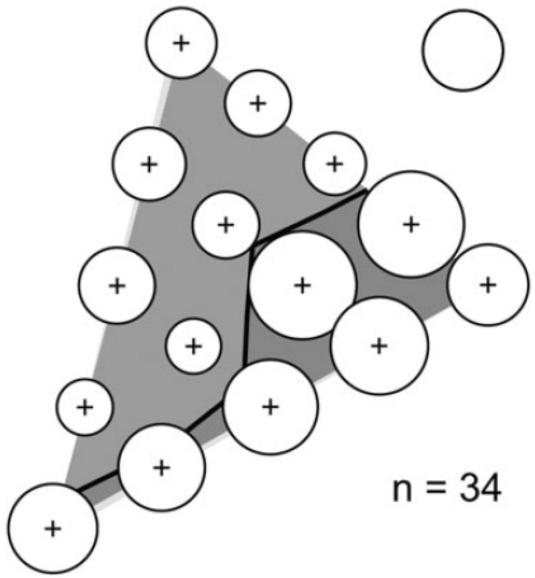
Komatsu *et al.* (1992) [Ref 10]



Komatsu *et al* (1992)

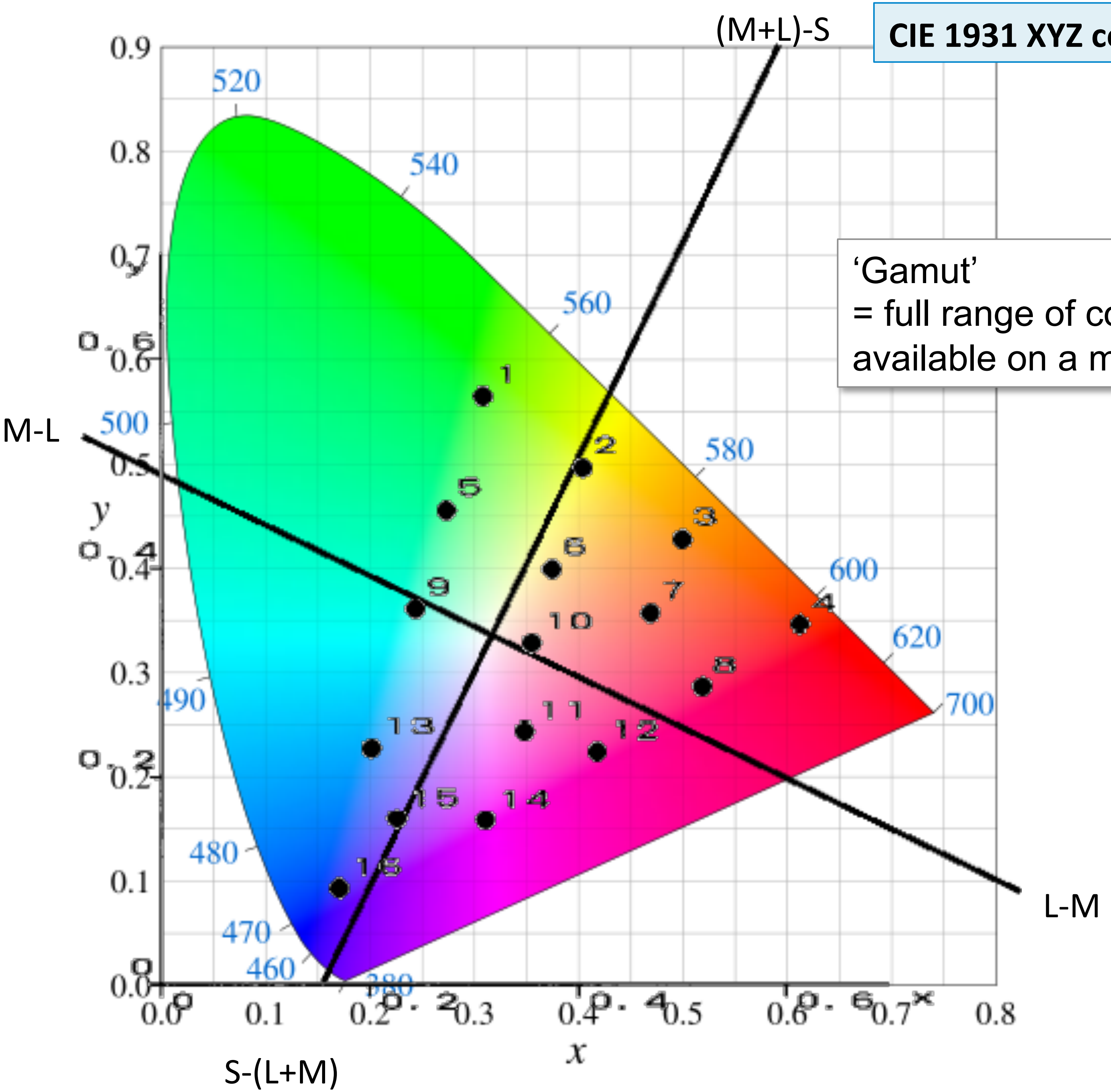


Yasuda *et al* (2010)



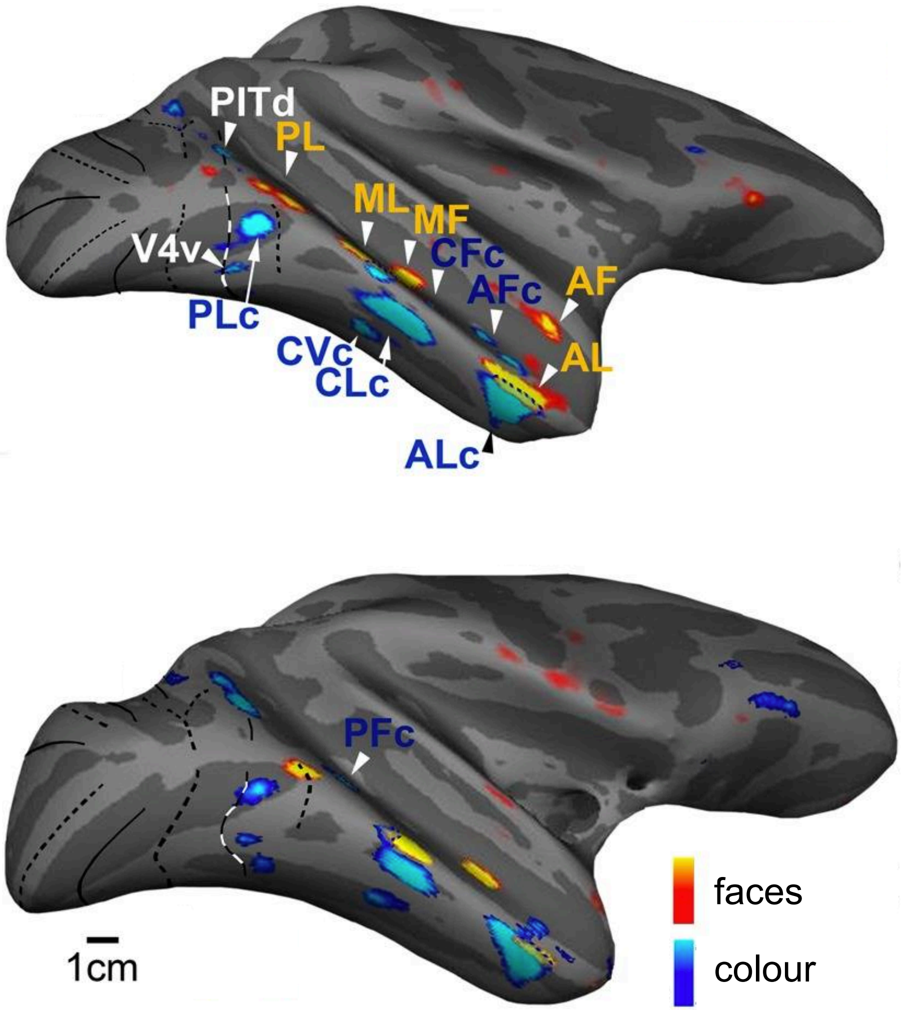
Pooled colour response fields of 19 IT neurons

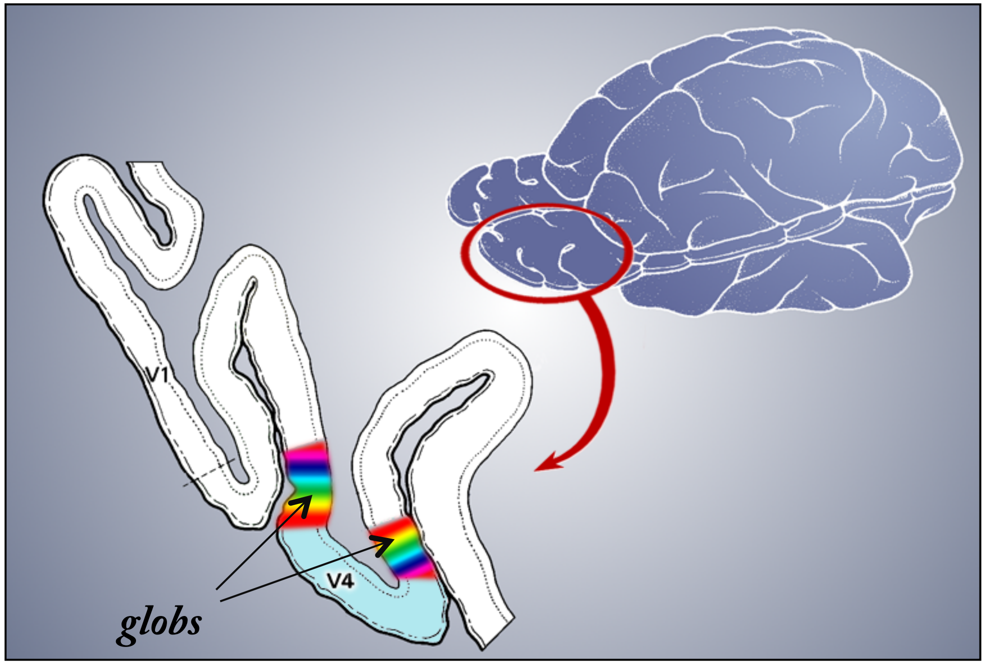
CIE 1931 XYZ color space

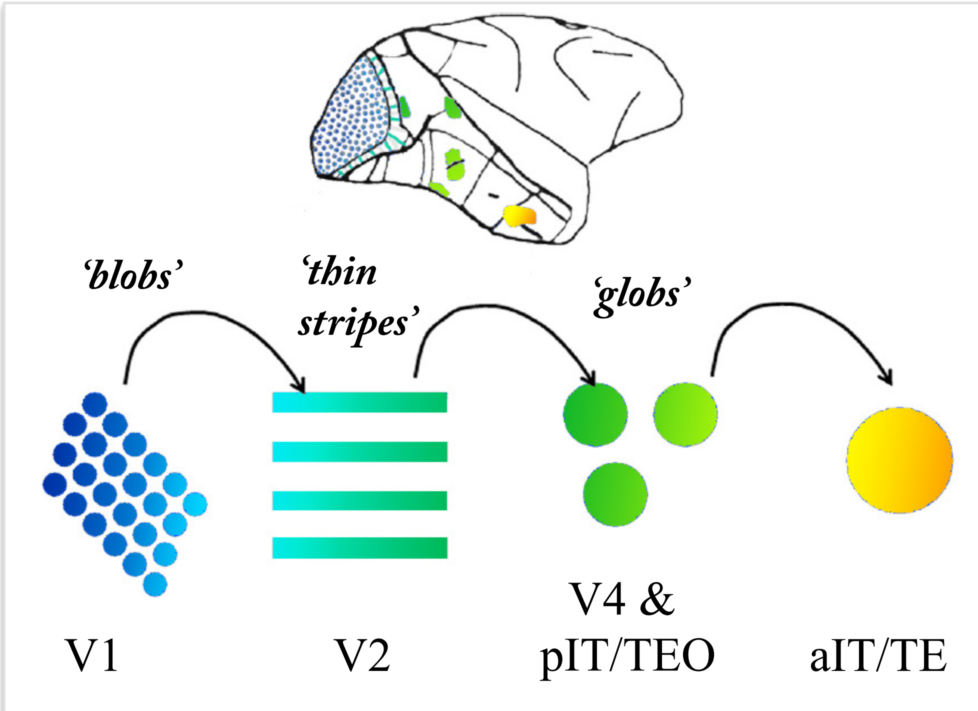


'Gamut'
= full range of colours available on a monitor

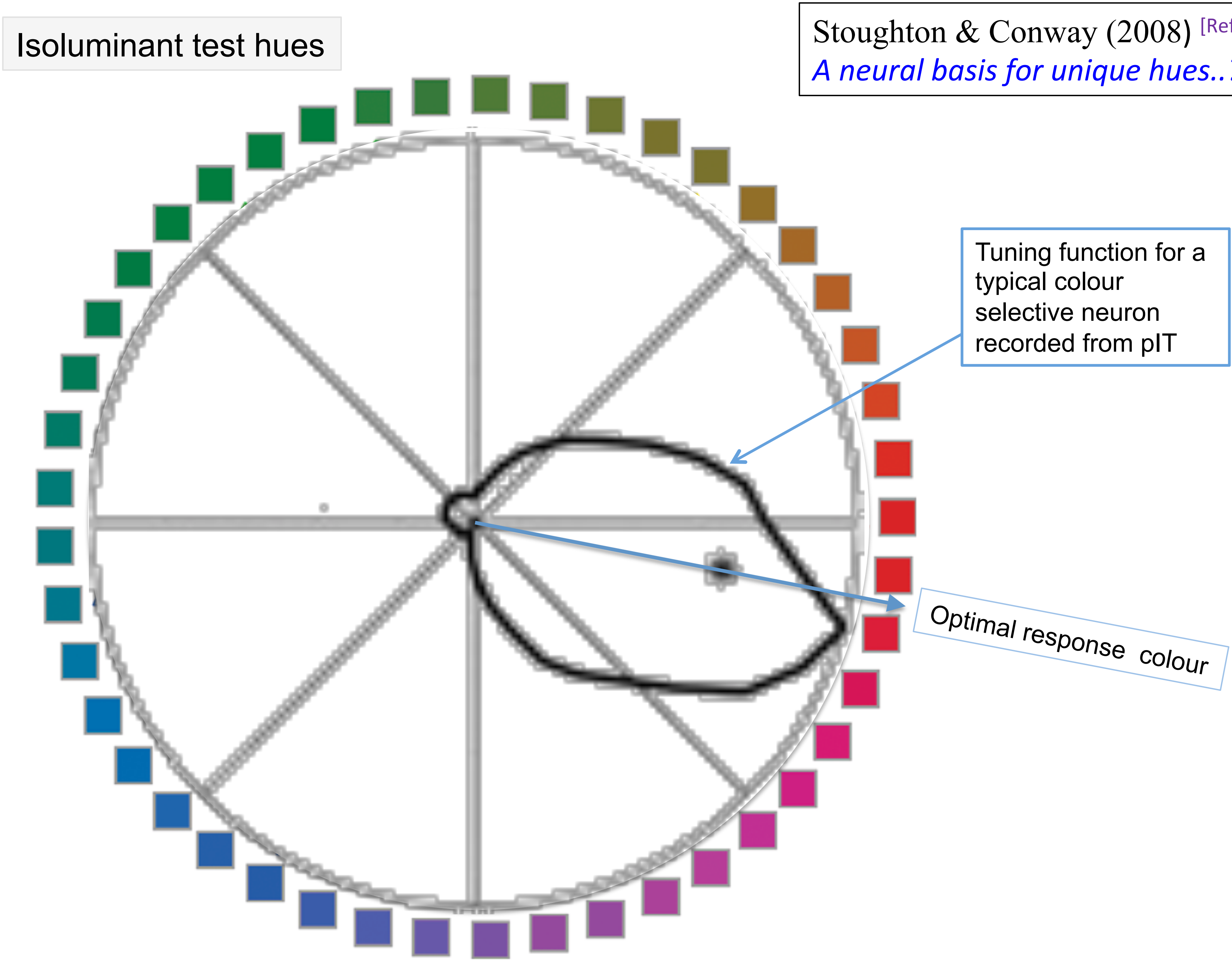
Conway *et al.* (2007) [Ref 12]
Lafer-Sousa & Conway (2013) [Ref 13]
Colour pathway 'globs' revealed by fMRI



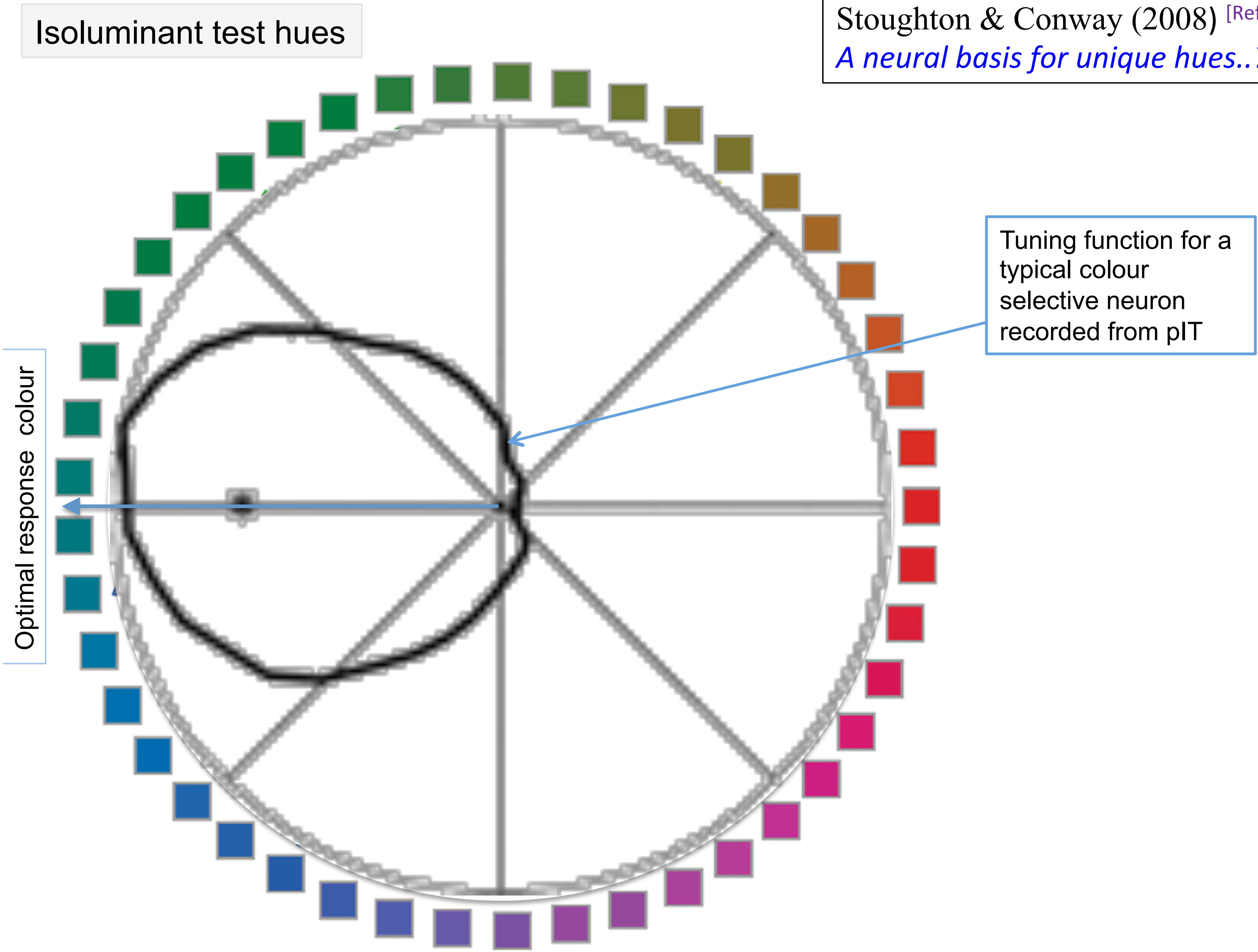




Stoughton & Conway (2008) [Ref 14]
A neural basis for unique hues..?

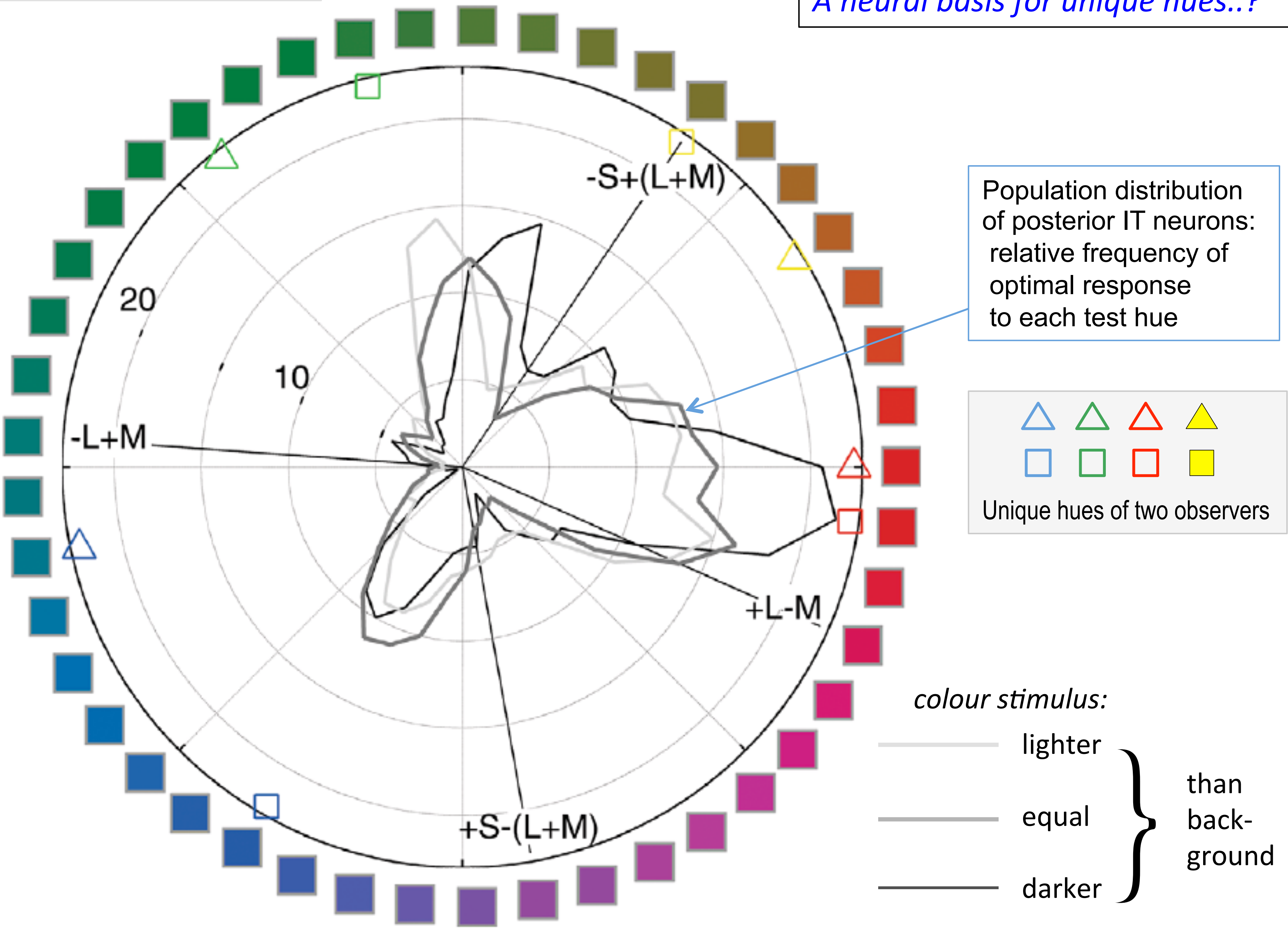


Stoughton & Conway (2008) [Ref 14]
A neural basis for unique hues..?



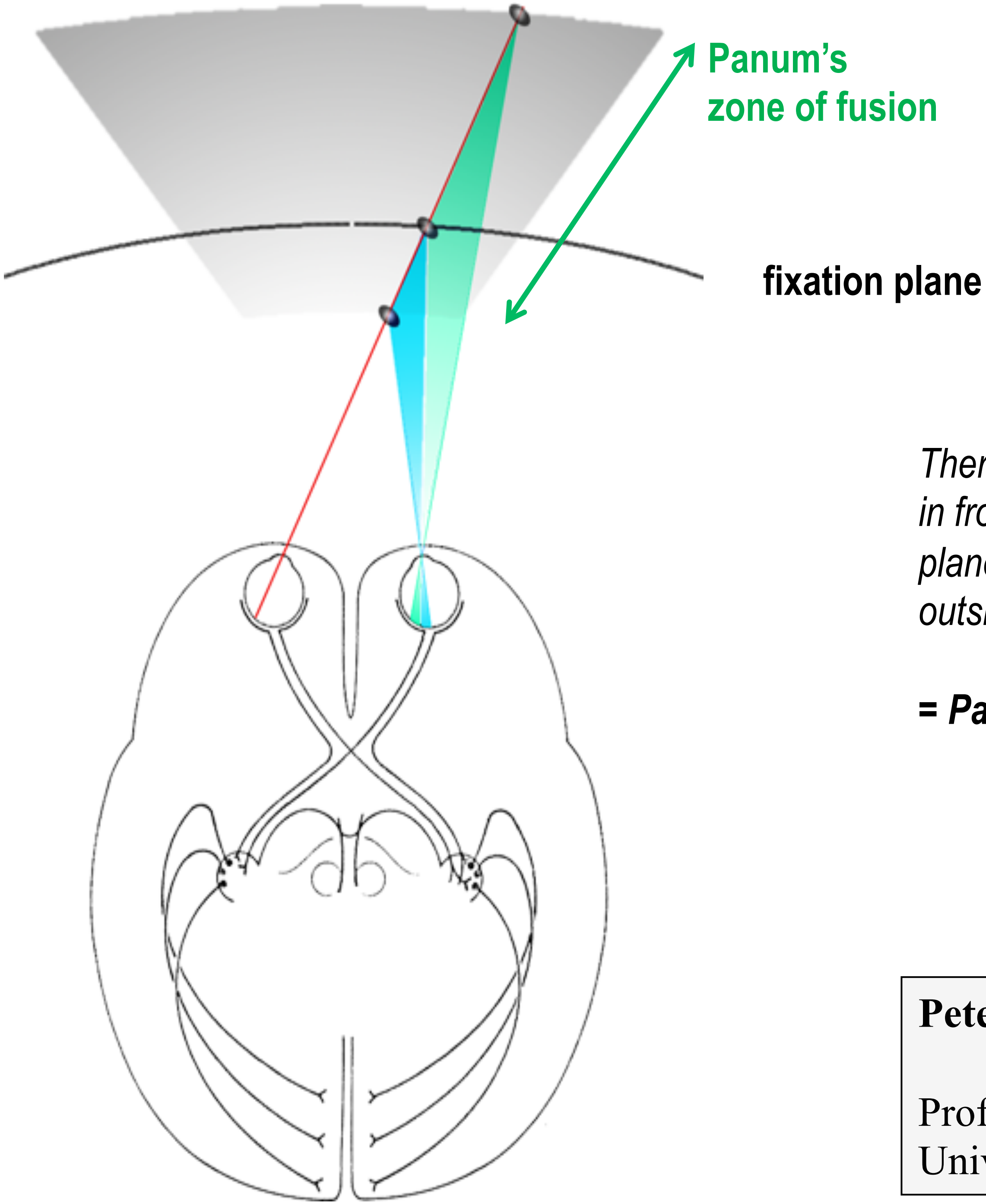
Isoluminant test hues

Stoughton & Conway (2008) [Ref 14]
A neural basis for unique hues..?



Stereoscopic Vision

BINOCULAR INTERACTION - PERCEPTION



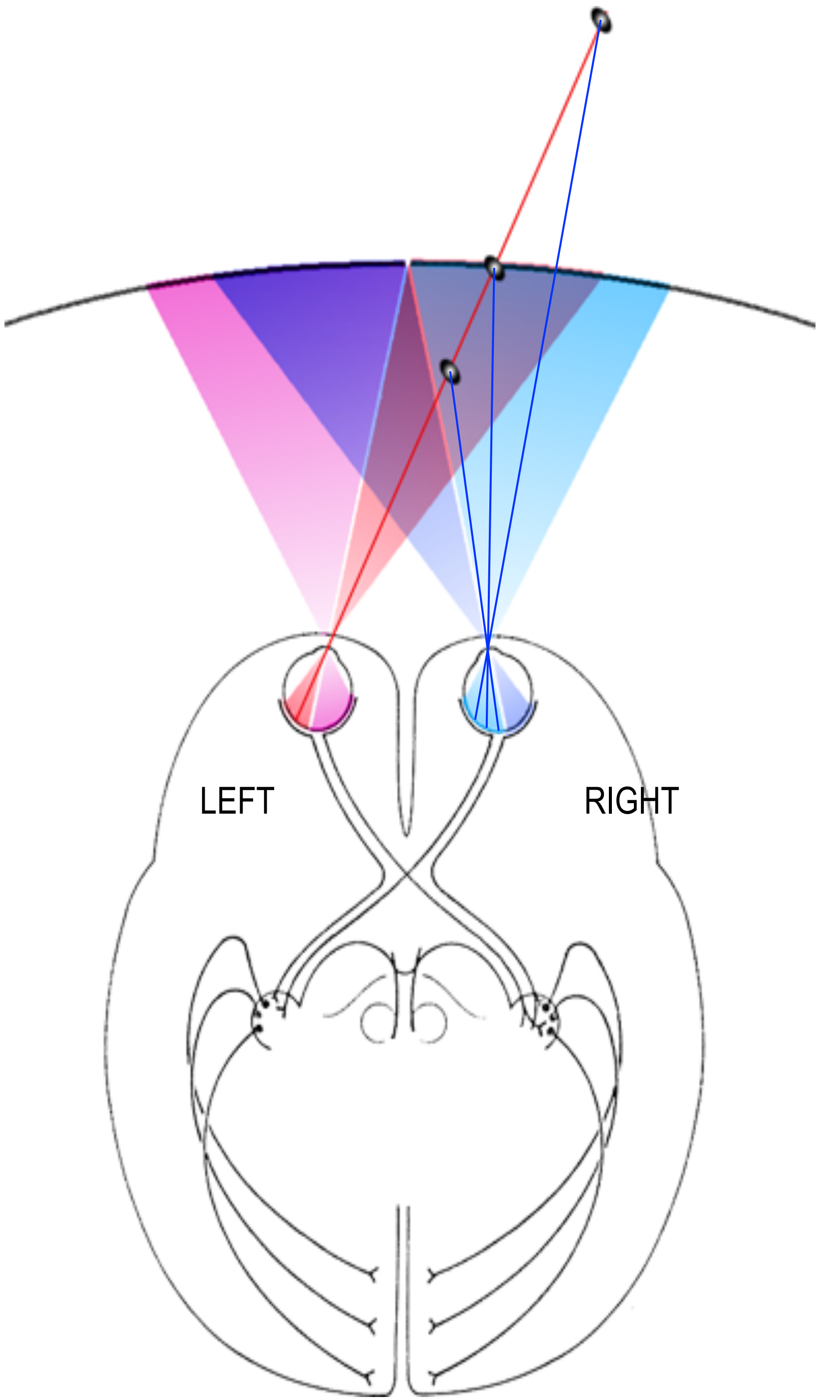
There is a limited range of depths in front, and behind, of the fixation plane in which a single image is seen; outside this range there is double vision.

= Panum's zone of fusion (c. 1860)

Peter Panum

Professor of Physiology
University of Kiel 1853-1864

BINOCULAR INTERACTION
- OPTICS

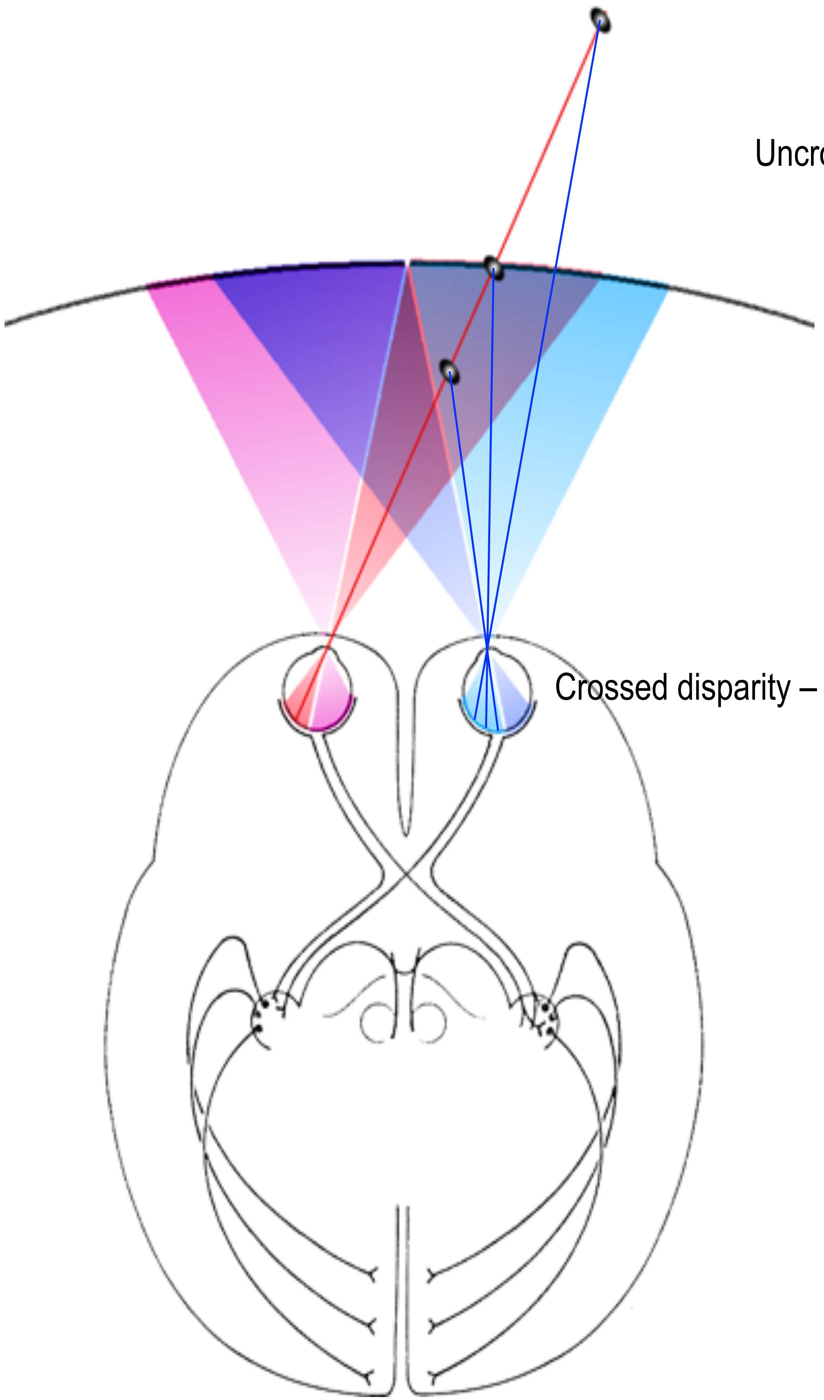


fixation plane - images of objects located on the plane of fixation fall at *corresponding locations* in each retina.

Objects at locations in front, or behind the fixation plane produce images at *non-corresponding* locations in each retina.

e.g.
3 items along the same line of sight in the left eye are imaged at 3 separate locations in the right eye.

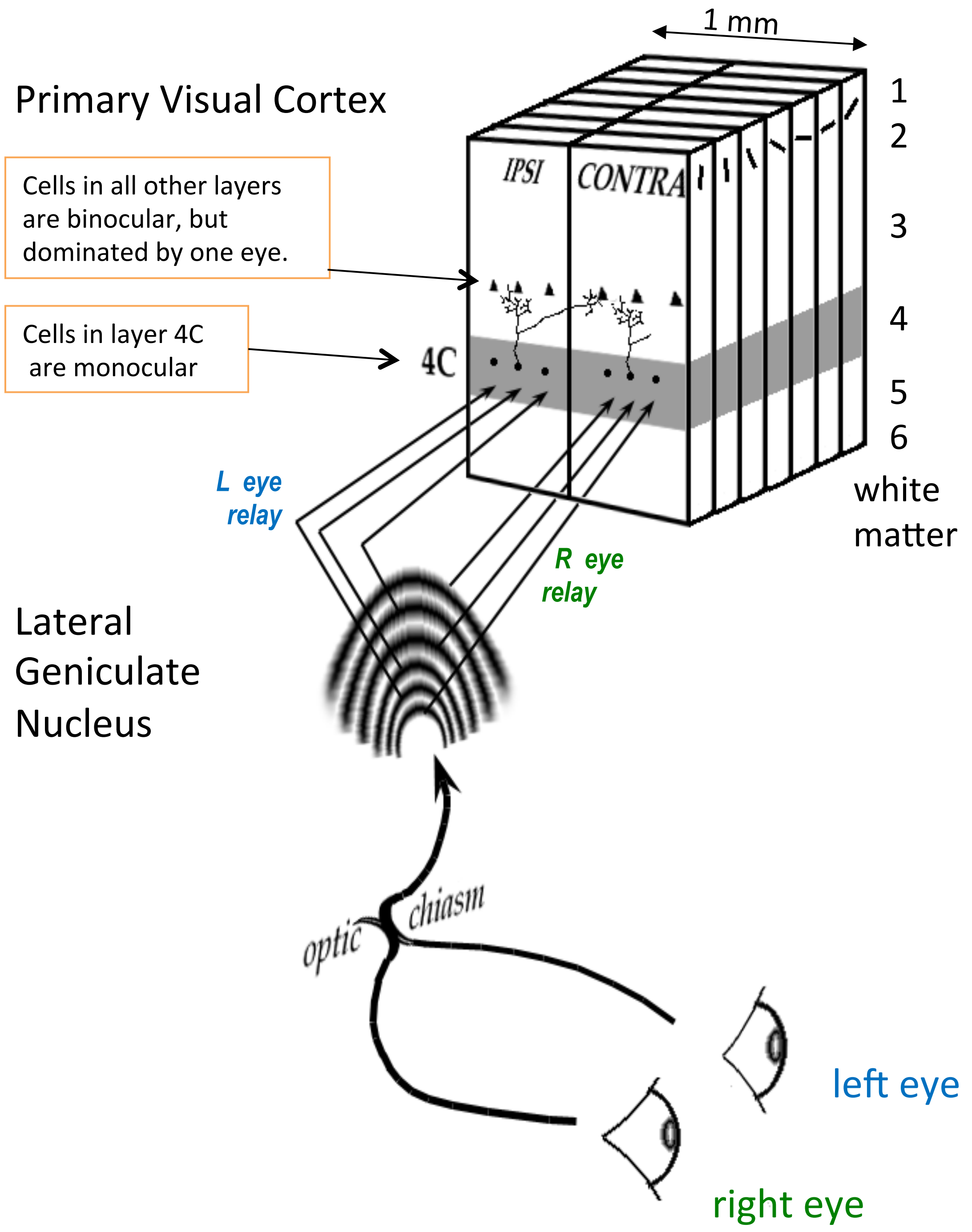
BINOCULAR INTERACTION - OPTICS



Horopter – the curved plane on which all points are imaged at corresponding retinal locations

FUNCTIONAL ARCHITECTURE OF PRIMARY VISUAL CORTEX

David **Hubel** & Torsten **Wiesel**



V1 (left)

two independent modular subsystems:

- *ocular dominance columns*
- *orientation columns*

LGN (left)

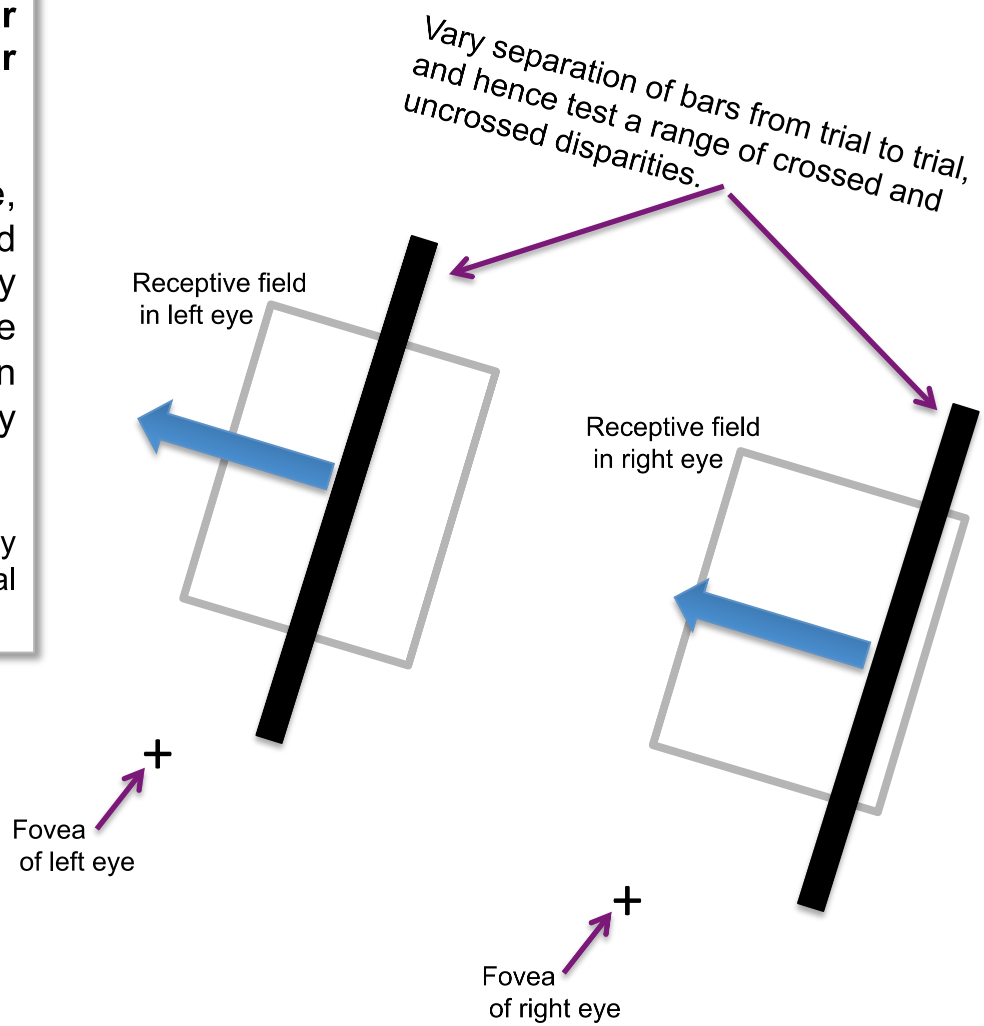
6 monocular layers;

- *each layer maps a right, or a left eye half-retina*

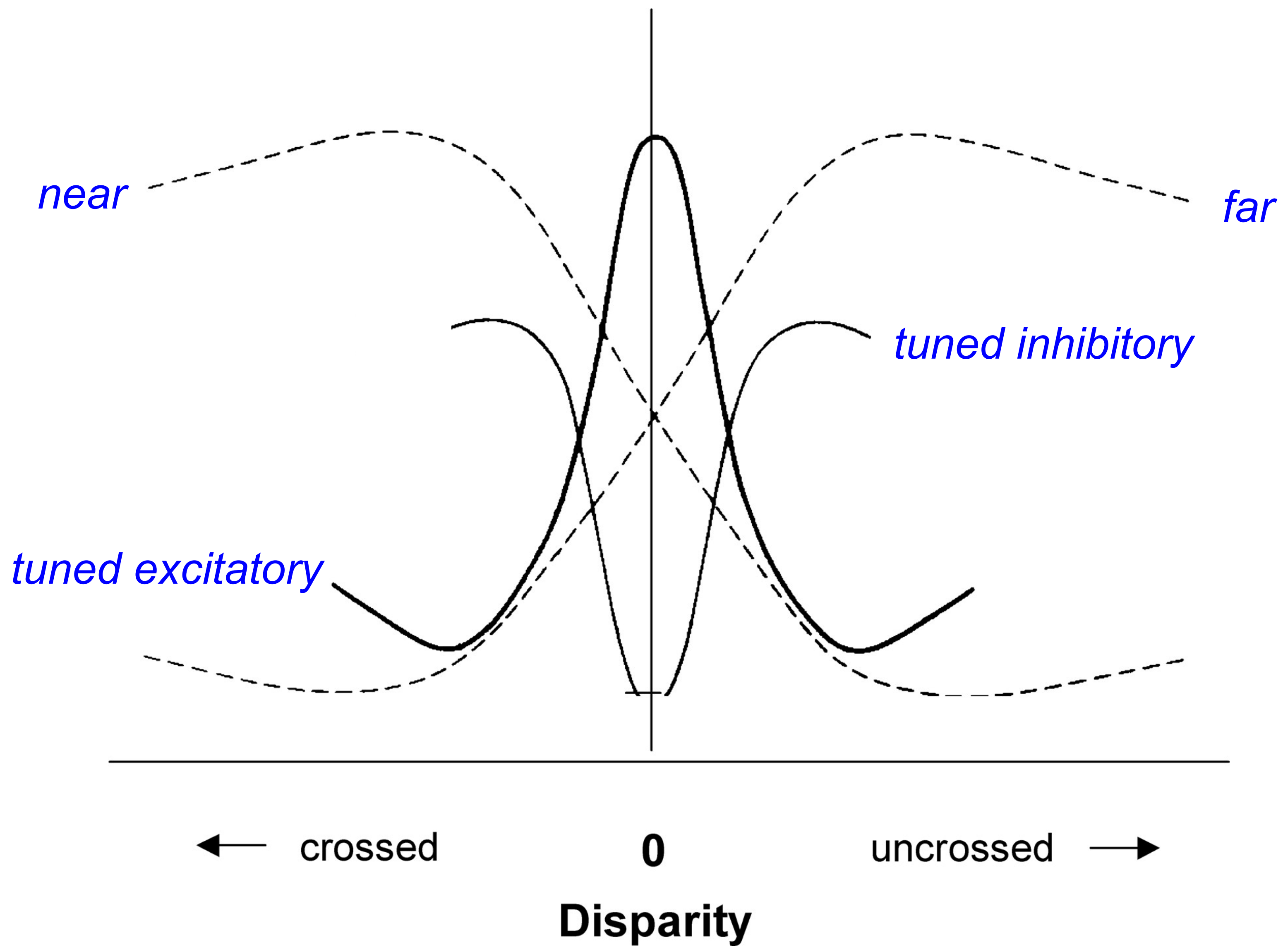
Typical methodology for testing binocular disparity tuning under conditions of ocular paralysis and anaesthesia.

Due to paralysis, the ocular axes diverge, separating the receptive fields in either eye, and allowing independent (dichoptic) stimulation by two separate bar stimuli. As there is only one stimulus (per receptive field) against a plain background, this is a test of absolute disparity tuning.

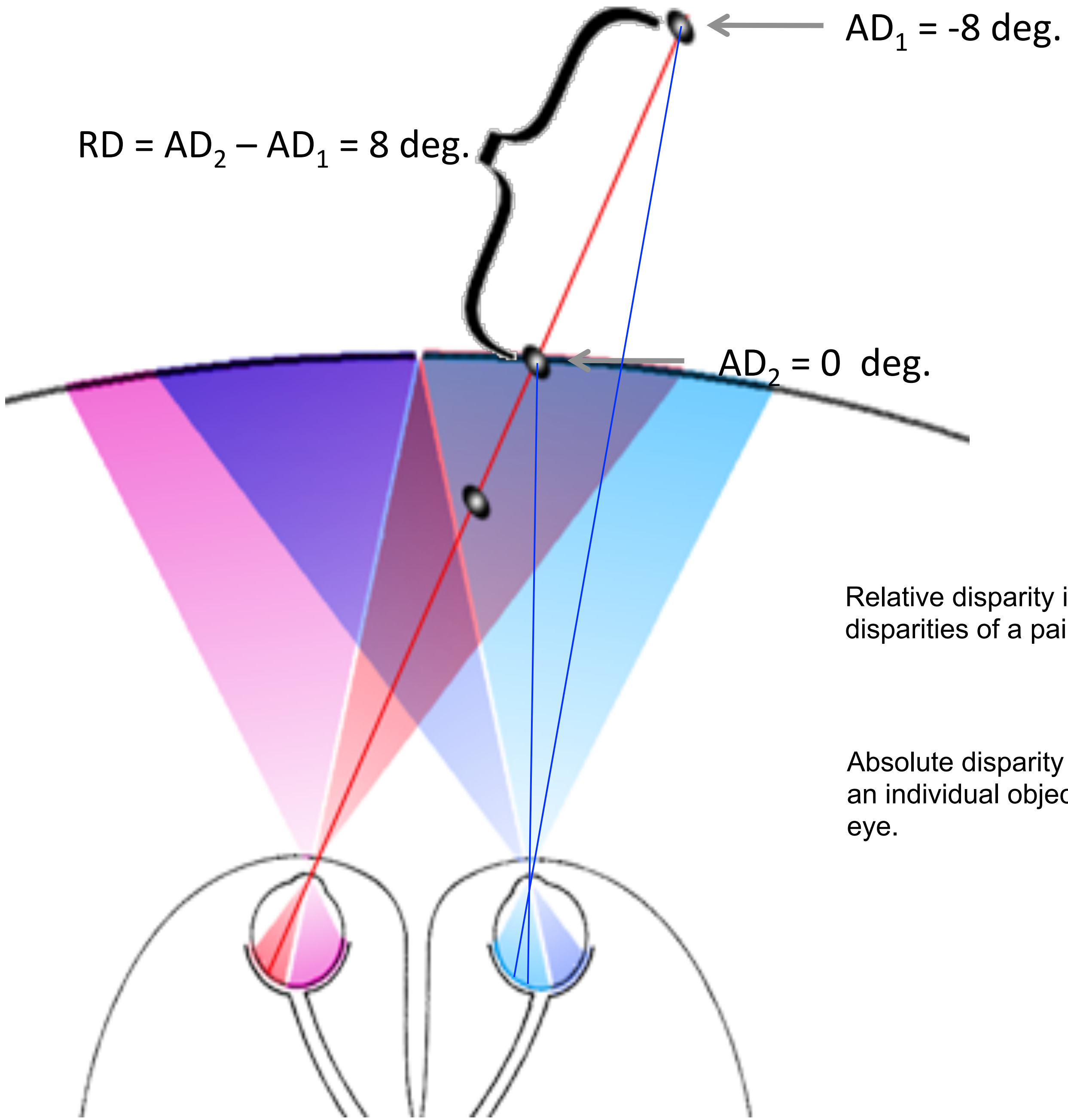
The following slide shows the four varieties of disparity tuning that have typically been observed in several separate studies of area V1, V2 & V3.



Typical absolute disparity tuning curves obtained in areas V1, V2 & V3



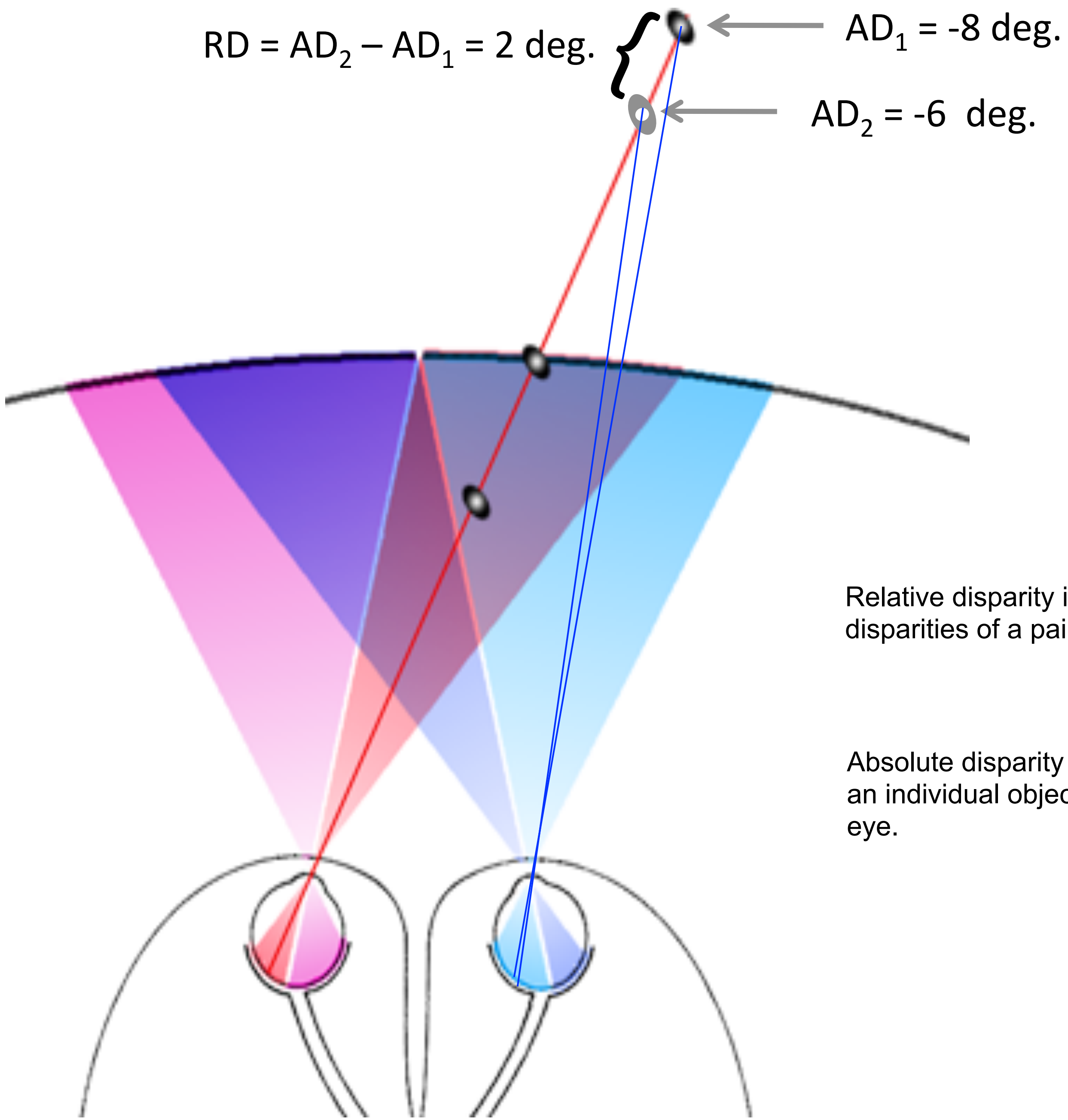
BINOCULAR INTERACTION
Absolute & Relative disparity



Relative disparity is the difference between the absolute disparities of a pair of objects.

Absolute disparity is the difference in the angular location of an individual object, between the images formed in each eye.

BINOCULAR INTERACTION
Absolute & Relative disparity



Relative disparity is the difference between the absolute disparities of a pair of objects.

Absolute disparity is the difference in the angular location of an individual object, between the images formed in each eye.

Absolute Disparity v. Relative Disparity

ABSOLUTE DISPARITY

- -

Value is dependent on eye vergence

Gives depth with respect to fixation plane (horopter)

Not very sensitive:

– threshold for detecting depth in front/behind fixation plane is 6 min, i.e. ± 8 cm at 1.0 m.

RELATIVE DISPARITY

- -

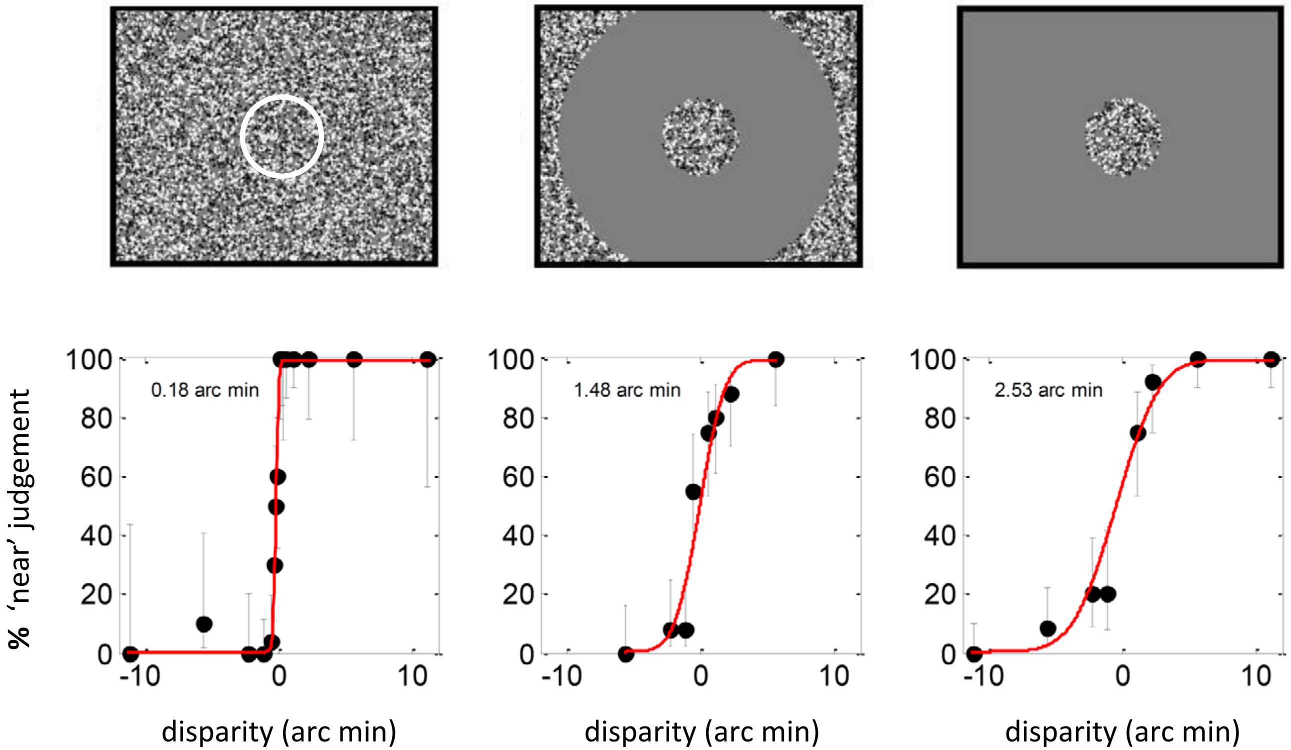
Value is independent of eye vergence

Gives relative depth irrespective of fixation plane (horopter)

Very sensitive:

– threshold for detecting depth in front/behind fixation plane is 6 sec, i.e. ± 3 mm at 1.0 m.

Relative disparity allows greater stereoacuity



Absolute Disparity v. Relative Disparity

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Characterises 'DORSAL SYSTEM' function (human fMRI)

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Value is independent of eye vergence

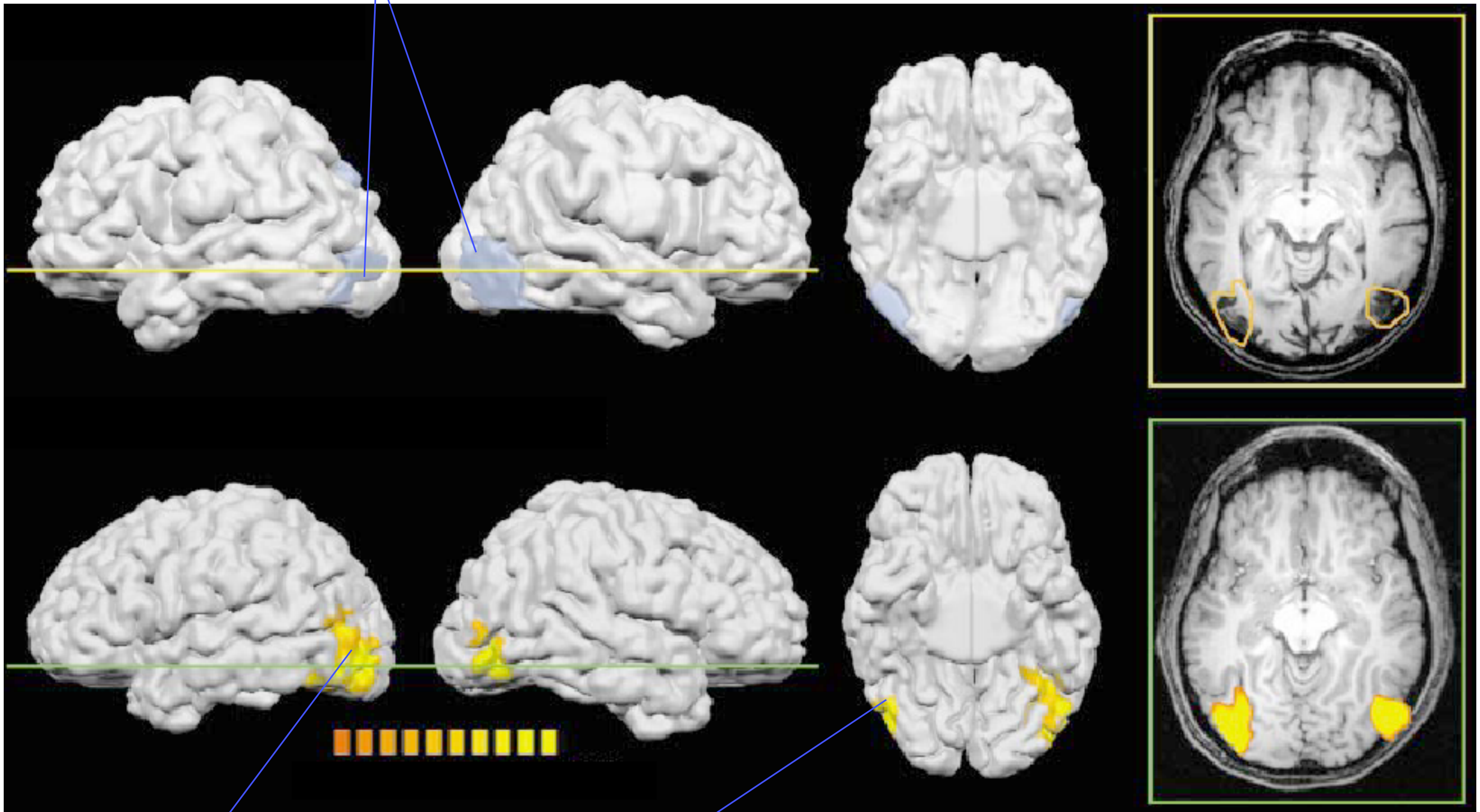
Gives relative depth irrespective of fixation plane (horopter)

Very sensitive:
- threshold for detecting depth in front/behind fixation plane is 6 sec, i.e. ± 3 mm at 1.0 m.

Characterises 'VENTRAL SYSTEM' function (human fMRI)

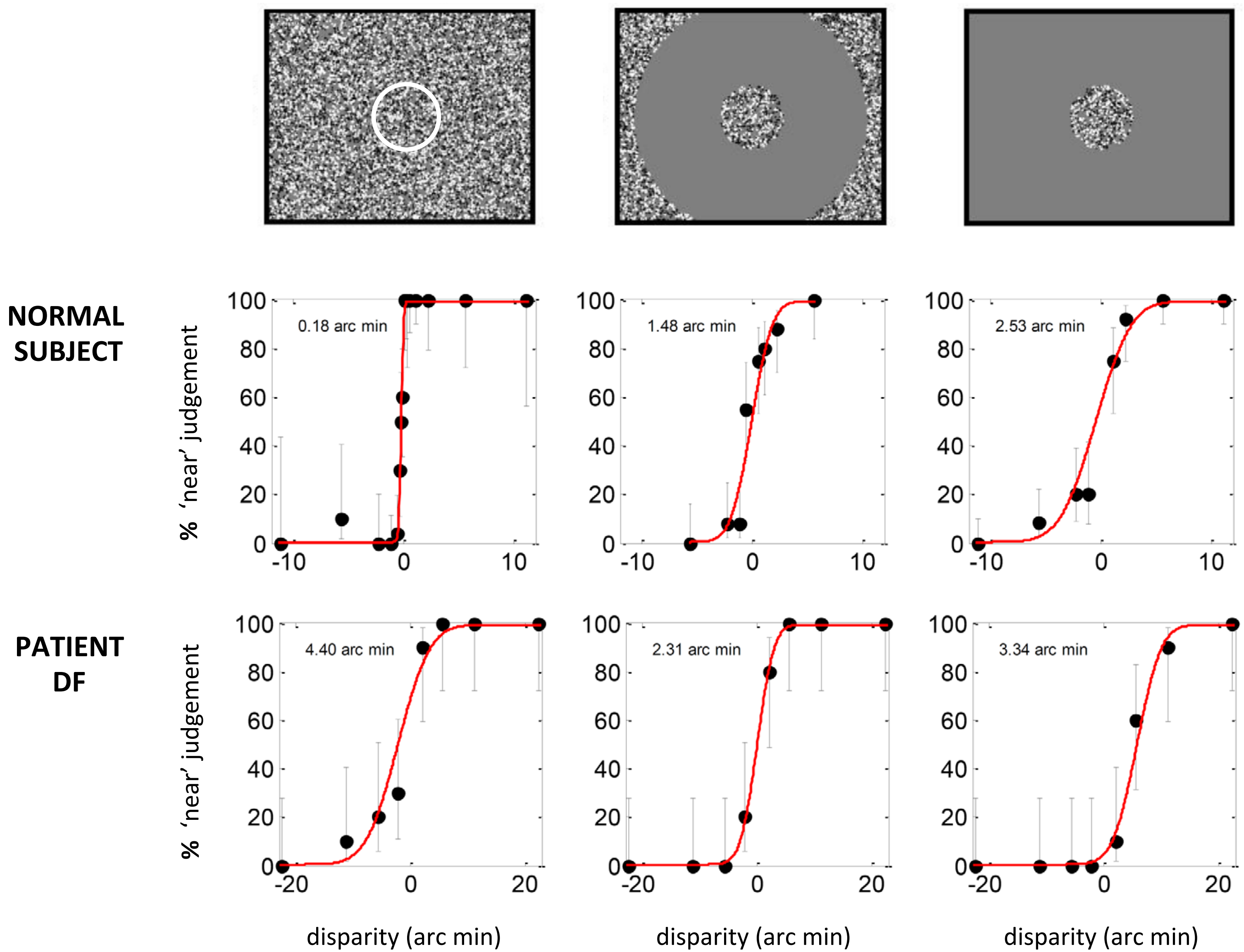
Patient DF (bilateral area LO lesions & agnosic)

brain lesions in patient DF (case of carbon monoxide poisoning)

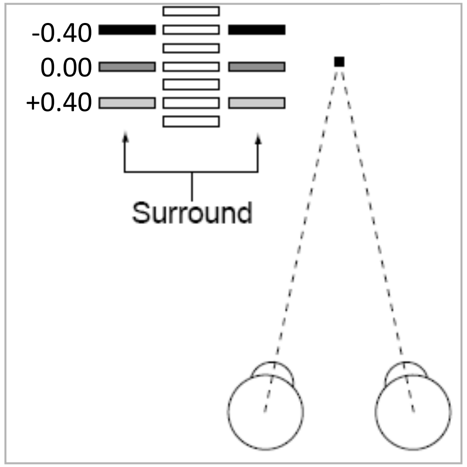


area LO in a normal subject

Relative disparity allows greater stereoacuity – but not for patient DF **Read *et al. (2010)*** [16]



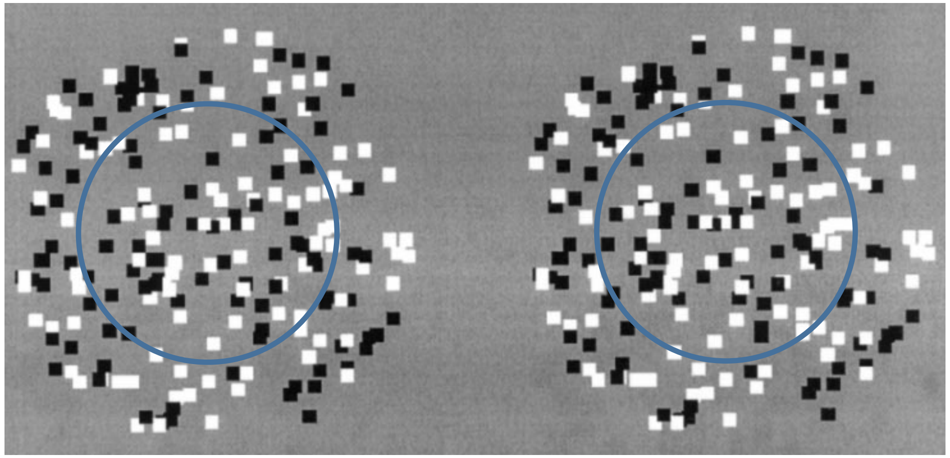
Comparison of neural selectivity for absolute & relative disparity in areas V1 V2 V3 V3A V4 & V5 [Refs 17-21]

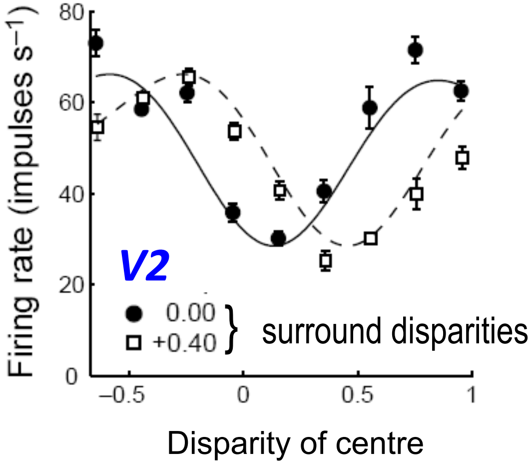


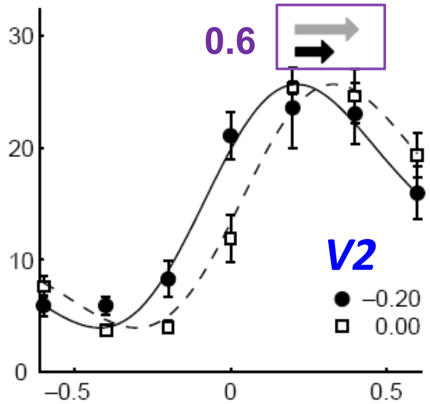
Stimulus set-up

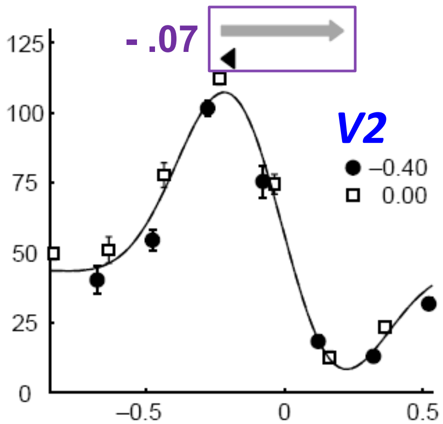
Dot stimulus is composed of centre & surround annulus differing in disparity

Receptive field of test neuron fits inside the centre region.





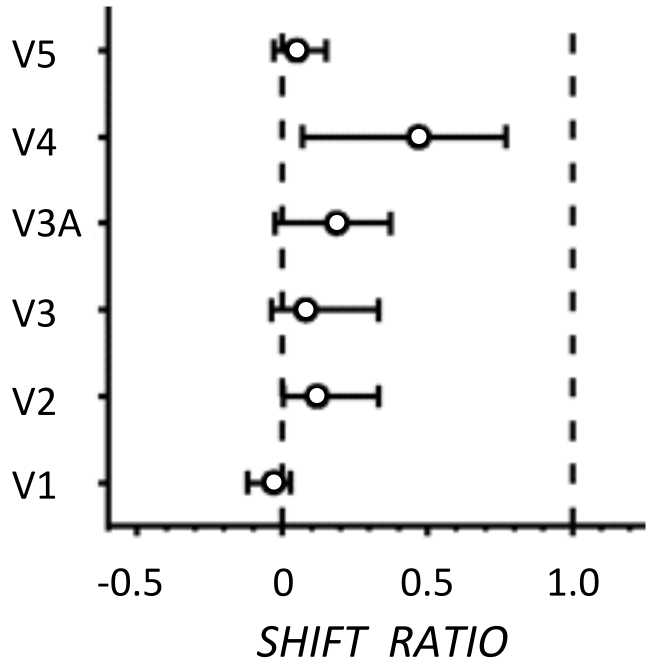




predicted shift (0.40)

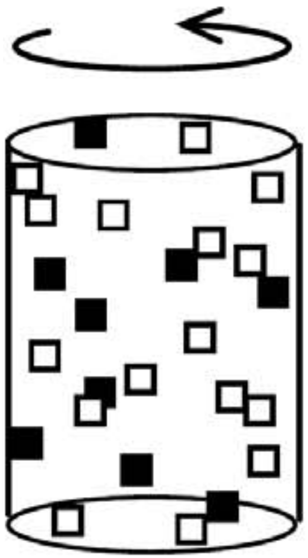
observed shift (0.32)

shift ratio = $\frac{0.32}{0.40}$ = **0.8**

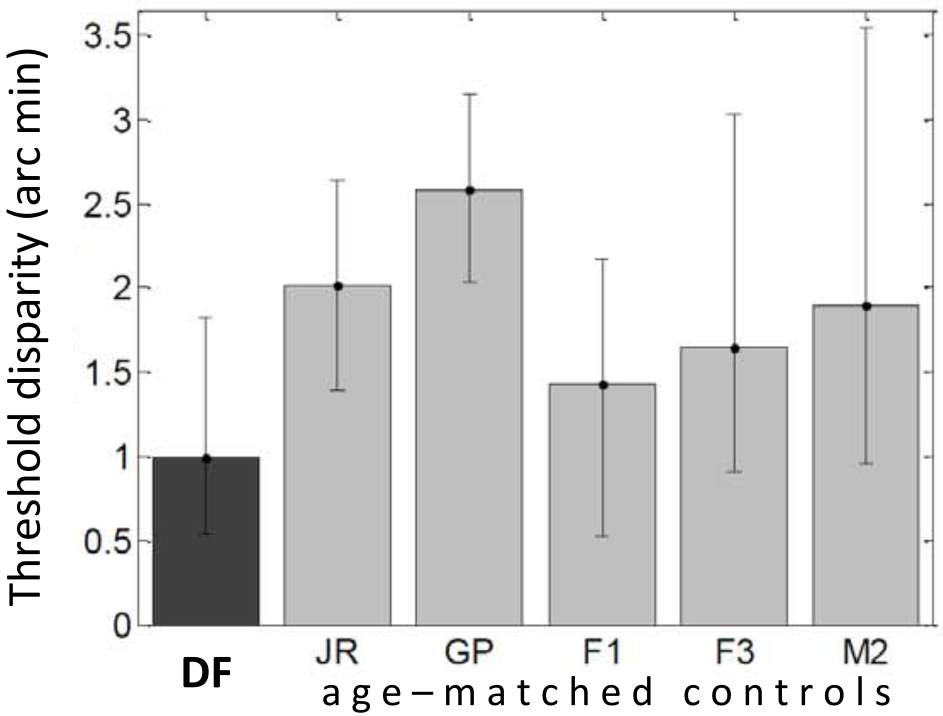


[shift ratio = 1 implies full selectivity for relative disparity; shift ratio = 0 implies selectivity for absolute disparity]

Read *et al.* (2010) [16] Stereovision of patient DF



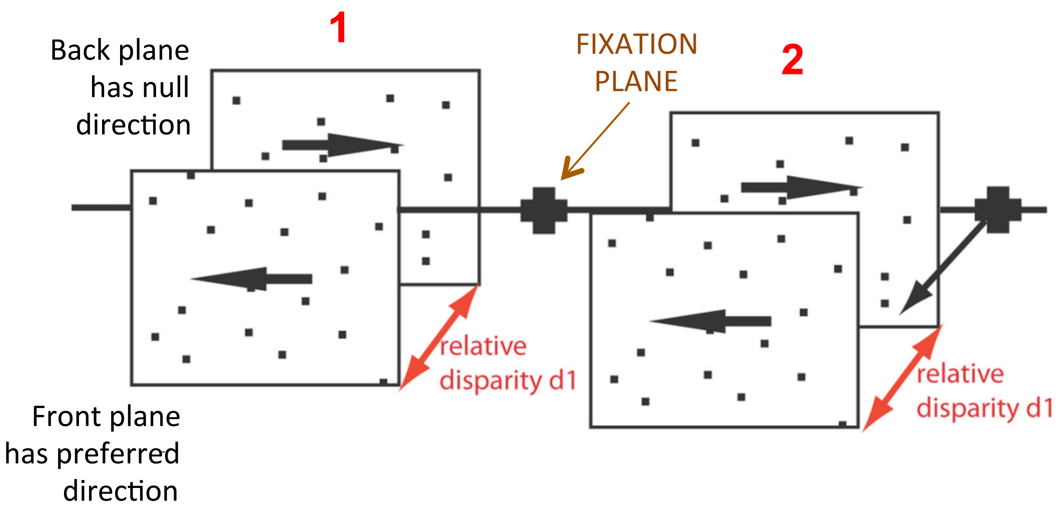
Simulated transparent, revolving cylinder.
Task: identify direction (L v R) of front surface

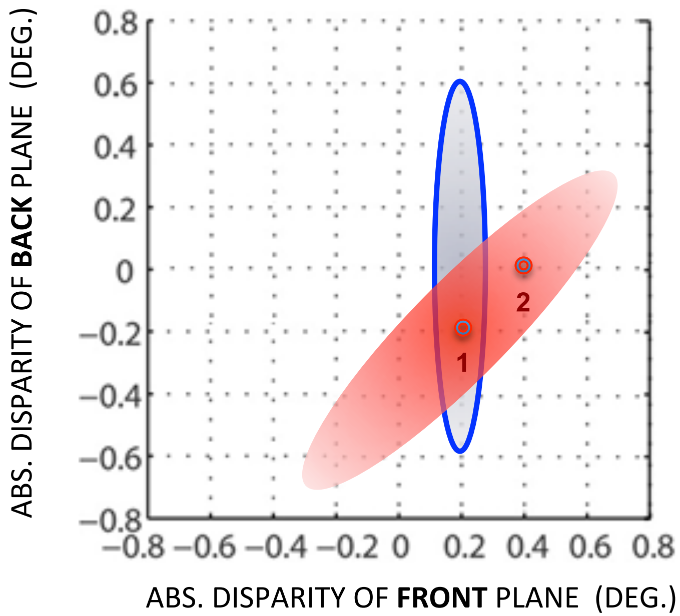


DF outperforms most normal subjects...!

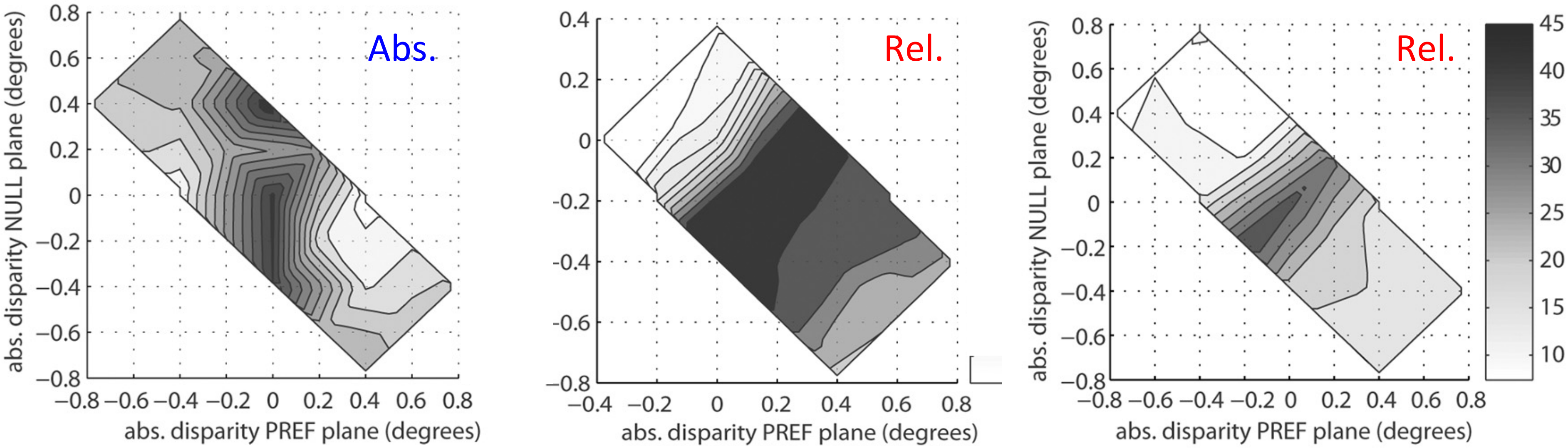
Krug & Parker (2011) [22] Neurons in area V5 signalling relative disparity

Stimulus: superimposed transparent planes of dots
with opposite directions of motion & differing disparity

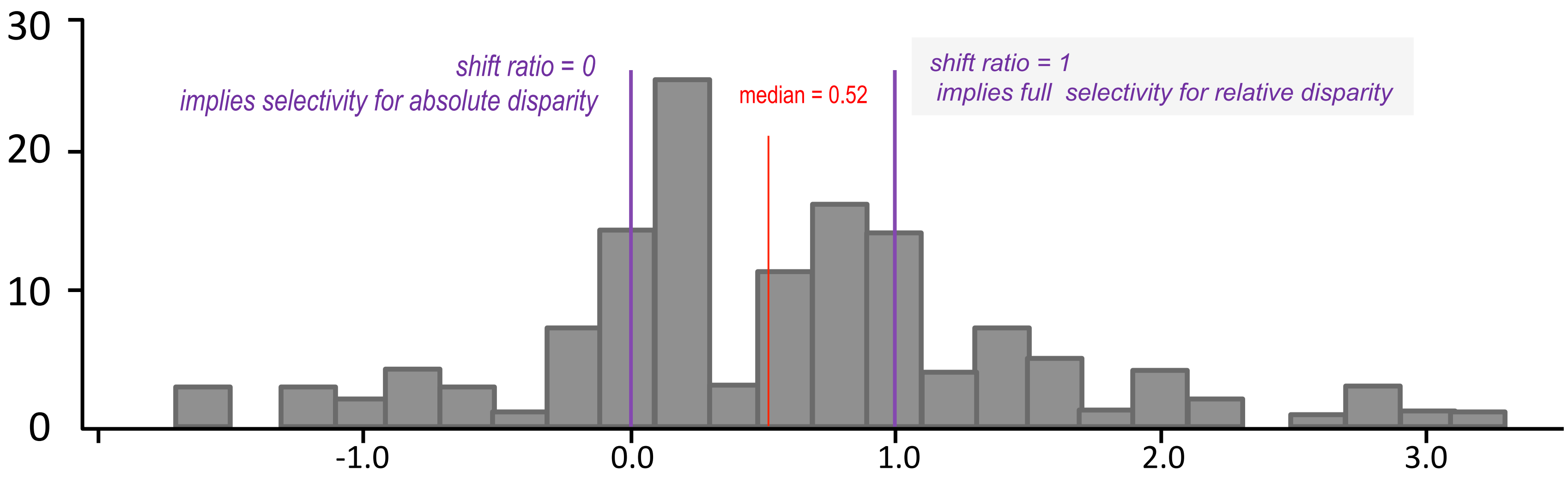


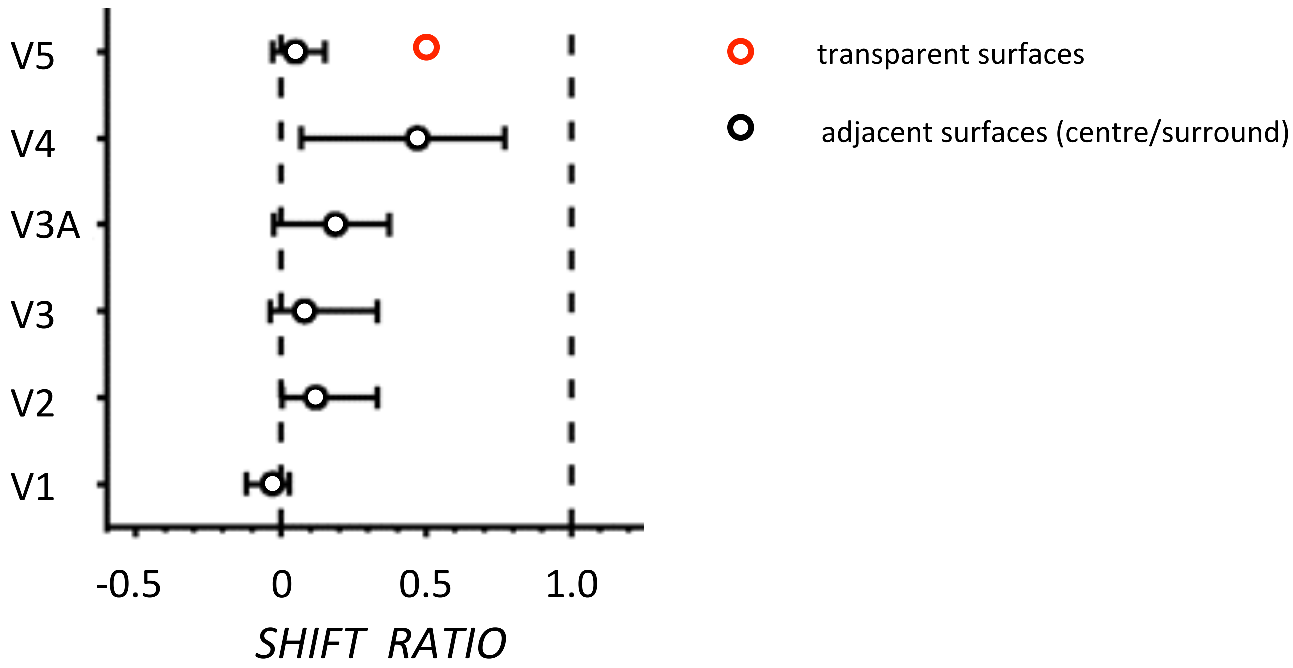


Prediction for absolute disparity tuning
Prediction for relative disparity tuning

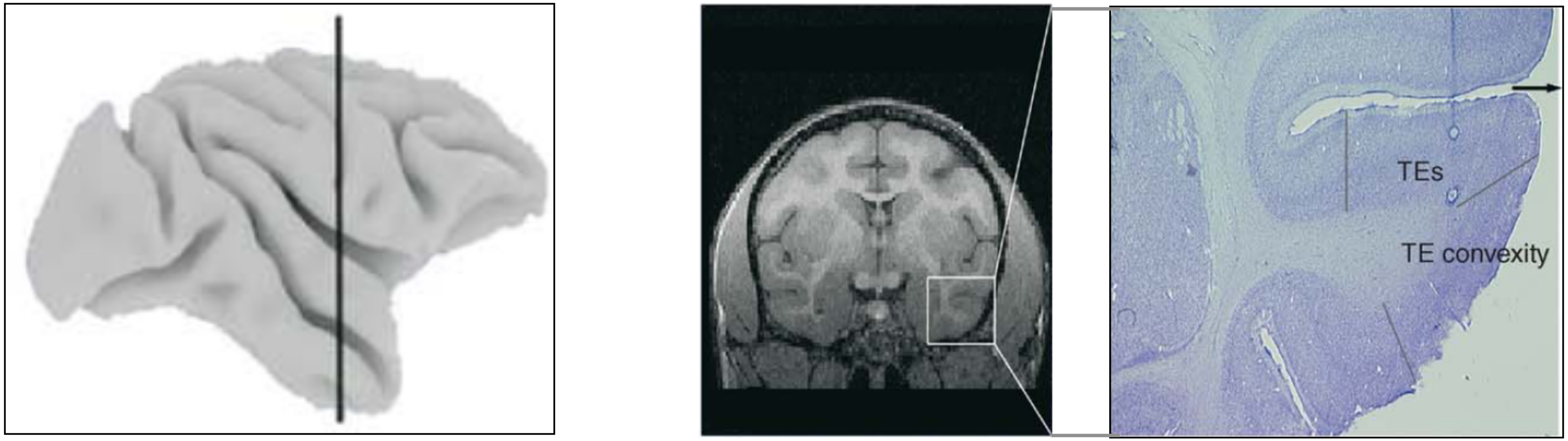


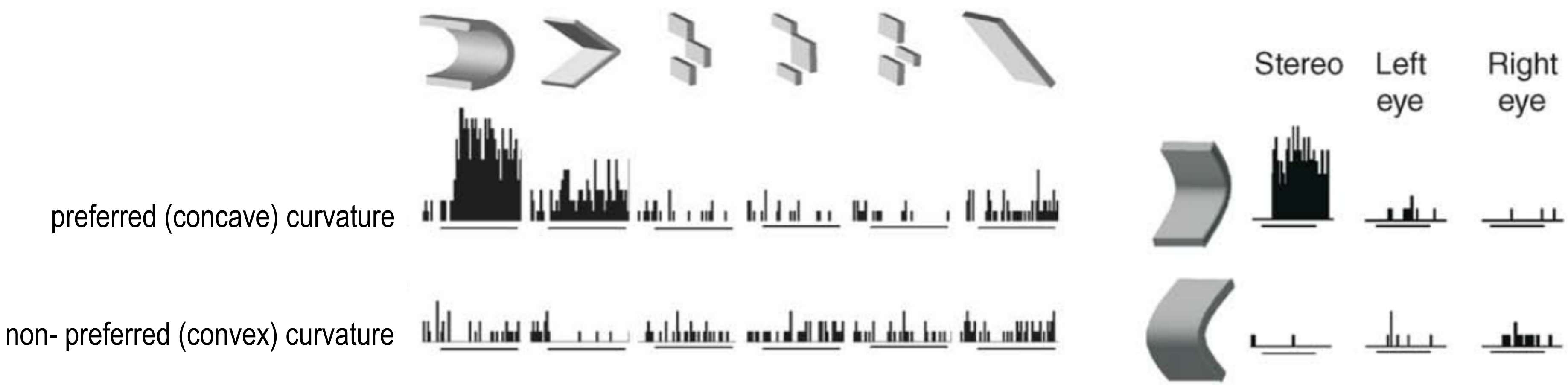
Krug & Parker (2011) [22] Neurons in area V5 signalling relative disparity





Janssen *et al.* (2000) [Ref 23] IT neurons selective for disparity curvature (area Tes)





Absolute Disparity v. Relative Disparity

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Gives depth with respect to fixation plane (horopter)

Not very sensitive:

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Characterises 'DORSAL SYSTEM' function (human fMRI)

RELATIVE DISPARITY

- -

Value is independent of eye vergence

Gives relative depth irrespective of fixation plane (horopter)

Very sensitive:

– threshold for detecting depth in front/behind fixation plane is 6 sec, i.e. ± 3 mm at 1.0 m.

Characterises 'VENTRAL SYSTEM' function (human fMRI)

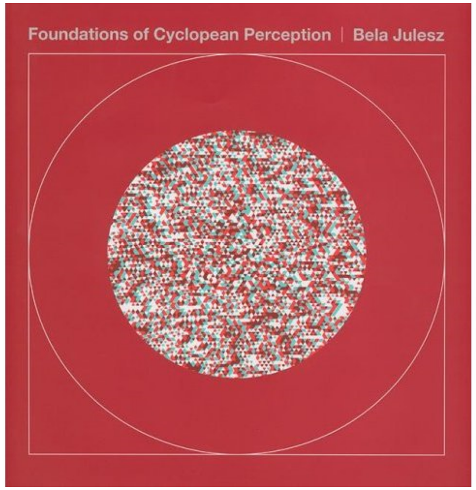
- especially for relative disparity between nearby, adjacent surfaces: e.g . for detecting slant, curvature.

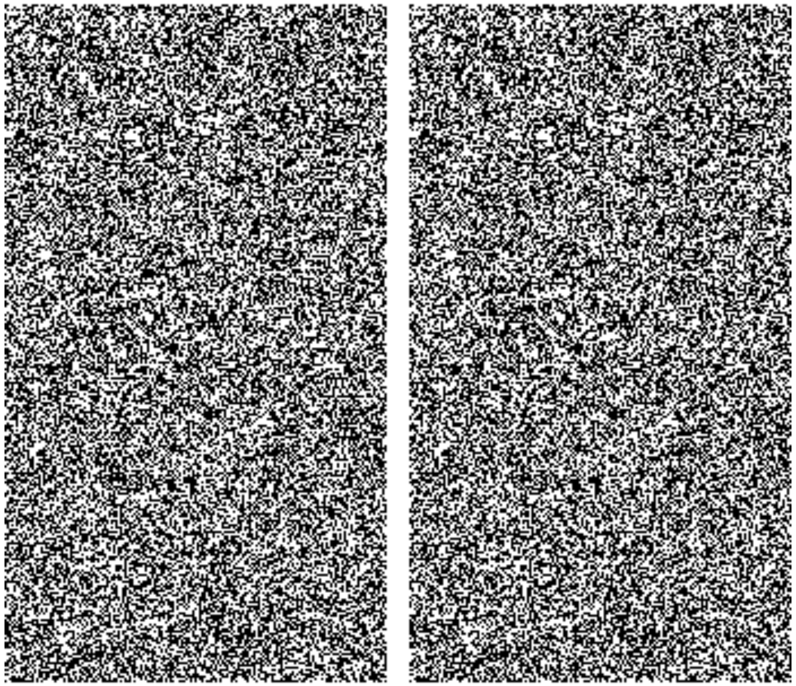
In 'DORSAL SYSTEM' may help top discriminate depth planes e.g. in detecting movement behind foliage (?)

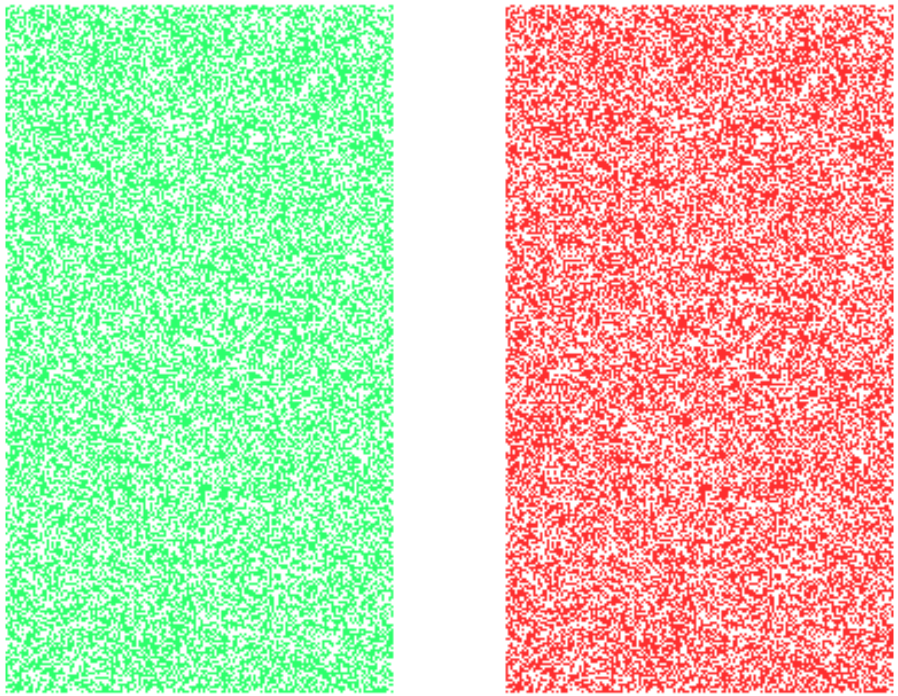
Cyclopean vision

Random dot stereograms demonstrate that stereoscopic mechanisms can process ‘raw’ visual texture. A preliminary stage of contour extraction or object recognition is not required; rather, stereoscopic mechanisms can produce their own contours and provide an independent mode of form recognition.

To do so the brain must solve the (so-called) ‘correspondence problem’ – find the correct dot in the right eye to match each dot in the left eye (or vice versa).





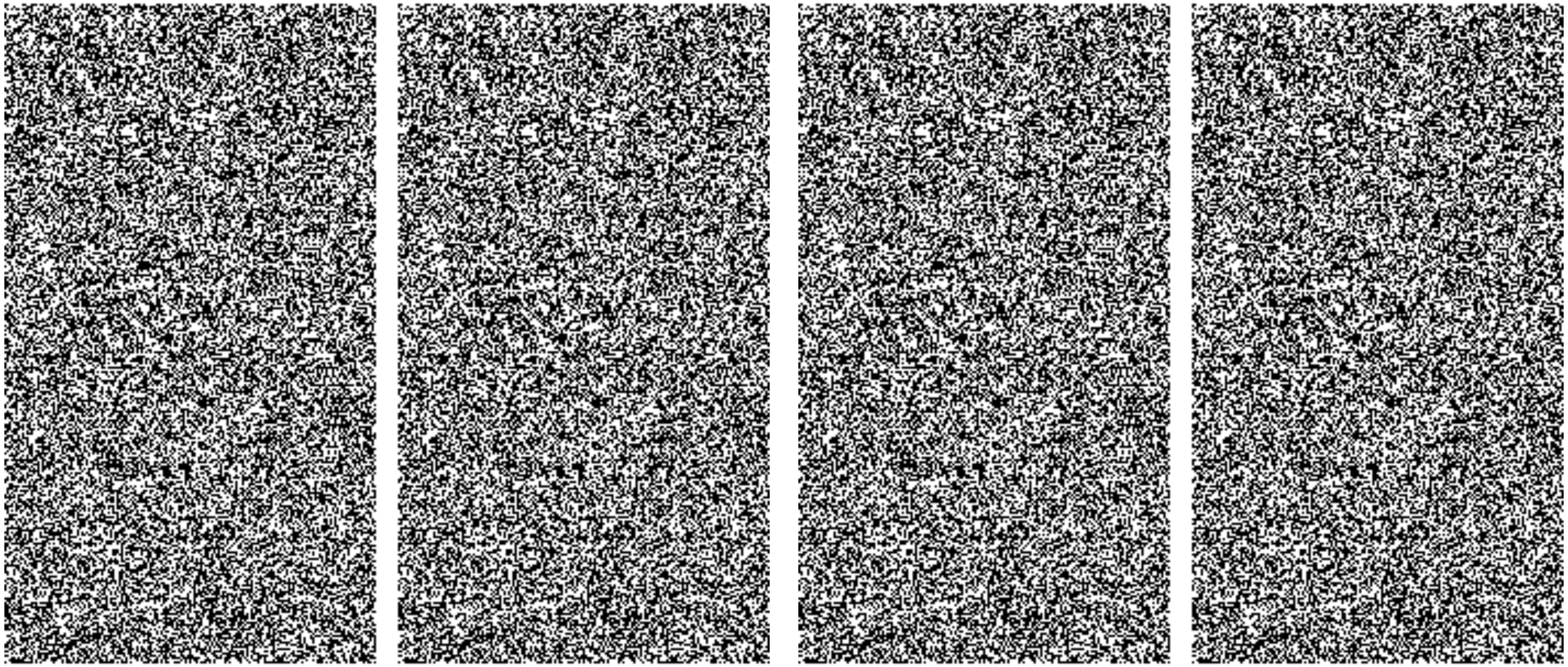


Cyclopean vision – ‘free fusion’

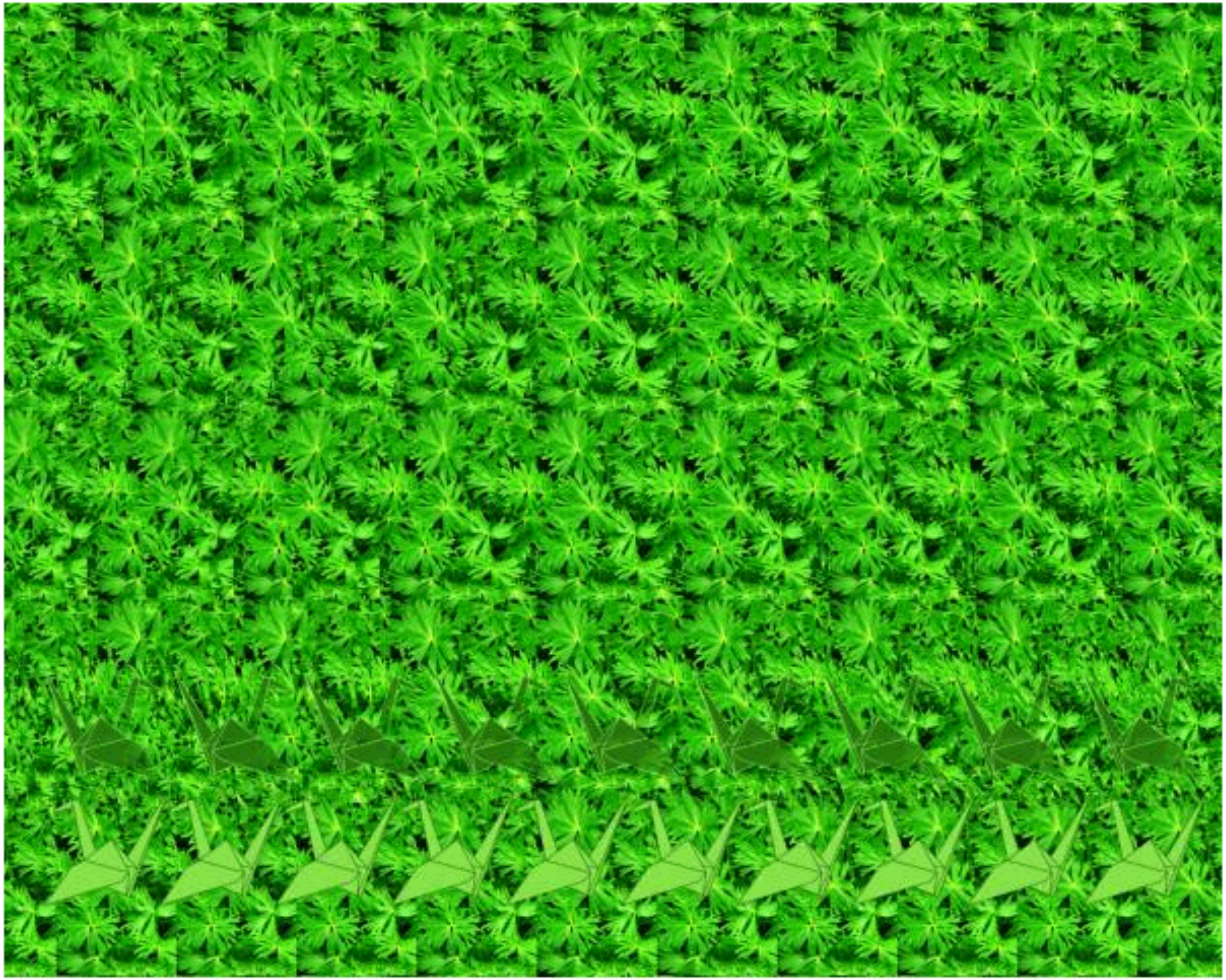
Random dot stereograms demonstrate that stereoscopic mechanisms can process ‘raw’ visual texture. A preliminary stage of contour extraction or object recognition is not required; rather, stereoscopic mechanisms can produce their own contours and provide an independent mode of form recognition.

To do so the brain must solve the (so-called) ‘correspondence problem’ – find the correct dot in the right eye to match each dot in the left eye (or vice versa).

Below, **a** & **b**, and **a’** & **b’**, are two identical stereograms, that display a number (from 0-9) in front of the background, when ‘solved’ by converging. At the same time, the same number will appear as a cut-out (i.e. behind the background) in the stereo pair formed by **b** and **a’**. Foreground and background depth is reversed if the stereograms are solved by diverging the eyes, i.e. to focus on a plane behind the screen. Typically, this is more difficult.



a b a’ b’



‘Magic eye’ pictures are based on exactly the same principle
(but normally require divergent free fusion to give the intended depth percept).