

COSMO 2012

Applications of
retinotopic mapping and
multivariate analysis

Learning objectives

- How different types of multivariate analysis can be used within a retinotopic mapping framework
- Statistical issues – how retino mapping helps and hurts.
- Case studies – what they have taught us
- Future directions

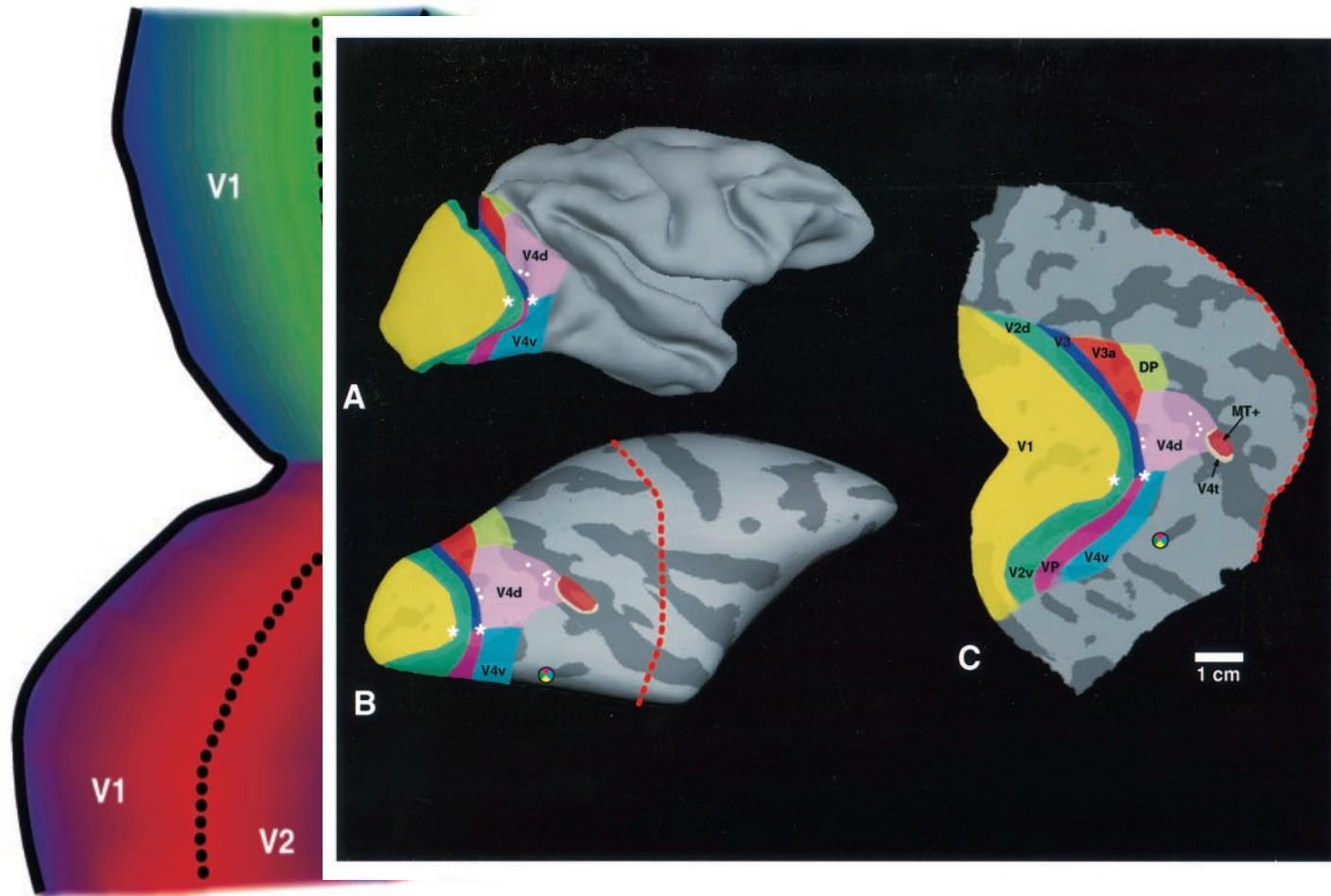
Recap of retinotopic areas

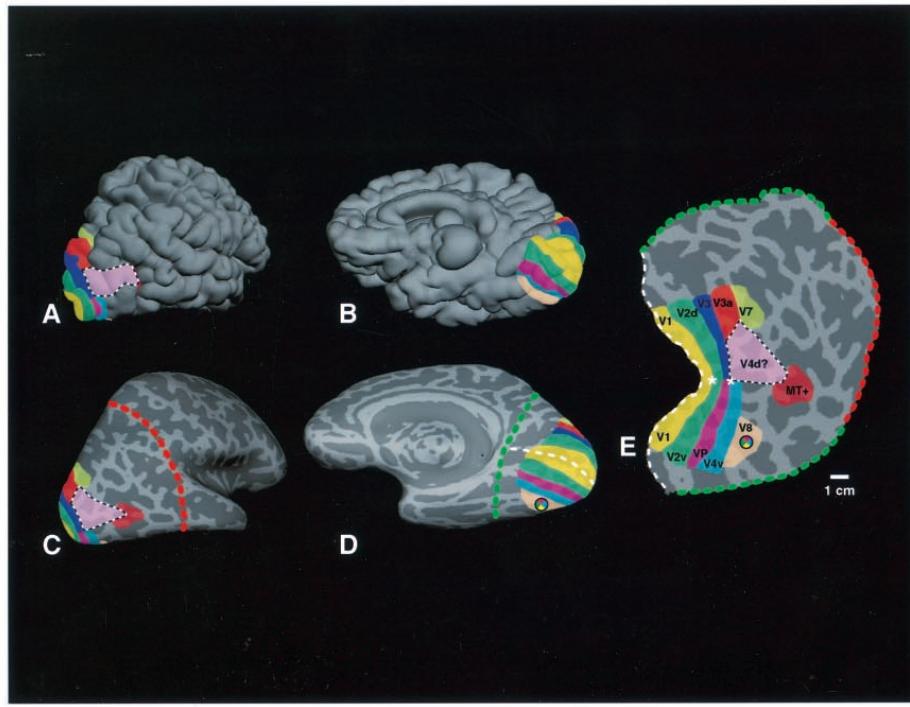
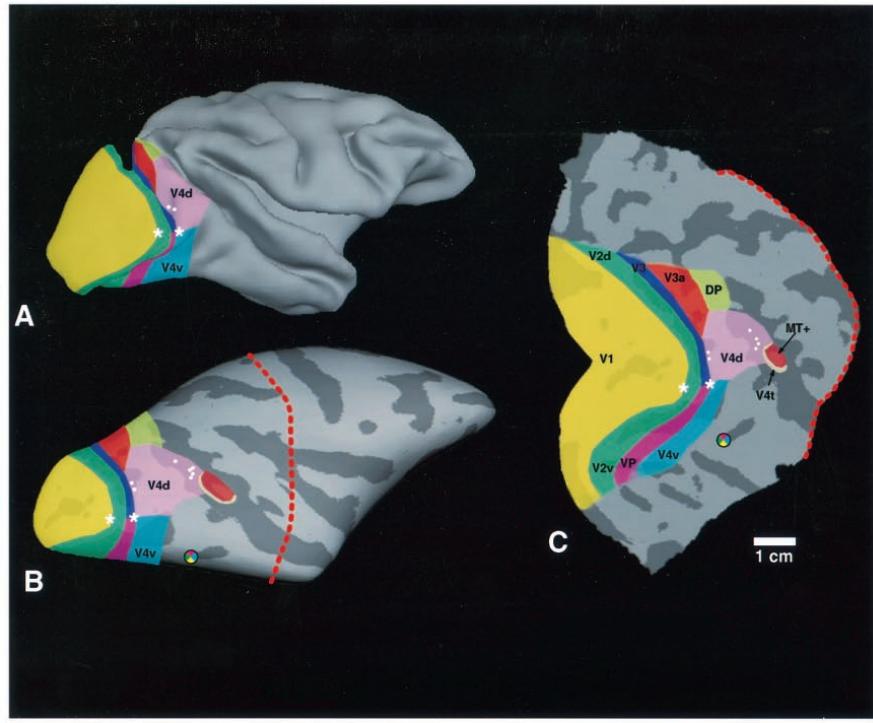
- Overview: Once a retinotopic area has been defined you can extract a set of voxels from it.
- You can then use the responses from these voxels in different conditions to perform multivariate analysis (see below).
- MVPA is one type of analysis
- What does the ability or failure to decode something tell you about that area?

Do's and don'ts

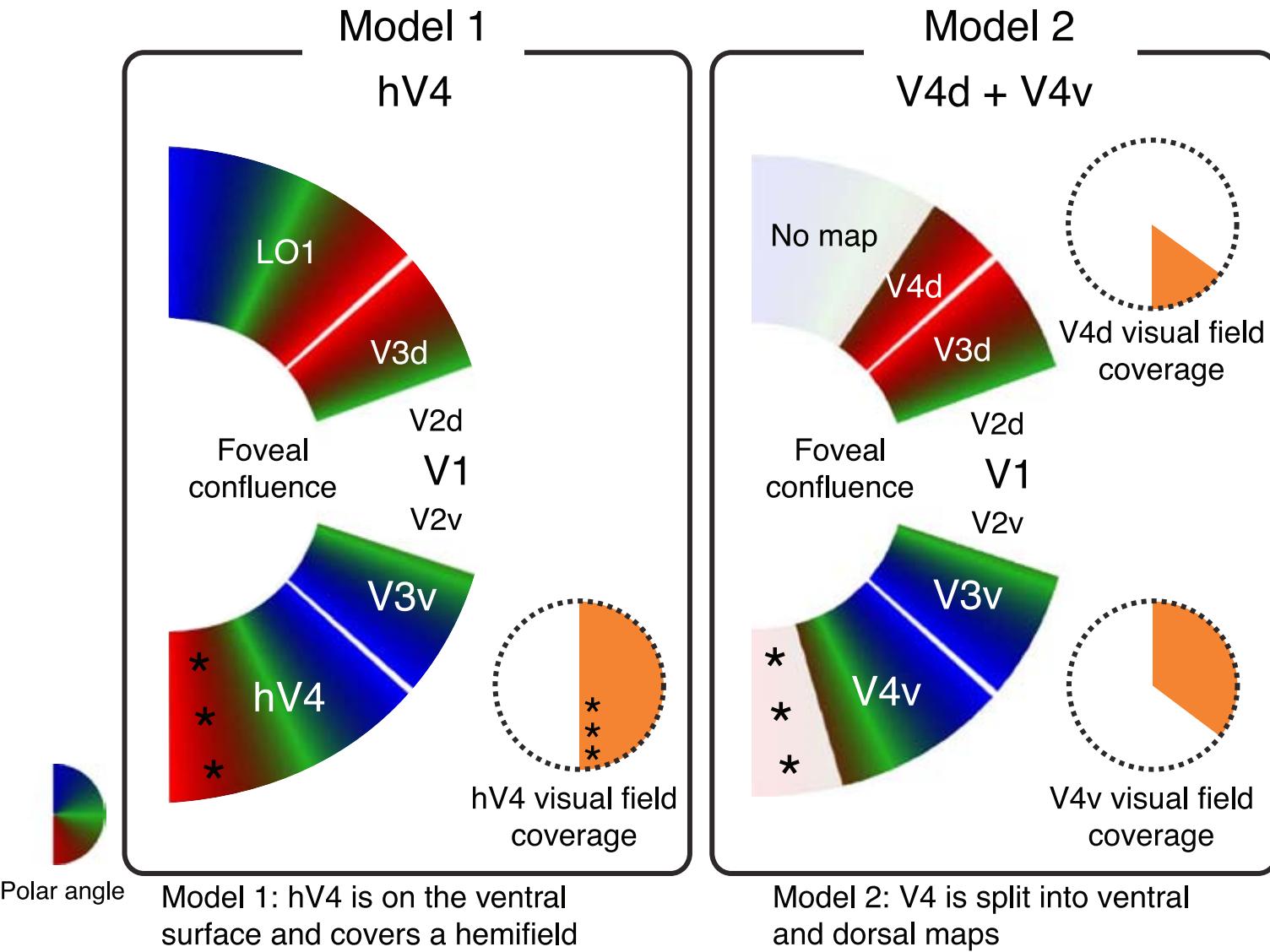
- The MVPA is sensitive to the number of voxels in the classifier and the **SNR** in each region
- This makes it hard (but not impossible) to compare classification results across areas (see Brouwer and Heeger – later)
- Comparing different conditions within an area is generally safer.

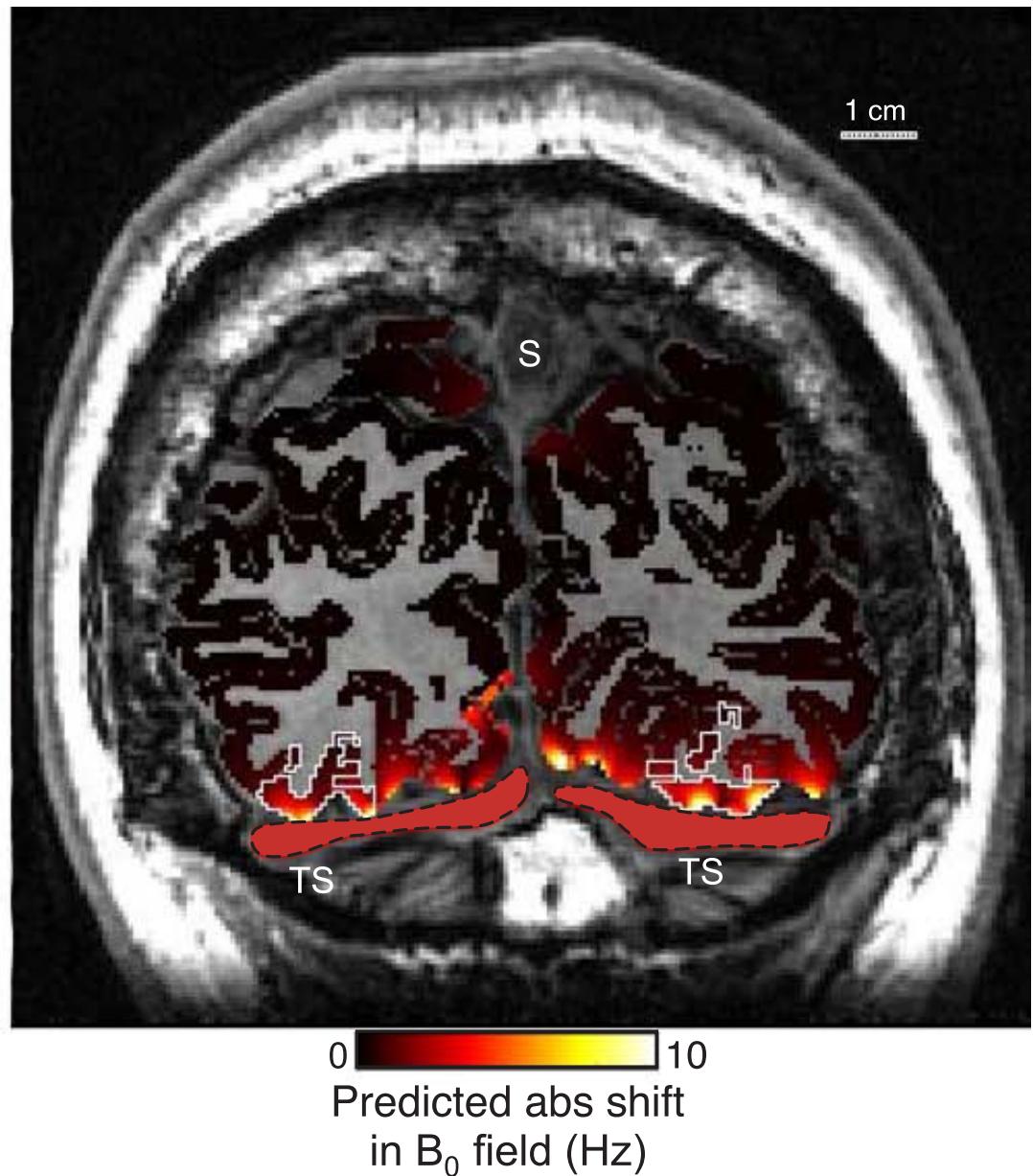
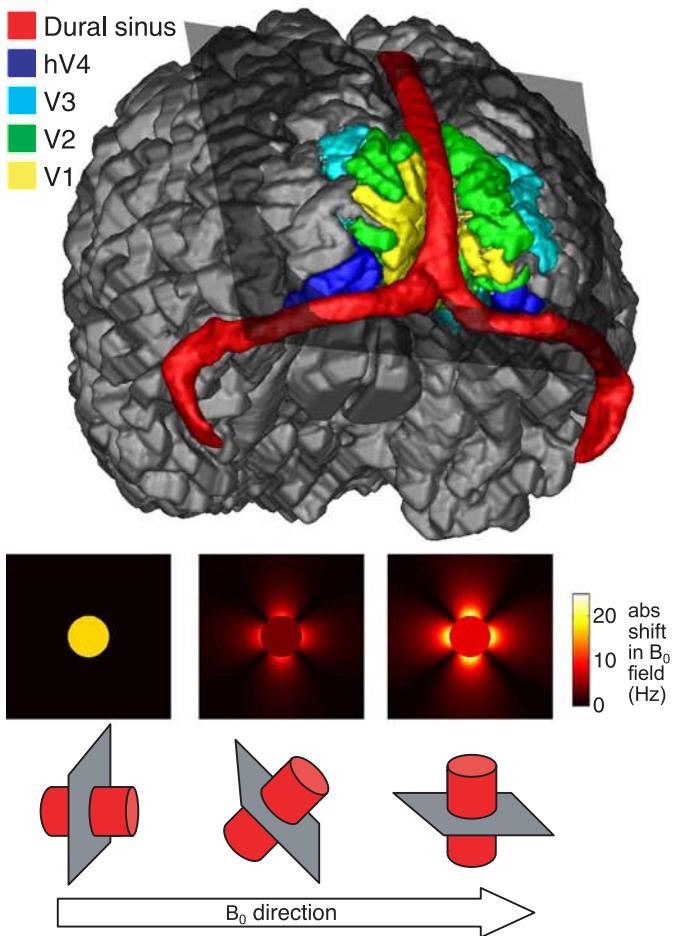
Case 1 – the venous eclipse and hV4





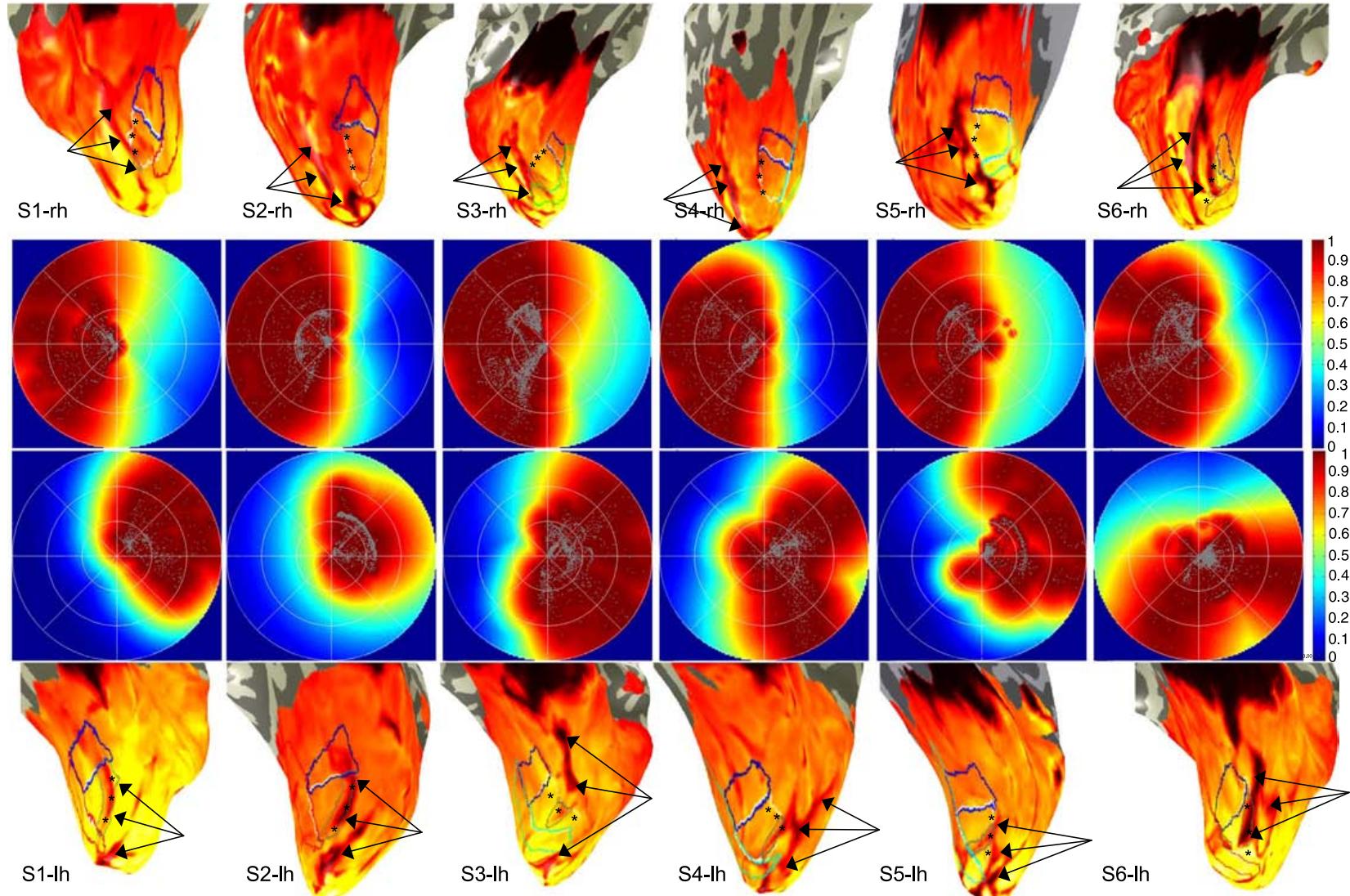
hV4



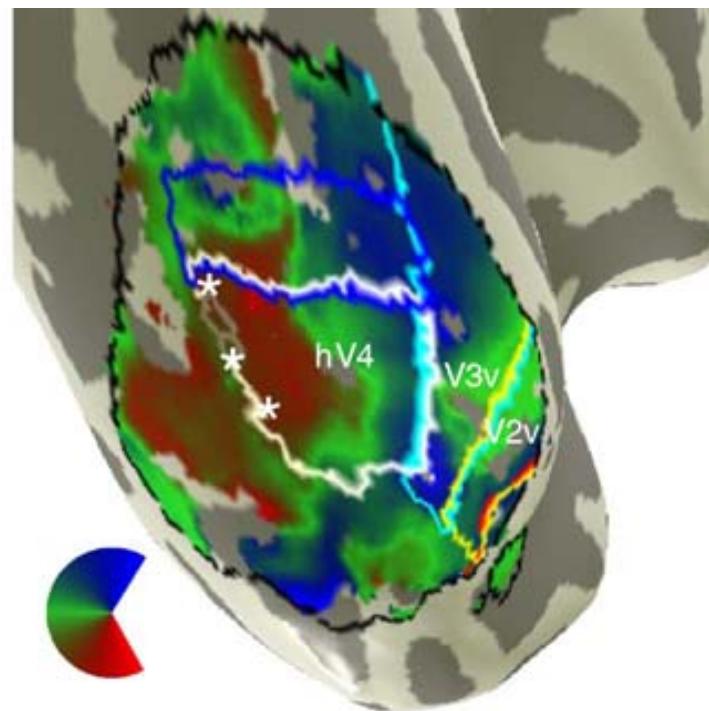
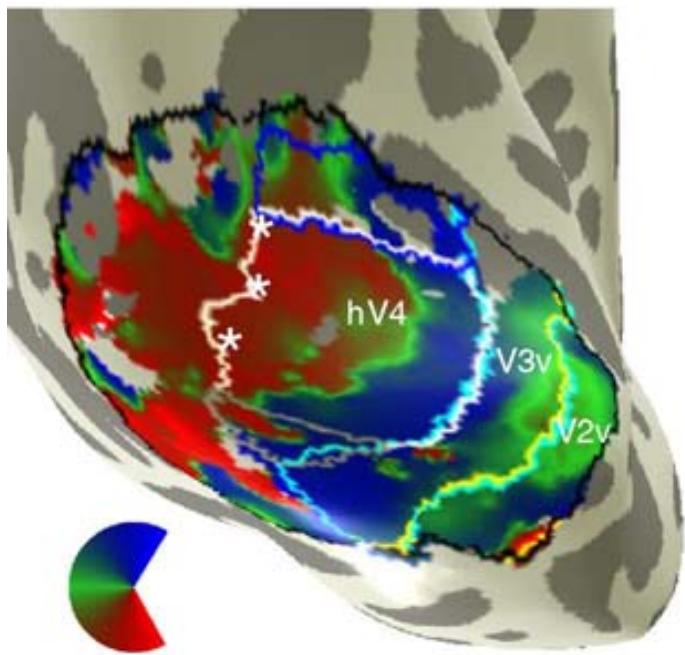


Winawer et al JOV 2010

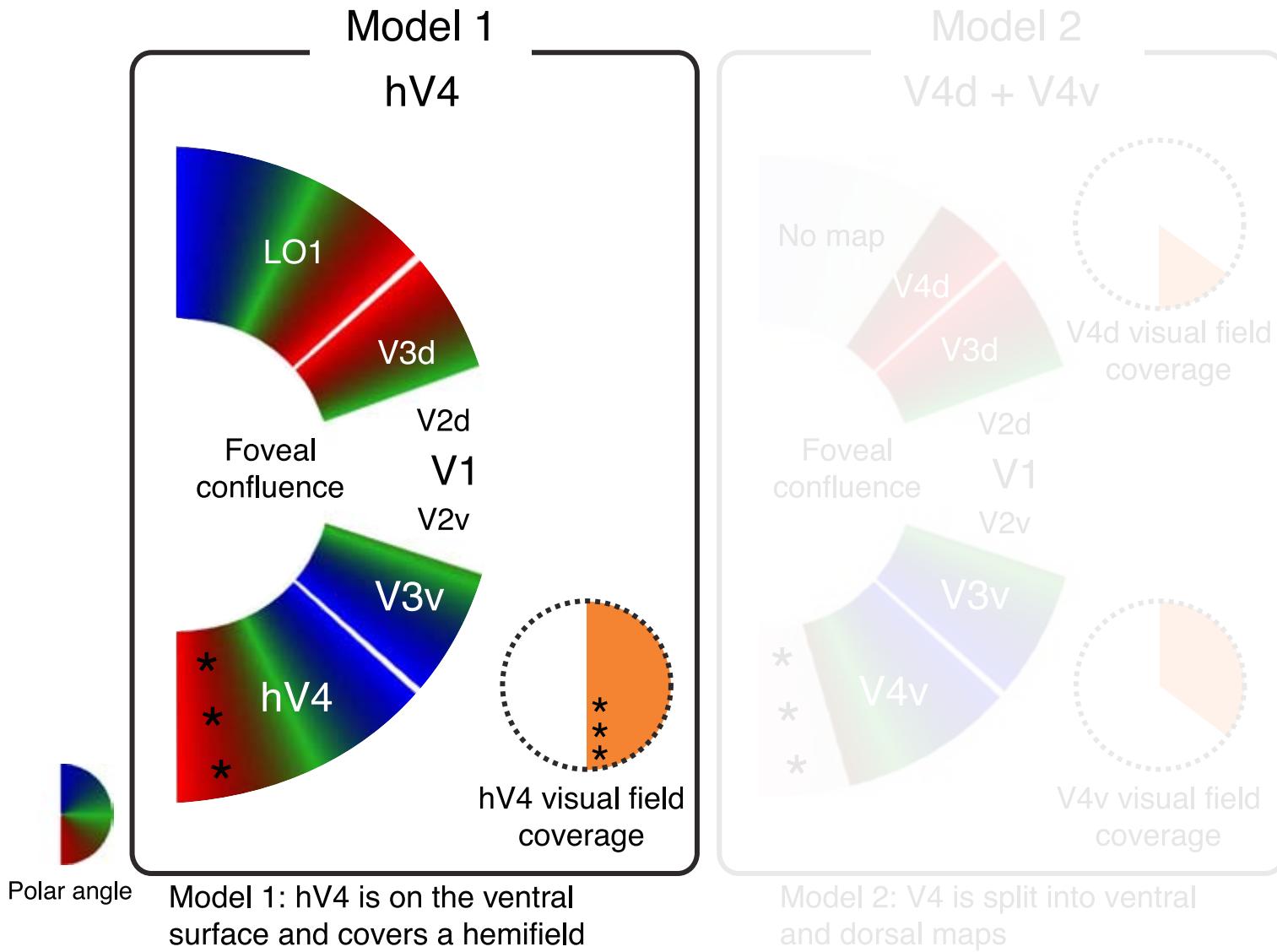
A case study in being careful:



a



hV4

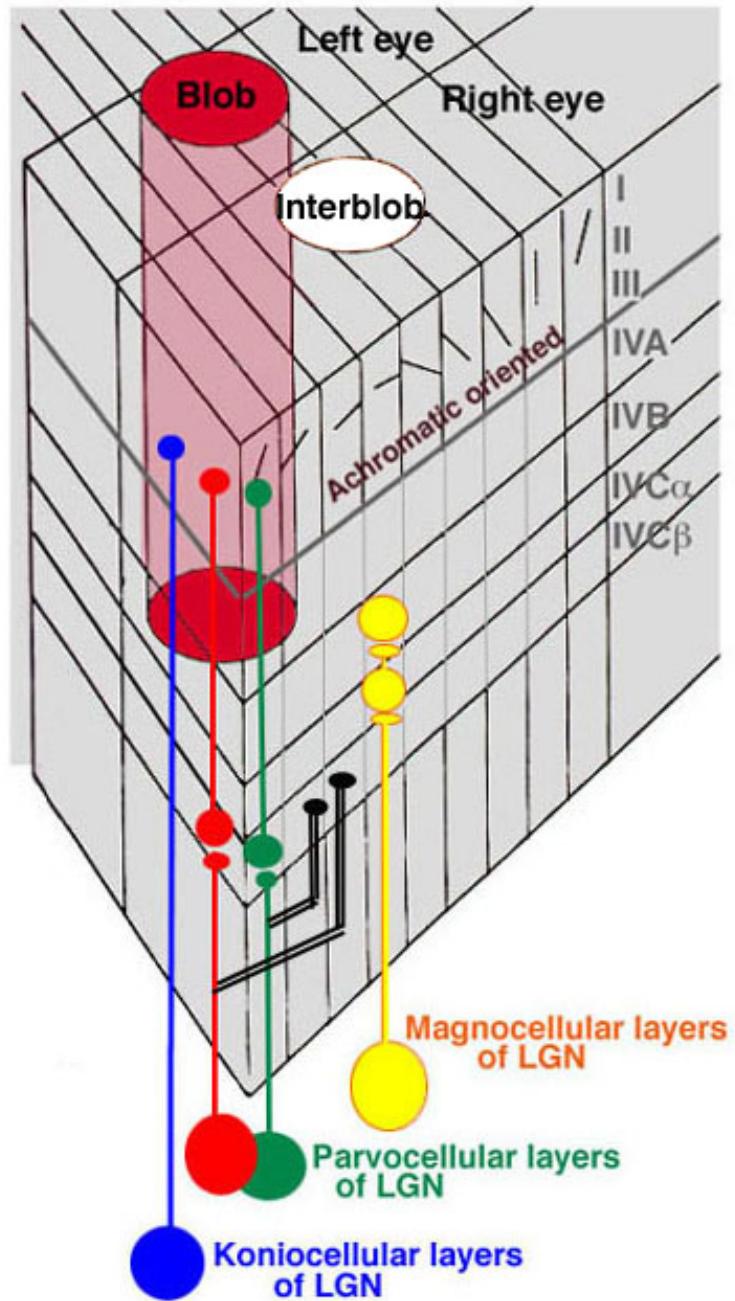


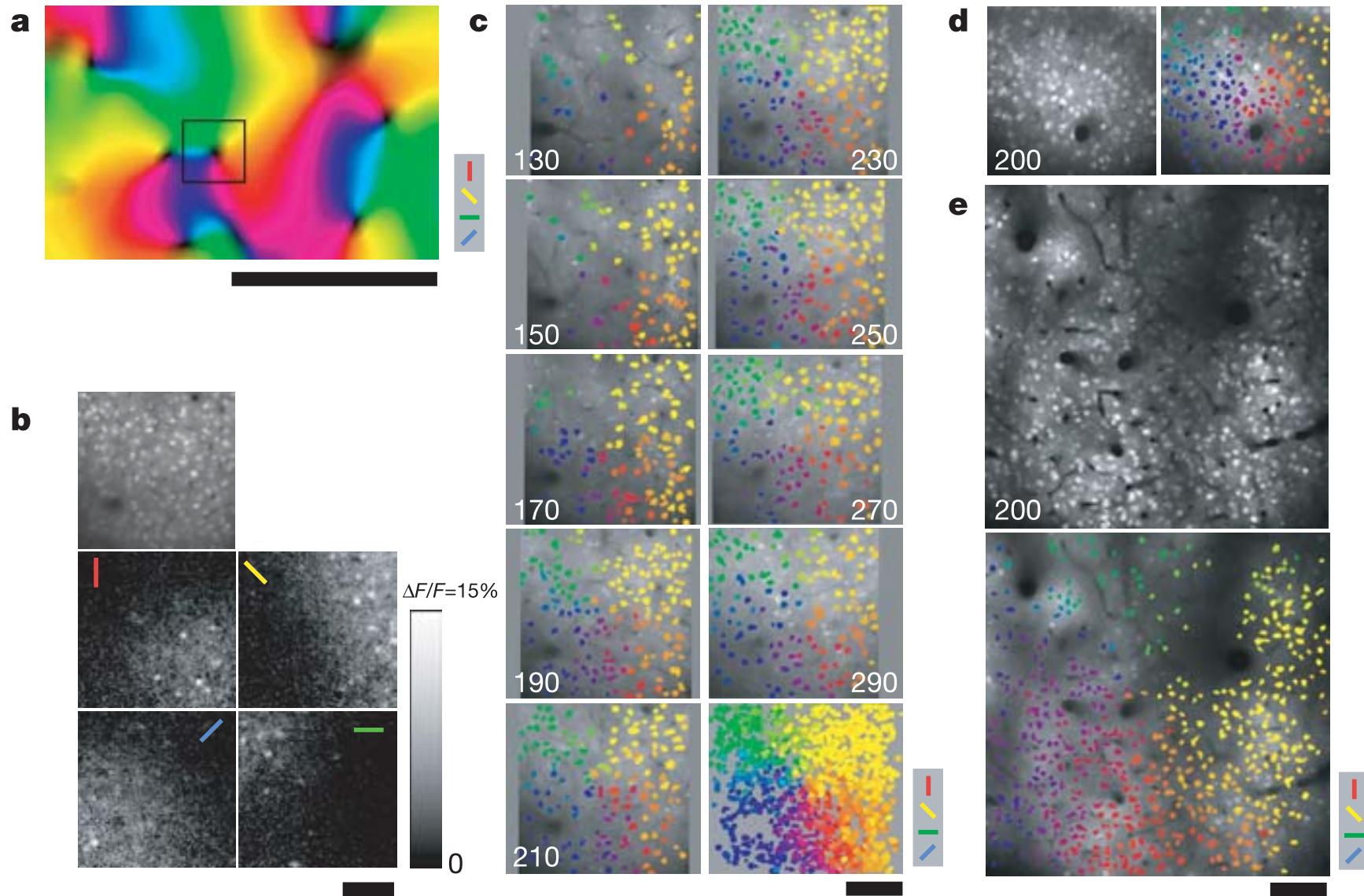
3 ways to use multivoxel information

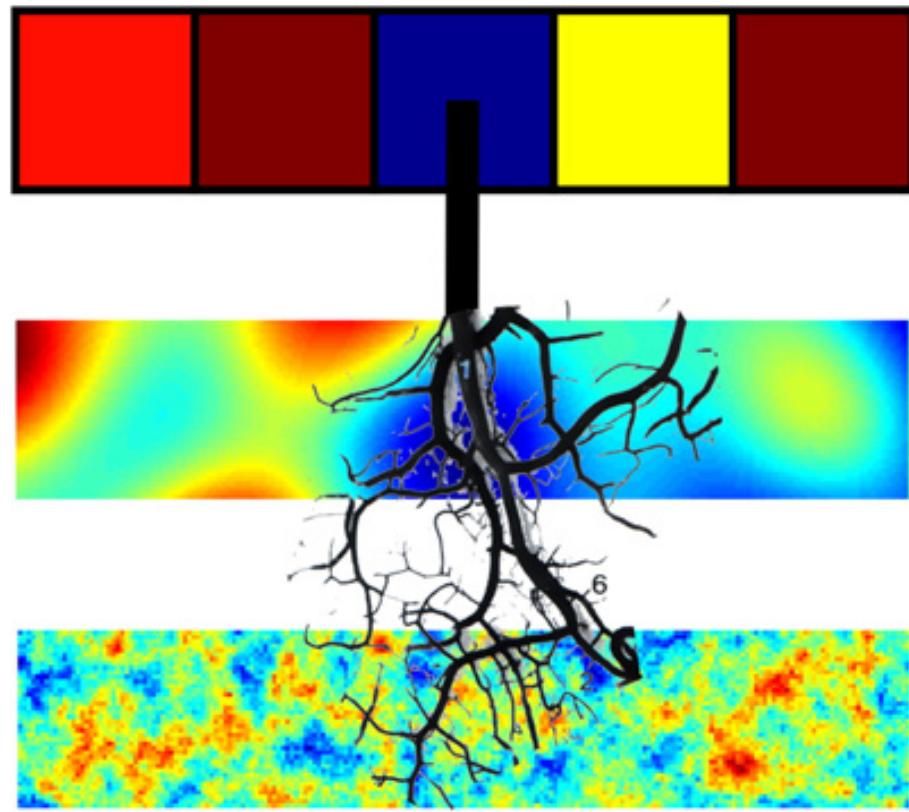
- Classifiers
- Forward models
- Tuning functions

History of using MVPA in early visual cortex

- MVPA was originally developed by Haxby et al (2001) et al to examine object representation in the ventral stream.
- Application to V1 orientation decoding by Kamitani and Tong (2005)
- Showed that they could classify orientation – but also *attended orientation*

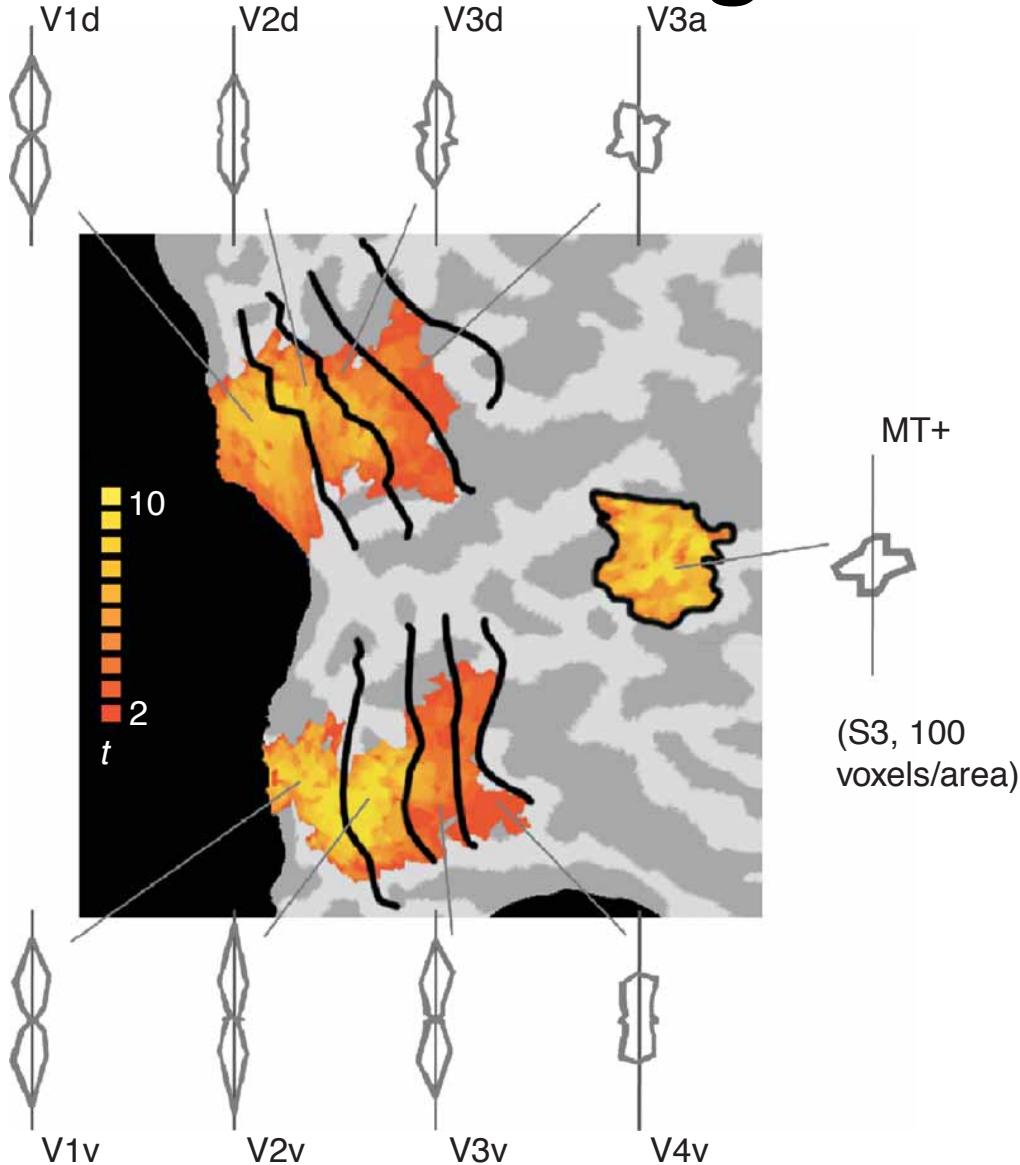




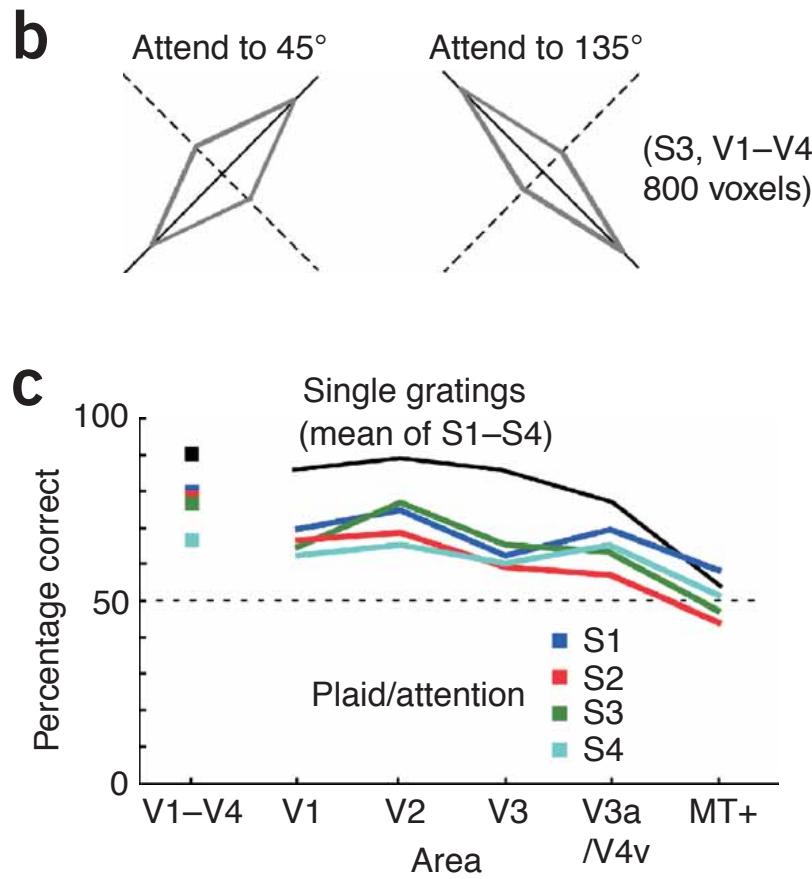
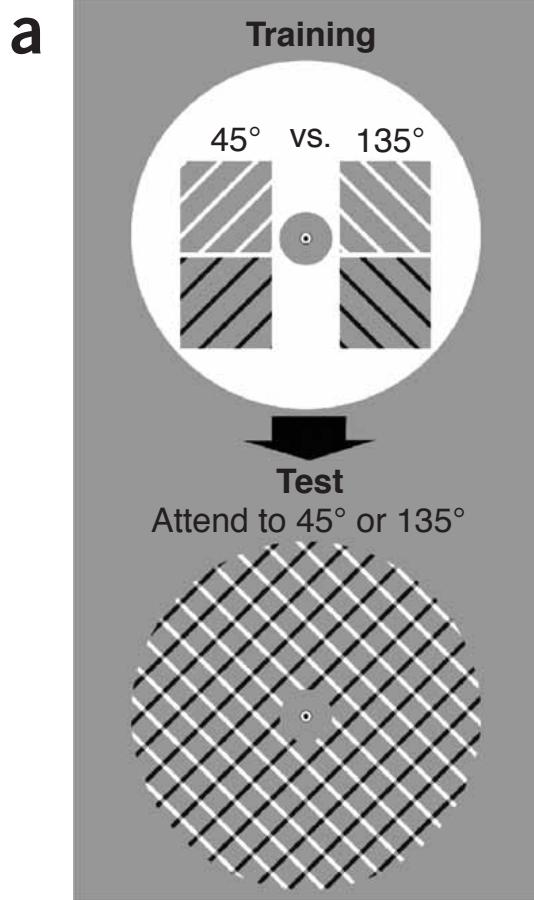


**voxel as
complex spatiotemporal filter
("multipronged sensor")**

Kamitani and Tong 2005



Attention



From Kamitani and Tong 2005

Kamitani et al

- Information about orientation is present in the pattern of V1 activity, even in the absence of univariate changes
- Attention to different orientations modulates orientation-tuned neurons selectively

Is voxel-level information necessary?

Behavioral/Systems/Cognitive

Orientation Decoding Depends on Maps, Not Columns

Jeremy Freeman,¹ Gijs Joost Brouwer,^{1,2} David J. Heeger,^{1,2} and Elisha P. Merriam^{1,2}

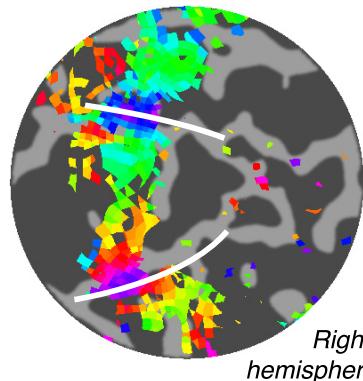
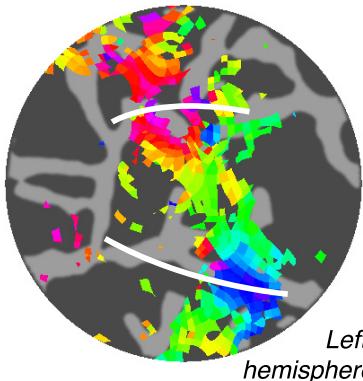
¹Center for Neural Science and ²Department of Psychology, New York University, New York, New York 10003

JNS March 2011

Maps not columns?

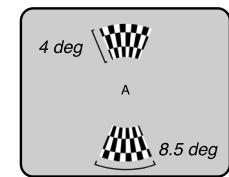
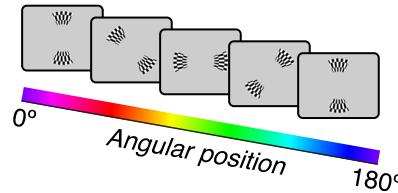
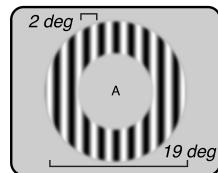
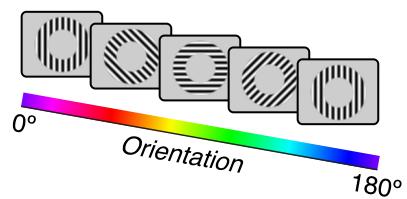
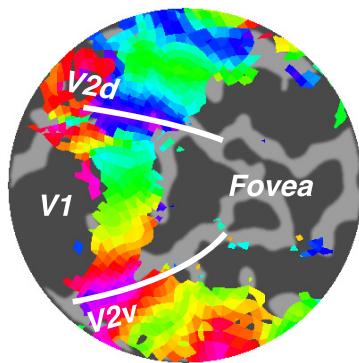
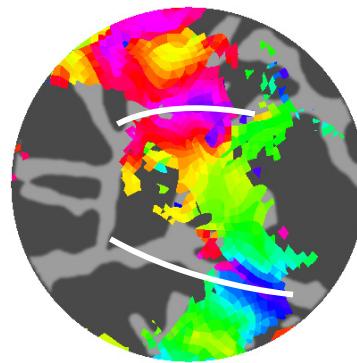
A

Orientation

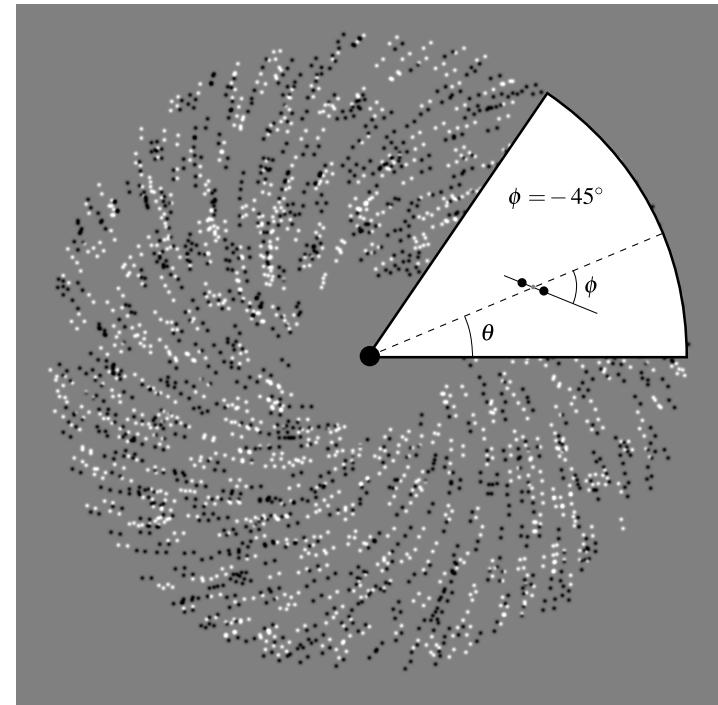
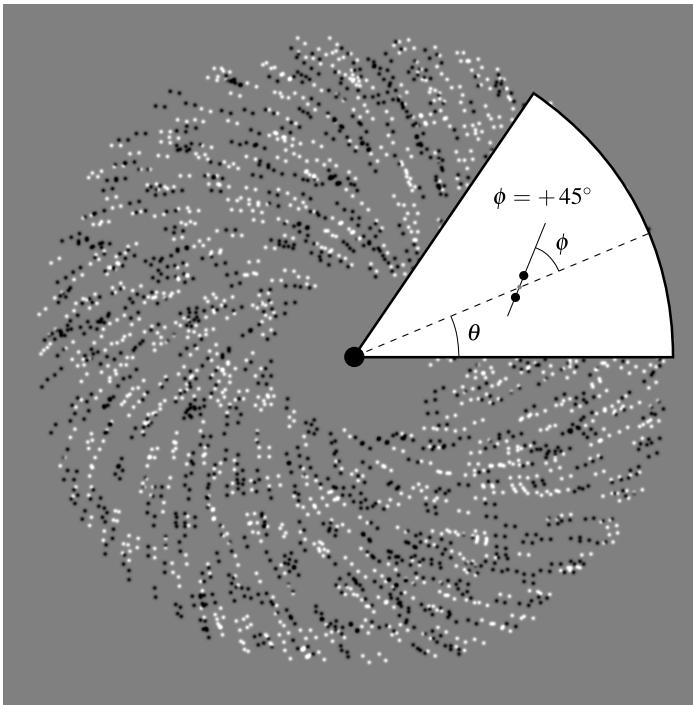


B

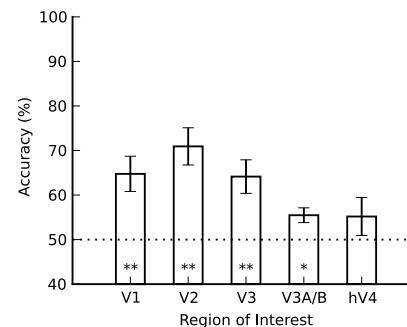
Angular position



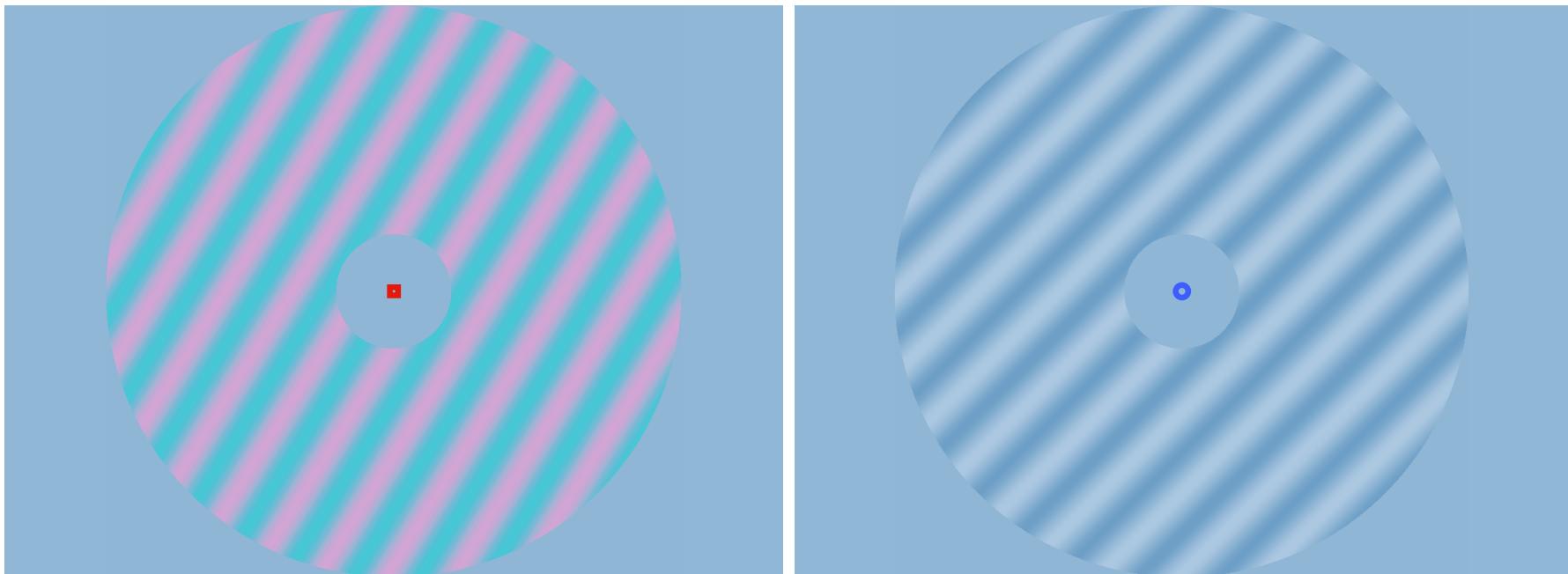
But classifiers work with spiral Glass patterns

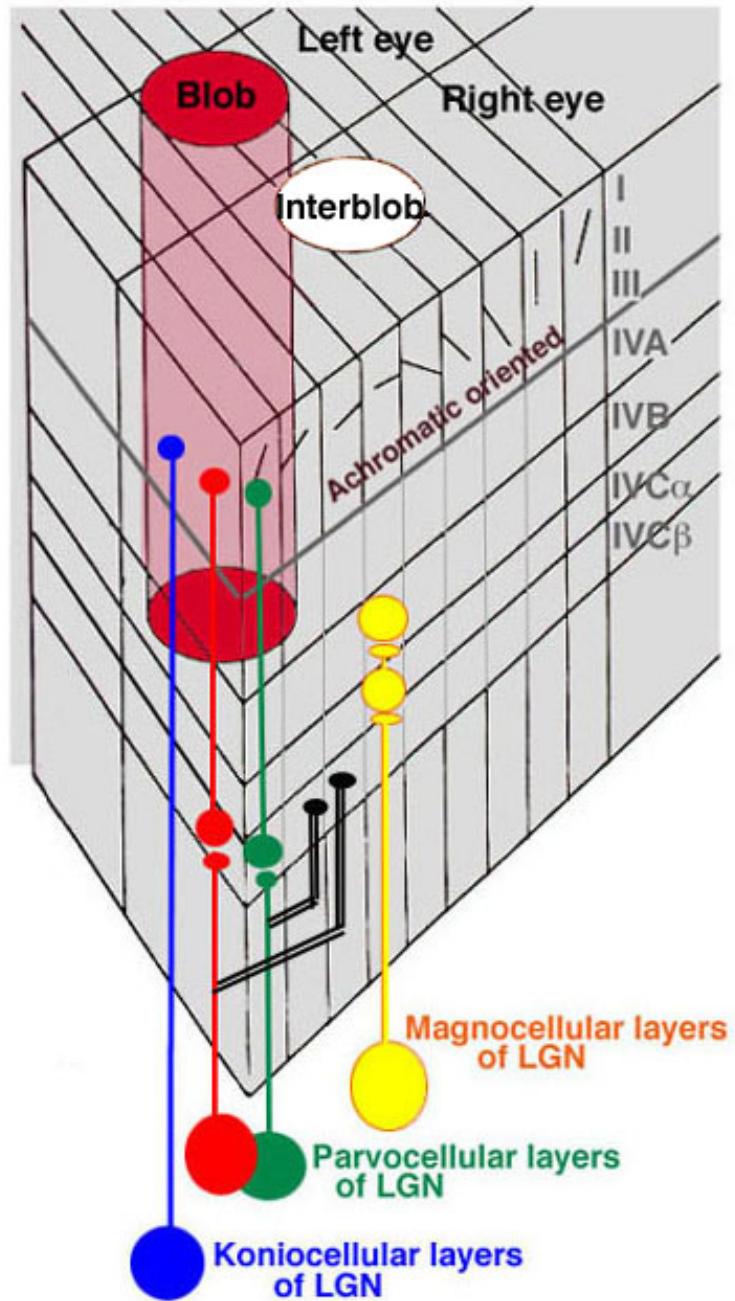


Mannion et al, 2009



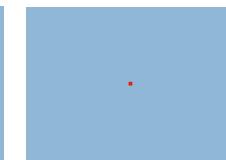
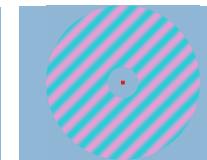
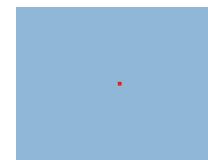
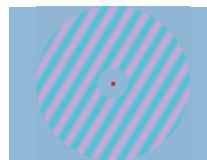
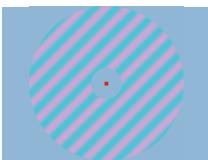
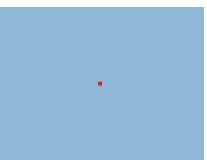
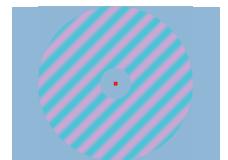
...and are also able to distinguish between attention to contrast / form for chromatic but not achromatic stimuli





16s

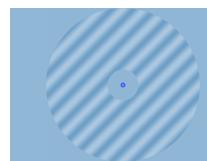
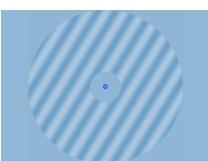
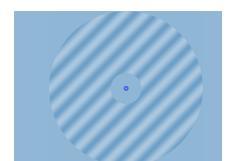
a)



O

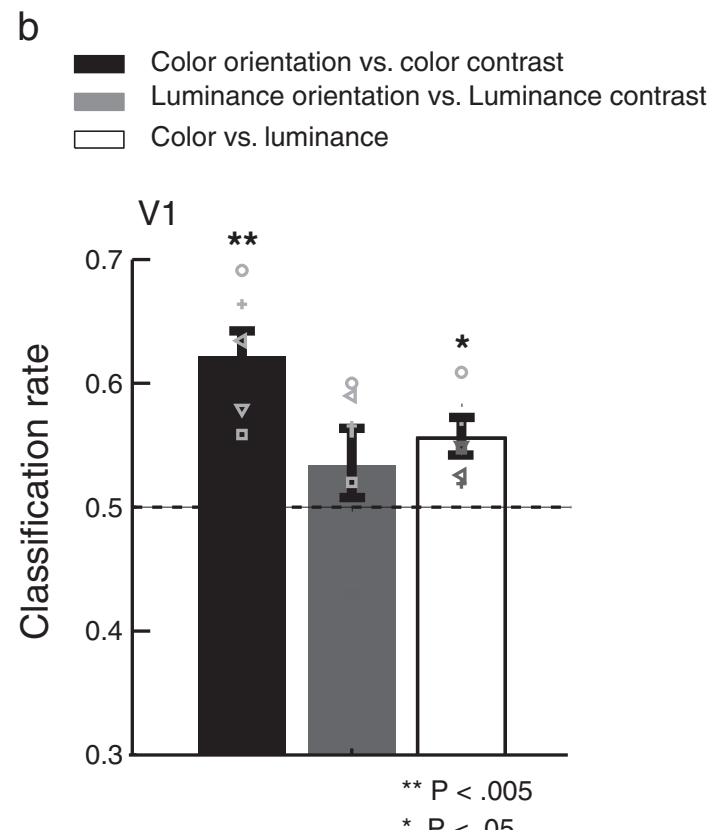
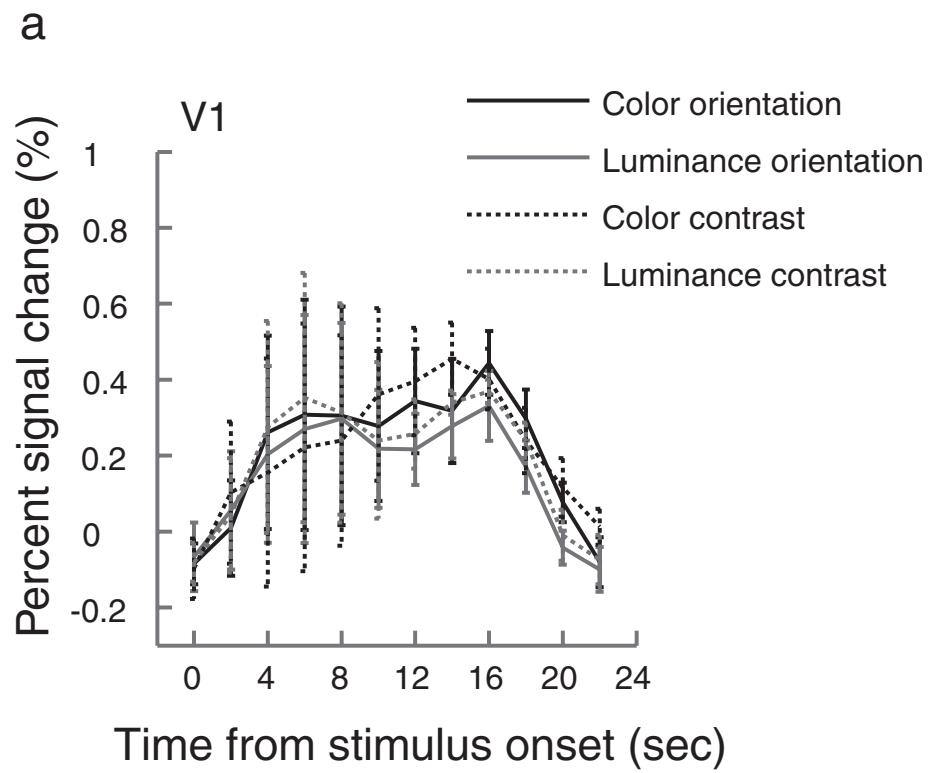
C

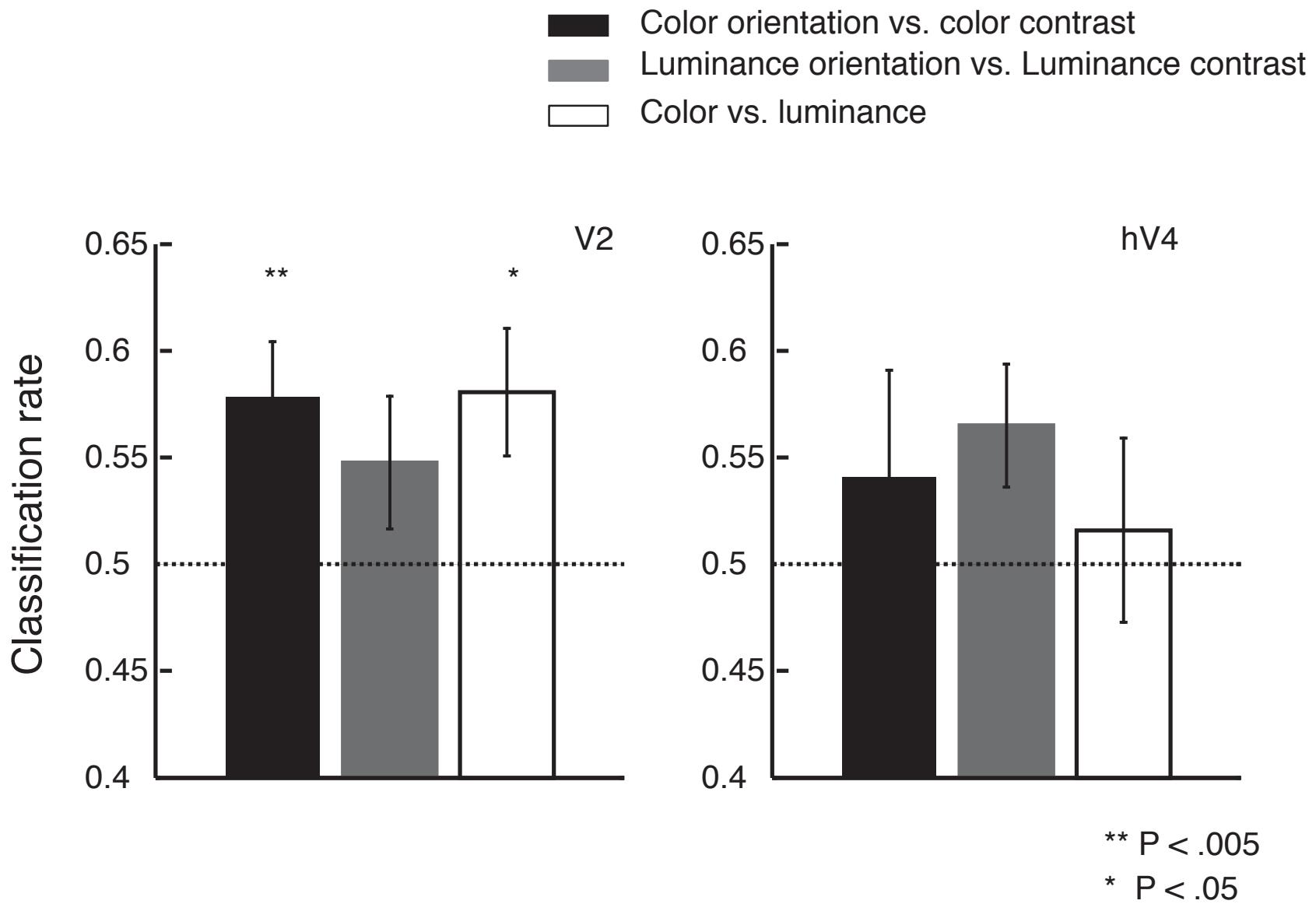
b)



O

C





Forward models

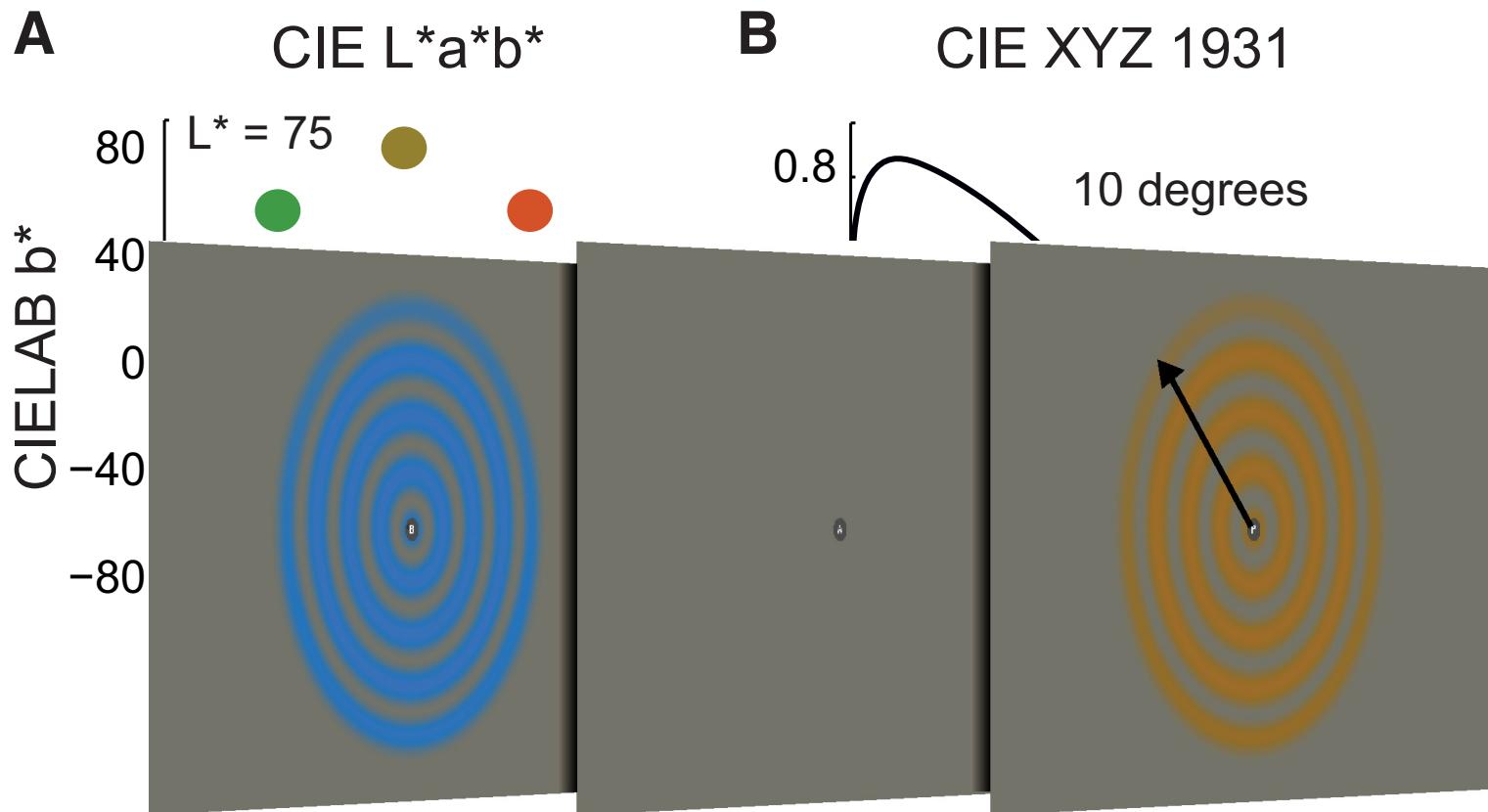
Behavioral/Systems/Cognitive

Decoding and Reconstructing Color from Responses in Human Visual Cortex

Gijs Joost Brouwer and David J. Heeger

Department of Psychology and Center for Neural Science, New York University, New York, New York 10003

Stimuli



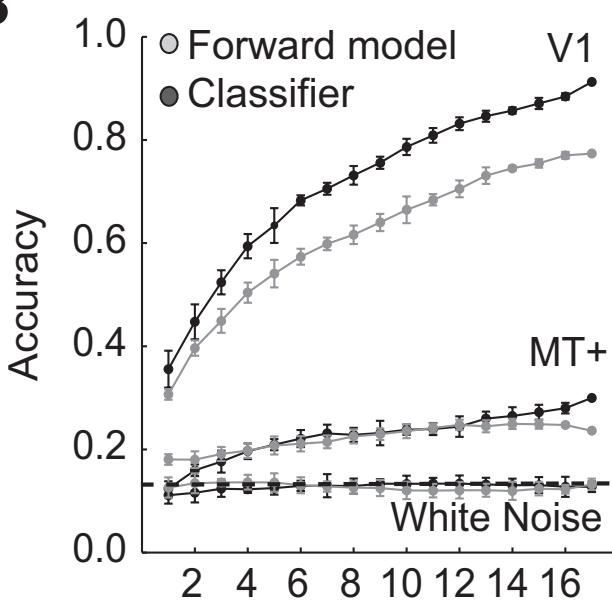
Stimulus
(1.5s)

ISI
(3 - 6s)

Classification

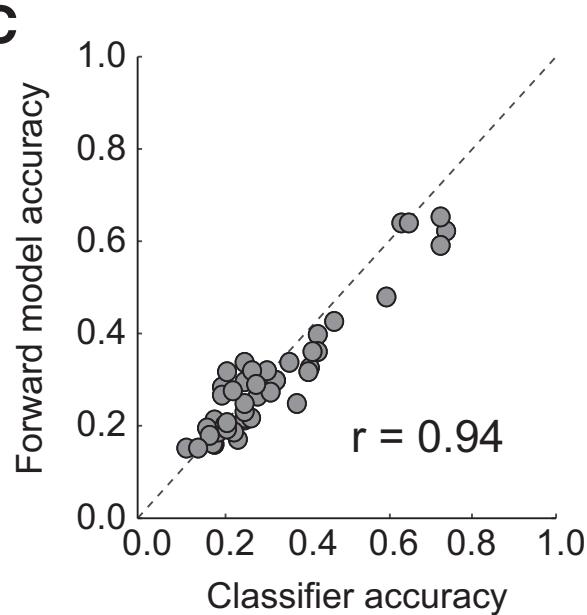
B

Accuracy for full data



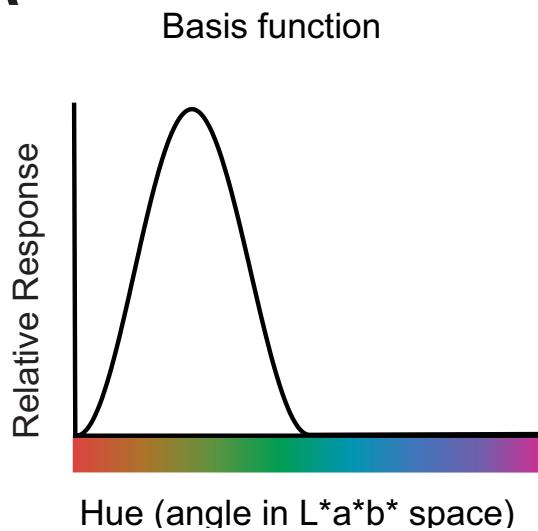
C

Number of combined sessions

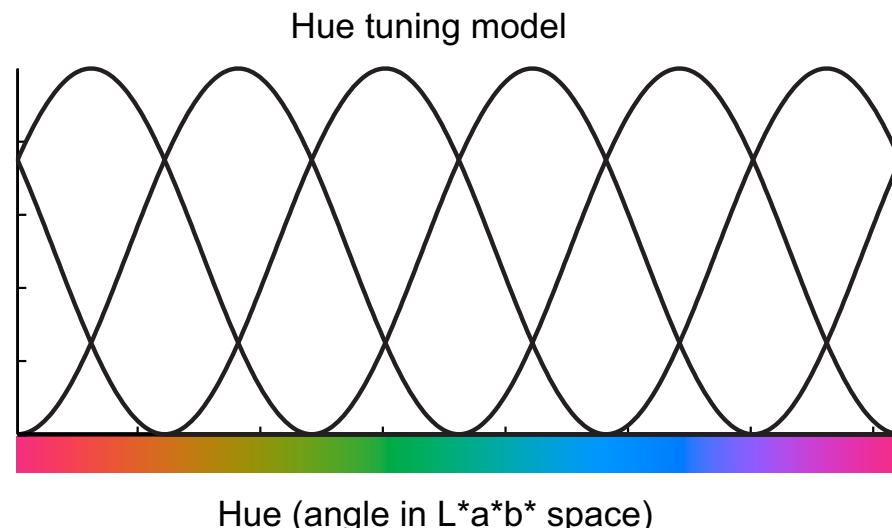


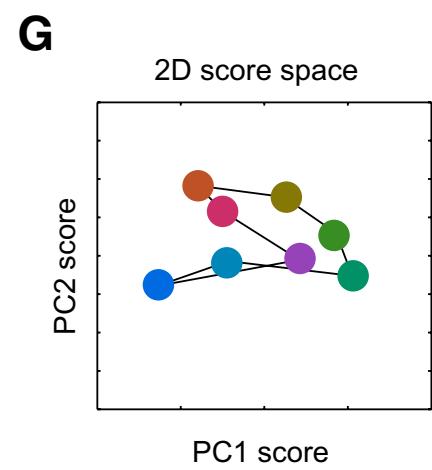
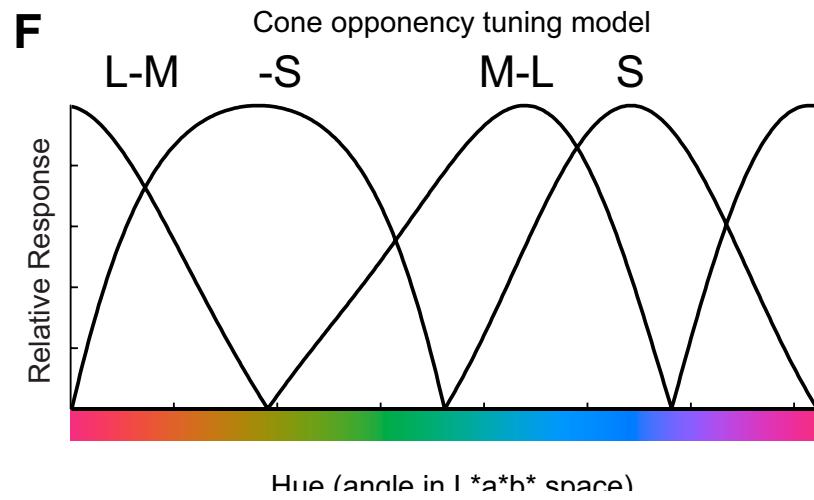
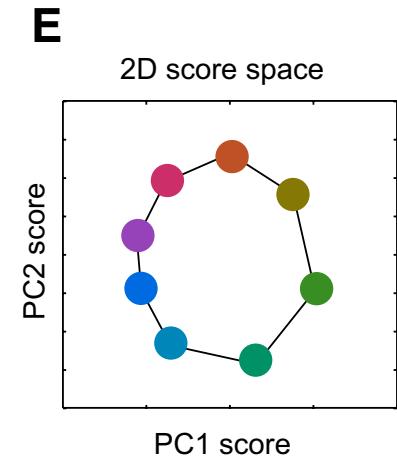
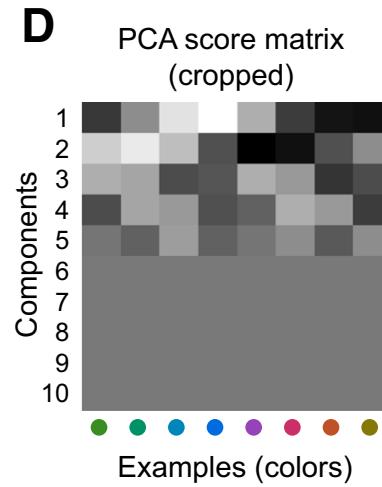
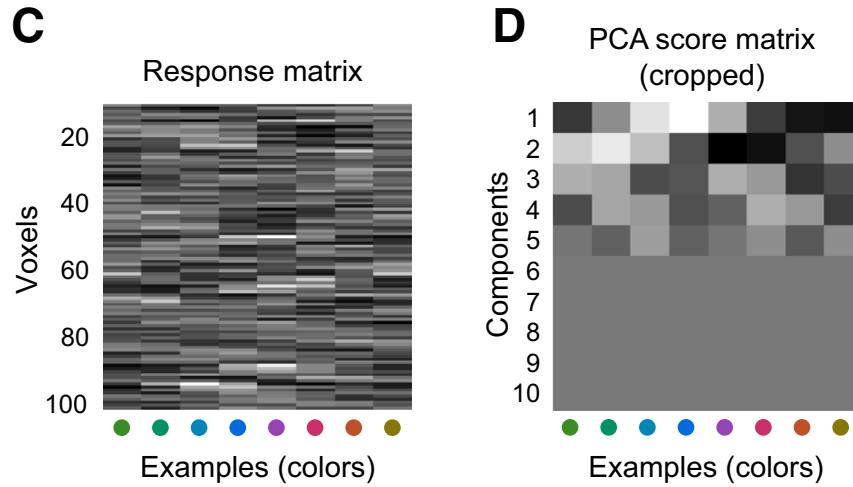
Forward model

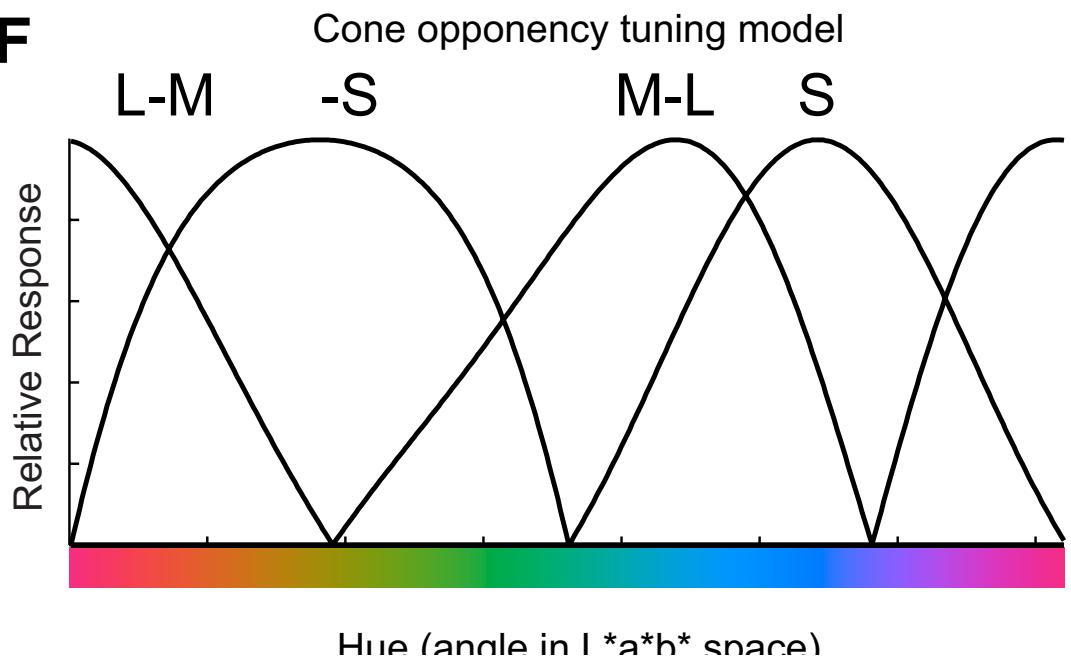
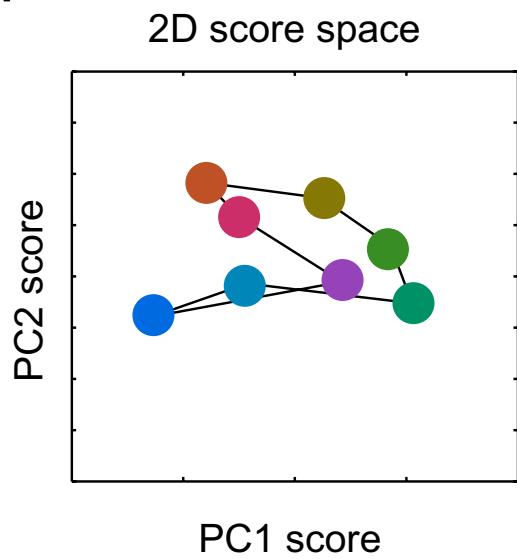
A



B

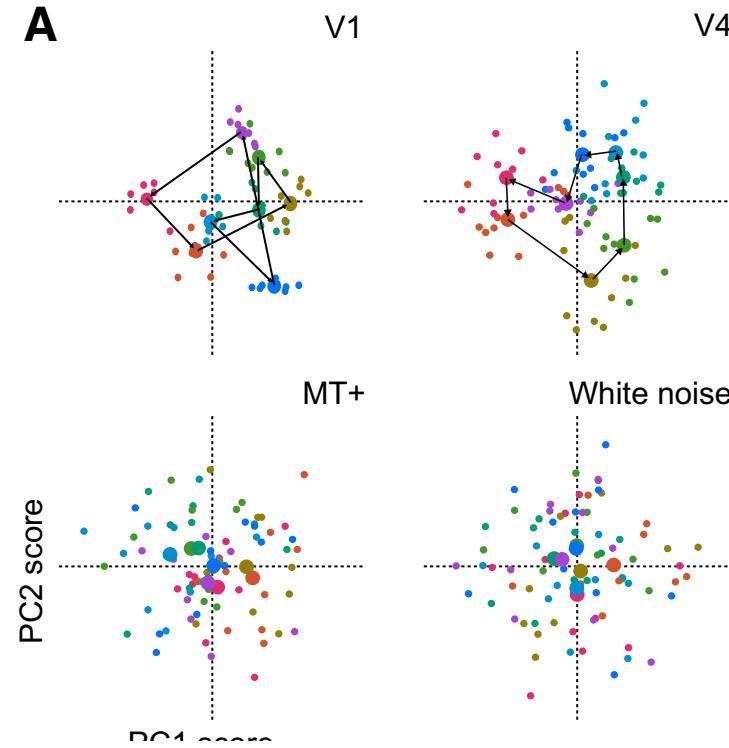




F**G**

Decoding possible from many areas

- But forward modelling revealed that ventral areas (V4) demonstrated a perceptual color space while V1 was consistent with a representation based on opponent color axes



In summary, the dissociation between clustering (highest in V1 and supporting the best decoding performance) and progression (highest in V4) implies a transformation from the color representation in V1 to a representation in V4 (and to a lesser extent VO1) that was closer to a perceptual color space.

Voxel-based tuning functions

NeuroImage 44 (2009) 223–231



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NeuroImage

journal homepage: www.elsevier.com/locate/ynim



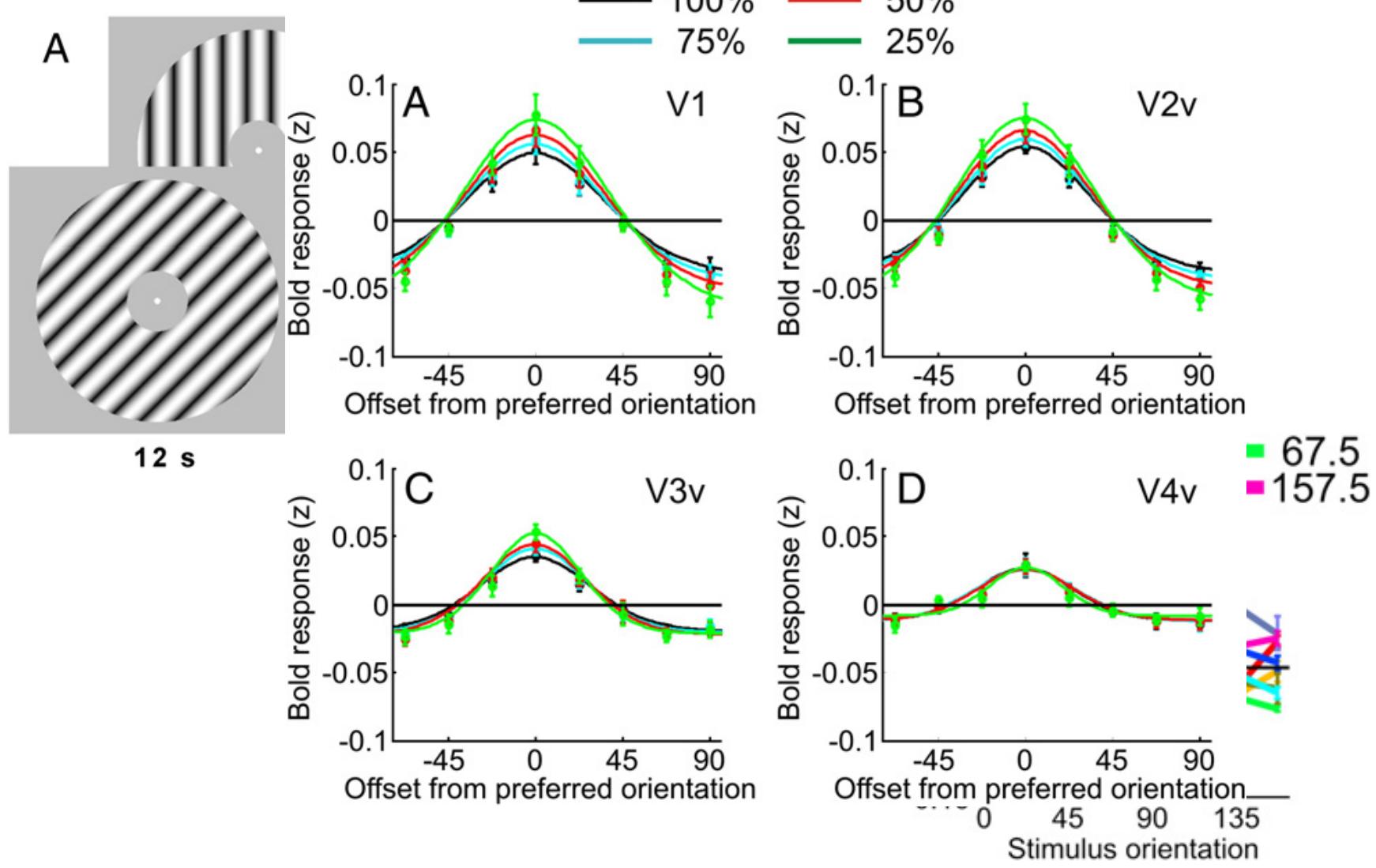
Estimating the influence of attention on population codes in human visual cortex using voxel-based tuning functions

John T. Serences ^{a,*¹}, Sameer Saproo ^{a,1}, Miranda Scolari ^{a,1}, Tiffany Ho ^{a,1}, L. Tugan Muftuler ^b

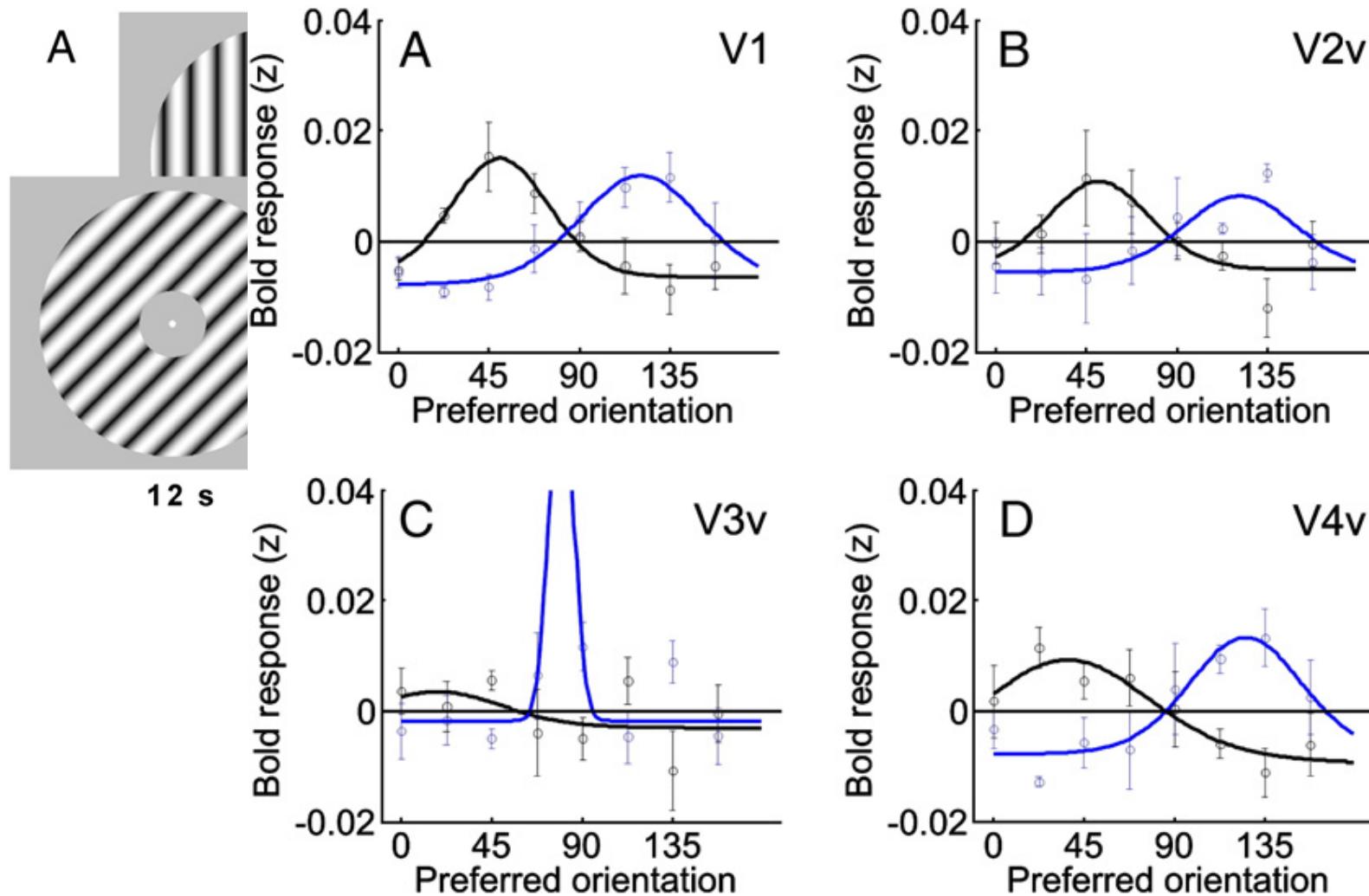
^a Department of Cognitive Sciences, University of California, Irvine, CA 92697-5100, USA

^b Radiological Sciences, School of Medicine, University of California, Irvine, CA 92697-5100, USA

Voxel-based tuning functions

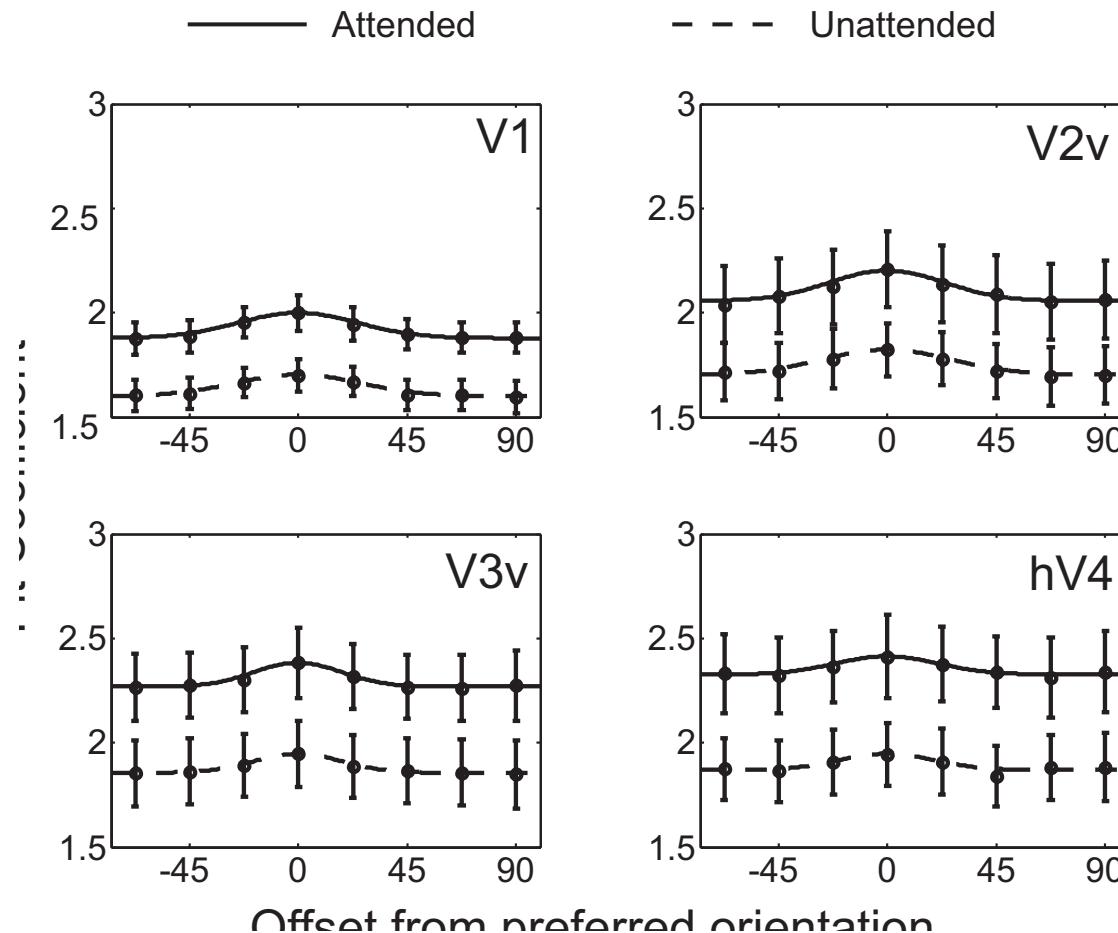


Voxel-based tuning functions... population changes with attention



Voxel based tuning functions can be used to ask questions about physiology directly

S. SARROU AND J.



Conclusion

- Classification analysis of V1 responses may reveal important features of early visual cortex
- Not all MV analyses require pattern classification
- Generating (and testing) forward models has led to an insight into cortical color representation
- Analyzing individual voxel tuning functions allows us to relate multivariate activity directly to known properties of visual neurons