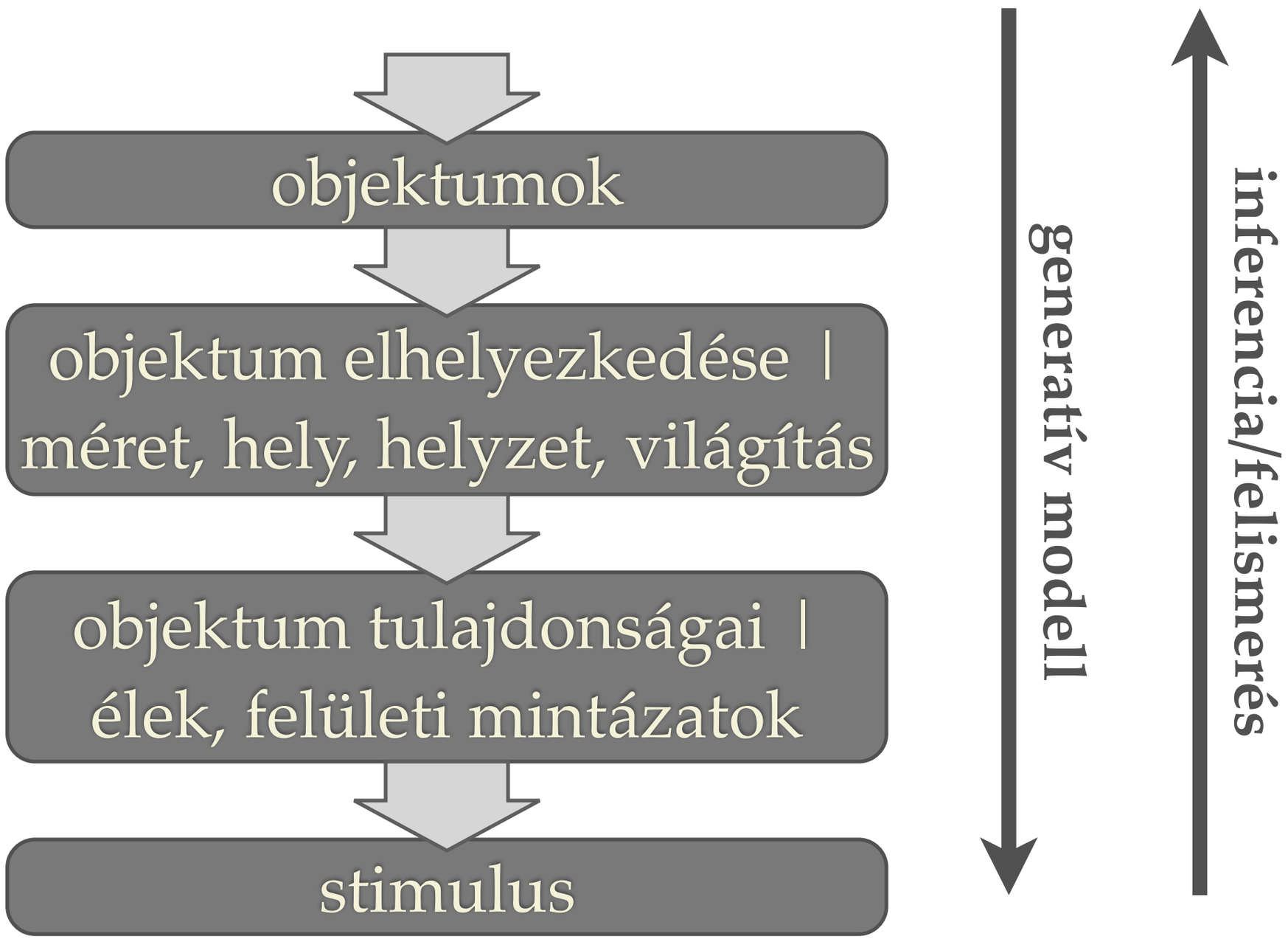
Statisztikus tanulás az idegrendszerben

ORBÁN GERGŐ

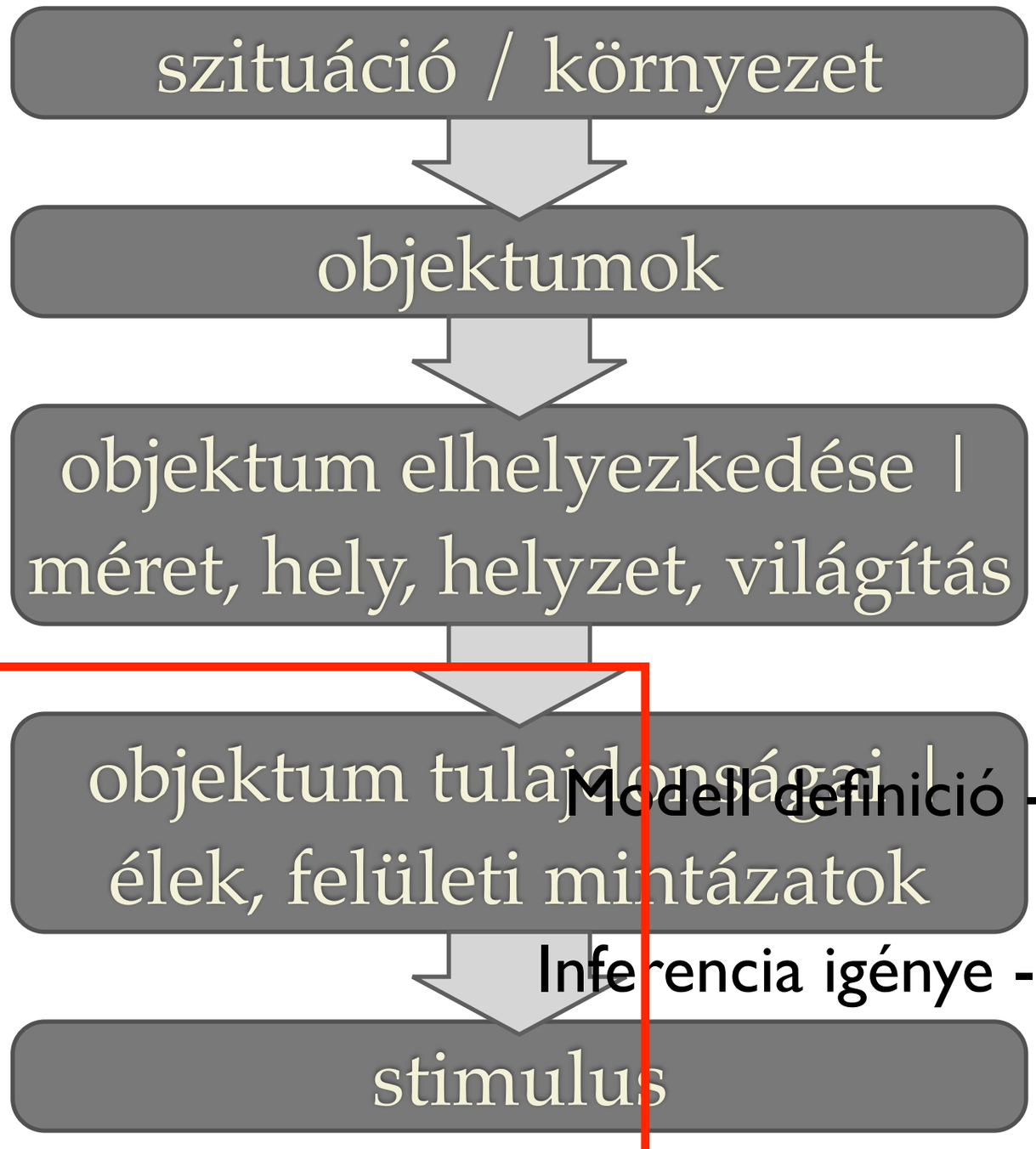
golab.wigner.mta.hu

WIGNER RESEARCH CENTRE FOR PHYSICS

Generatív/rekogniciós modell



Generatív/rekogniciós modell



Modell definició -> generáció:
P(x | z)

Inferencia igénye -> rekogníció:
P(z | x)

Lineáris modellek

V1 receptive mezők:
- orientált
- sáváteresztő
- lokalizált

$x = A\,z + eps$

V1 stimulus-függés
- kontraszt invariancia
- extra-klasszikus receptív mezők

$x = c\,(A\,z) + eps$

Scale Mixtures of Gaussians and the Statistics of Natural Images

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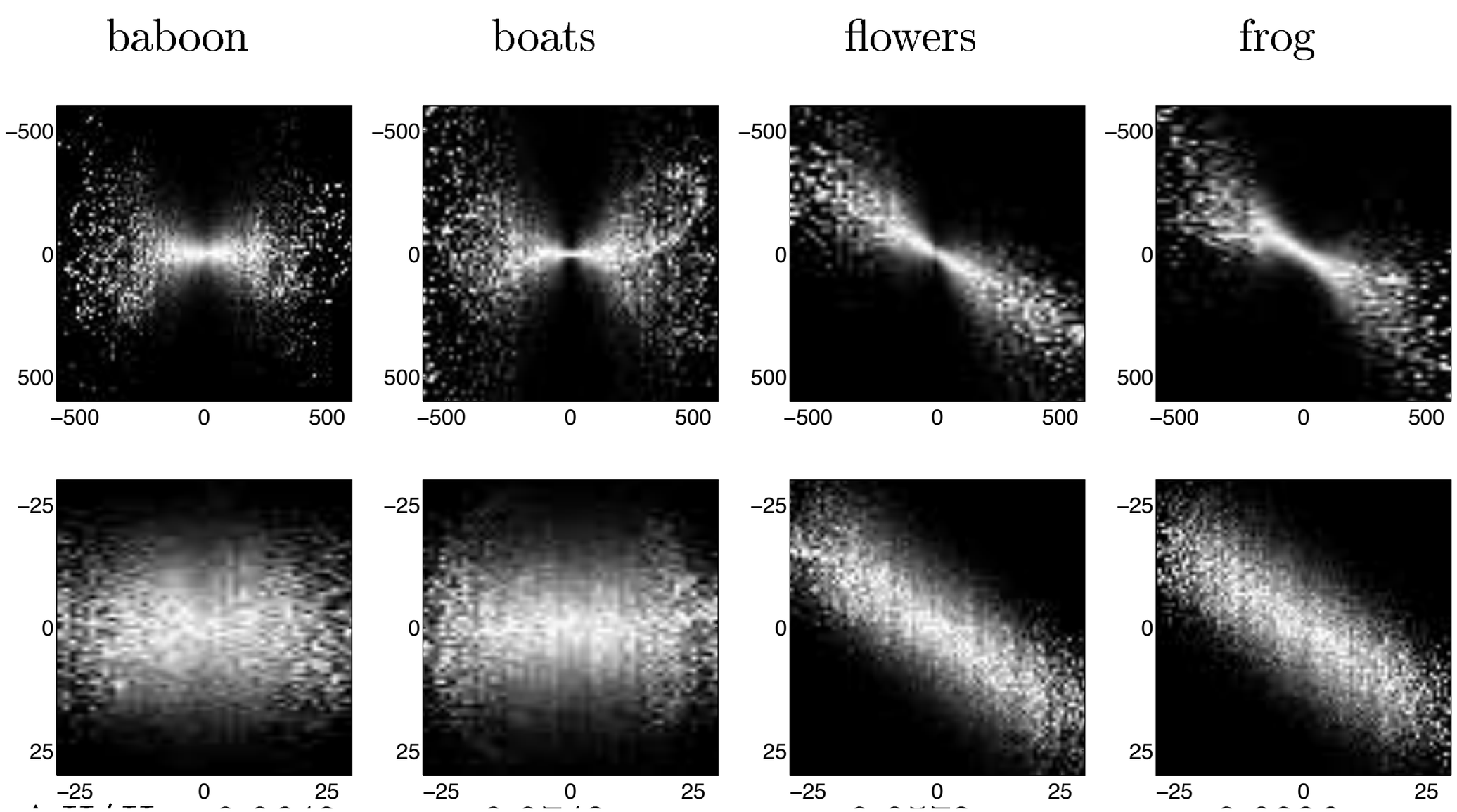
Abstract

The statistics of photographic images, when represented using multiscale (wavelet) bases, exhibit two striking types of non-Gaussian behavior. First, the marginal densities of the coefficients have extended heavy tails. Second, the joint densities exhibit variance dependencies not captured by second-order models. We examine properties of the class of Gaussian scale mixtures, and show that these densities can accurately characterize both the marginal and joint distributions of natural image wavelet coefficients. This class of model suggests a Markov structure, in which wavelet coefficients are linked by hidden scaling variables corresponding to local image structure. We derive an estimator for these hidden variables, and show that a nonlinear "normalization" procedure can be used to Gaussianize the coefficients.


baboon
boats
flowers
frog
−500
0
500
−25
25

Gauging V2 responses so far

- gratings
- contours
- angles
- other forms of second order stats
- border ownership

THE GOBBLING GLUTTONS

ONCE UPON A TIME, WALDO EMBARKED UPON A FANTASTIC JOURNEY. FIRST, AMONG A THRONG OF GOBBLING GLUTTONS, HE MET WIZARD WHITEBEARD, WHO COMMANDED HIM TO FIND A SCROLL AND THEN TO FIND ANOTHER AT EVERY STAGE OF HIS JOURNEY. FOR WHEN HE HAD FOUND 12 SCROLLS, HE WOULD UNDERSTAND THE TRUTH ABOUT HIMSELF.

IN EVERY PICTURE FIND WALDO, WOOF (BUT ALL YOU CAN SEE IS HIS TAIL), WENDA, WIZARD WHITEBEARD, ODLAW, AND THE SCROLL. THEN FIND WALDO'S KEY, WOOF'S BONE (IN THIS SCENE IT'S THE BONE THAT'S NEAREST TO HIS TAIL), WENDA'S CAMERA, AND ODLAW'S BINOCULARS.

THERE ARE ALSO 25 WALDO-WATCHERS, EACH OF WHOM APPEARS ONLY ONCE SOMEWHERE IN THE FOLLOWING 12 PICTURES. AND ONE MORE THING! CAN YOU FIND ANOTHER CHARACTER, NOT SHOWN BELOW, WHO APPEARS ONCE IN EVERY PICTURE EXCEPT THE LAST?

International Journal of Computer Vision 40(1), 49–71, 2000

A Parametric Texture Model Based on Joint Statistics of Complex Wavelet Coefficients

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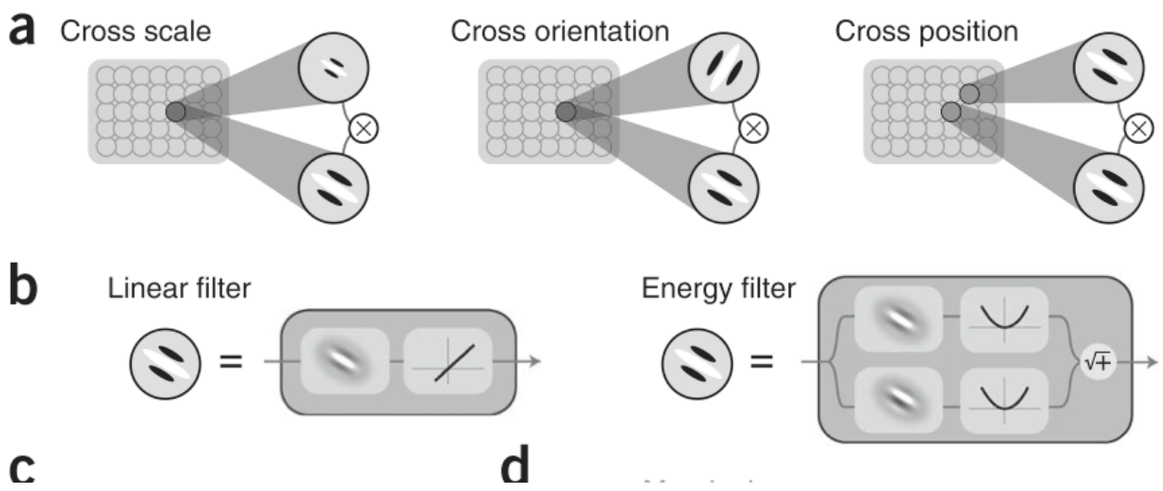
Center for Neural Science, and Courant Institute of Mathematical Sciences, New York University, New York, NY 10003, USA

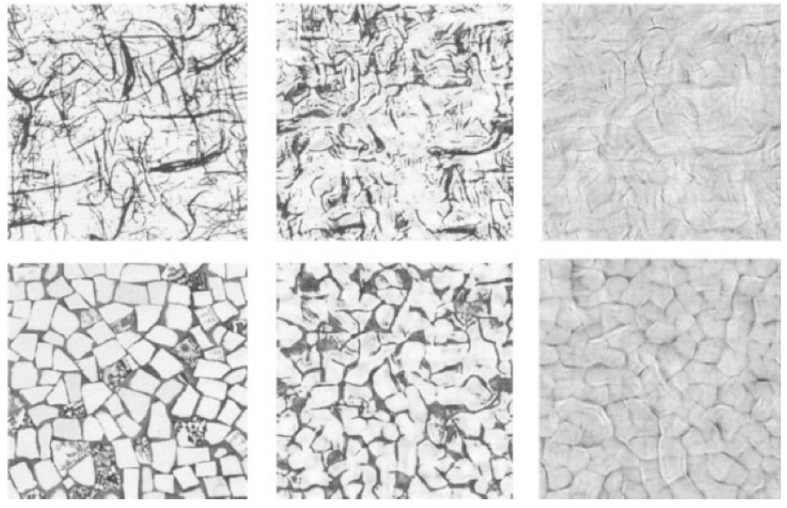
Learning about the stats of an image

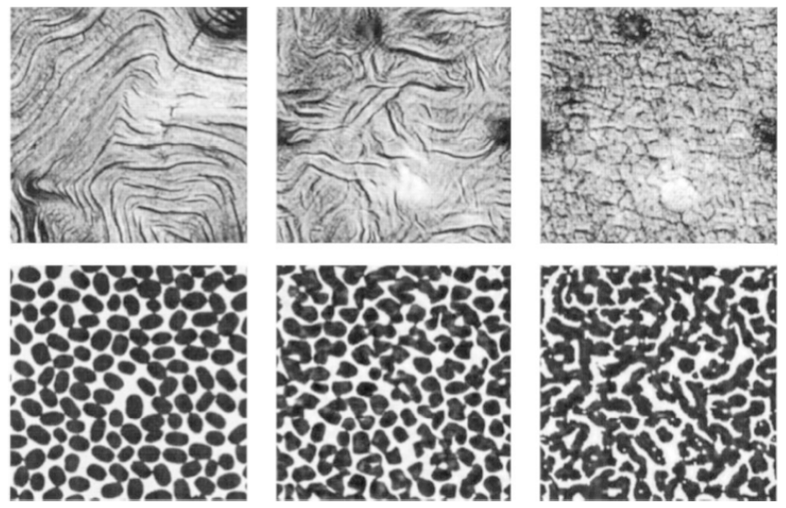
- Registering the responses of linear filters (simple cells)
- Registering the responses of energy filters (complex cells)
- Marginal statistics: variance, kurtosis, skewness

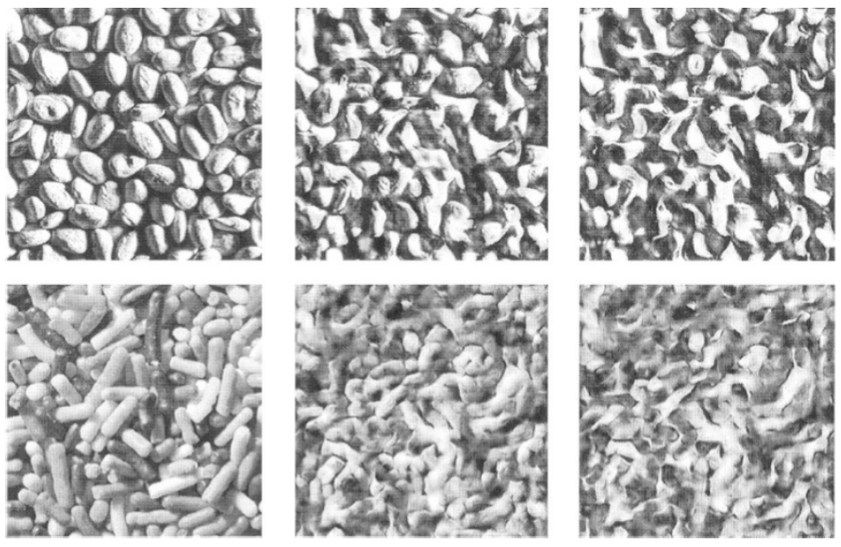
- Registering correlations between orientations
- Registering correlations between spatial frequencies
- Registering correlations across positions



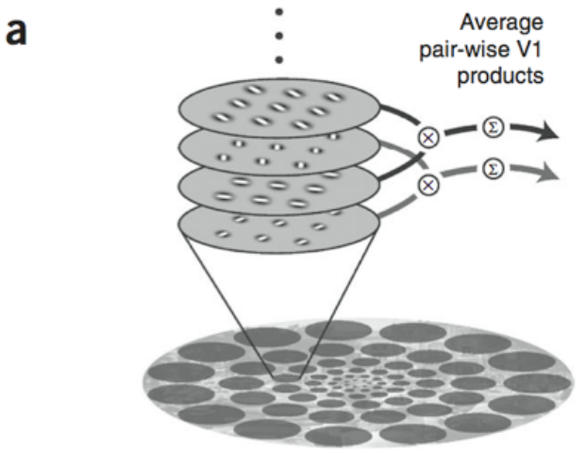
Synthetic textures

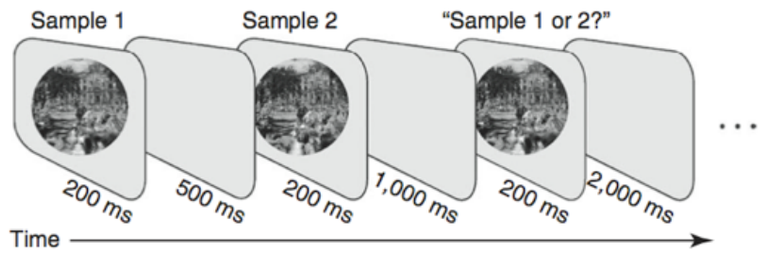






nature neuro

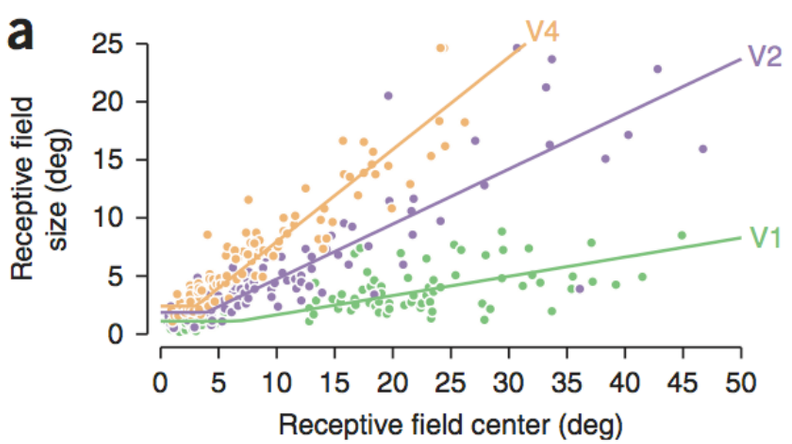


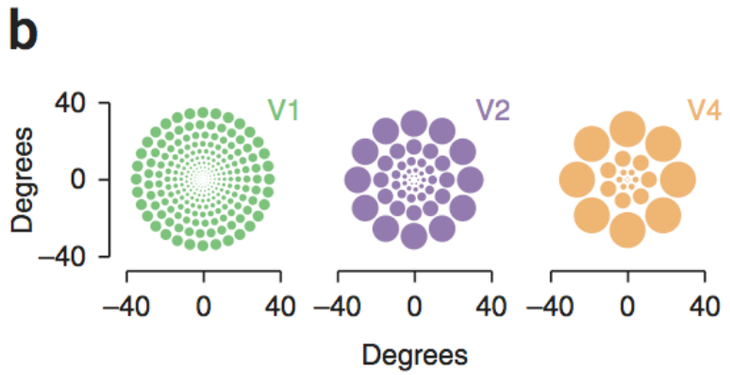


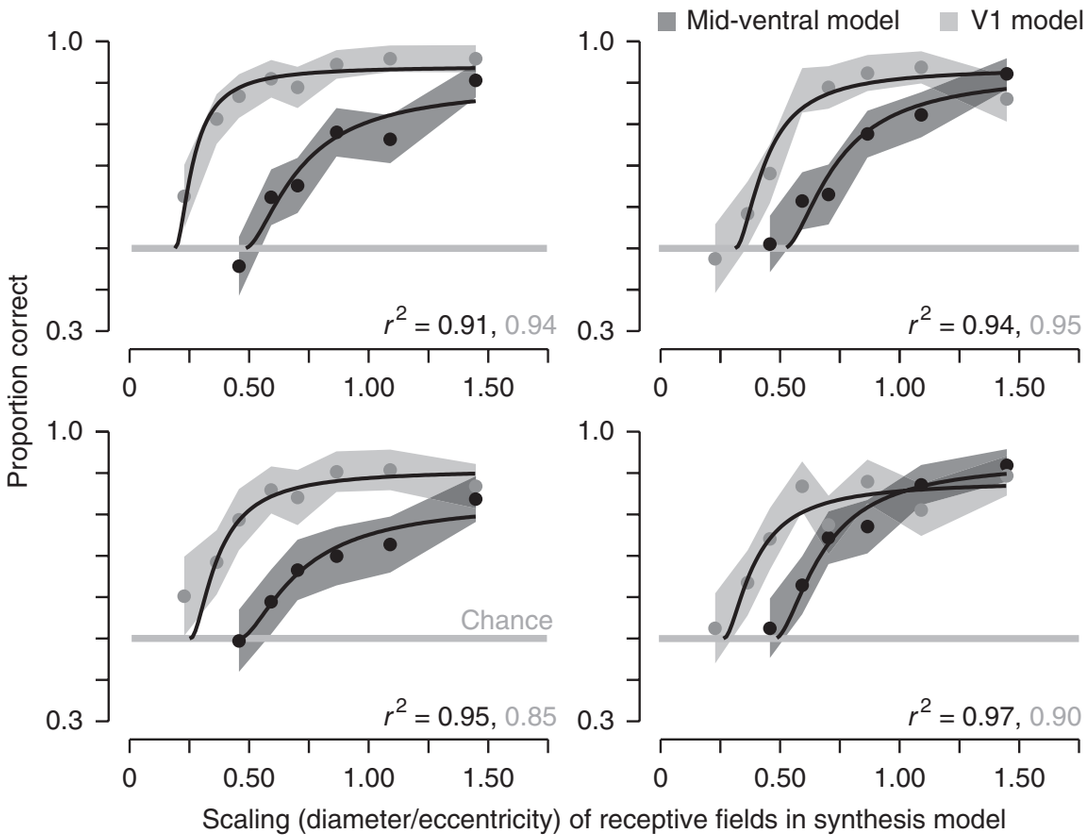
Meta

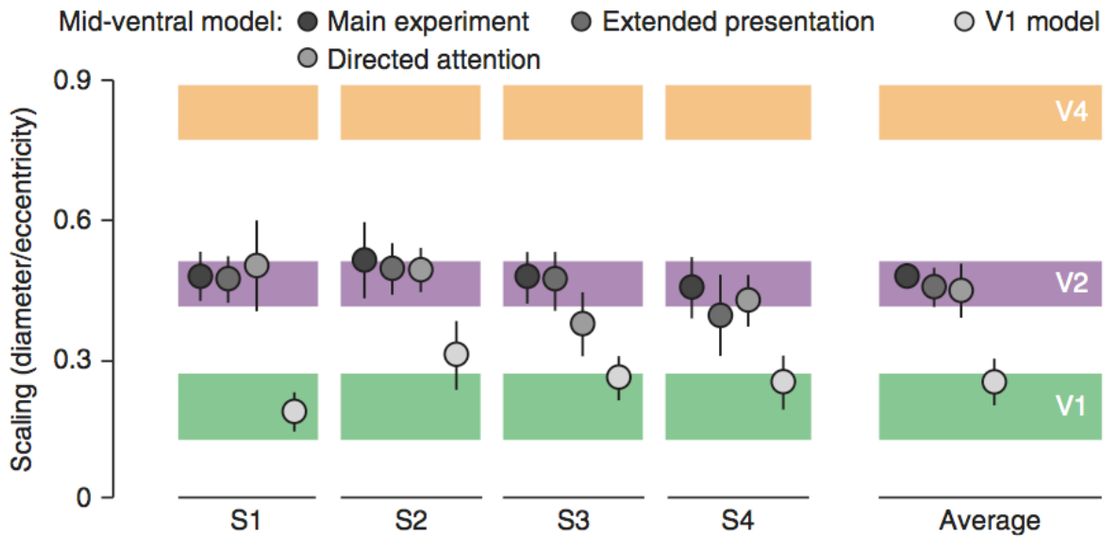
Jeremy F

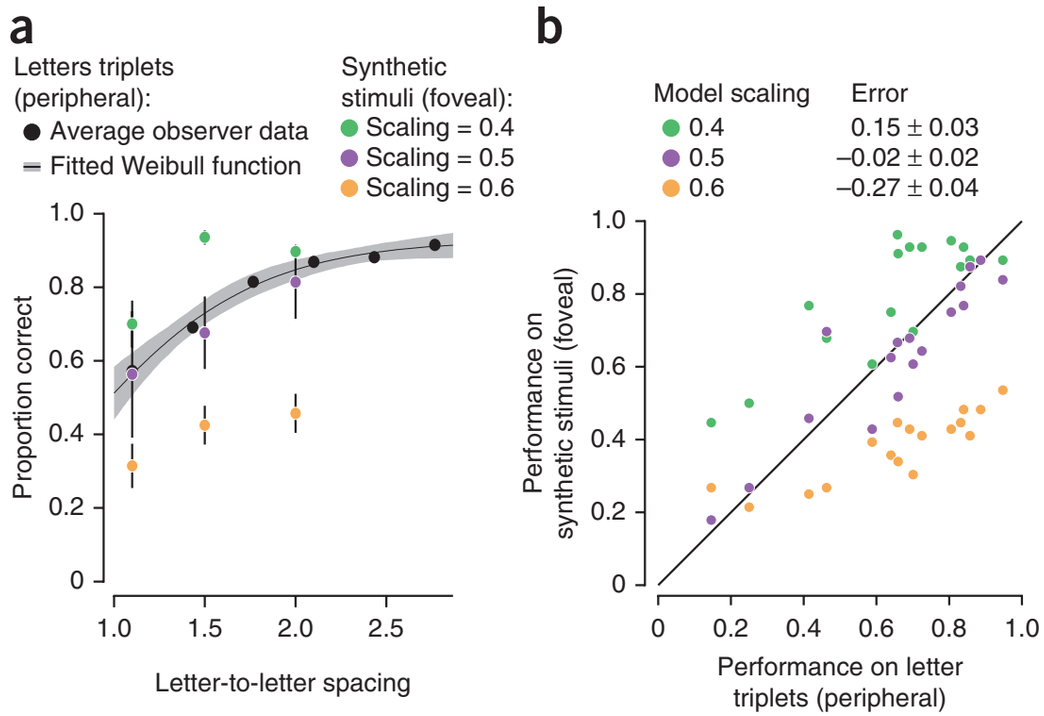
The human, beginning
with prima ons of V1
responses metamers,
stimuli tha the
receptive f eam, our
behavioral cate visual
area V2, p own as
crowding,






Mid-ventral model
V1 model
Proportion correct
1.0
0.3
0
0.50
1.00
1.50
r^2 = 0.91, 0.94
r^2 = 0.94, 0.95
Chance
r^2 = 0.95, 0.85
r^2 = 0.97, 0.90
Scaling (diameter/eccentricity) of receptive fields in synthesis model


Mid-ventral model:
Main experiment
Extended presentation
V1 model
Directed attention
Scaling (diameter/eccentricity)
0.9
0.6
0.3
0
V4
V2
V1
S1
S2
S3
S4
Average


a
Letters triplets (peripheral):
Average observer data
Fitted Weibull function
Synthetic stimuli (foveal):
Scaling = 0.4
Scaling = 0.5
Scaling = 0.6
Proportion correct
1.0
0.8
0.6
0.4
0.2
0
1.0
1.5
2.0
2.5
Letter-to-letter spacing
b
Model scaling
Error
0.4
0.15 ± 0.03
0.5
–0.02 ± 0.02
0.6
–0.27 ± 0.04
Performance on synthetic stimuli (foveal)
Performance on letter triplets (peripheral)

ARTICLES

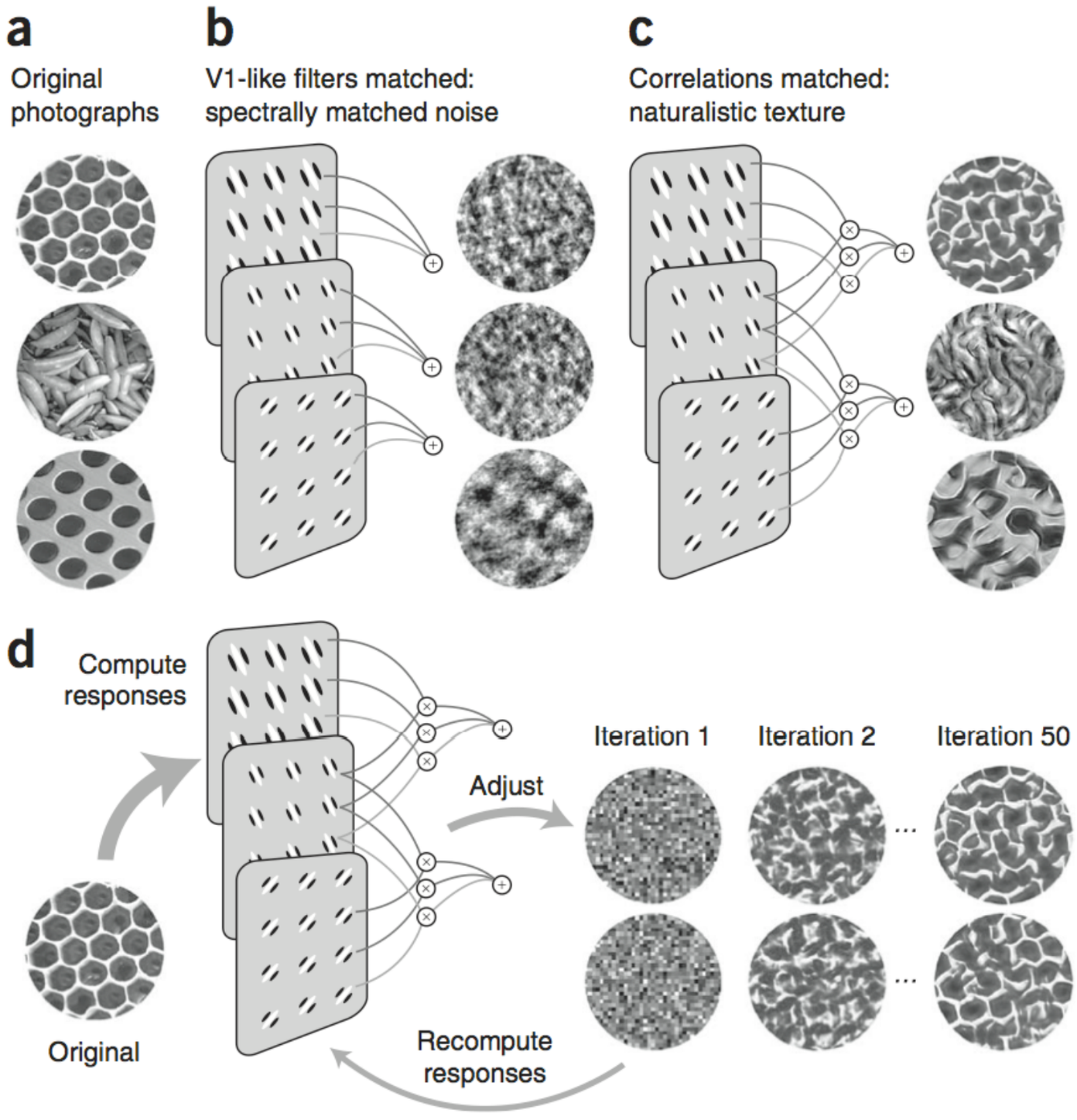
nature neuroscience

A functional and perceptual signature of the second visual area in primates

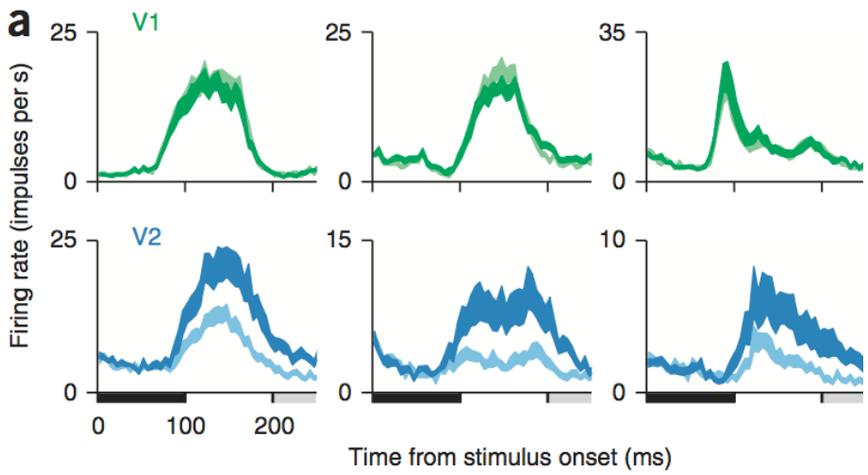
Jeremy Freeman[1,5,7], Corey M Ziemba[1,5], David J Heeger[1,2], Eero P Simoncelli[1–4,6] & J Anthony Movshon[1,2,6]

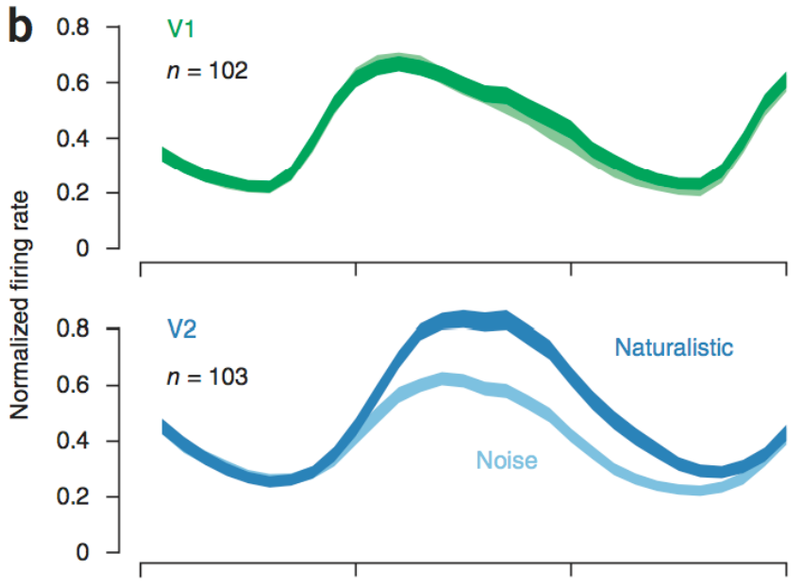
There is no generally accepted account of the function of the second visual cortical area (V2), partly because no simple response properties robustly distinguish V2 neurons from those in primary visual cortex (V1). We constructed synthetic stimuli replicating the higher-order statistical dependencies found in natural texture images and used them to stimulate macaque V1 and V2 neurons. Most V2 cells responded more vigorously to these textures than to control stimuli lacking naturalistic structure; V1 cells did not. Functional magnetic resonance imaging (fMRI) measurements in humans revealed differences between V1 and V2 that paralleled the neuronal measurements. The ability of human observers to detect naturalistic structure in different types of texture was well predicted by the strength of neuronal and fMRI responses in V2 but not in V1. Together, these results reveal a particular functional role for V2 in the representation of natural image structure.

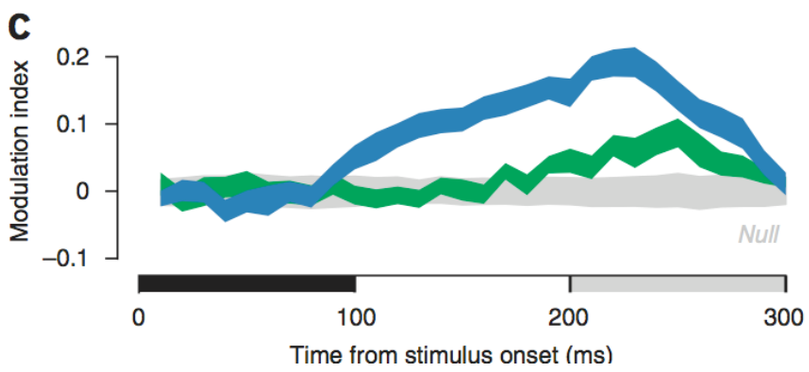
Synthetising images

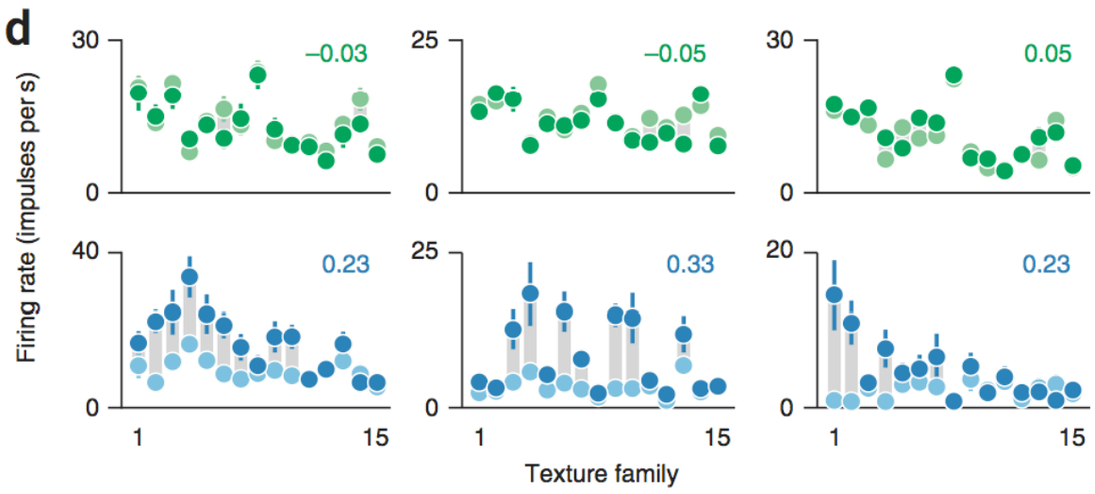


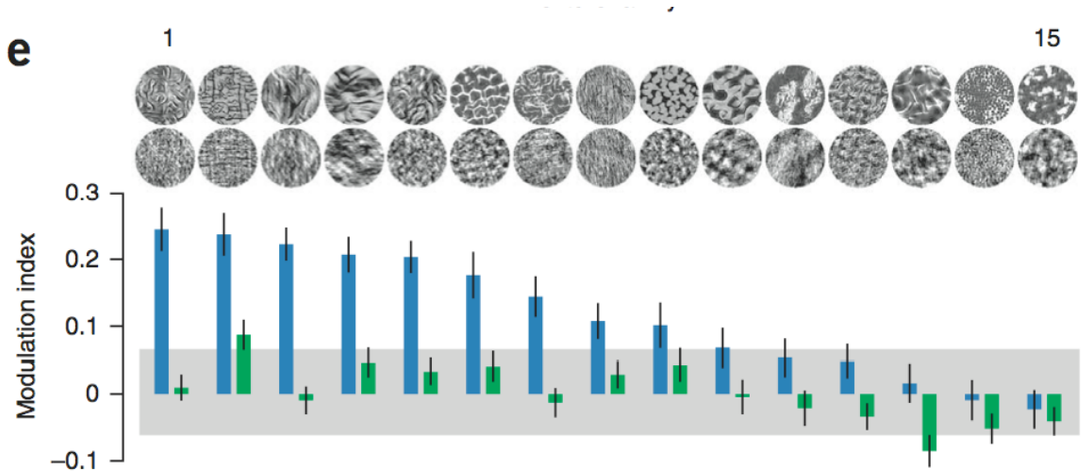
V2 responses to Portilla textures

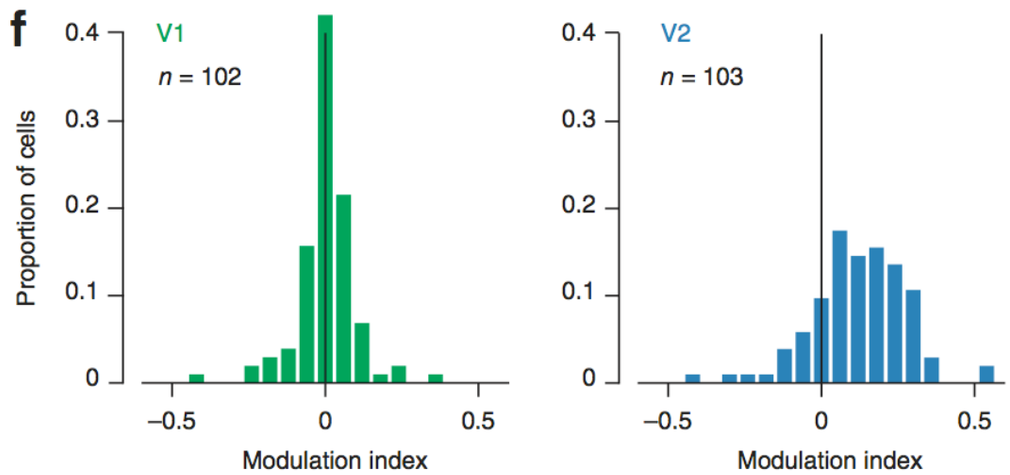




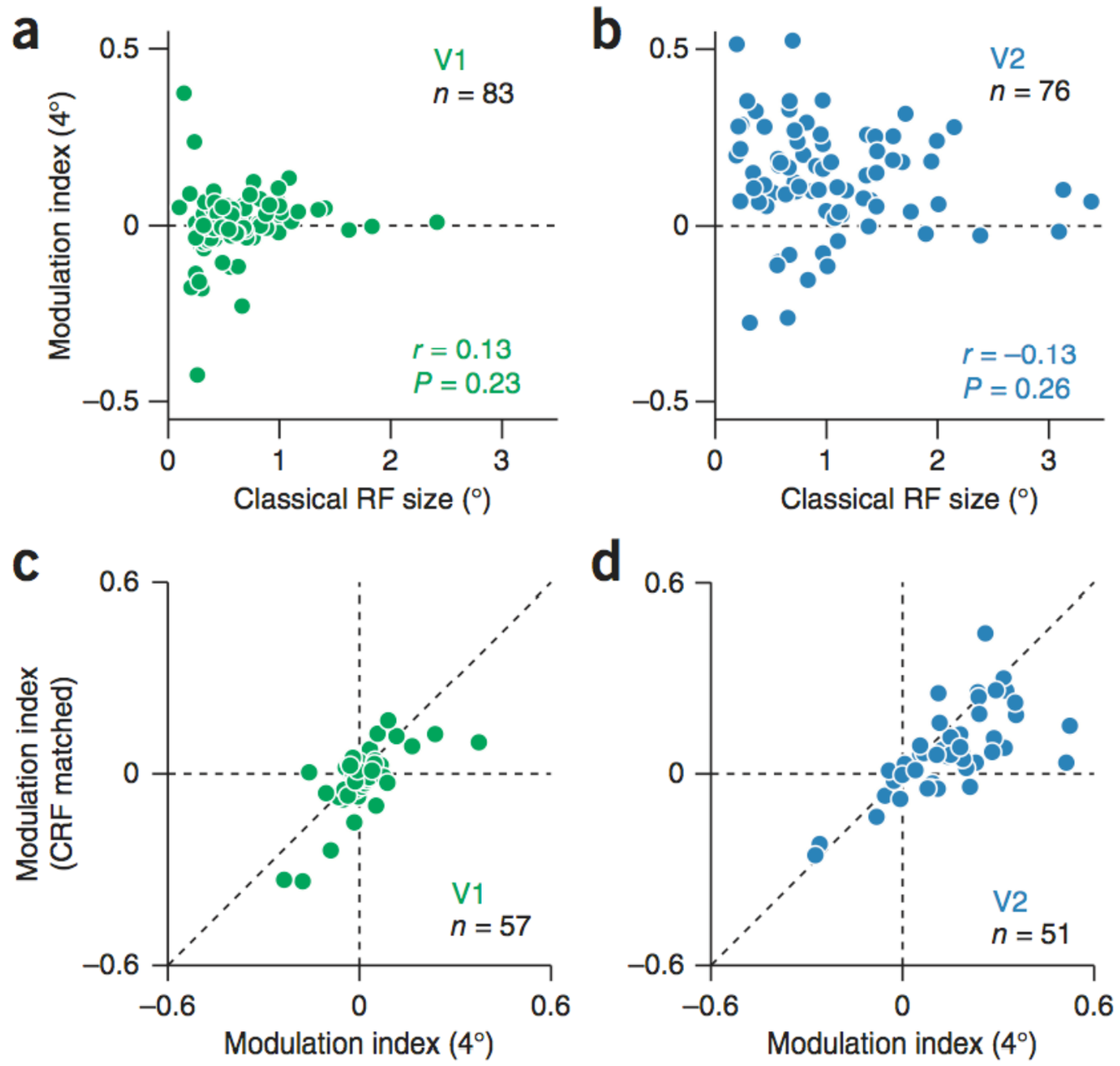




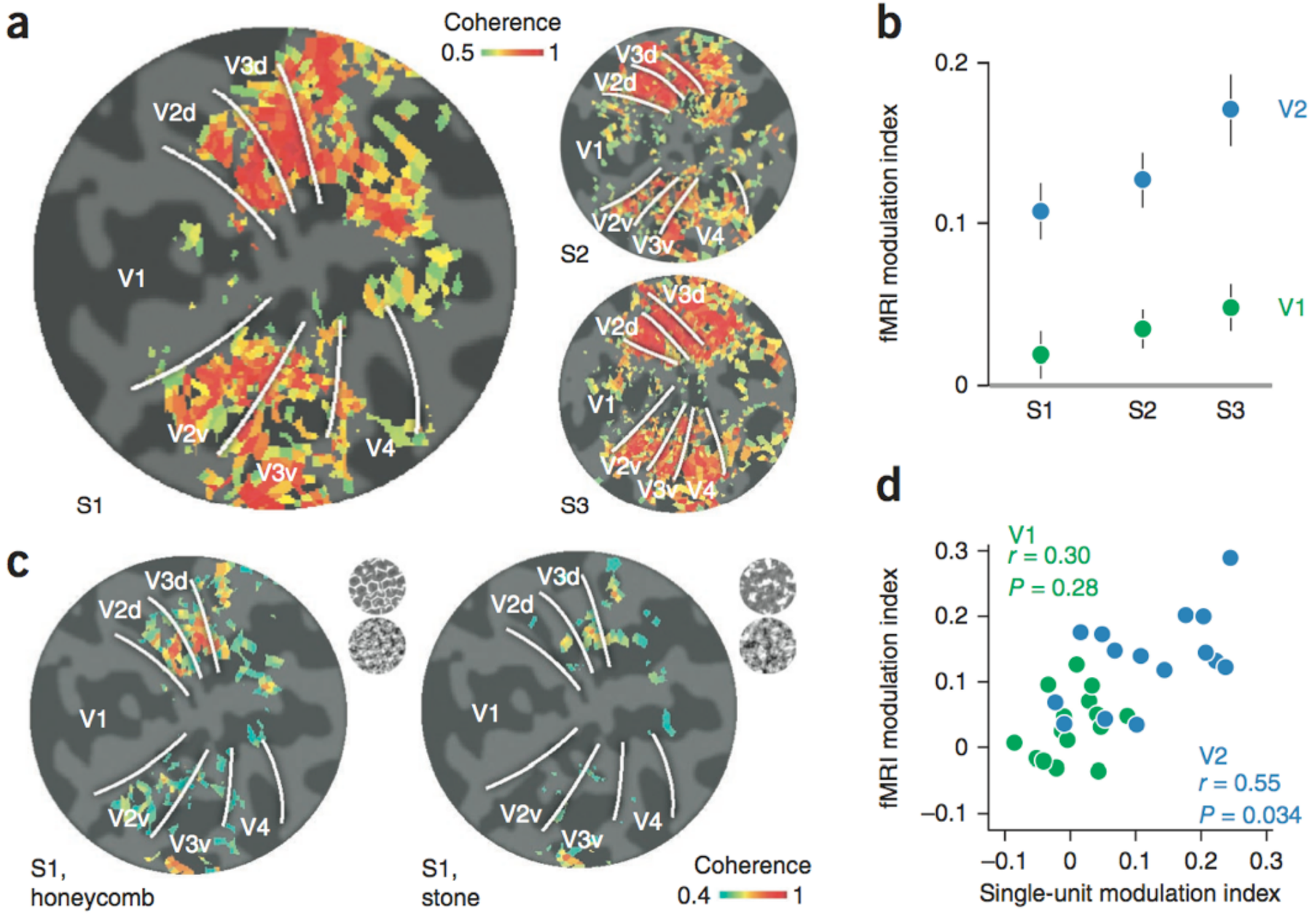




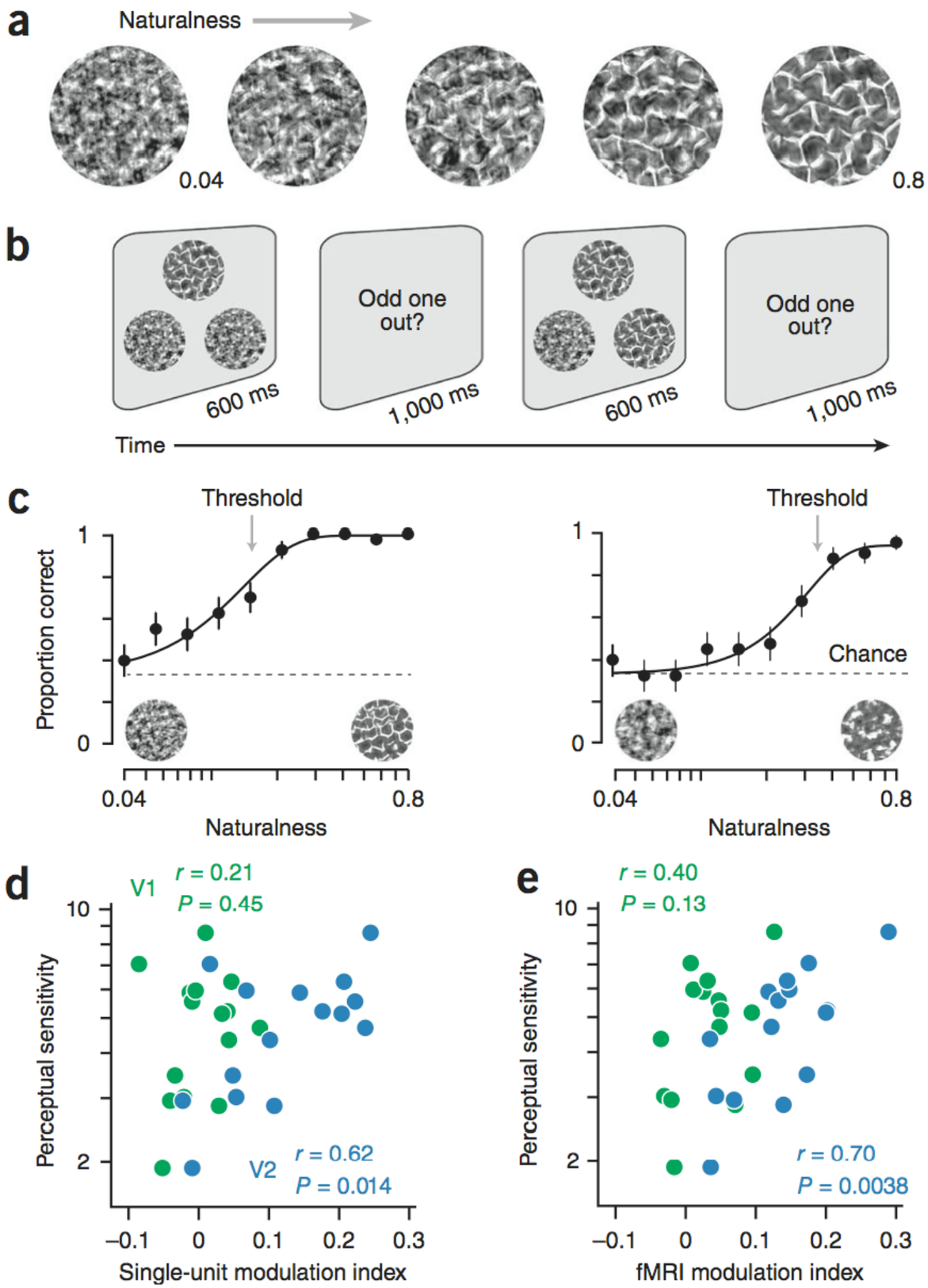
V2 responses to Portilla textures



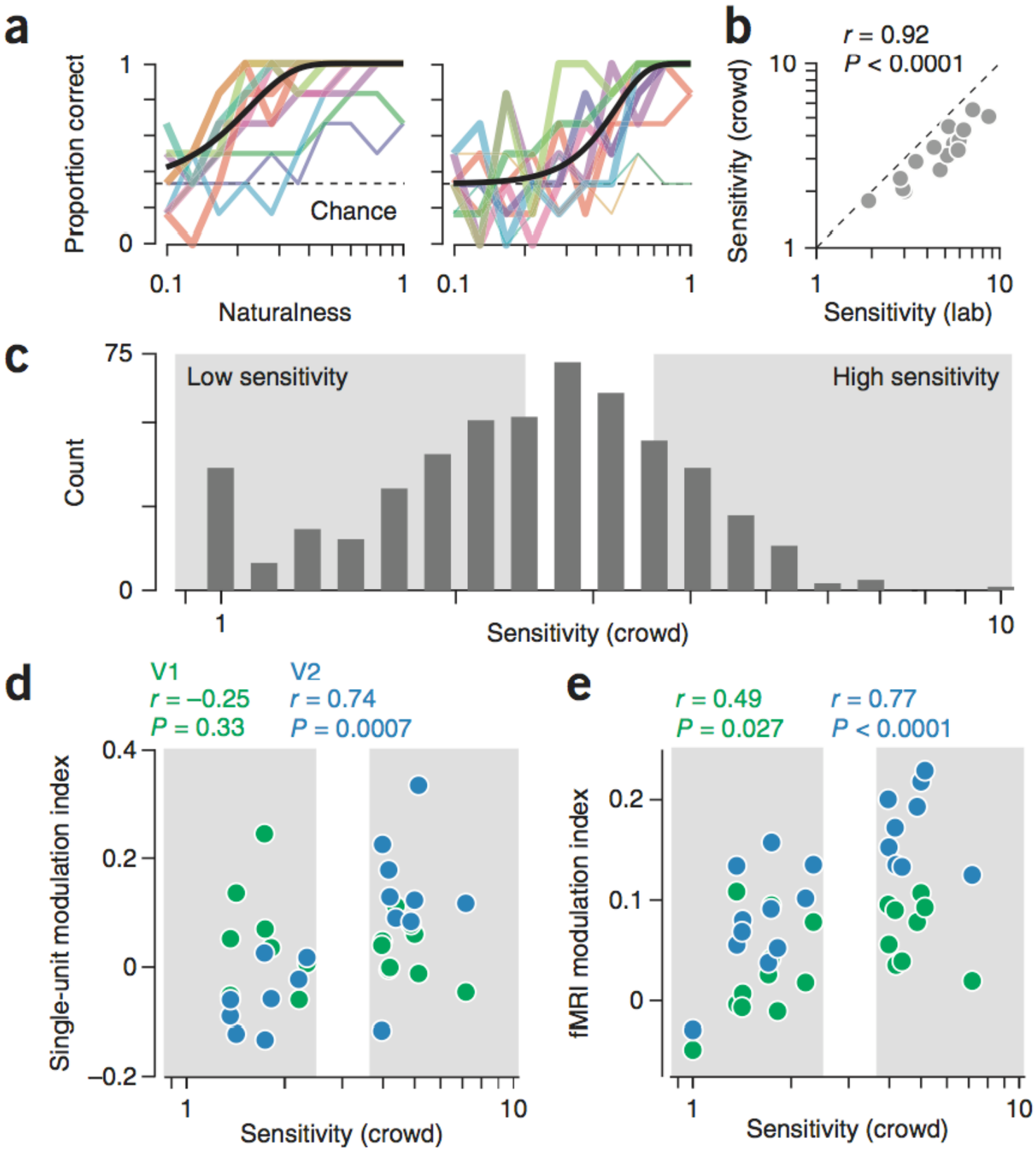
fMRI responses to Portilla textures



Perceptual correlates



The mechanical Turk challenge



The mechanical Turk challenge