Network-level interactions drive response properties in word- and face- selective cortex
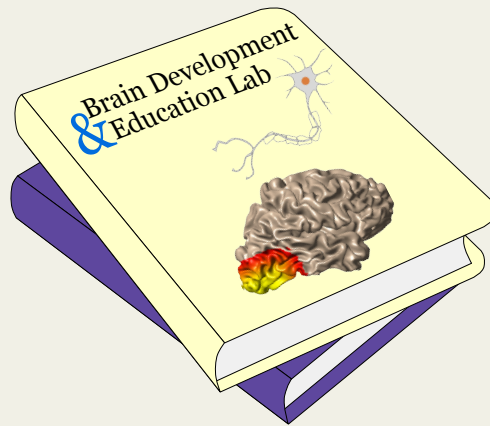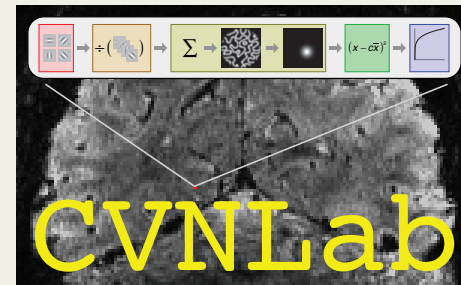
Jason D. Yeatman   &   Kendrick N. Kay
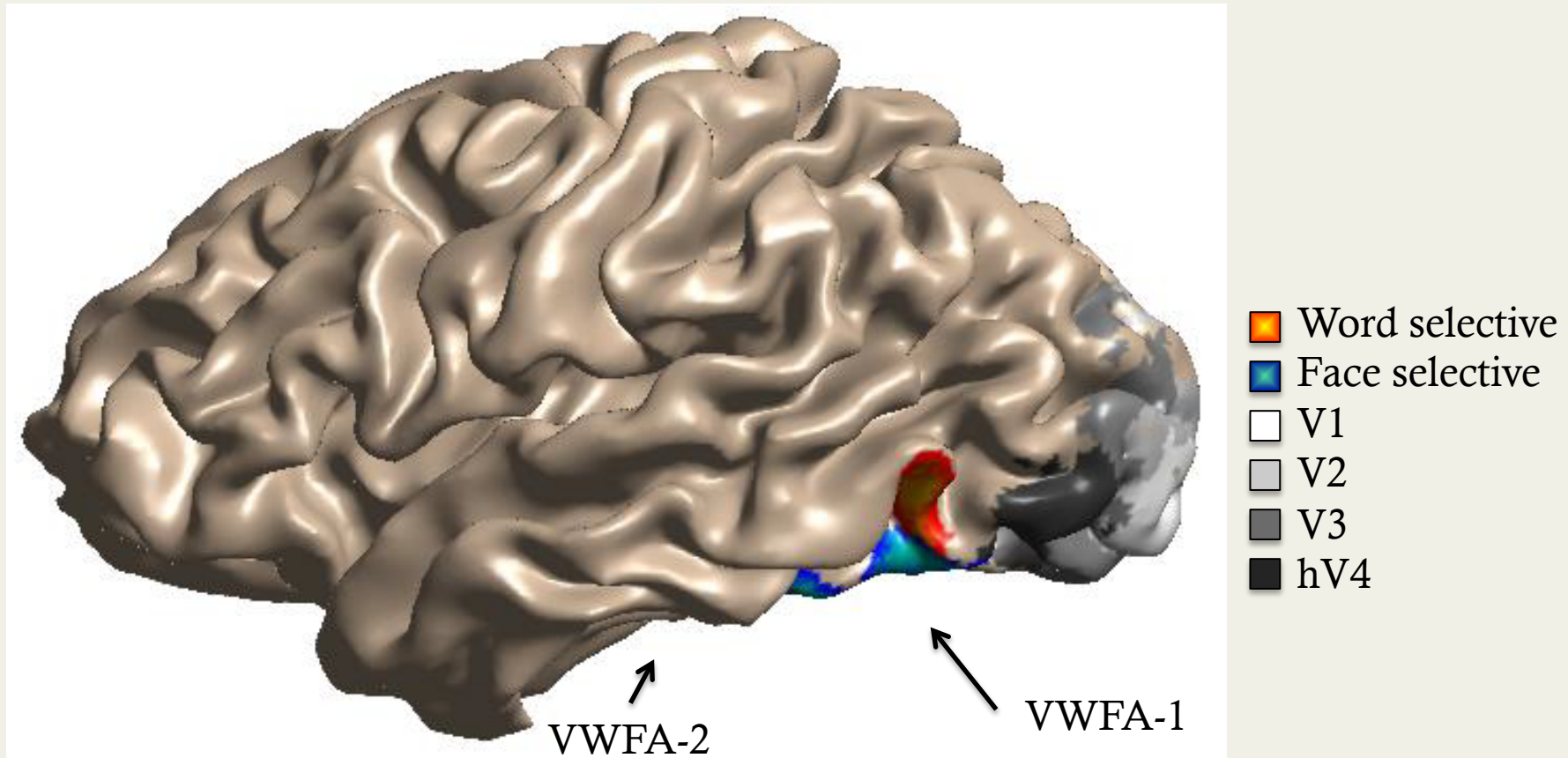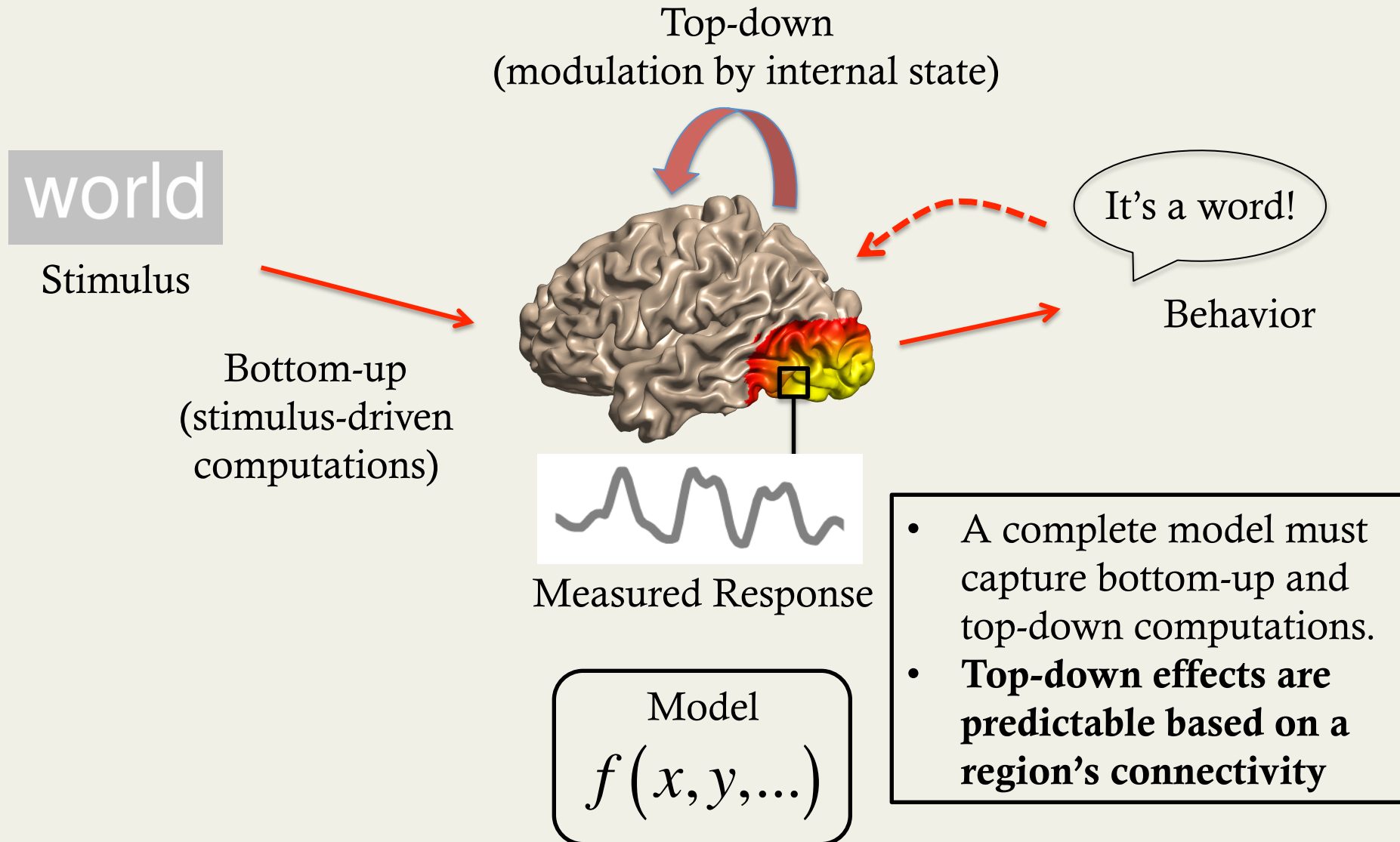
Word selective cortex lies at the intersection of vision and language

What does connectivity tell us about cortical computation?

Word selective
Face selective
V1
V2
V3
hV4

VWFA-2

VWFA-1

Arcuate Fasciculus (AF) ▢
Inferior Longitudinal Fasciculus (ILF) ▢
Vertical Occipital Fasciculus (VOF) ▢

Modeling word- and face-selective cortex

Top-down
(modulation by internal state)

world

Stimulus

Bottom-up
(stimulus-driven
computations)

It's a word!

Behavior

Measured Response

Model
$$f(x, y, \ldots)$$

- A complete model must capture bottom-up and top-down computations.
- **Top-down effects are predictable based on a region's connectivity**

Localizing word and face selective cortex

Retinotopy

Localizer: Face, object and word selective regions

1s
1s
1s

16s 16s 16s 16s

Word selective
Face selective
V1
V2
V3
hV4

VWFA-2
FFA-2
FFA-1
VWFA-1
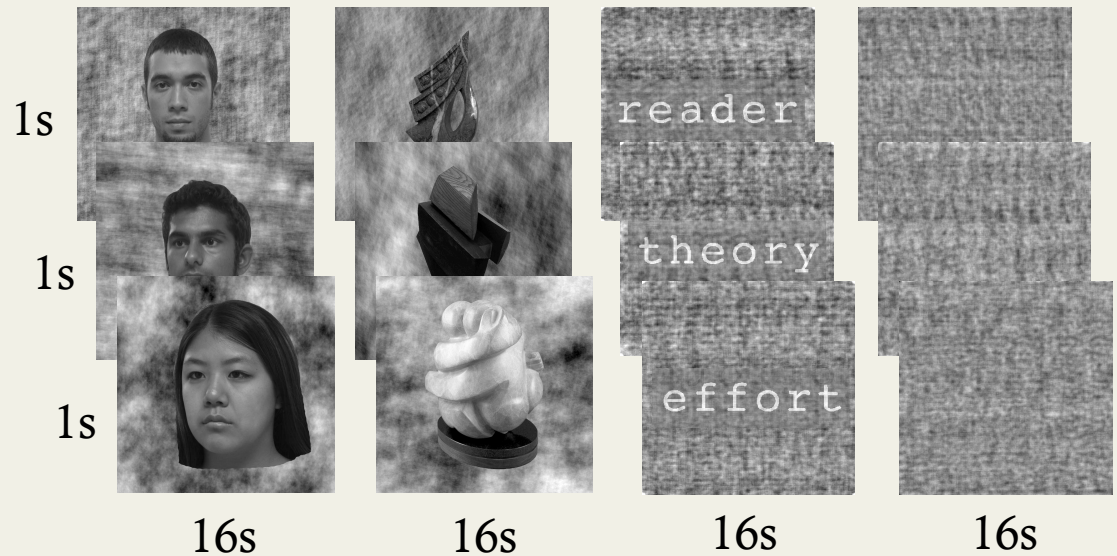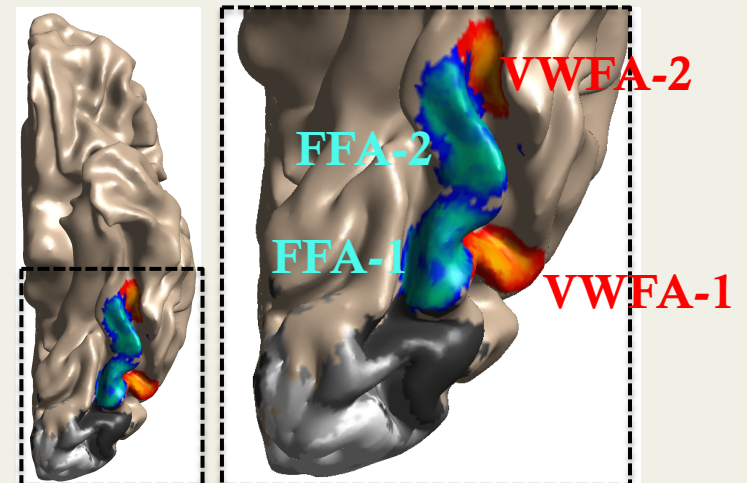
Retinotopy courtesy of K. Kay
Face and object images courtesy of
K. Weiner & K. Grill-Spector

Grill-Spector & Weiner, 2014, *Nat. Rev. Neurosci.*

Isolating bottom-up computations

Fixation Task
Is the dot red?

0.8 (s)   0.8 (s)   0.8 (s)   0.8 (s)

4 (s)

VWFA is sensitive to <u>low-level</u> properties and the <u>category</u> of the image

Word

Face

Noise

Fixation Task

Category model

BOLD response (% change)

Contrast (%)

Kay & Yeatman, *pre-print* http://biorxiv.org/content/early/2016/05/16/053595
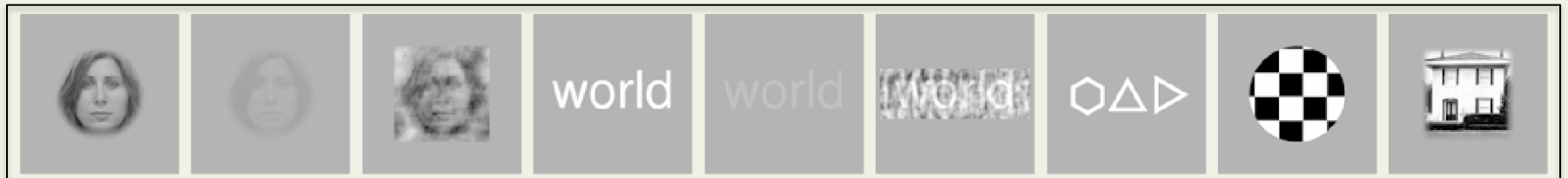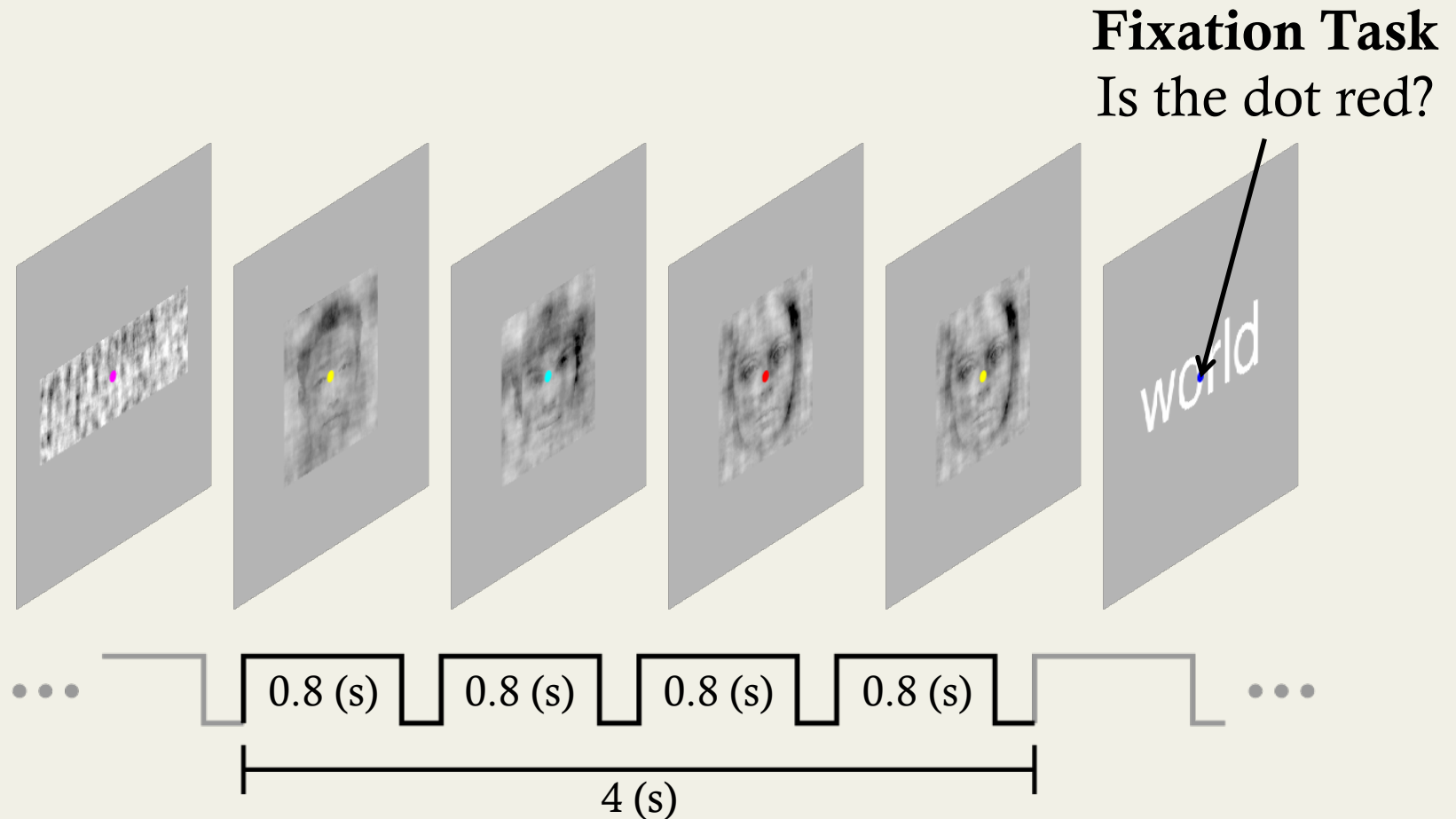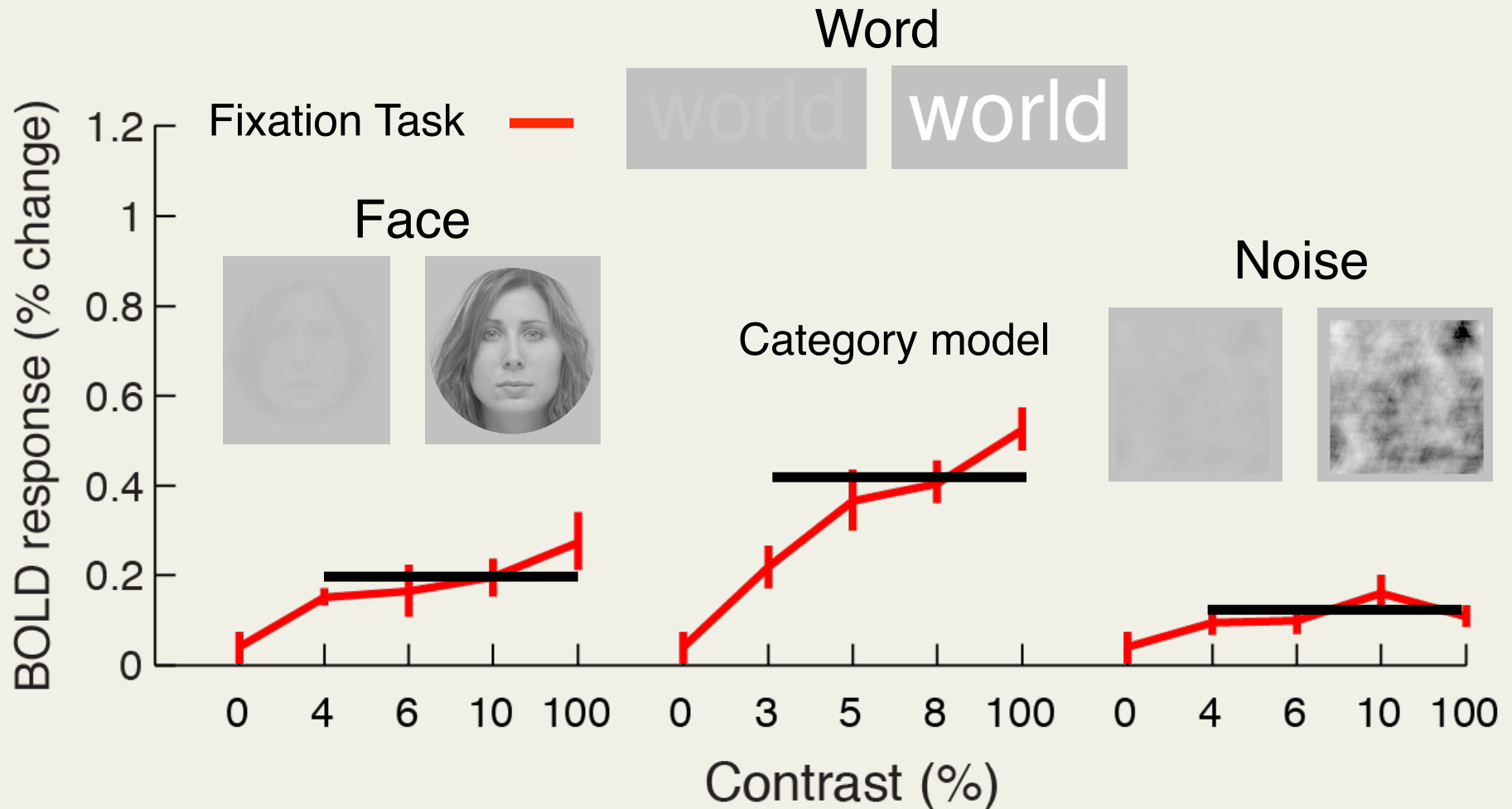
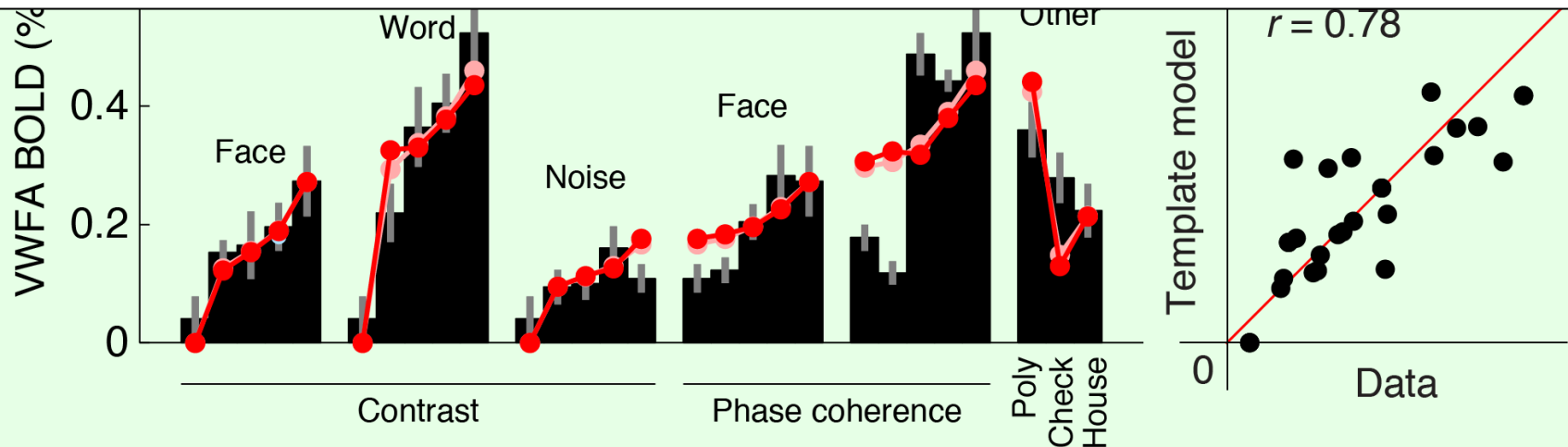# Bottom-up model based on image computations

Model architecture - Template model of ventral temporal cortex
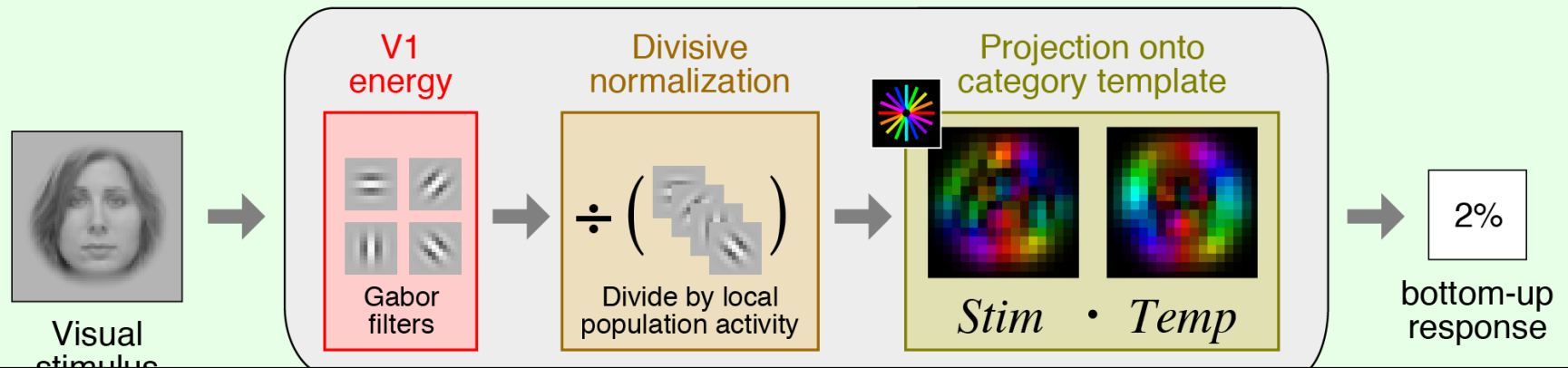
Poster #33.4071 Sunday, May 15, 8:30 am - 12:30 pm: <u>A fully computable model of bottom-up and top-down processing in high-level visual cortex</u>
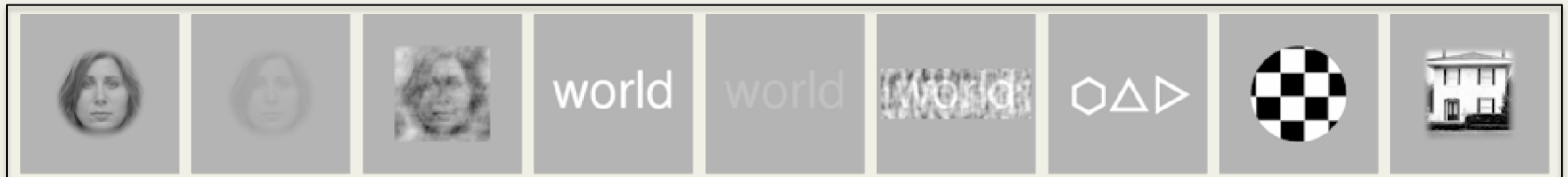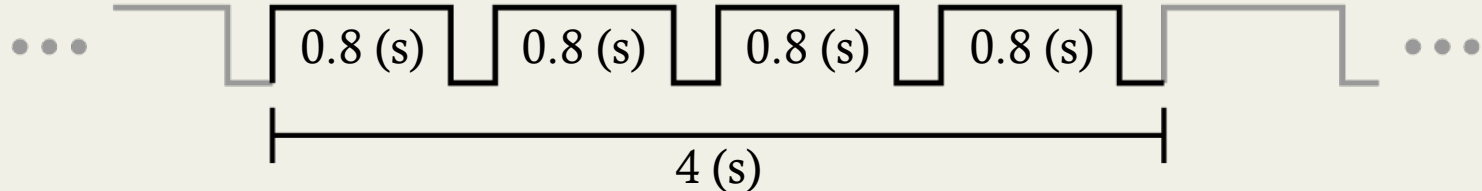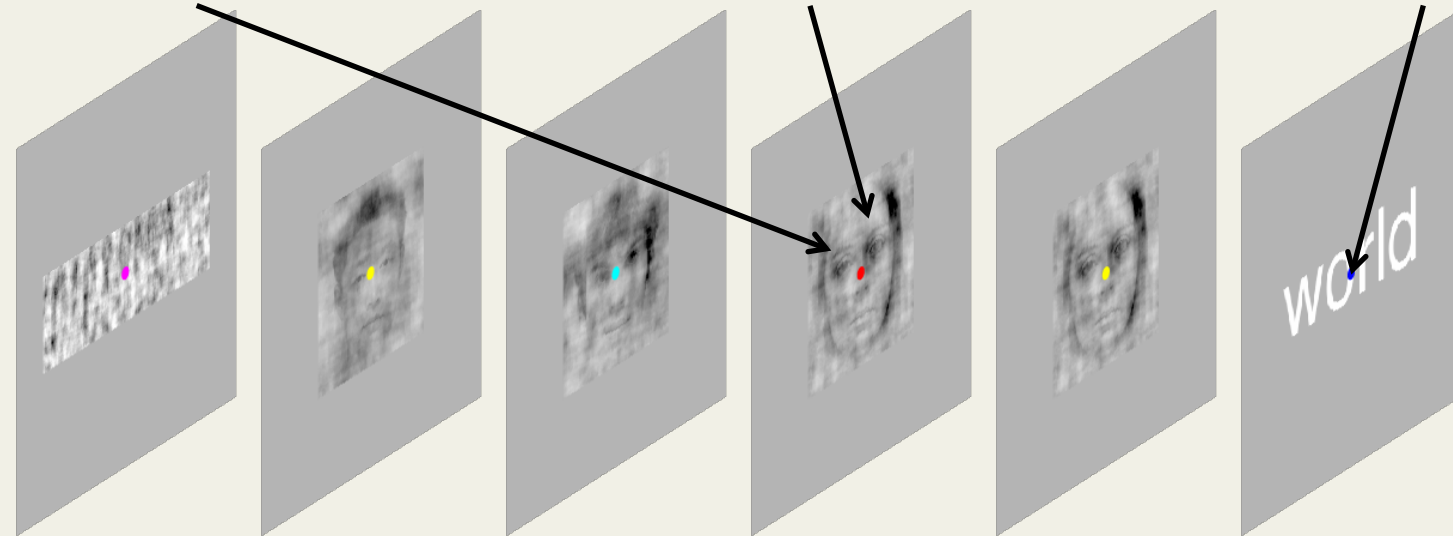
Measuring top-down modulation

One-back Task
Did an image repeat?

Categorization Task
Word, face or other?

Fixation Task
Is the dot red?

VWFA is sensitive to <u>low-level</u> properties and the <u>category</u> of the image
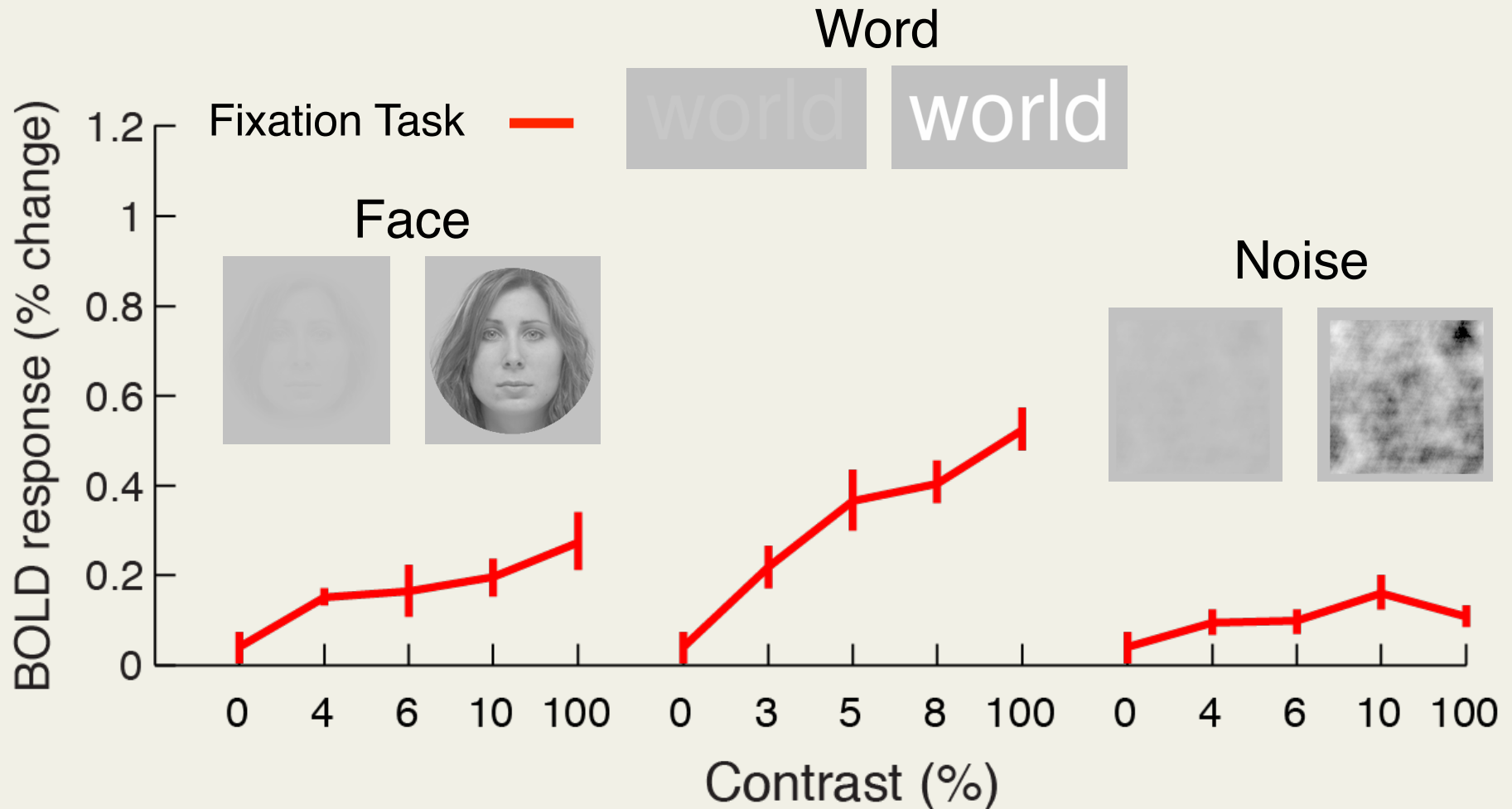
Kay & Yeatman, *pre-print http://biorxiv.org/content/early/2016/05/16/053595*

Stimulus specific scaling during the execution of a cognitive task

- Scaling reflects task demands.

Categorization — (green)
Fixation Task — (red)

Face

BOLD response (% change)

Contrast (%)

Stimulus specific scaling during the execution of a cognitive task

- Scaling reflects task demands.
- Bottom-up, image model cannot account for the responses profile.
- Are these computations intrinsic to the VWFA or do they reflect the influence of other regions in the circuit?

Kay & Yeatman, *pre-print http://biorxiv.org/content/early/2016/05/16/053595*
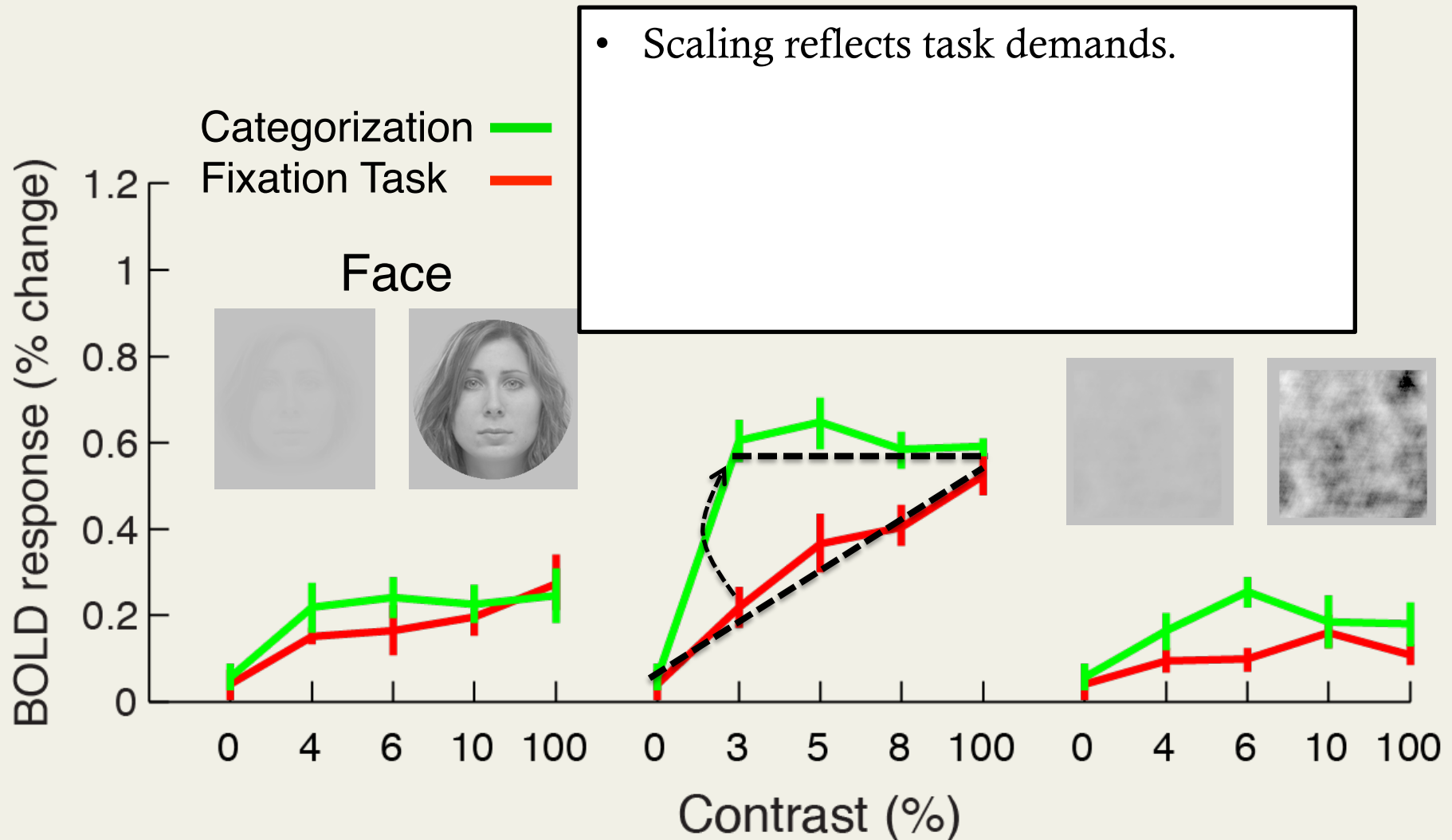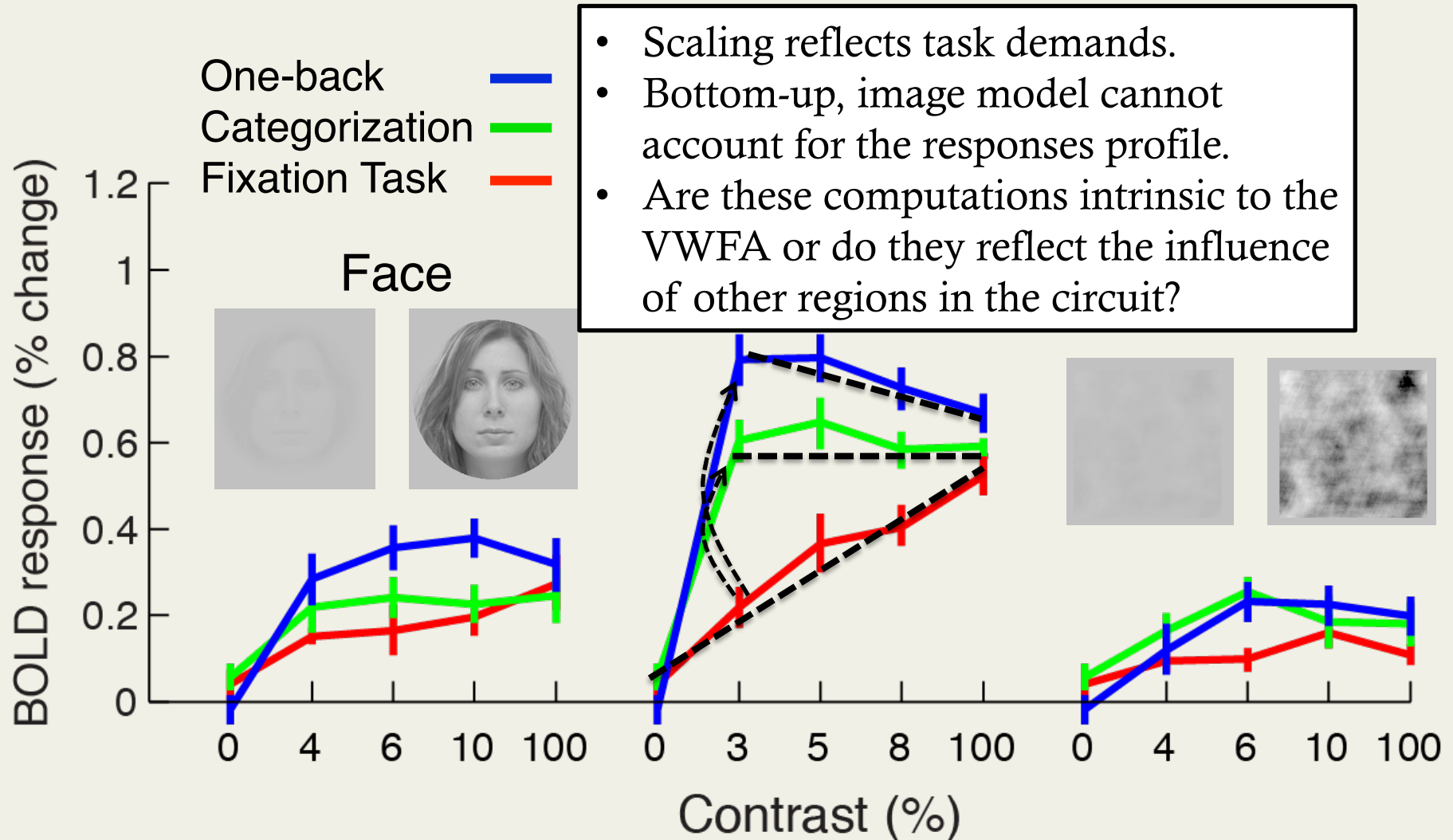
Isolating the effect of top-down modulation

Kay & Yeatman, *pre-print http://biorxiv.org/content/early/2016/05/16/053595*
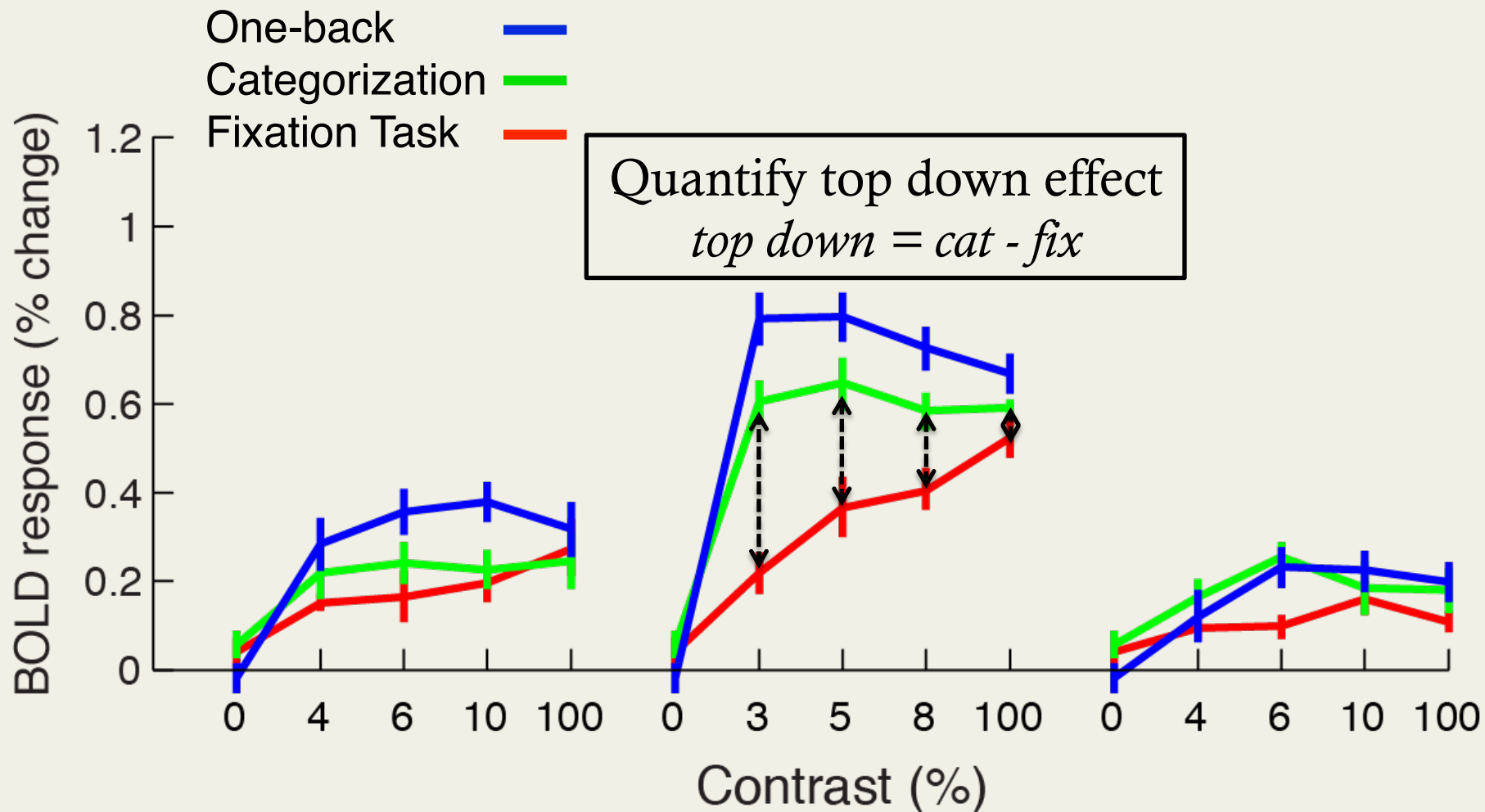
IPS predicts stimulus specific response gain

Task-related response gain (VWFA)

One-back ———   Categorization ———

Kay & Yeatman, *pre-print http://biorxiv.org/content/early/2016/05/16/053595*
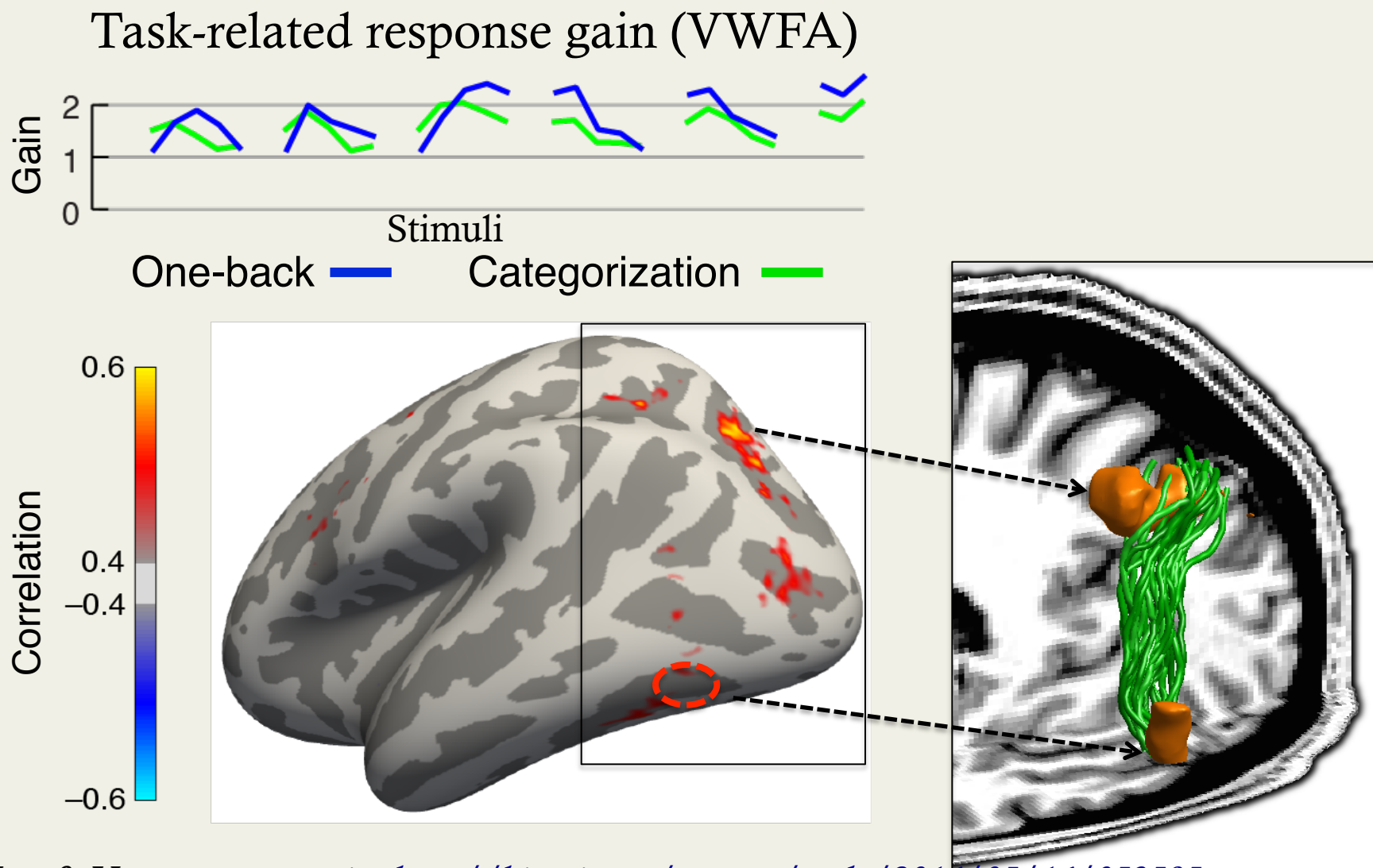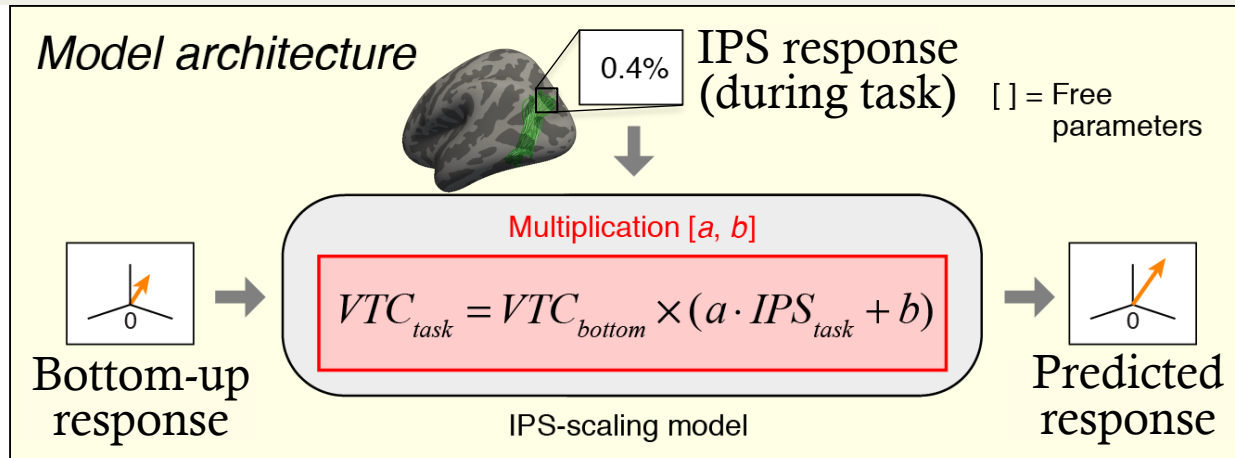
IPS-scaling model

Model architecture
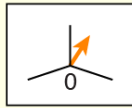
Bottom-up
response

IPS-scaling model

IPS-scaling model

Model architecture

IPS response (during task)

[ ] = Free parameters

0.4%

Bottom-up response

Multiplication [a, b]

$$VTC_{task} = VTC_{bottom} \times (a \cdot IPS_{task} + b)$$

IPS-scaling model

Predicted response
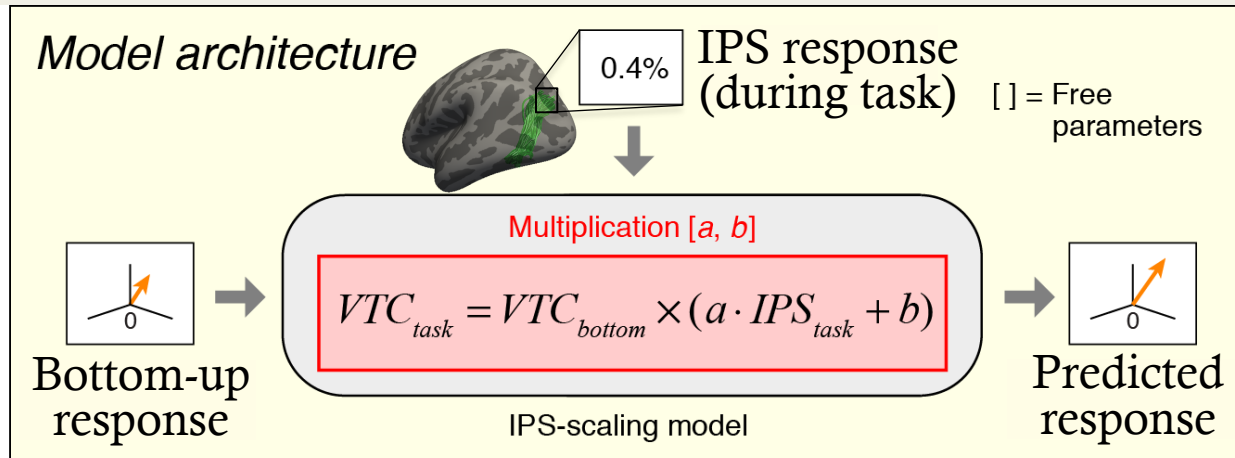
Cross-validation performance

IPS-scaling model

$r = 0.96$

VWFA

Model / Data

Gain

BOLD (% change)

Face, Word, Noise, Word

Contrast — Phase coh. — Other

Face, Word, Noise, Face, Word

Contrast — Phase coh. — Other

Face, Word, Noise, Face, Word

Contrast — Phase coh. — Other

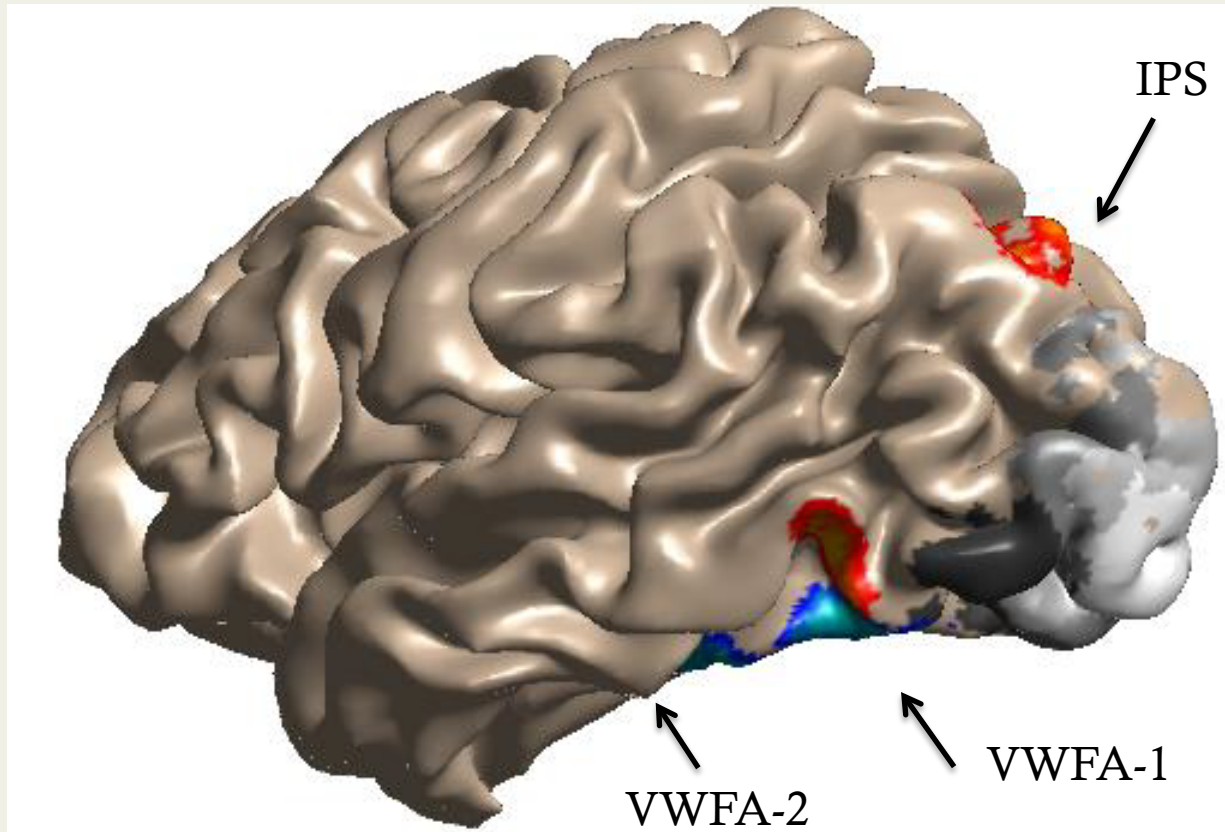Fixation Task   Categorization task   One-back Task
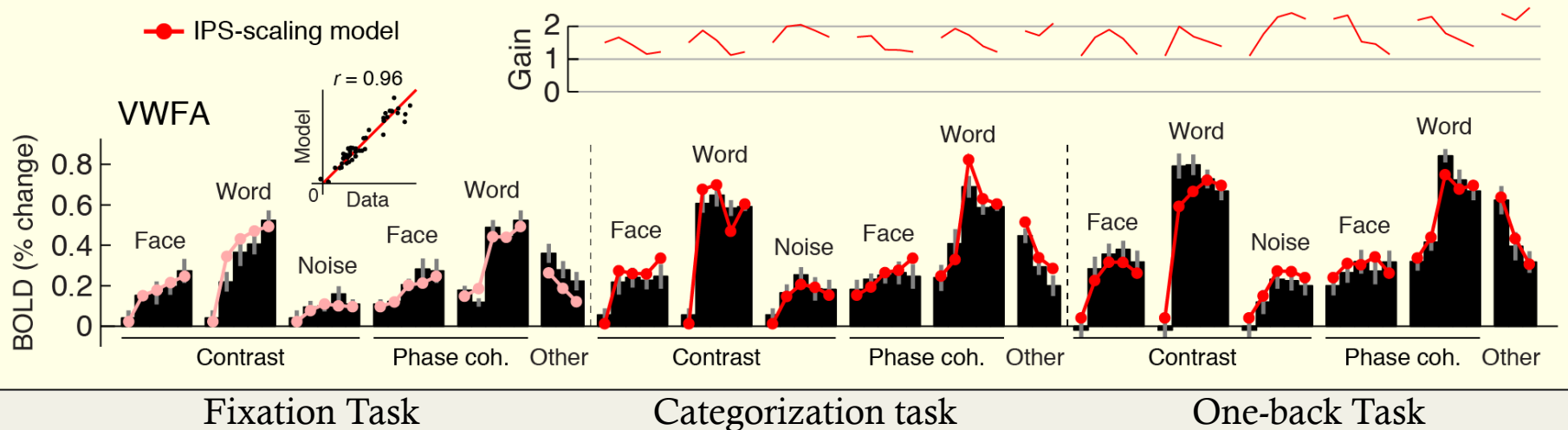
Perceptual functions reflects local computations and circuit level interactions

IPS

VWFA-2

VWFA-1

Arcuate Fasciculus (AF) ■
Inferior Longitudinal Fasciculus (ILF) ■
Vertical Occipital Fasciculus (VOF) ■

- Bottom-up responses can be predicted from image based computations.

- The representation of the stimulus is scaled, through interactions with the IPS, to meet the perceptual demands of the task.

- The VOF is the anatomy that underlies this computation.

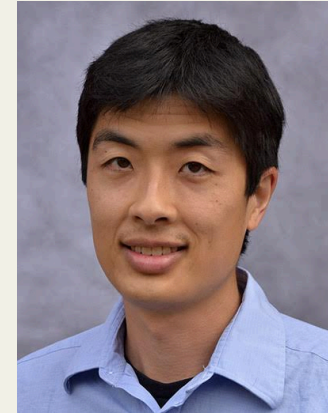- How does VWFA-2 differ from VWFA-1?

Thank you

BCS - 151330

Contact:
jyeatman@uw.edu

Kendrick Kay

Poster #33.4071 Sunday, 8:30 am - 12:30 pm

UNIVERSITY *of* WASHINGTON

UNIVERSITY OF MINNESOTA

Stimulus specific scaling in VTC