The human brain mechanisms of afterimages:
From networks to cortical layers

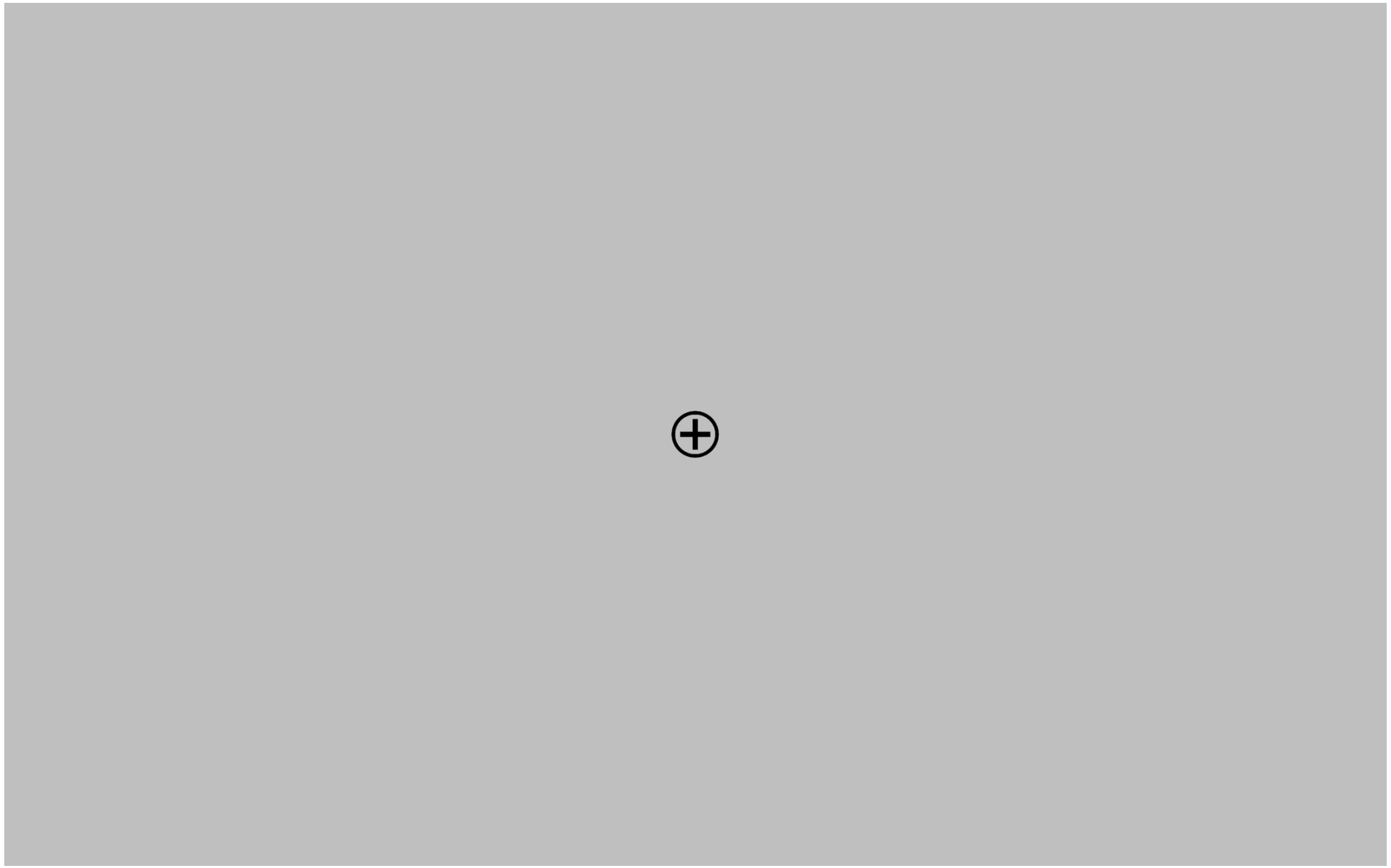
Burak Akin, Micah Holness, Tyler Morgan, Renzo Huber, Paul A. Taylor, Javier Gonzalez-Castillo, Daniel Handwerker, Peter Bandettini

Sharif I. Kronemer

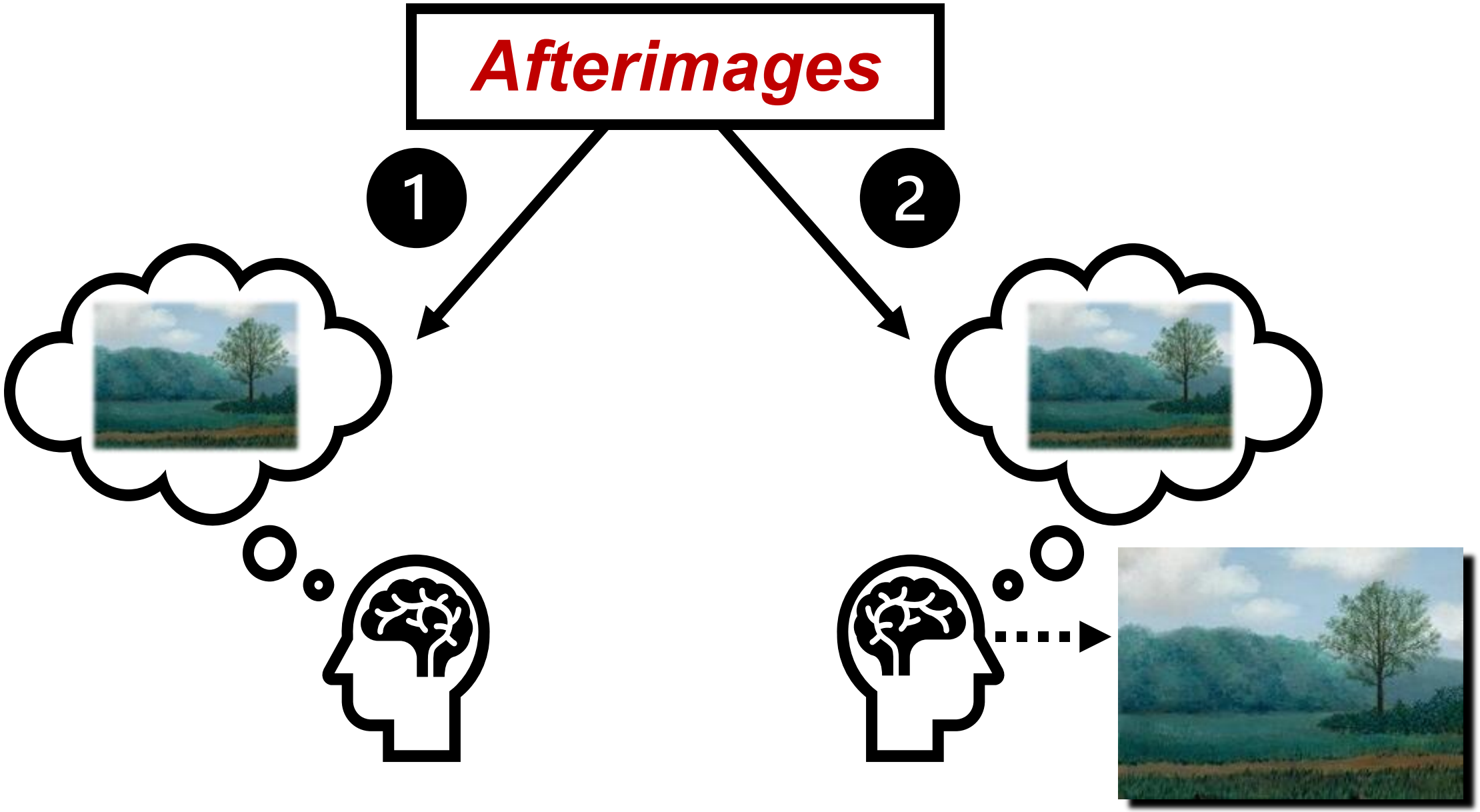
August 18, 2025

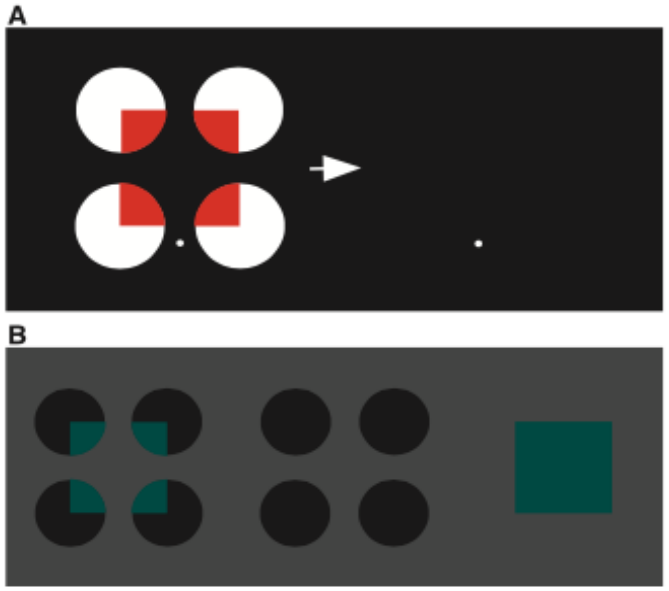
The Human Condition (1933)
Rene Magritte

Afterimages

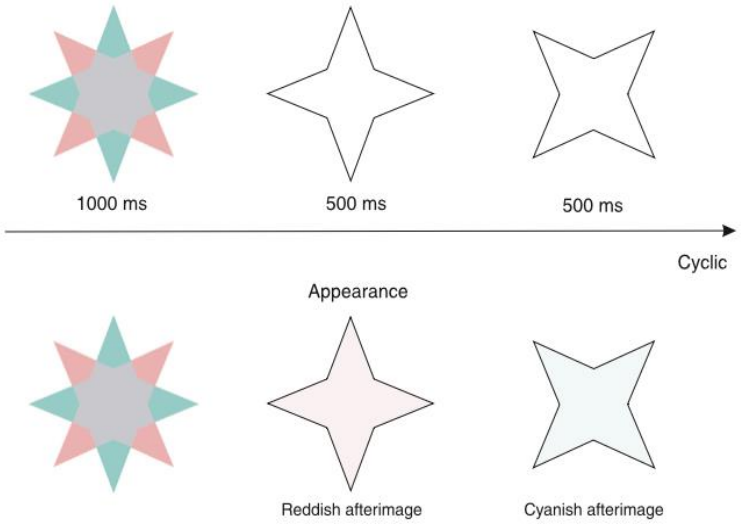


"Are afterimages retinal or cortical?"

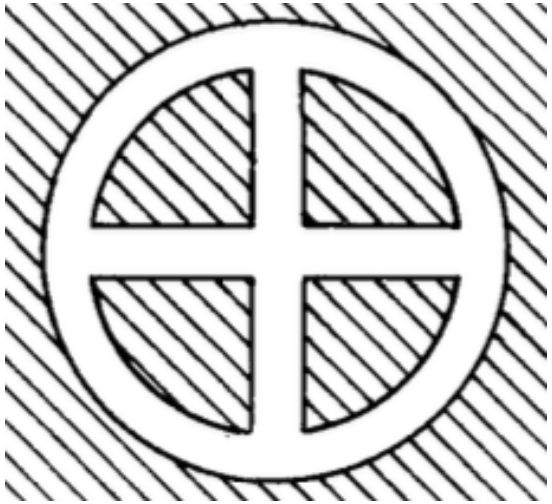


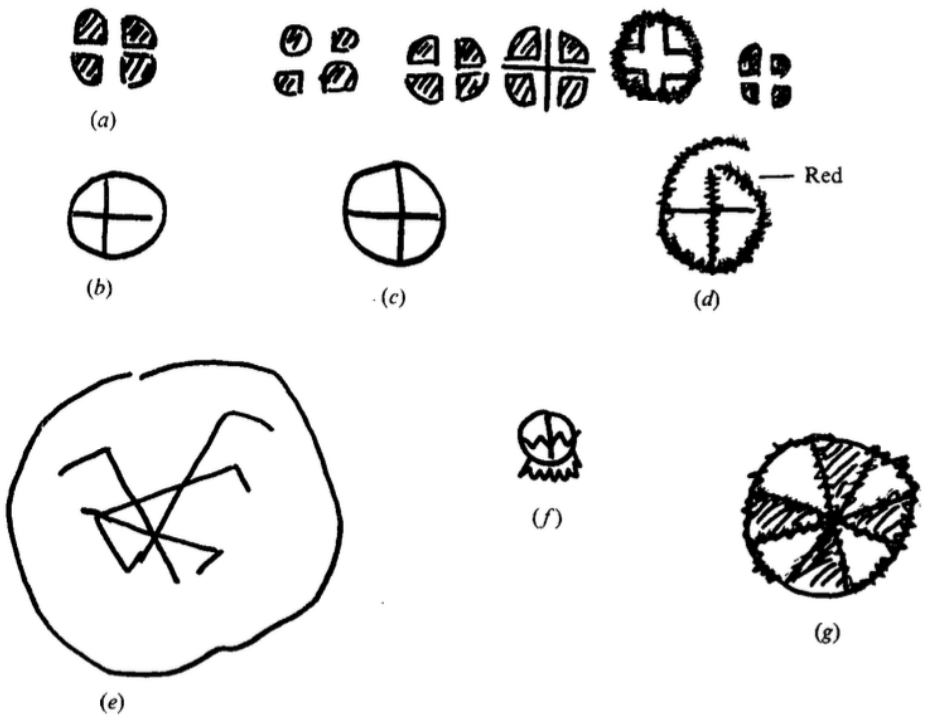


Shimojo et al., *Science*, 2001



Van Lier et al., *Curr Biol*, 2009





Davies, *J Psych*, 1974

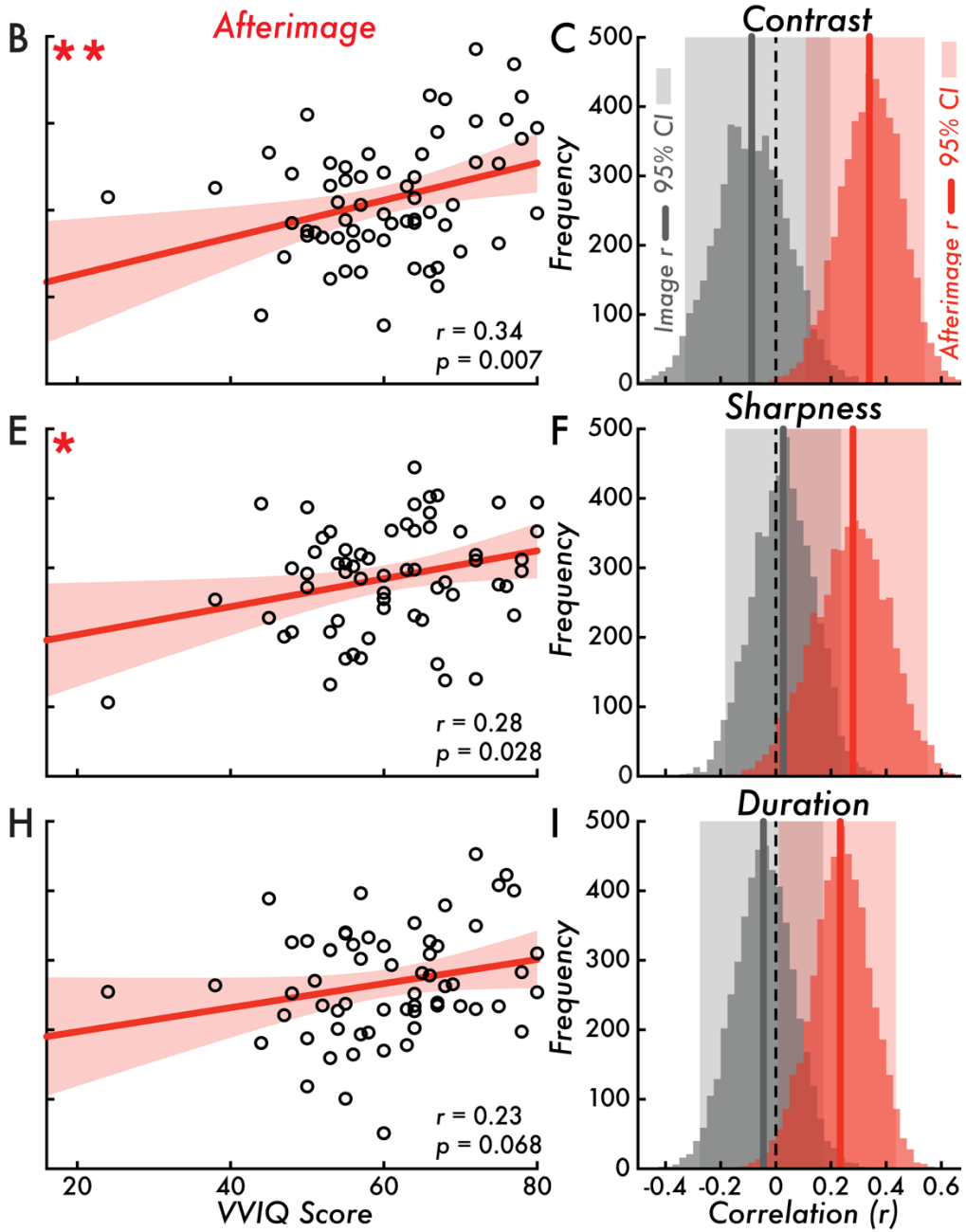
TABLE 2

AFTERIMAGES OF "IMAGINED" COLORS DURING "WAKING"

(GB and JB participated in Experiment 2; PM and SS participated in Experiment 3)

Subject	Colors *S* Was Asked to "Imagine"	Afterimage Reported by *S*
GB	Blue	Yellow
JB		Yellow
PM		Butter yellow
SS		Gold
GB	Red	Greenish violet
JB		Traffic light green
PM		Bluish
SS		Green
GB	Yellow	Bluish green
JB		Blue grey
PM		Greenish-blue
SS		Greeny-blue
GB	Green	Pinkish
JB		Pink
PM		Nut brown
SS		Red
GB	Orange	Blue
JB		Greenish blue
PM		Pale blue
SS		Purple

Downey, *Psych Review*, 1901
Weiskrantz, *J Exp Psych*, 1950
Oswald, *J Exp Psych*, 1957
Barber, *J Ab Psych*, 1959

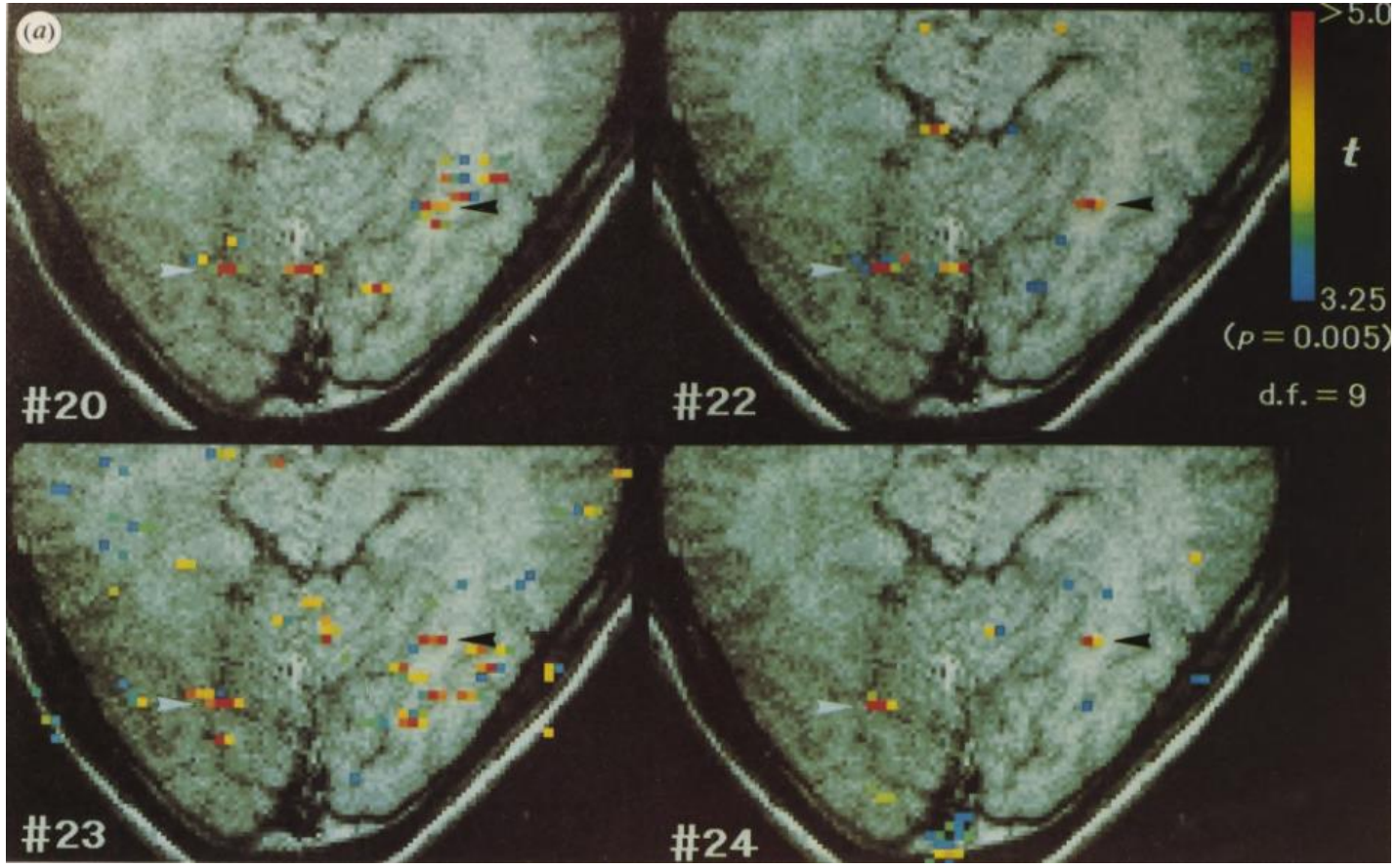


Kronemer et al., *NoC*, 2024

Functional mapping of the human colour centre with echo-planar magnetic resonance imaging

KUNIYOSHI SAKAI[1]†, EIJU WATANABE[2], YUKARI ONODERA[3], IDAI UCHIDA[1], HIDEKI KATO[1], ETSUJI YAMAMOTO[3], HIDEAKI KOIZUMI[3] AND YASUSHI MIYASHITA[1]

[1] *Department of Physiology, School of Medicine, University of Tokyo, Tokyo 113, Japan*
[2] *Department of Neurosurgery, Tokyo Metropolitan Police Hospital, Tokyo 102, Japan*
[3] *Central Research Laboratory, Hitachi, Ltd., Tokyo 185, Japan*



Sakai, et al., 1995

What are the brain mechanisms of afterimages?

Aim 1

Map the whole brain contributions for afterimages with fMRI.

Aim 2

Map the V1 cortical layer contributions for afterimages with fMRI.

Aim 1

Whole-Brain, 7T fMRI

(TR = 1000ms; Voxel Size 1.2mm iso)

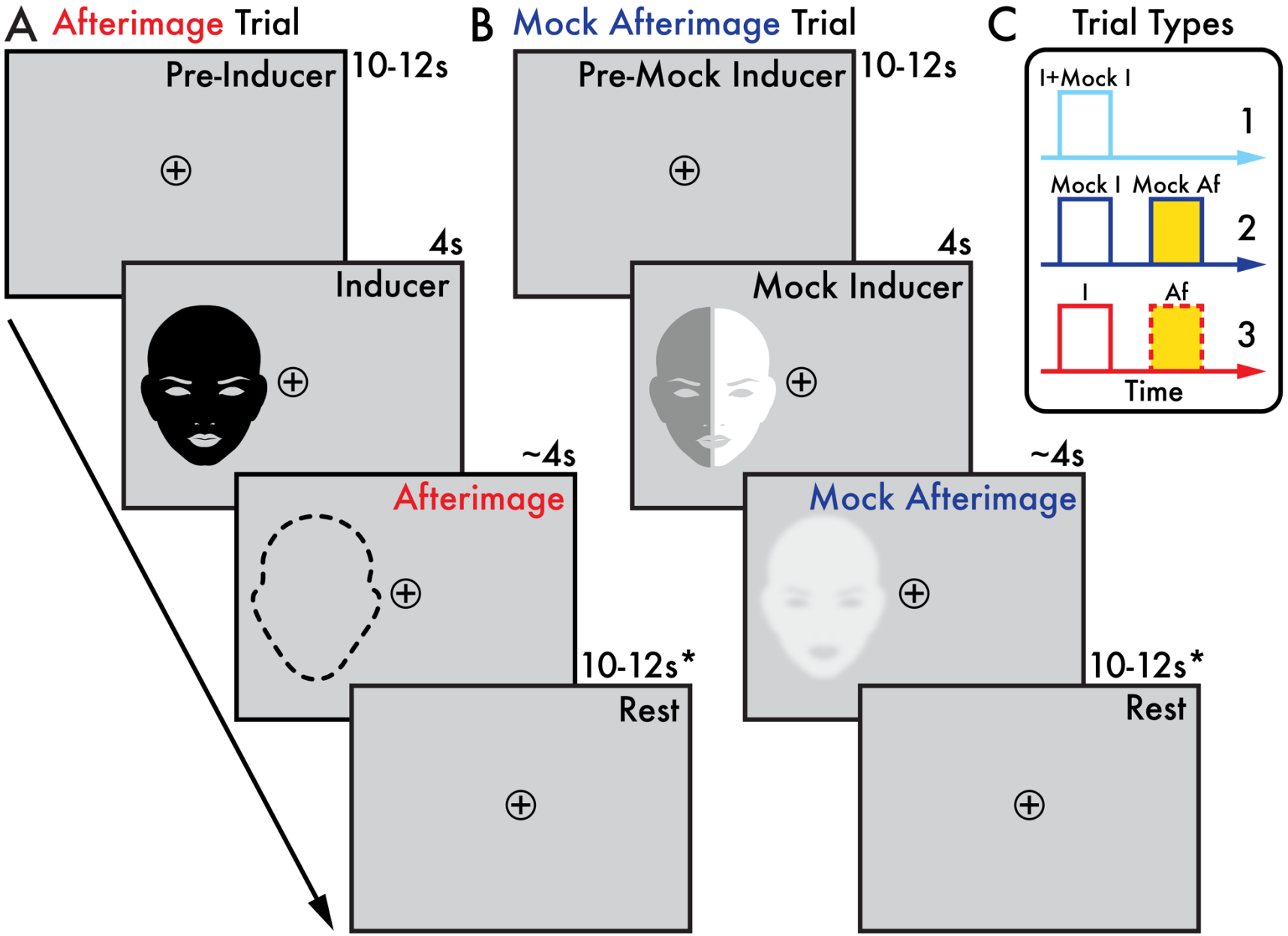
+

Eye-tracking & pupillometry

(1000Hz; right eye)

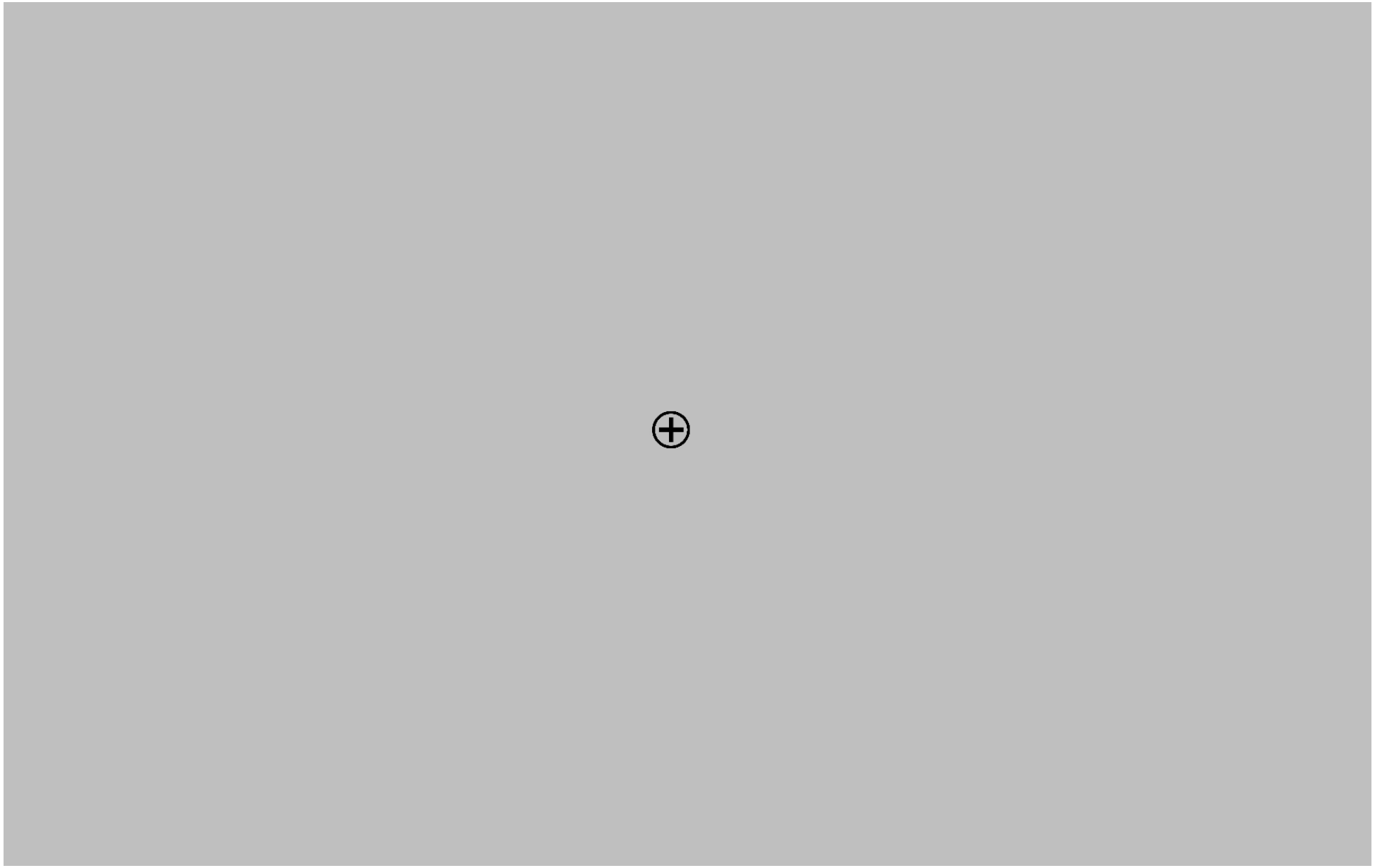
+

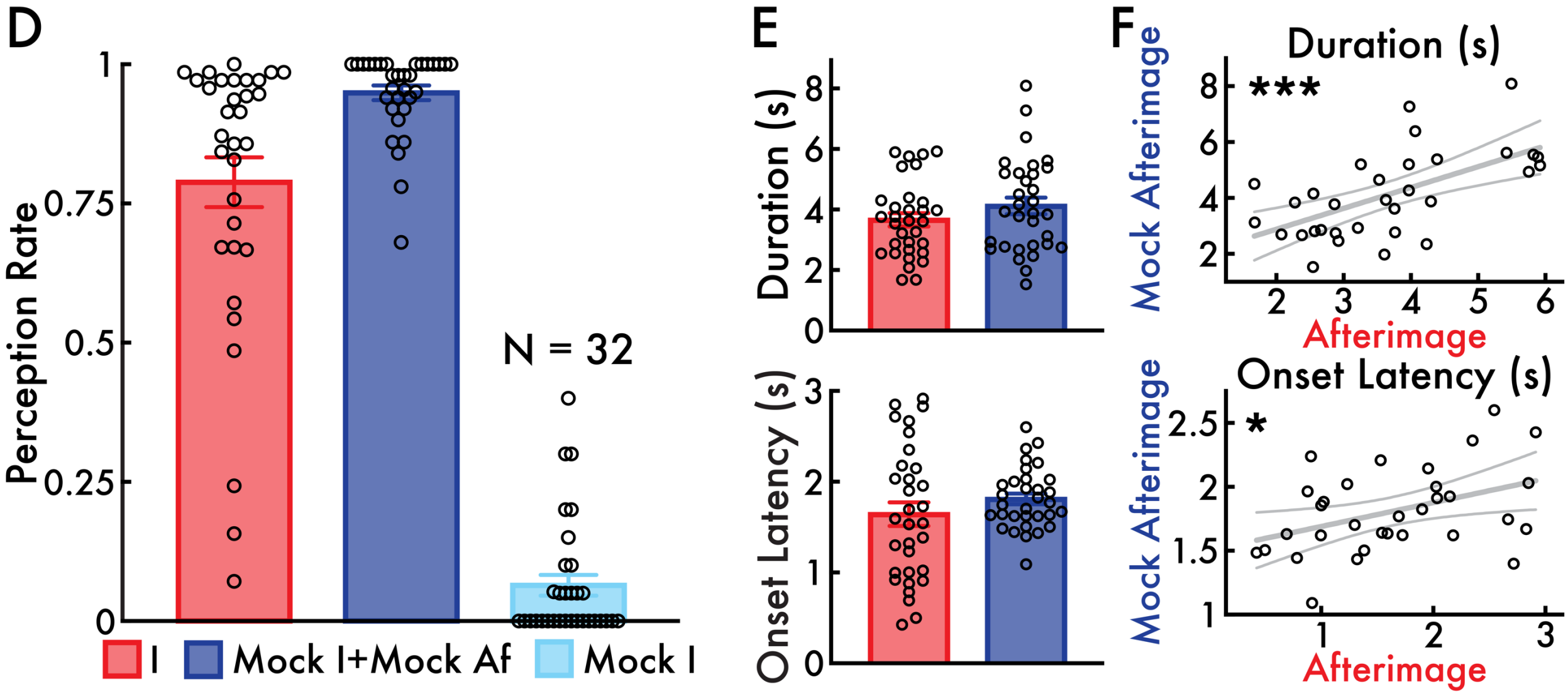
N = 35 healthy participants



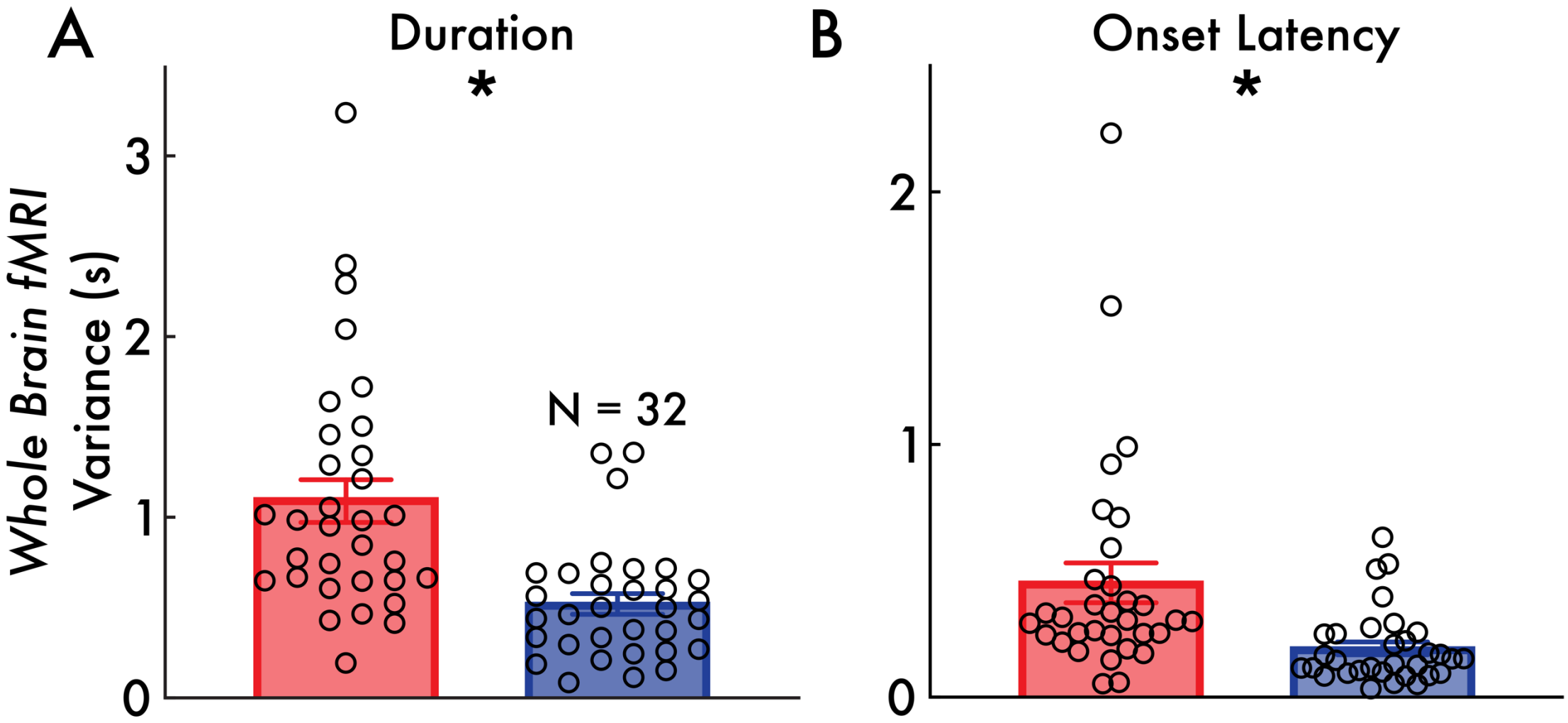
Kronemer et al., in prep

Mock Afterimage

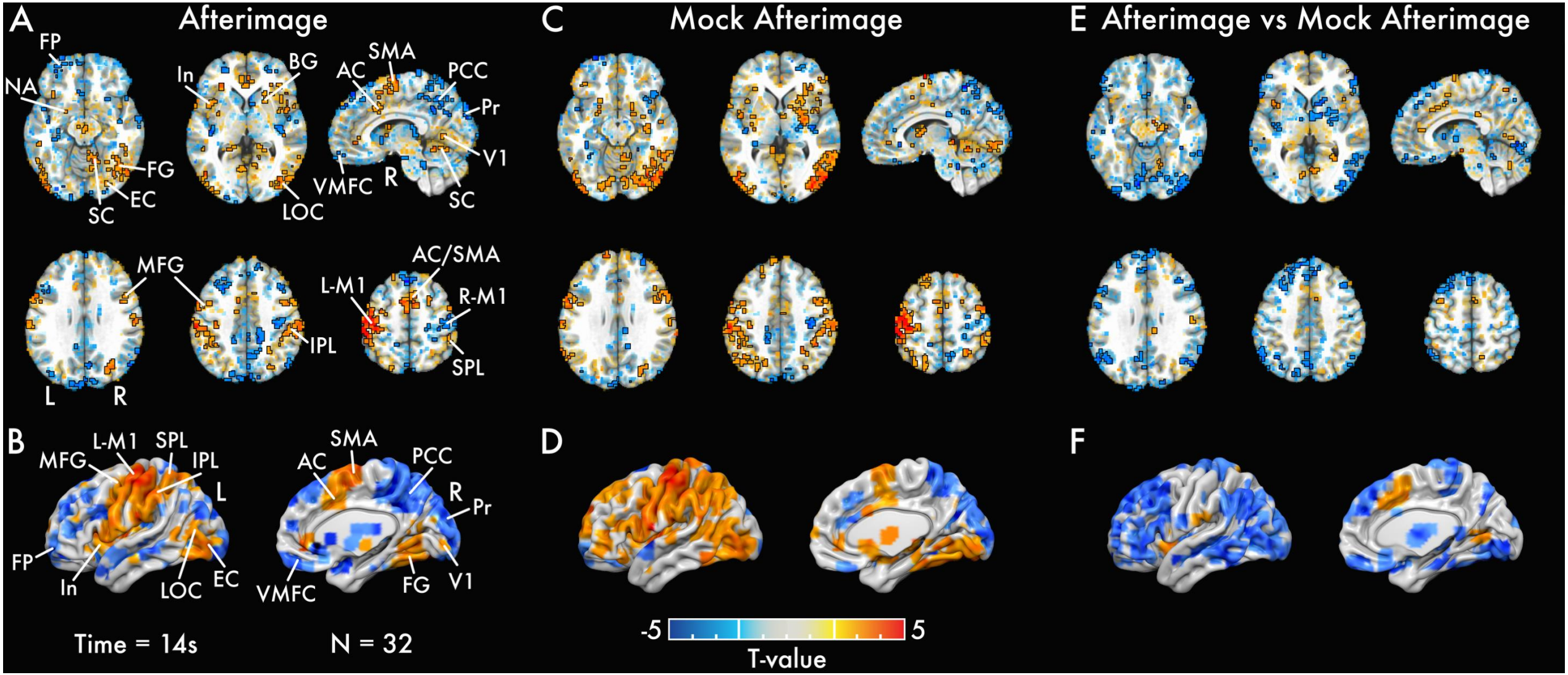




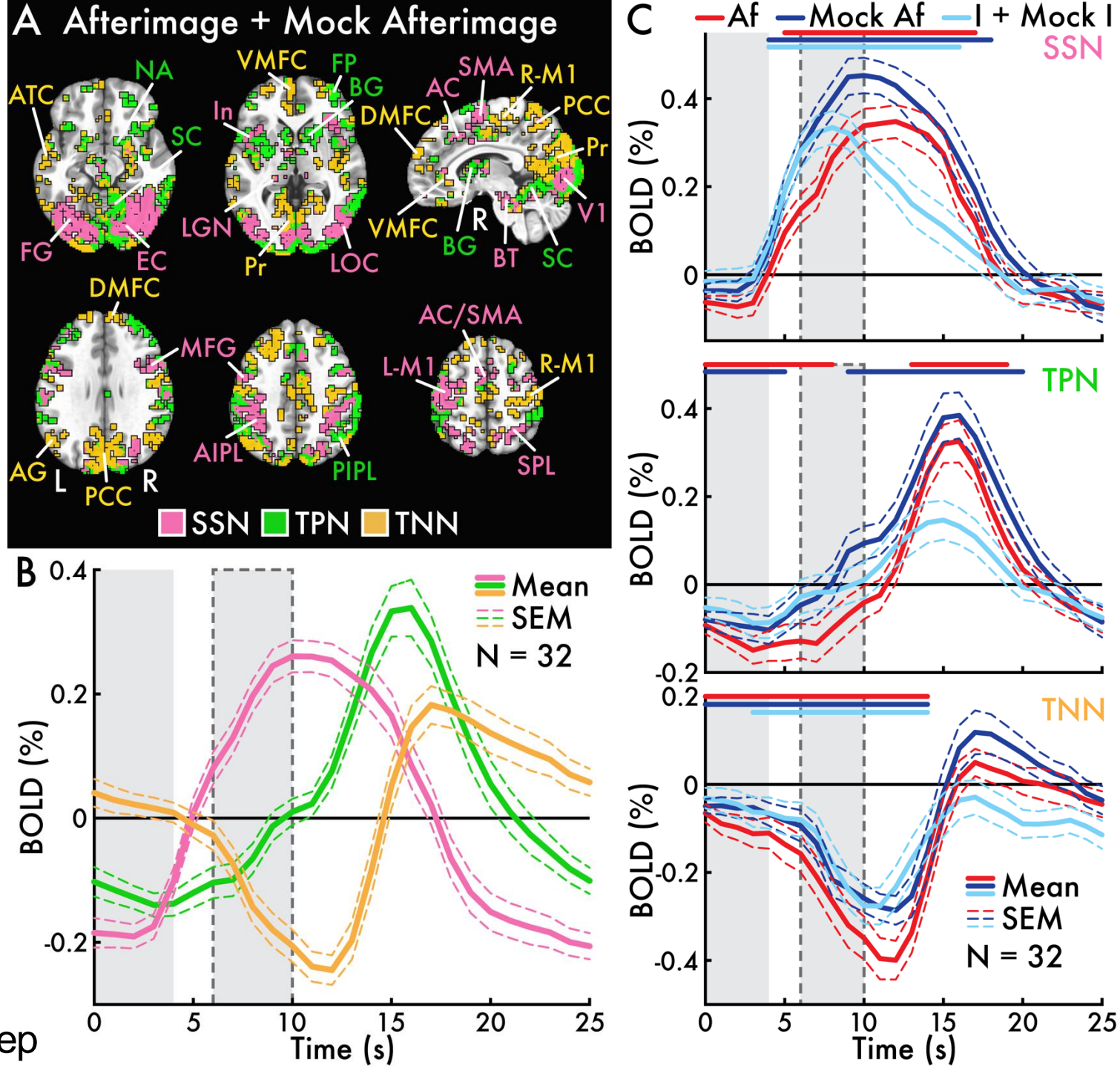
Kronemer et al., in prep



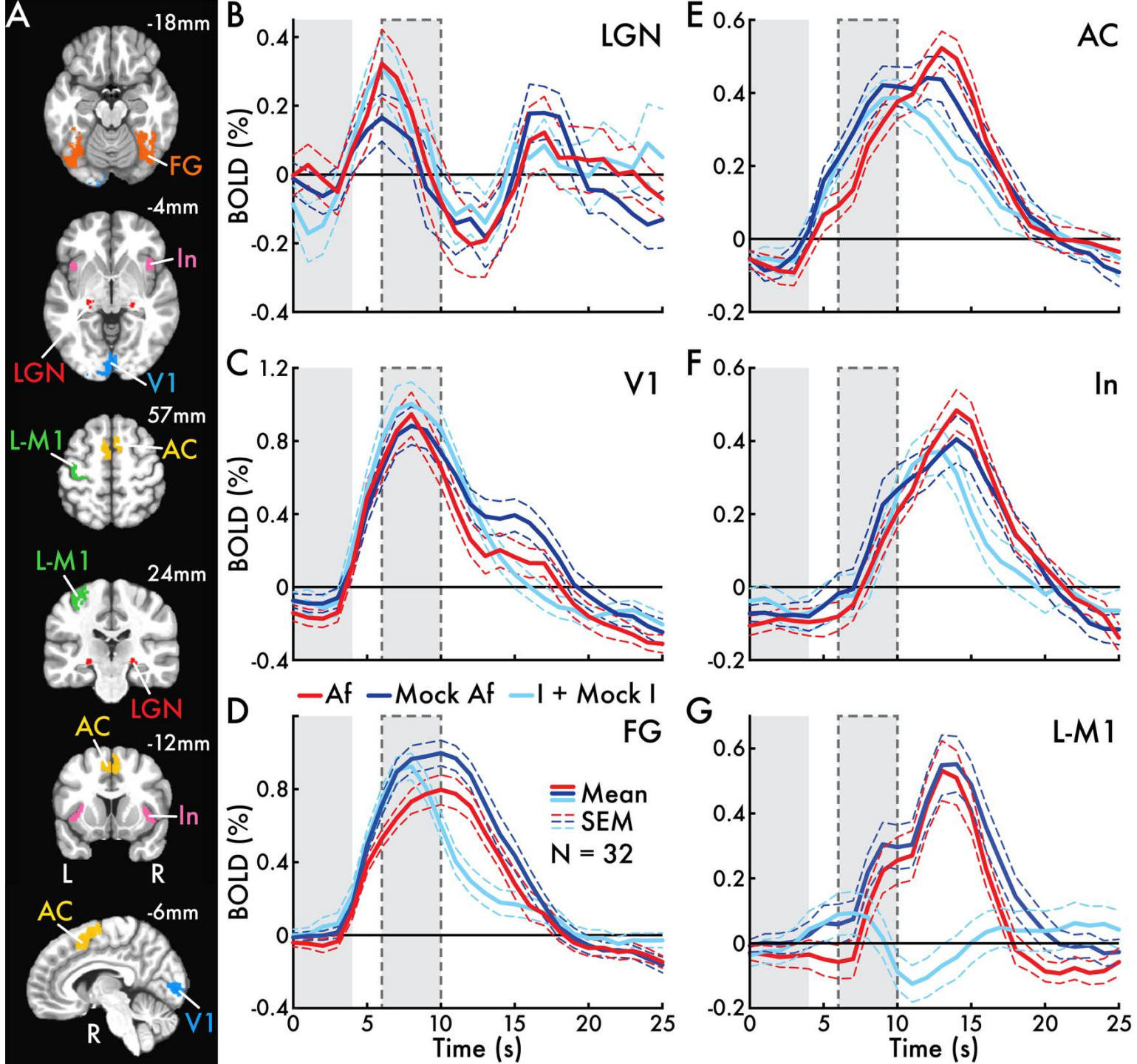
Kronemer et al., in prep



Kronemer et al., in prep



Kronemer et al., in prep



Kronemer et al., in prep

Aim 2

V1 Layer, 7T fMRI VASO/BOLD

(TR = 3100ms; Voxel Size 0.8mm iso)

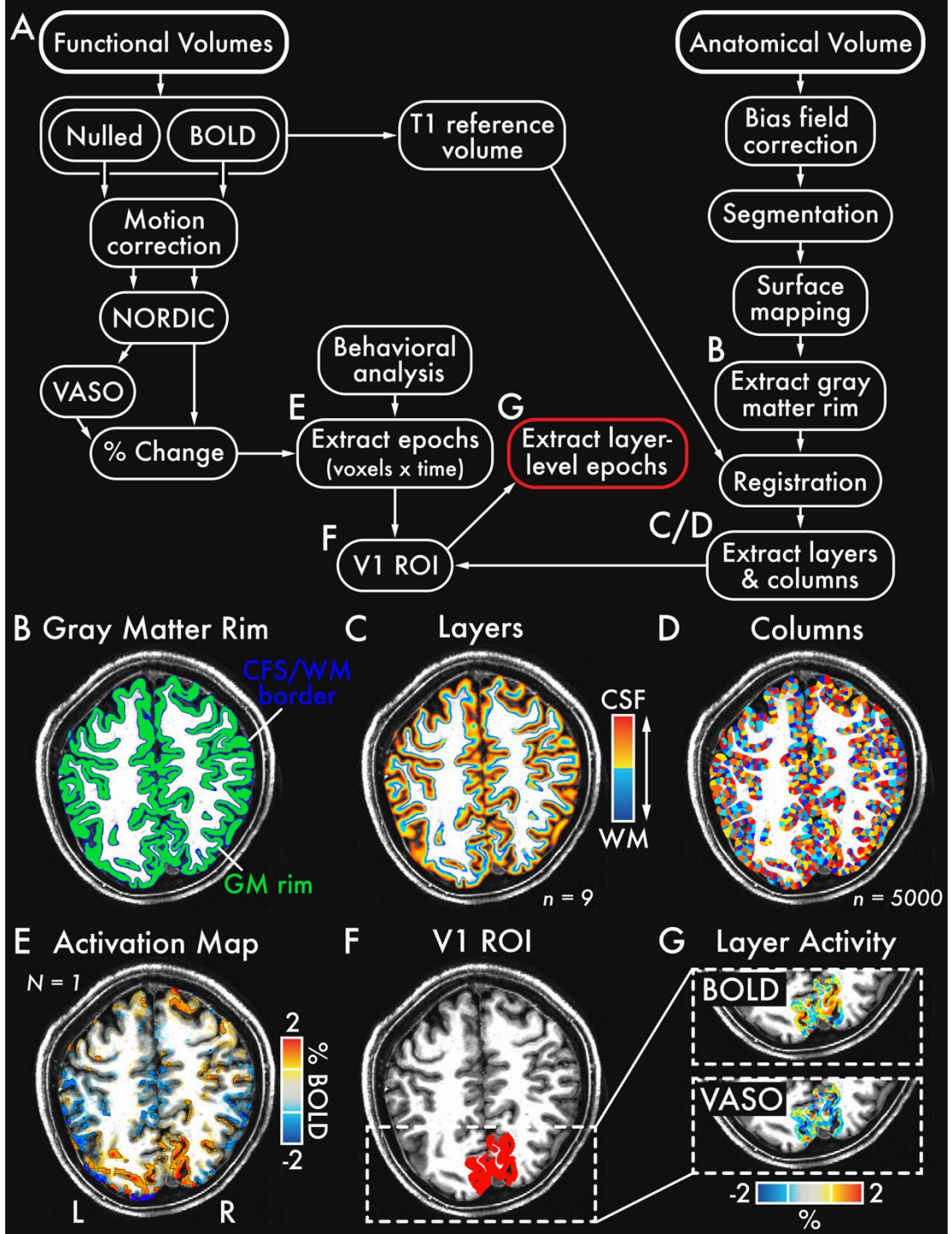
+

Eye-tracking & pupillometry

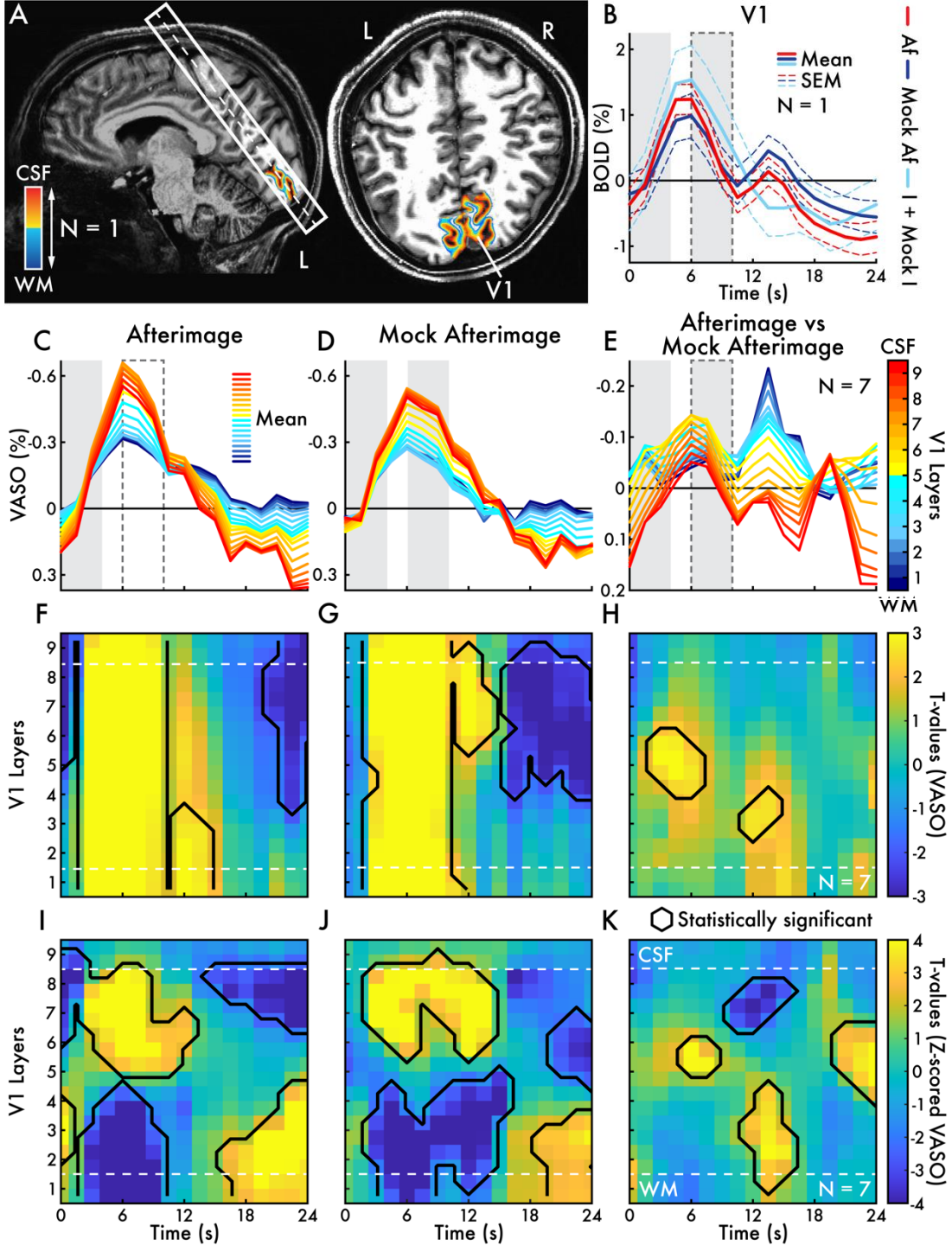
(1000Hz; right eye)

+

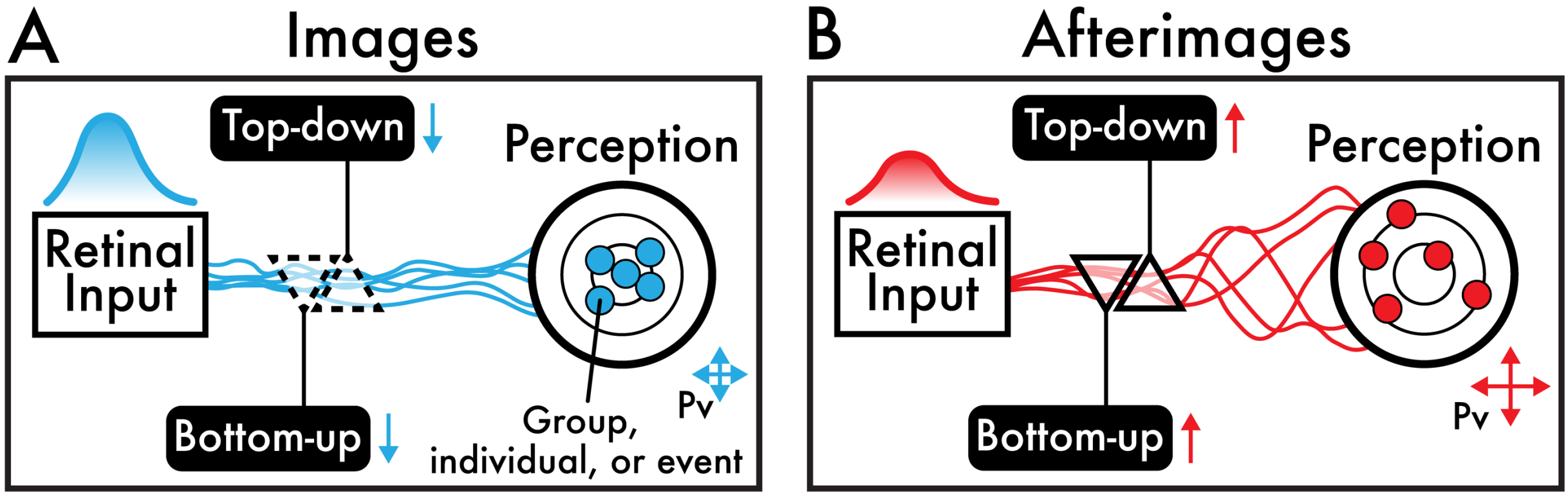
N = 12 healthy participants



Kronemer et al., in prep



Kronemer et al., in prep



Kronemer et al., in prep

Are afterimages retinal or cortical?

(false dichotomy) Both!

Acknowledgements

Email: sharif.kronemer@nih.gov
Website: sharifkronemer.com

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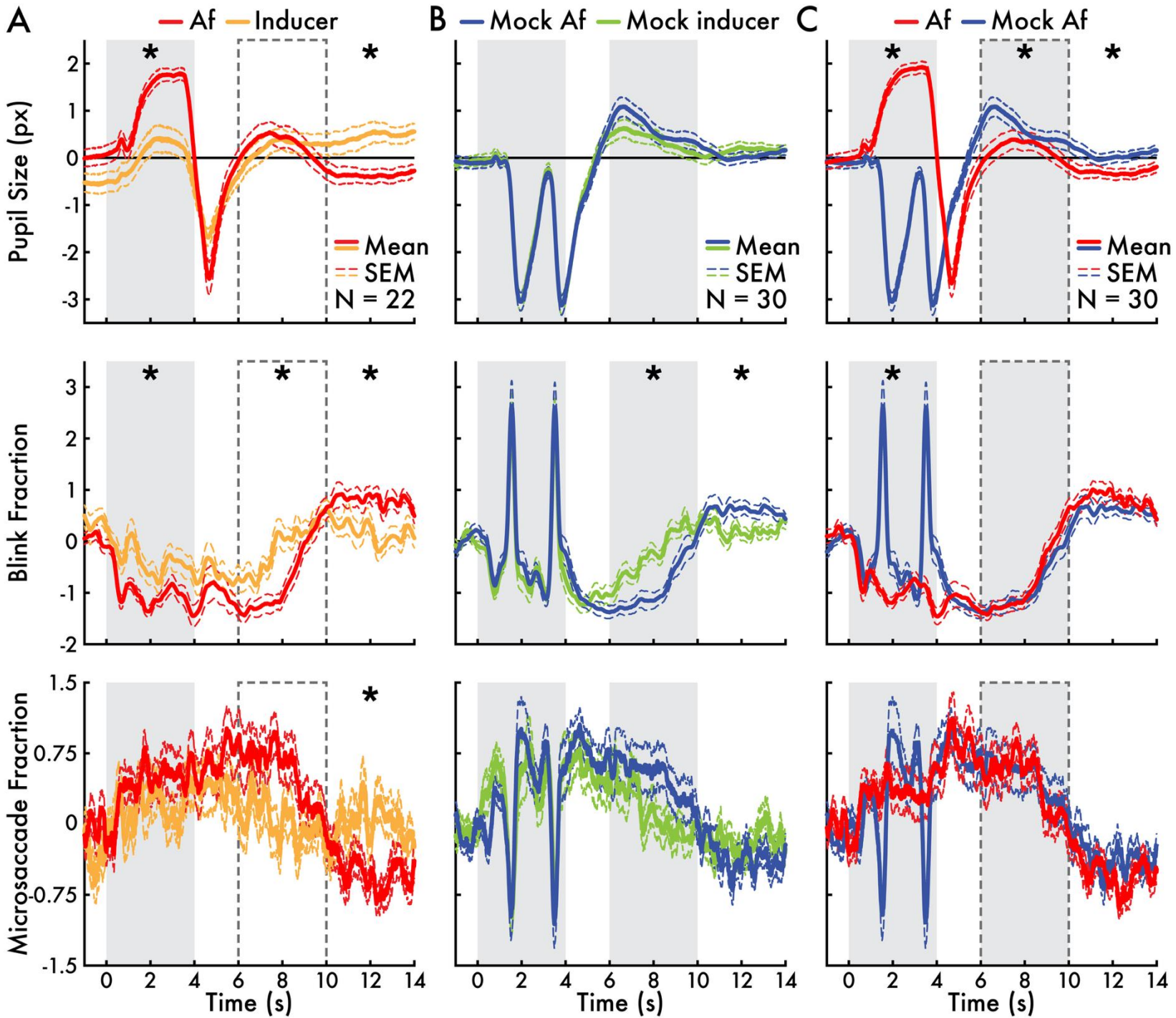
Stephanie Swegle
Marly Rubin
Plyfaa Suwanamalik-Murphy
Marlene Smith
Catherine Walsh
Esther Lin

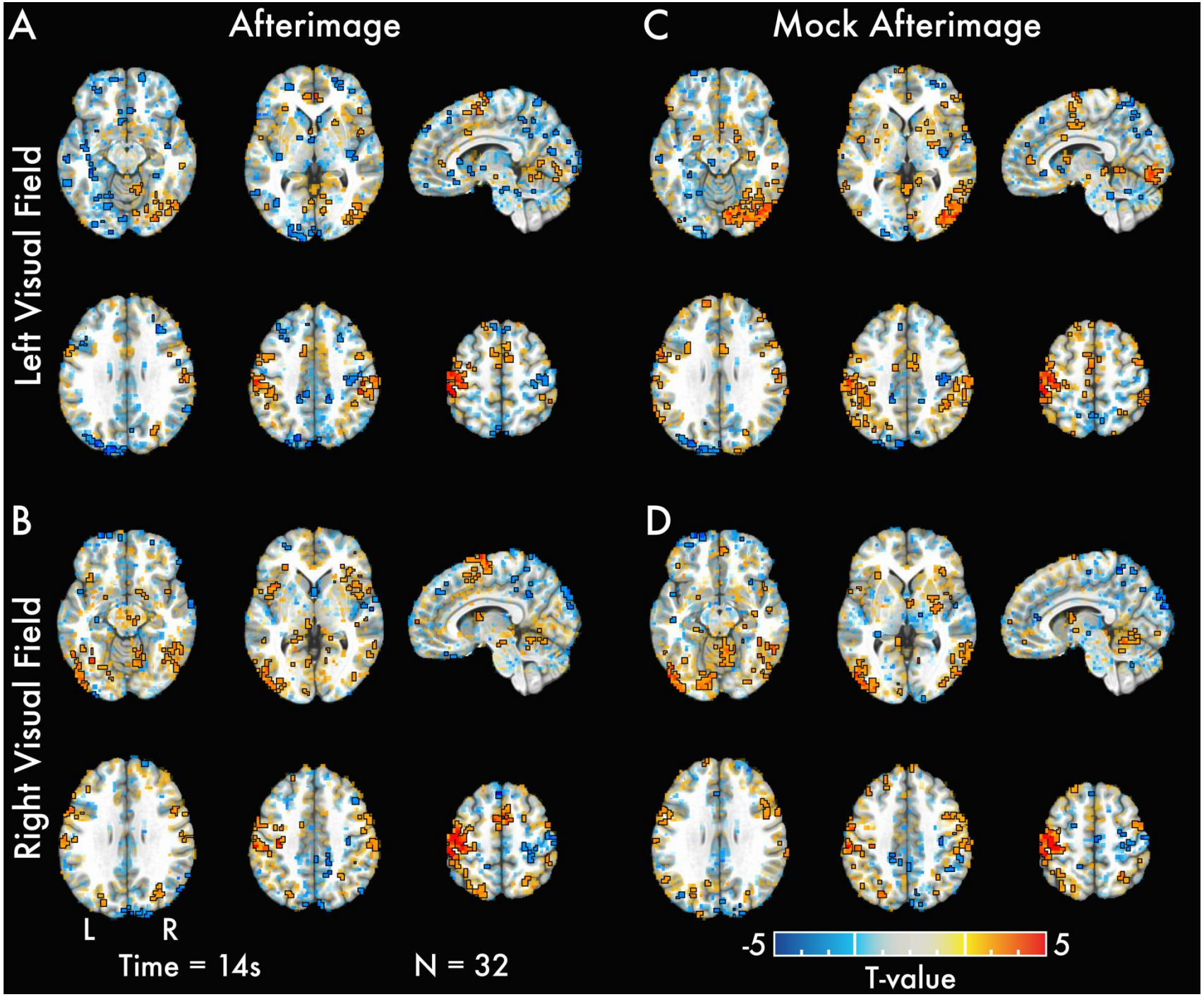
NIH National Institute of Mental Health

Thank you for your attention!
Questions?

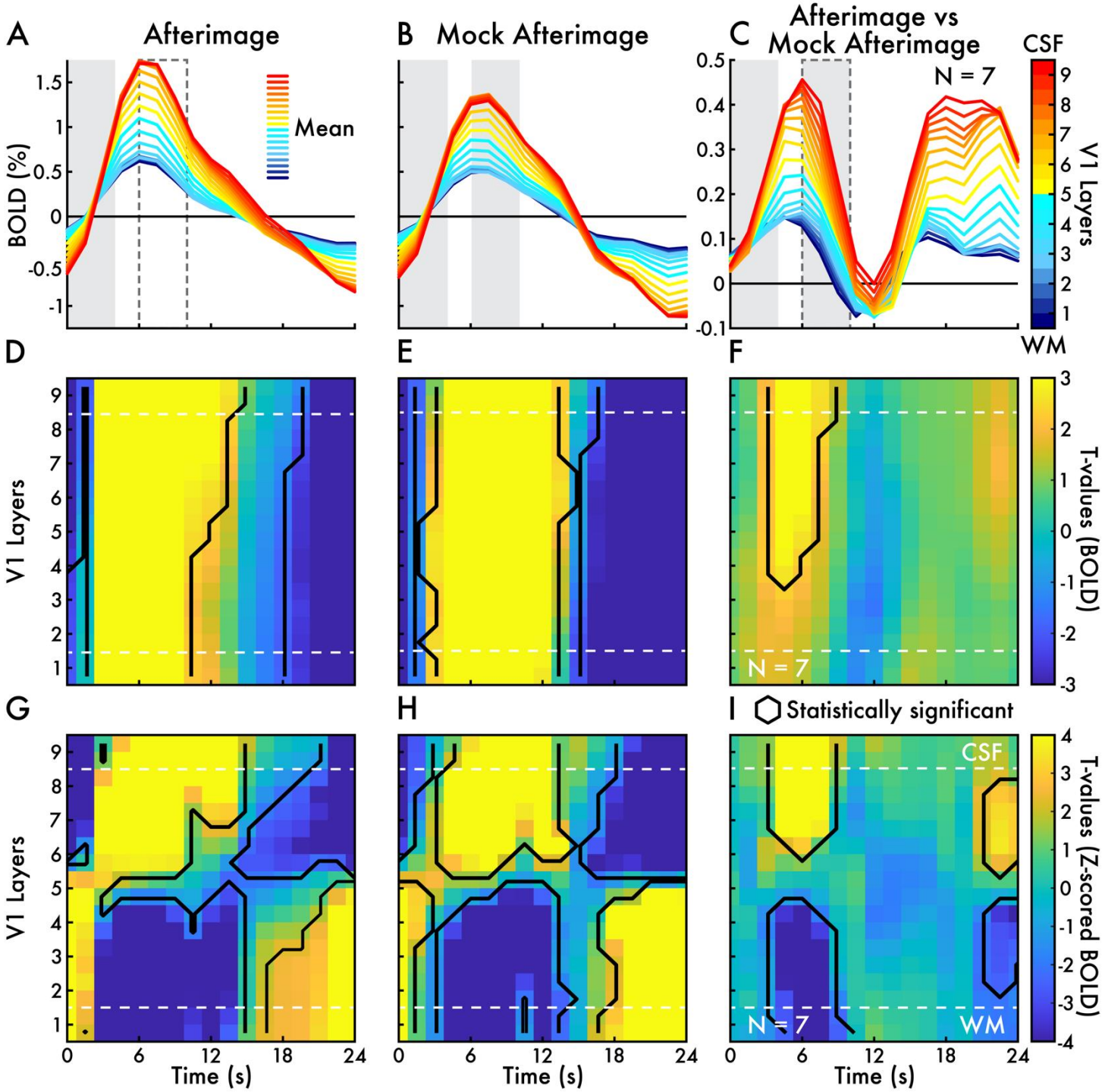
Extra Slides



Kronemer et al., in prep



Kronemer et al., in prep

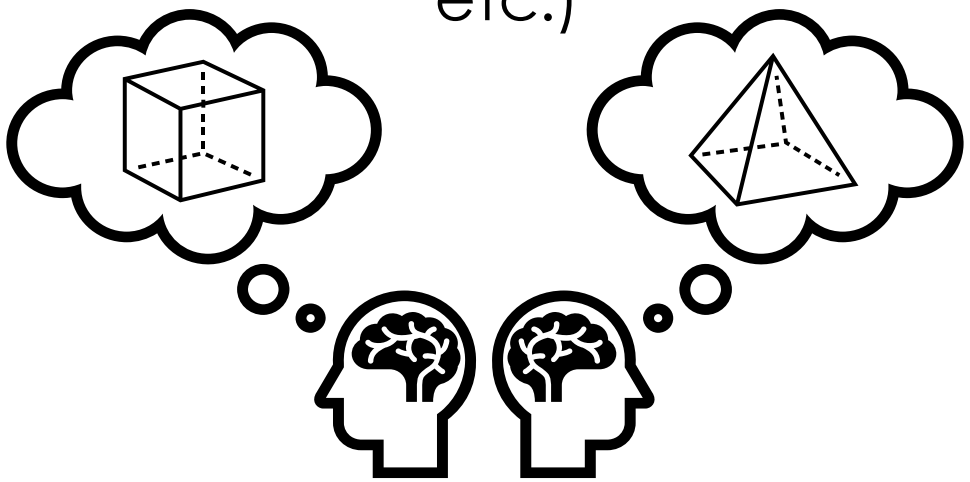


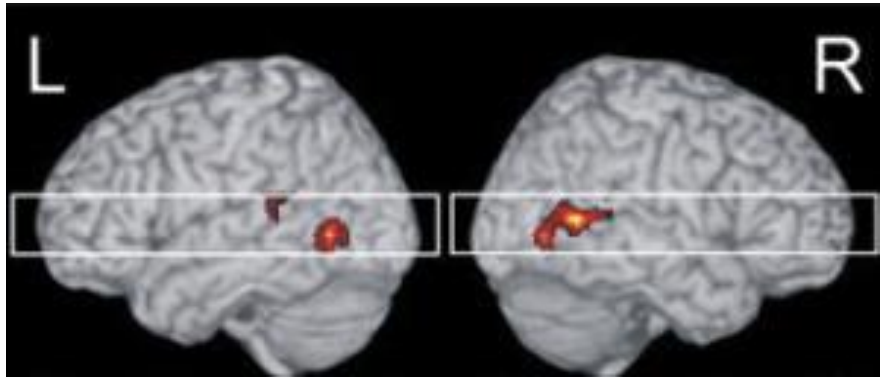
Kronemer et al., in prep

Why Mock Afterimages?

1 Perceptual Heterogeneity

(e.g., vividness, timing, content, etc.)

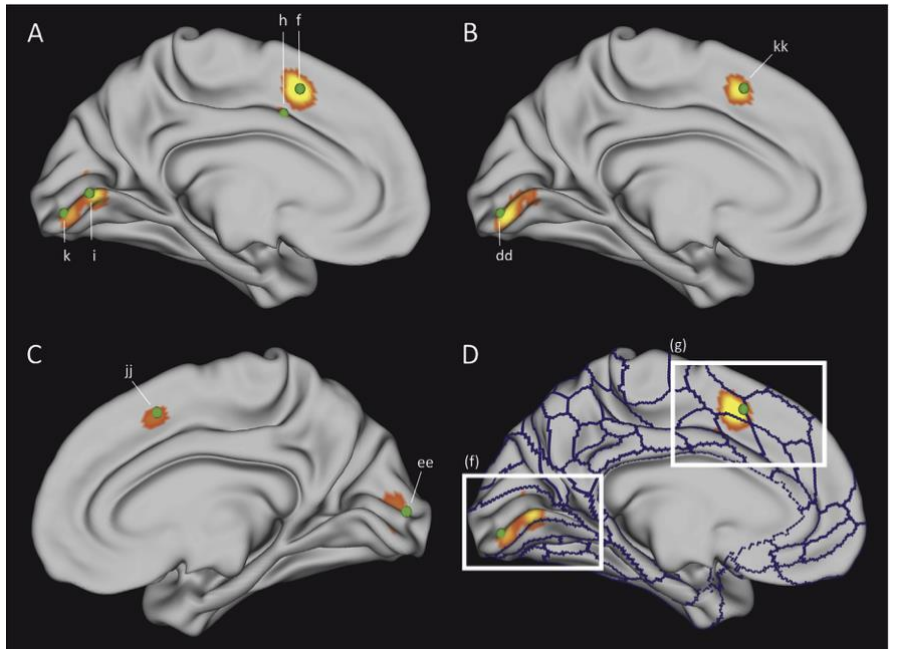




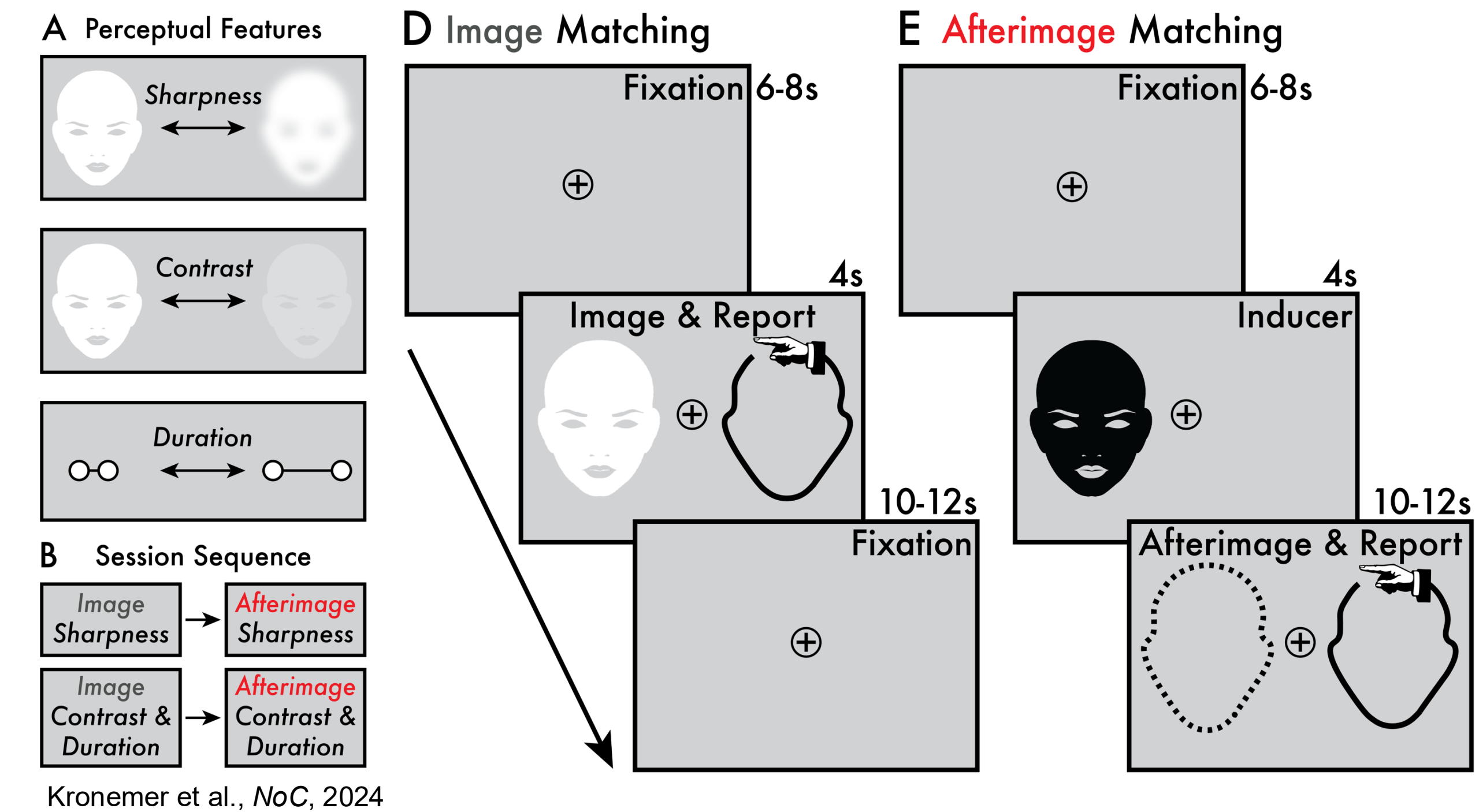
Bunzeck et al., *NeuroImage*, 2005

2 Task-Based Contributions

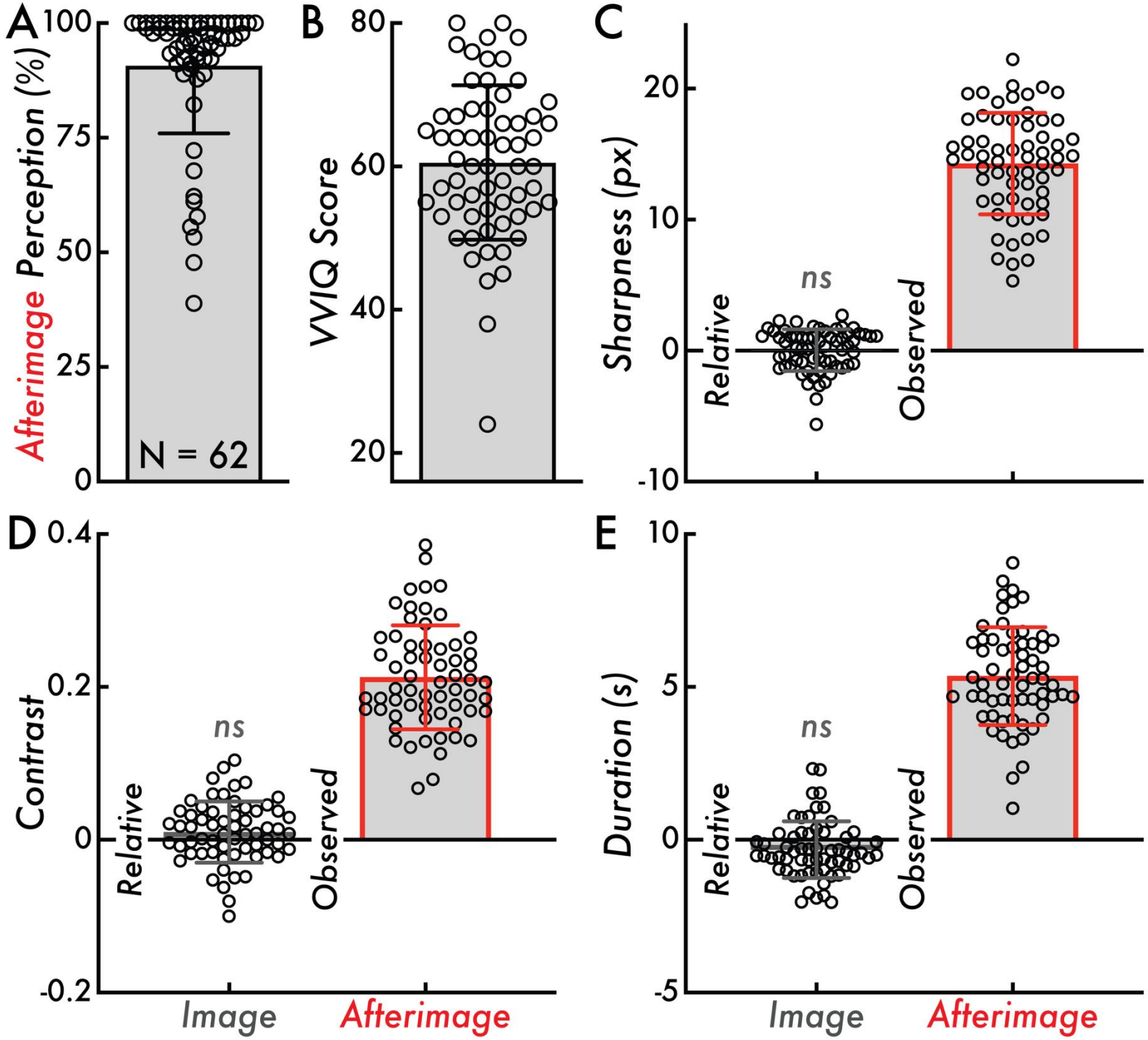
(e.g., passive viewing vs imagination, fine vs coarse imagery demands)

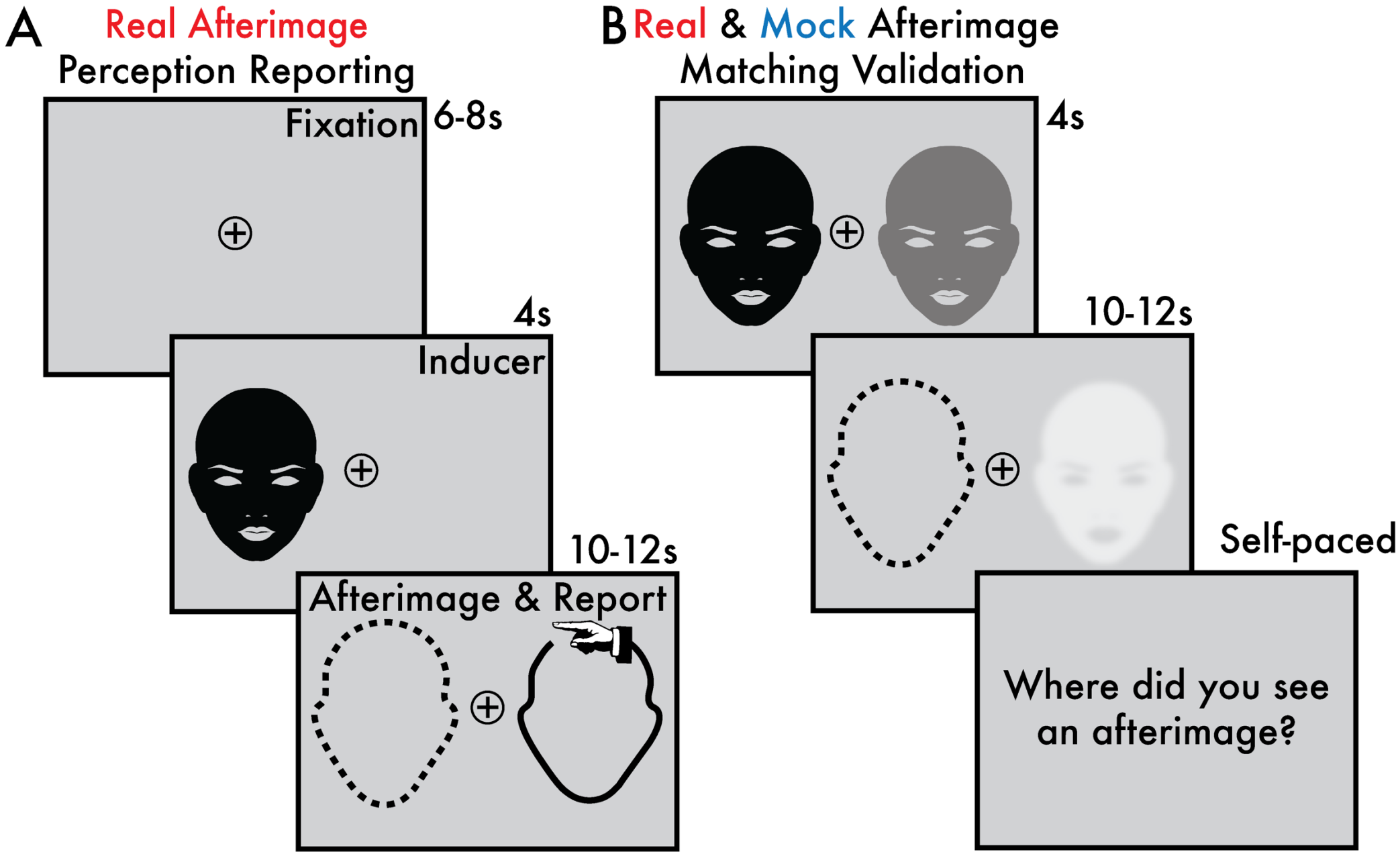


Winlove et al., *Cortex*, 2018



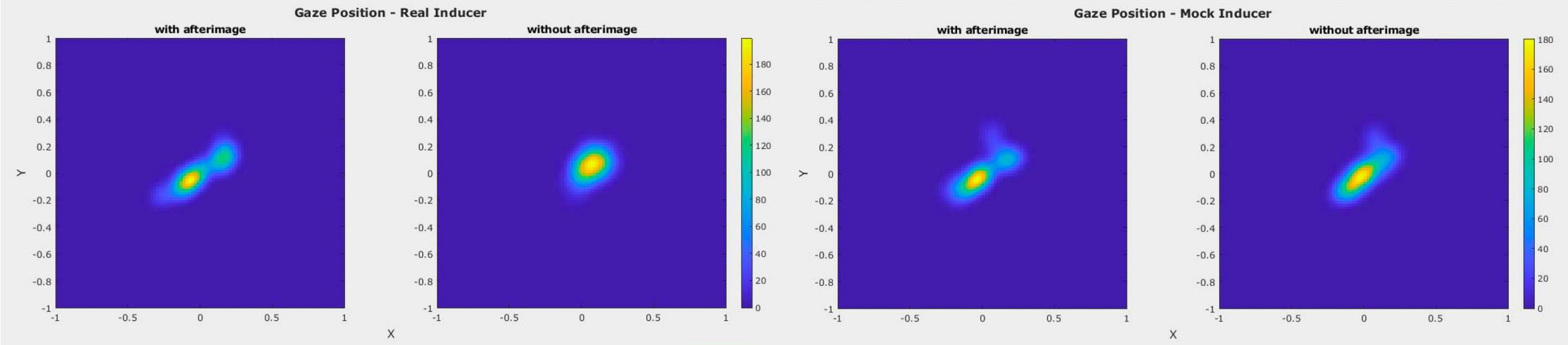
Kronemer et al., *NoC*, 2024


A
Afterimage Perception (%)
100
75
50
25
0
N = 62
B
VVIQ Score
80
60
40
20
C
Sharpness (px)
20
10
0
-10
ns
Relative
Observed
D
Contrast
0.4
0.2
0
-0.2
ns
Relative
Observed
Image
Afterimage
E
Duration (s)
10
5
0
-5
ns
Relative
Observed
Image
Afterimage



Kronemer et al., in prep

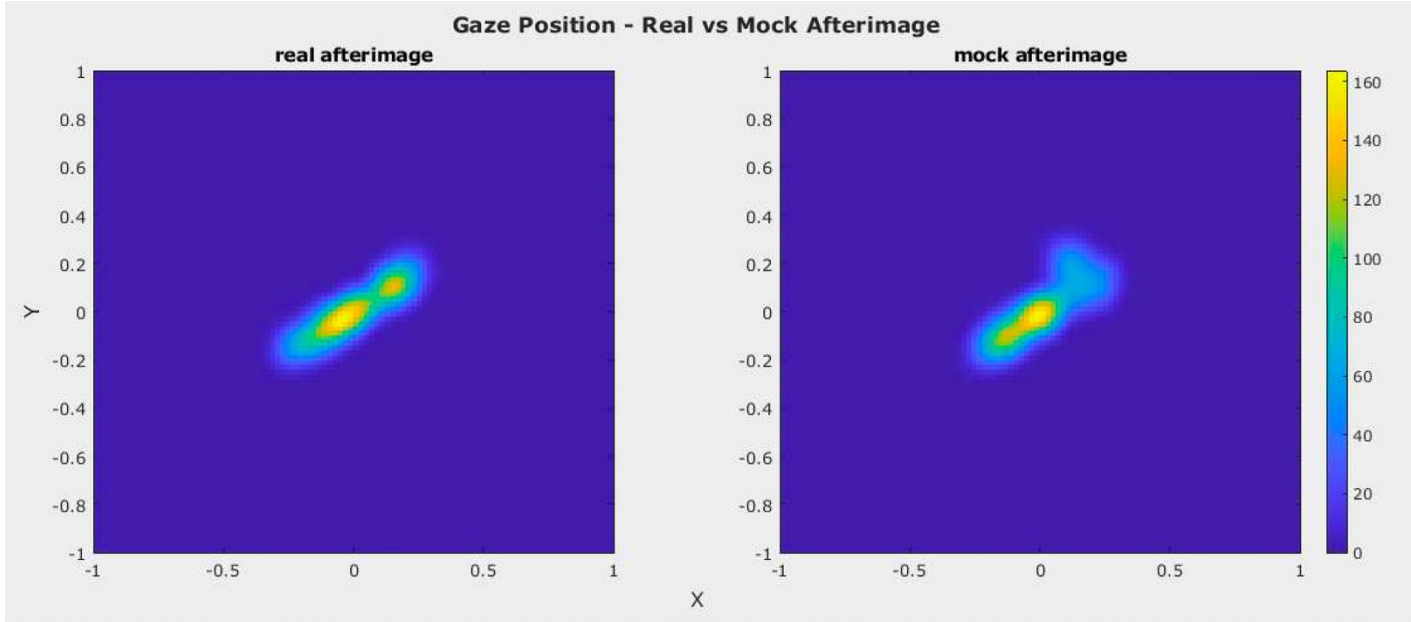
Group Gaze Position Heatmaps



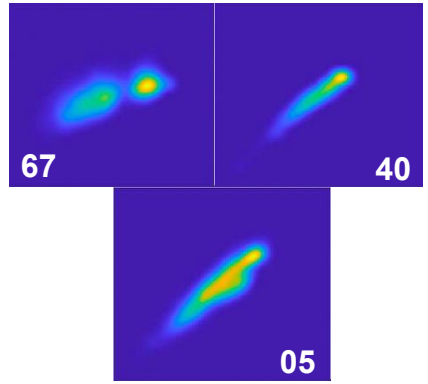
Participants were generally fixating on the center fixation cross throughout the trials

Deviation was due to either:

1) Afterimage experience
2) Natural eye movement
3) Bore vibration

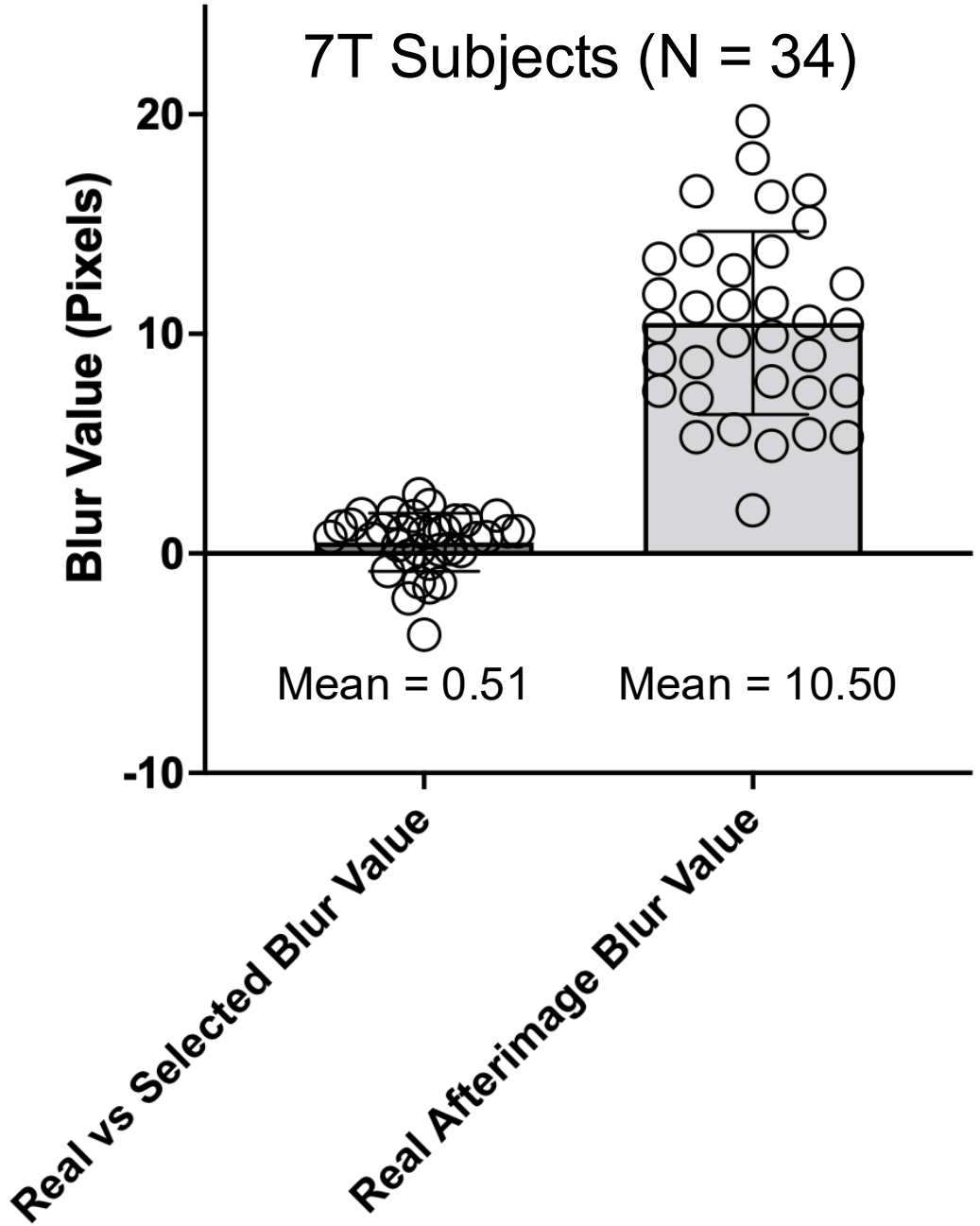


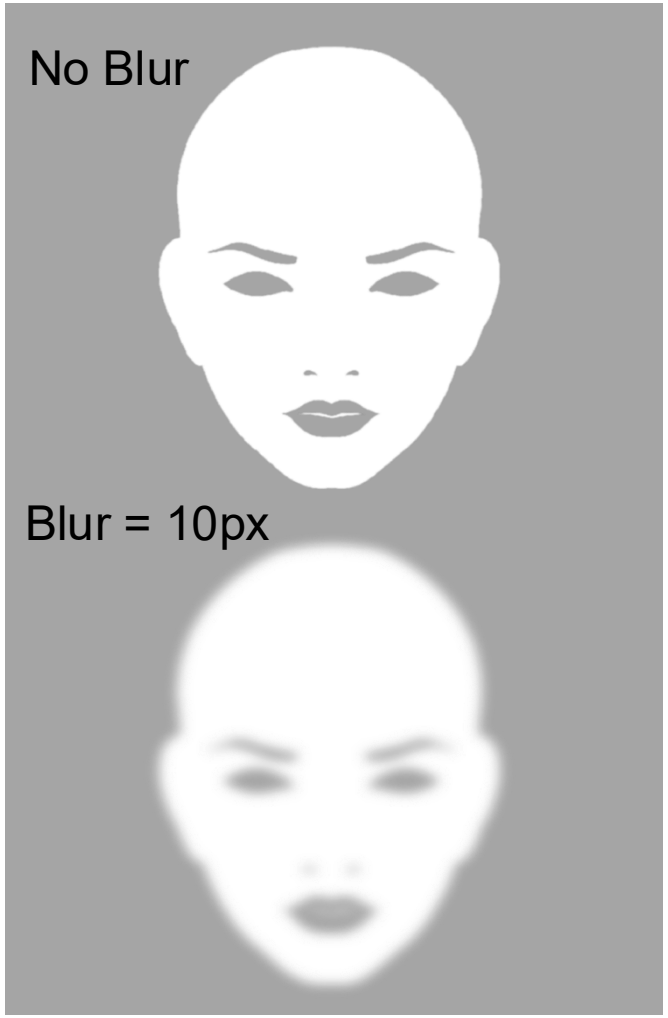
Single Subject Variants:



Real Afterimage Onset

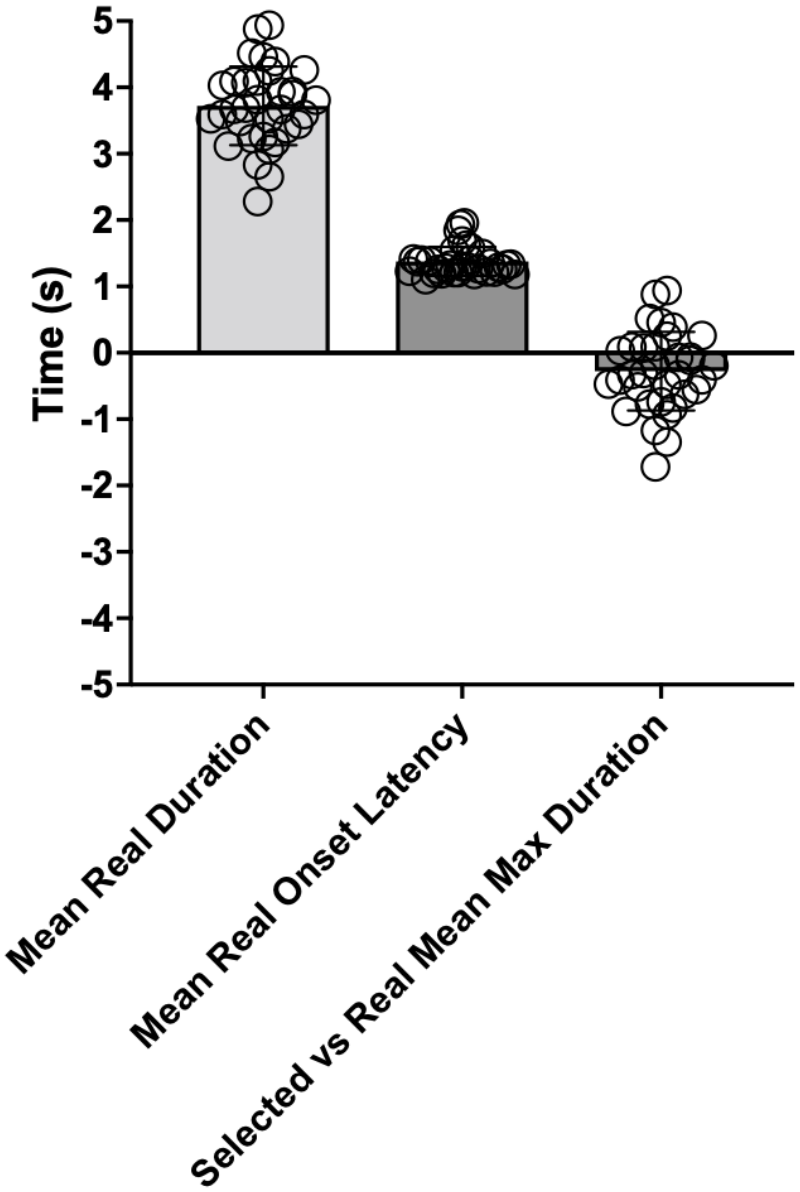
Blur Matching

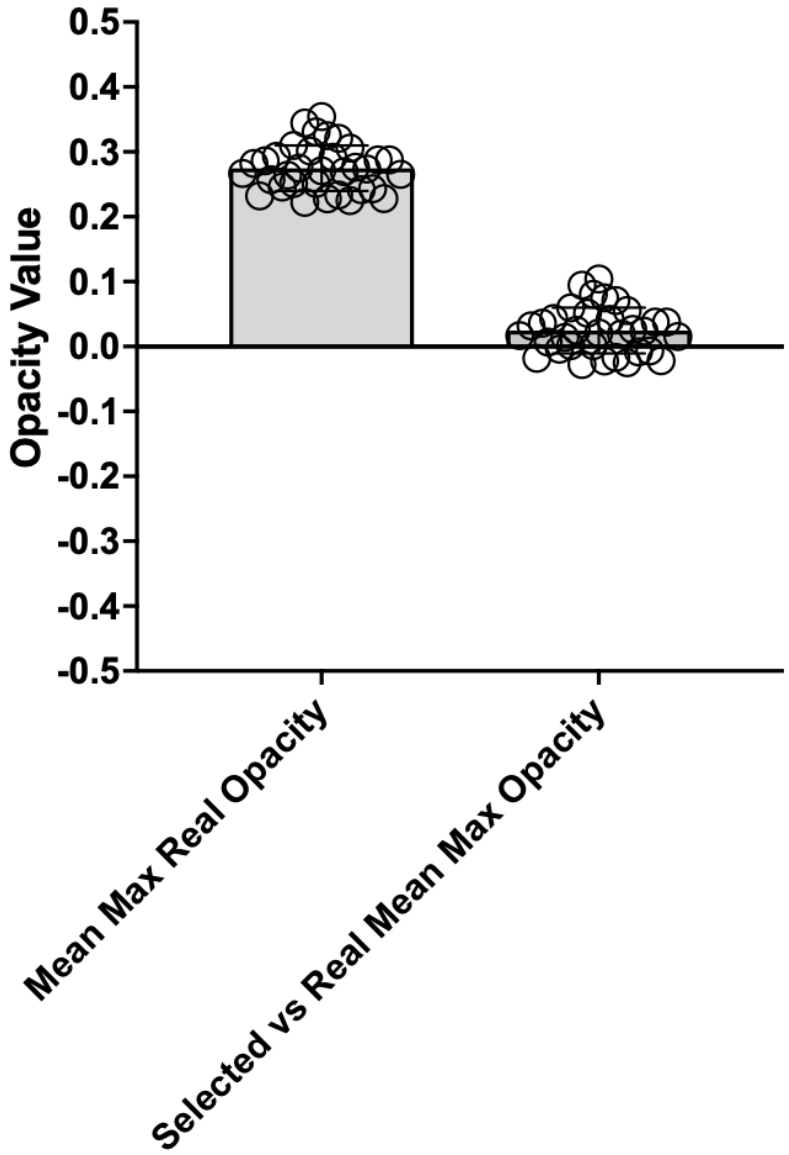


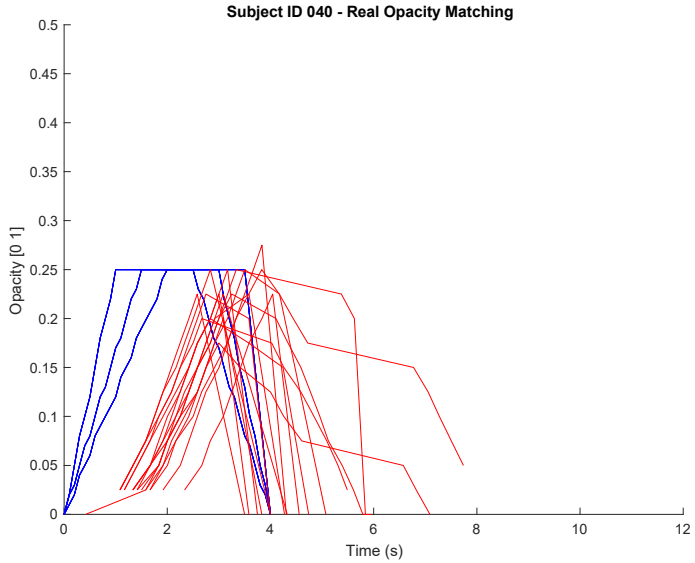


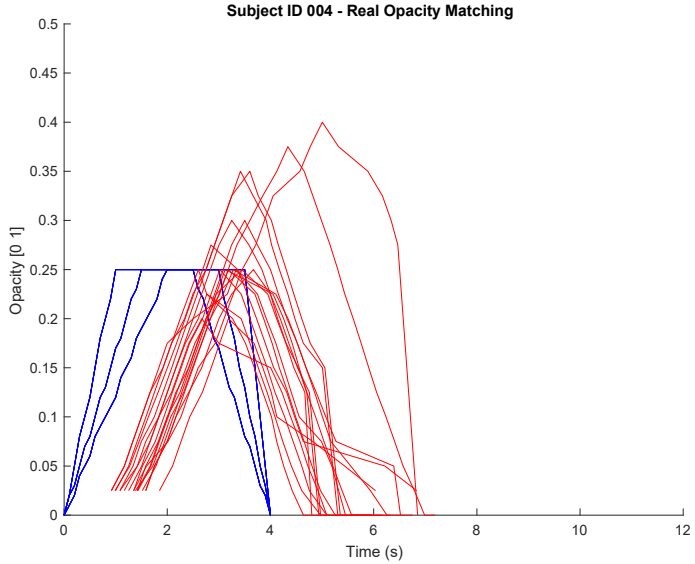
Opacity/Duration Matching

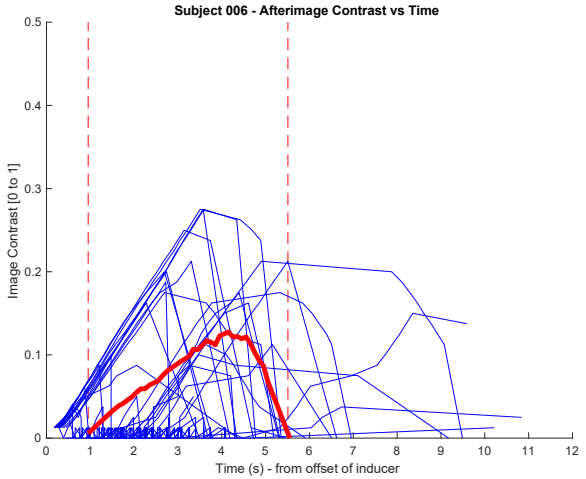
7T Subjects (N = 34)

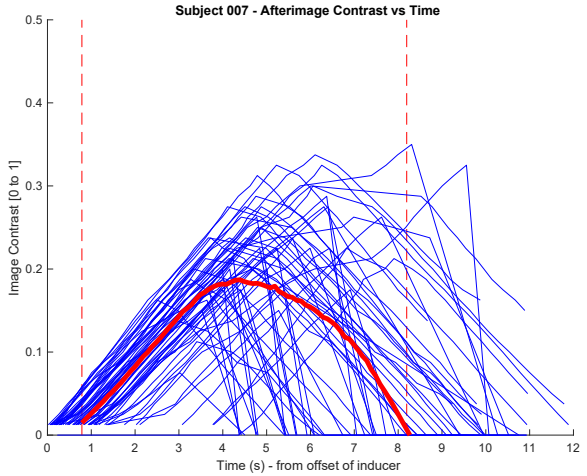


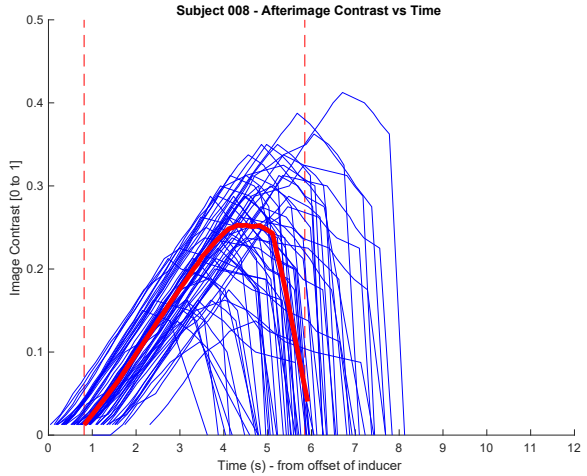


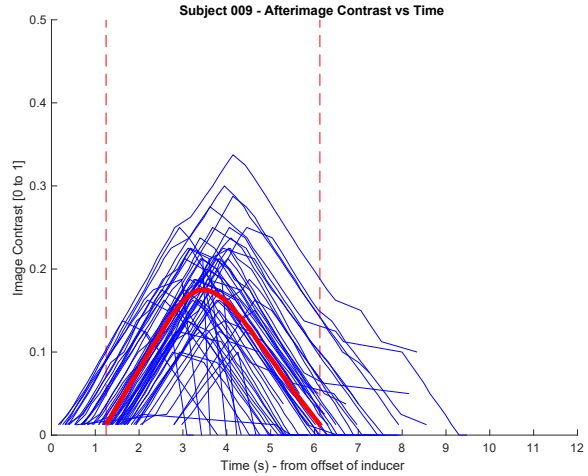


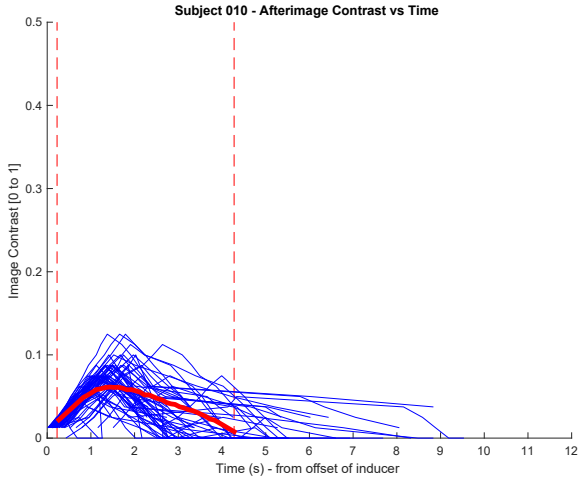


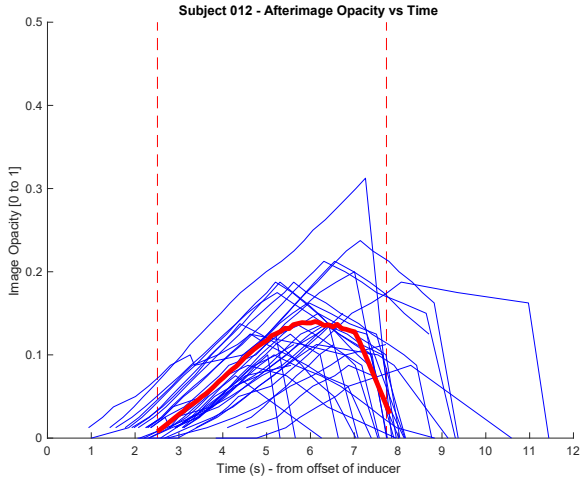


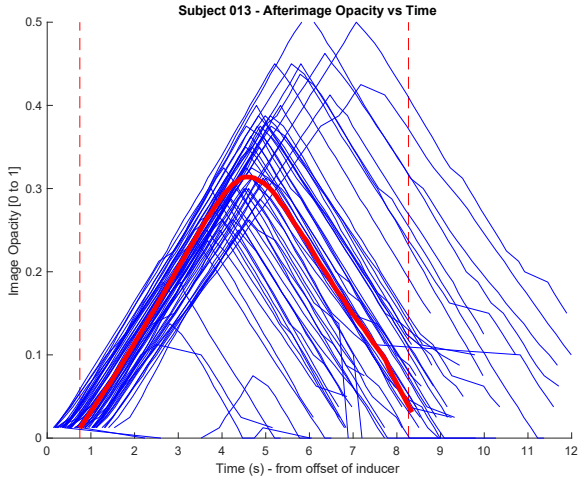


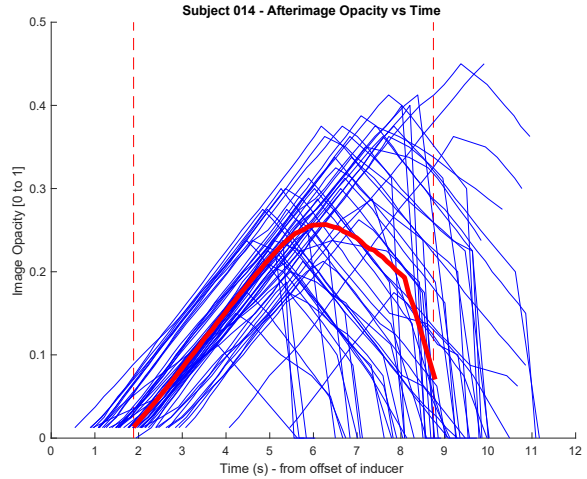


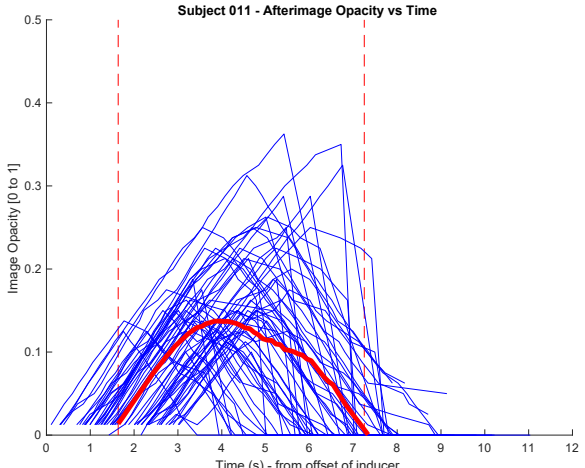


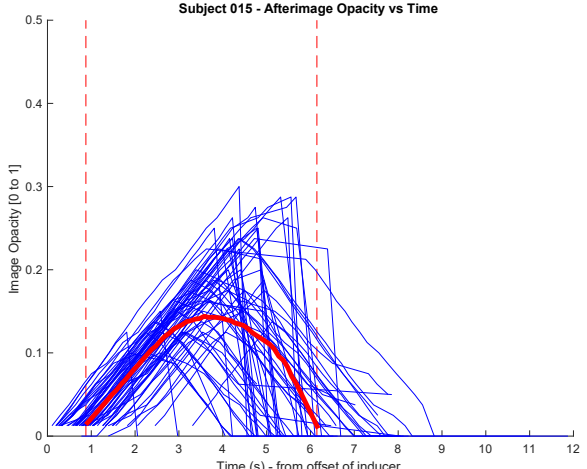










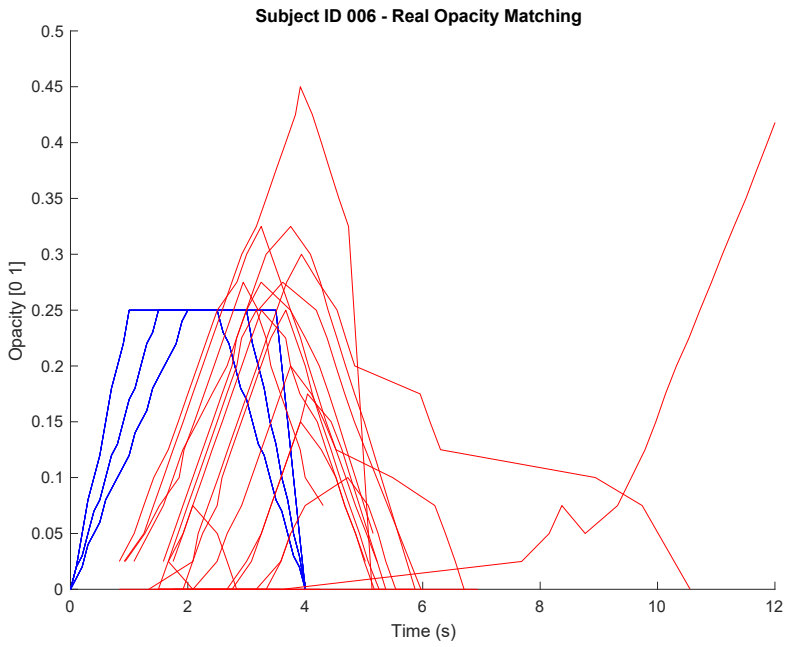


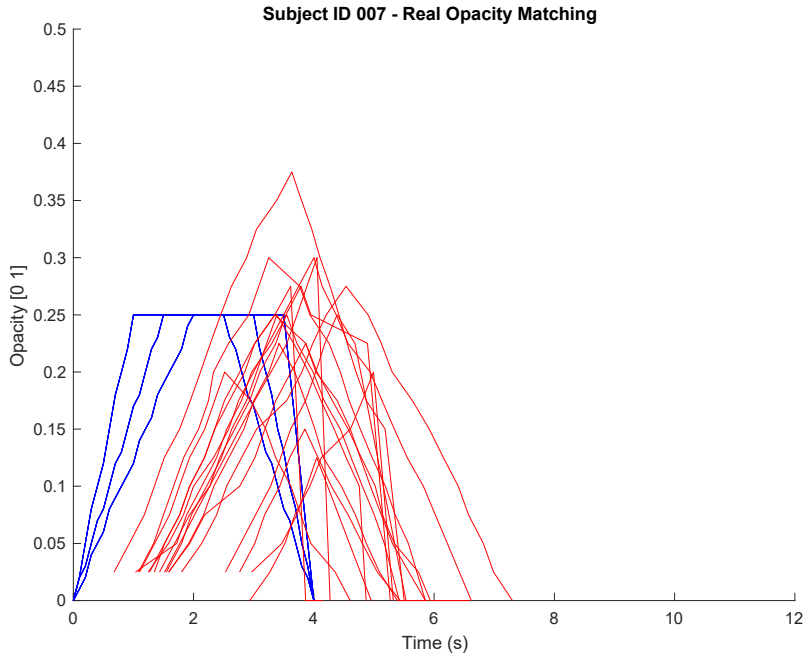
Subject Reported Afterimages

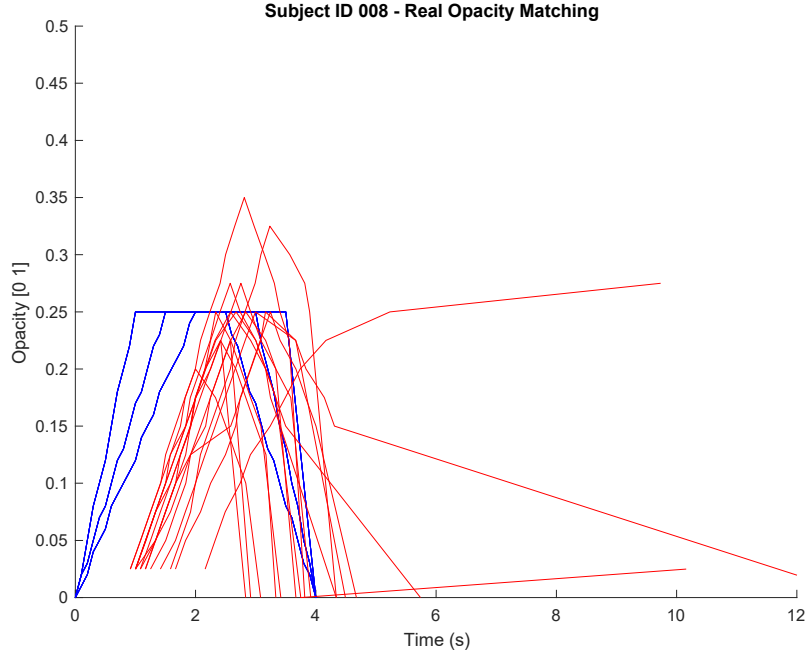
Afterimage (time vs opacity)

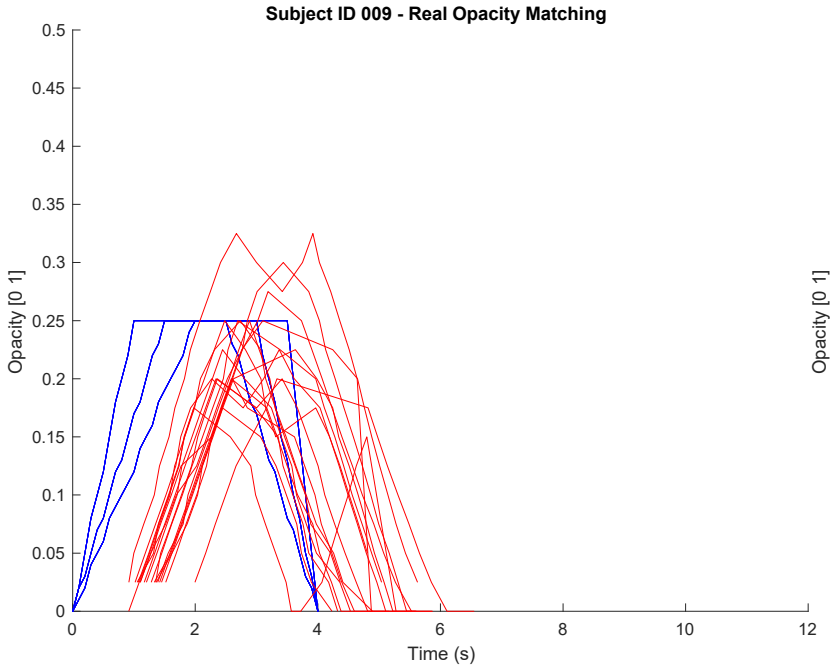
Reconstructed Afterimage

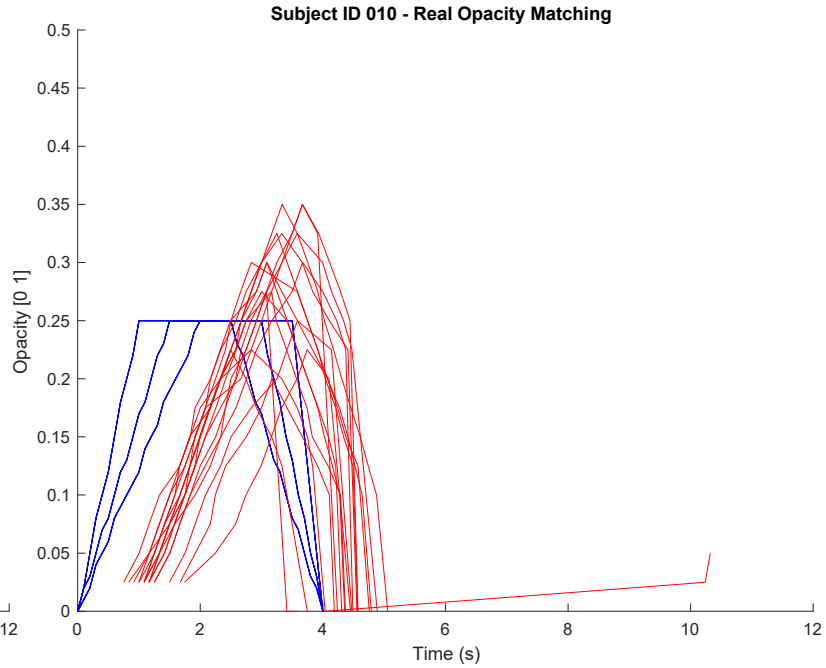
Kronemer et al., unpublished

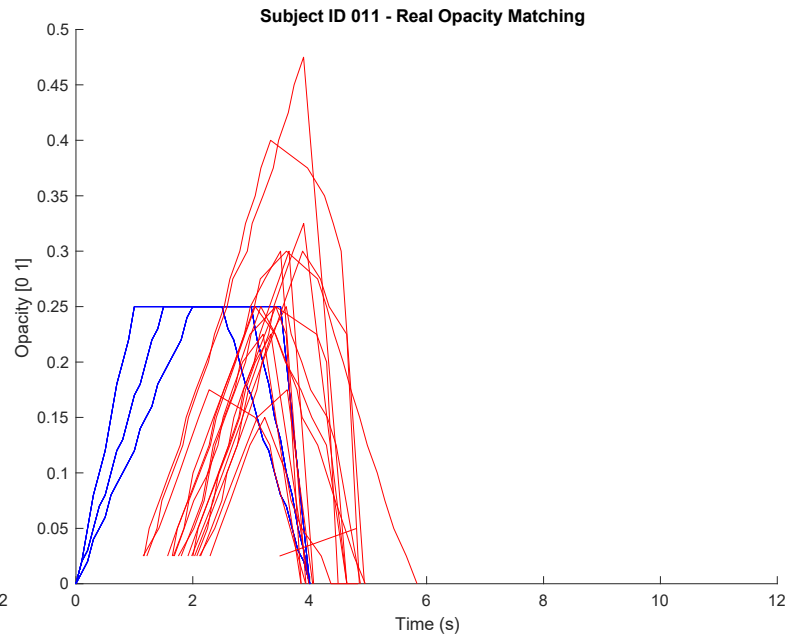




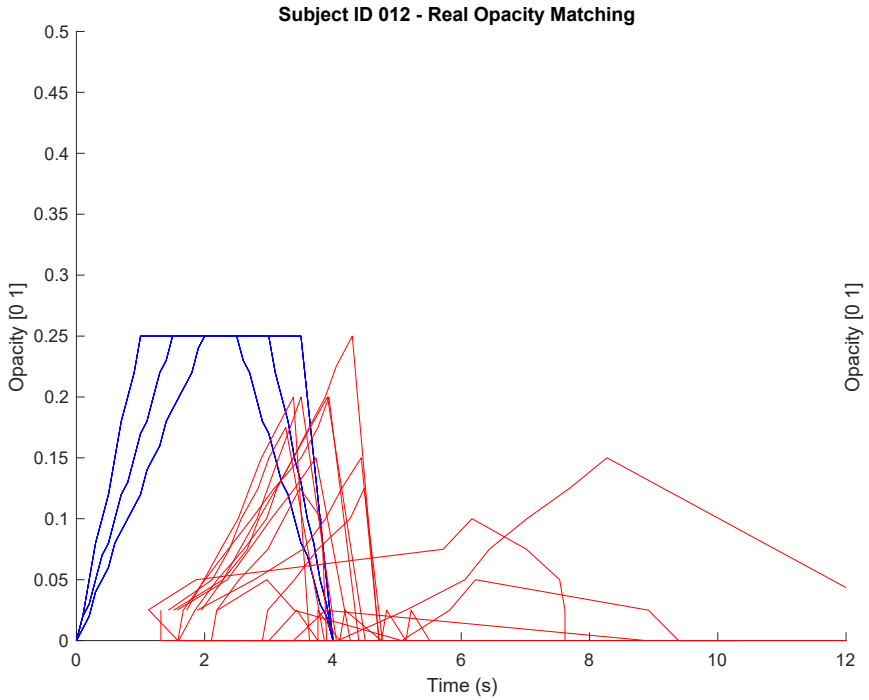


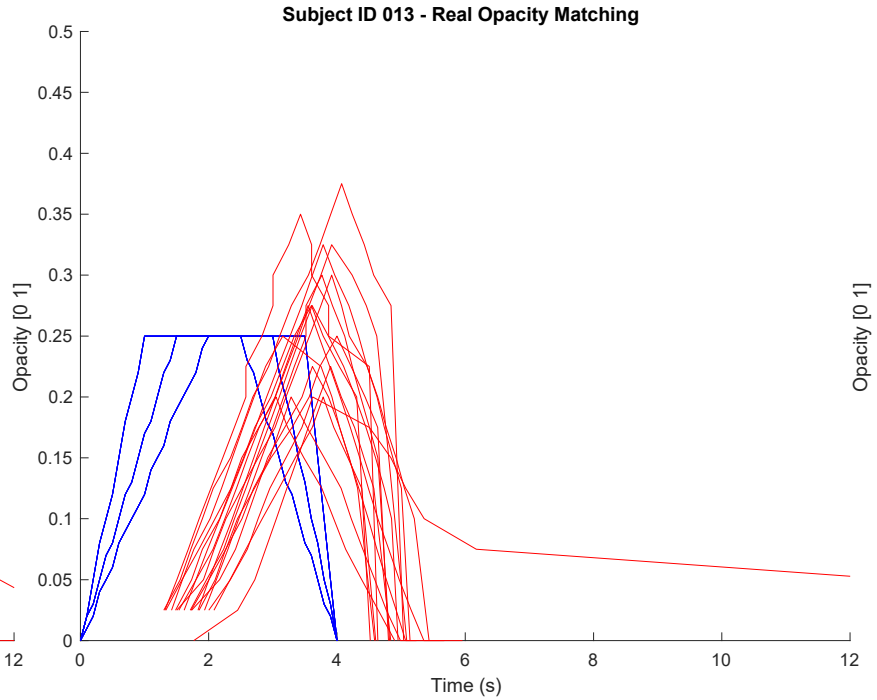


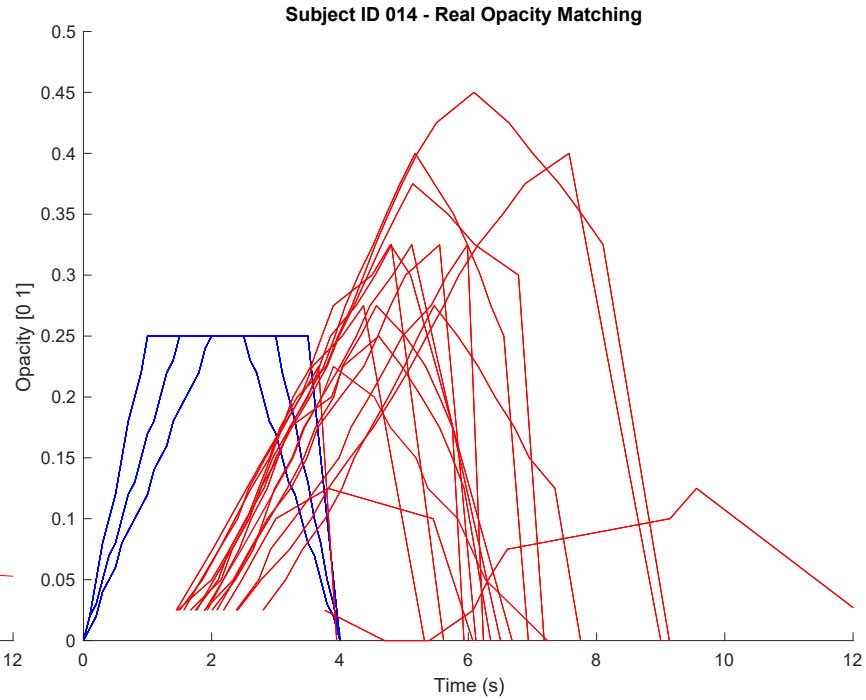


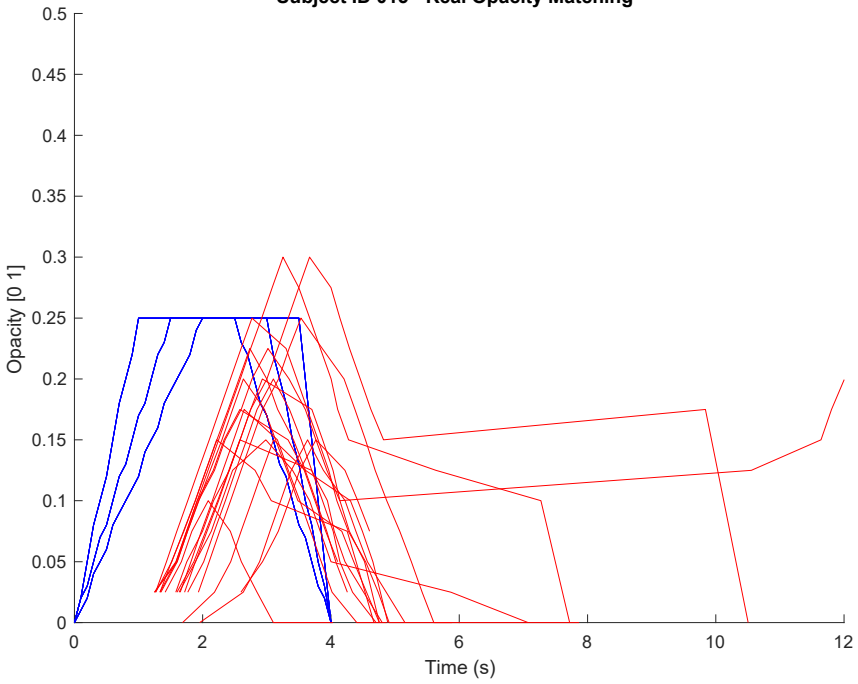


Kronemer et al., unpublished



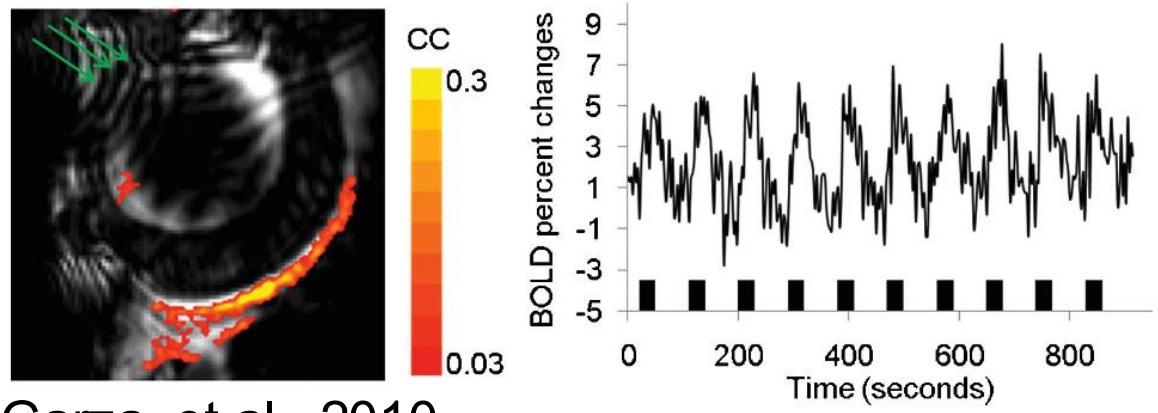






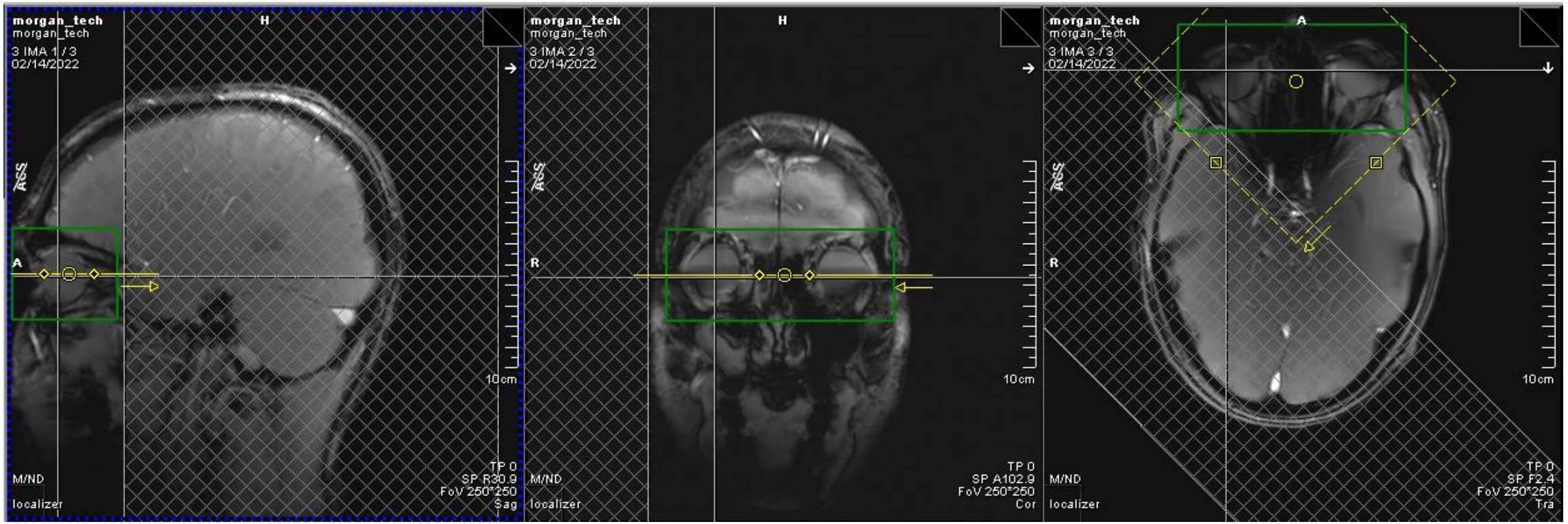
Kronemer et al., unpublished

Aim 1: Retinal fMRI

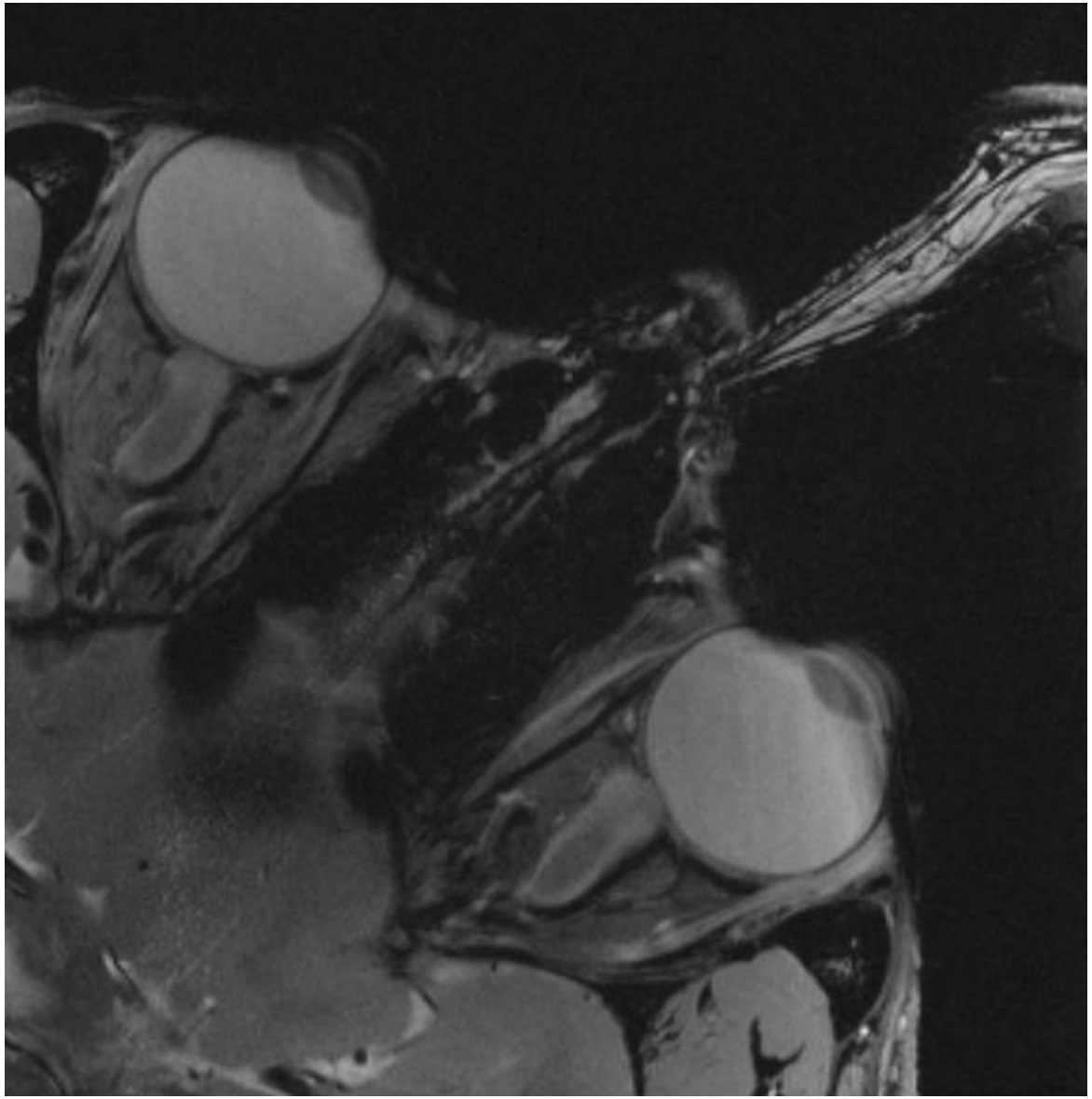


Garza, et al., 2010

2D FLASH Sequence
TR = 55ms
TEs (3 values) = 7.3 to 30ms
Slice thickness = 0.8mm
45deg Sat. Pulse



Aim 1: Retinal fMRI



Kronemer et al., unpublished