Neurocinematics

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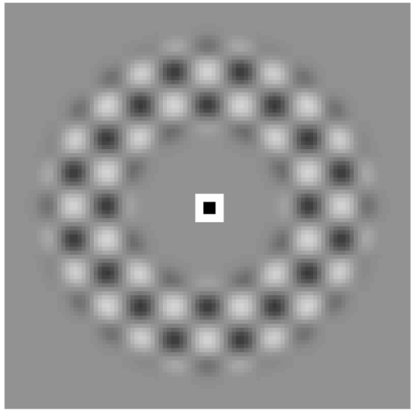
How the human brain interacts with the world in real life

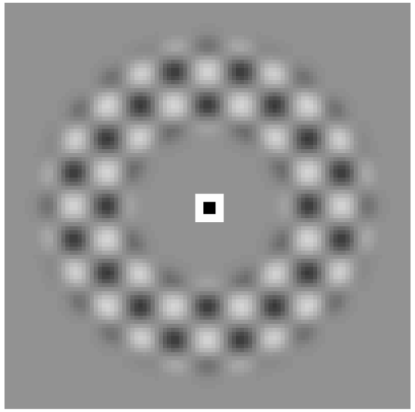
Simple sensory stimuli:

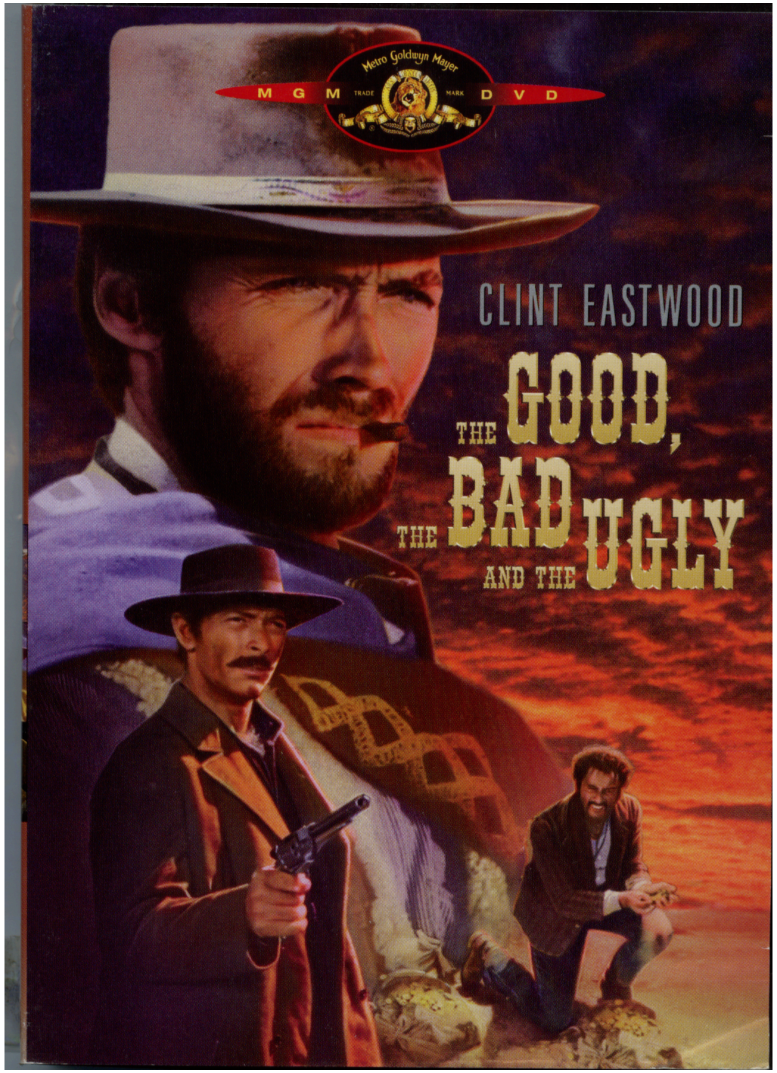


How the human brain interacts with the world in real life

The full complexity of real life:

Simple sensory stimuli:

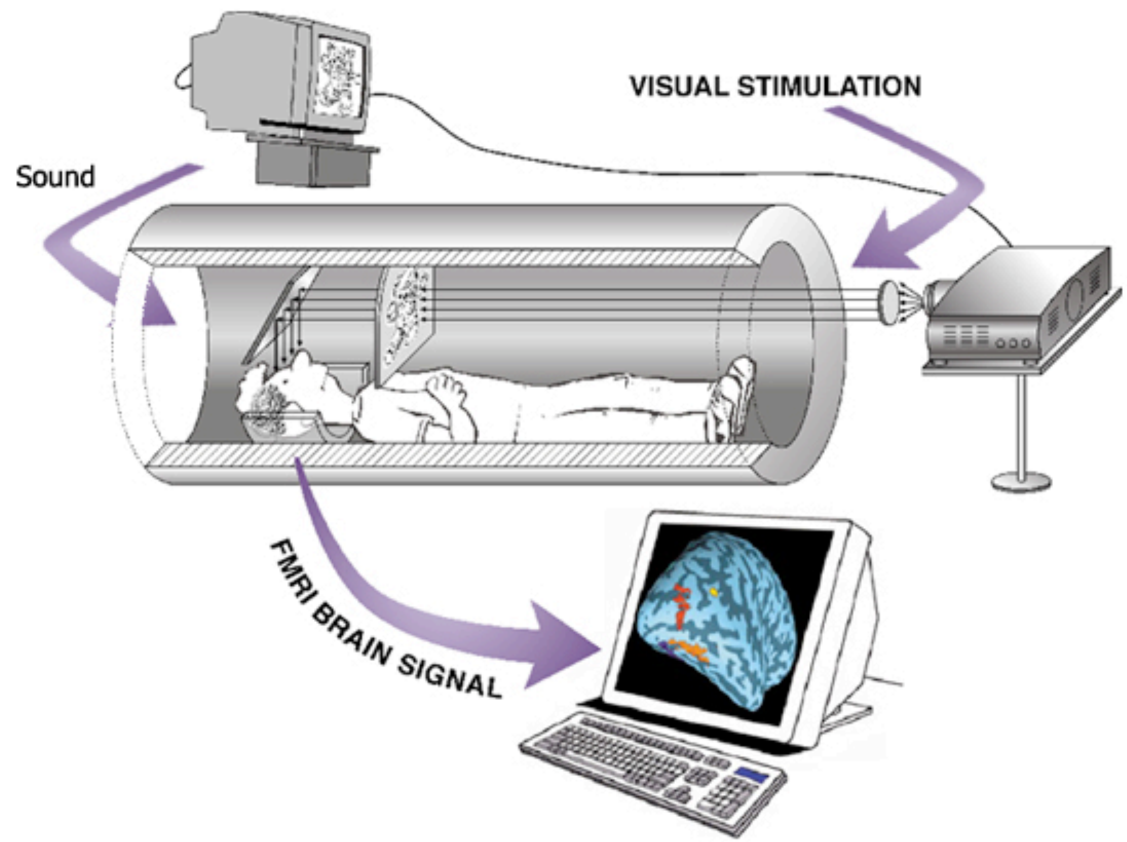




Hasson et al., Science (2004)
see also:
- Bartels & Zeki, Hum Brain Mapp (2004)
- Bartels & Zeki, Neuroimage (2004)

Protocol

1) Put subject in scanner
2) Instructions: “just watch”
3) Start movie & fMRI acquisition



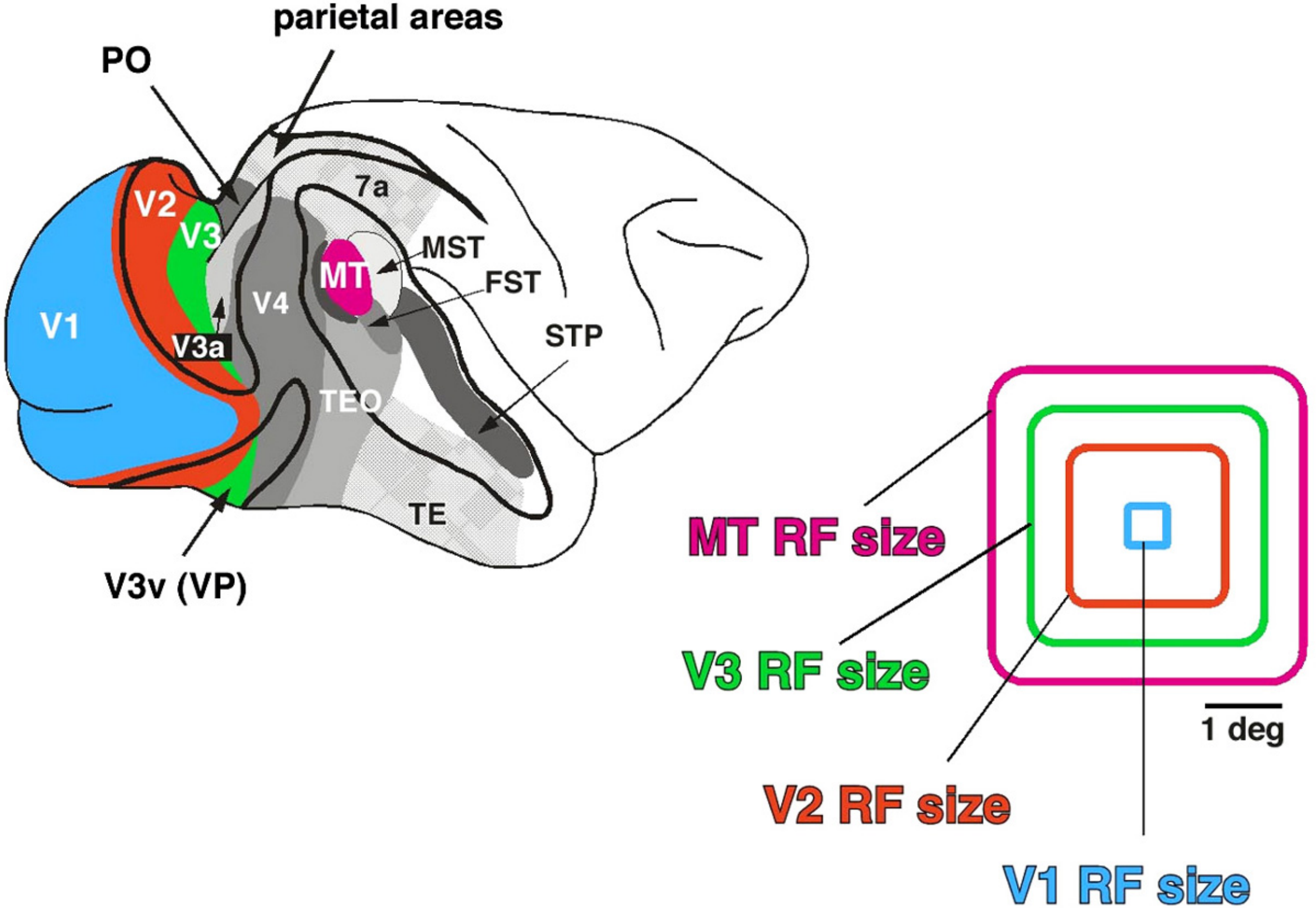
Events unfold over time

Events unfold over time

Hypothesis

Hierarchy of increasing “temporal receptive windows” from low level (sensory) to higher level (perceptual and cognitive) brain areas, i.e., responsive to sensory information accumulated over different time scales.

Analogy: increasing receptive field size



Experimental manipulation of time

Backward

Scrambled

Experimental manipulation of time

Backward

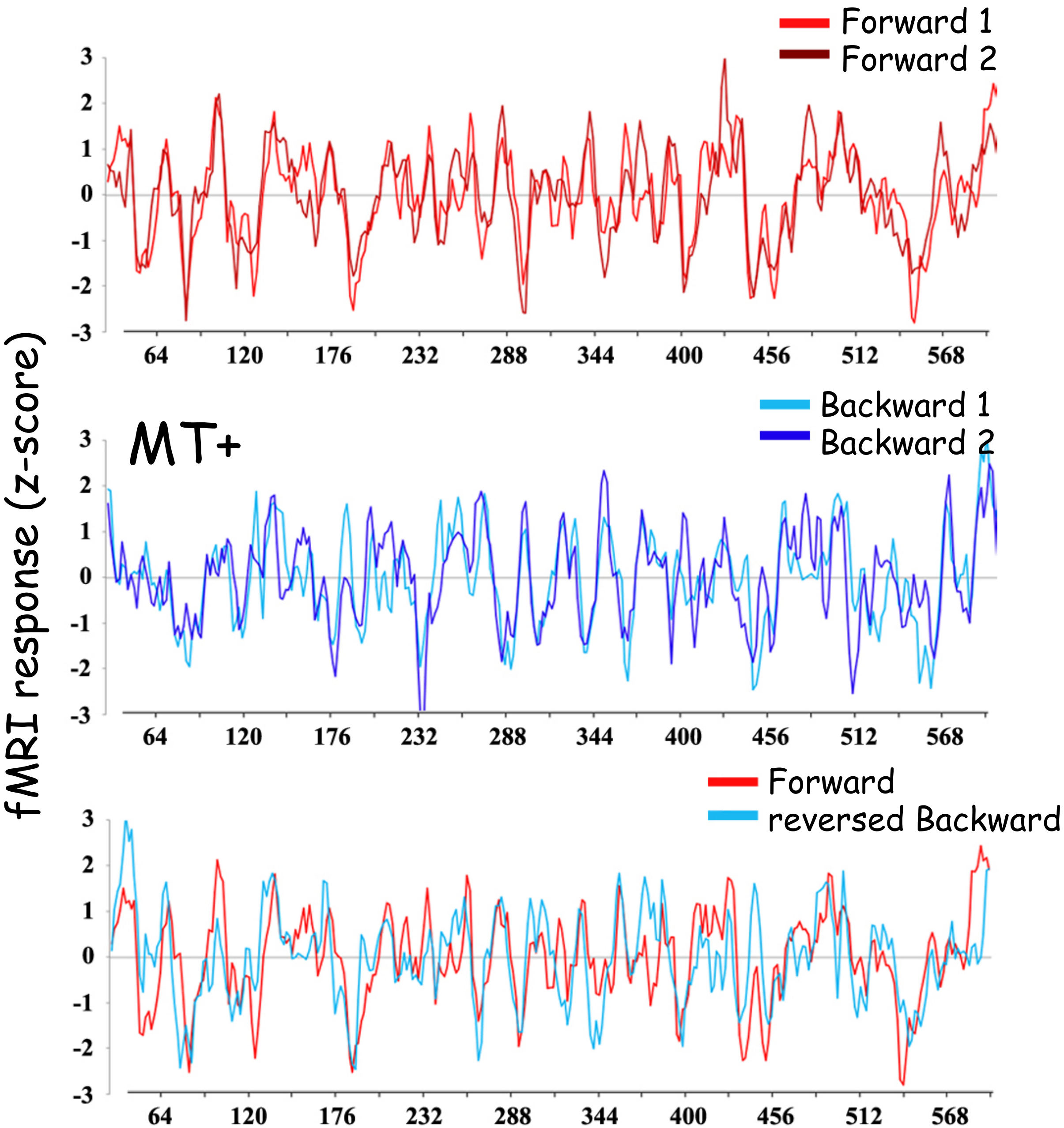
Scrambled

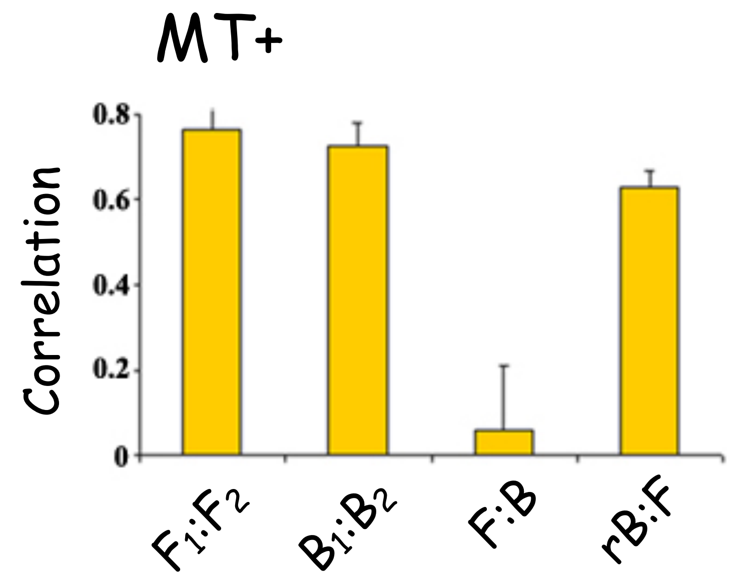
Experimental manipulation of time

Backward

Scrambled

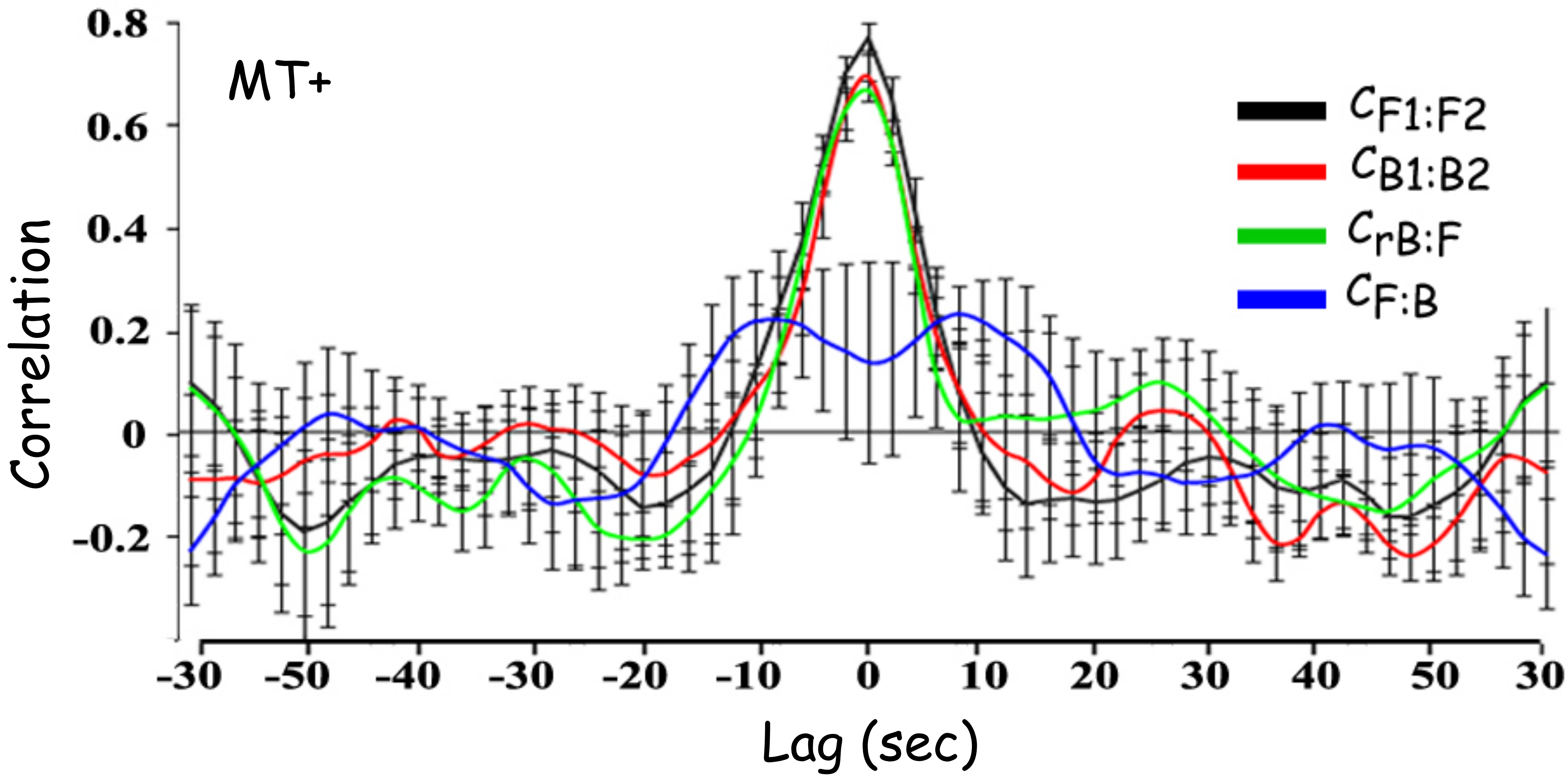
MT+ operates at a short time scale





Hasson et al., J Neurosci (2008)

Independence of time reversal



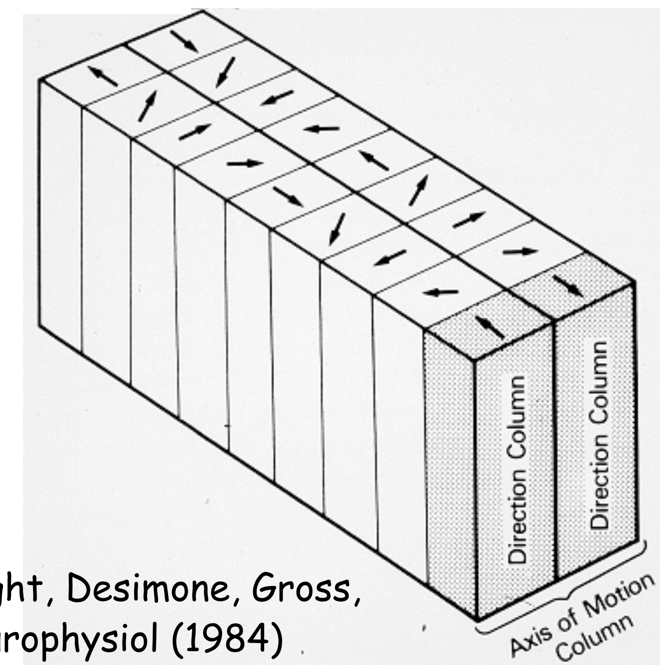
Hasson et al., J Neurosci (2008)

Why are MT+ responses time-reversible?

Forward: left to right movement

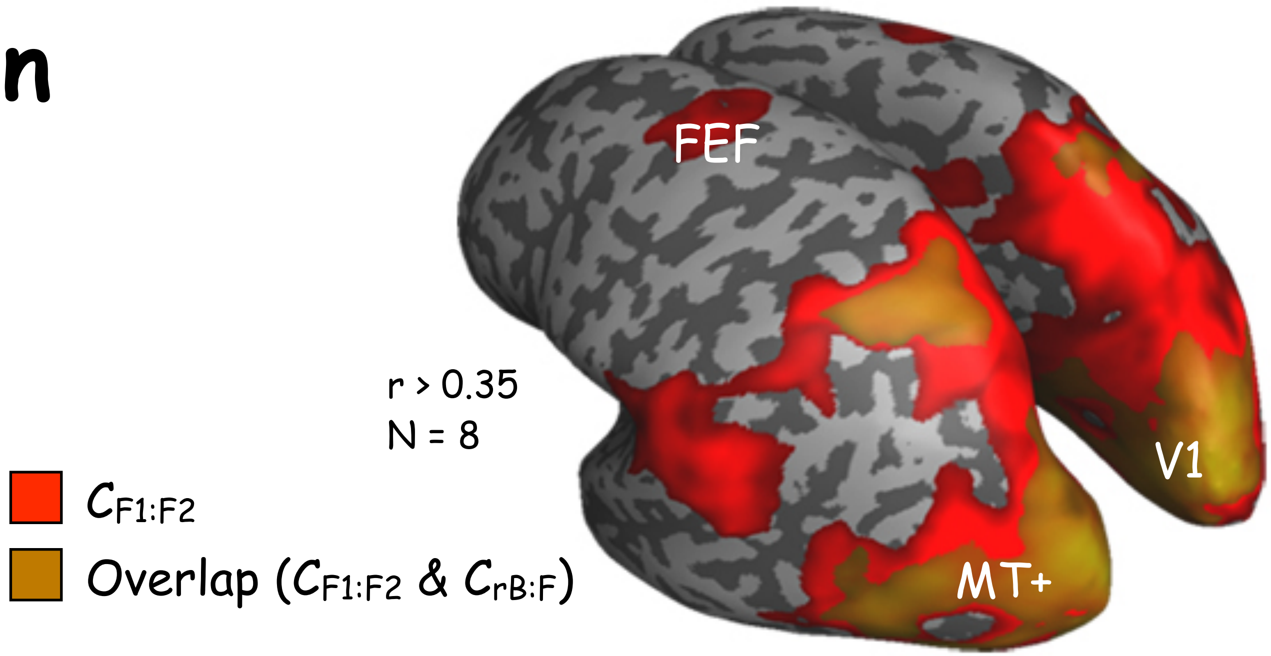
Backward: right to left movement

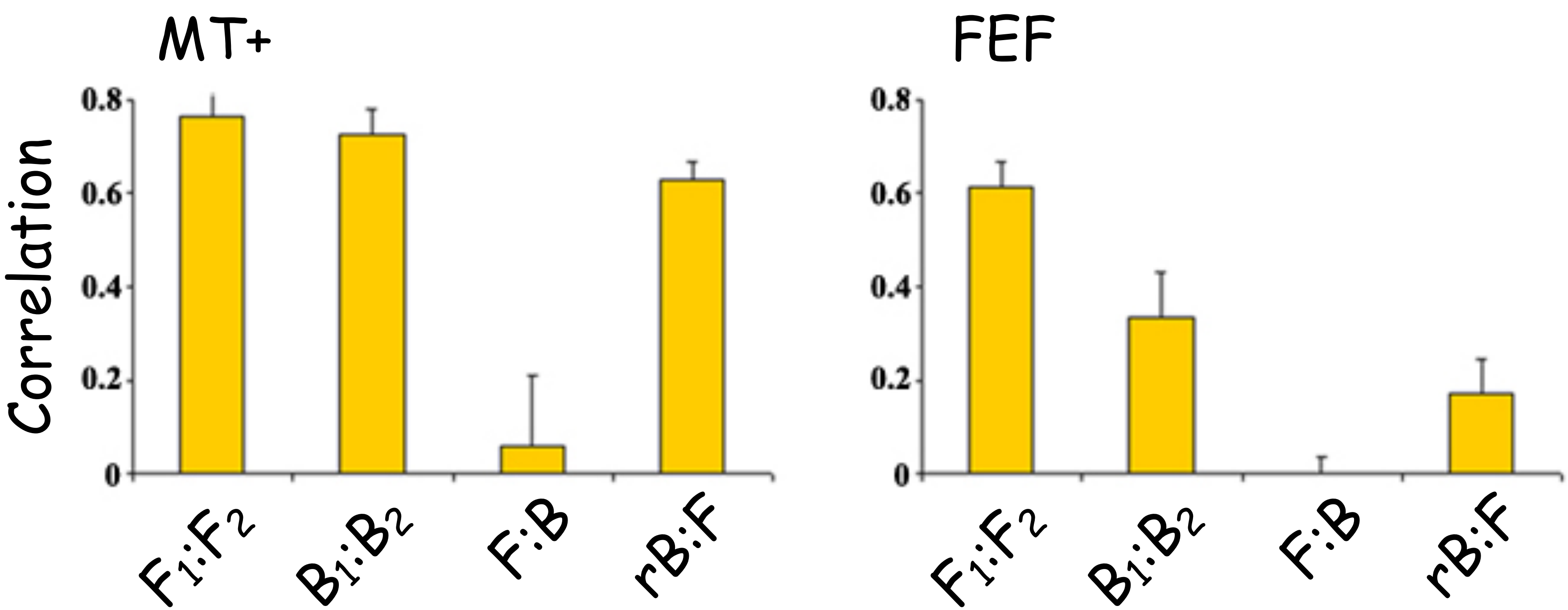
MT+ voxel: equal numbers of right- and left-selective neurons, with symmetrical responses to onsets and offsets.



Albright, Desimone, Gross, J Neurophysiol (1984)

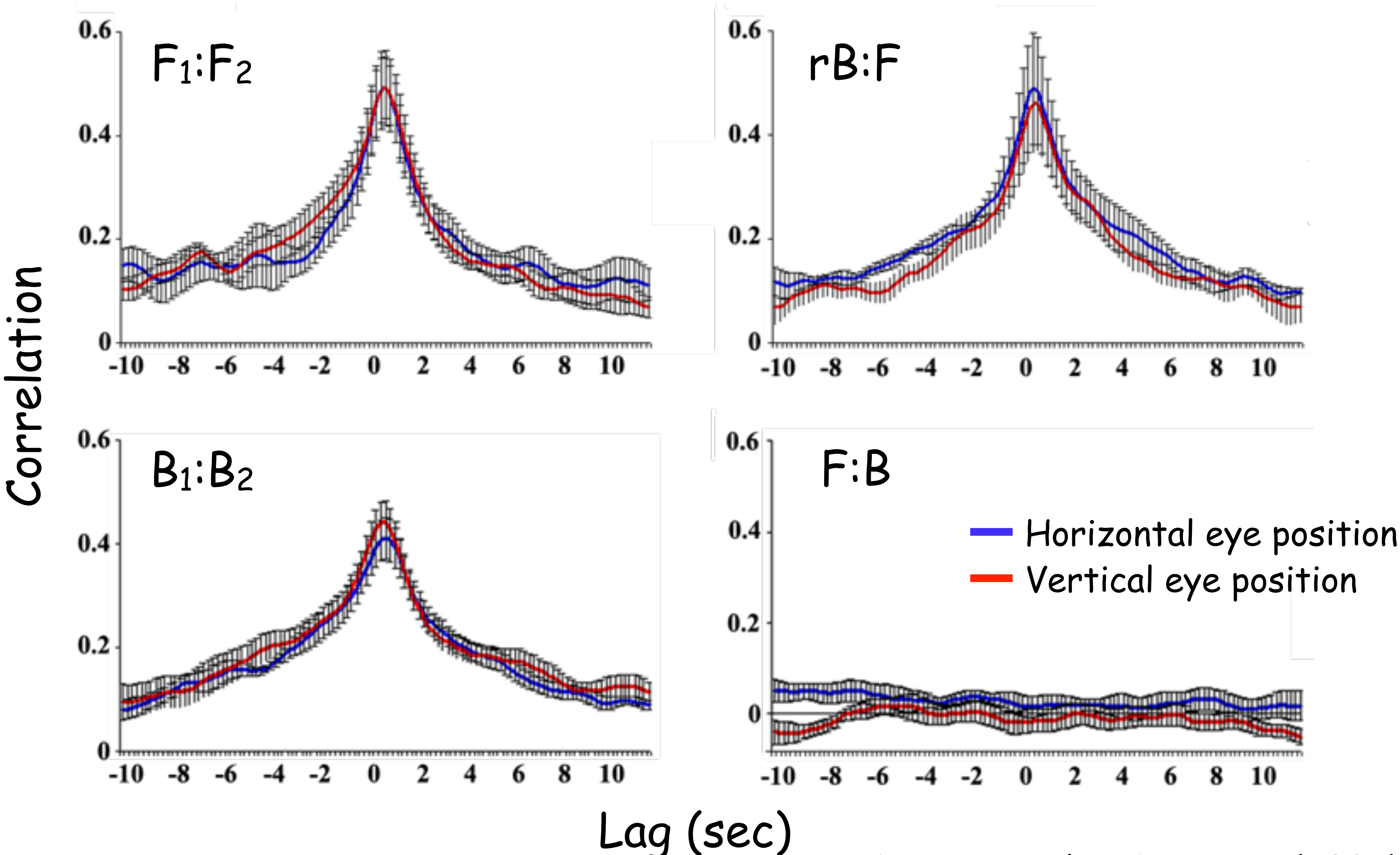
Dependence on time reversal





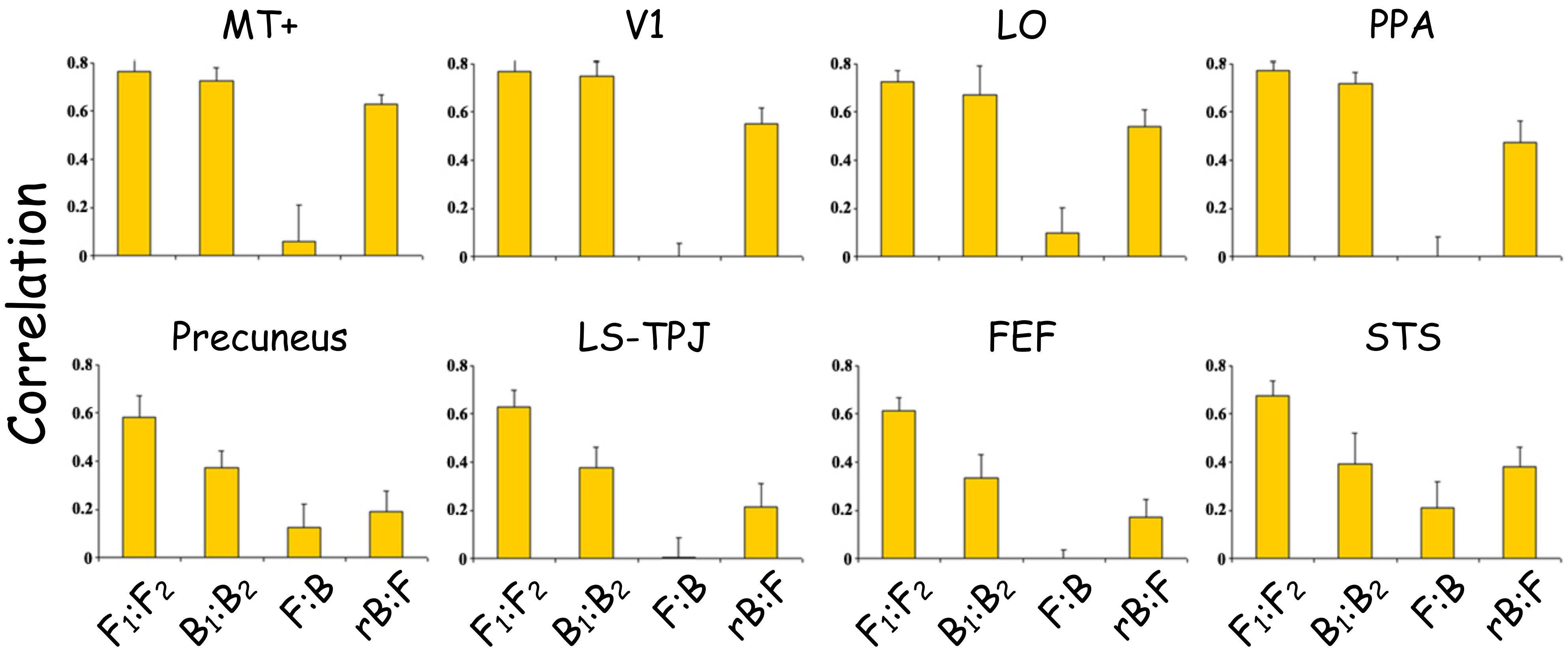
Hasson et al., J Neurosci (2008)

Reproducible eye movements regardless of time reversal



Hasson et al., J Neurosci (2008)

Dependence on time reversal



Hasson et al., J Neurosci (2008)

Parametric manipulation of time scale

Short (~4 sec) Medium (~12 sec) Long (~36 sec)

Parametric manipulation of time scale

Short (~4 sec) Medium (~12 sec) Long (~36 sec)

Parametric manipulation of time scale

Short (~4 sec)

Medium (~12 sec)

Long (~36 sec)

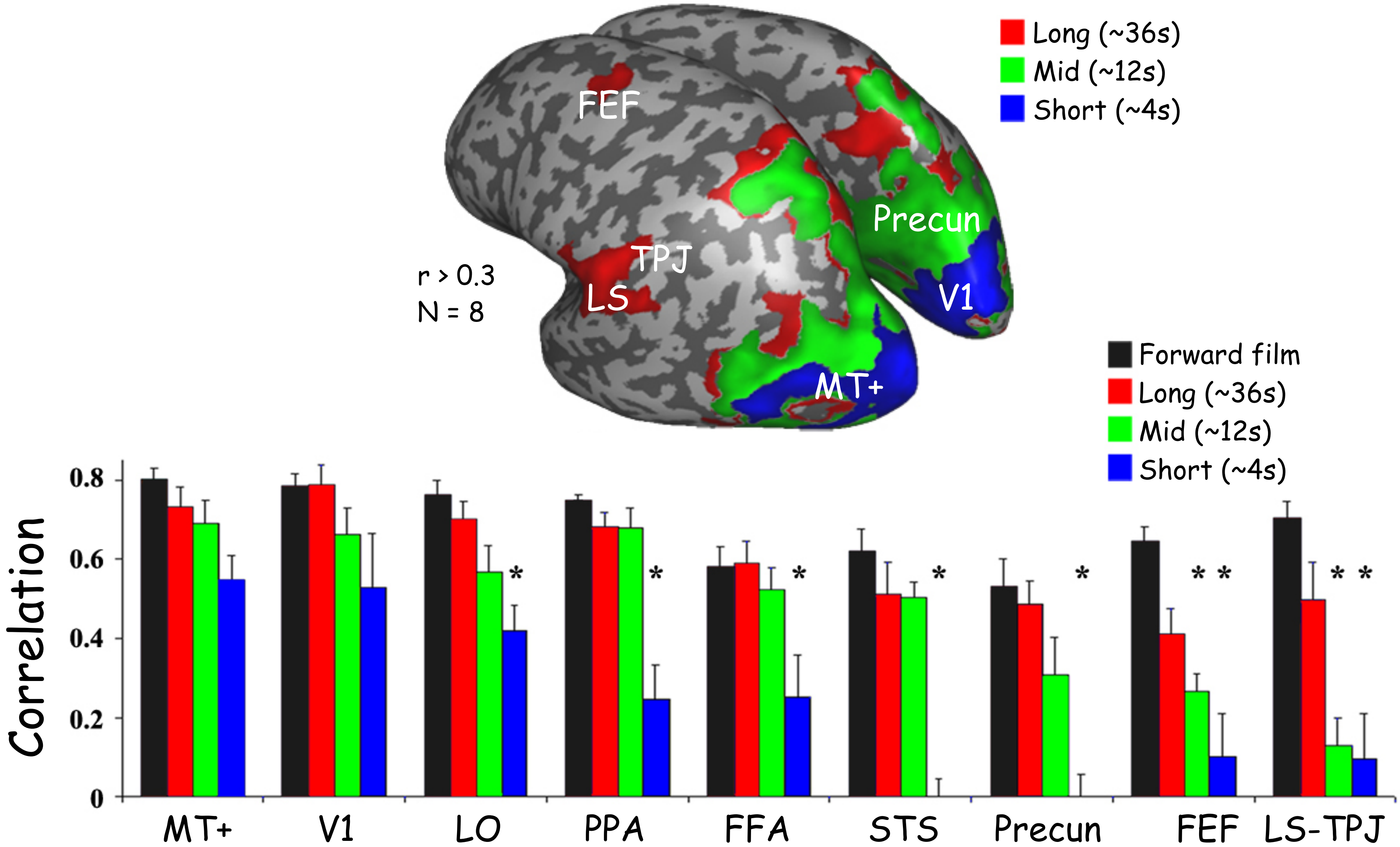
Parametric manipulation of time scale

Short (~4 sec)

Medium (~12 sec)

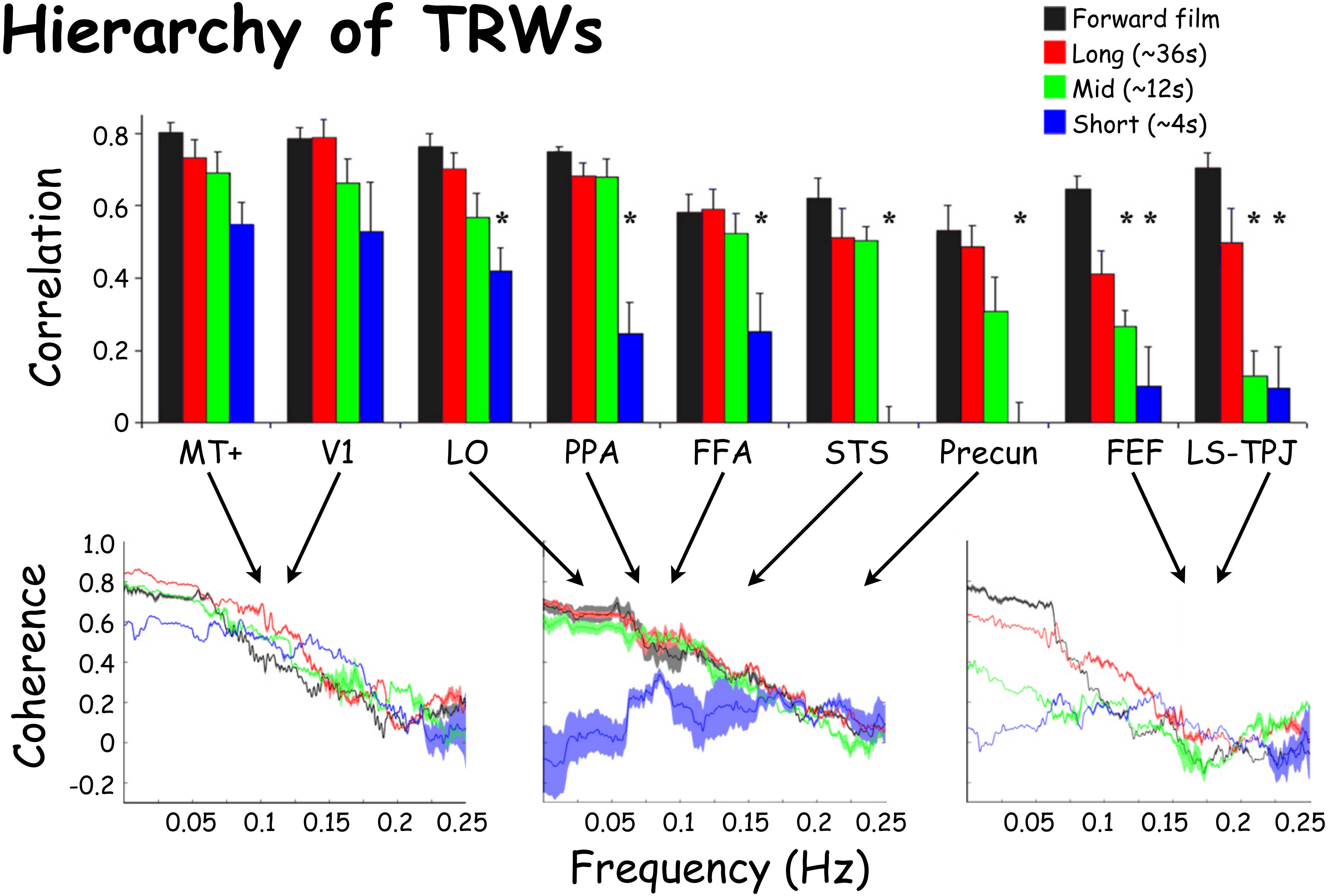
Long (~36 sec)

Hierarchy of TRWs



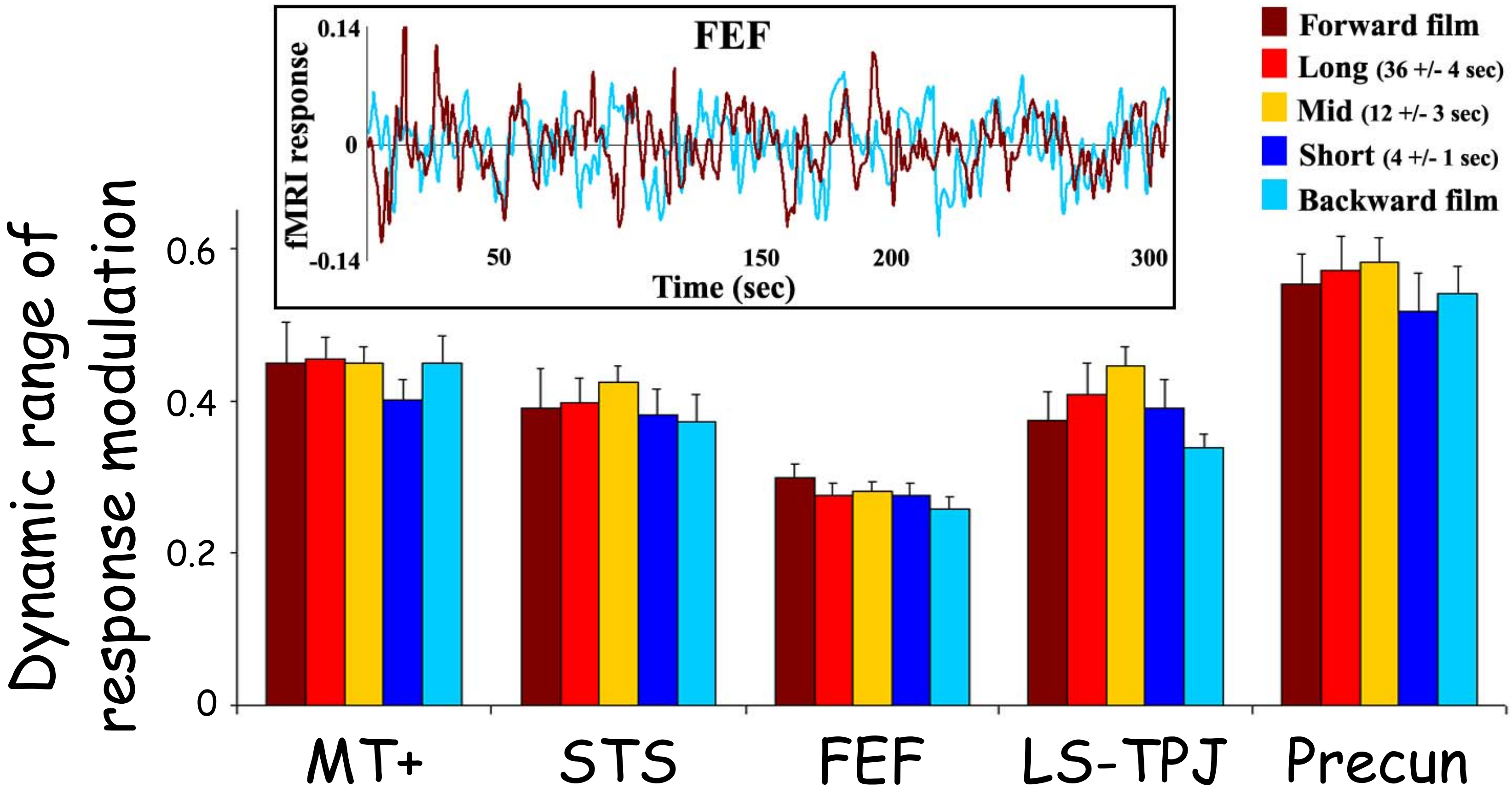
Hasson et al., J Neurosci (2008)

Hierarchy of TRWs



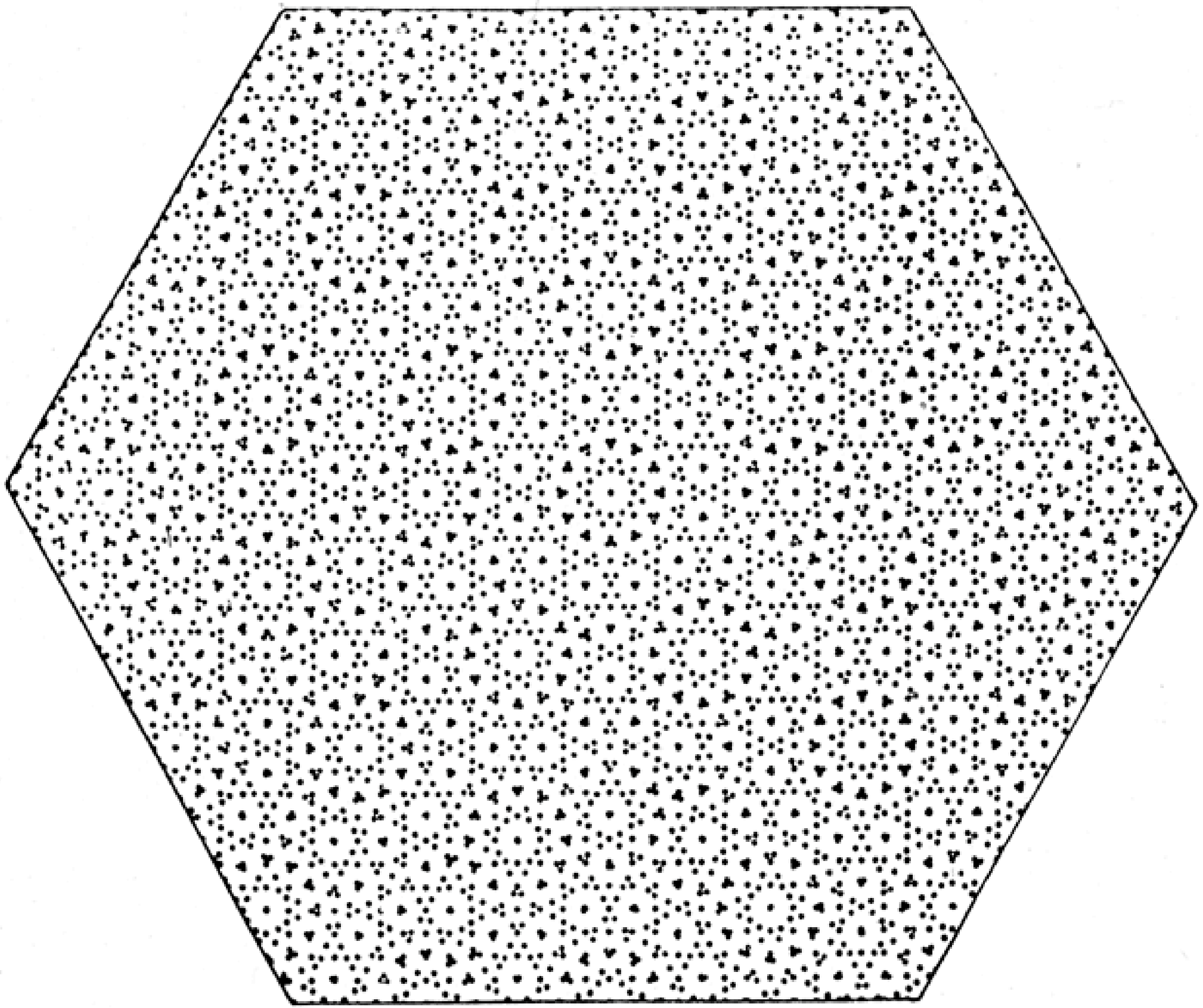
Hasson et al., J Neurosci (2008)

Dissociation between response amplitude and reliability



Strong response amplitudes for all conditions regardless of temporal receptive window.

Hasson et al., J Neurosci (2008)

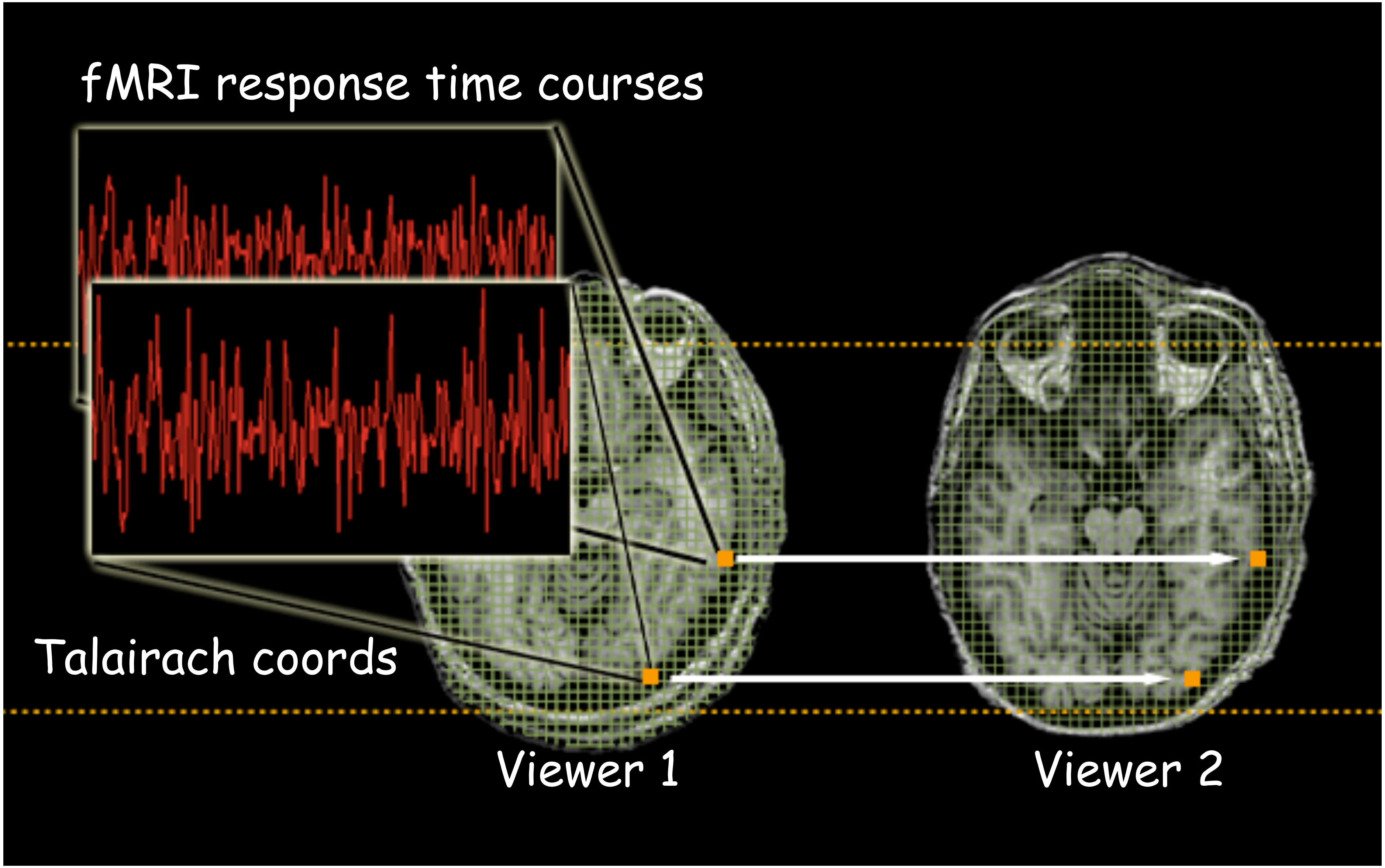


Marroquin (1976)

Neurocinematics

Measuring the effectiveness (i.e., level of experimental control) of popular media on viewers' brains .

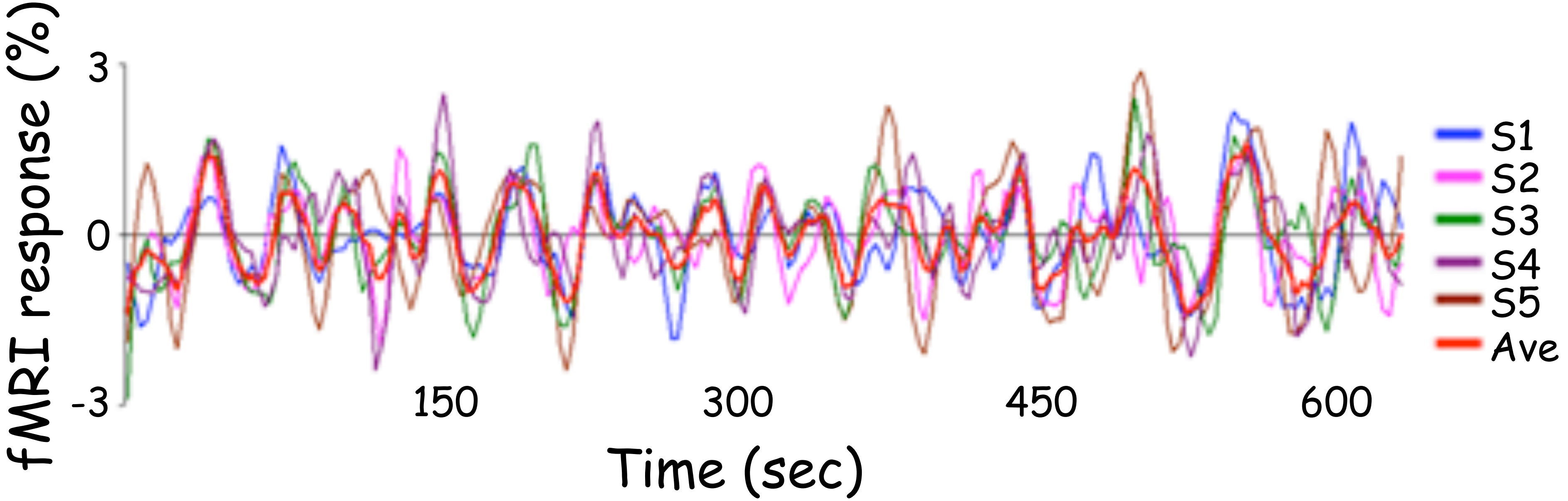
Inter-subject correlation



Hasson et al., Science (2004)

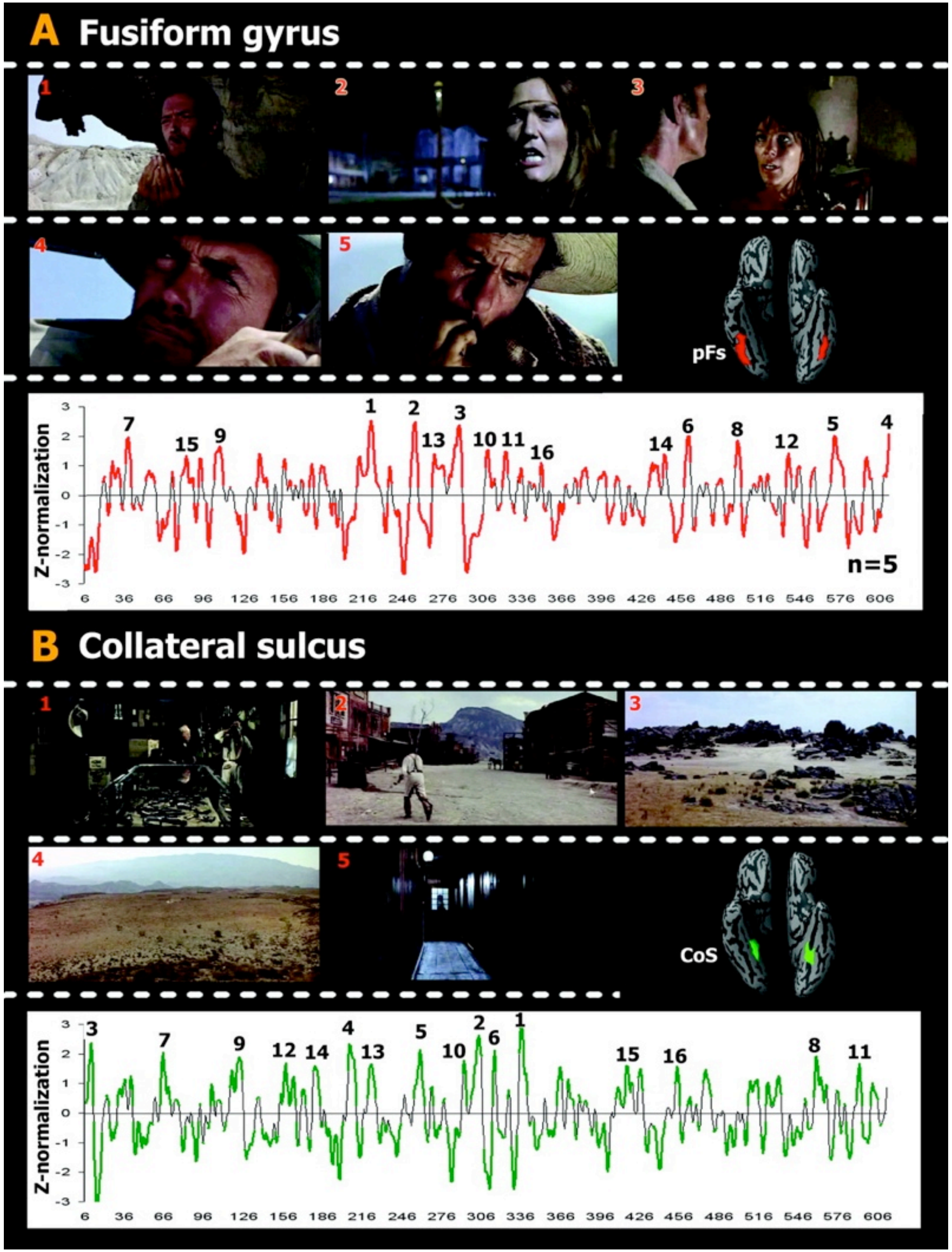
Inter-subject correlation (ISC)

FFA: mean ISC = 0.45



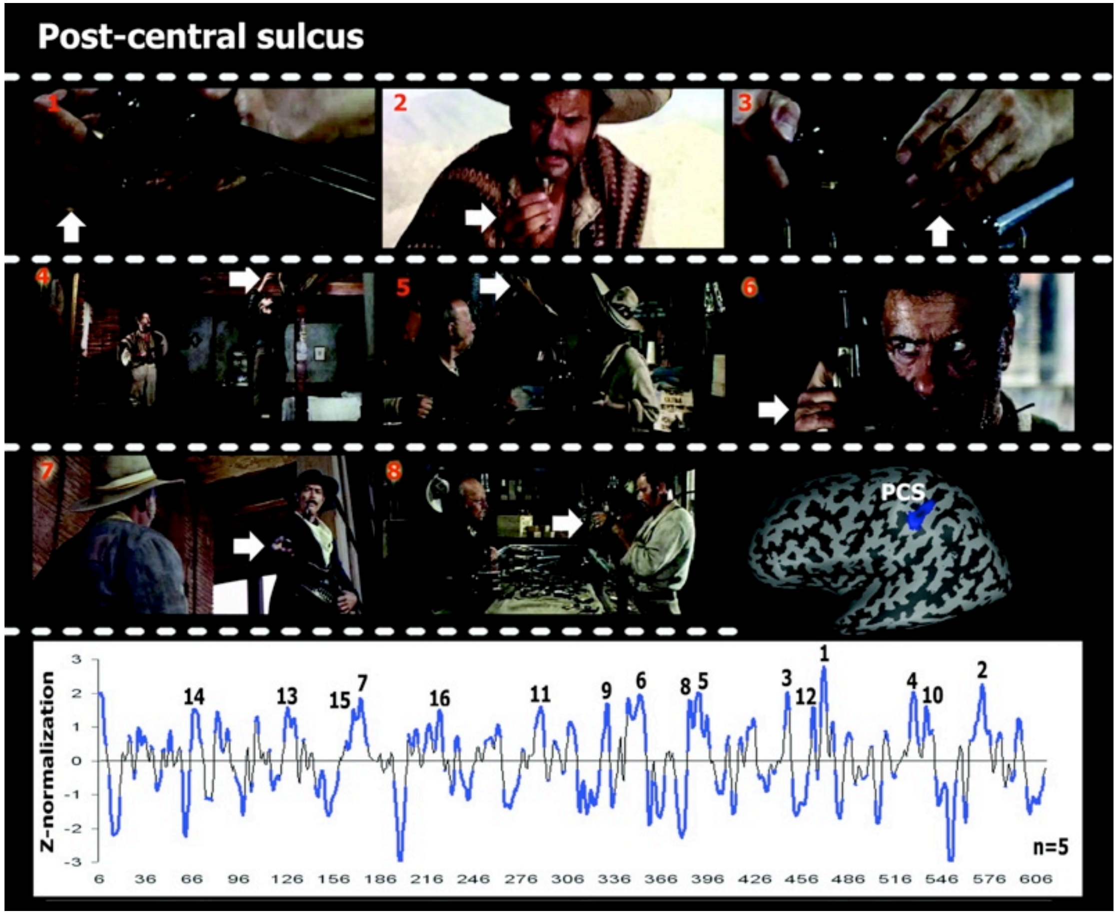
Hasson et al., Science (2004)

Functional specialization: faces & places



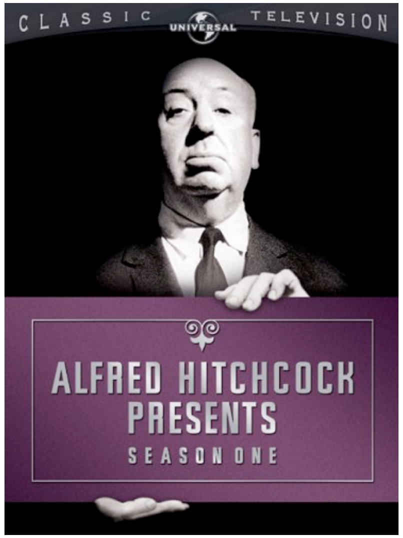
Hasson et al., Science (2004)

Functional specialization: hand movements



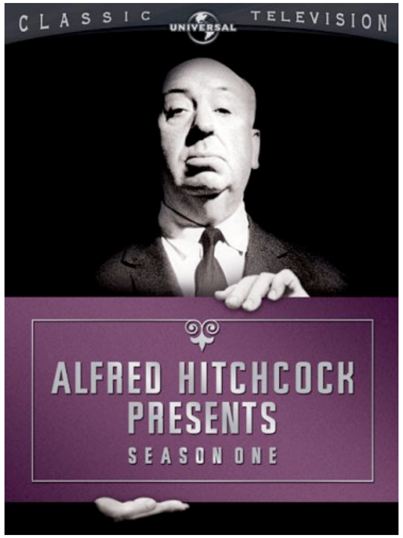
Hasson et al., Science (2004)

Maximizing ISC (control over brain activity)



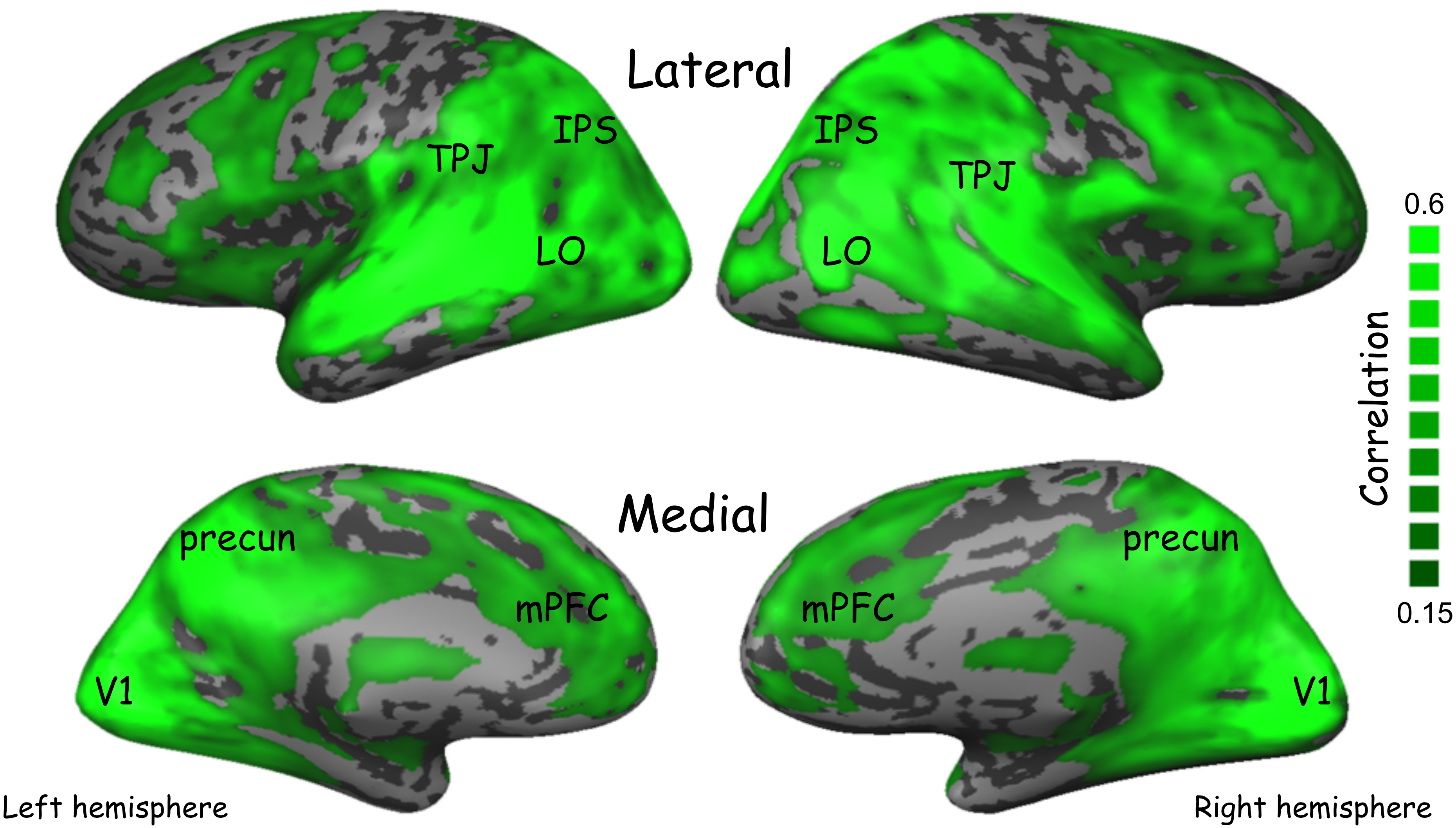
Hasson, Knappmeyer et al., Projections (2008)

Maximizing ISC (control over brain activity)



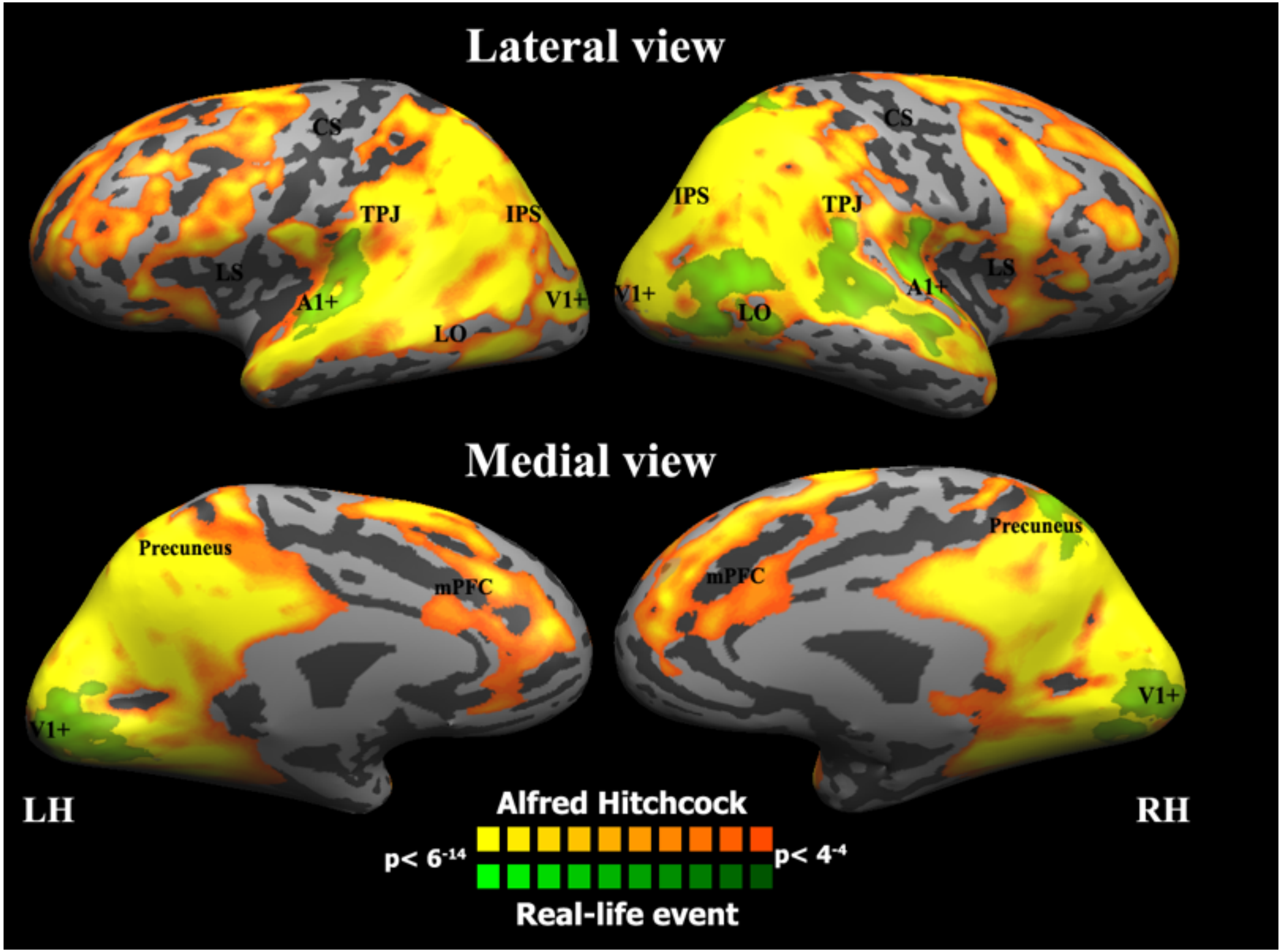
Hasson, Knappmeyer et al., Projections (2008)

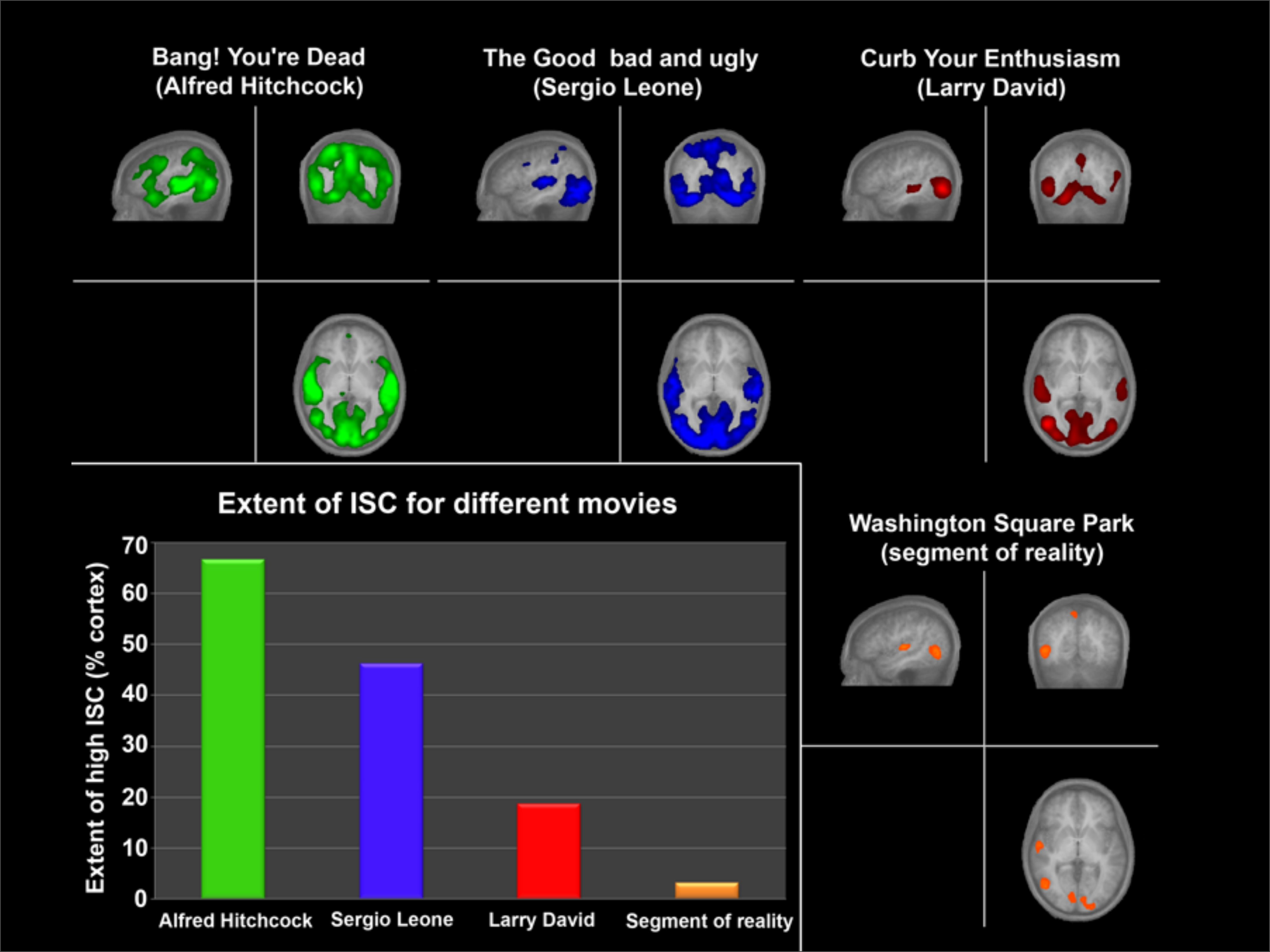
ISC for Hitchcock



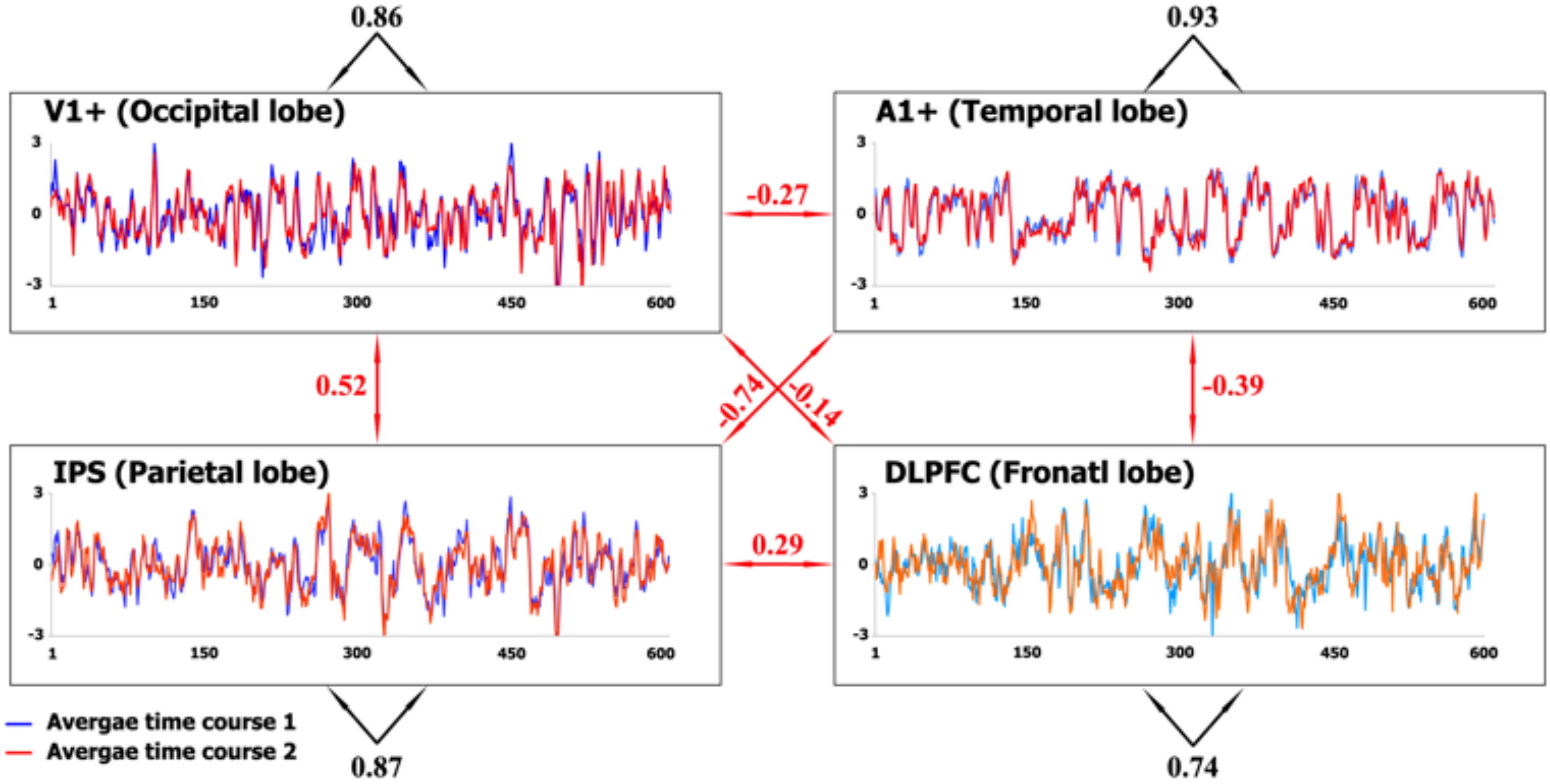
Hasson, Knappmeyer et al., Projections (2008)

ISC depends on stimulus content



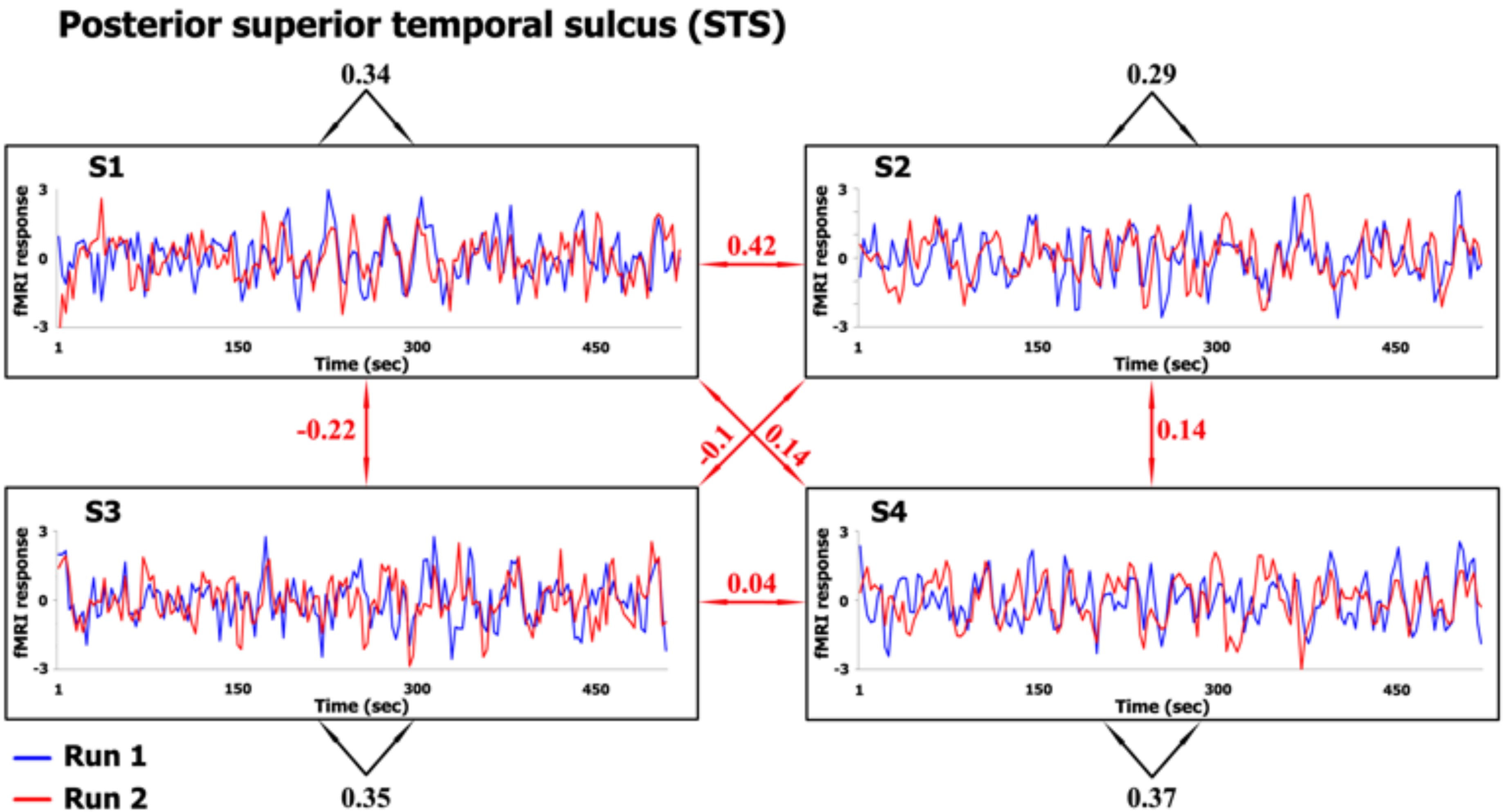

Bang! You're Dead
(Alfred Hitchcock)
The Good bad and ugly
(Sergio Leone)
Curb Your Enthusiasm
(Larry David)
Extent of ISC for different movies
Extent of high ISC (% cortex)
70
60
50
40
30
20
10
0
Alfred Hitchcock
Sergio Leone
Larry David
Segment of reality
Washington Square Park
(segment of reality)

Selectivity of ISC



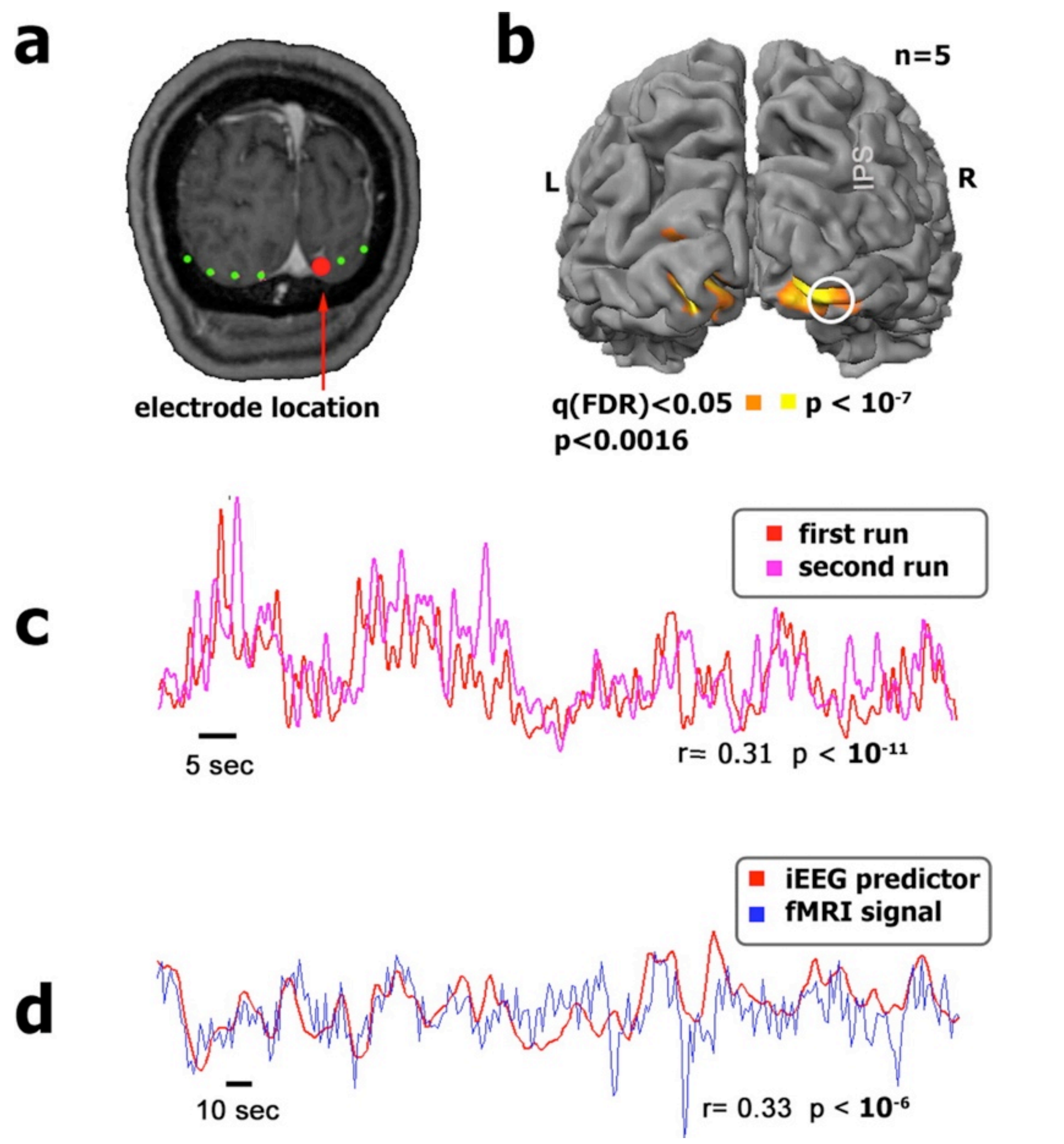
Similar responses across subjects for each brain area.
Different responses across brain areas.

Individual differences



Activity in this brain area differed across subjects, but for each individual subject responses were similar across repeated presentations.

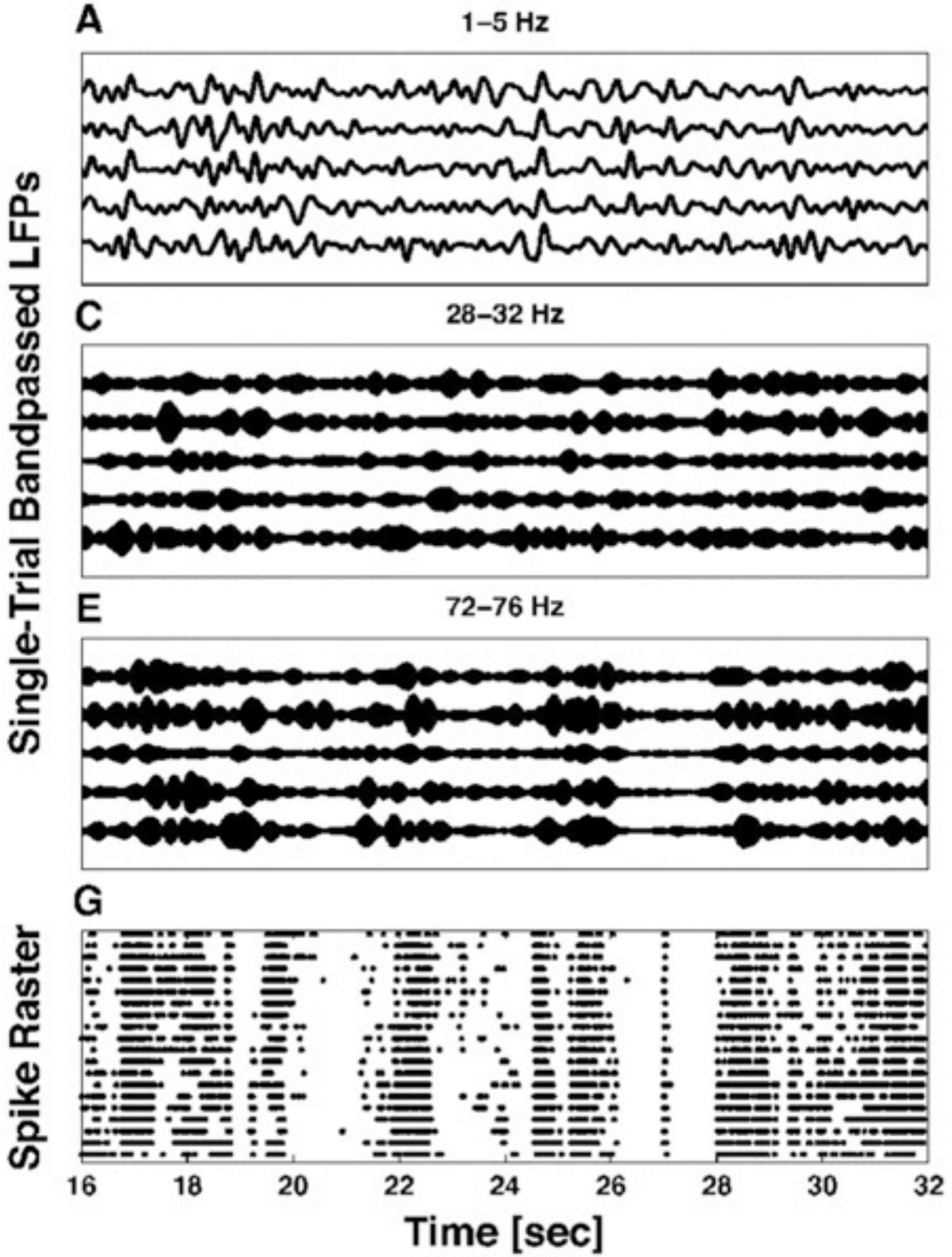
Inter-trial correlation in iEEG and ISC with fMRI



Privman et al., J Neurosci (2008)

Inter-trial correlation in LFP and spiking

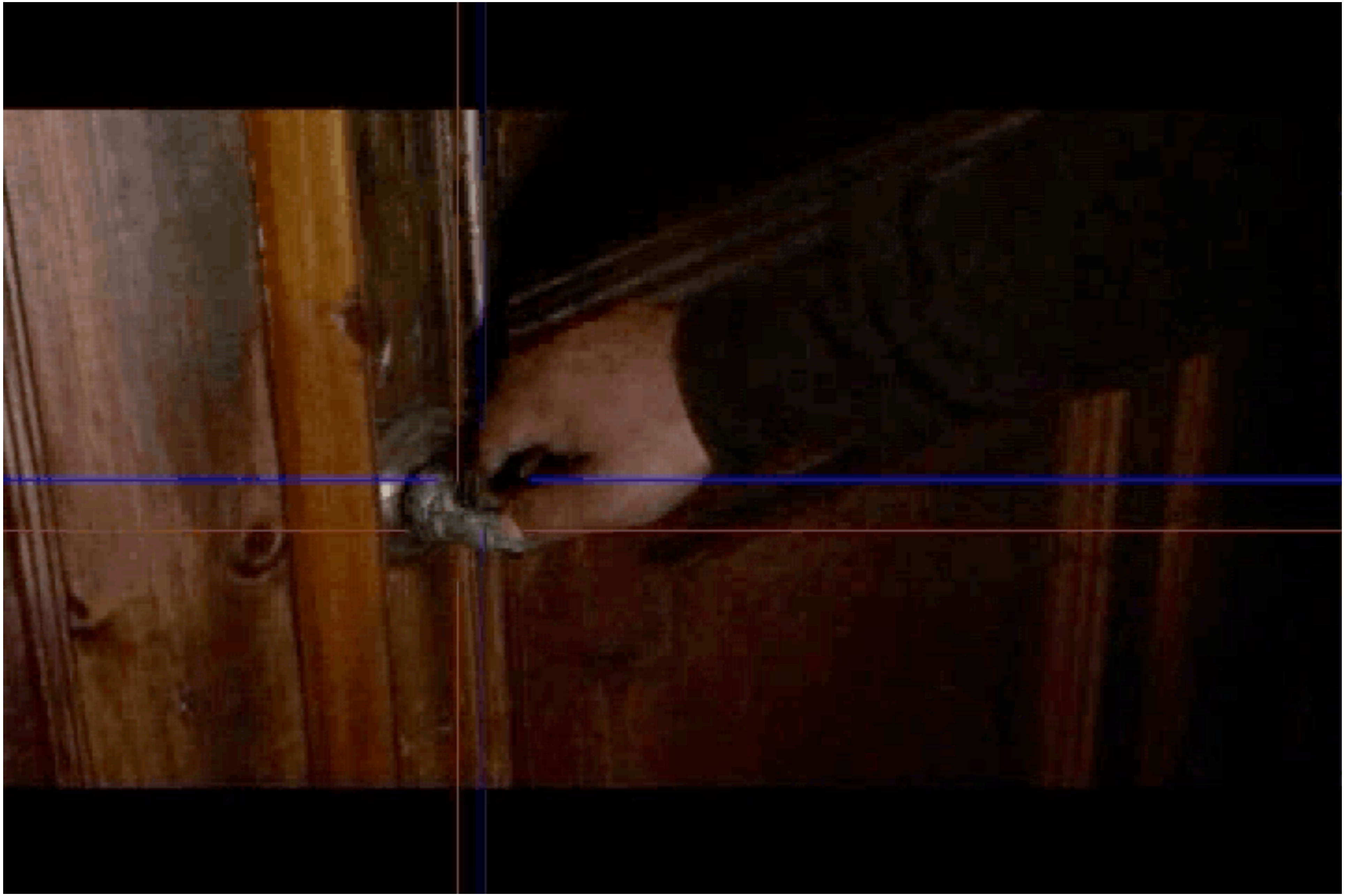
Anesthetized monkey
primary visual cortex



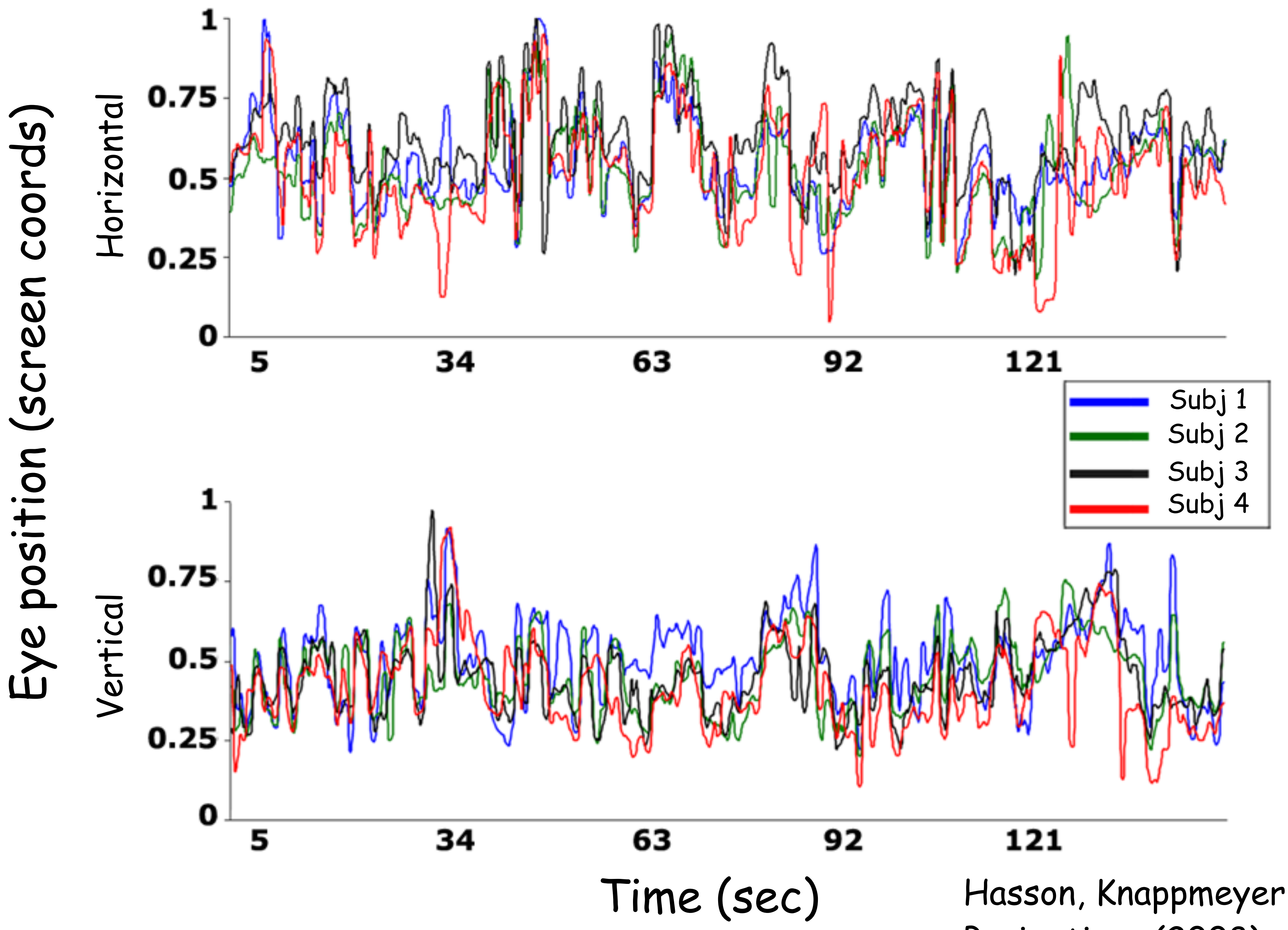
Belitski et al., J Neurosci (2008)

Eye position correlation

Eye position correlation



Eye position correlation



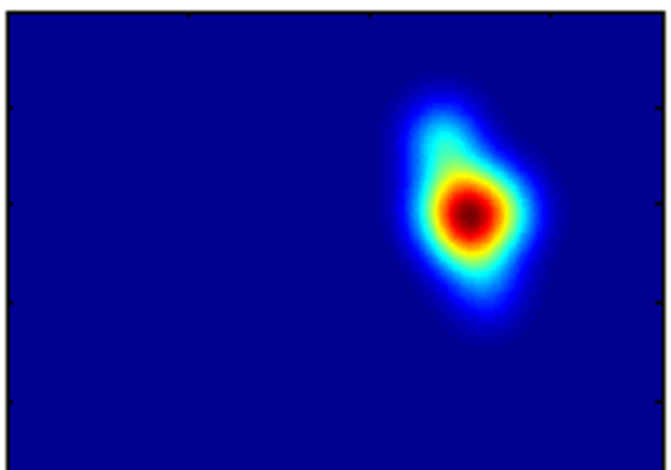
Hasson, Knappmeyer et al., Projections (2008)

Eye position correlation in depends on content

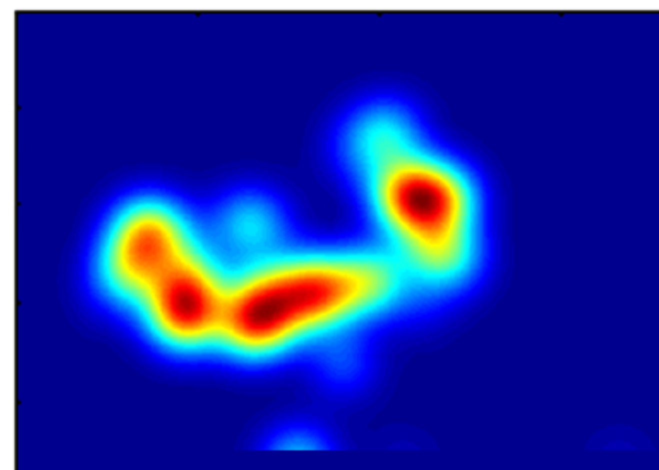
Structured movie

Unstructured movie

Average gaze map (0.5 s)



Average gaze map (0.5 s)



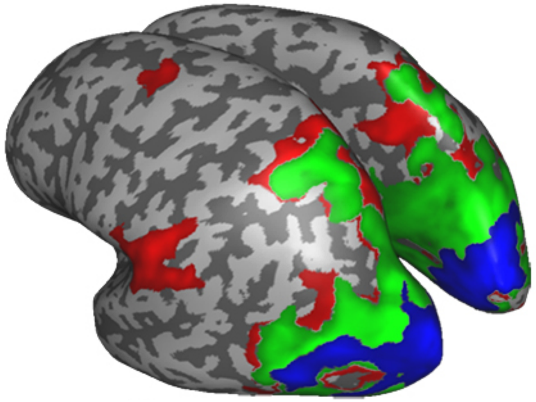
Hasson, Knappmeyer et al., Projections (2008)

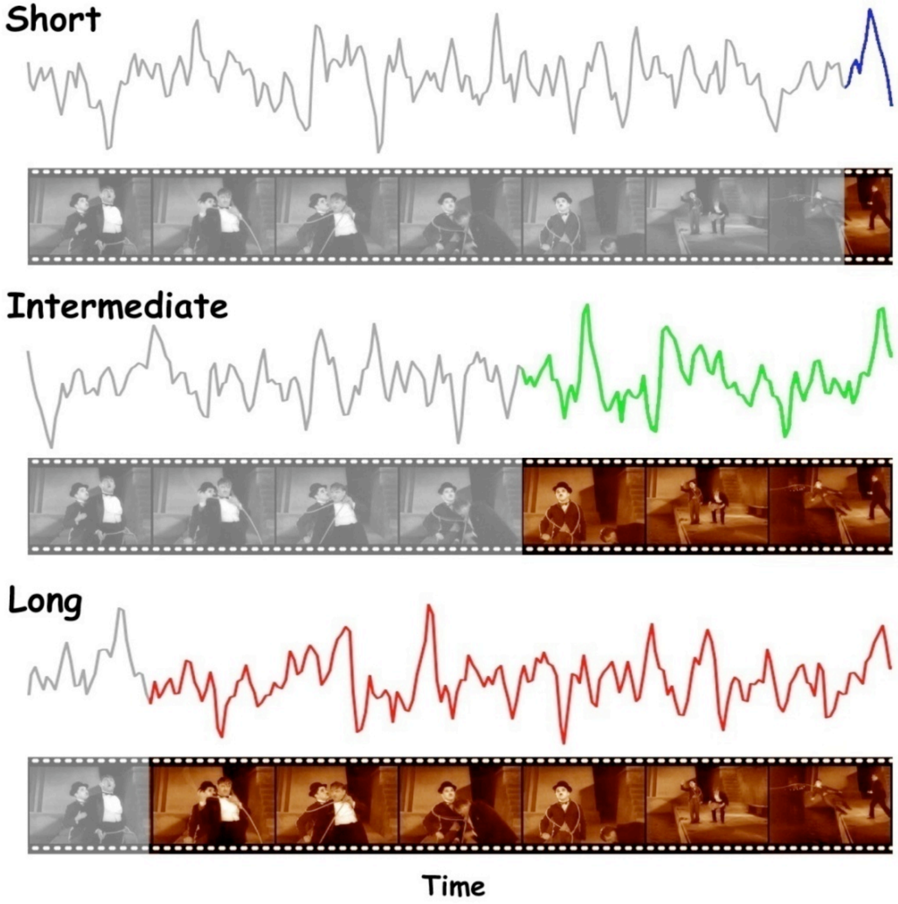
Summary

- Some films can exert considerable control over brain activity and behavior (e.g., eye movements).

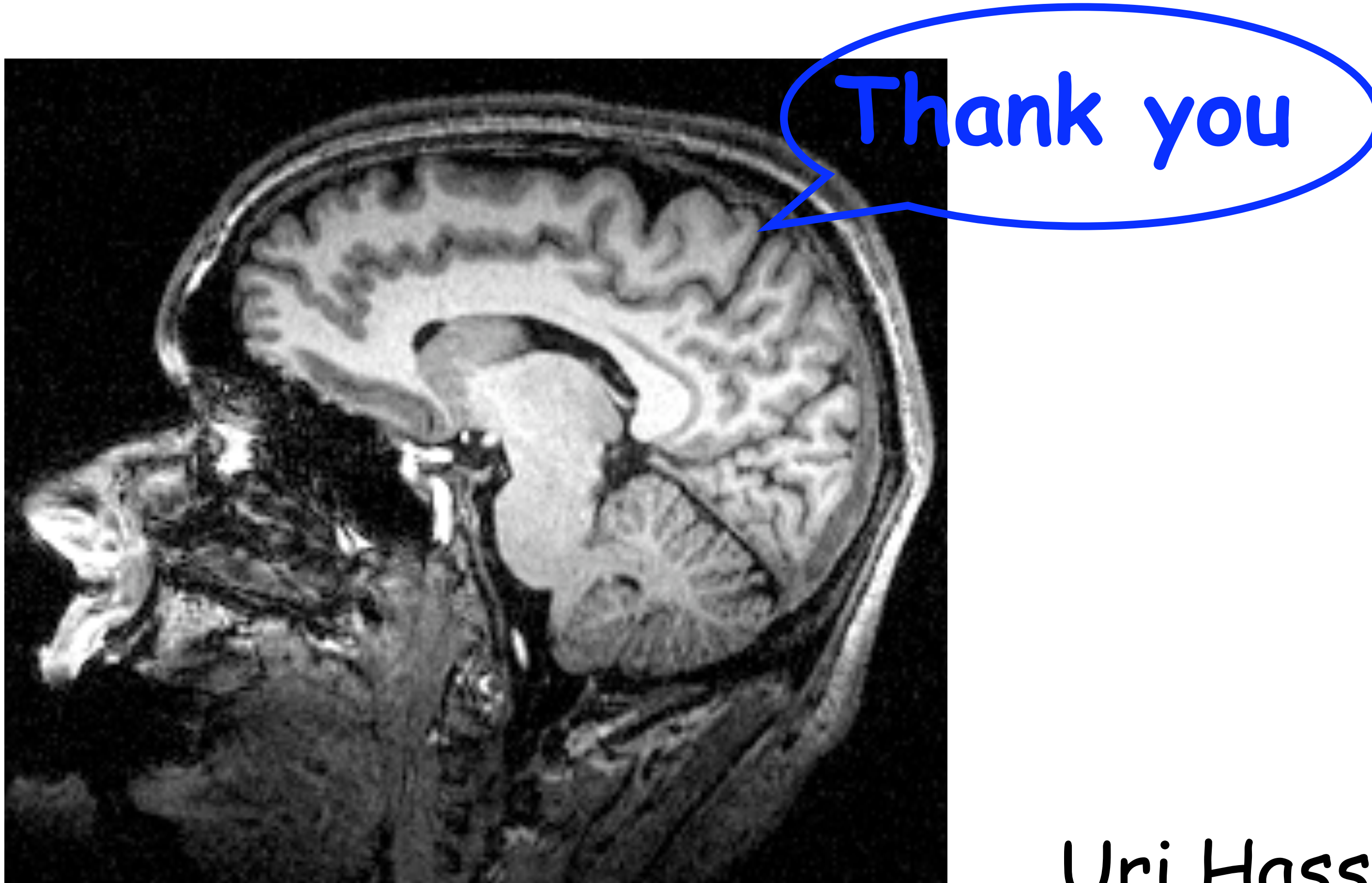
- Dissociation between response reliability and response amplitudes.

- Hierarchy of temporal receptive windows, responsive to sensory information accumulated over different time scales.





Uri Hasson
Nava Rubin
Barbara Knappmeyer
Eunice Yang
Ignacio Vallines



Uri Hasson

Nava Rubin

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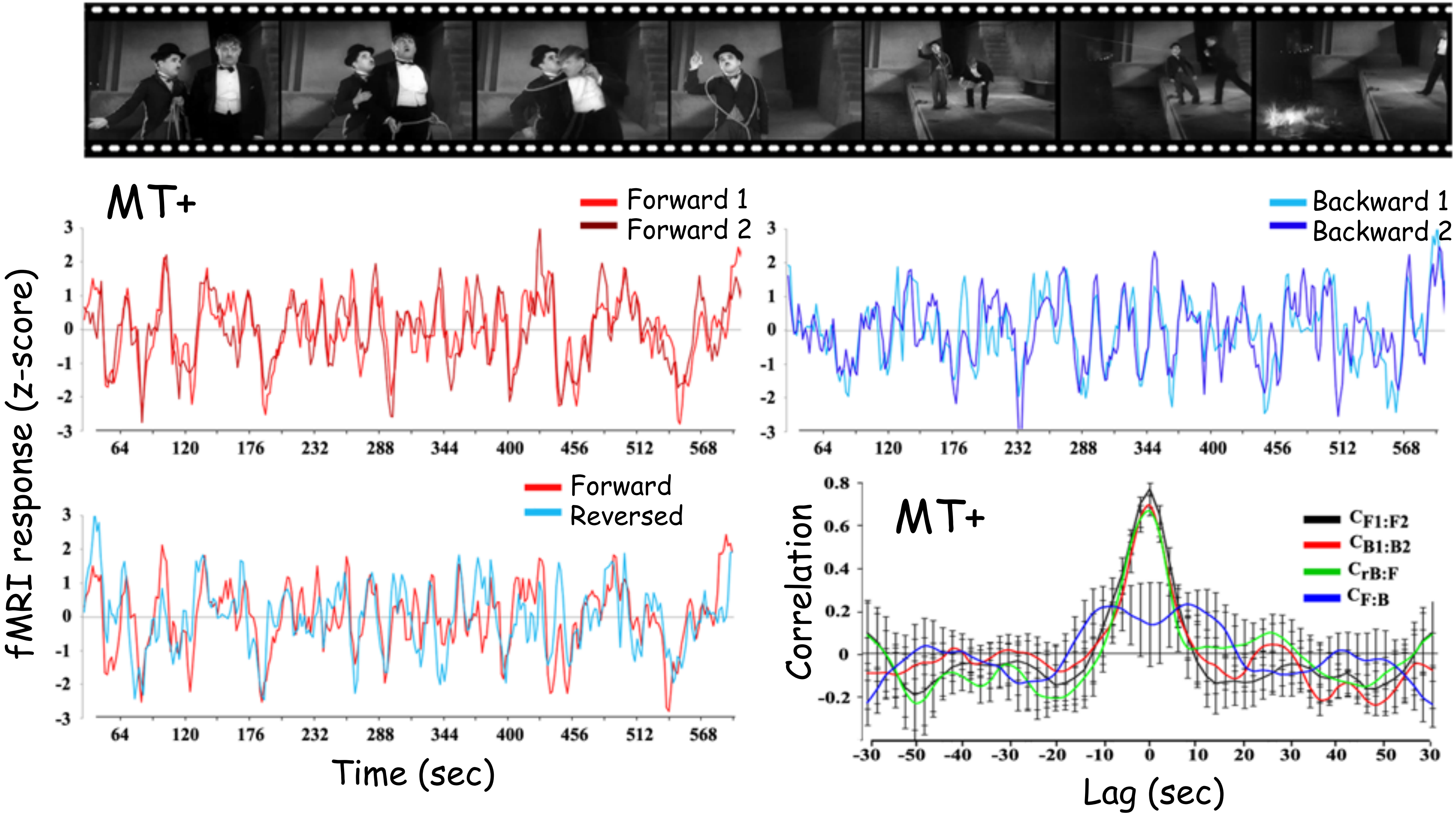
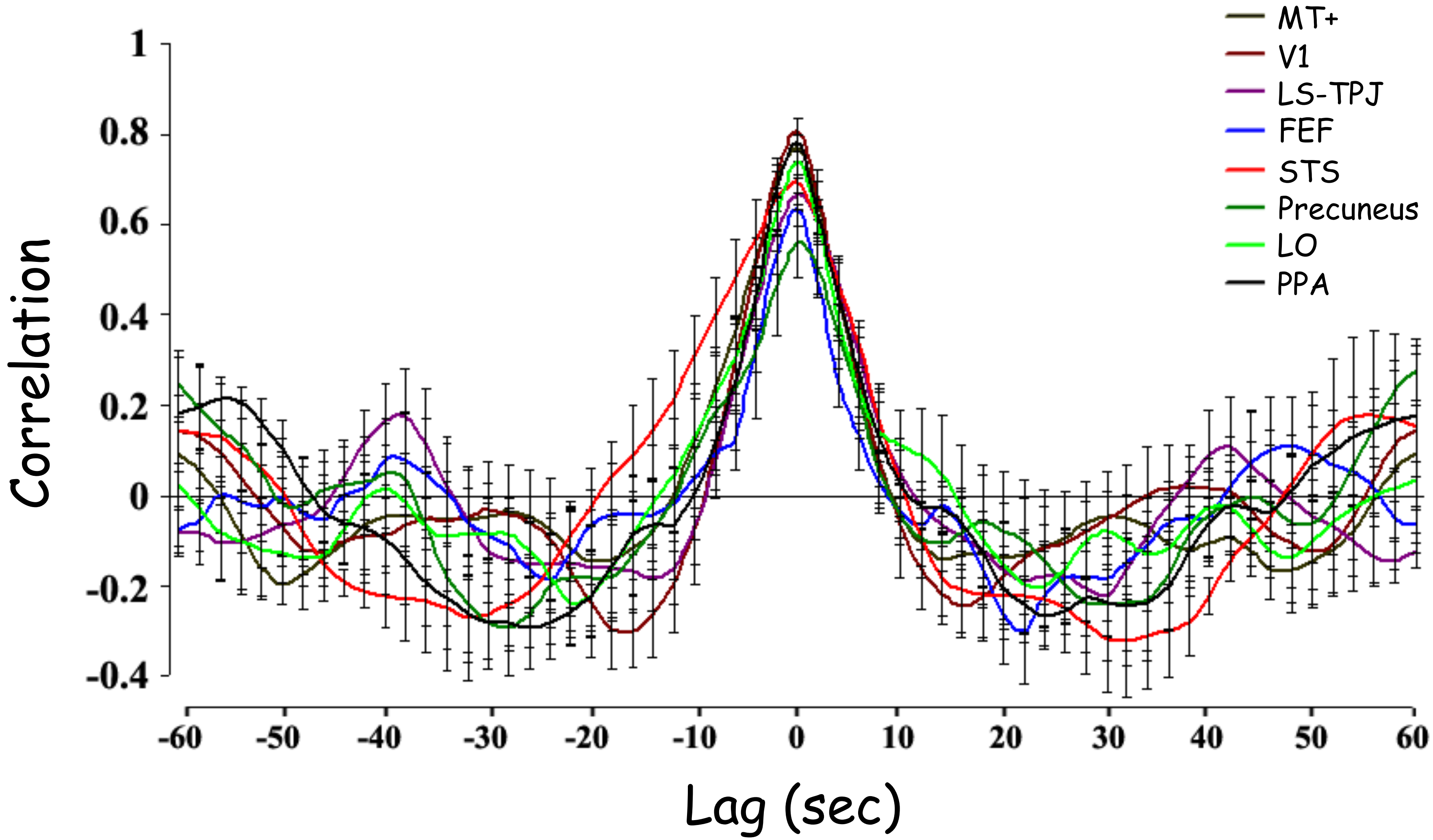
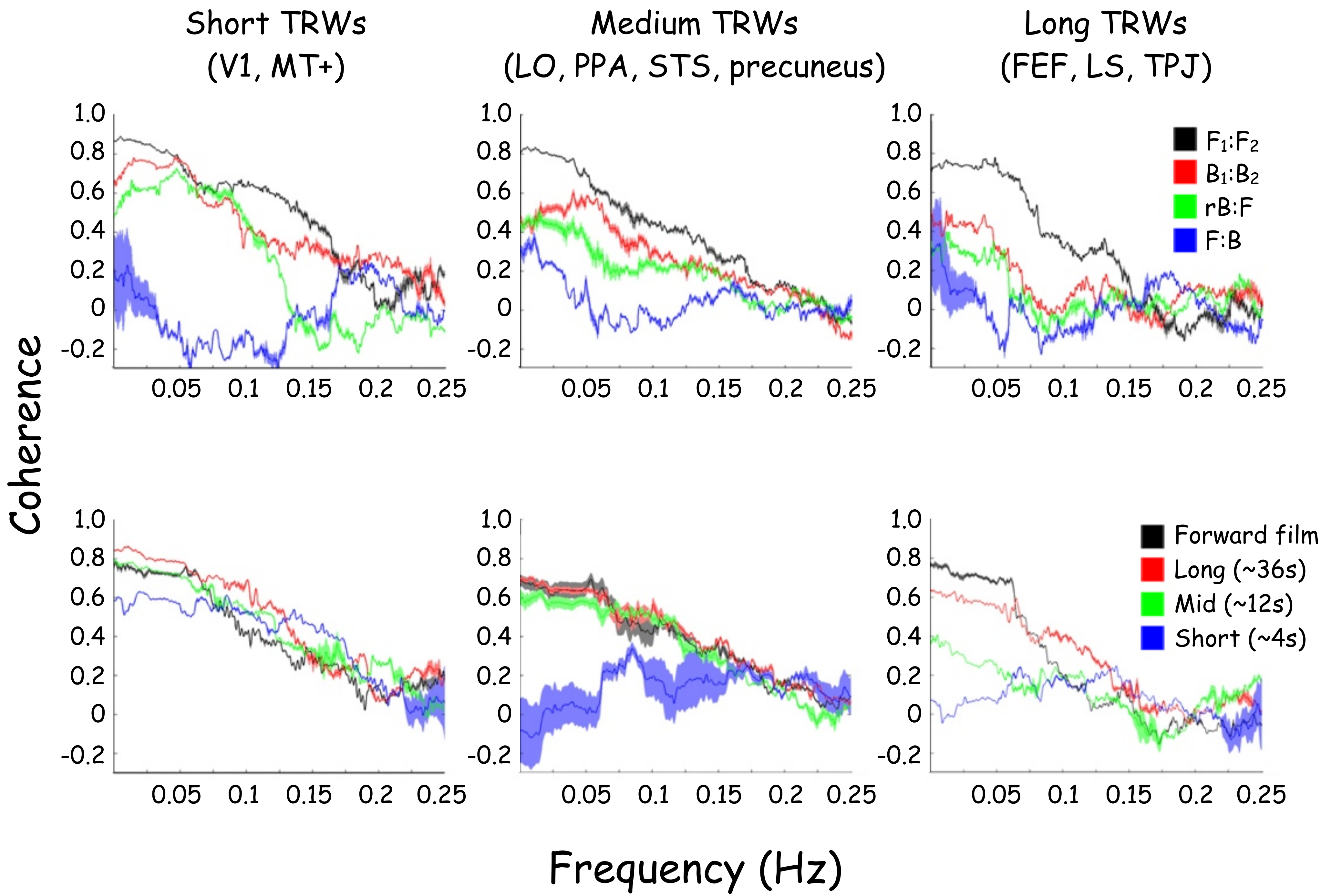
Ignacio Vallines

Independence of time reversal



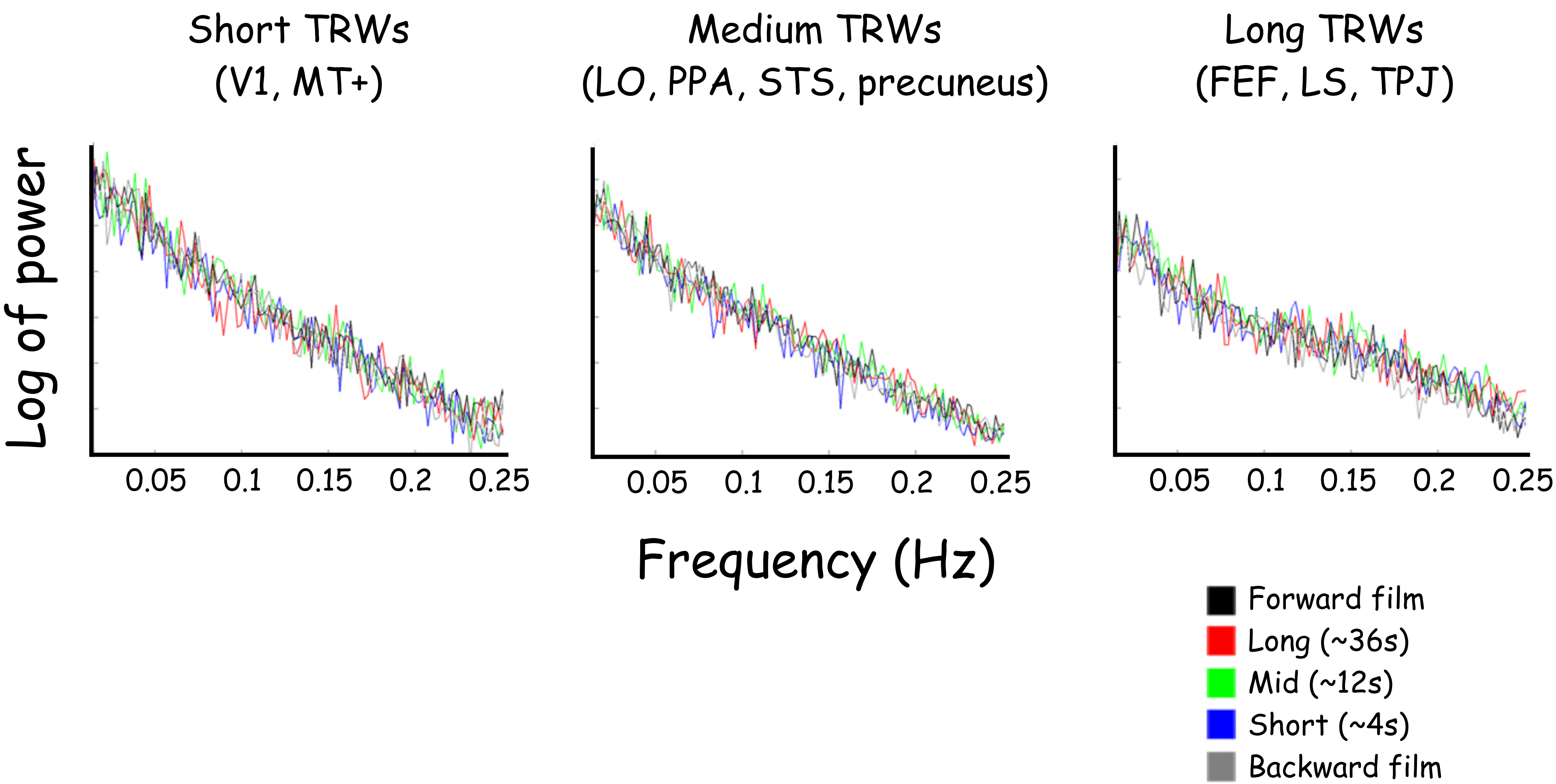
Time-locked responses regardless of temporal receptive window





Short TRWs
(V1, MT+)
Medium TRWs
(LO, PPA, STS, precuneus)
Long TRWs
(FEF, LS, TPJ)
F1:F2
B1:B2
rB:F
F:B
Forward film
Long (~36s)
Mid (~12s)
Short (~4s)
Coherence
Frequency (Hz)

Equal response power



Control experiment

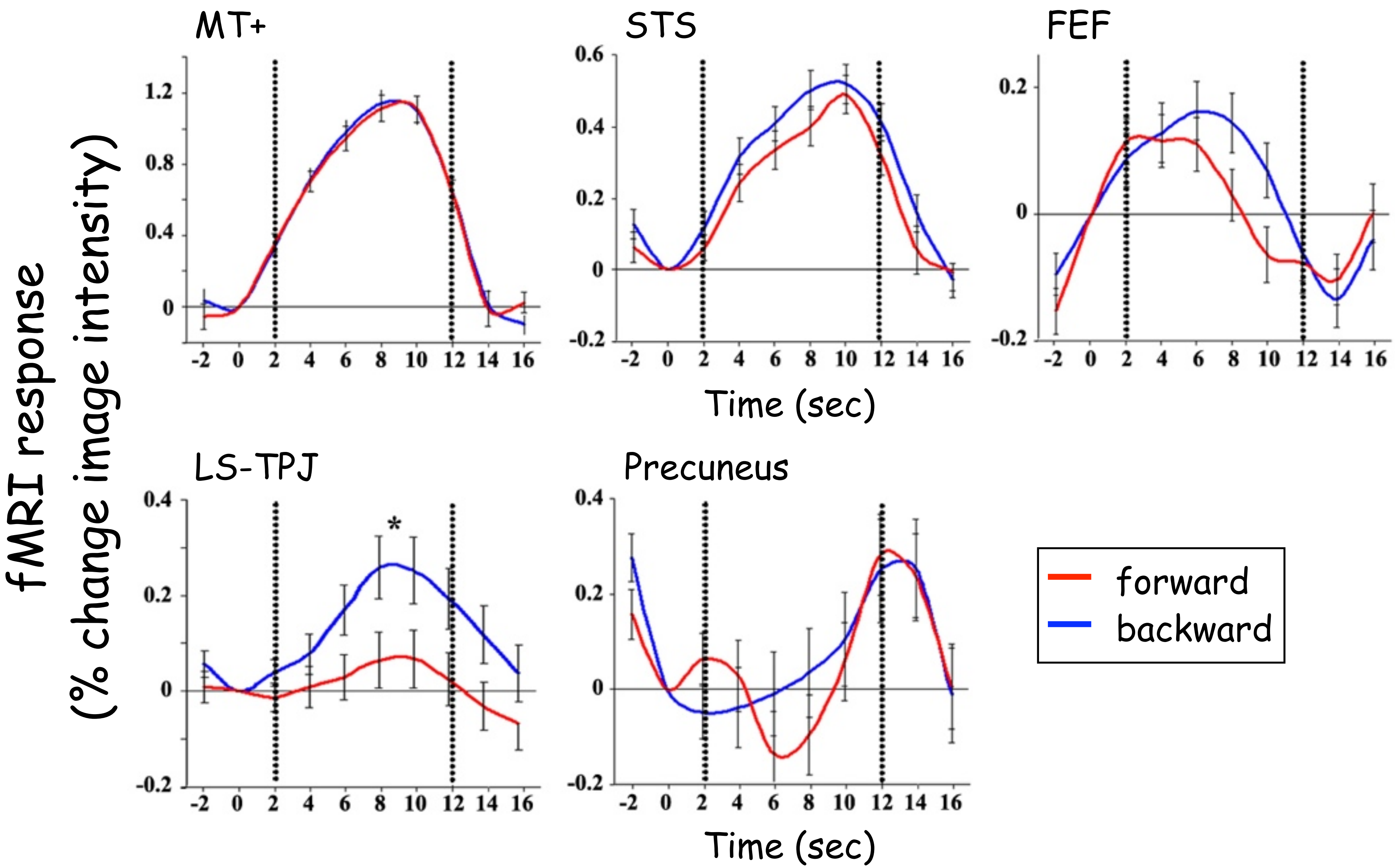
Control experiment

Control experiment

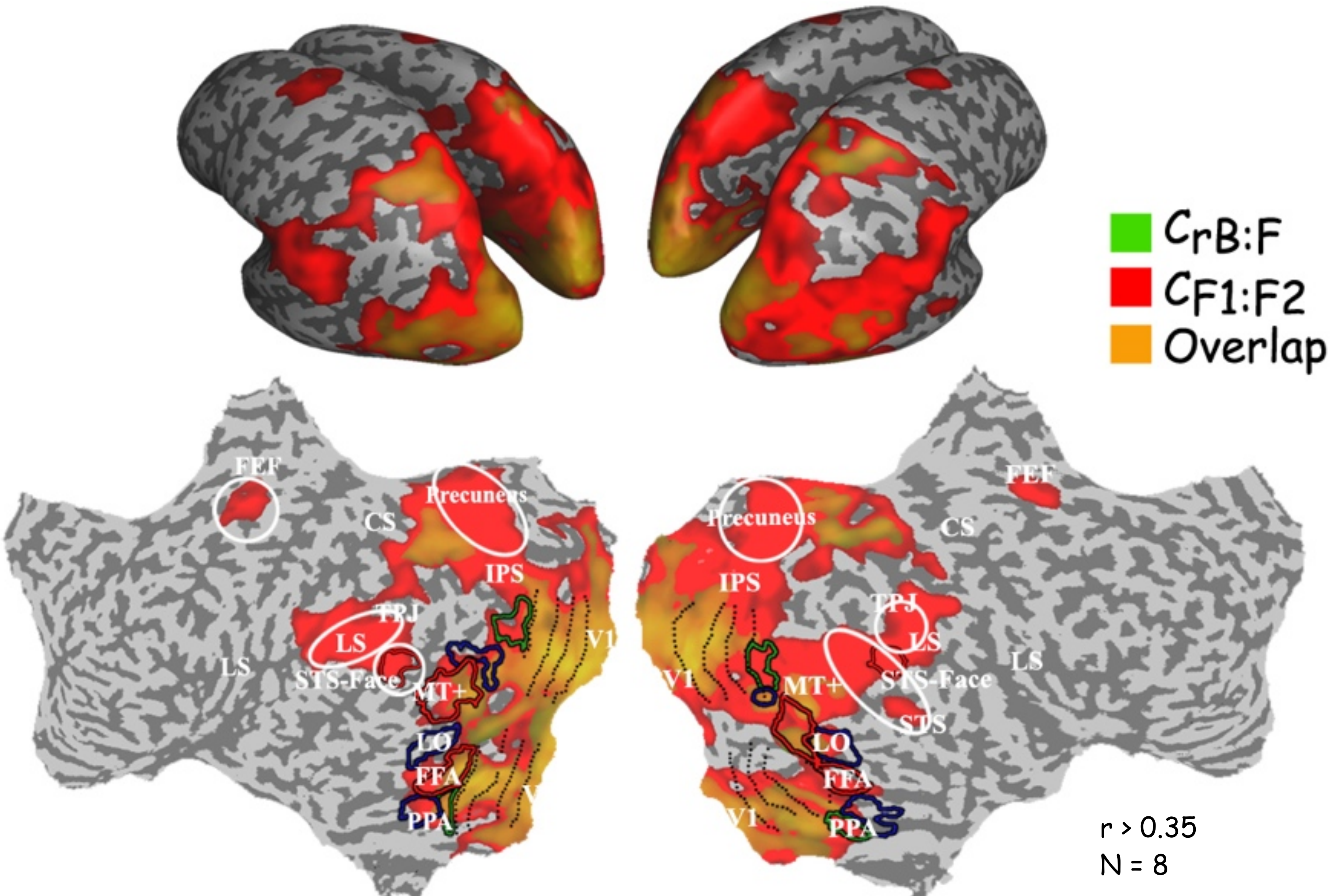
Control experiment

Control experiment

Control expt: strong responses regardless of time reversal

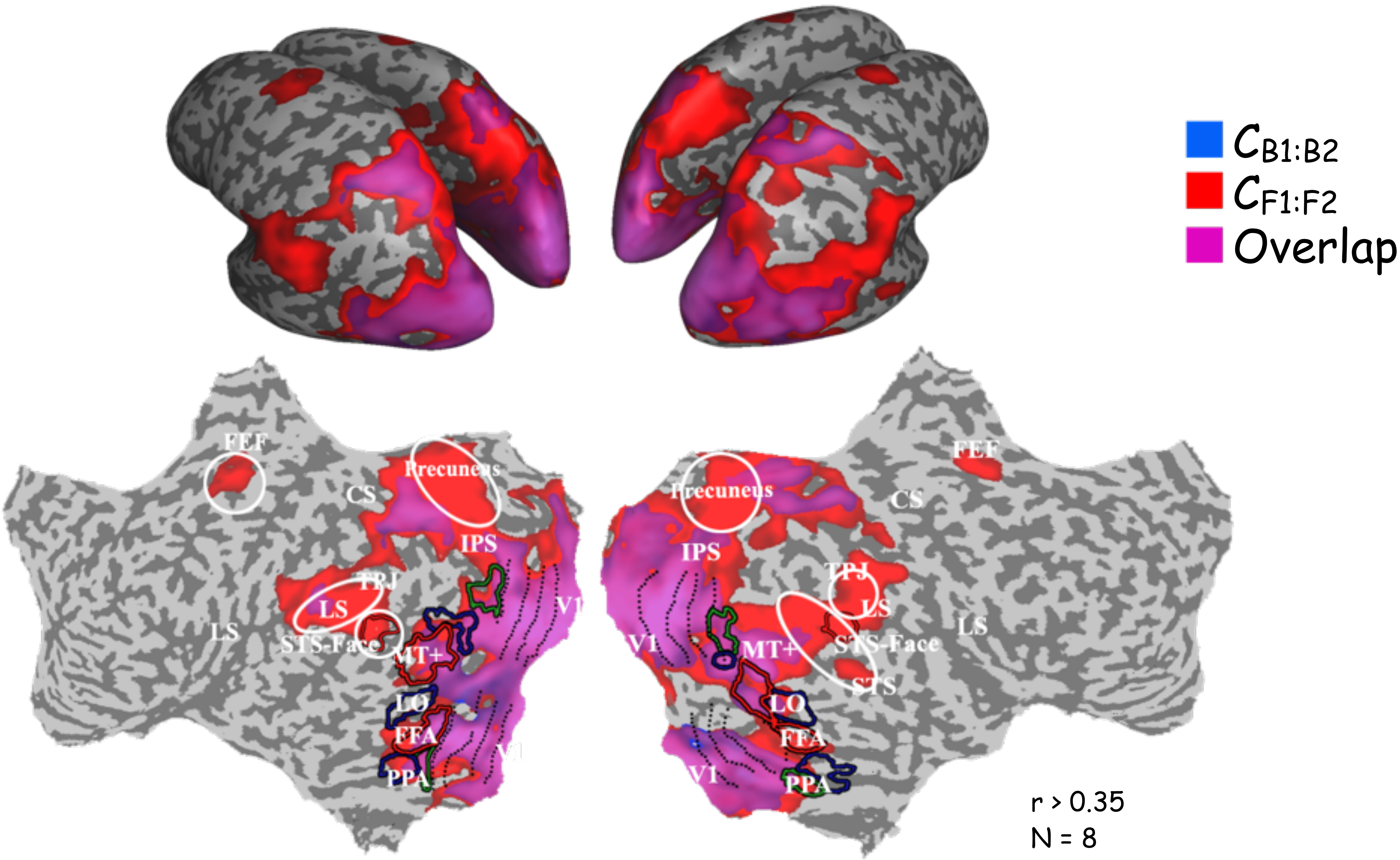


Dependence on time reversal

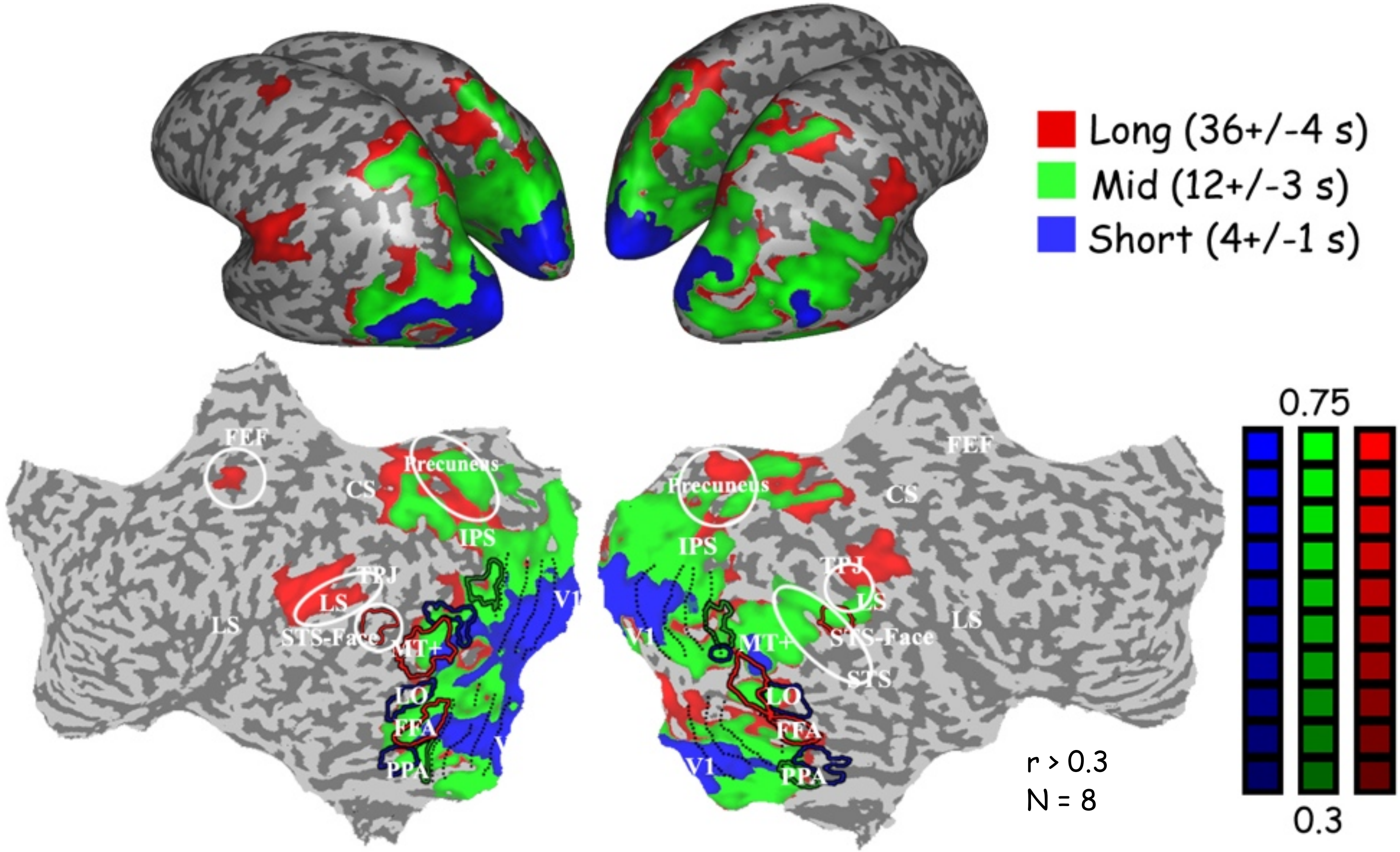


r > 0.35
N = 8

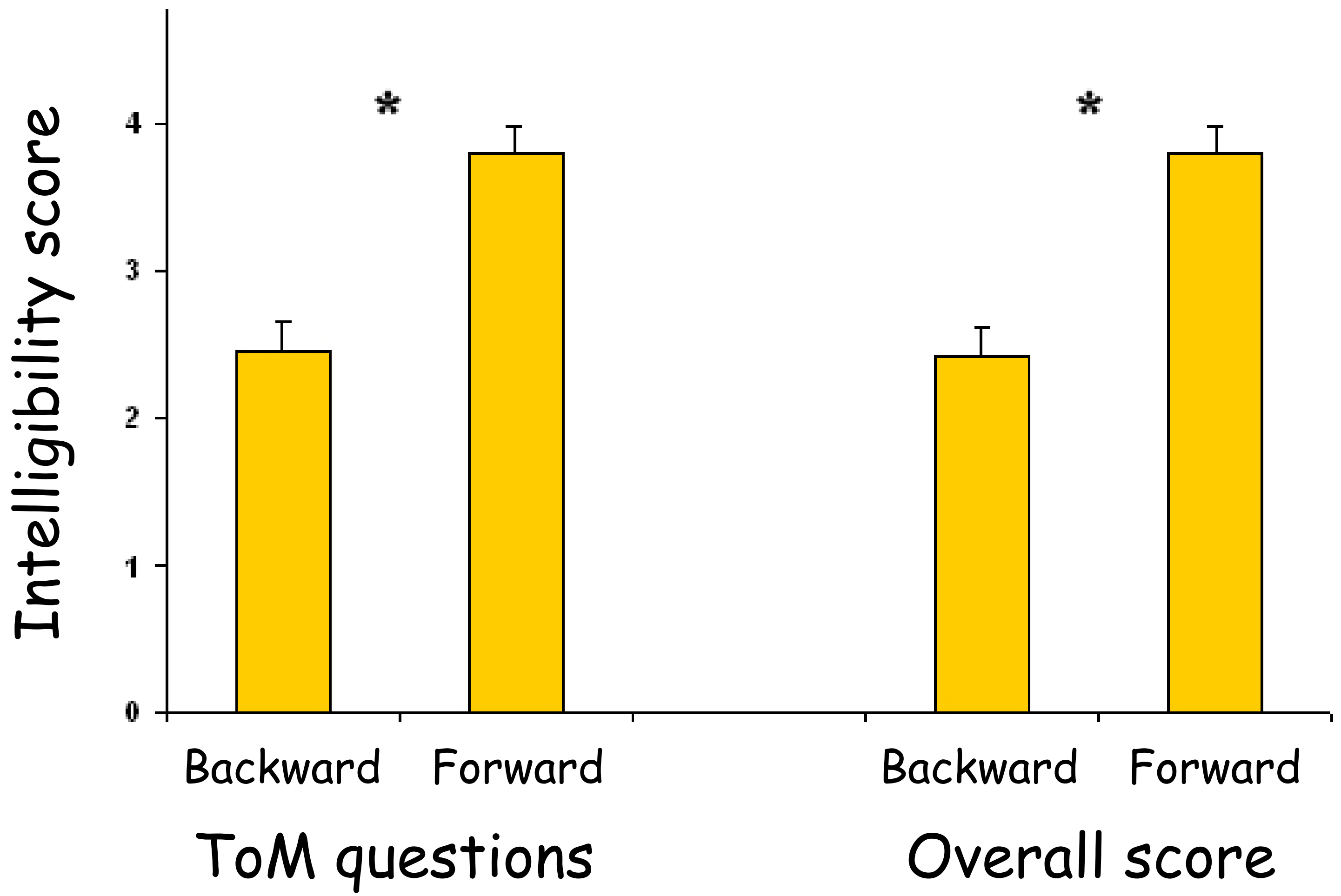
Dependence on time reversal



Different time scales in different brain areas



Behavioral effect of time reversal



Possible functions of cortical areas that exhibit long temporal receptive window

- Theory of mind (e.g., Gallagher & Frith, 2003; Saxe & Kanwisher, 2003).

- Narrative (e.g., Xu et al., 2005; Schmithorst et al., 2006).

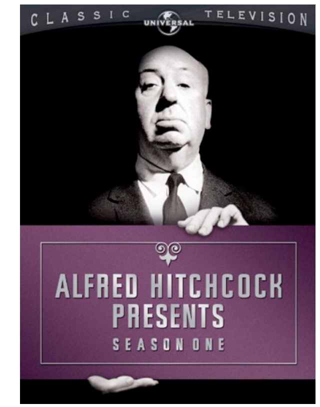
- Inferences of cause and effect (e.g., Eisenstein & Leyda, 1949; Fonlupt, 2003).

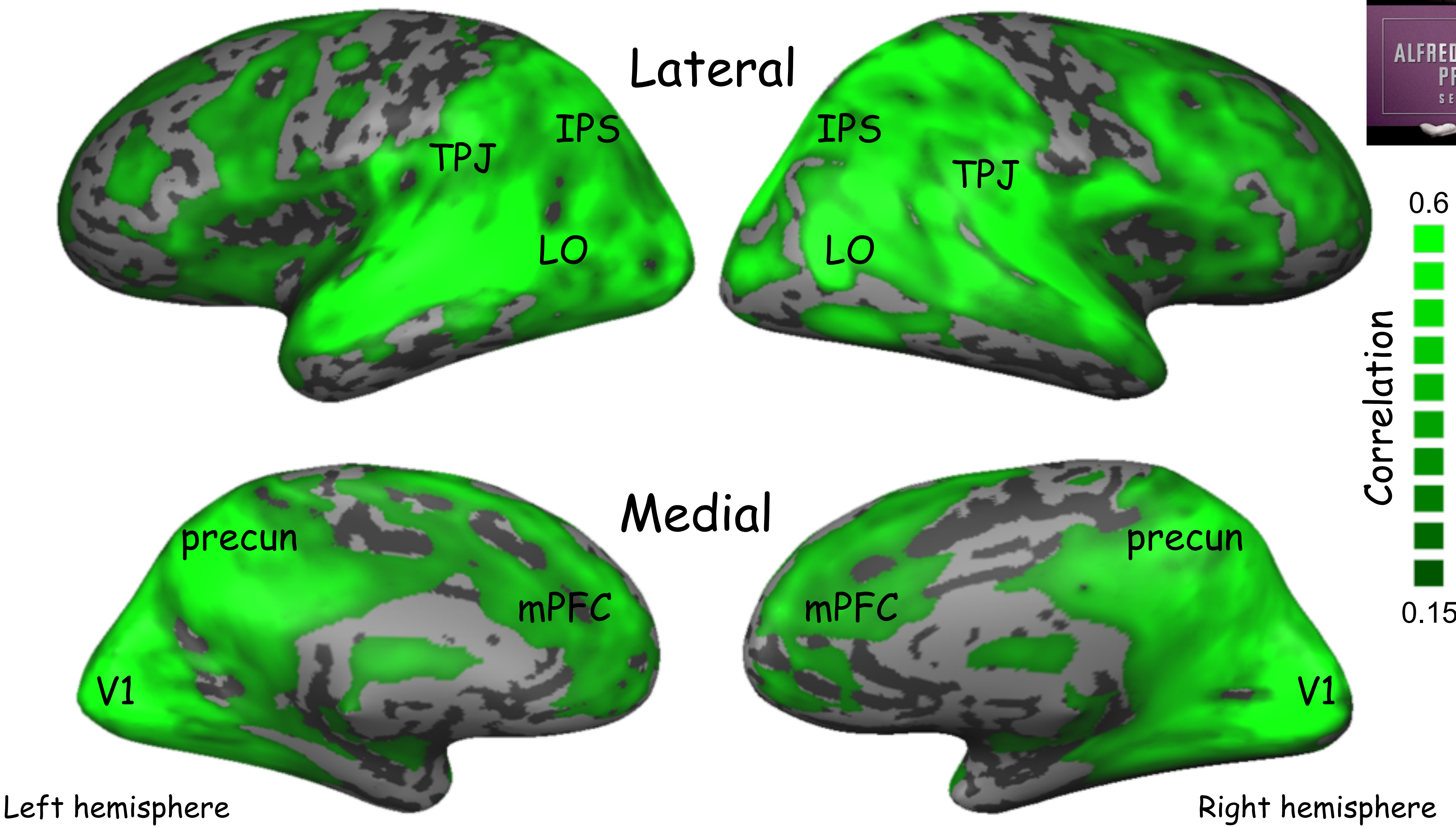
- Expectancy, prediction, & prediction error (e.g., Mumford, 1992; Bischoff-Grethe et al., 2000; Schultz, 2000; Kersten et al., 2004).

- Event segmentation (e.g., Zacks et al., 2001).

- Any/all of the above at a variety of different time scales.

Do we share the same conscious experience from the same sensory stimulus?

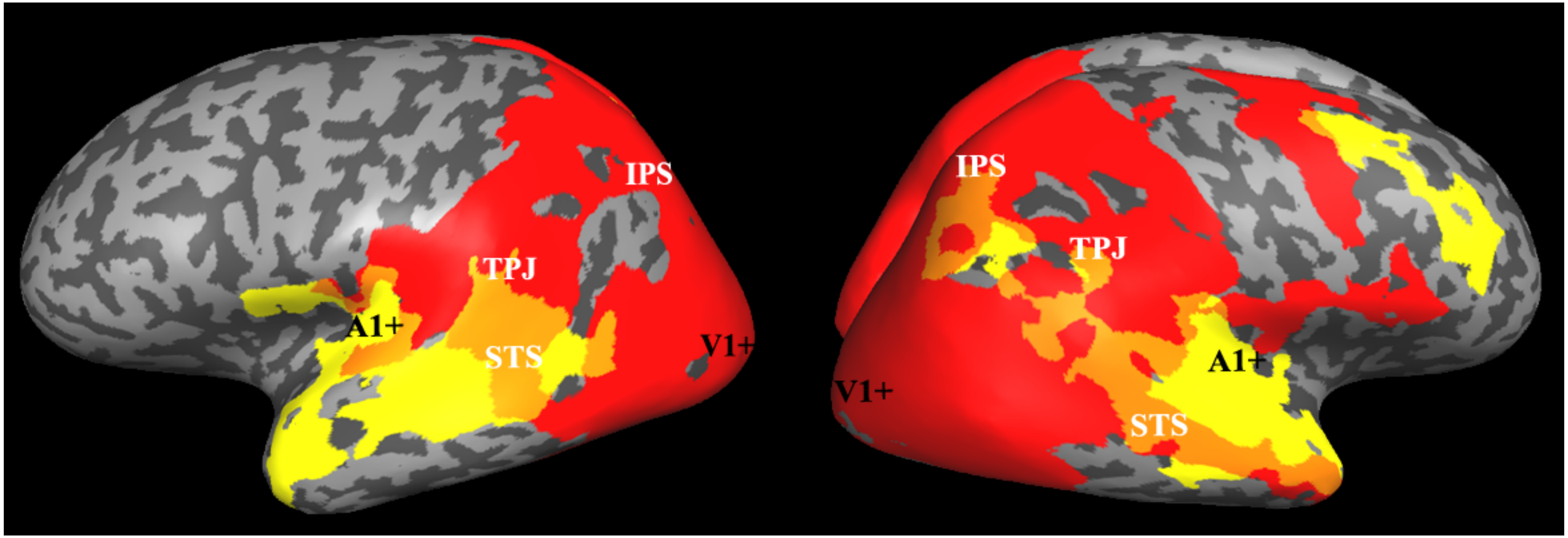




Hasson, Knappmeyer et al., Projections (2008)




ISC for visual vs audio media



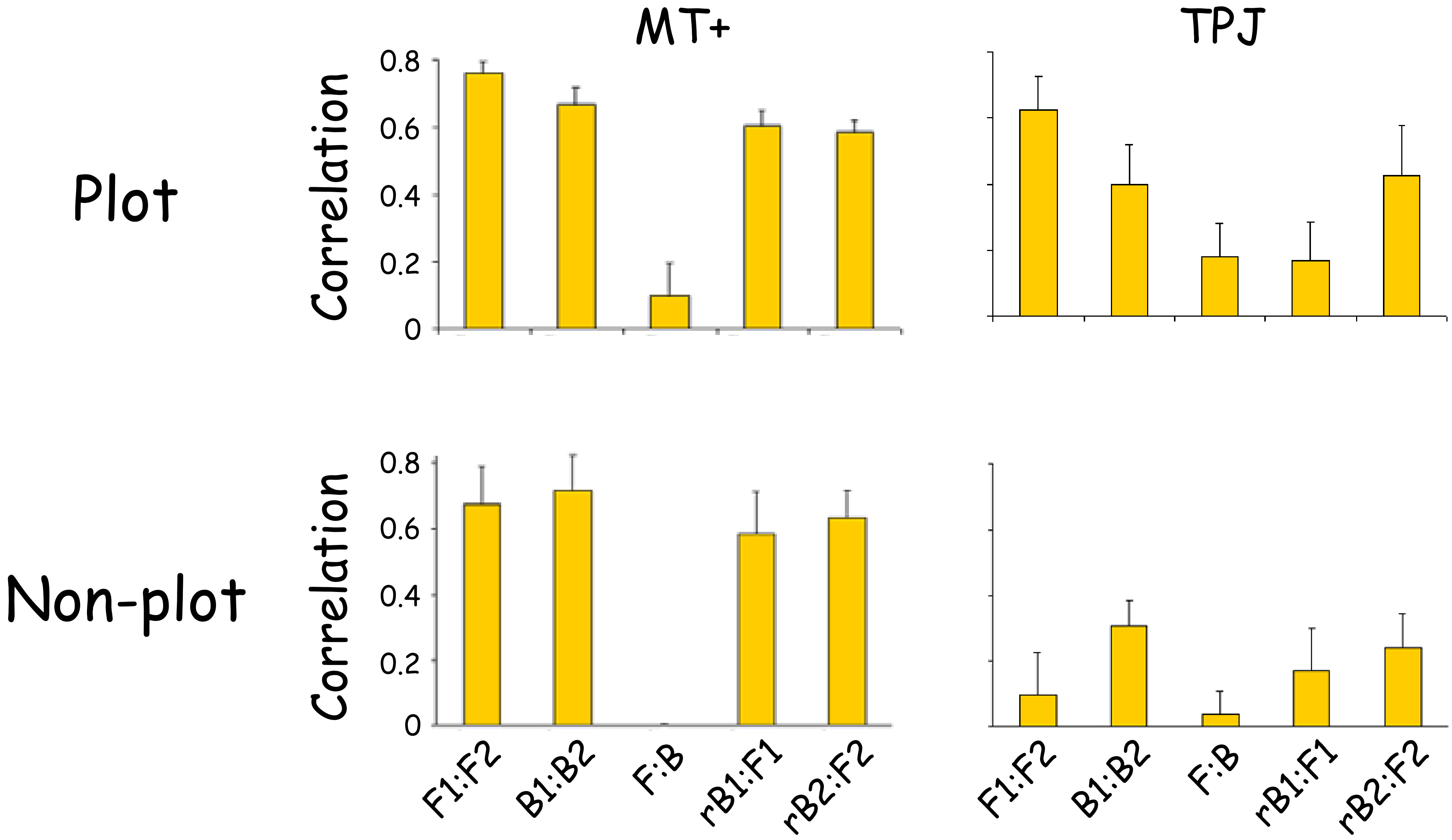
Silent film
Overlap
Audio-book

Manipulation of the movie content

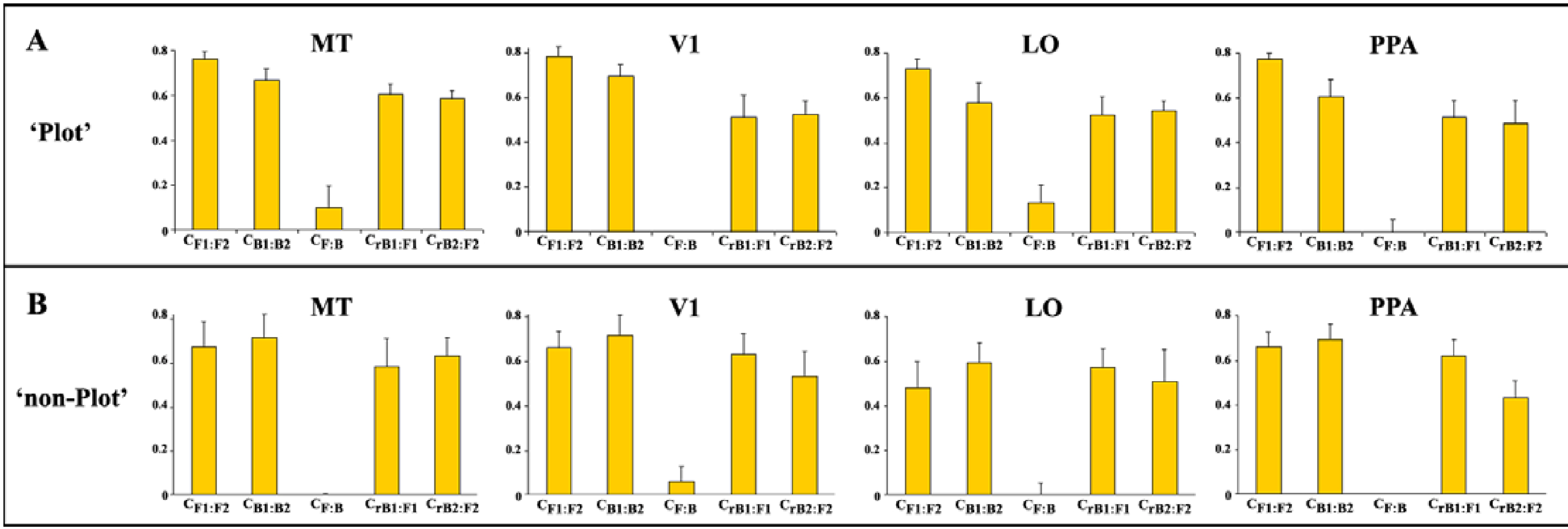
Physical motion

Biological motion

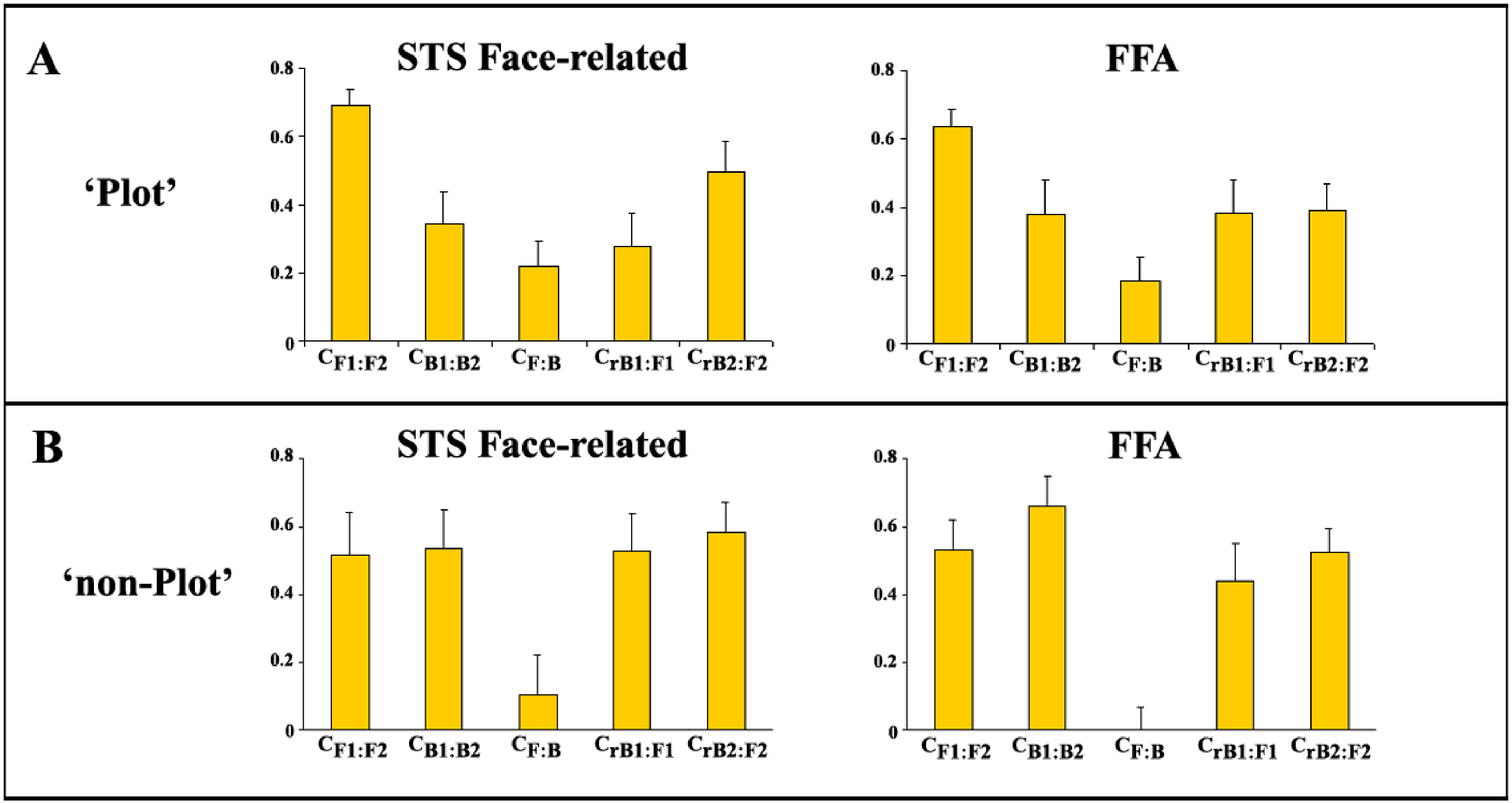
Dependence on movie content



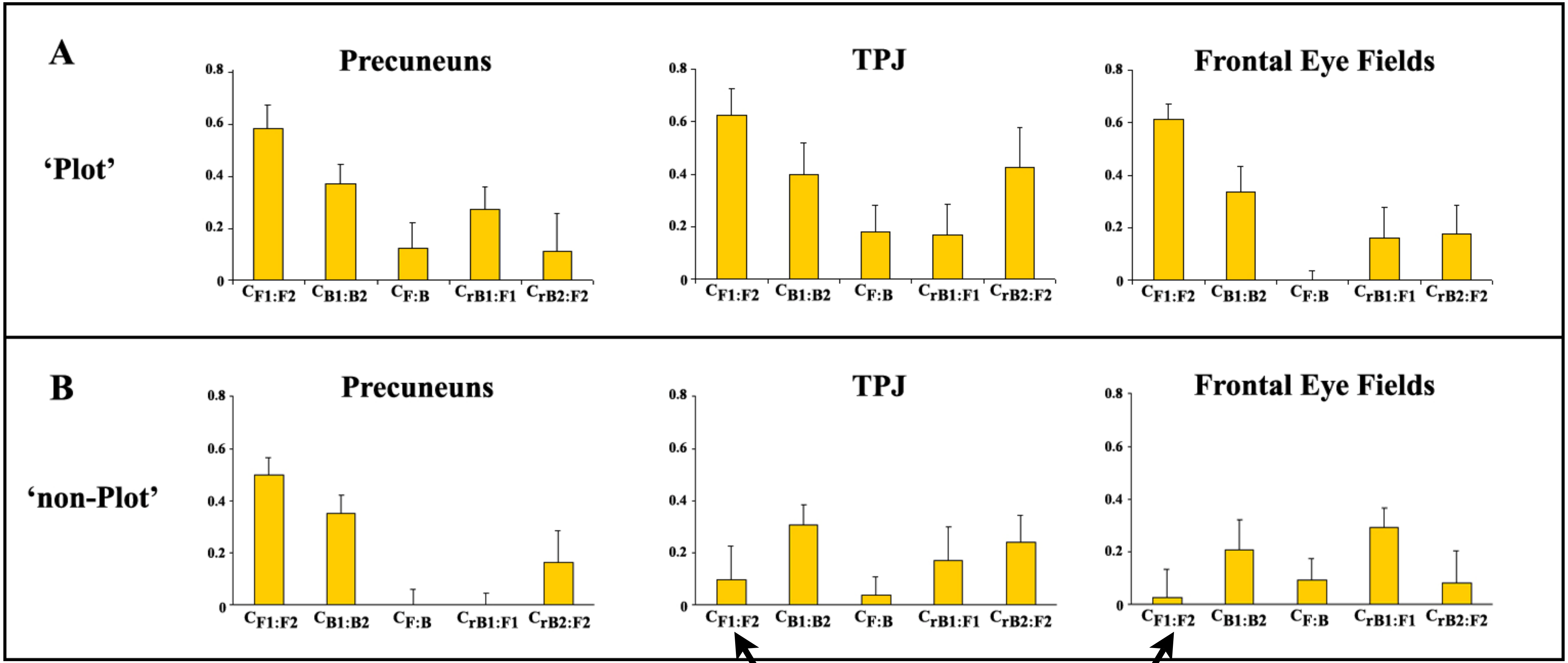
Independence of time reversal regardless of movie content



Dependence on time reversal only for plot movies



Dependence on time reversal regardless of movie content



Reproducible responses only for plot movies