

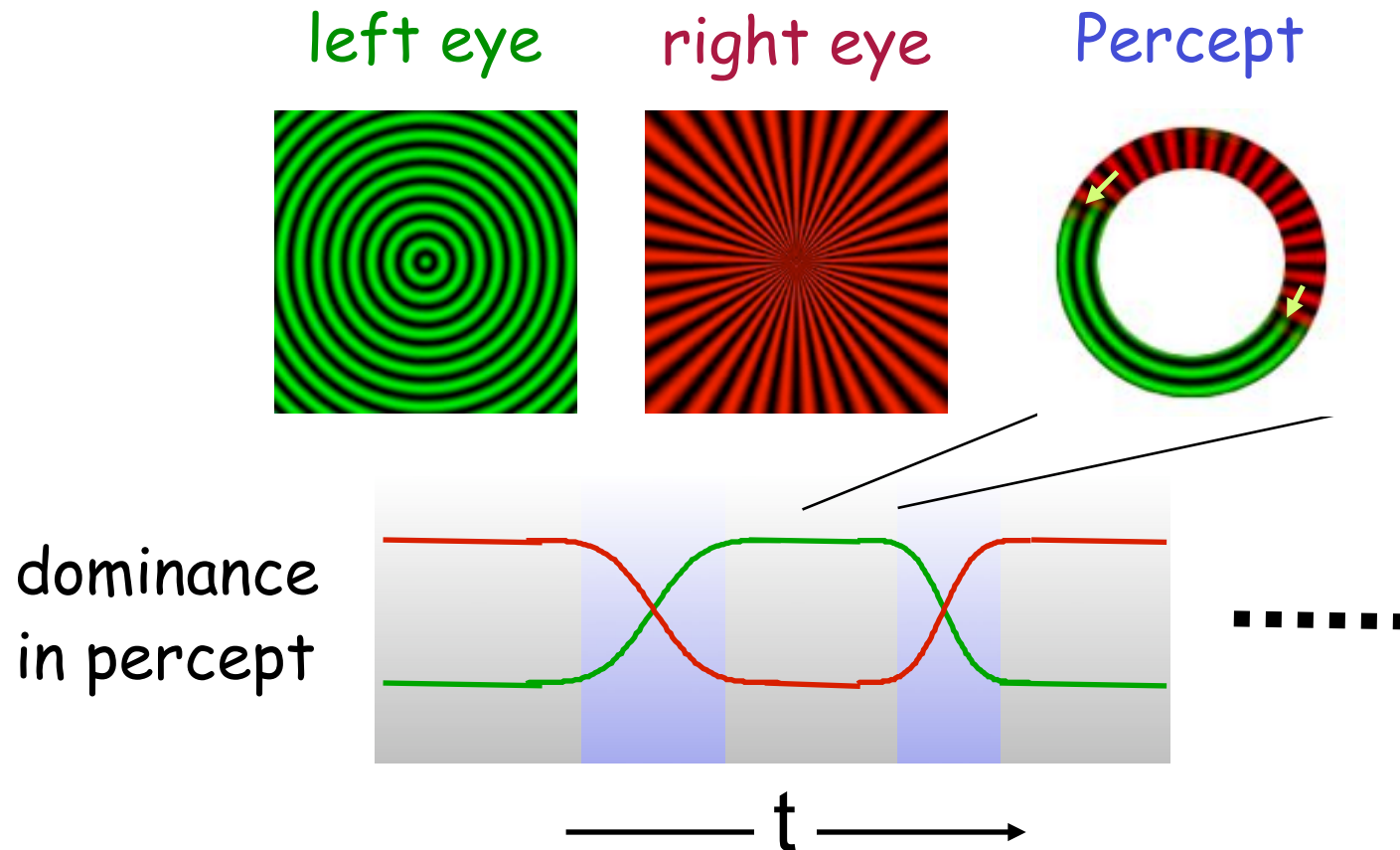
Traveling Waves of Activity in Visual Cortex During Binocular Rivalry

Collaborators:

Sang-Hun Lee, Seoul National University

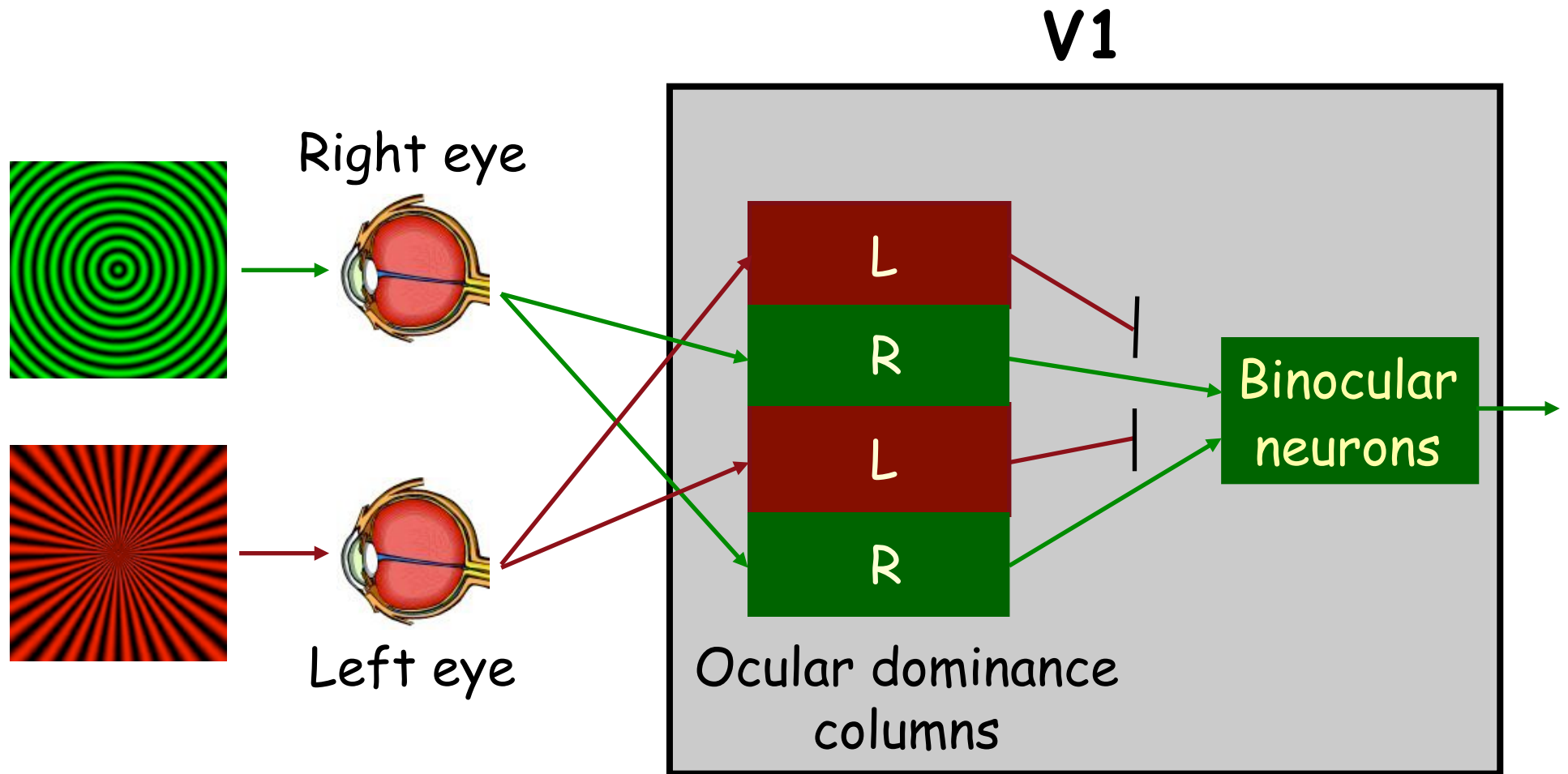
Randolph Blake, Vanderbilt University

Spatiotemporal dynamics during binocular rivalry





V1 suppression hypothesis



Unresolved issues

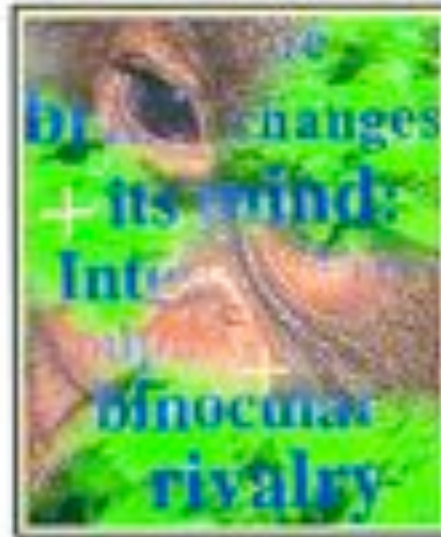
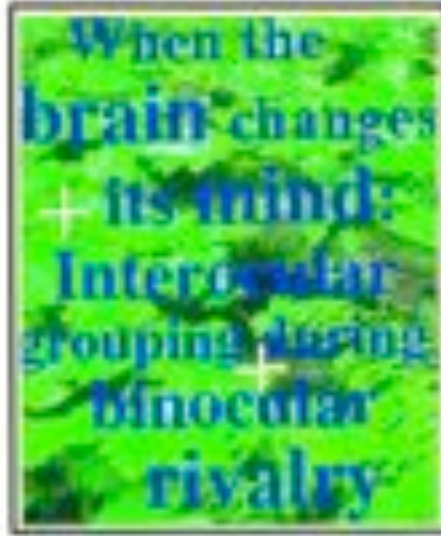
- Early versus late.
- Eye versus pattern.
- Transitions vs sustained periods of dominance.
- Role of attention.
- Local processing vs feedback from higher visual areas.

Pattern rivalry

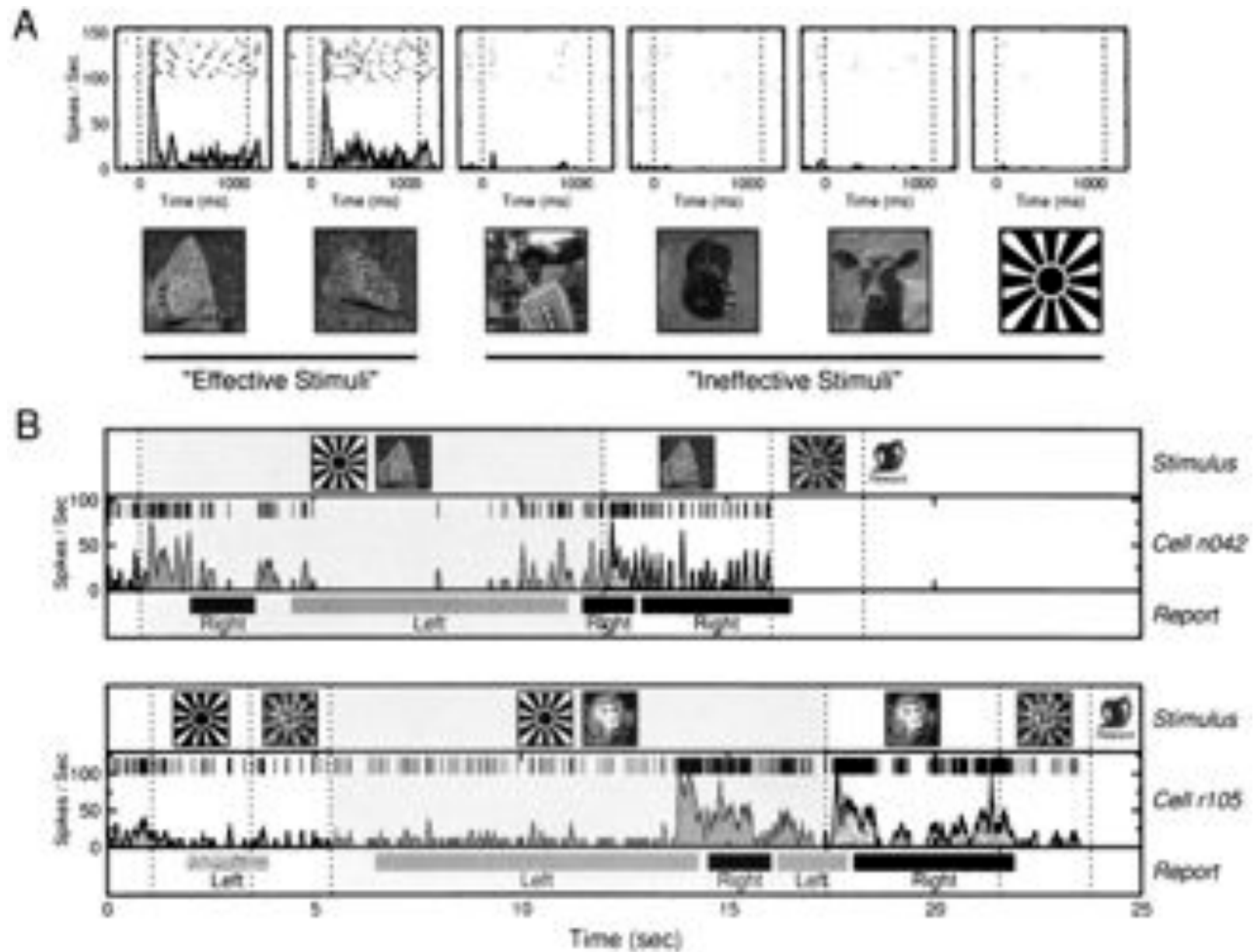
Left eye



Right eye

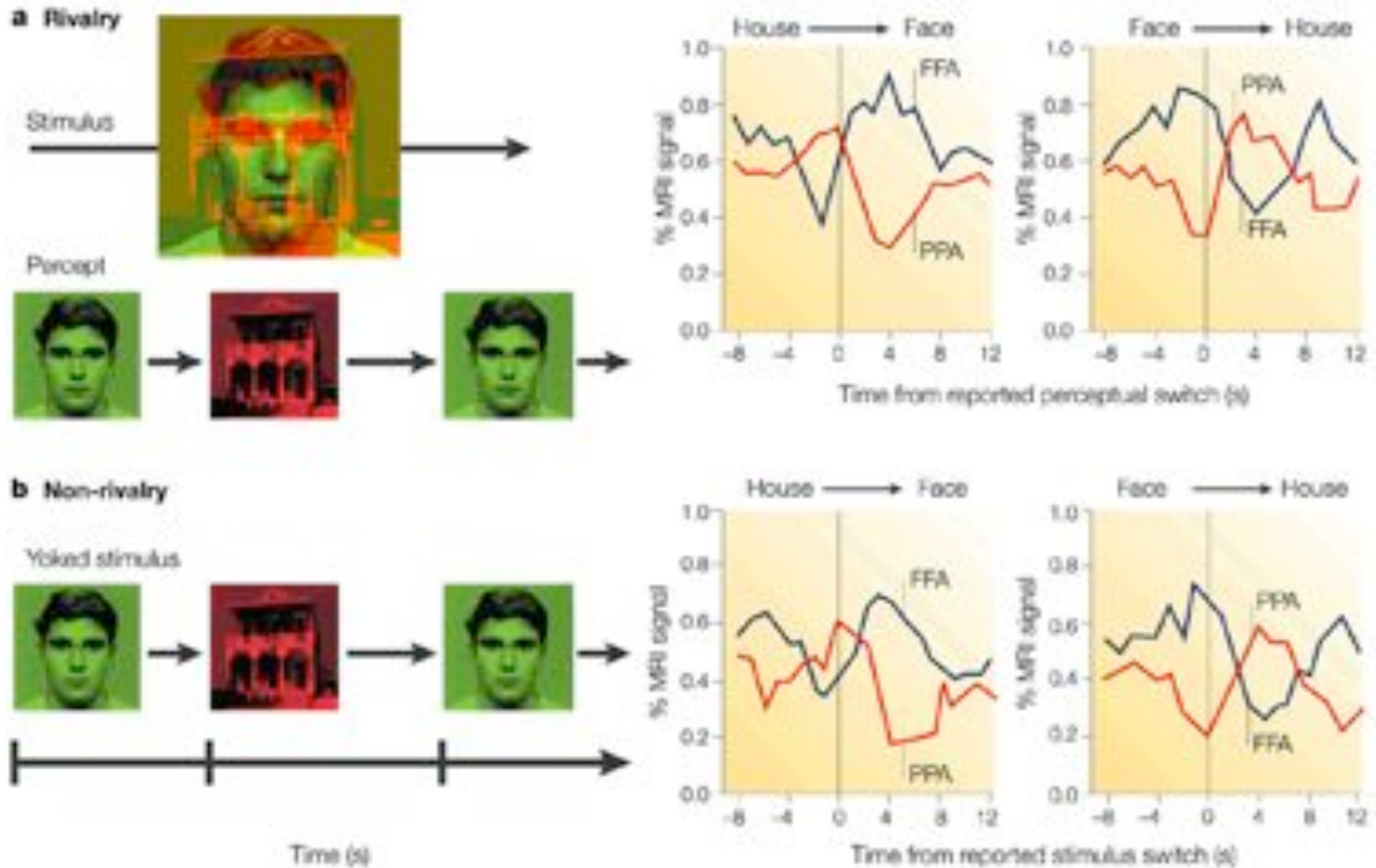


Binocular rivalry in monkey IT



Sheinberg & Logothetis, PNAS (1997)

Binocular rivalry in human IT

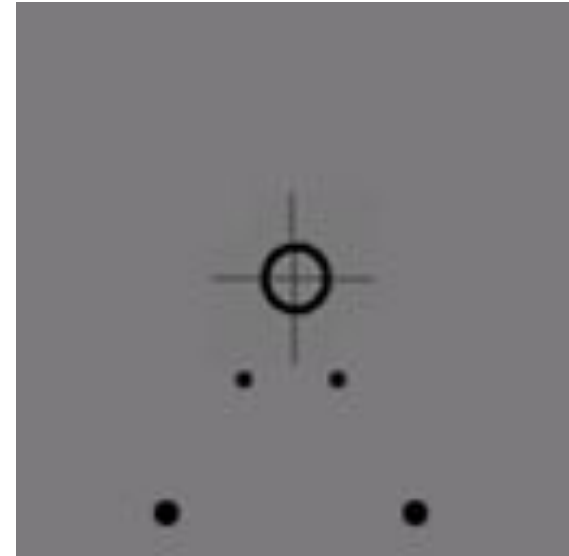
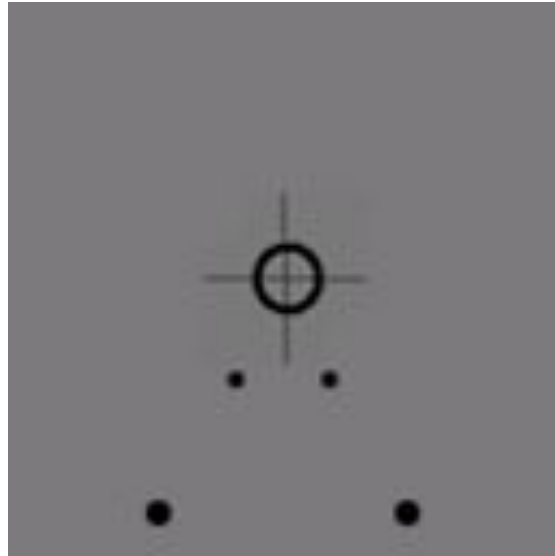


Perceptual traveling waves

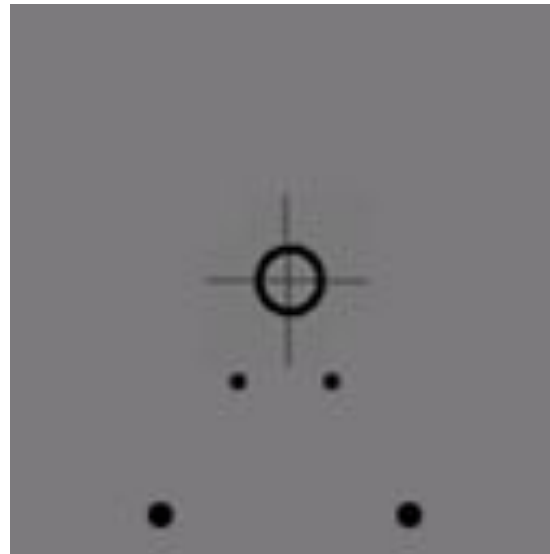
left eye

right eye

Display



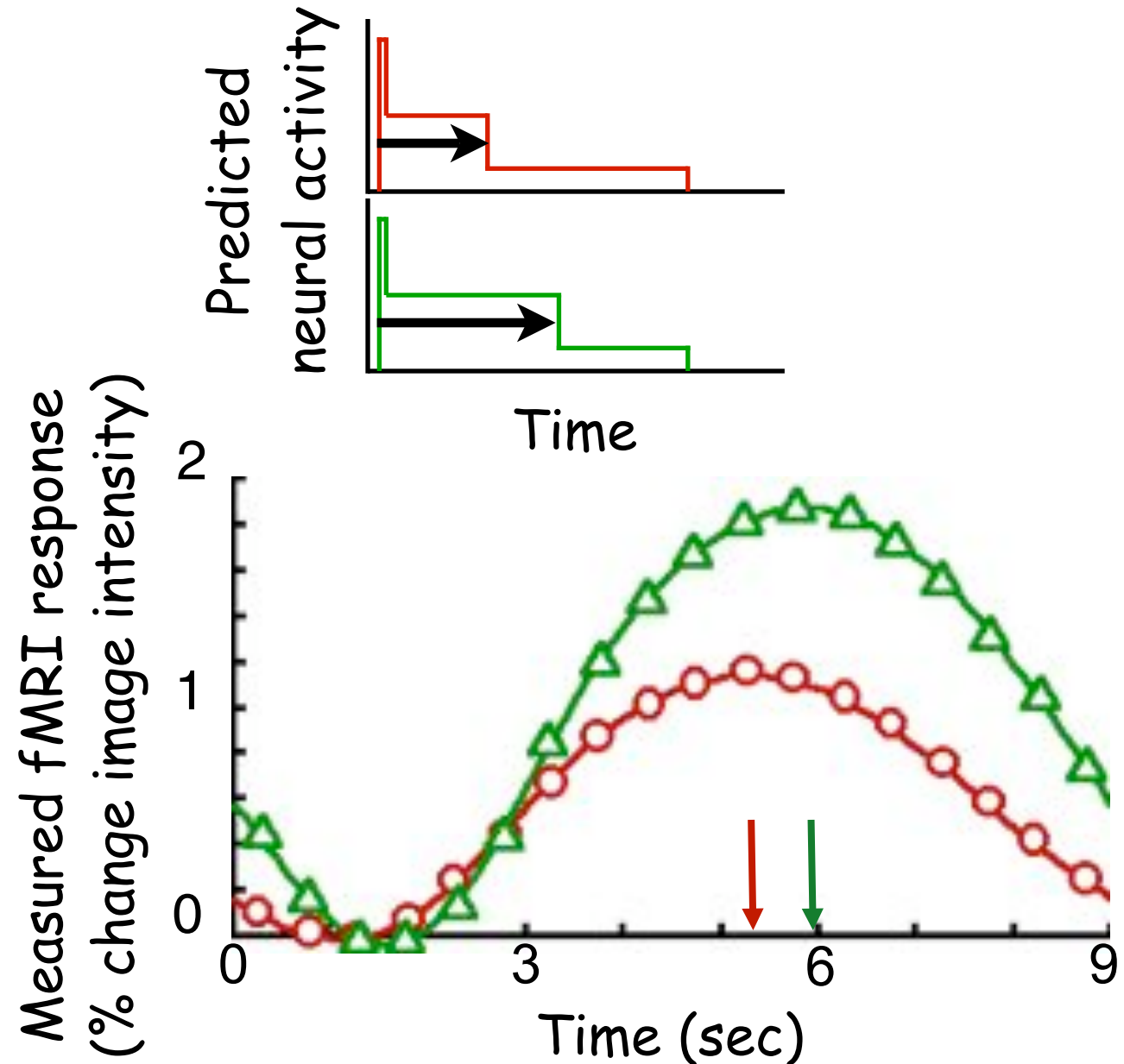
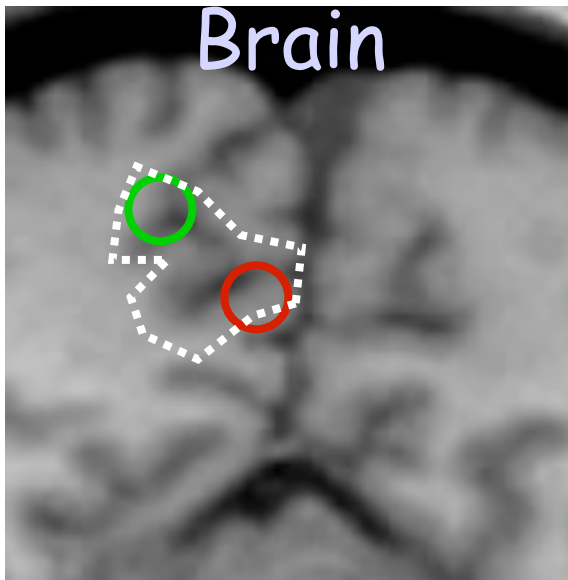
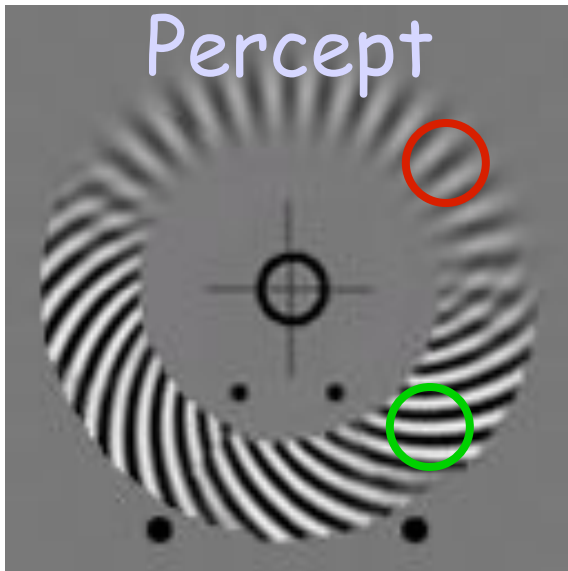
Percept



Latency

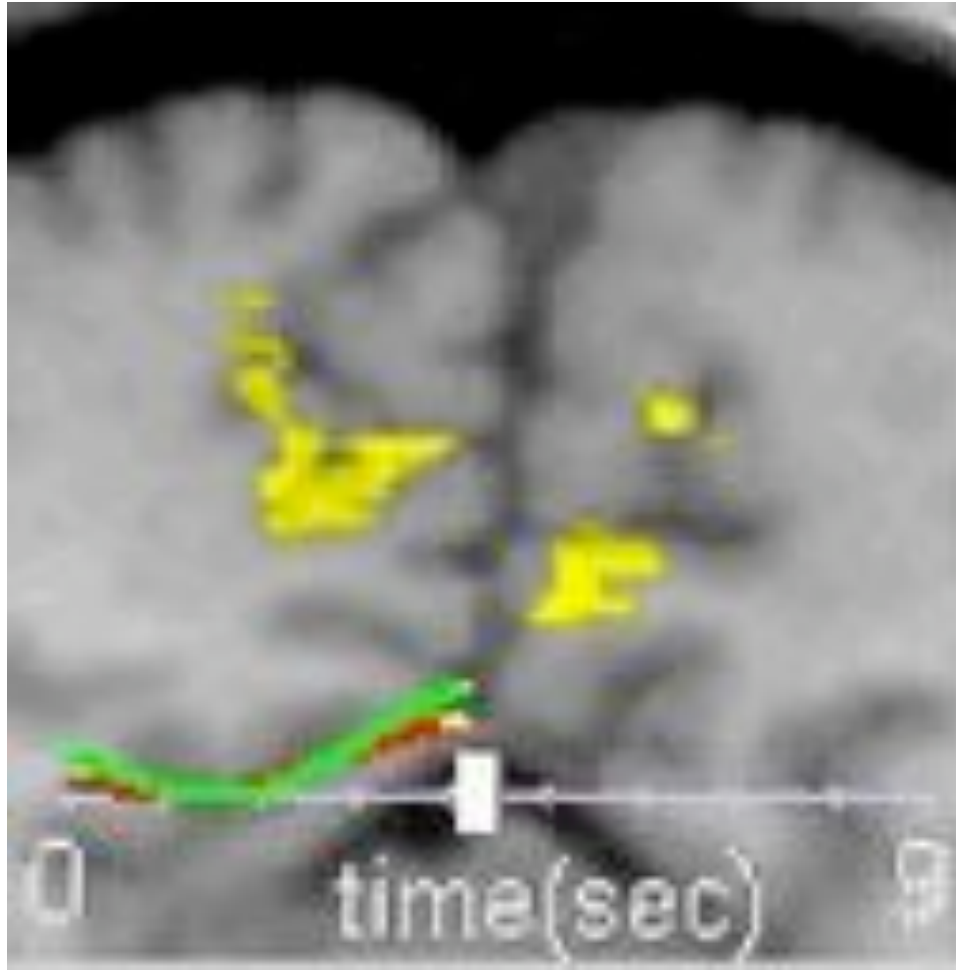
L / R / N

Predicted and measured responses

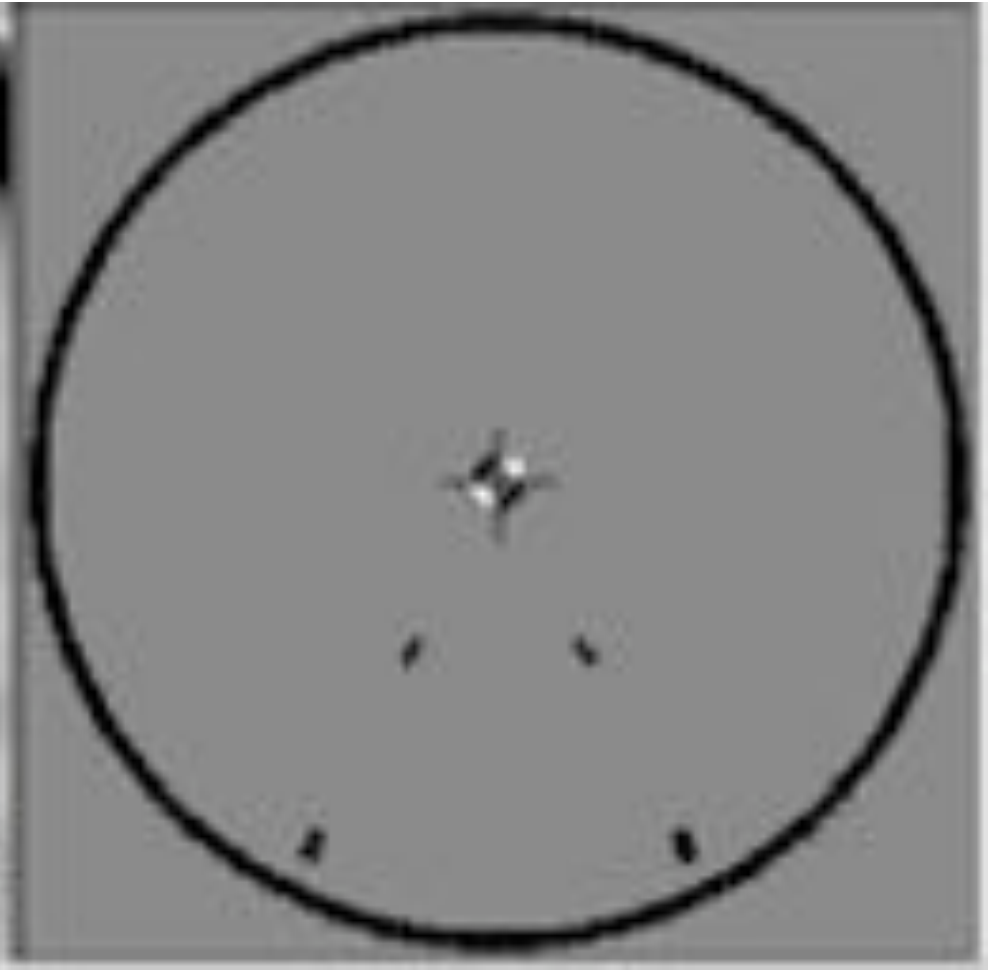


Perceptual and neural traveling waves

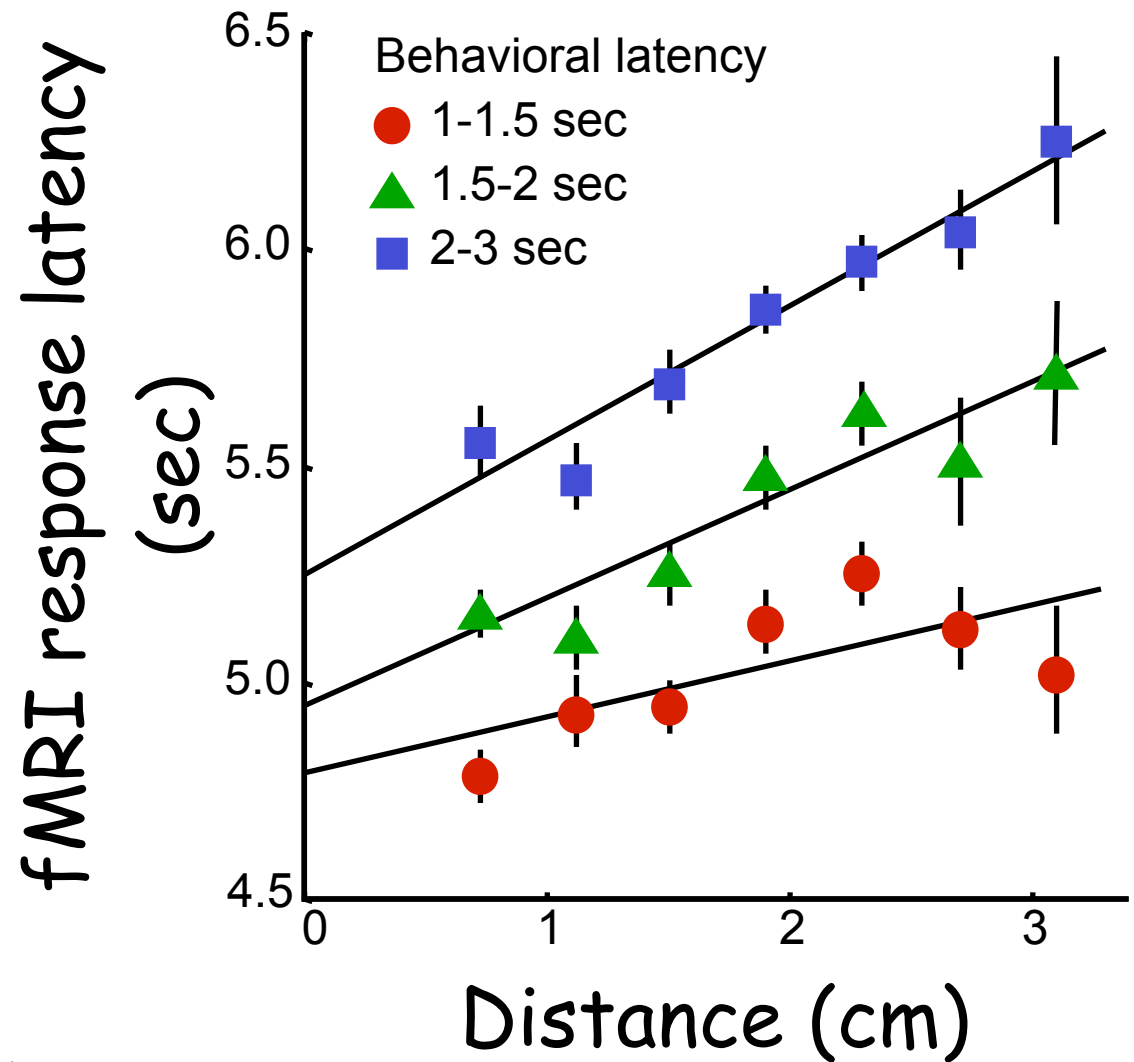
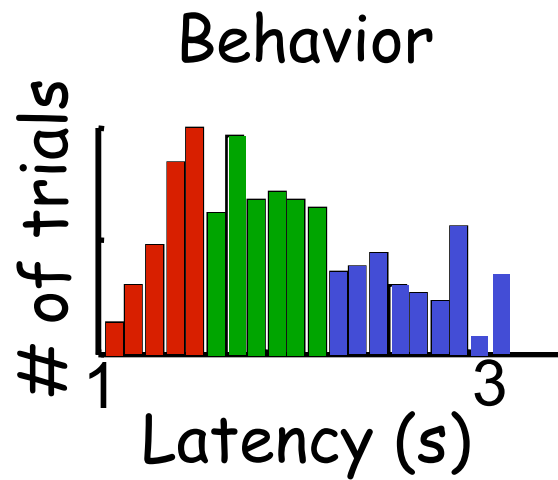
Peak fMRI response



Percept

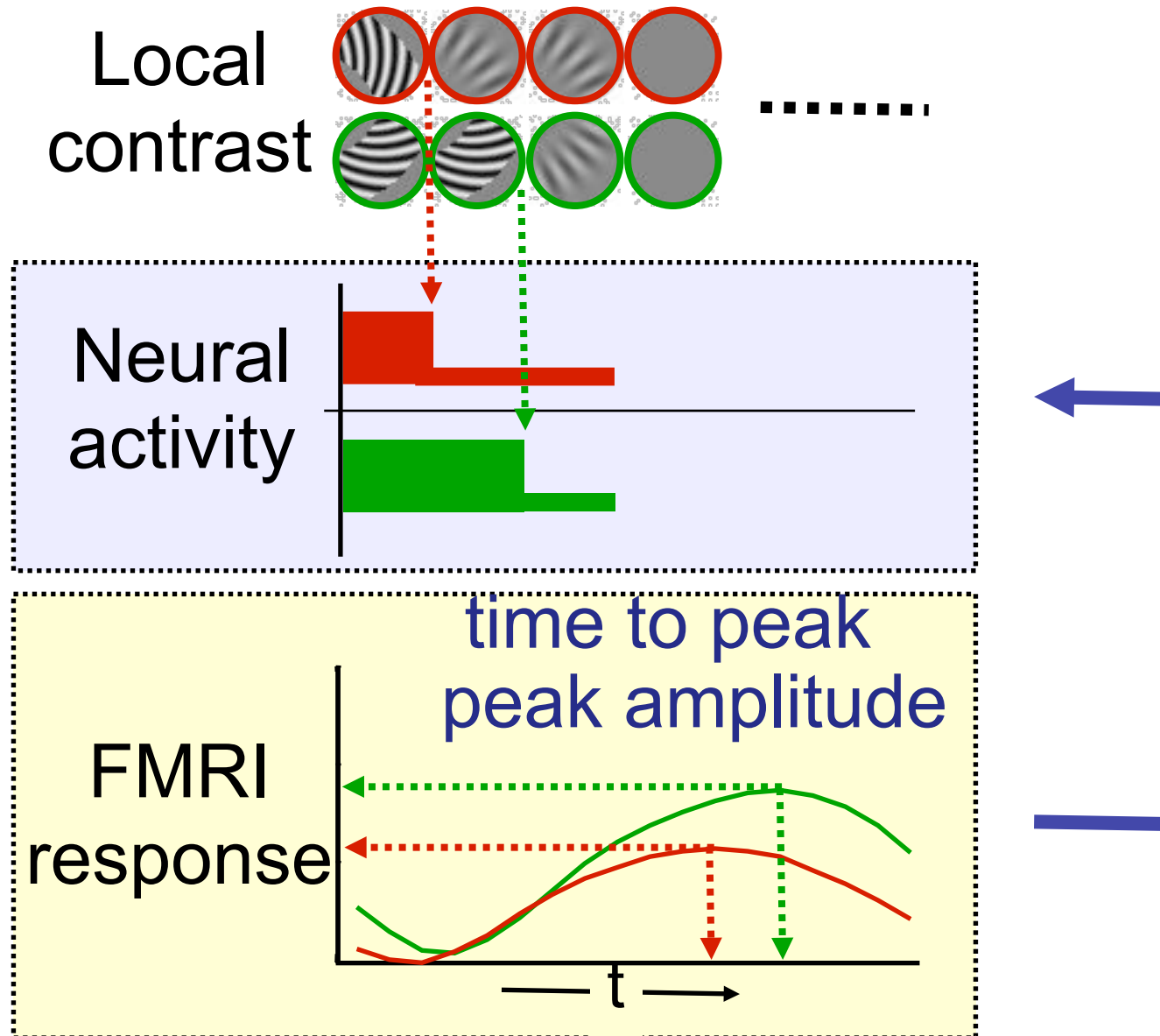


Activity correlates with perceived latency

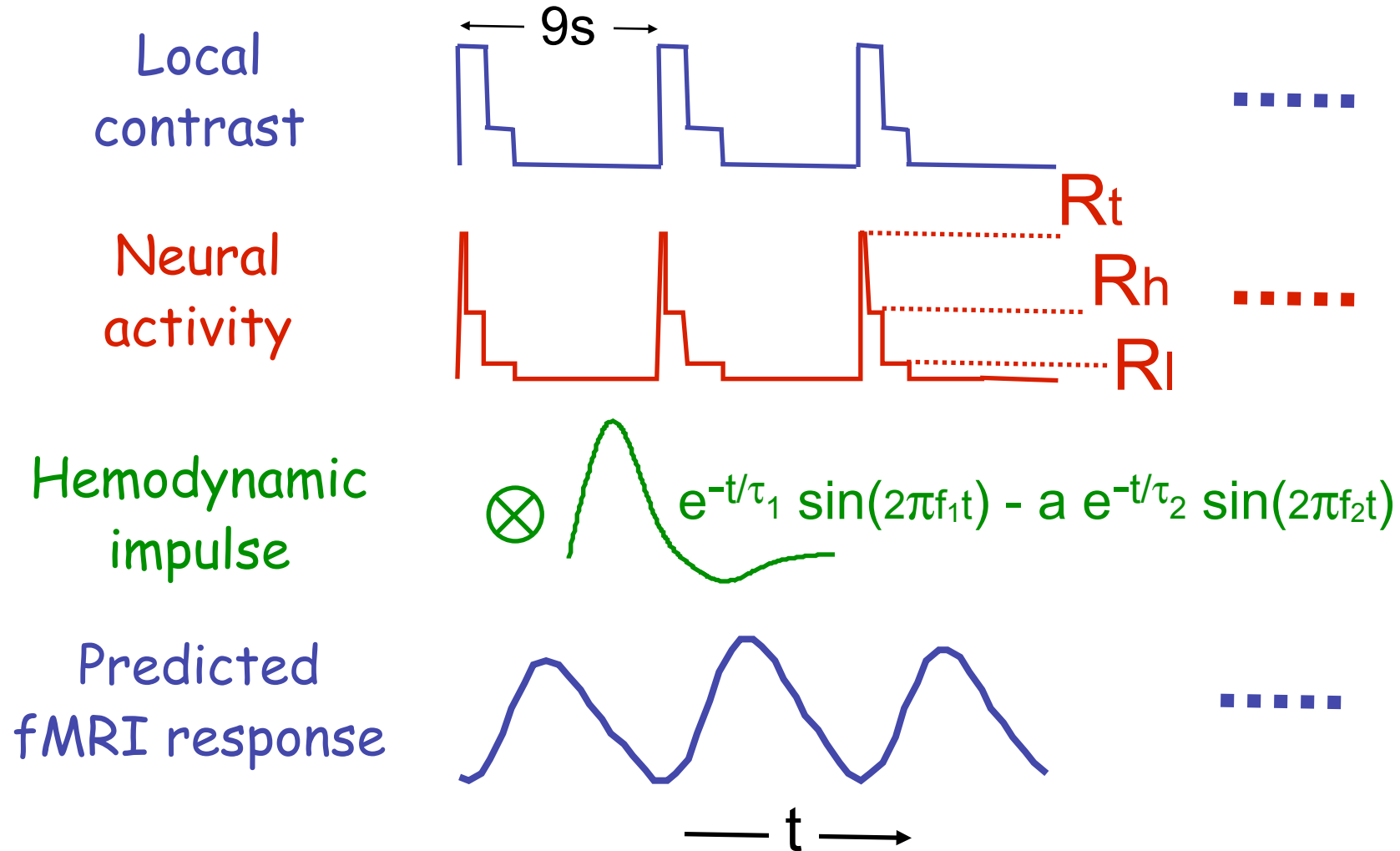


Infer ~115 ms timing difference over ~3.5 mm distance.

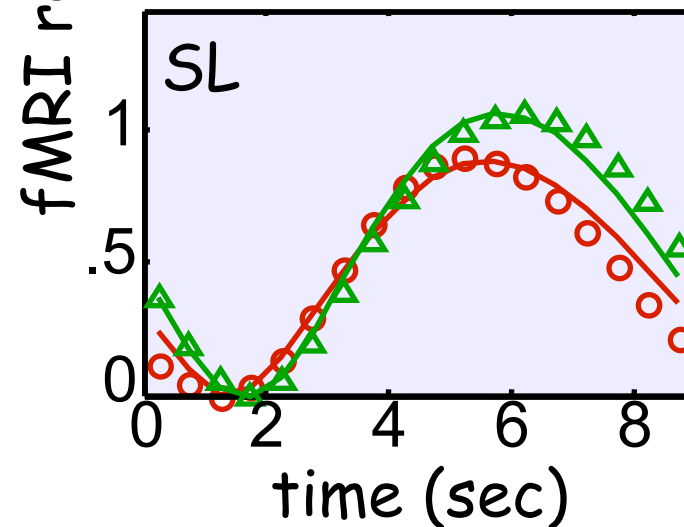
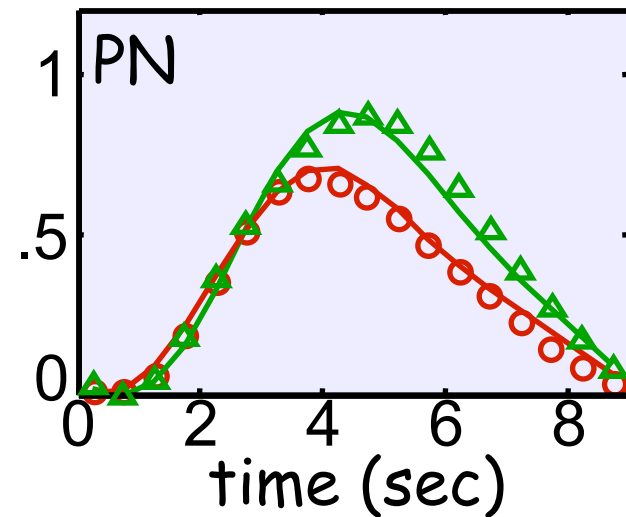
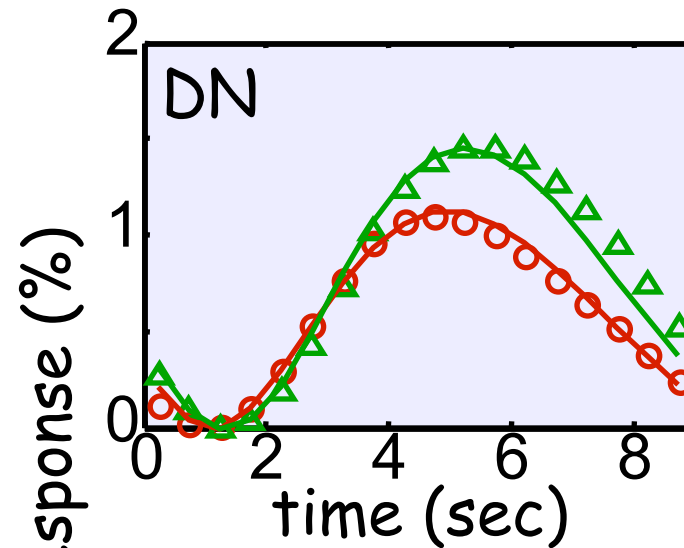
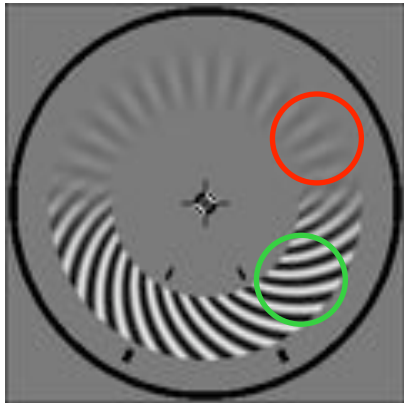
Estimating neural activity



Model of cortical activity & hemodynamic impulse



Model fits

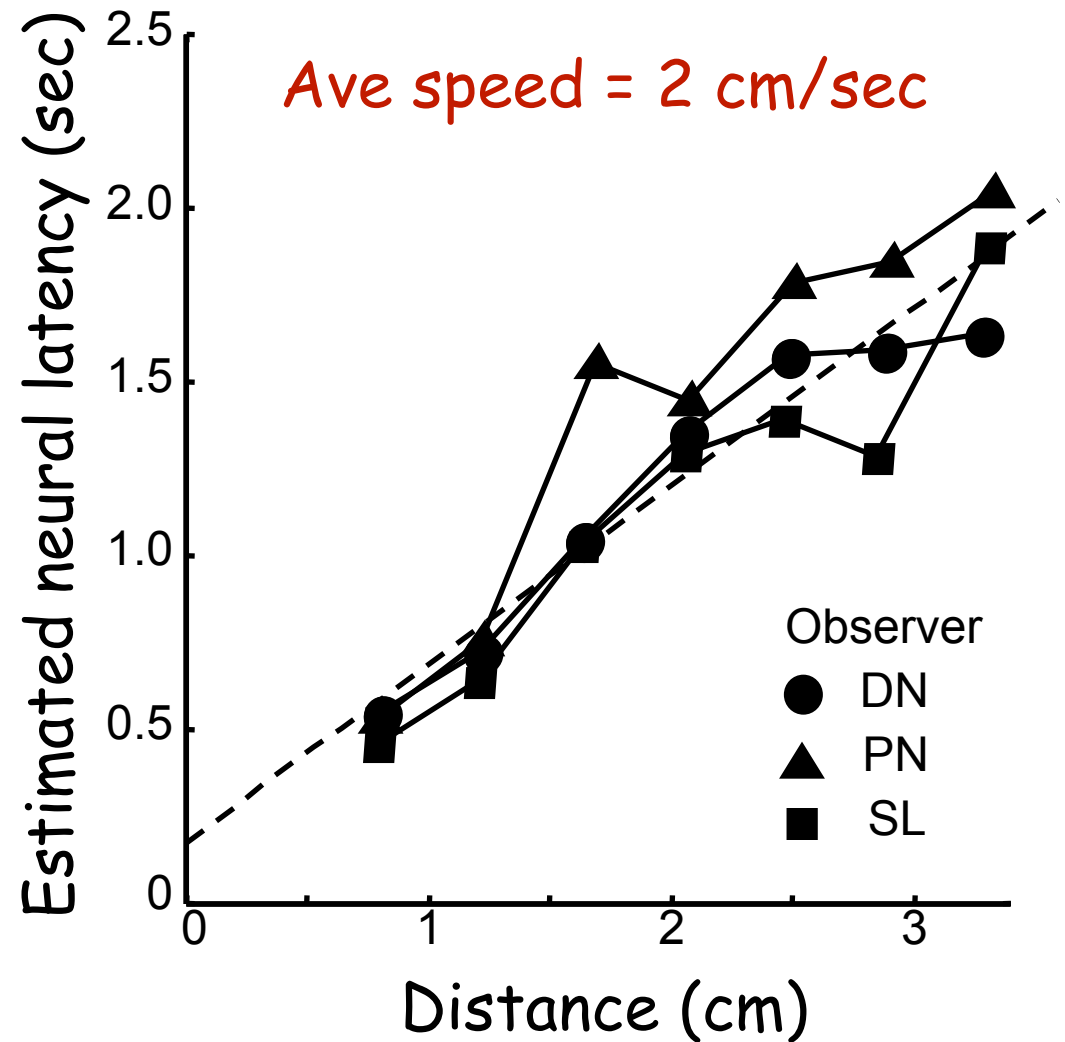
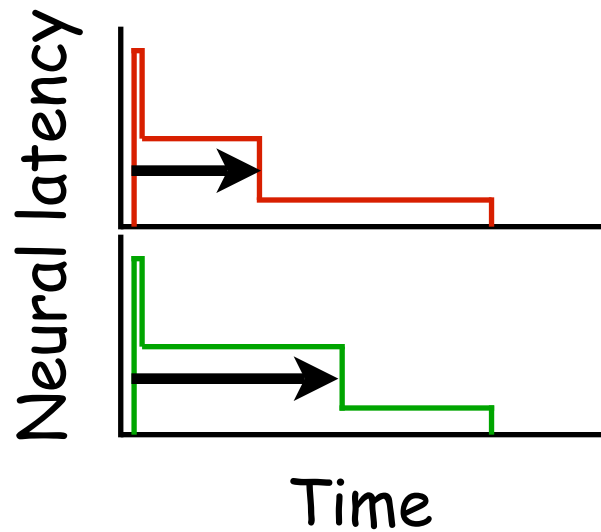


	DN	PN	SL
R_t	.5	.75	.5
R_h/R_l	8	6.5	5.5
τ_1	7.0	6.5	7.0
f_1	.035	.065	.053
a	.08	.1	.1

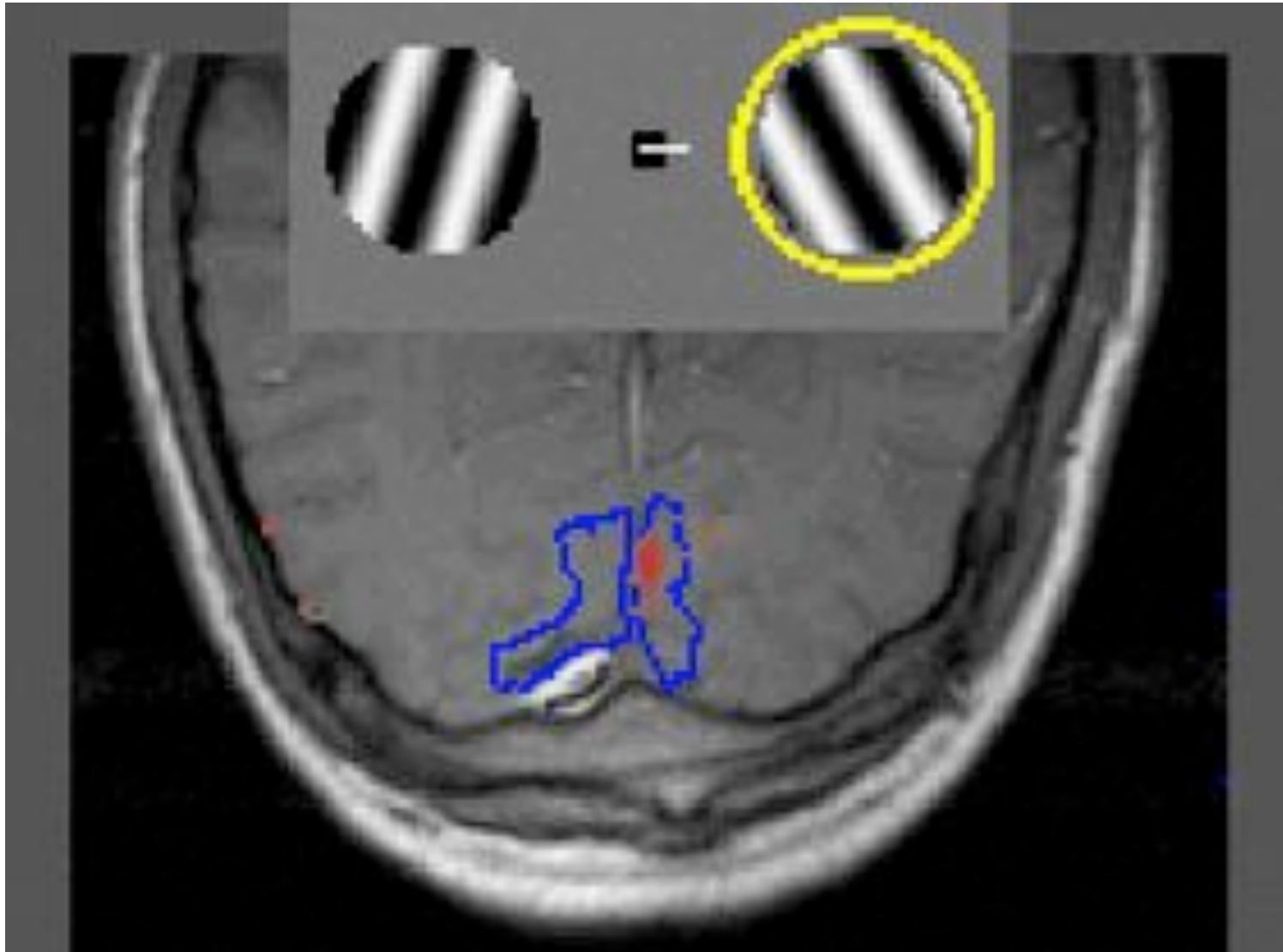
fixed parameters:

$$\tau_2=7.4, f_2=.12$$

Estimated neural latency

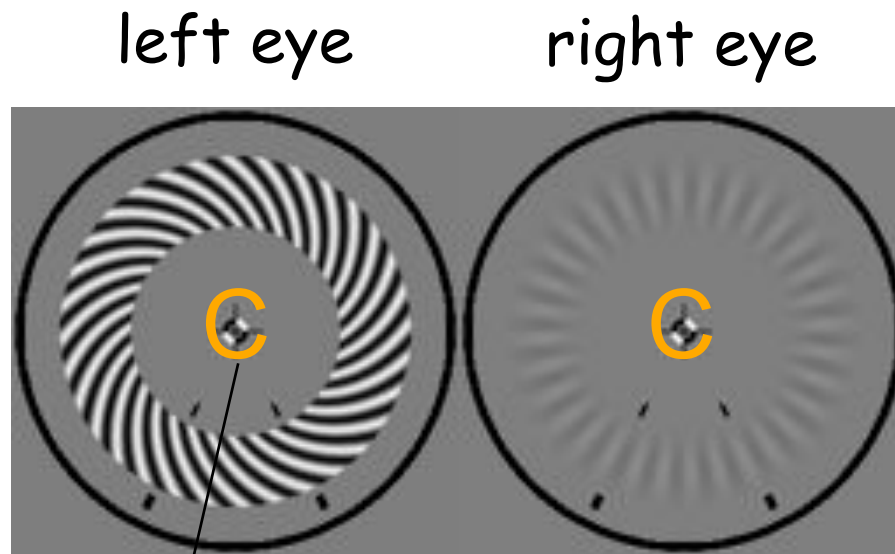


Attention signals in V1



Gandhi, Heeger, & Boynton, PNAS (1999)

Diverted attention

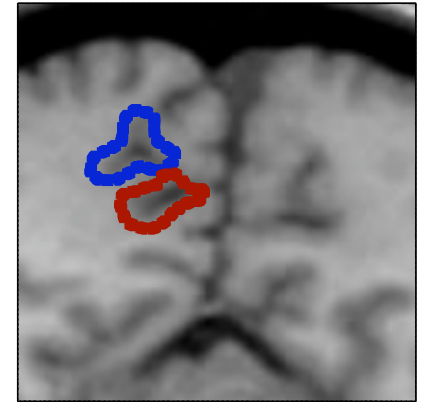


C2DA3B42D...

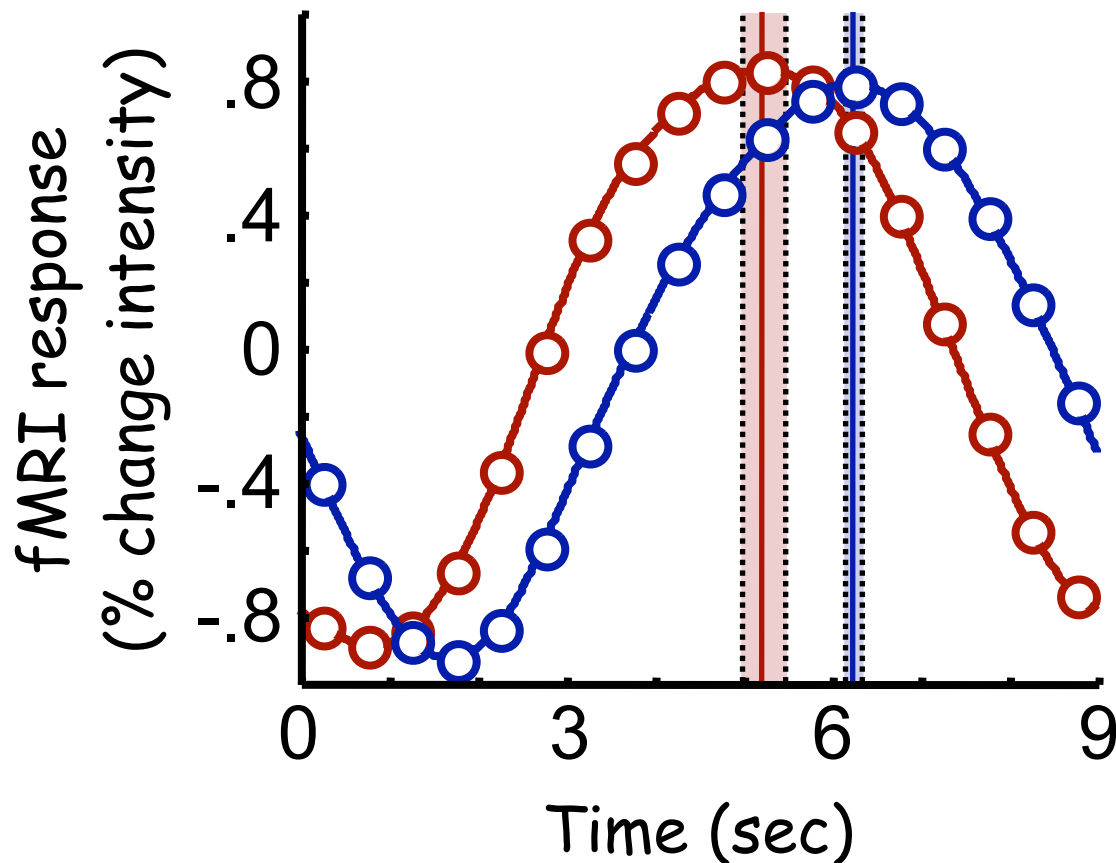
→
Time

Detect repetition

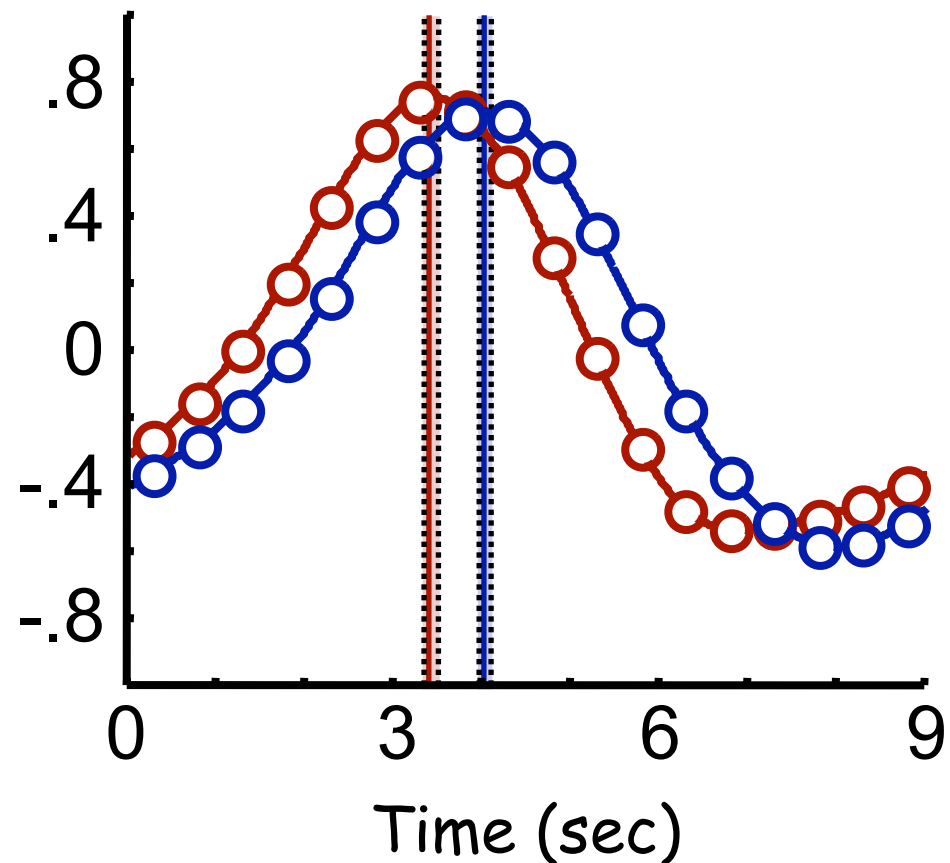
Waves in V1 without attention/perception



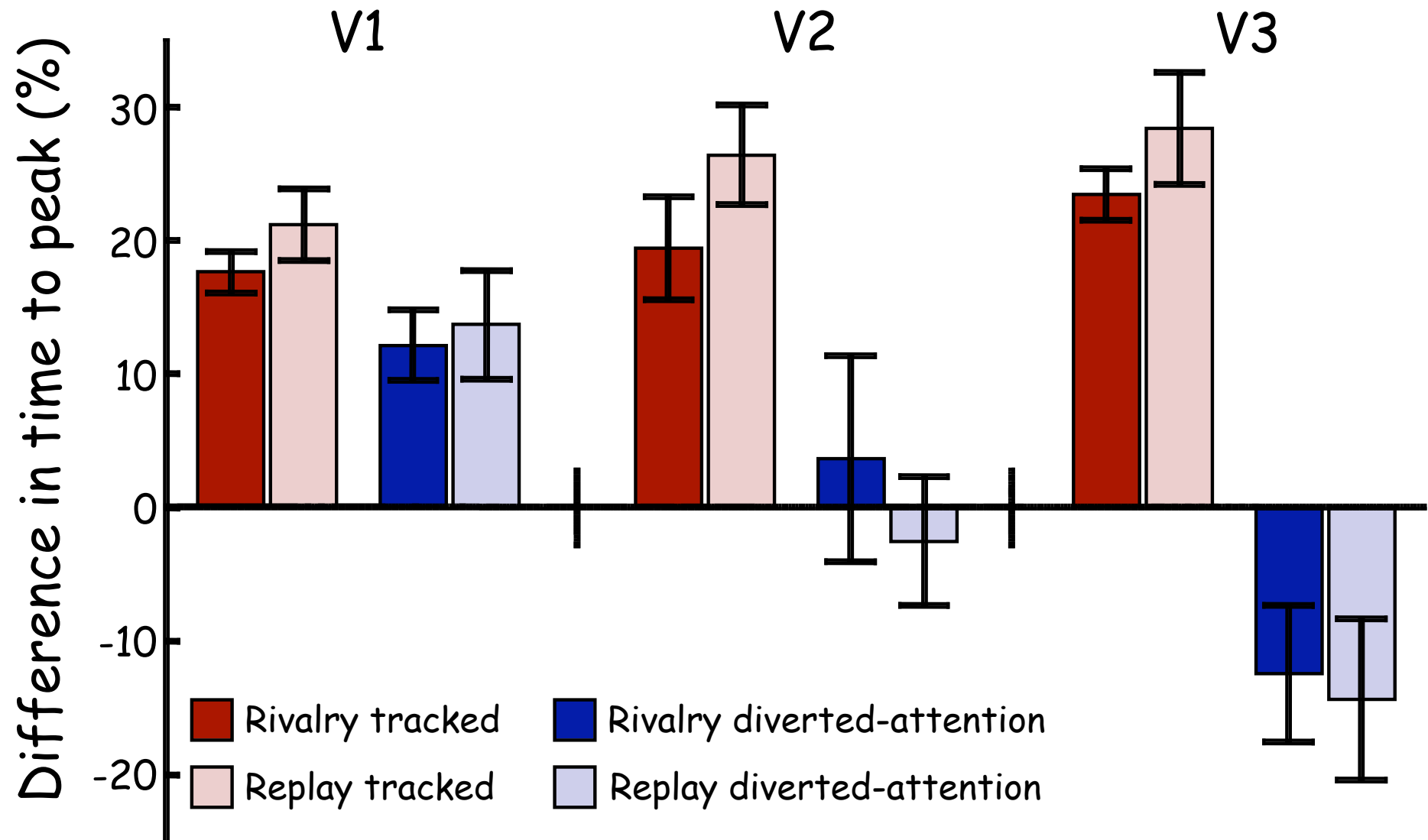
Rivalry (perceived)



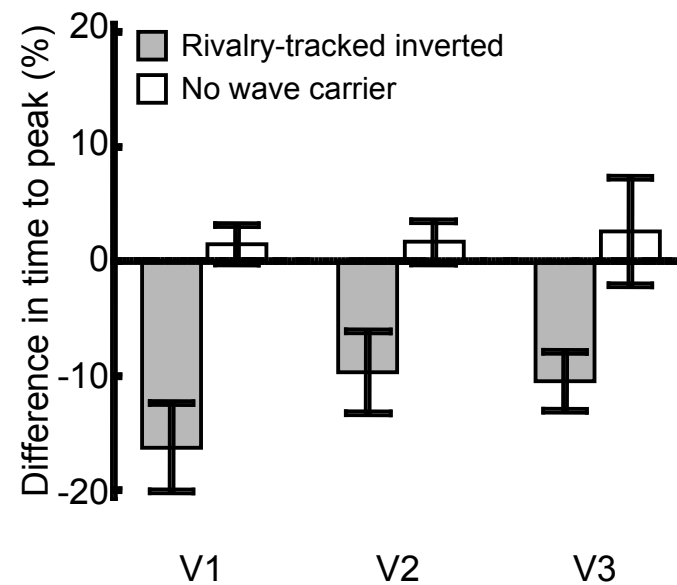
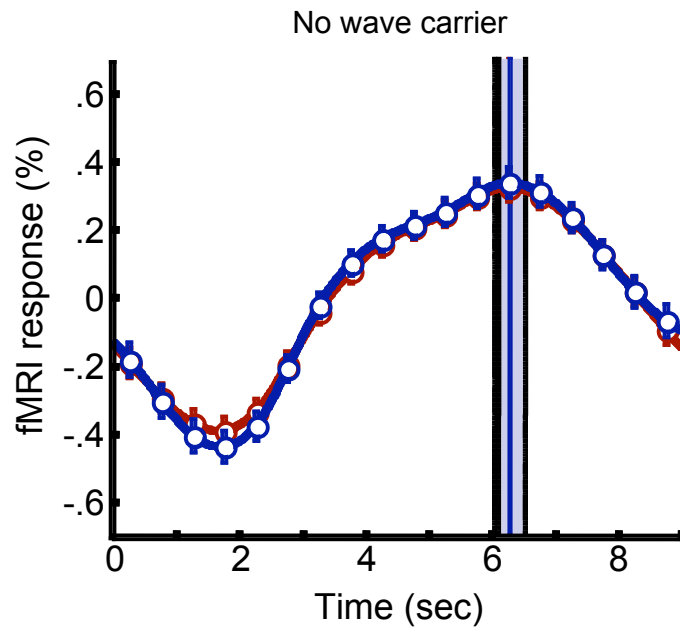
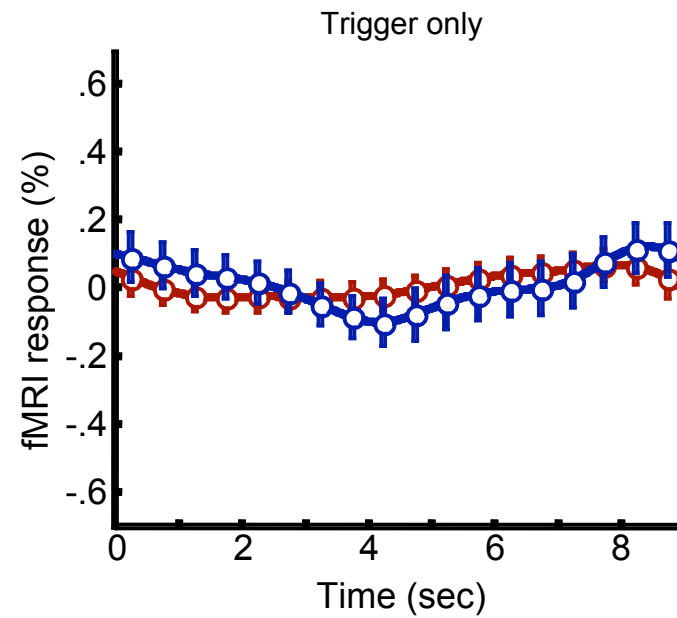
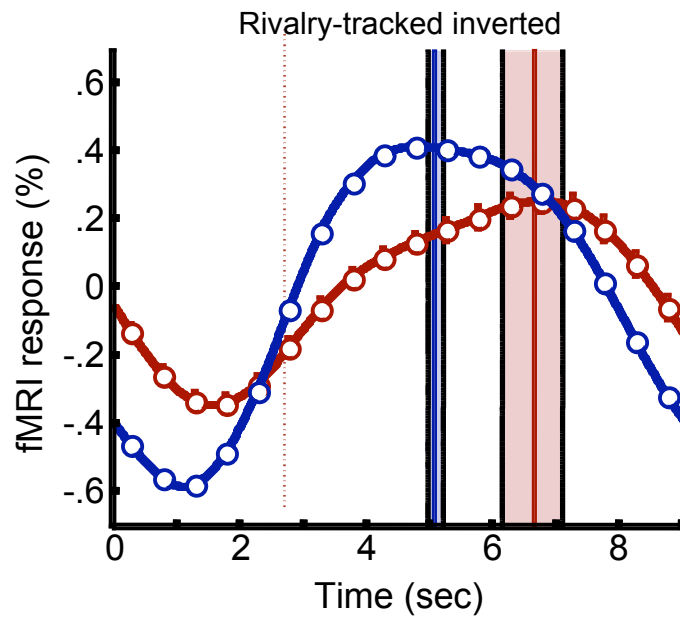
Diverted attention



Diverting attention eliminates waves in V2 & V3



Control experiments



Summary

- V1 activity correlated with spatio-temporal dynamics of perceptual waves during binocular rivalry.
- The velocity of neural waves in V1 matched the latency of perceptual waves.
- Neural waves in V1 were still present when attention was diverted, but weaker in amplitude and faster in velocity.
- V2 and V3 exhibited cortical waves of activity during rivalry but the waves were eliminated when attention was diverted.

Implications

- Neural wave propagation is intrinsic to V1.
- Attention is required for neural waves to be consciously perceived, through interactions between V1 and later visual areas.
- Constrains models of binocular rivalry (rivalry hierarchy: both early and late).
- Constrains models of processing and circuitry in V1 (waves are slow relative to action potential propagation and synaptic transmission).