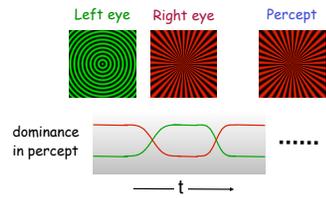


## Waves of Activity in Early Visual Cortex during Binocular Rivalry

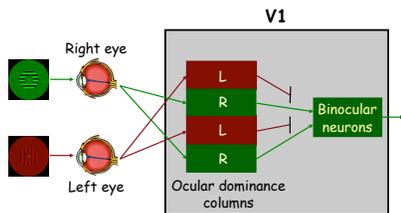


Sang-Hun Lee, Seoul National University  
 Randolph Blake, Vanderbilt University  
 David J. Heeger, New York University

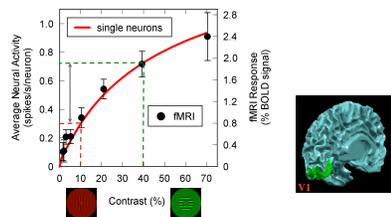
### Binocular rivalry



### V1 suppression hypothesis

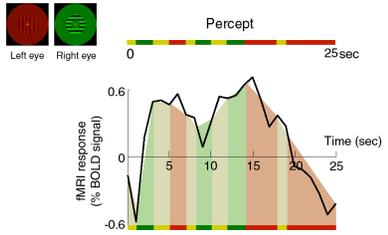


### V1 contrast response



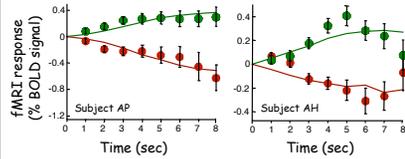
Huk et al, Nature Neurosci (2000)

### Sample V1 response during rivalry



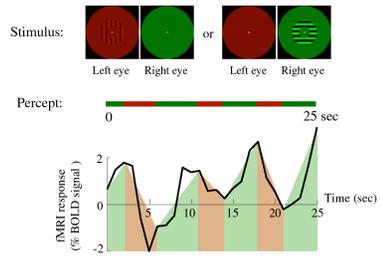
Polonsky et al, Nature Neurosci (2000)

### V1 activity correlates with percept during rivalry

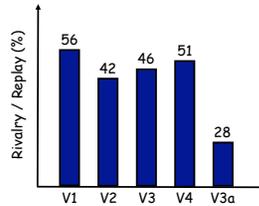


Polonsky et al, Nature Neurosci (2000)

### Sample V1 response during replay



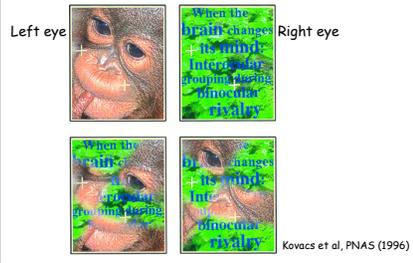
### Rivalry vs replay across visual areas



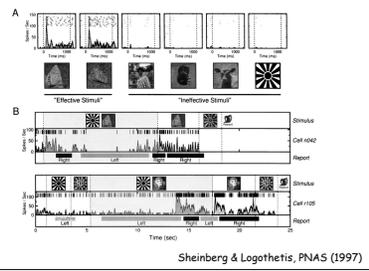
Response during rivalry is ~50% of response during replay, roughly equal in V1, V2, V3, and V4

Polonsky et al, Nature Neurosci (2000)

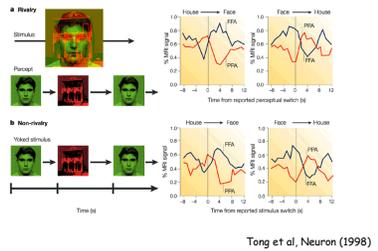
### Pattern rivalry



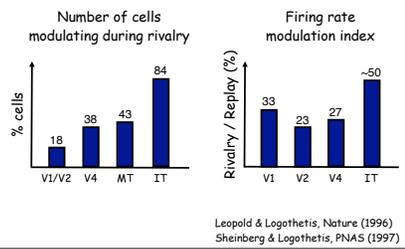
### Binocular rivalry in monkey IT



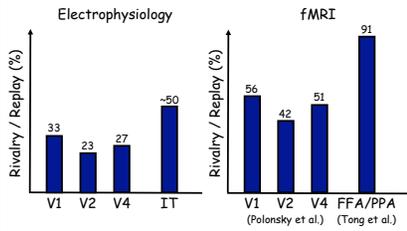
### Binocular rivalry in human IT



### Reanalysis of electrophysiology



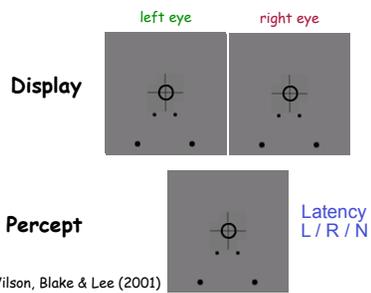
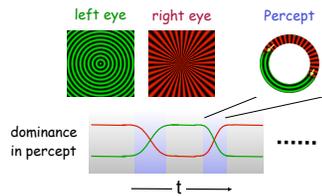
### Electrophysiology vs fMRI



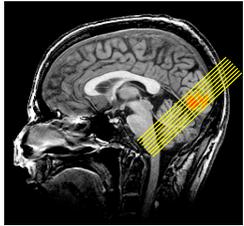
### Unresolved issues

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

### Spatiotemporal dynamics during binocular rivalry

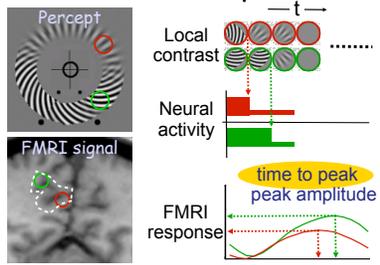


### fMRI protocol

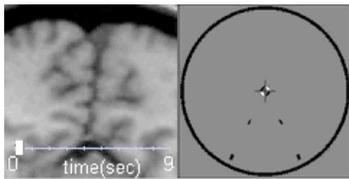


TR = 500 ms  
32 scans/subj  
25 trials/scan  
800 trials/subj  
3 subjects

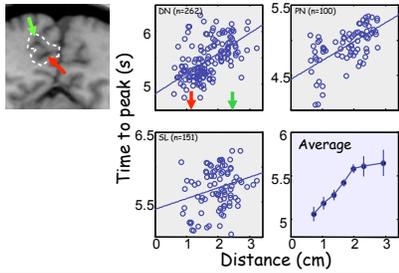
### Predicted fMRI responses

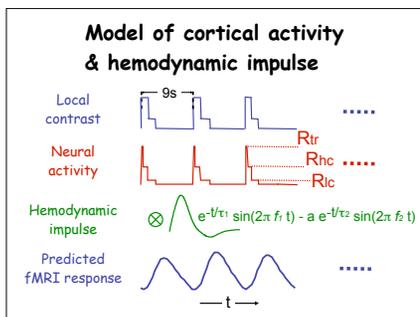
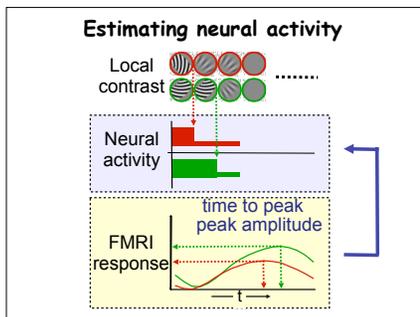
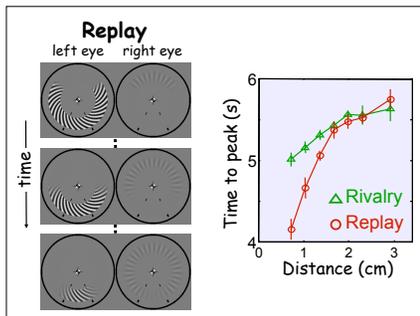
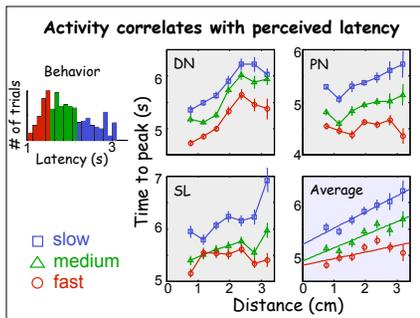


### Peak fMRI response      Percept

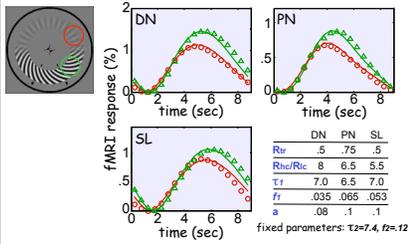


### V1 activity correlates with percept

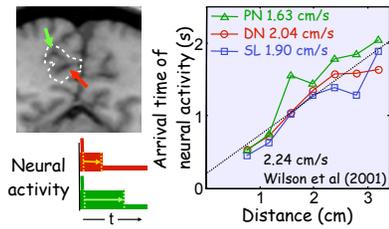




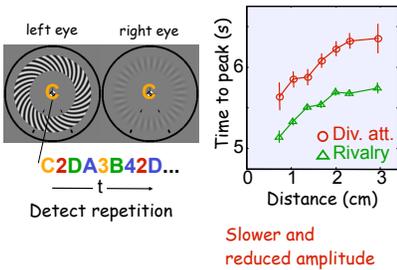
### Results of model fits



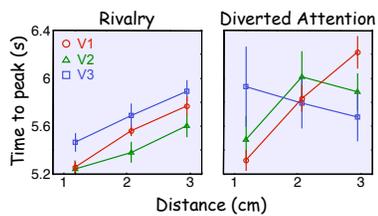
### Estimated velocity of underlying neural activity during rivalry



### Diverted attention



### Differential effects of attention across visual areas



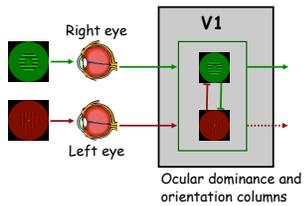
### Summary

- 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 slower in velocity.
- V2 and V3 exhibited cortical waves of activity during rivalry but the waves were abolished when attention was diverted.

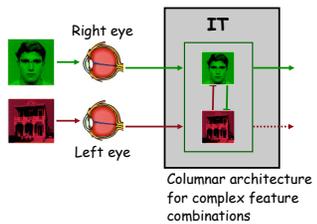
### Implications

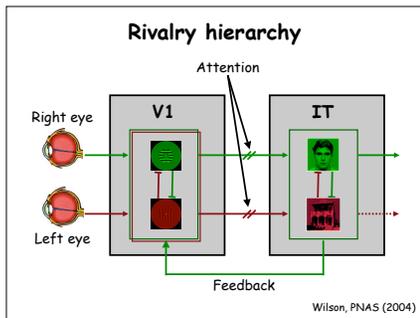
- Neural waves during rivalry appear to originate in V1.
- Attention is required for those neural waves to be transmitted through the visual cortex and to be consciously experienced by observers.
- Rivalry hierarchy: both early and late, both eye- and pattern-rivalry.
- Constrains models of the functional organization and neural circuitry in V1 (propagation is slow relative to the latency of action potential and synaptic transmission).

### Competitive and cooperative interactions in V1



### Competitive and cooperative interactions in IT





### Traveling waves in the cortex

**In vitro:** rat cortical slices (Chervin et al., 1988; Golomb & Amitai, 1997; Wu et al., 1999)

**In vivo:** rat somatosensory cortex (Nicollelis et al., 1995)  
 turtle visual cortex (Prechtl et al., 1999; Senseman, 1997)  
 cat visuomotor cortex (Roelfsema et al., 1997)  
 cat visual cortex (Jancke et al., 2004)

### Waves in perception: Aura in migraine

Lashley (1941)

Painted by Huber Airy in Gowers (1907)