Waves of Activity in Early Visual Cortex during Binocular Rivalry

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Binocular rivalry

V1 suppression hypothesis

V1 contrast response

Sample V1 response during rivalry

V1 activity correlates with percept during rivalry

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.
Pattern rivalry
Left eye
Right eye
Kovacs et al, PNAS (1996)

Binocular rivalry in monkey IT
Sheinberg & Logothetis, PNAS (1997)

Binocular rivalry in human IT
Tong et al, Neuron (1998)

Reanalysis of electrophysiology
Leopold & Logothetis, Nature (1996)
Sheinberg & Logothetis, PNAS (1997)
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

Display

Percept

Wilson, Blake & Lee (2001)
fMRI protocol

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

Predicted fMRI responses

Local contrast
Neural activity
FMRI signal
FMRI response

Time to peak
Peak amplitude

Distance (cm)
Time to peak (s)

Average

V1 activity correlates with percept
Activity correlates with perceived latency

- Behavior
- Latency (s)
- Distance (cm)
- Time to peak (s)

Replay
- Left eye
- Right eye

Estimating neural activity
- Local contrast
- Neural activity
- FMRI response
- Peak amplitude
- Time to peak

Model of cortical activity & hemodynamic impulse
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**

![Diagram of V1 with competitive and cooperative interactions](image1)

- Ocular dominance and orientation columns

**Competitive and cooperative interactions in IT**

![Diagram of IT with competitive and cooperative interactions](image2)

- Columnar architecture for complex feature combinations
Rivalry hierarchy

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 (Nicolelis 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

Painted by Huber Airy in Gowers (1907)