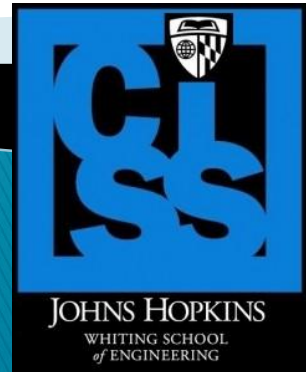


A neural model for perceptual organization of 3D surfaces

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What are surfaces good for?



What are surfaces good for?



- Scene understanding

What are surfaces good for?



- ▶ Scene understanding
- ▶ Motor planning

What are surfaces good for?



- ▶ Scene understanding
- ▶ Motor planning
- ▶ Spatial navigation

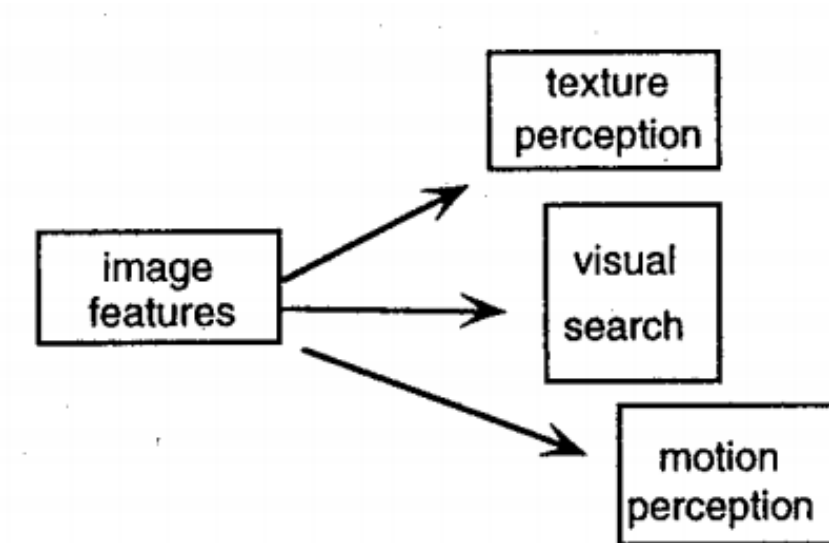
What are surfaces good for?



- ▶ Scene understanding
- ▶ Motor planning
- ▶ Spatial navigation
- ▶ *Etc.*

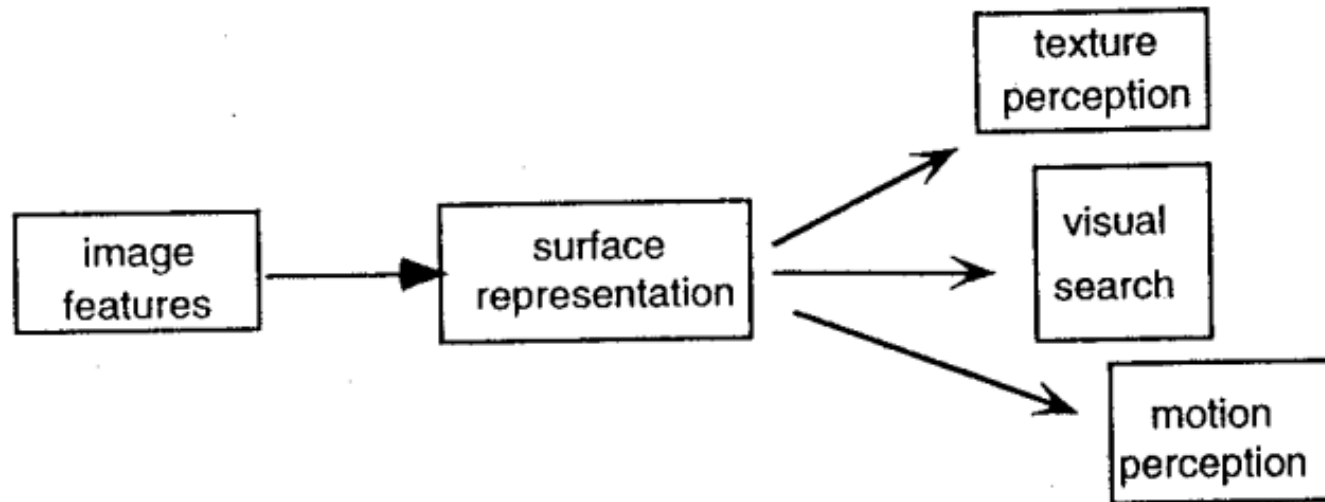
Intermediate-level vision: features

- ▶ The traditional view is that rapid visual processing only requires access to features



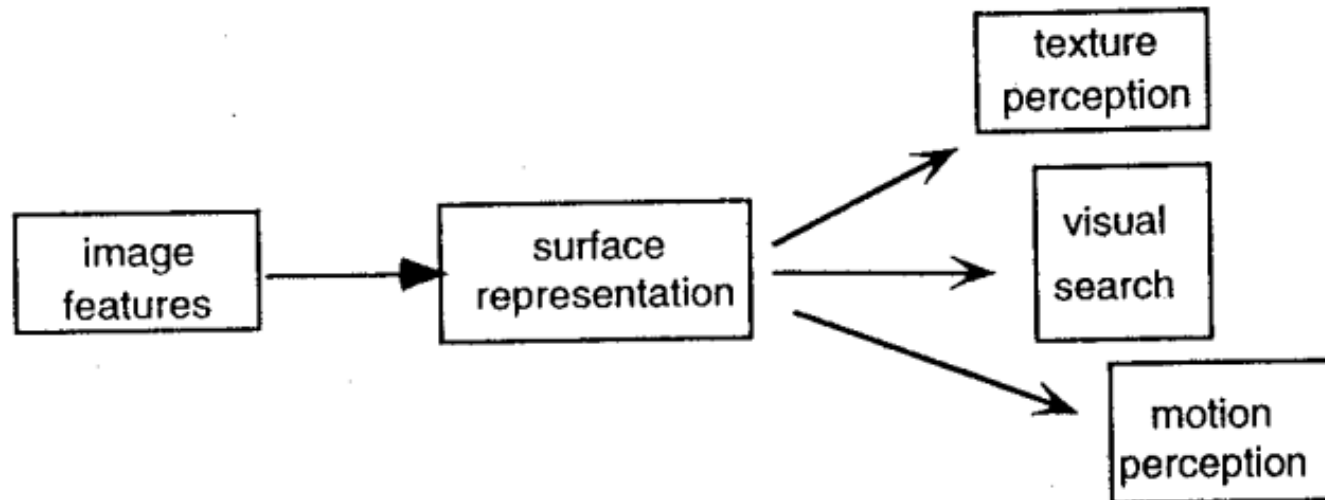
Intermediate-level vision: surfaces

- ▶ An alternative view is that surfaces, not features, organize intermediate-level vision



Intermediate-level vision: surfaces

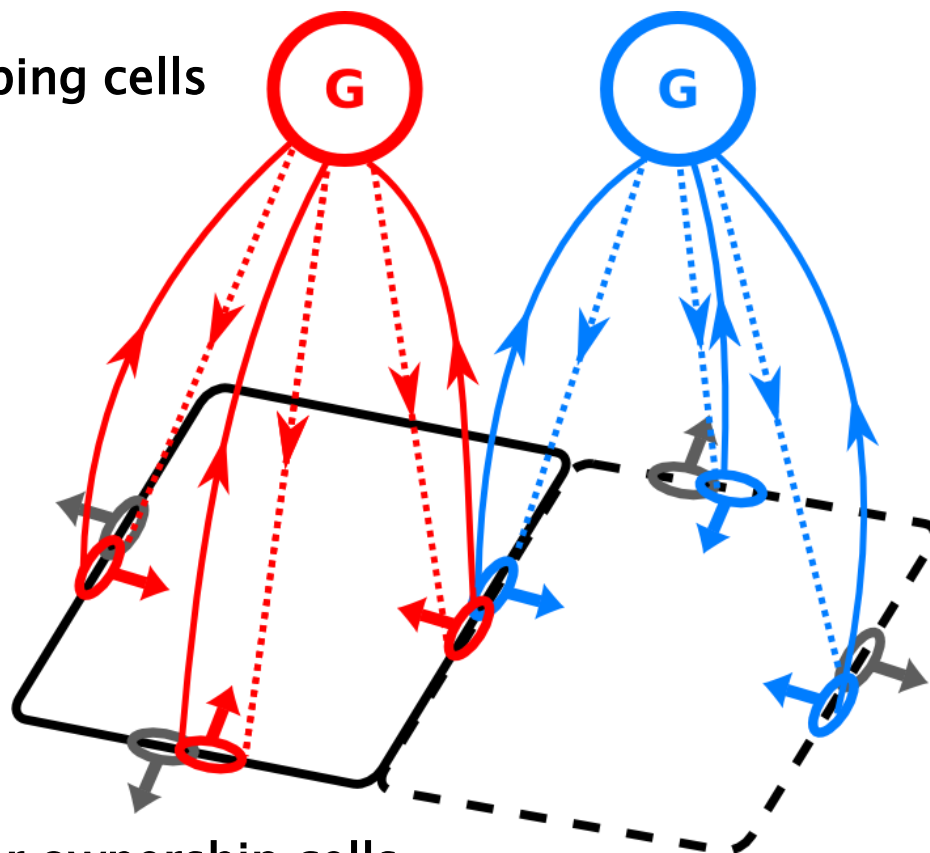
- ▶ An alternative view is that surfaces, not features, organize intermediate-level vision



How are surfaces represented in the brain?
How is this surface representation computed?

Perceptual organization in 2D

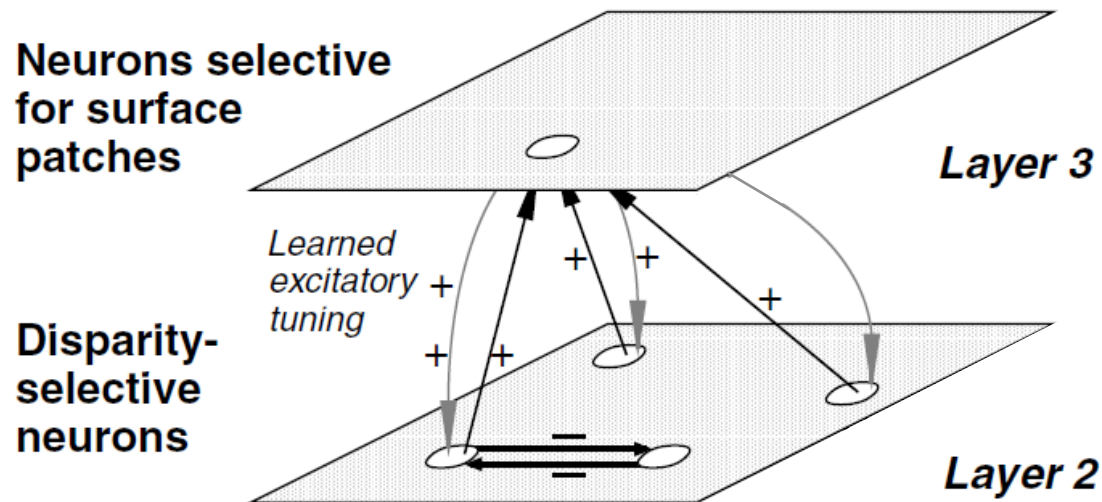
Grouping cells



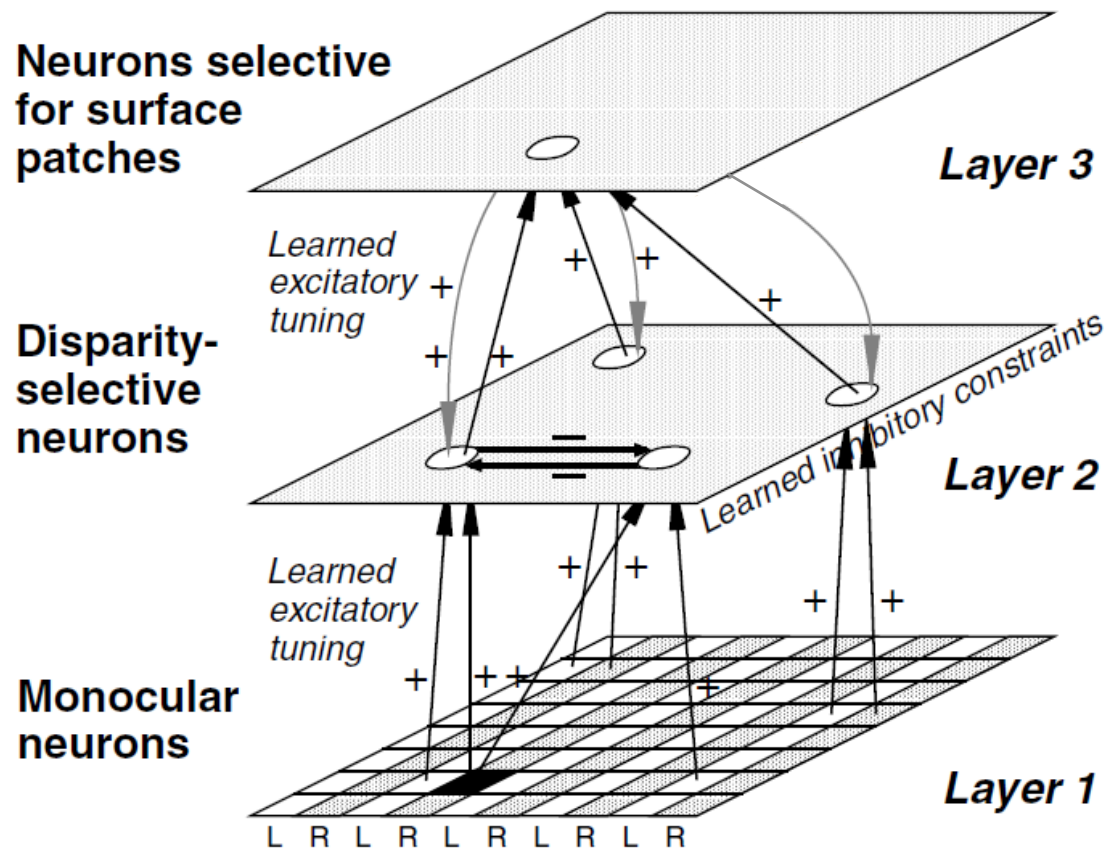
Border ownership cells

- ▶ **Red**: feedback grouping circuit for solid line object
- ▶ **Blue**: feedback grouping circuit for dashed line object

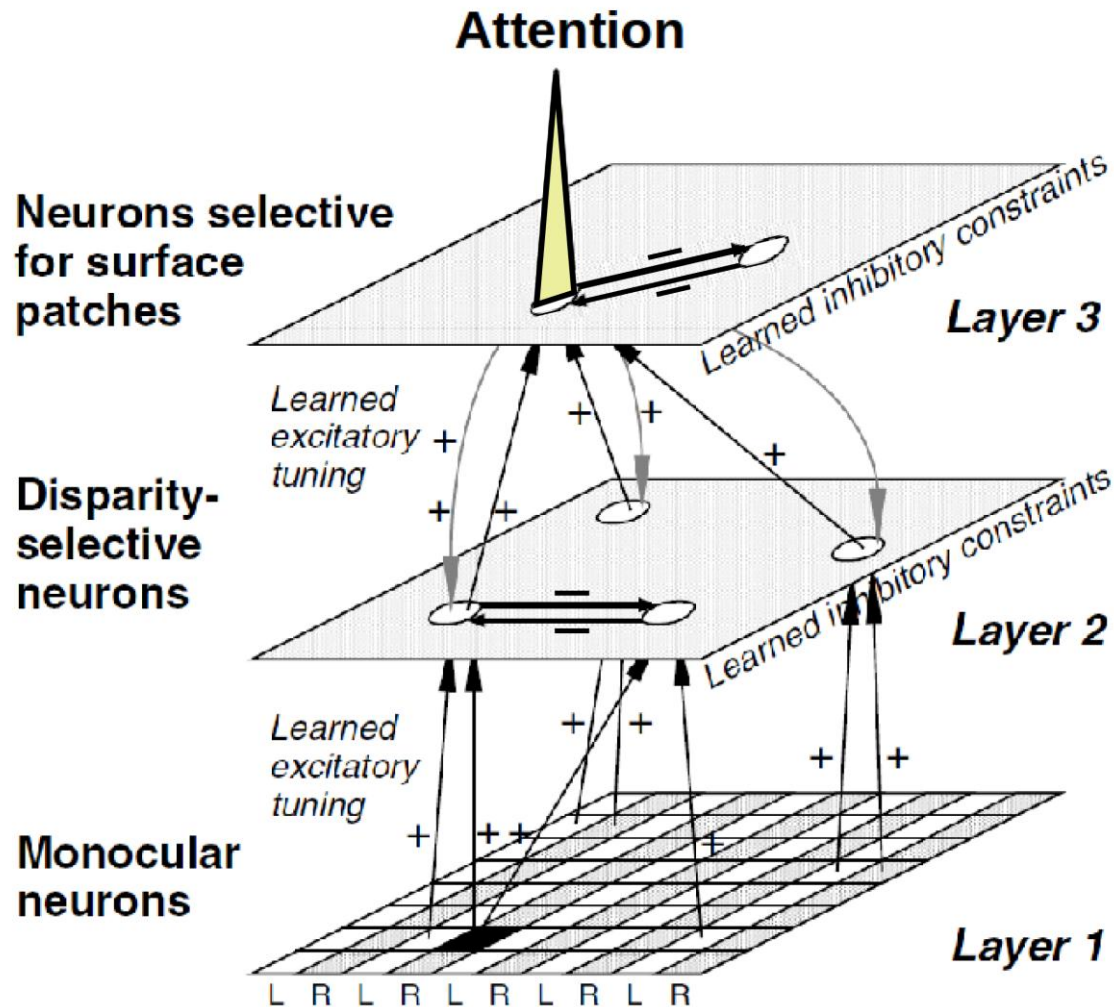
Perceptual organization in 3D



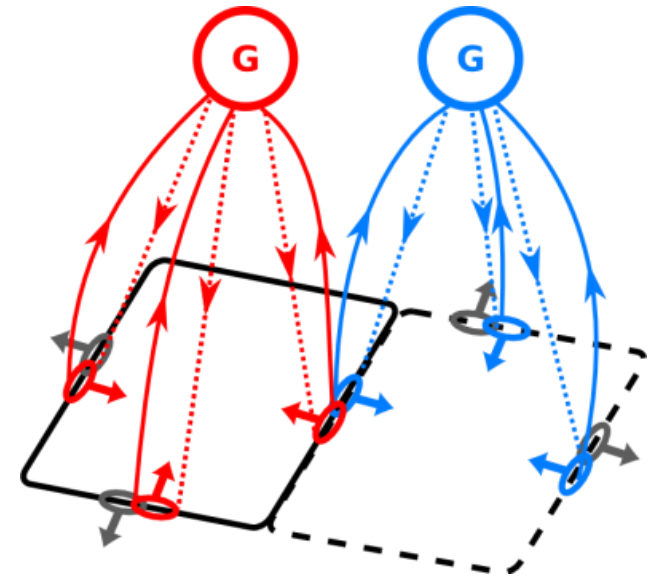
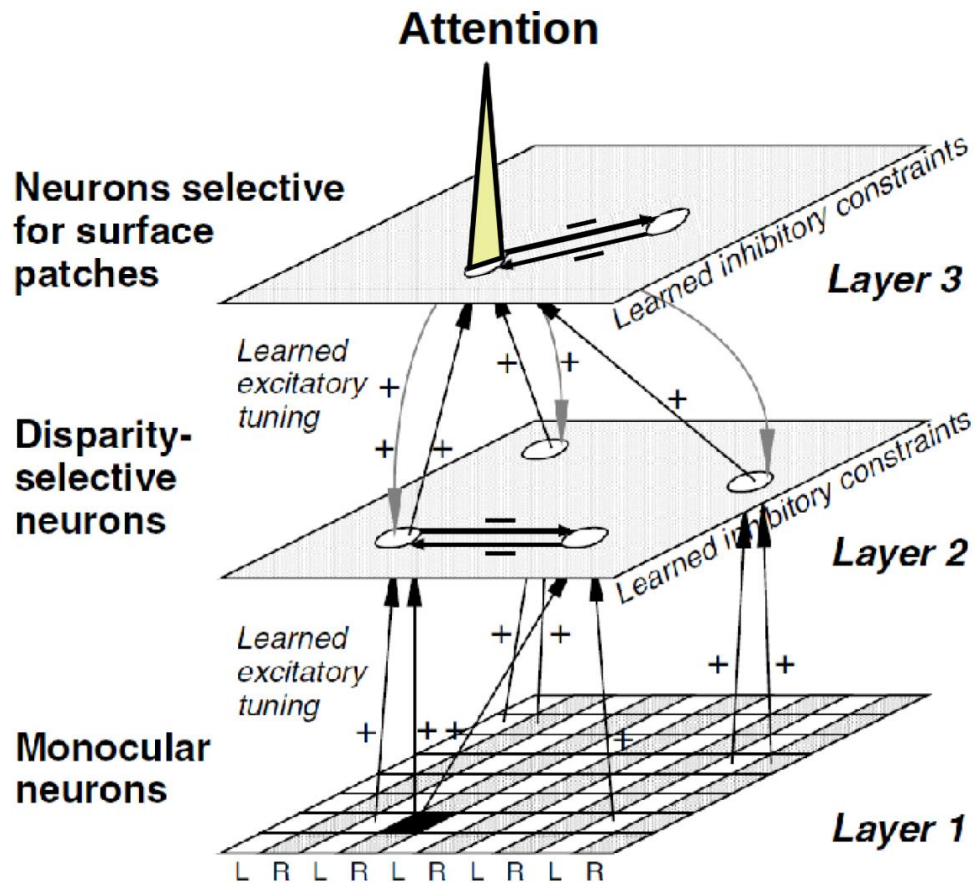
Perceptual organization in 3D



Our model



Our model

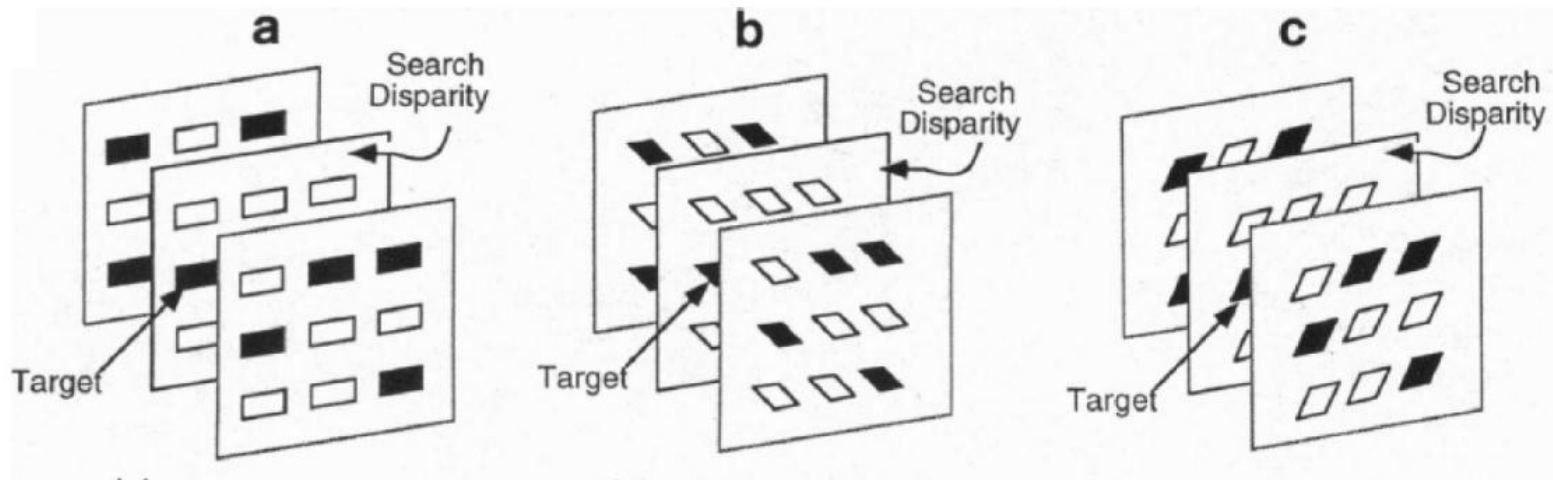


Model details

- ▶ Input to the model is a pair of stereo images
- ▶ Neural activity is modeled as a continuous variable (*i.e.* rate coding)
- ▶ Neurons are zero-threshold linear, with excitatory feedforward/feedback connections, and inhibitory lateral connections
- ▶ Attention is modeled as an additive input at the level of planar grouping neurons

Psychophysical experiments

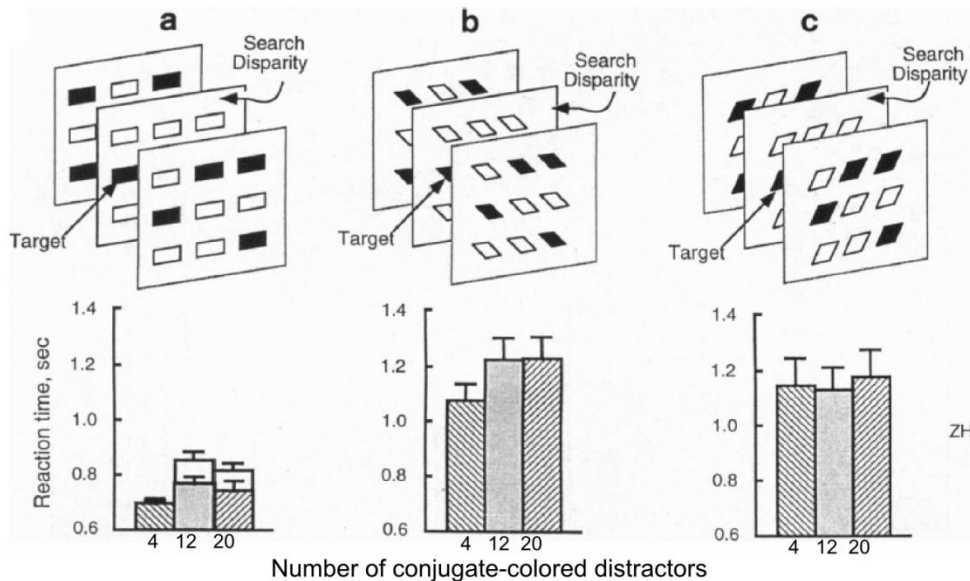
- Subjects had to search for odd-colored target among distractors within a cued disparity-defined surface



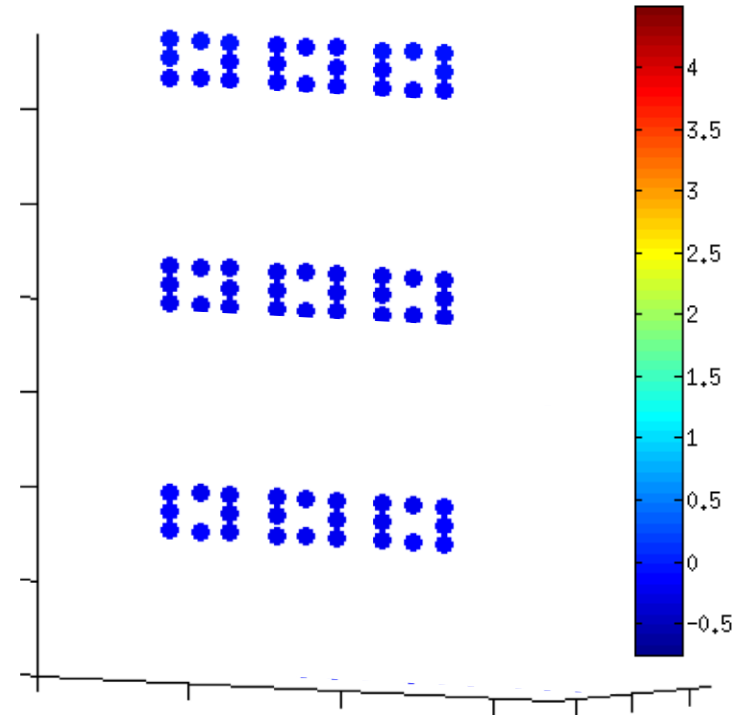
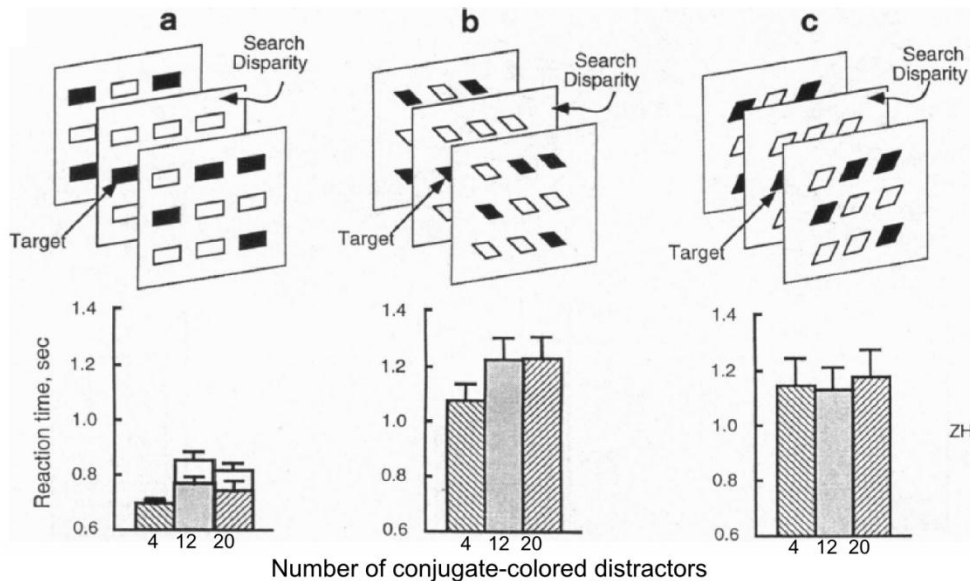
Psychophysical experiments

- ▶ Efficient search is characterized by low reaction times (*i.e.* pop-out search)
- ▶ We simulate response enhancement of disparity-selective cells on the attended plane instead of reaction times

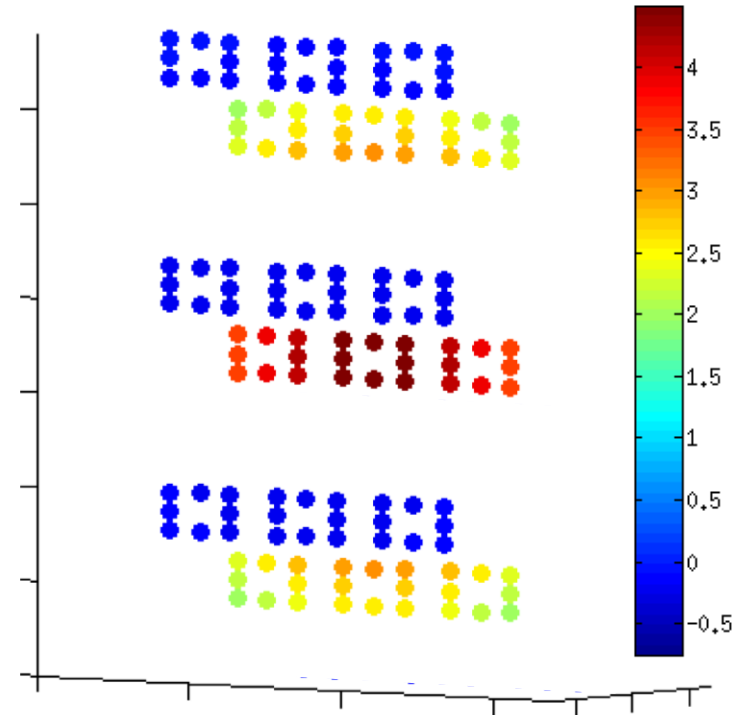
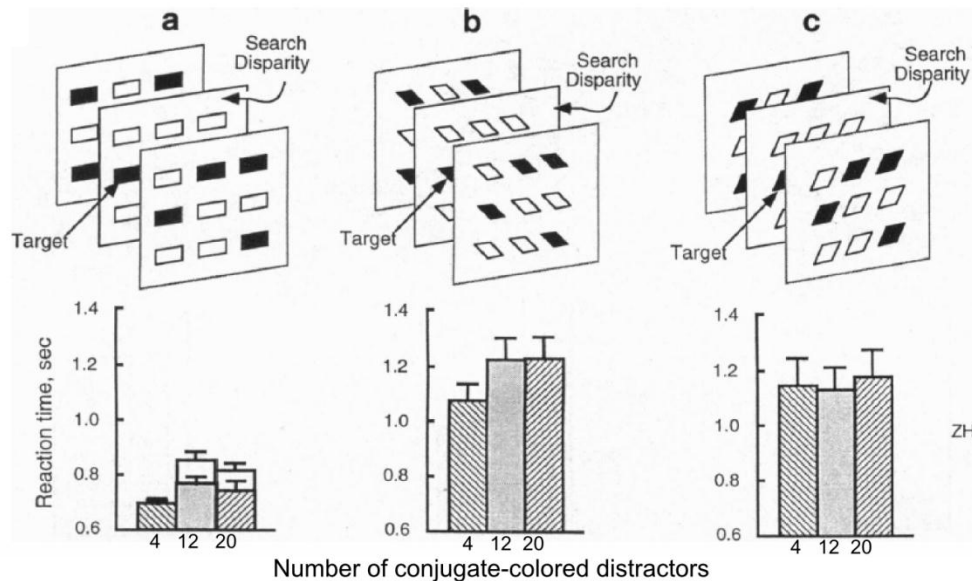
Attention spreads across fronto-parallel surfaces



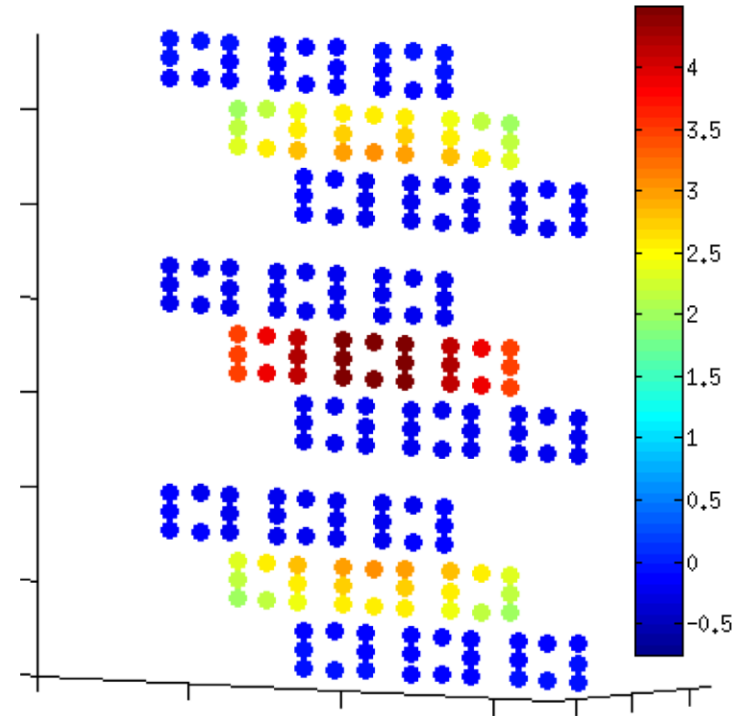
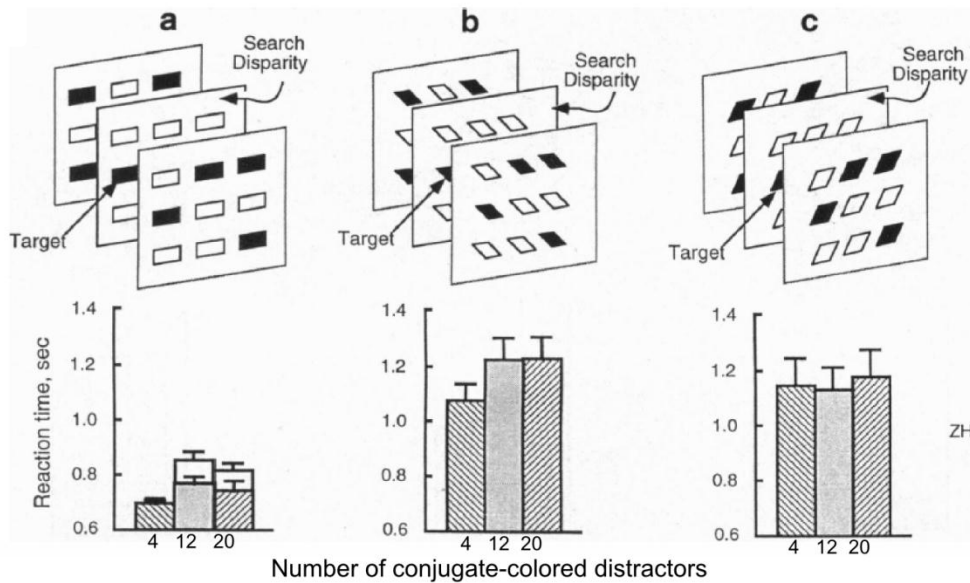
Attention spreads across fronto-parallel surfaces



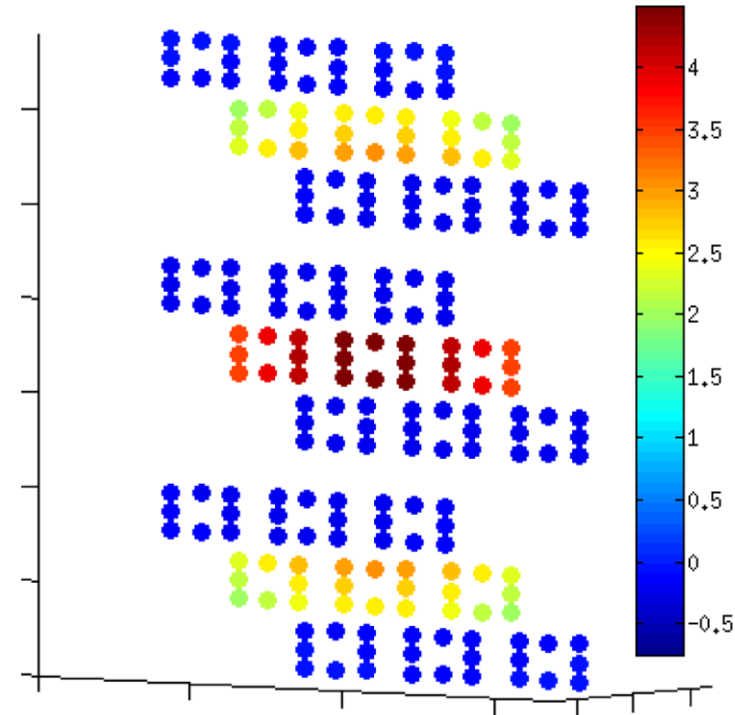
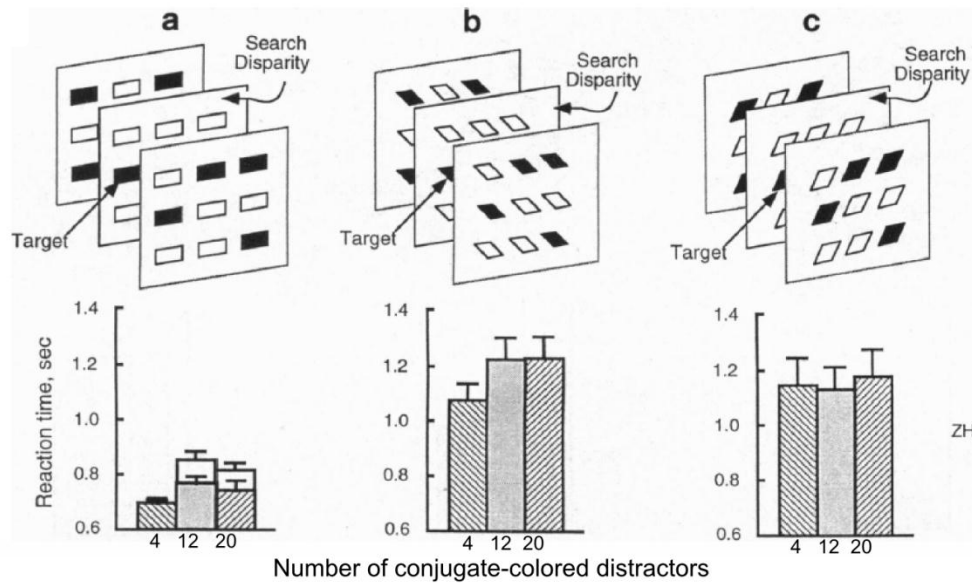
Attention spreads across fronto-parallel surfaces



Attention spreads across fronto-parallel surfaces

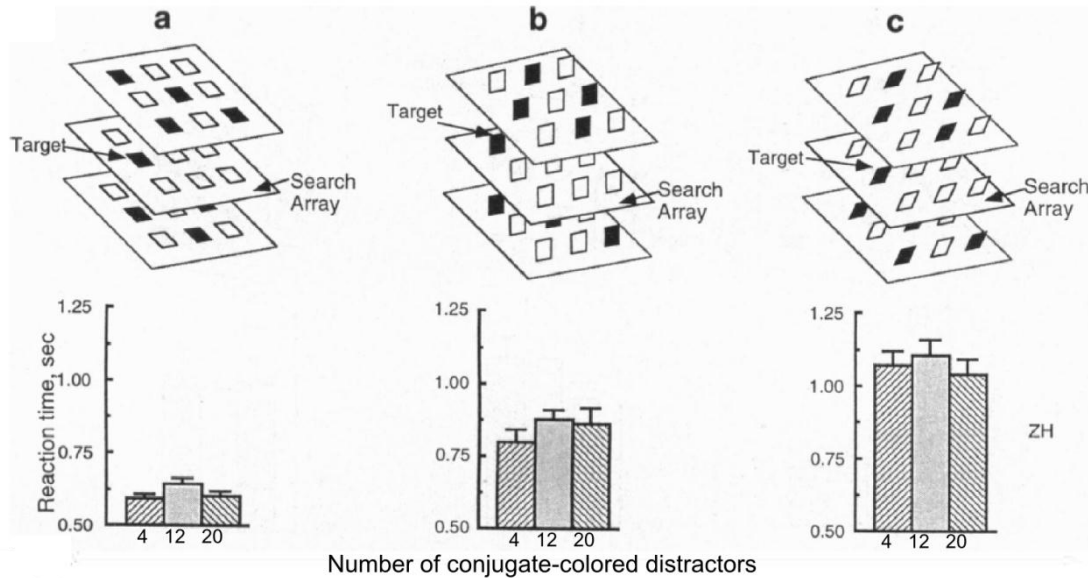


Attention spreads across fronto-parallel surfaces

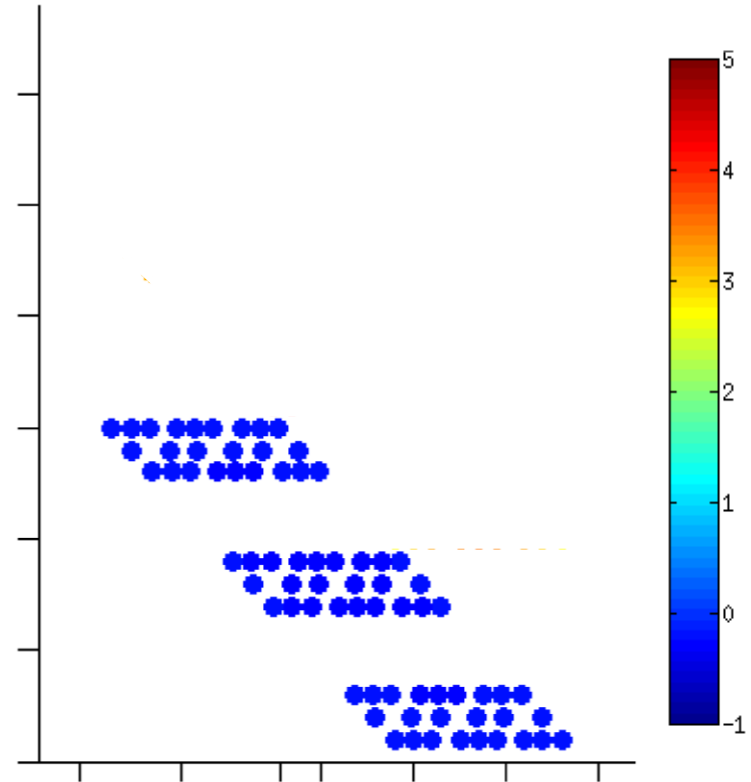
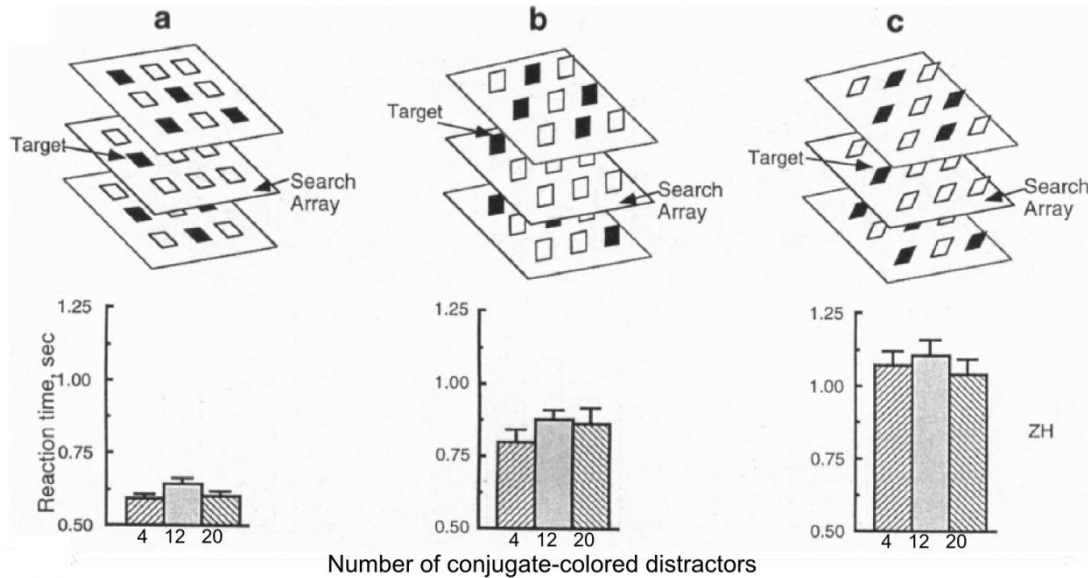


Surface Modulation Index

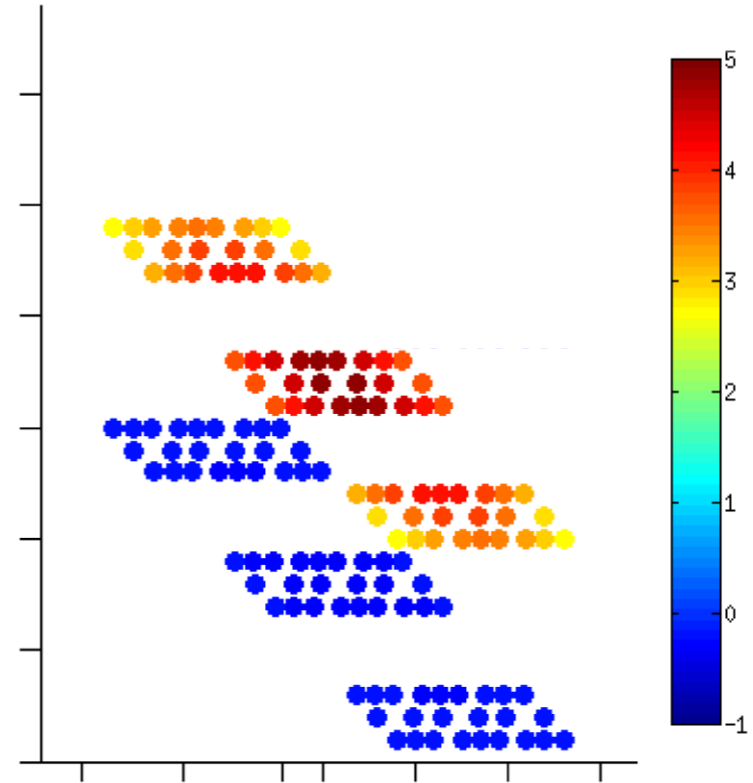
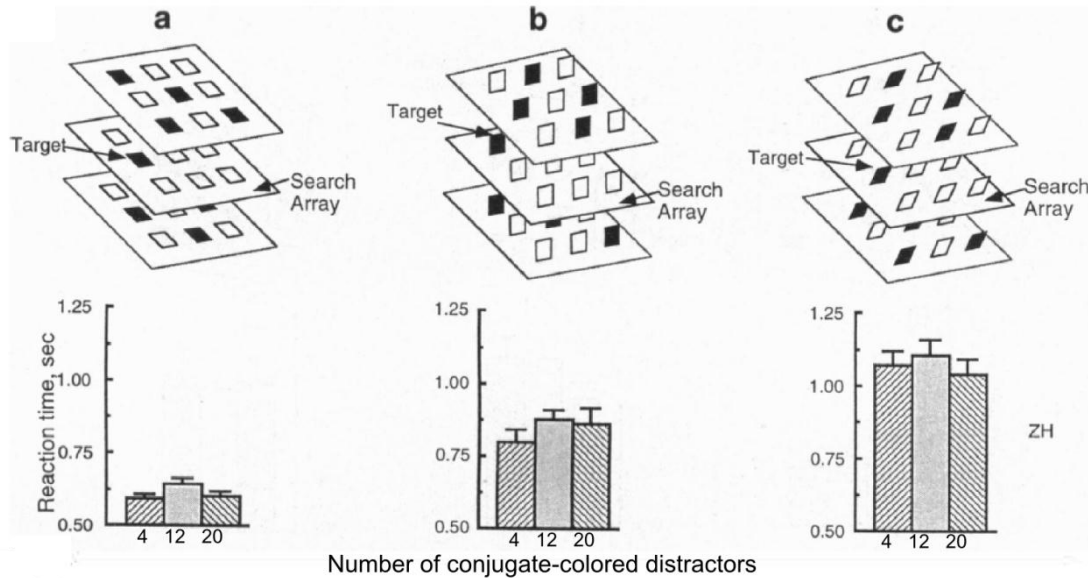
Attention spreads across slanted surfaces



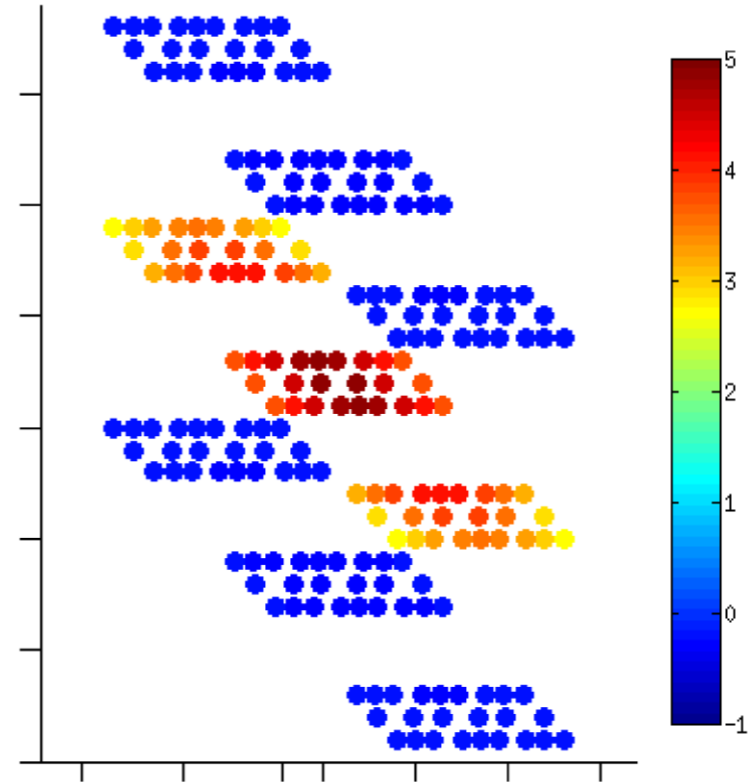
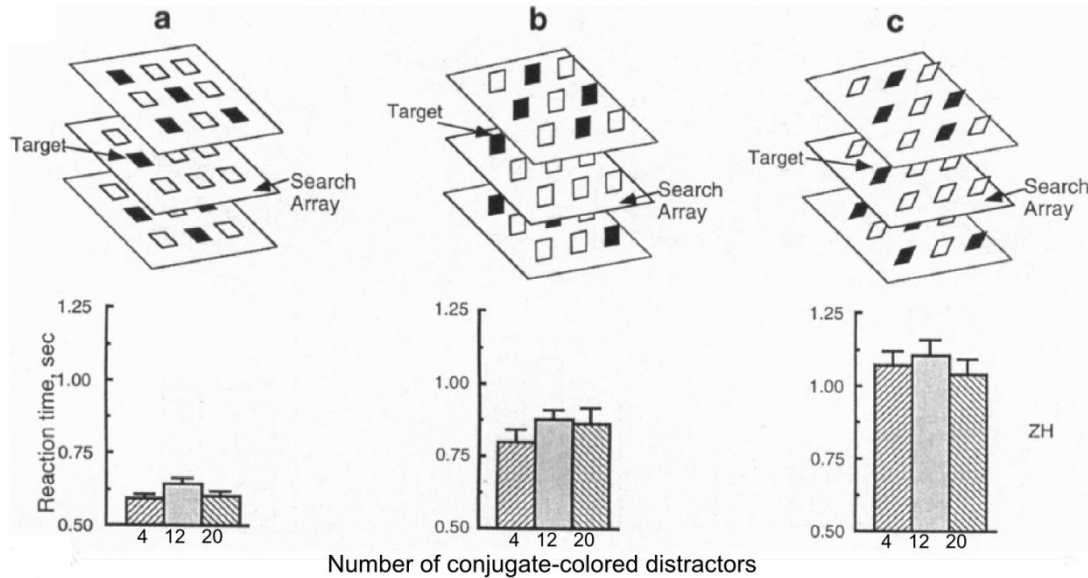
Attention spreads across slanted surfaces



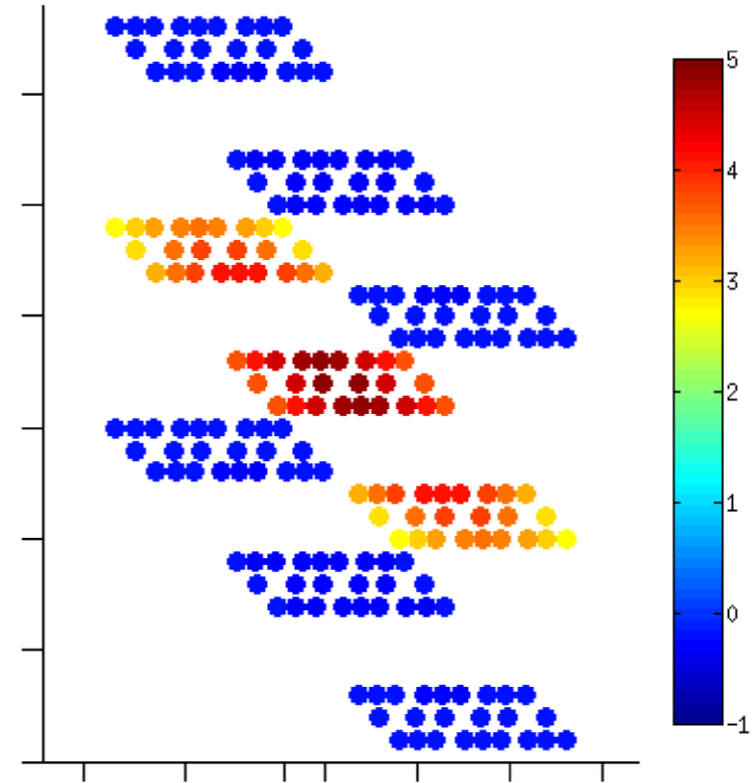
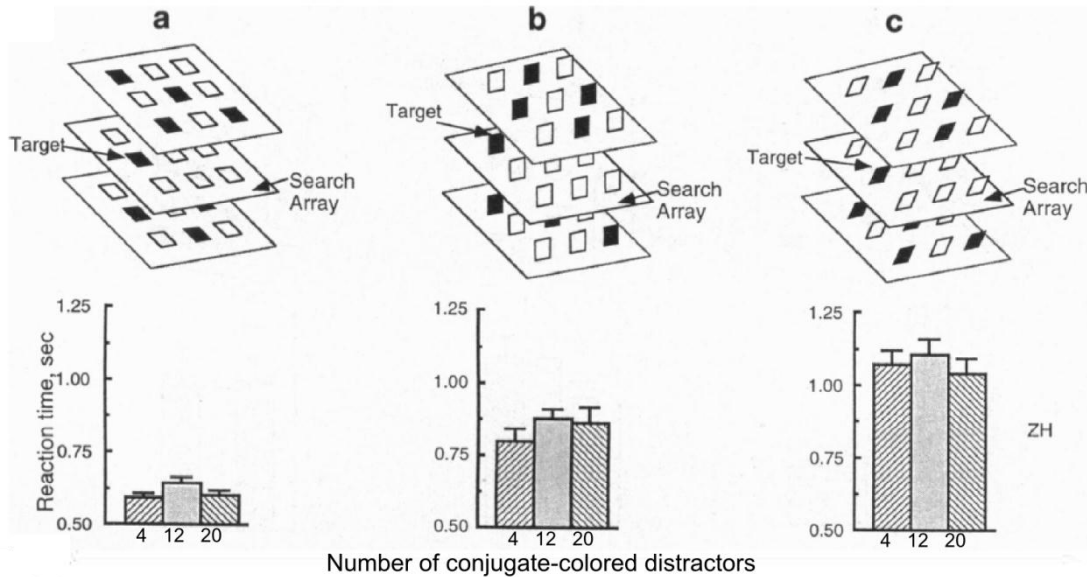
Attention spreads across slanted surfaces



Attention spreads across slanted surfaces



Attention spreads across slanted surfaces



Surface Modulation Ir

Conclusion

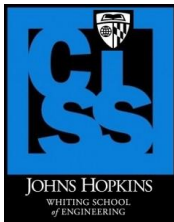
- ▶ Planar grouping cells organize the scene and also provide “handles” for top–down attention
- ▶ Our model reproduces psychophysical results from a visual search task requiring attention to be directed to surfaces
- ▶ Competition between grouping cells results in surface enhancement of the attended plane and suppression of other planes

Acknowledgement

This work is supported by the Office of Naval Research grant N000141010278, the National Institutes of Health grant R01EY016281-02, and the Visual Neuroscience Training Program fellowship (T32EY07143).



Questions?



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