Disparity and Luminance Preference are Correlated in Macaque V1, Matching Natural Scene Statistics.

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The Statistics of Natural Images

- have helped us to understand how images are represented in the brain.
- More than images alone is necessary to understand *inference.*

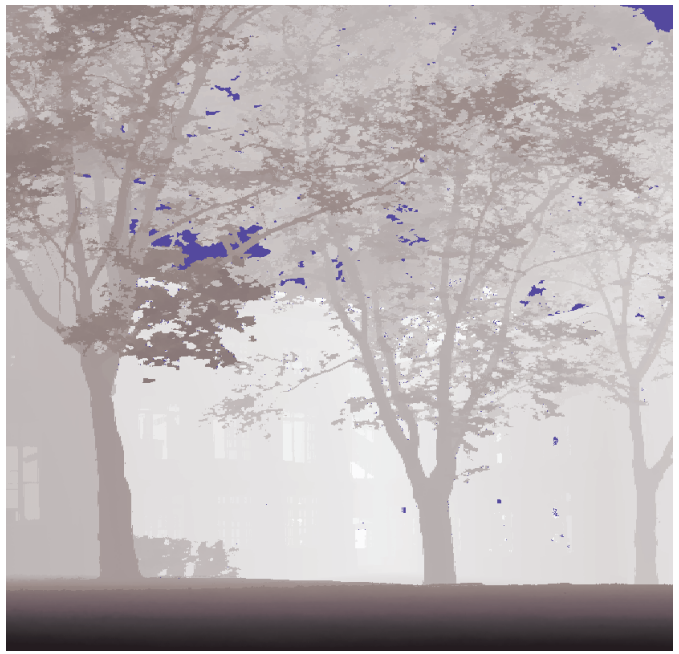
Today's Talk:

- Some findings from the statistics of natural *3D scenes*
- We show how the macaque visual system exploits these trends to better infer depth from images

Acquiring a Co-Registered Range & Color Image Database

Riegl LMS-Z360

Color Image



Range Image

Da Vinci Correlation

- Correlation between log-intensity and log-distance: r = -0.23
- *Among bodies equal in size and distance, that which shines the more brightly seems to the eye nearer.* - Leonardo da Vinci
- Later, psychologists verify this rigorously.
- The correlation is thought to arise from shadowing: concave surfaces and object interiors tend to be more shadowed than convex surfaces.
- This effect is especially obvious in:

Foliage:

B. Potetz, T. S. Lee, “Statistical correlations between two-dimensional images and three-dimensional structures in natural scenes,” 2003.

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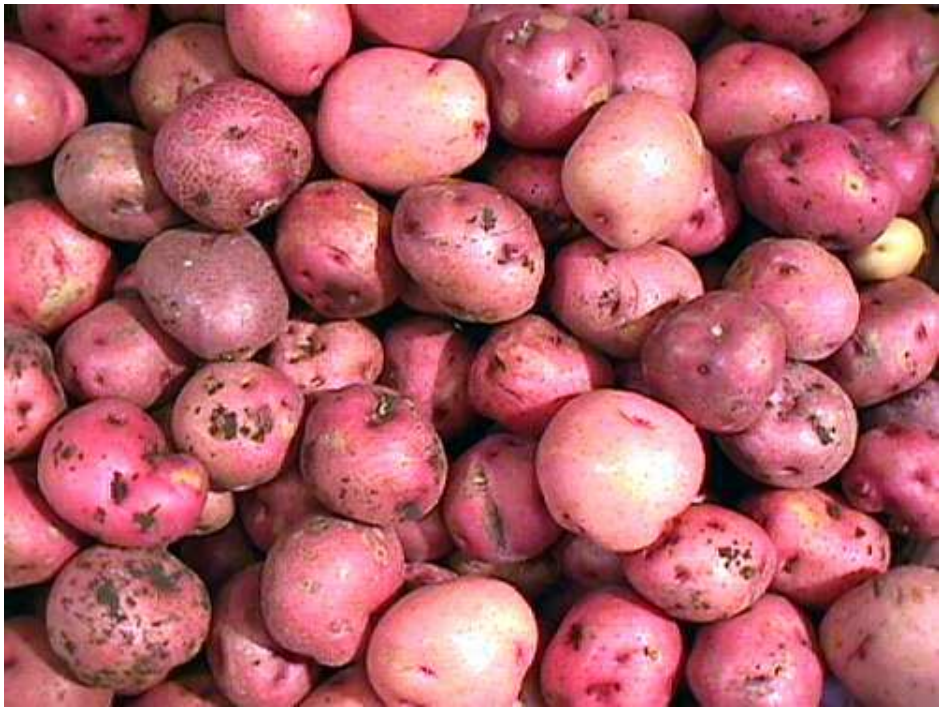
Piles of objects:



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Folds in fabric:

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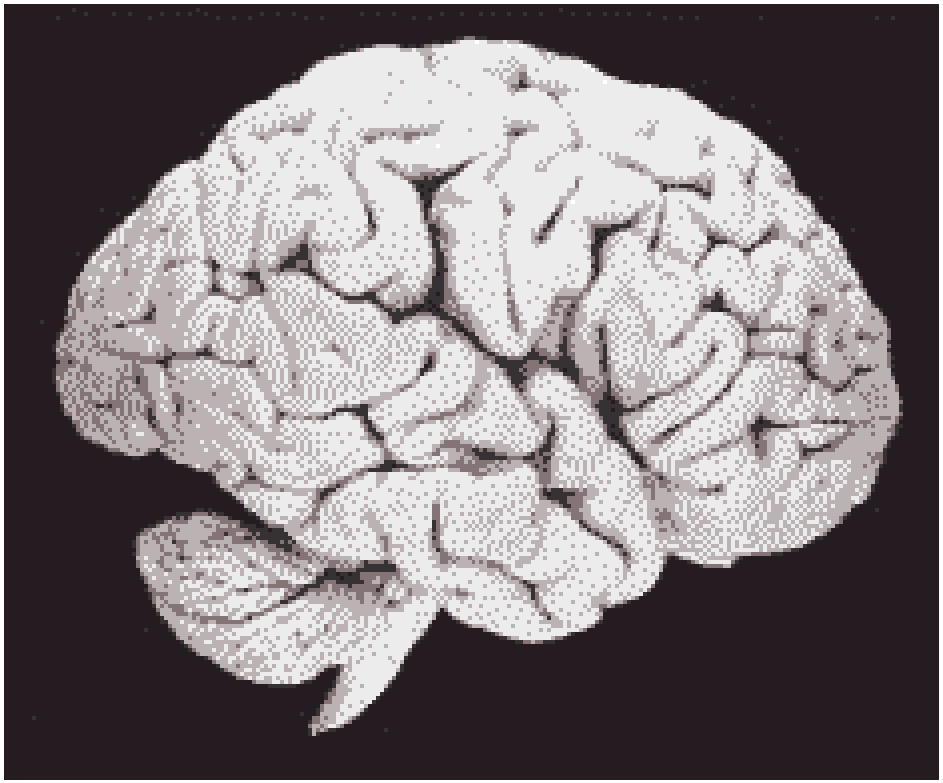
Folds in anything:



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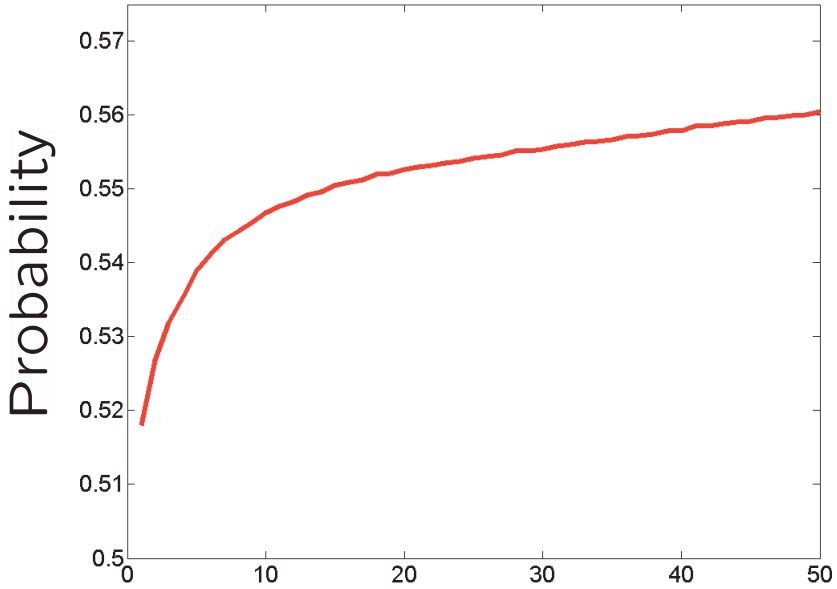
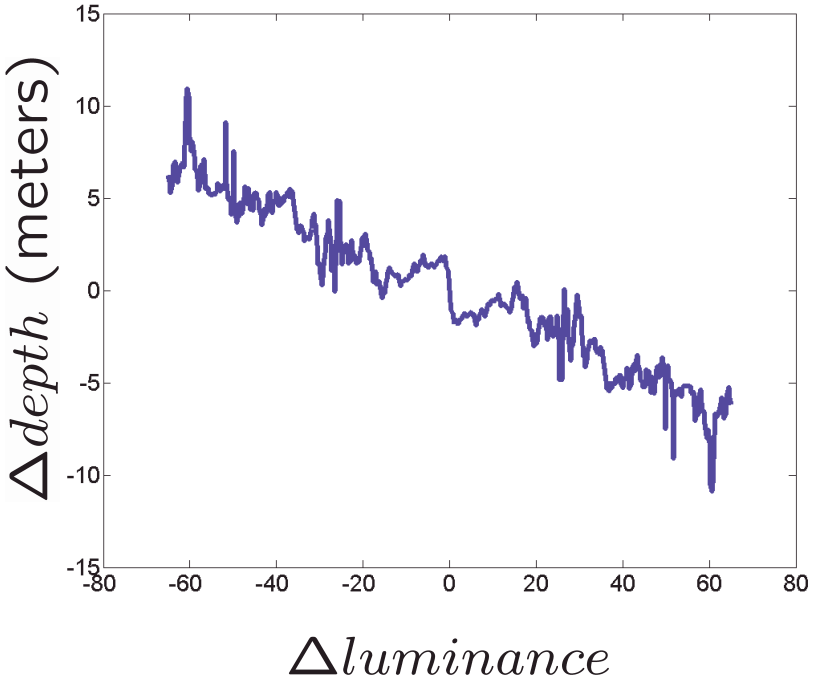
Two Pixel Statistics

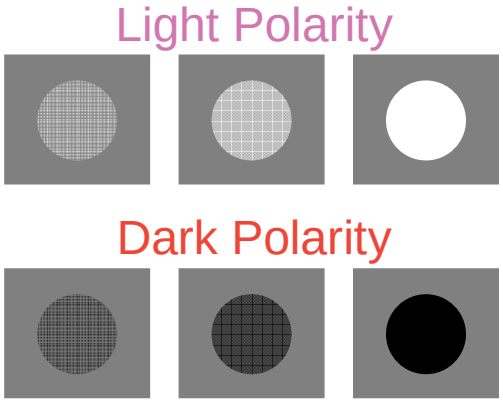
Probability that closer pixel is also brighter

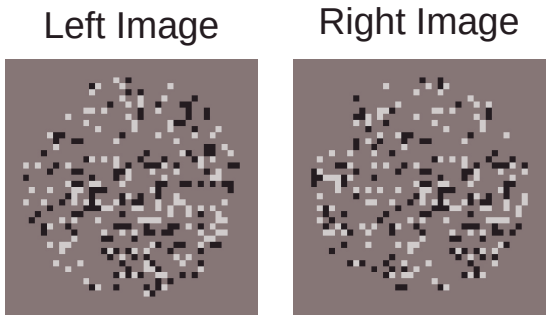


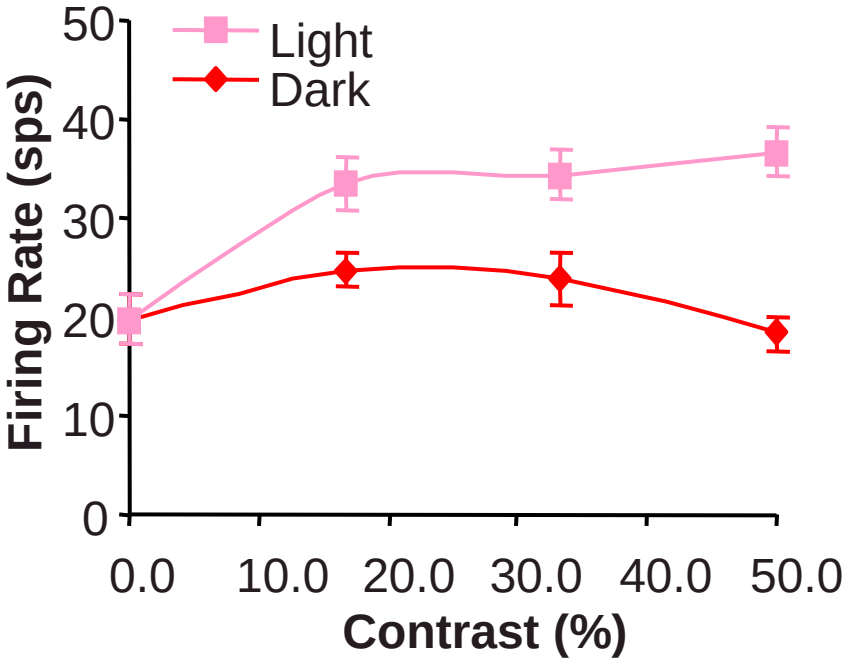
Expected value of $\Delta depth$ given $\Delta luminance$

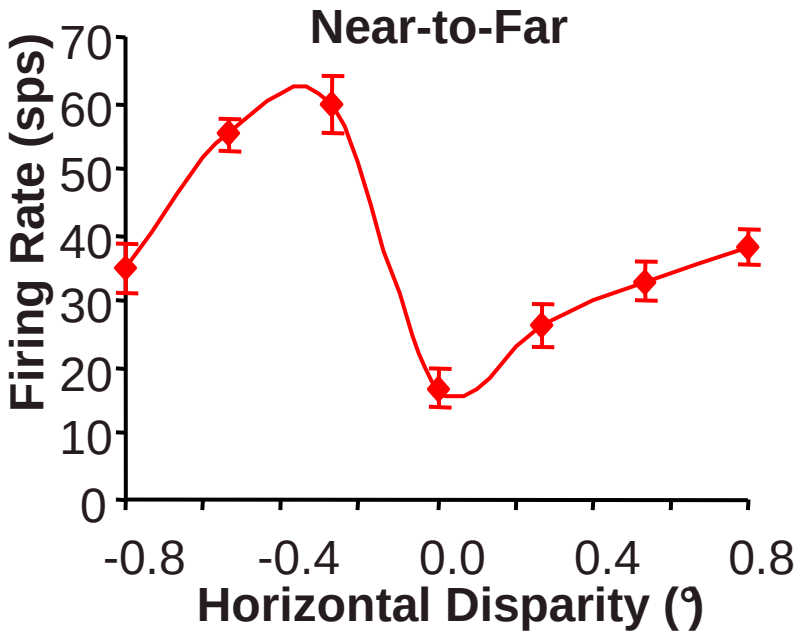


Single Cell Recording Experiment

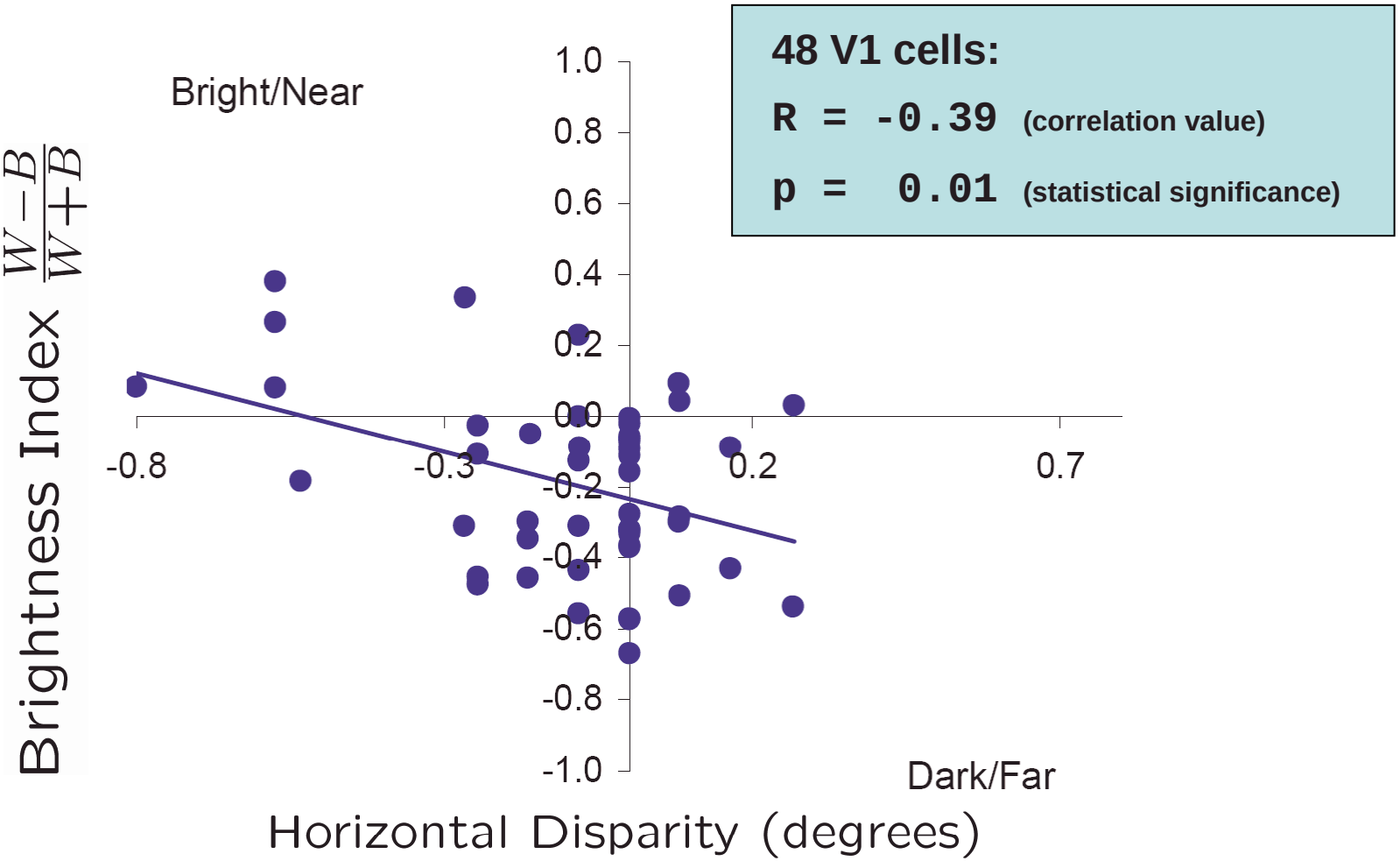




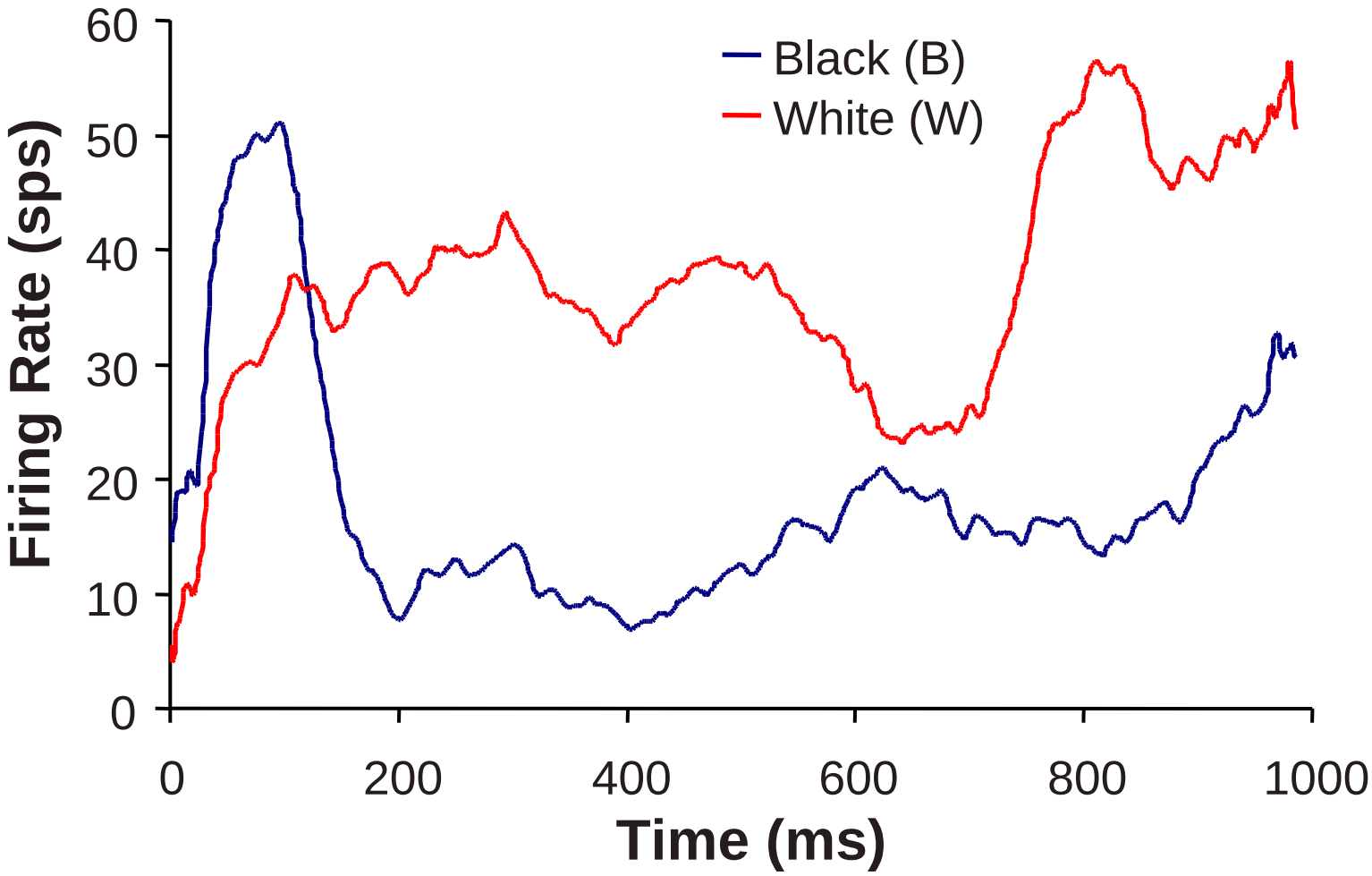




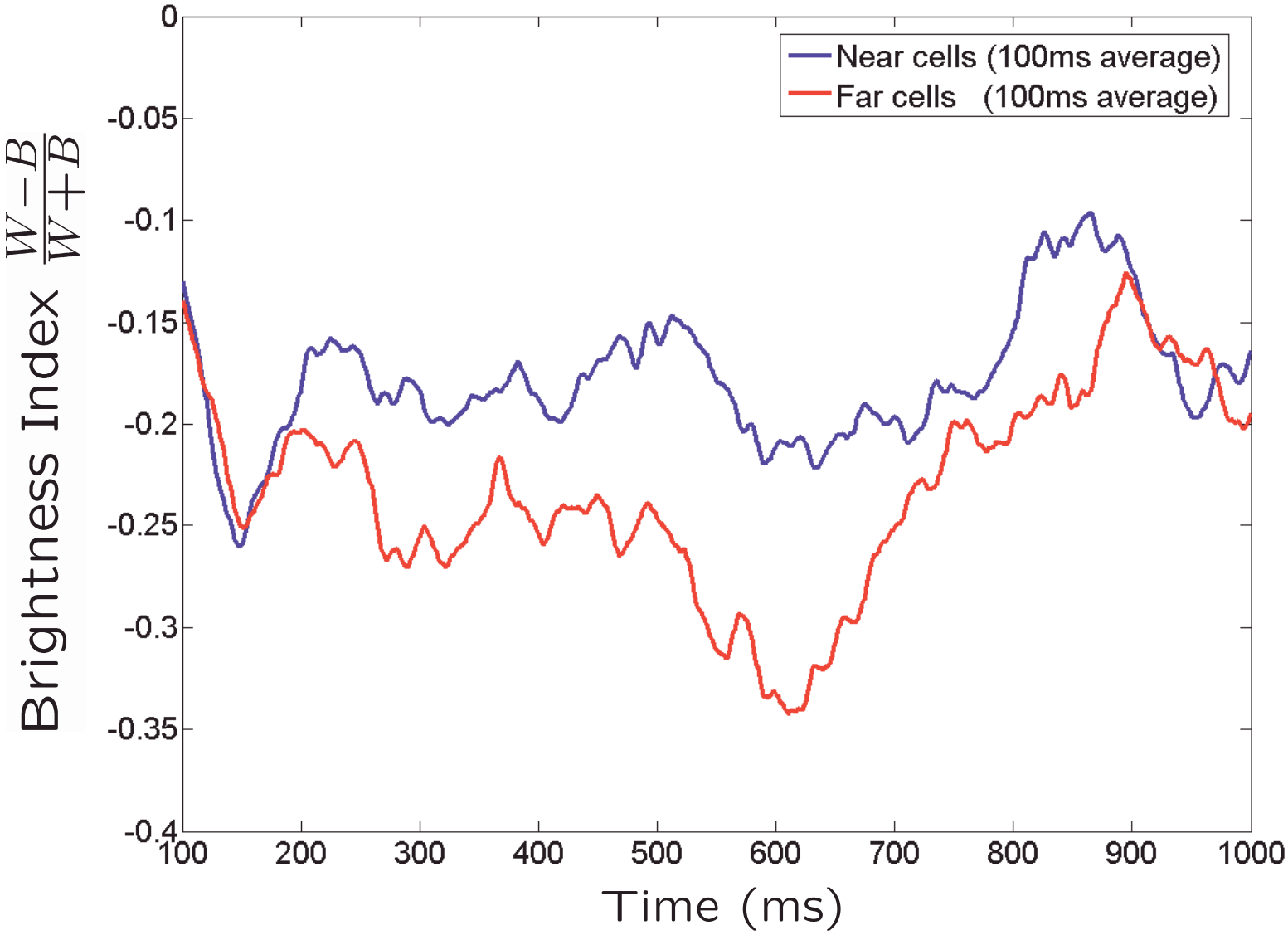
Correlation between brightness and disparity preferences of V1 cells



Near cell that prefers white, responding to white & black discs



Brightness Selectivity Is Delayed



Why this is important:

- Shows that the study of natural scene statistics can predict neural behavior in the brain.
- Shows that V1 is either directly involved with multiple-cue depth inference, or receives feedback from areas that are.
- Opens up a new avenue for exploring how the visual system performs inference under ambiguity.

Thank You!

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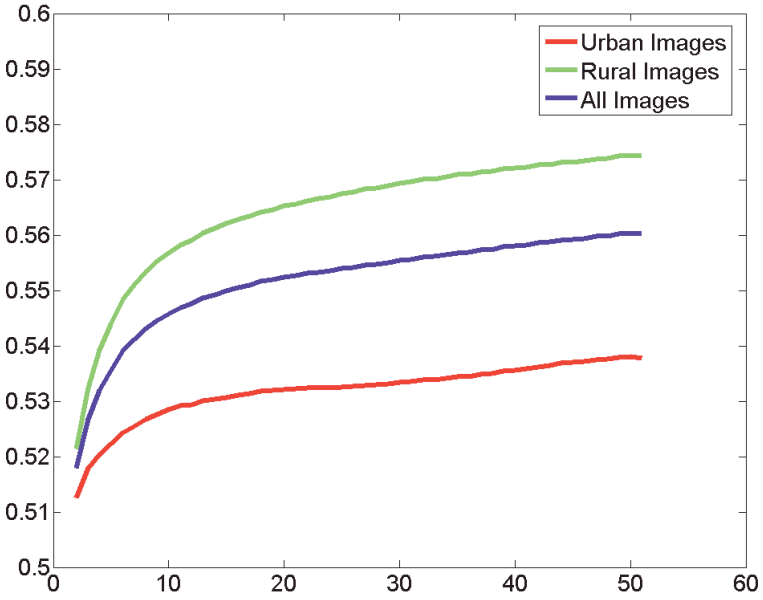
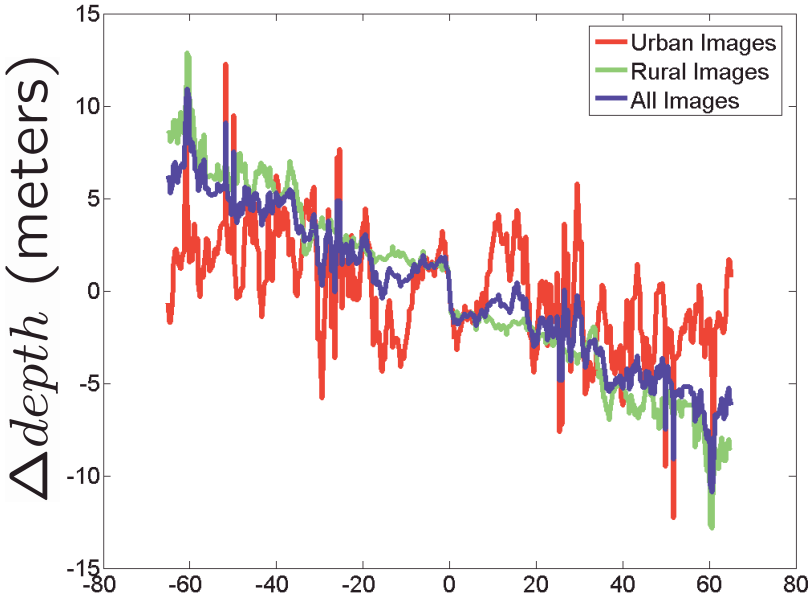
Rural vs Urban Images

Probability that closer pixel is also brighter



Distance between pixels

Expected value of $\Delta depth$ given $\Delta luminance$



$\Delta luminance$

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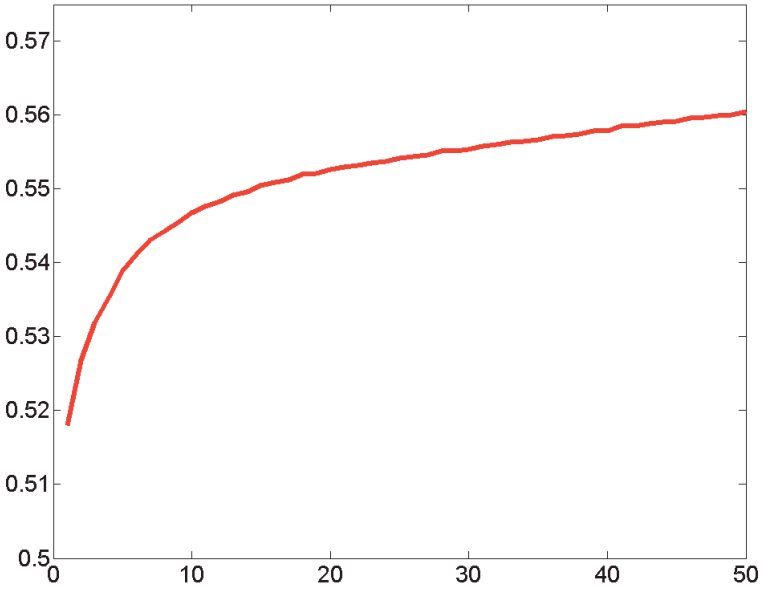
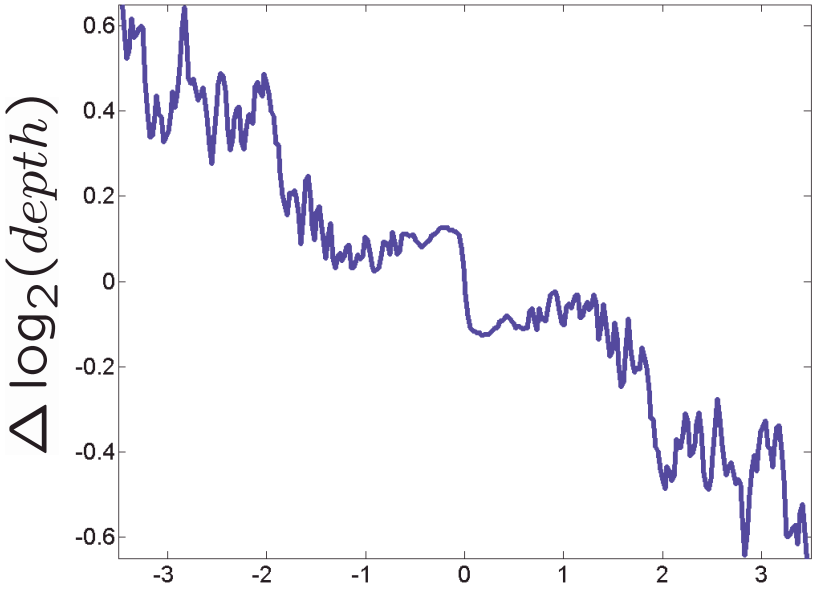


Distance between pixels

Expected value of $\Delta \log(depth)$ given $\Delta \log(luminance)$

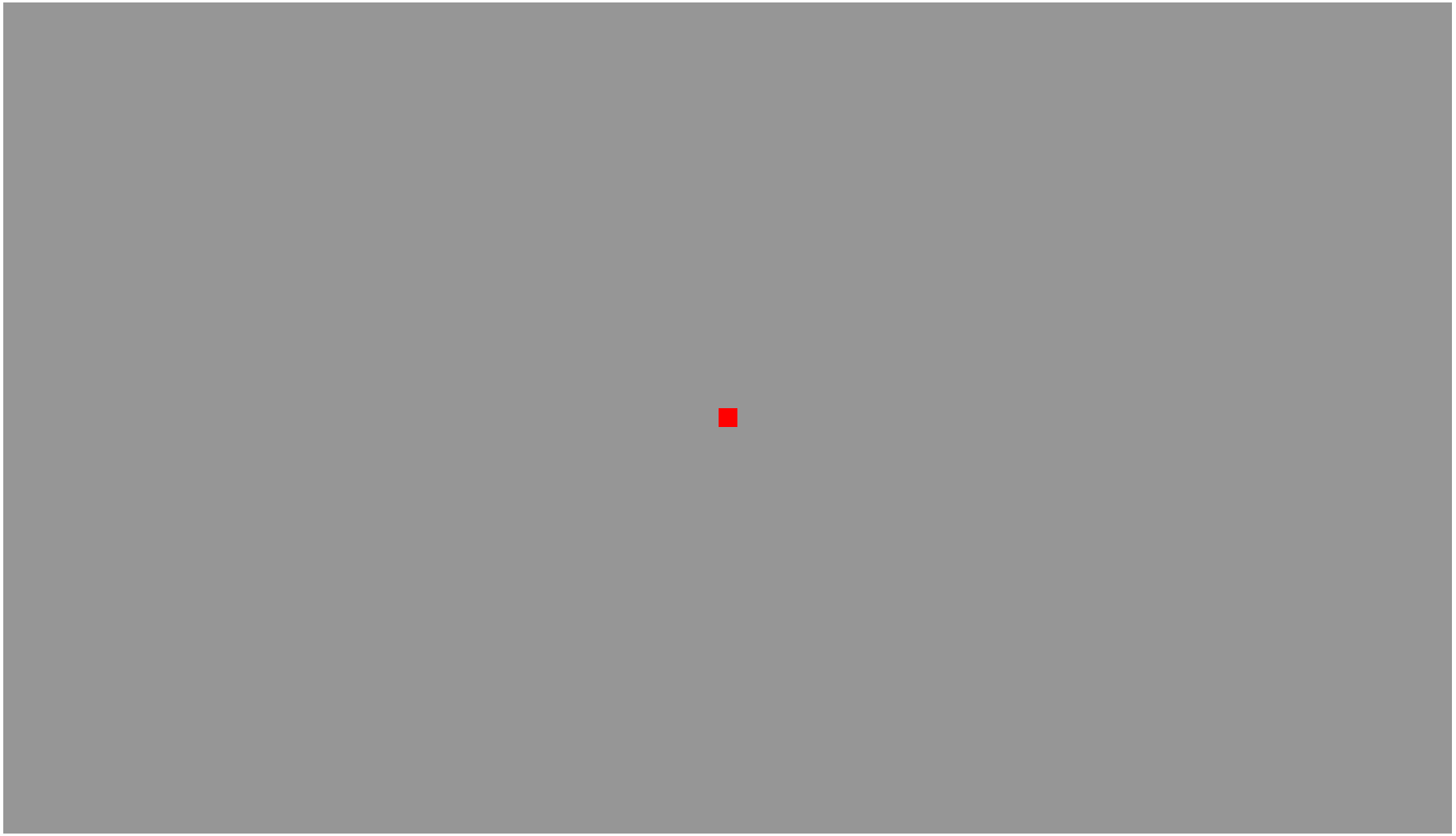


$\Delta \log_2(luminance)$

Other Brightness Metrics

Metric	R (Correlation)	p (Significance)
$\frac{W-B}{W+B}$	**-0.39**	**0.01**
$\frac{(W-G)-(B-G)}{\lvert W-G\rvert+\lvert B-G\rvert}$	**-0.35**	**0.02**
$\frac{\sum W-\sum B}{\sum W+\sum B}$	**-0.39**	**0.01**
$\frac{W-B}{\lvert W-B\rvert+2\sqrt{\frac{SSE}{n-m}}}$	**-0.31**	**0.03**
Center of Mass	**-0.28**	**0.06**

Example Luminance Stimulus



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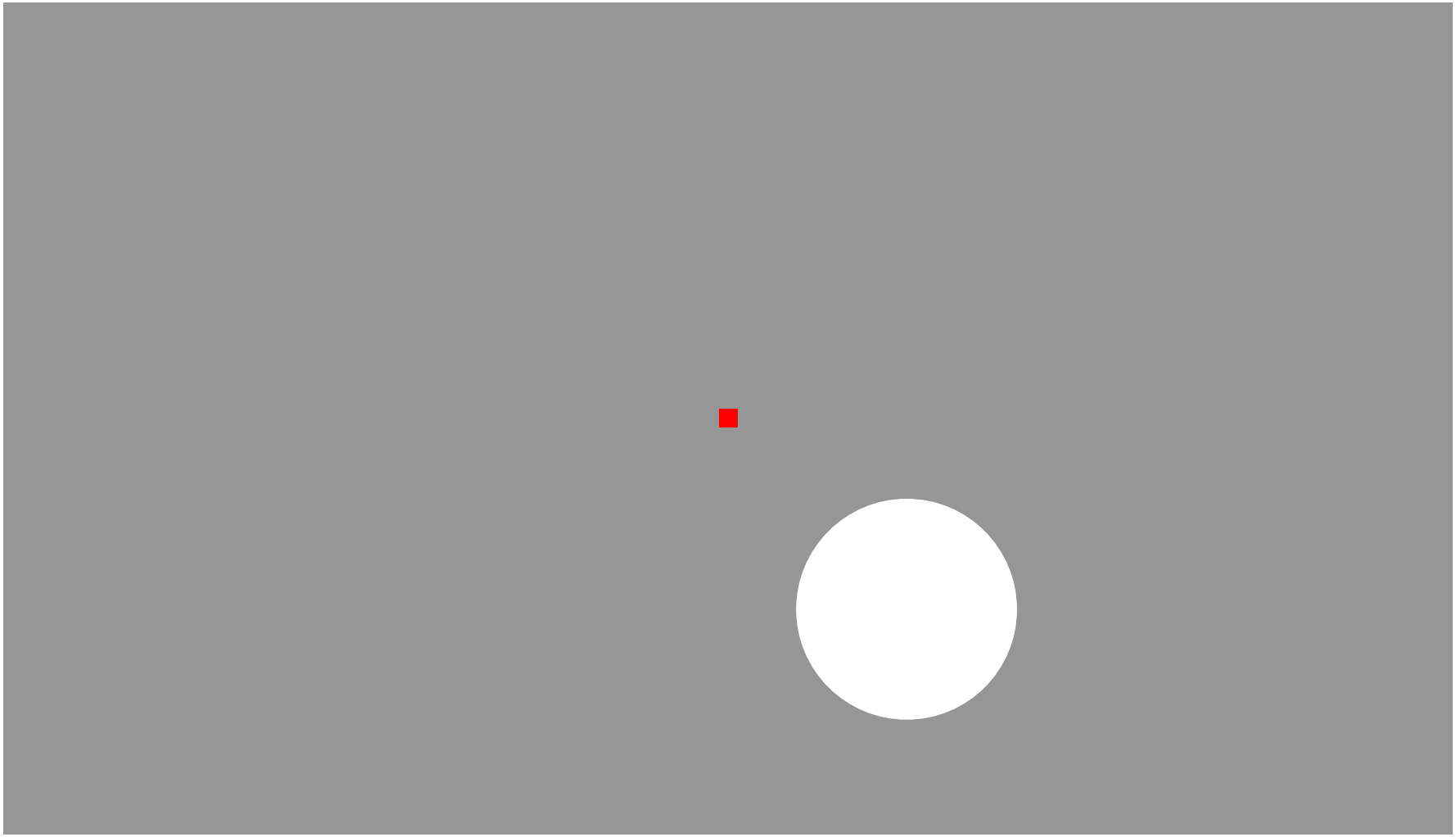

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