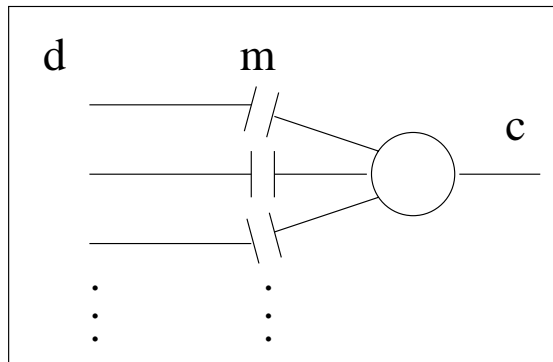
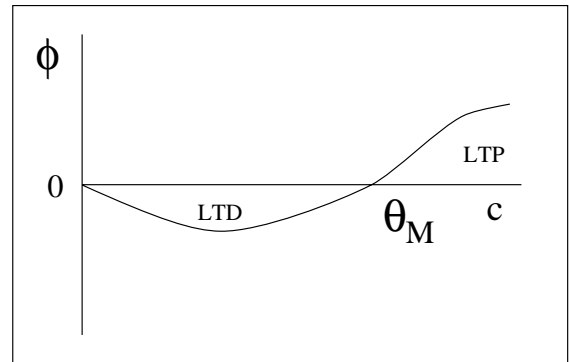
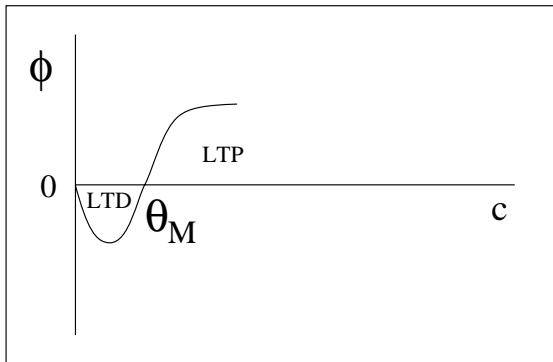

Dynamics of Synaptic Plasticity:
A Comparison between BCM and
Experimental Results in Visual Cortex

What is BCM?

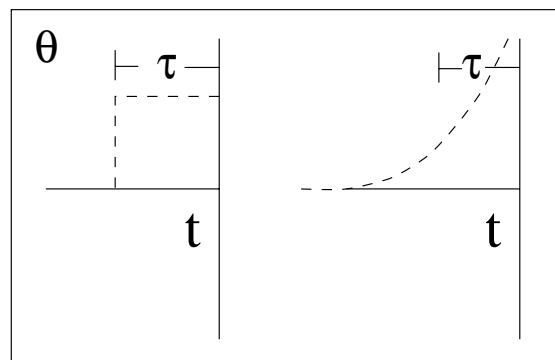
- $\dot{m} = \eta \phi(c, \theta) d$



-

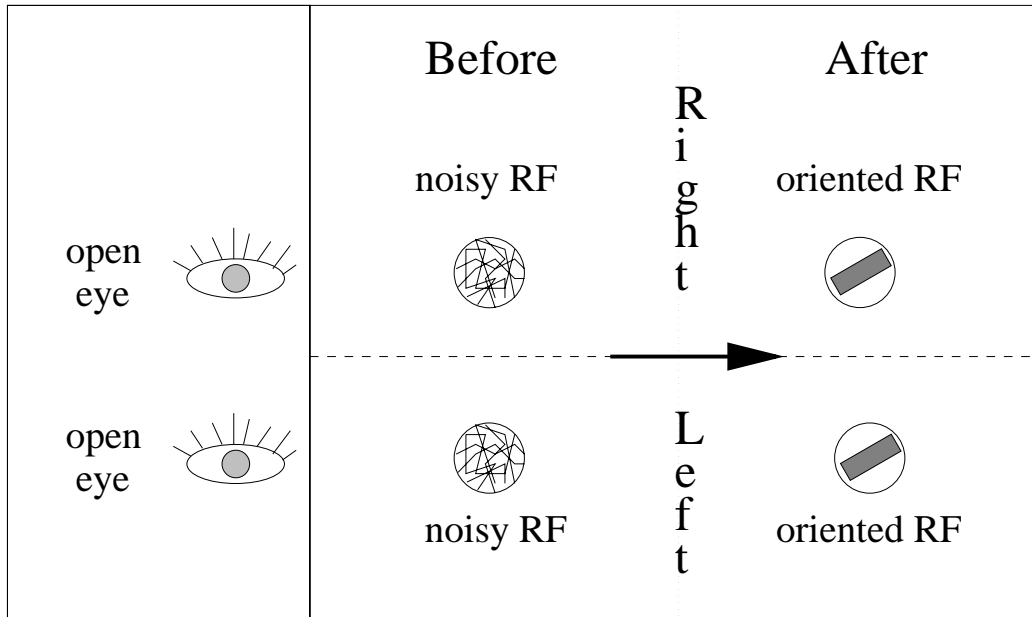


- $\theta \sim E_\tau[c^2]$

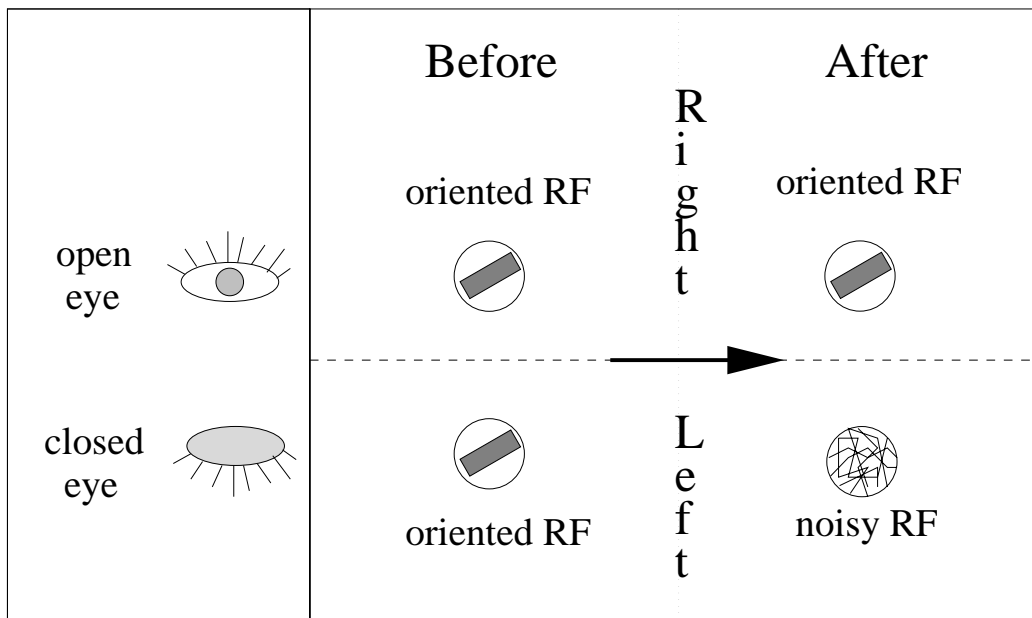


Deprivation Experiments

Normal Rearing

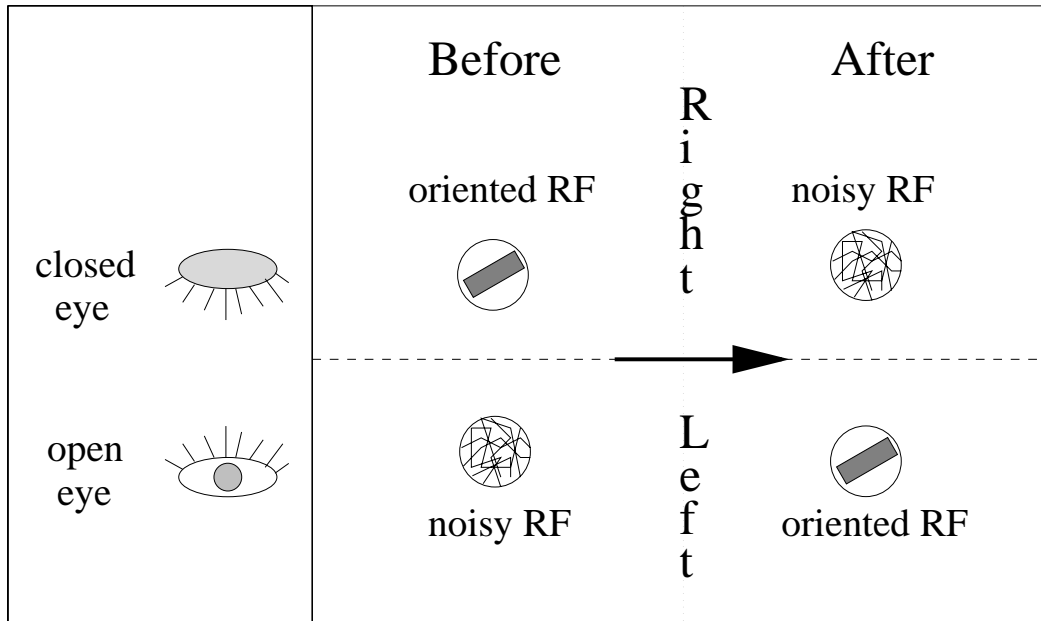


Monocular Deprivation

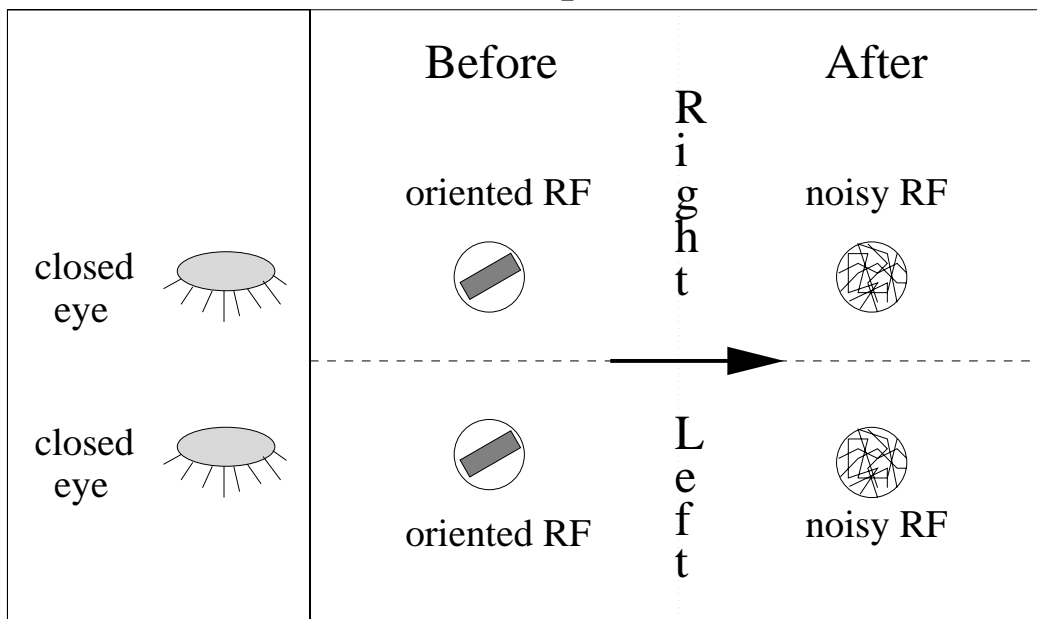


Deprivation Experiments

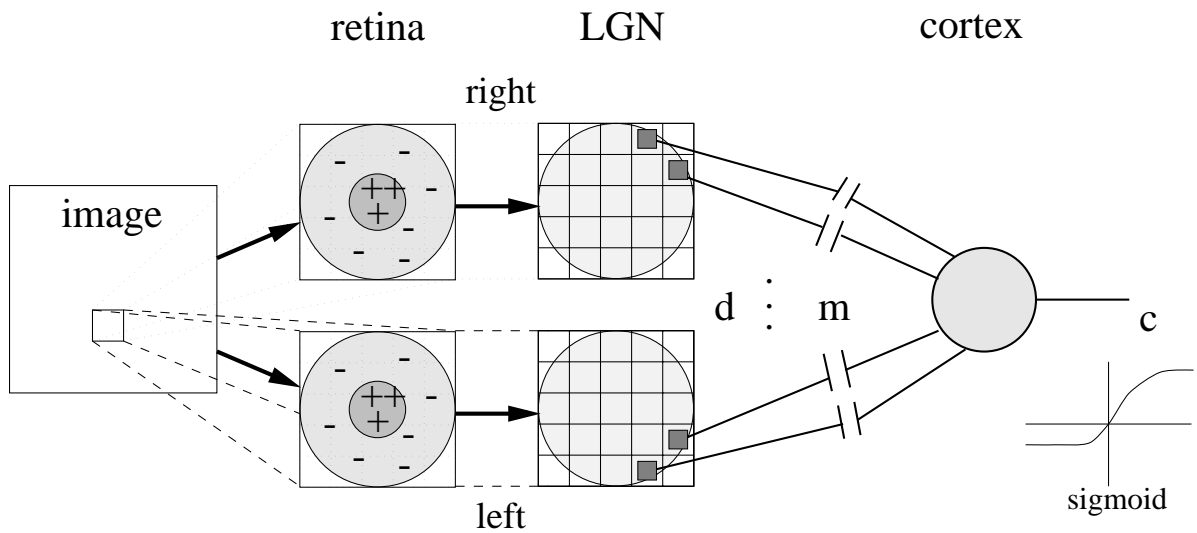
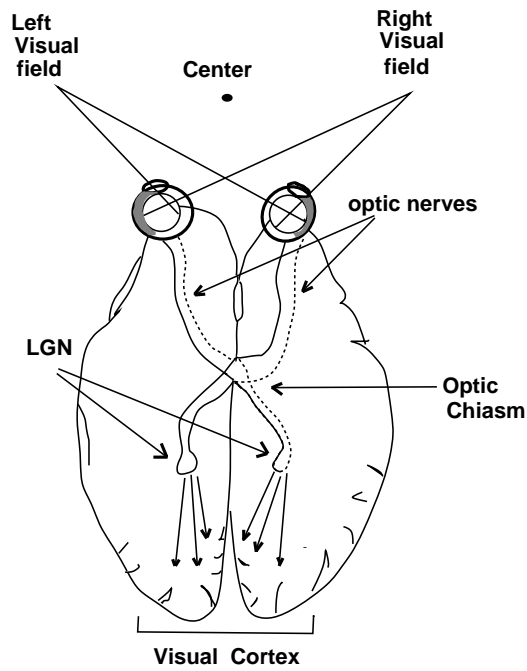
Reverse Suture



Binocular Deprivation



Biological Visual Pathway¹ and Implementation



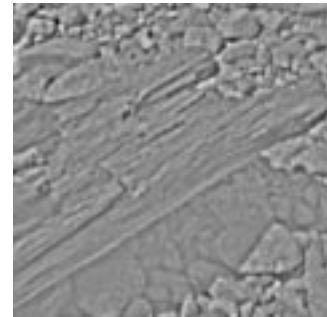
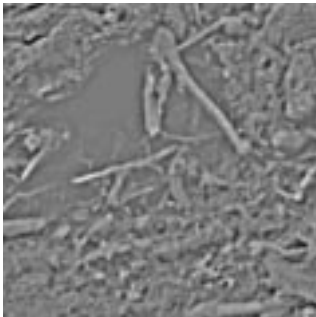
¹adapted from: Sensation and Perception by S. Coren, C. Porac and L.M. Ward

Natural Scene Environment

- before retinal preprocessing

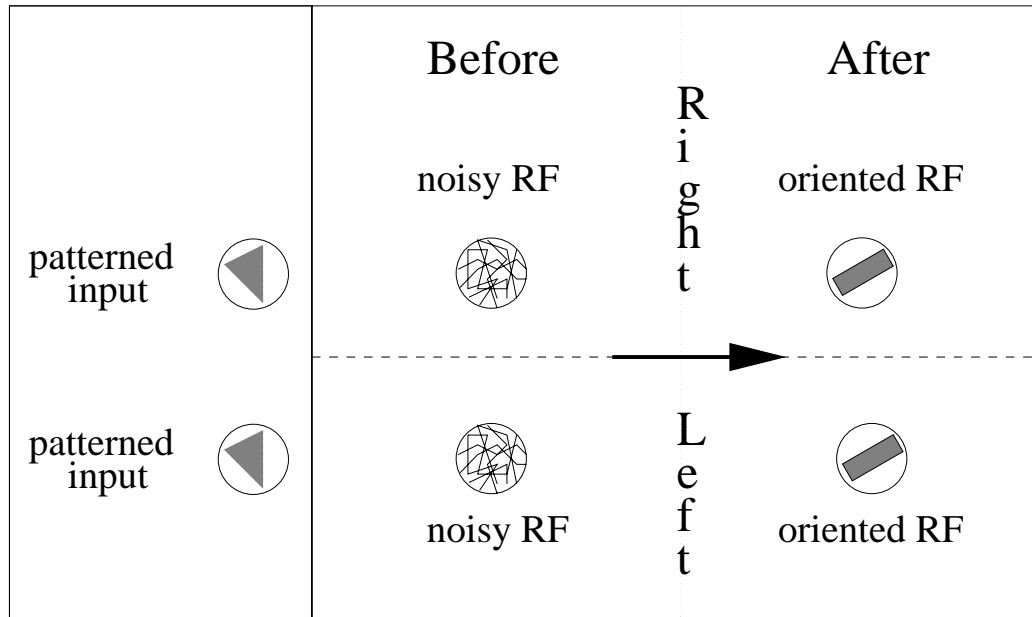


- after retinal preprocessing

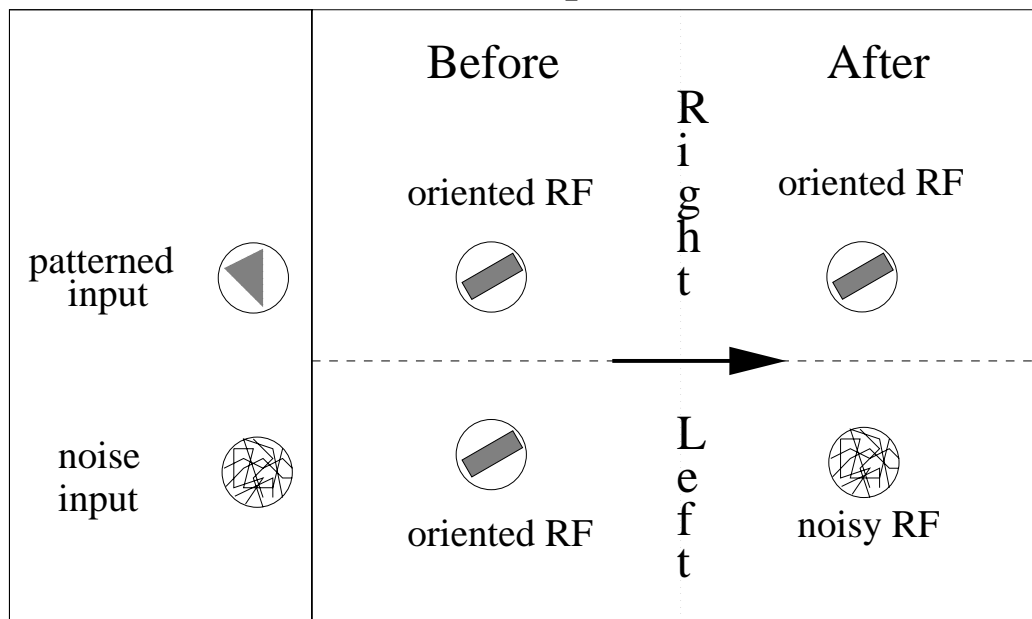


Deprivation Experiments

Normal Rearing

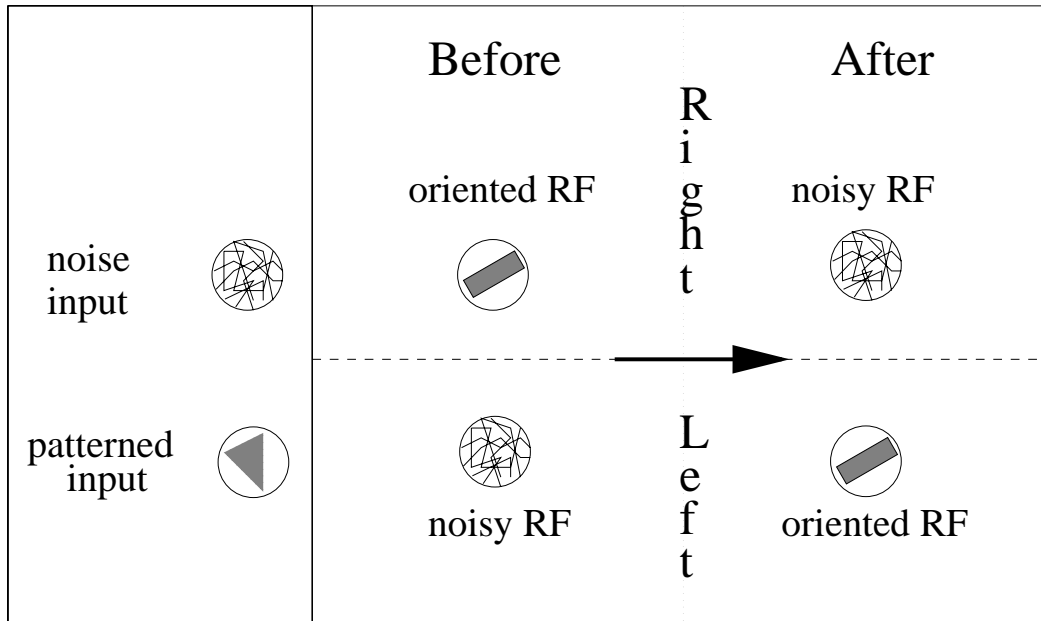


Monocular Deprivation

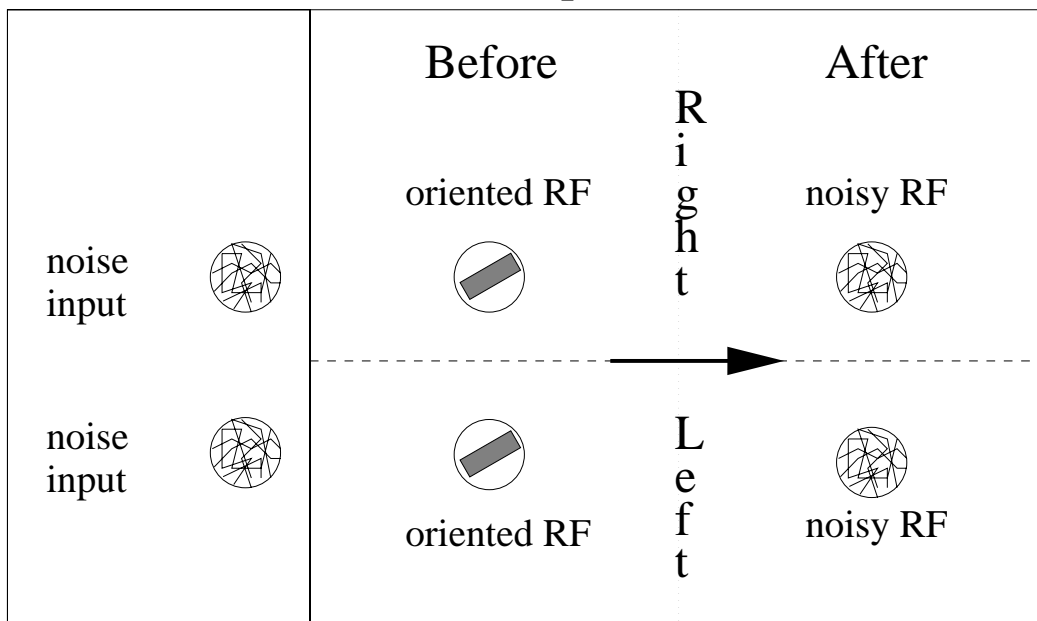


Deprivation Experiments

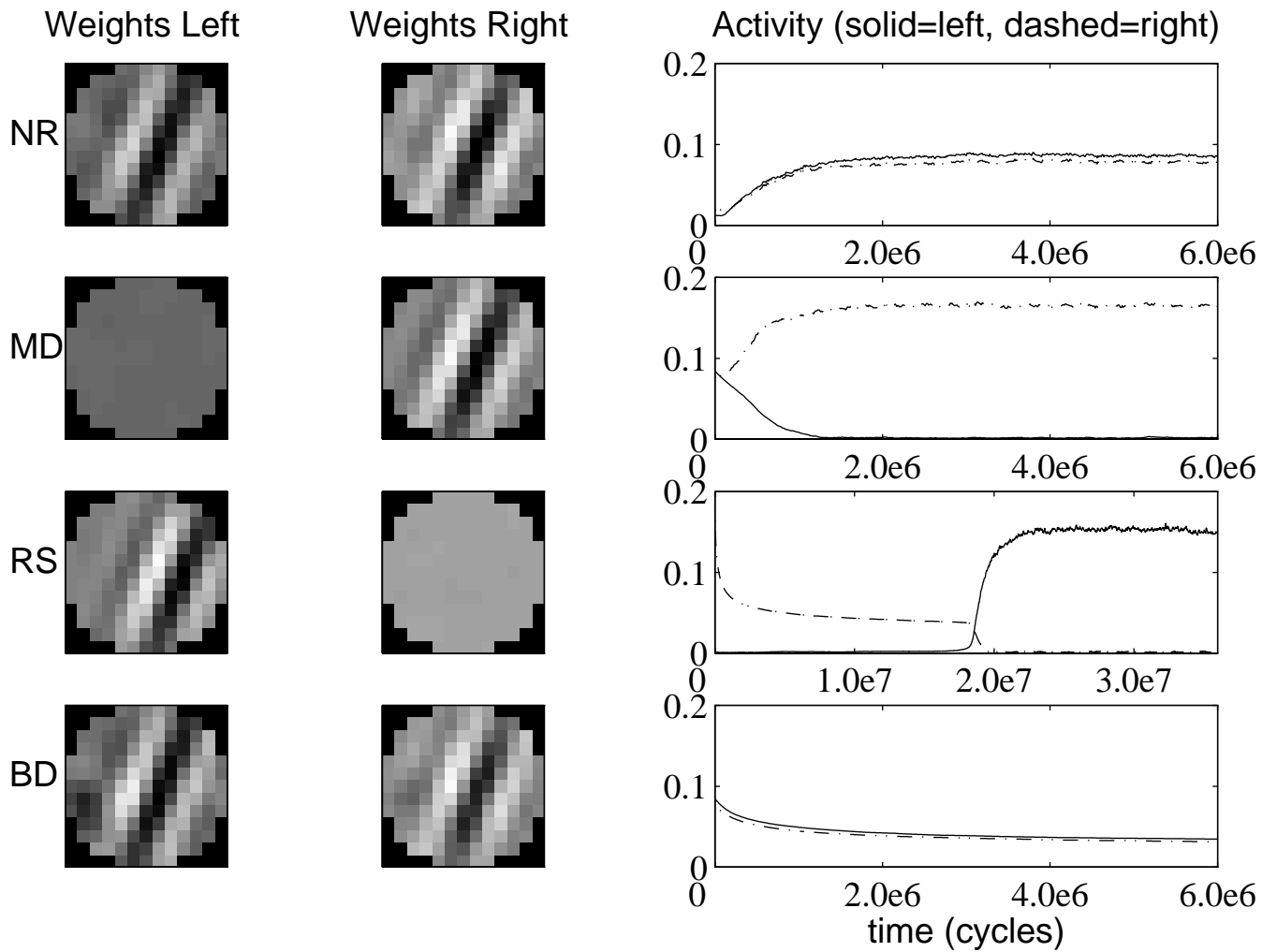
Reverse Suture



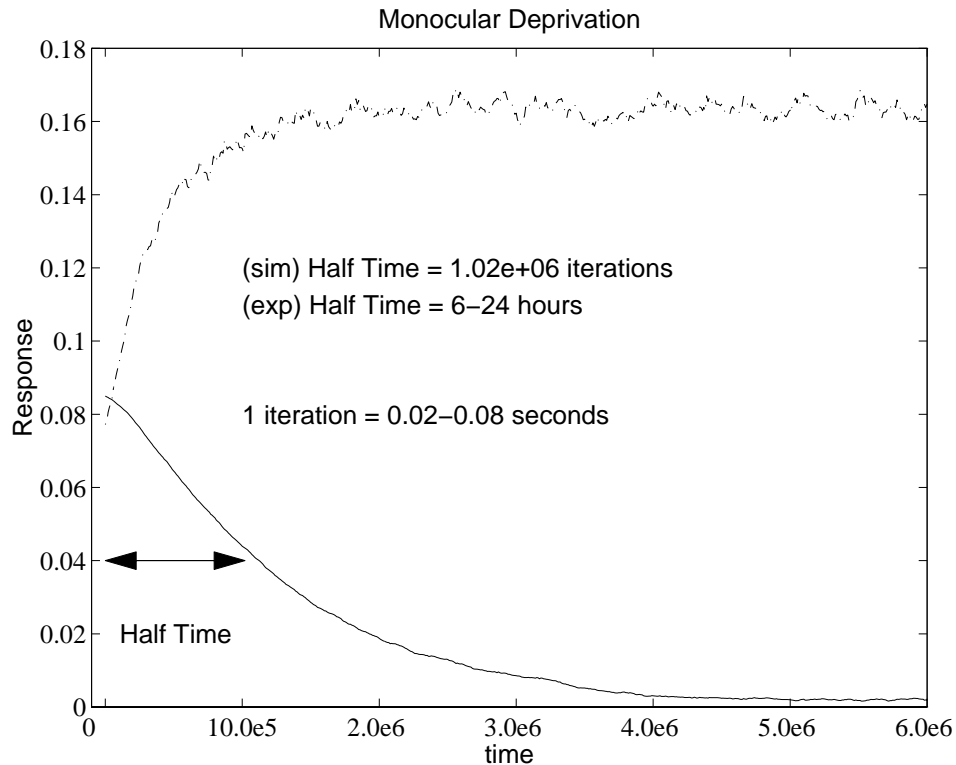
Binocular Deprivation



BCM Simulation

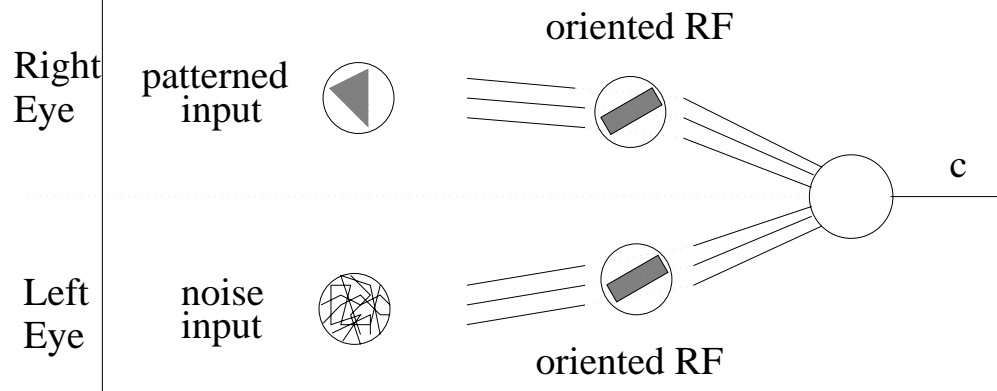


Calculating Parameters



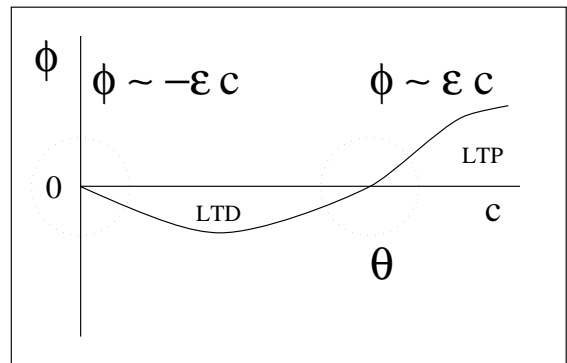
- relies crucially on good experimental values for half-times
- good simulation parameter regime defined by having *all* simulation half-times match the experimental results
- from the experimental results to date
 - $\tau = \frac{1}{2}$ minute up to 1 – 2 hours
 - 1 iteration (related to η) = 0.01 – 0.1 sec
 - \bar{n}^2 (compared to 1.0 for natural images) = 0.8 – 2

Monocular Deprivation



- start with oriented receptive fields in each eye and present noise to one eye and normal patterned input to the other

- how do the weights modify?



- Case 1: non optimum patterns into open eye: $c \approx 0$
- Case 2: optimum patterns into open eye: $c \approx \theta$

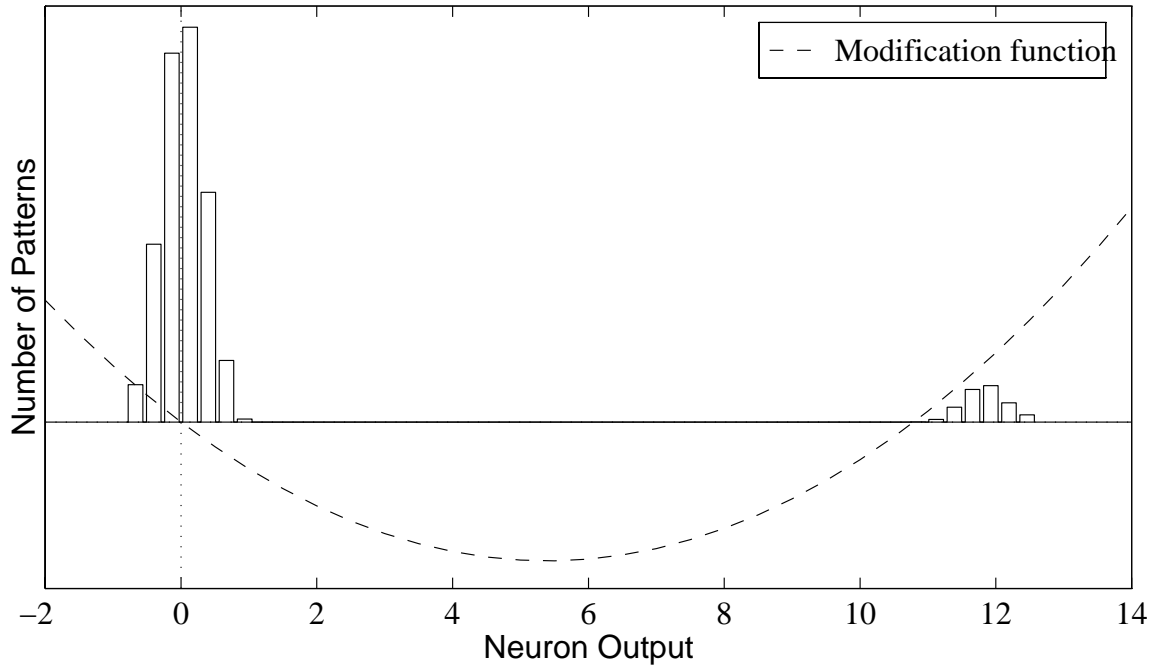
- modification:

- Case 1: $\frac{d\mathbf{m}^{\text{left}}}{dt} \approx \eta(-\epsilon)n^2\mathbf{m}^{\text{left}} \Rightarrow$ weights decrease
- Case 2: $\frac{d\mathbf{m}^{\text{left}}}{dt} \approx \eta(+\epsilon)n^2\mathbf{m}^{\text{left}} \Rightarrow$ weights increase

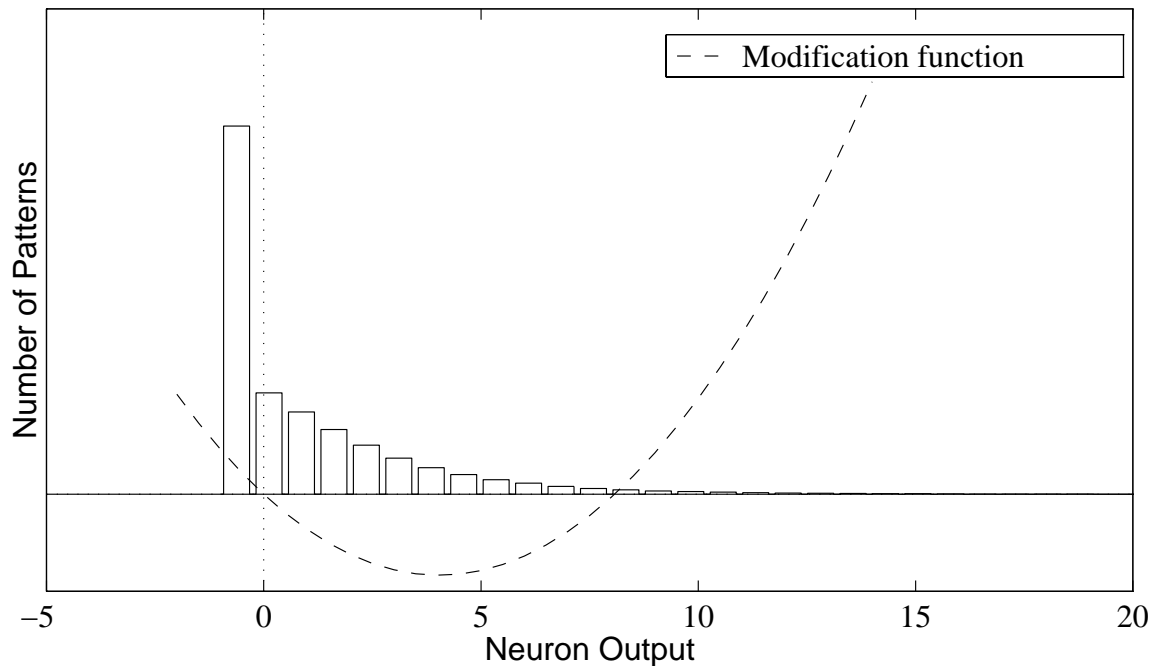
- response to closed eye cuts off if the N_{opt} is smaller than the $N_{\text{non opt}}$

Output Histograms

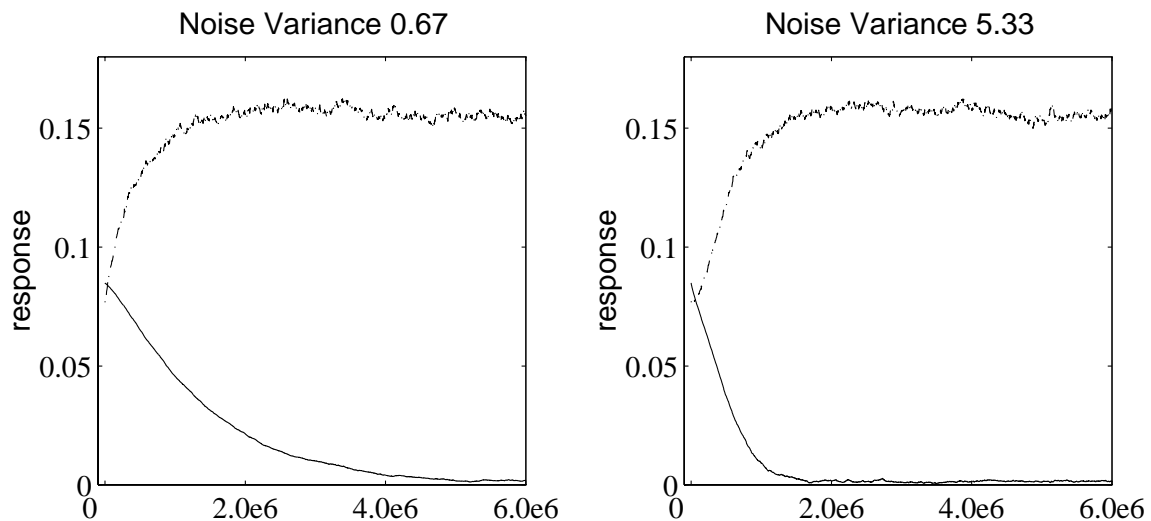
- NR Output Histogram for Abstract Input Environment



- NR Output Histogram for Natural Scene Environment

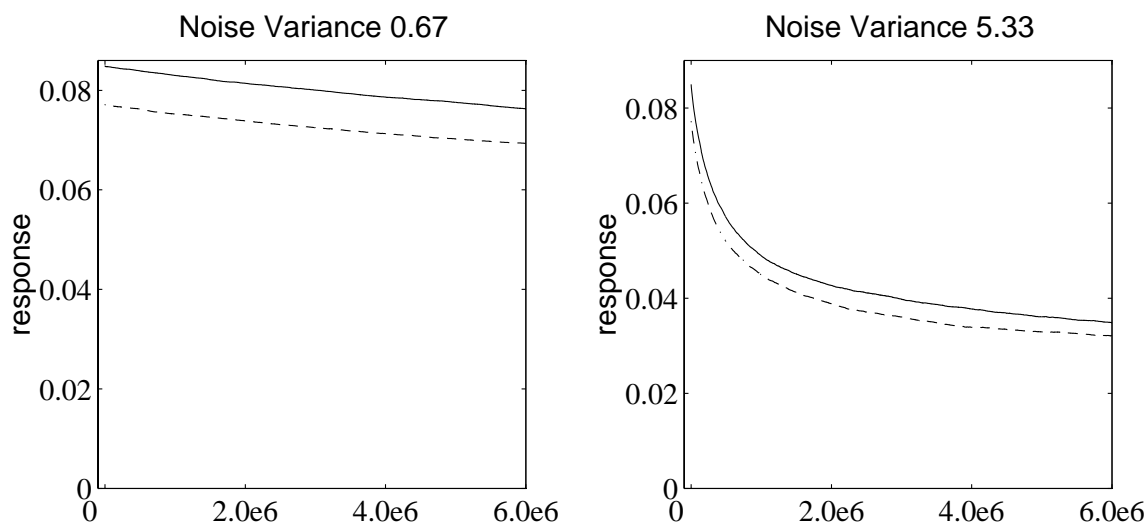


Example Monocular Deprivation



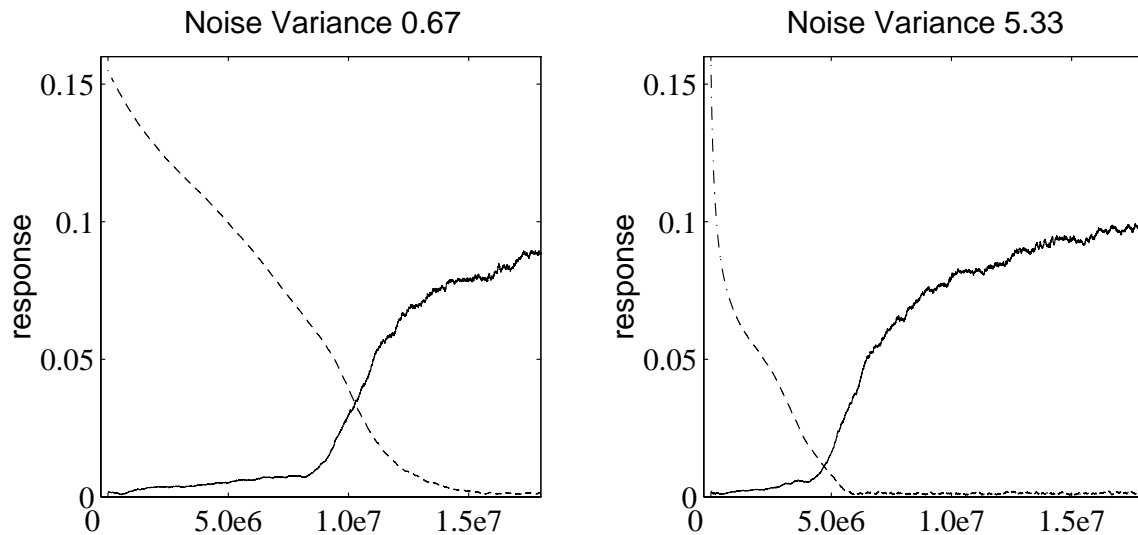
- loss of response to closed eye significantly faster with higher noise
- this can be tested by changing the level of retinal input to LGN for different MD protocols (opaque lens, lid suture, diffuse lens, etc.)
- is the observed increase in the activity of the open eye an artifact of the model, or is it reflected in experiment?

Example Binocular Deprivation



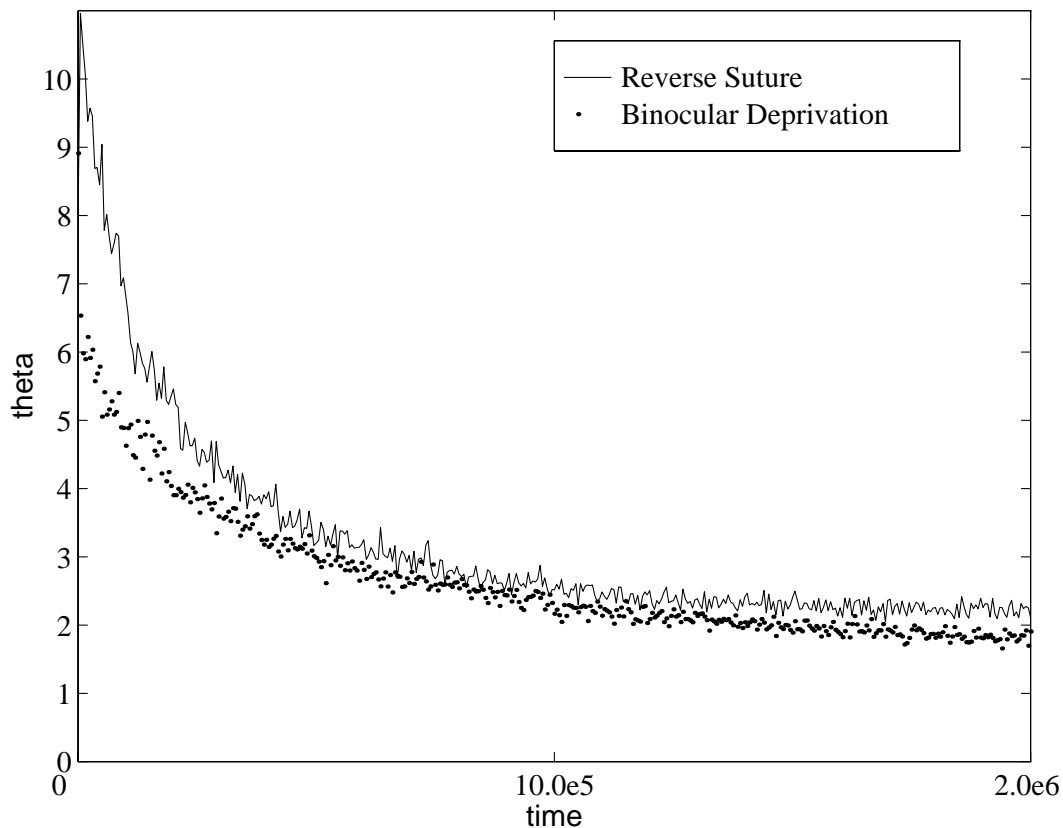
- noise level changes both the *speed* of the loss of response, and the final *value* of the response
- a chronic experiment of binocular deprivation is necessary to determine which parameters yield consistent behavior
 - do different input protocols (opaque lens, lid suture, etc.) have the expected result?
 - is there a quick drop of response, followed by a more shallow decay, or is the loss of response linear?

Example Reverse Suture



- a chronic experiment of reverse suture is necessary to determine which parameters yield consistent behavior
 - do different input protocols (opaque lens, lid suture, etc.) have the expected result?
 - does the newly closed eye cut off *first*, before the recovery of the newly open eye?

Difference Between θ Development in Binocular Deprivation and Reverse Suture



- very small difference in θ produces a substantial difference in development
- this subtle effect is due to the natural image environment, and is not seen in the abstract input environment

Conclusions

- BCM can be used to reasonably model the rough dynamics of the deprivation experiments
 - with good experimental time values for the deprivation experiments, we can calculate the values of BCM parameters, such as τ , in real units (seconds, hours, etc.)
-

Things we'd like to know

- How do LGN spontaneous levels change with different deprivation protocols (lid suture, opaque lens, retina TTX, etc.)?
 - How does the LGN spontaneous level differ from its response to natural input?
 - What happens with chronic measurements of neuronal response during MD, RS, and BD?
-