TTX and BCM

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Brown University

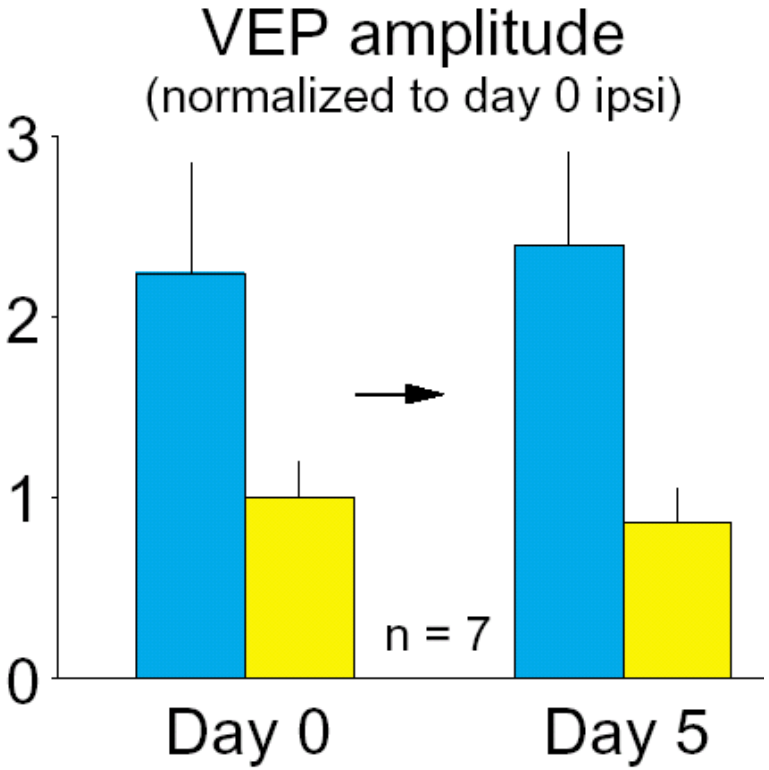
Bear Lab Meeting, August 2, 2007

Outline

Normal Rearing (NR)

Frenkel and Bear, 2004

- contralateral bias magnitude ~ 2.5
- VEP includes responses from *populations* of cells



Monocular Suture (MS) and Inactivation (MI)

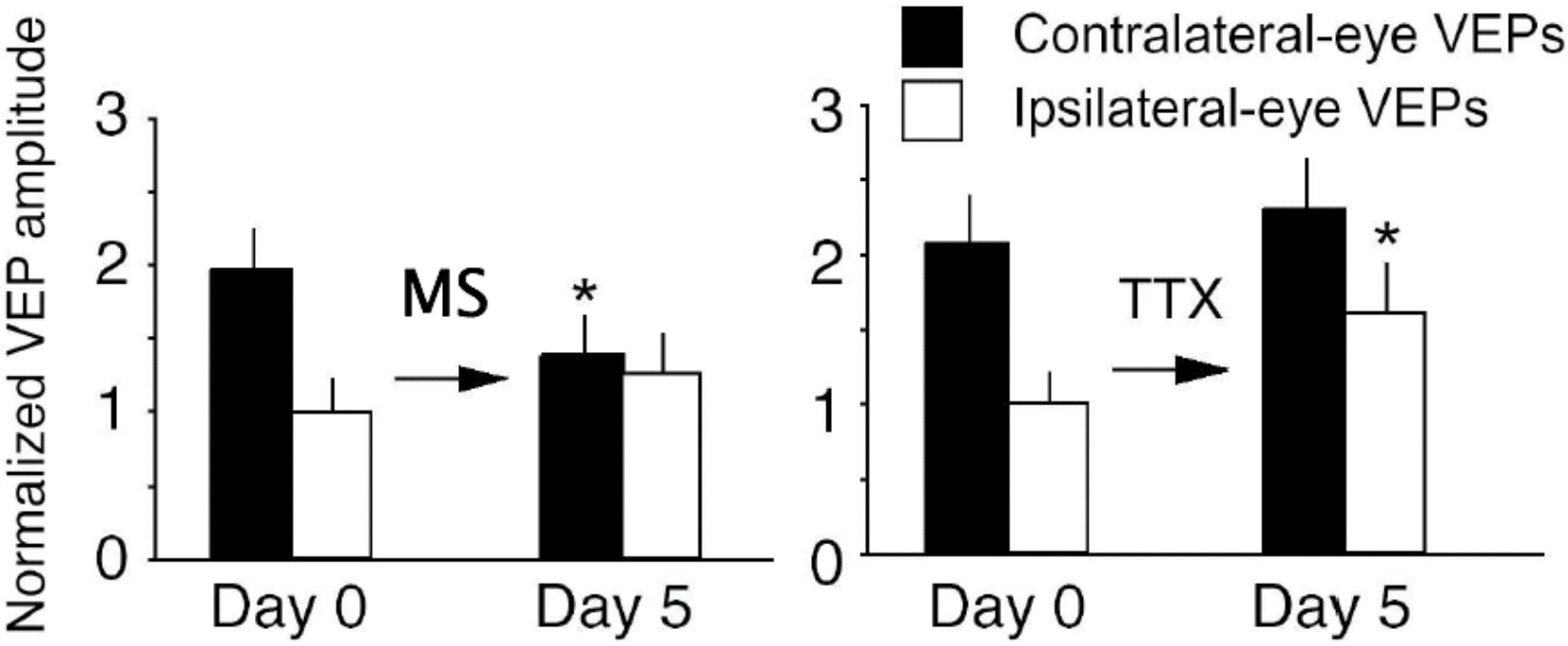
Frenkel and Bear, 2004

MS

- contra responses decrease

MI

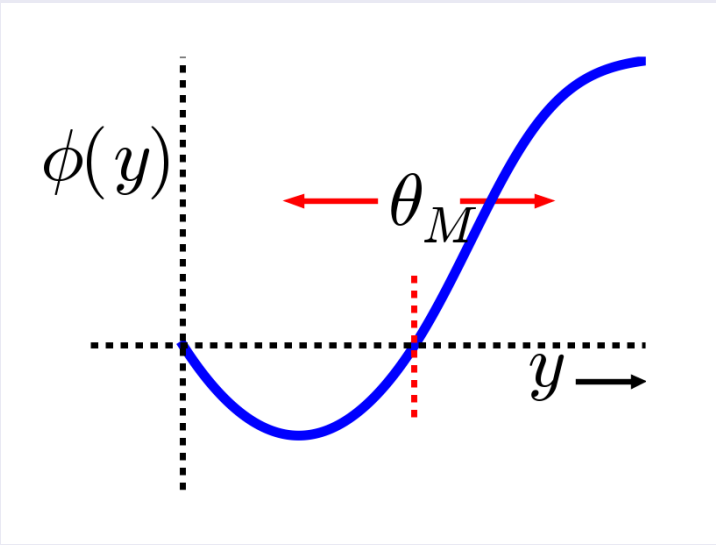
- contra responses constant
- ipsi responses increase *faster* than MS



Visual Cortex Receptive Field Plasticity

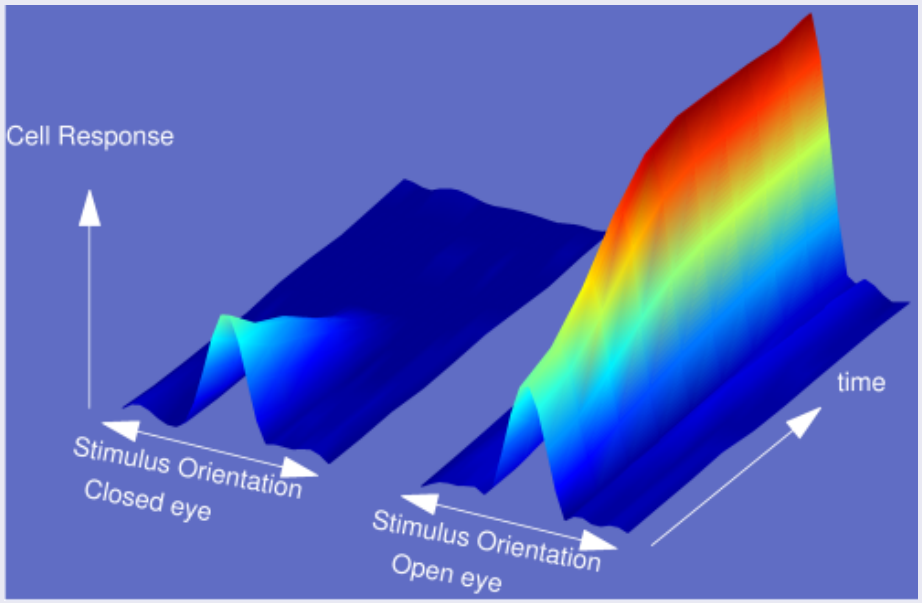
Blais et.al, 1999

BCM Synaptic Modification



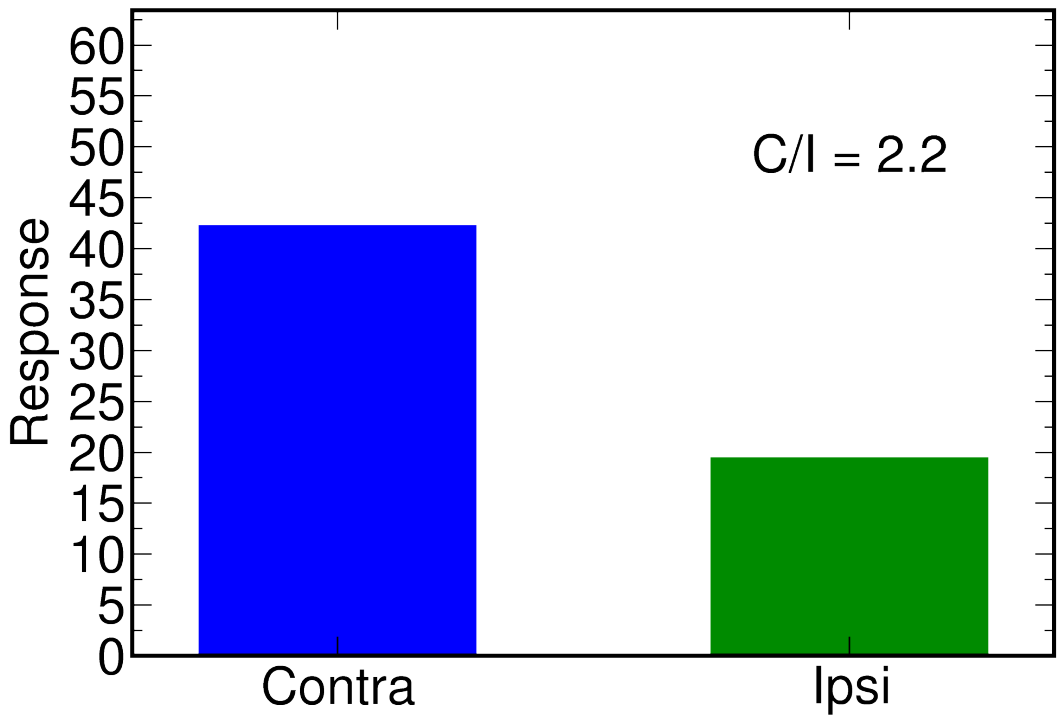
$$\frac{dw_i}{dt} = \phi(y, \theta_M)x_i$$
$$\theta_M \sim E[y^2]$$

BCM Rule Predicts Deprivation Dynamics



- Natural Images
- Requires Pre-synaptic Activity
- Model Architecture: Cat

Normal Rearing
Simulations



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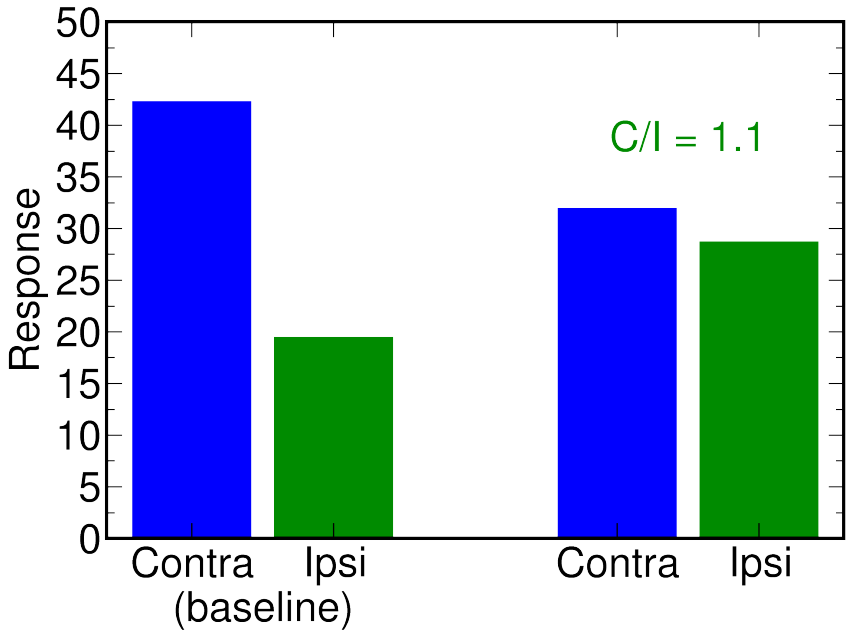
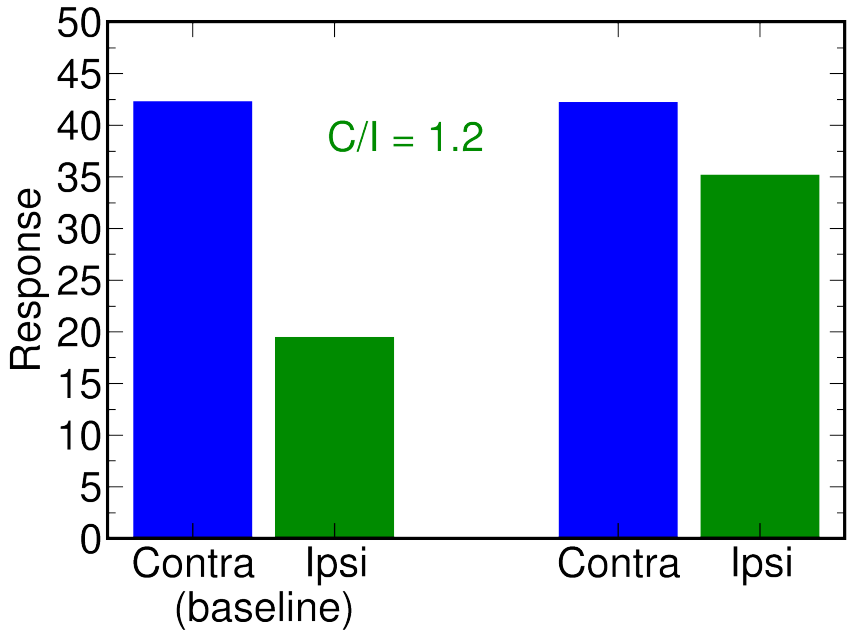
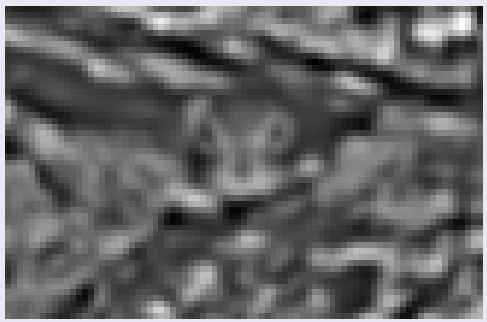




Monocular Suture
Natural Input versus Noise

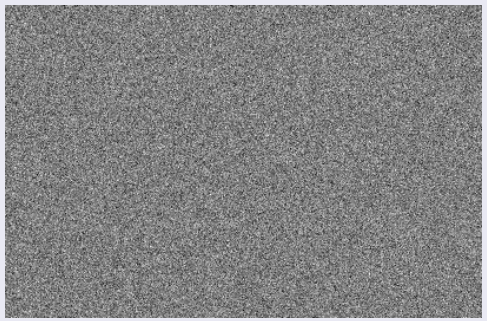
Normal Input

- Structure



Deprived

- Noise



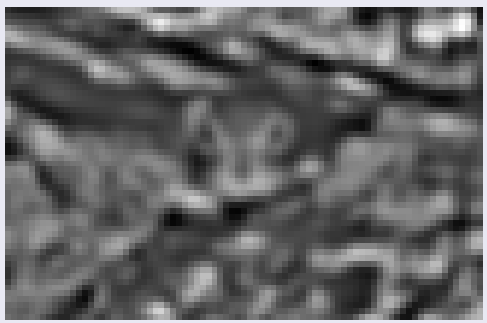
- structure is correlated: nearby inputs have similar activities
- noise is uncorrelated: inputs have unrelated activities

Monocular Inactivation

Natural Input versus Low Noise

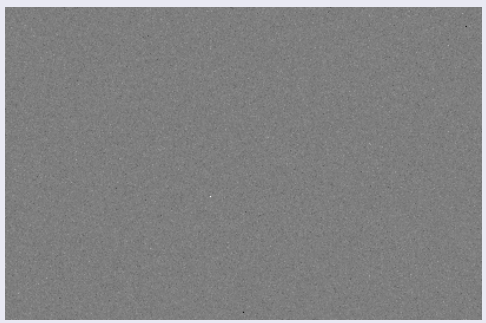
Normal Input

- Structure



Inactivated

- Noise

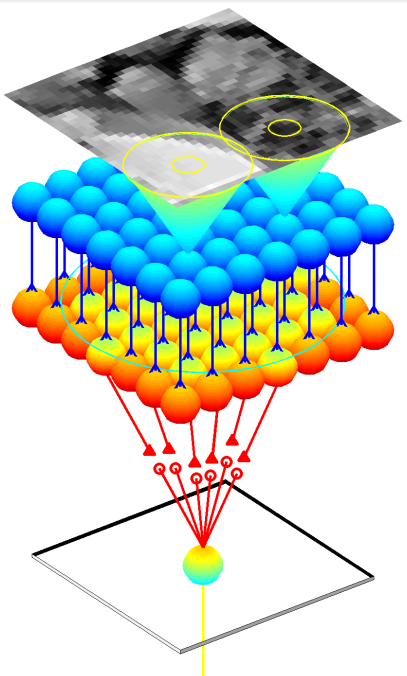


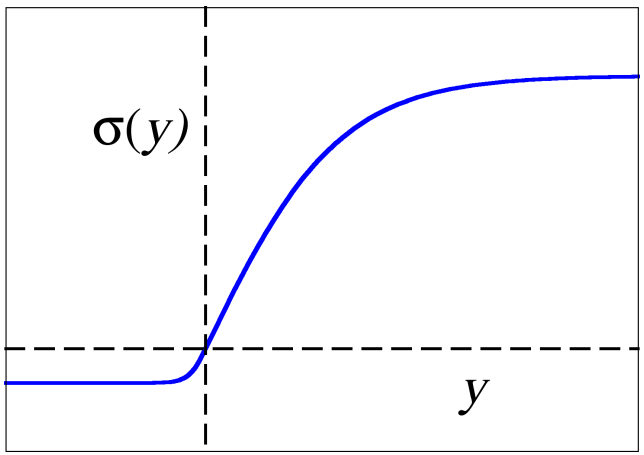
- noise has smaller variance than for lid suture
- noise is uncorrelated: inputs have unrelated activities

Notation

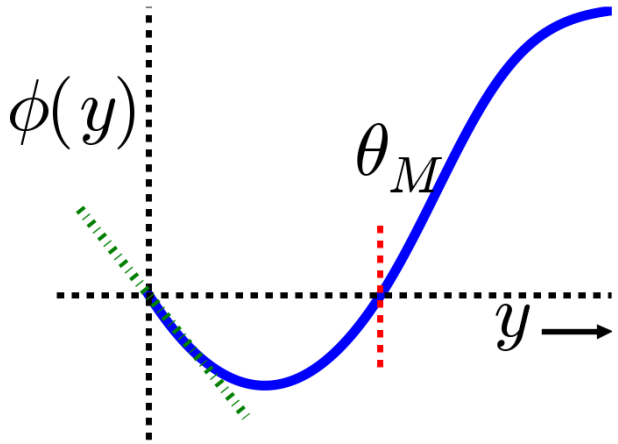
Equations

$$\begin{aligned} \text{inputs: } \boldsymbol{x} &= (x_1, x_2, \cdots) \\ \text{weights: } \boldsymbol{w} &= (w_1, w_2, \cdots) \\ \text{output: } y &= \sigma(x_1 \cdot w_1 + x_2 \cdot w_2 + \cdots) = \sigma(\boldsymbol{x} \cdot \boldsymbol{w}) \end{aligned}$$





BCM and Deprivation



w_{ic}, w_{io}: closed/open eye synapses

Case 1: Activities Around Zero

$$\frac{dw_{ic}}{dt} = -\epsilon y n_i$$

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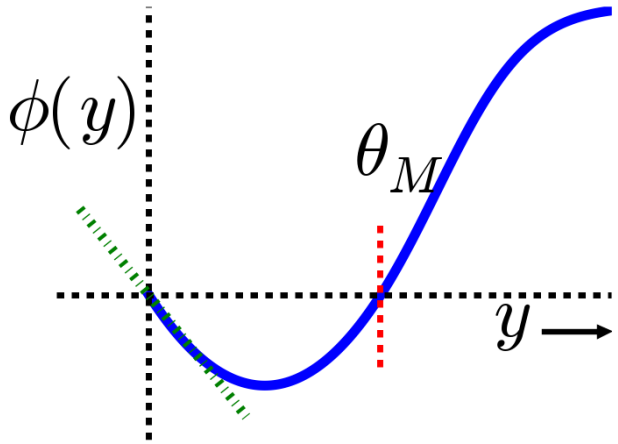

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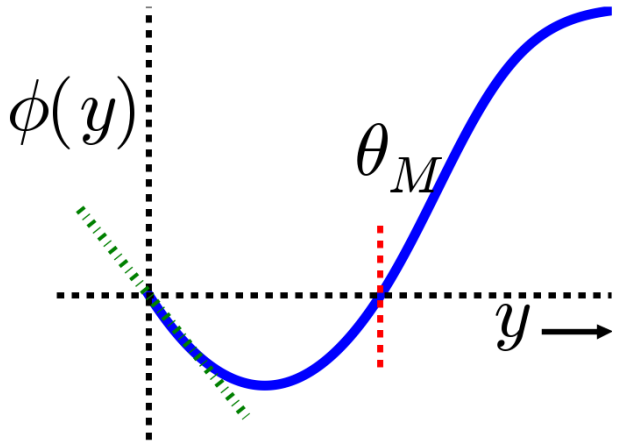

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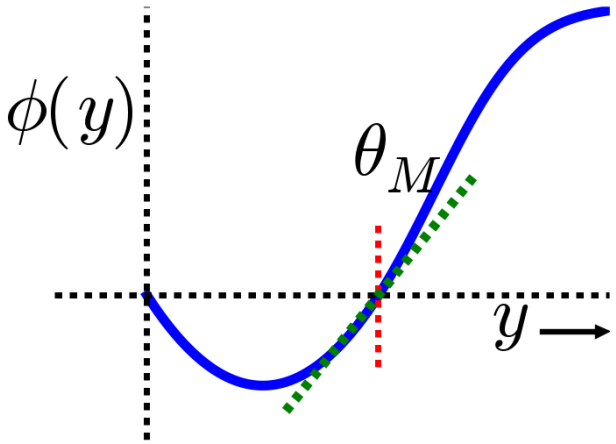

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Case 2: Activities Around θ_M

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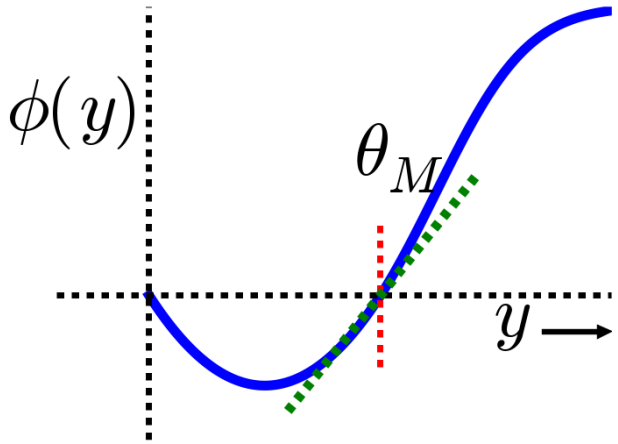
BCM and Deprivation



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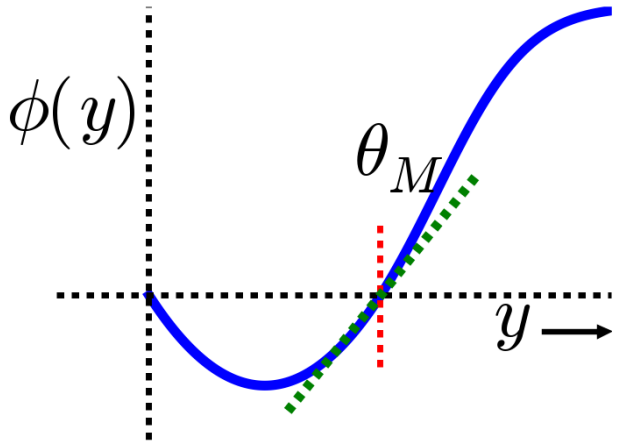

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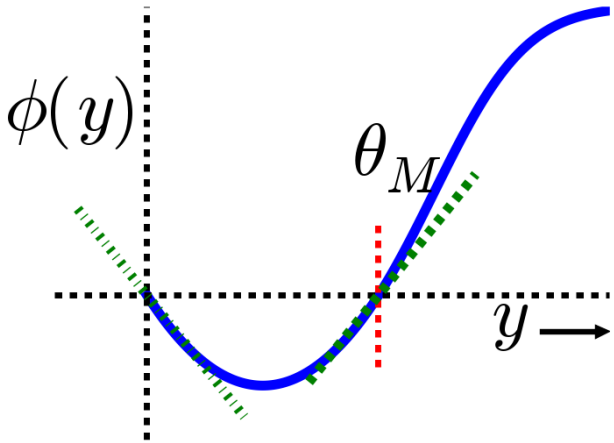
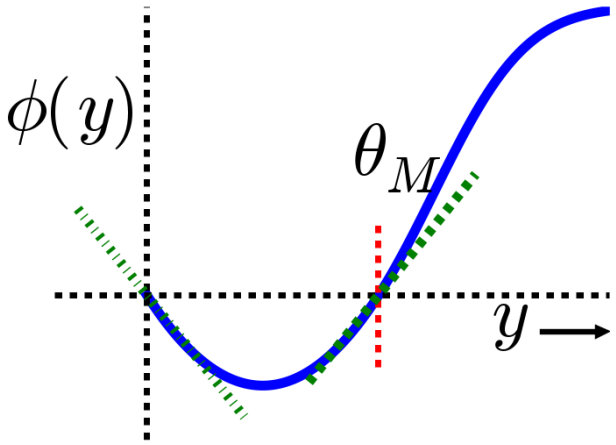


w_{ic}, w_{io}: closed/open eye synapses

Case 1 (0) and Case 2 (θ_M)

$$\frac{dw_{ic}}{dt} = \overbrace{-N_0 \times \epsilon w_{ic} < n_i^2 >}^{\text{pulled down}} + \underbrace{N_\theta \times \epsilon w_{ic} < n_i^2 >}_{\text{pushed up}}$$

BCM and Deprivation



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$$N_0 \gg N_\theta \text{ (selective)}$$

Monica's Experiments

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- LGN activity for normal viewing, lid suture, and TTX are very similar

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- LGN activity for normal viewing, lid suture, and TTX are very similar
- LGN activity with TTX is *more correlated*, and bursty, then LGN activity with lid suture

One Attempt

Assumption for LGN Activity during TTX

Instead of small variance, mean zero noise for TTX, assume small variance *positive mean* noise

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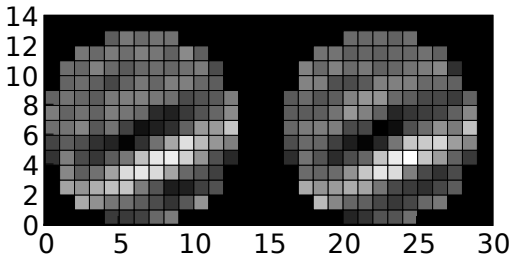
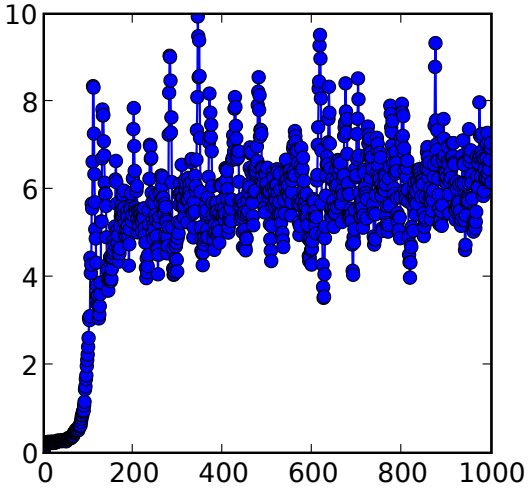
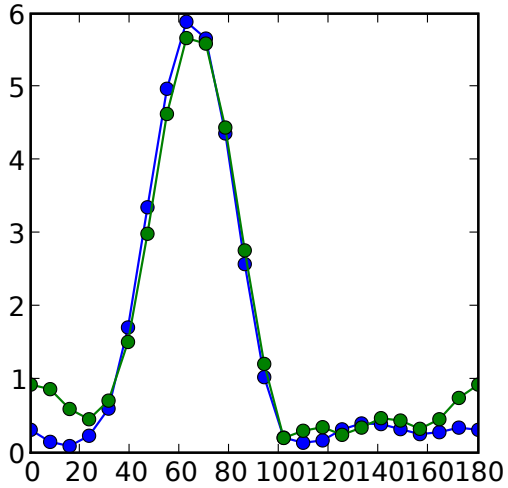
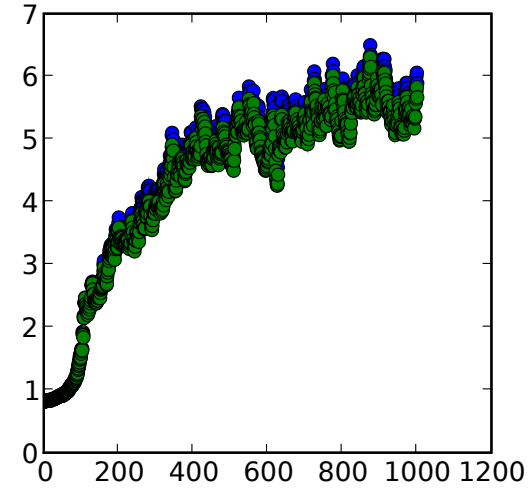
What happens?

Normal Development (Cats)



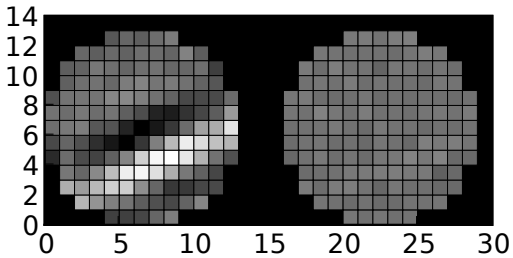


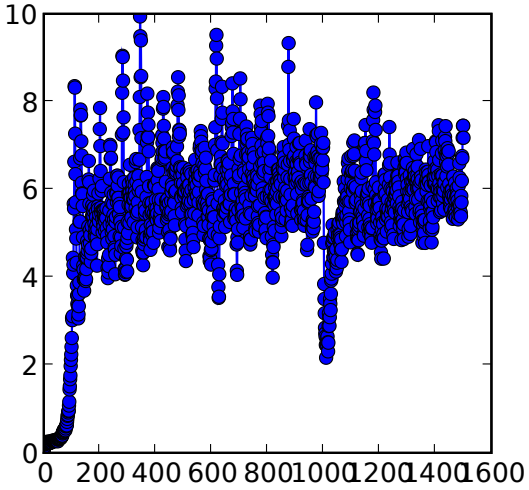


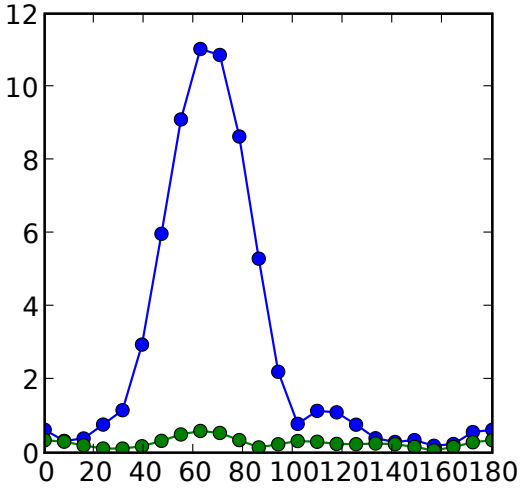


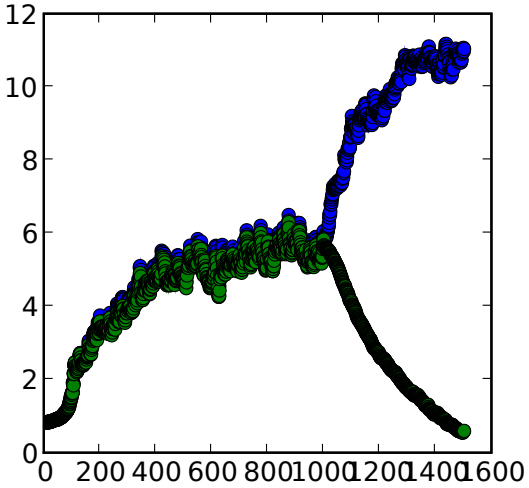
Exploratory mode: use cat sims for speed

Monocular Suture (Cats)





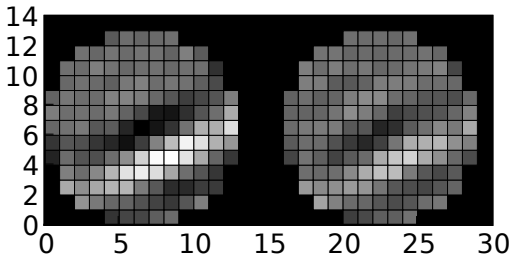


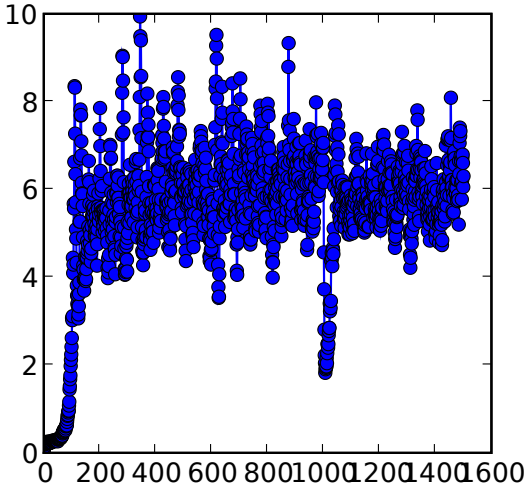


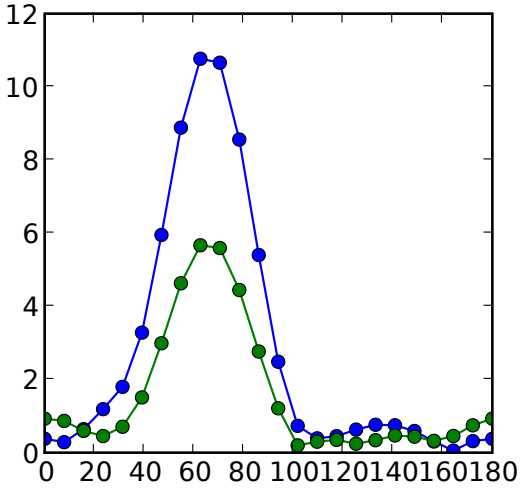
Noise

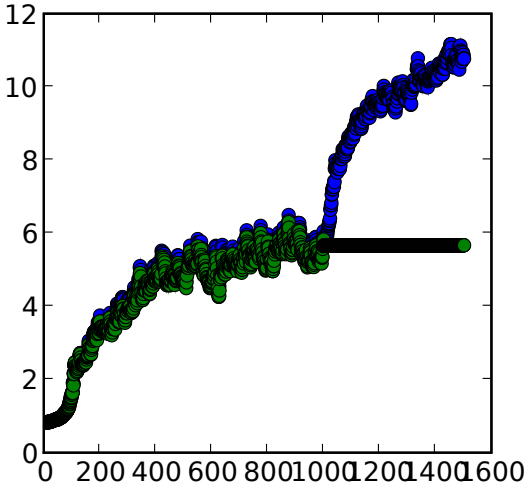
- Mean 0.0
- Std 0.8

Monocular Inactivation (Cats)





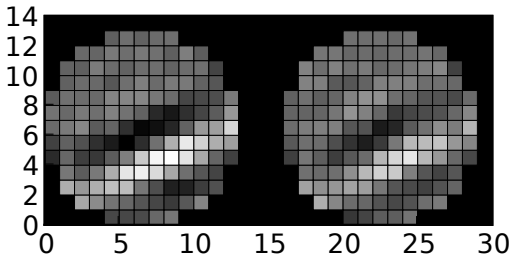


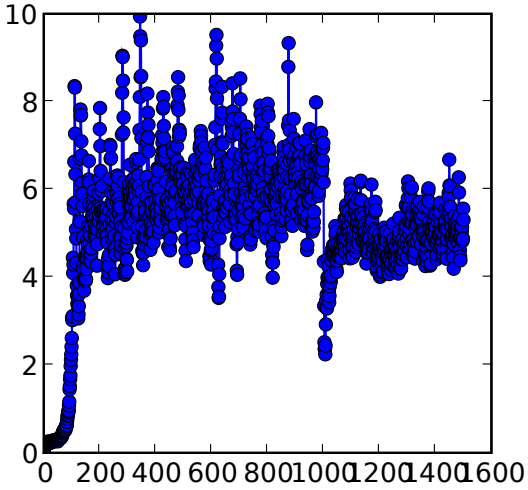


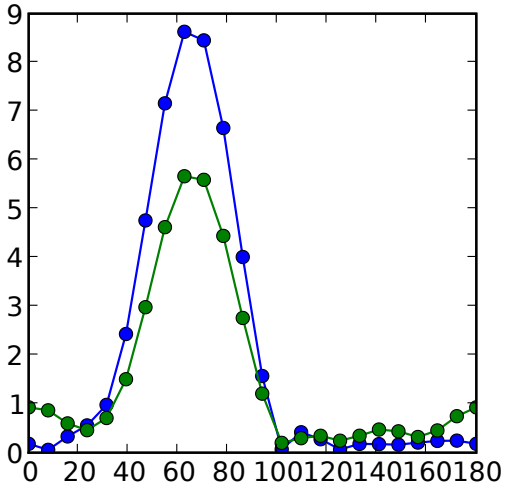
Noise

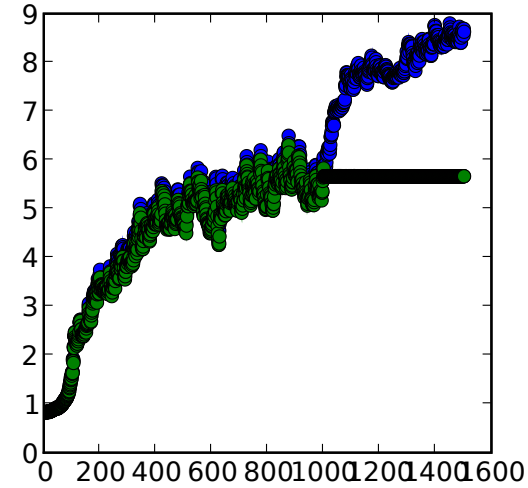
- Mean 0.0
- Std 0.005

Monocular Inactivation (Cats)









Noise

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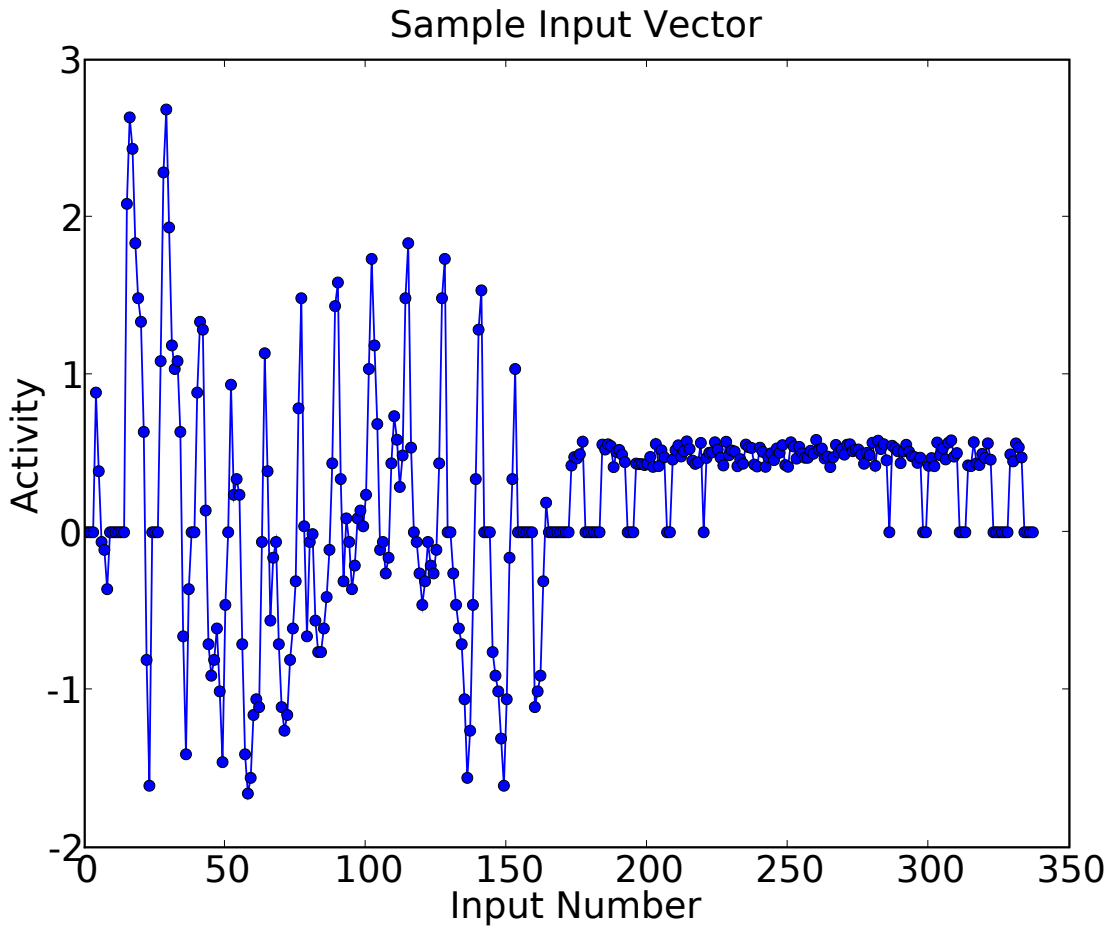
Monocular Inactivation (Cats)



Noise

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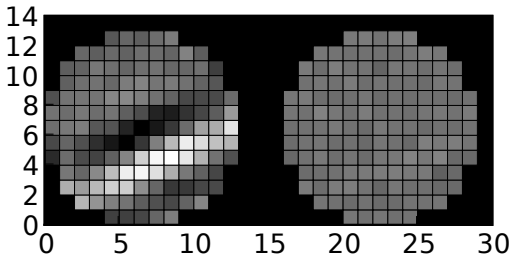
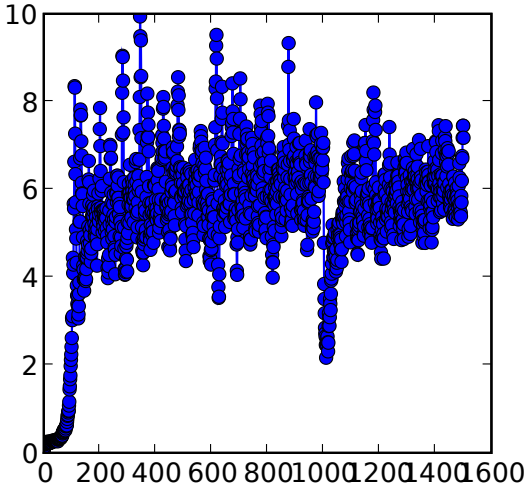
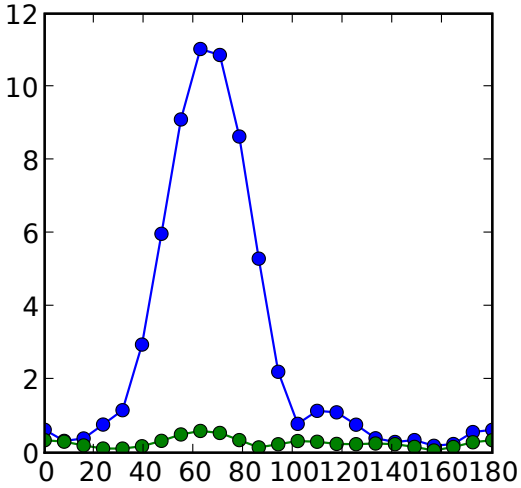
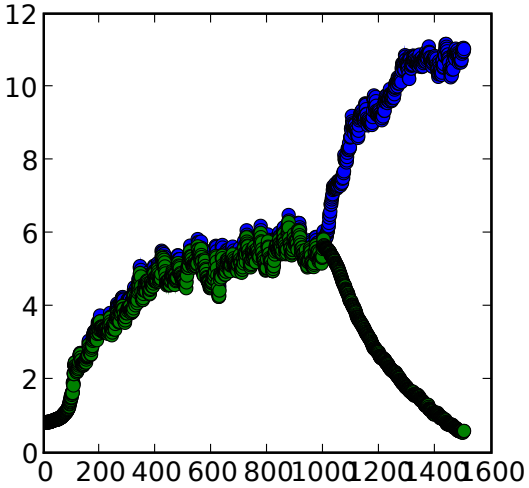
Monocular Suture (Cats)









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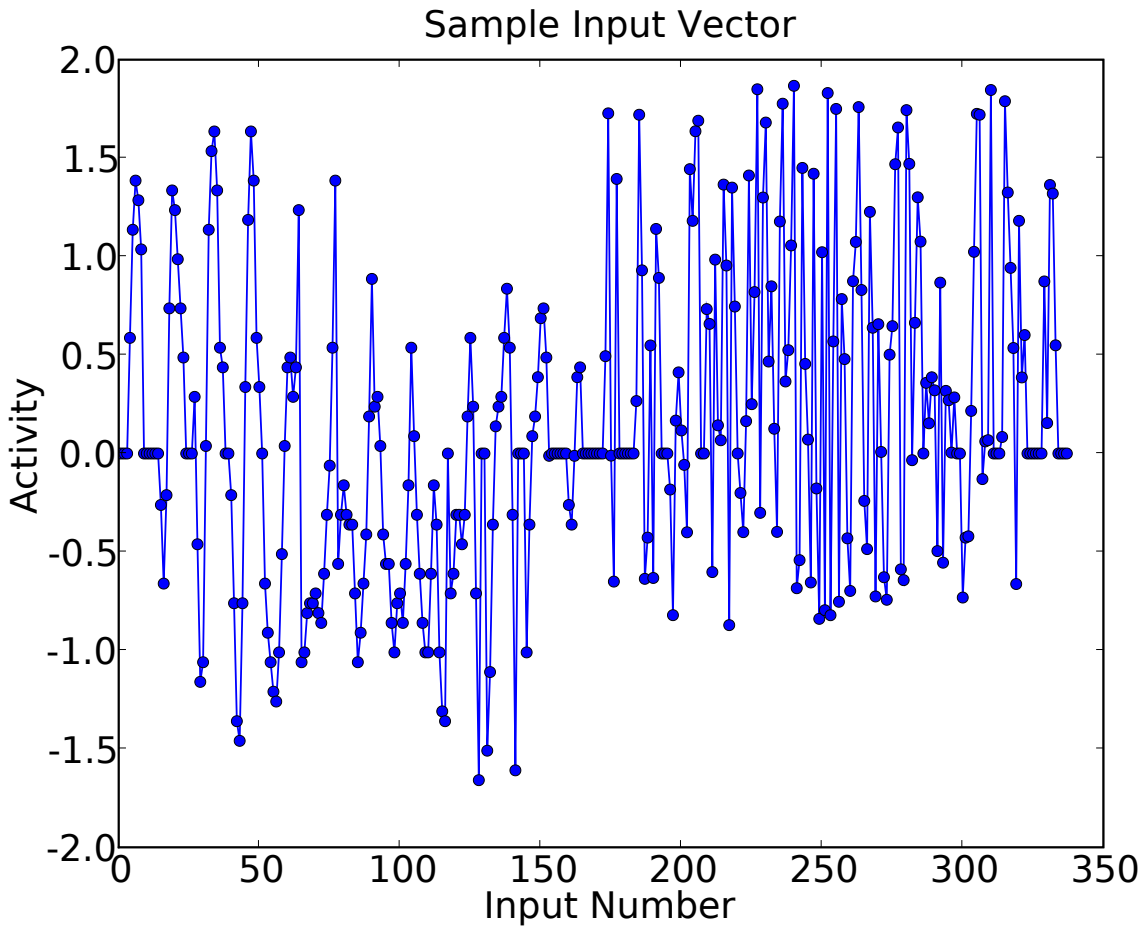

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Conclusions

Using non-zero mean noise...

- ...the TTX activities become *very* correlated
- ...the *results* for MS and MI are *identical*