Simulations of Monocular Deprivation in Mouse

Brian Blais
Scott Kuindersma

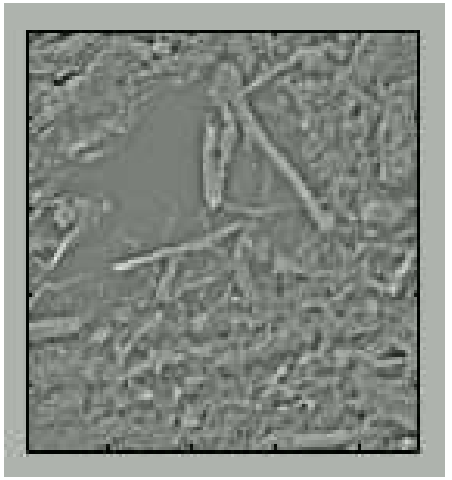
Bryant
UNIVERSITY

Mouse Simulations

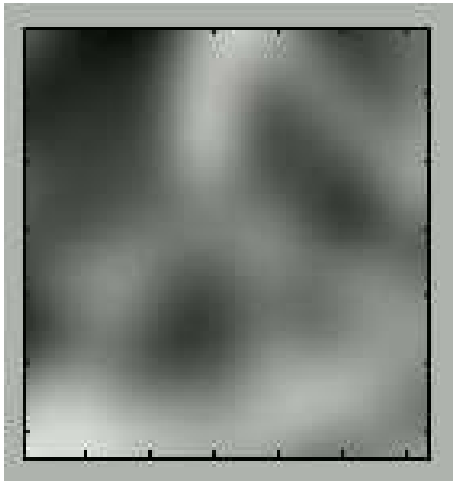
- larger retinal filter
- contralateral bias

The inputs for the normal rearing (NR) simulations were a set of 12 natural images with the retinal filter (Difference of Gaussian) increased by a factor of 10.

No Filter



Cat
DoG 1:3



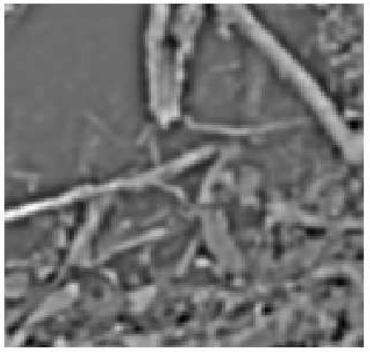
Mouse
DoG 10:30

Two methods for contralateral bias

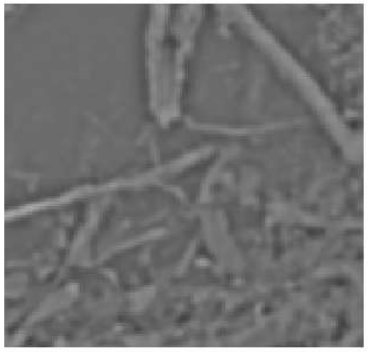
- Alter image intensity
- Reduce number of weights

Different image sets were used for the left and right input channels. The right (ipsilateral) channel image intensity was reduced by a factor of 2.5.

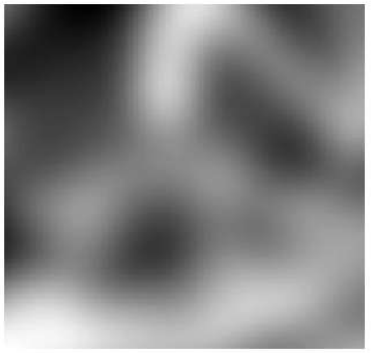
Cat
DoG 1:3



Cat with
bias



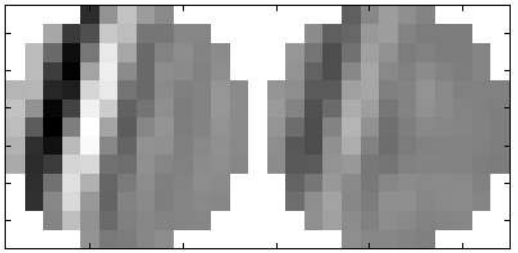
- Cats do not actually have a bias



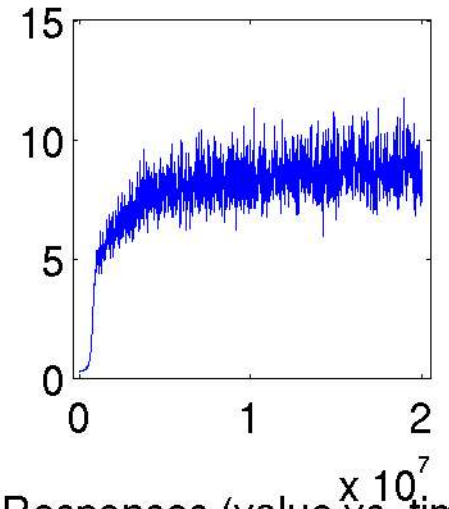
Mouse
DoG 10:30

Cat with contralateral bias – NR, intensity induced bias

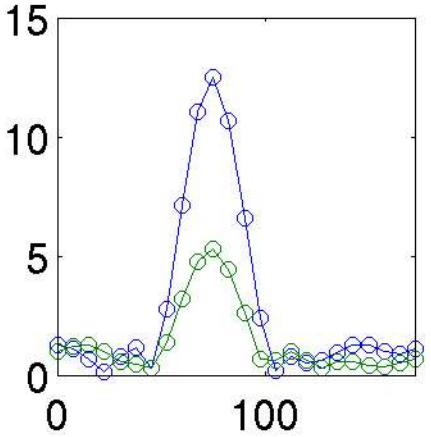
Weights



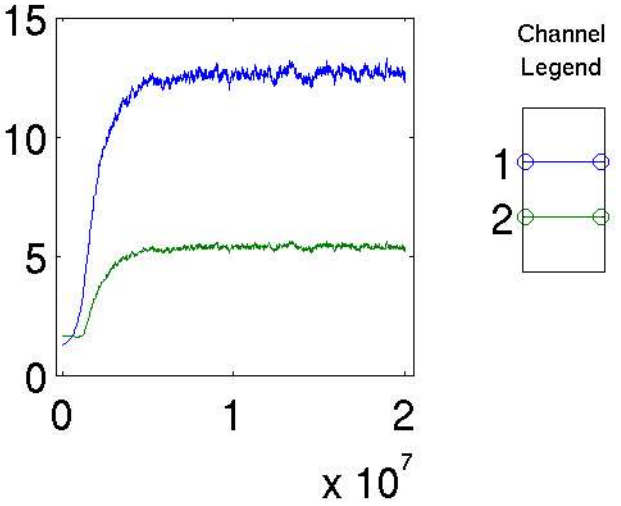
Thresholds (value vs. time)



Tuning Curves (response vs. angle)

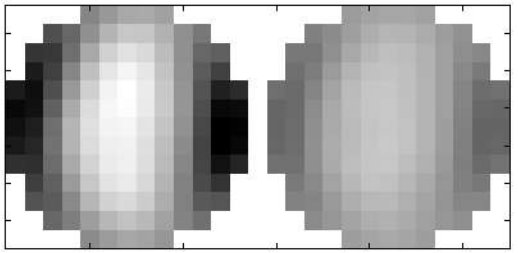


Responses (value vs. time)

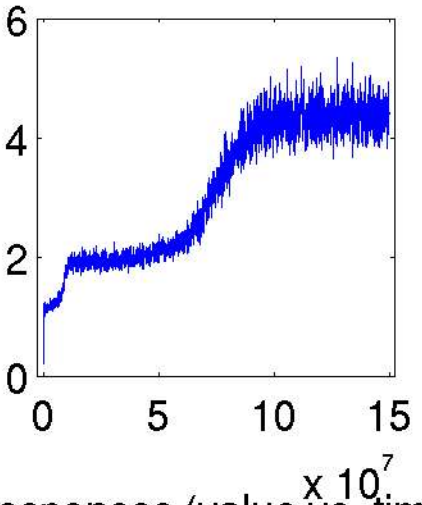


Mouse - NR, intensity induced bias

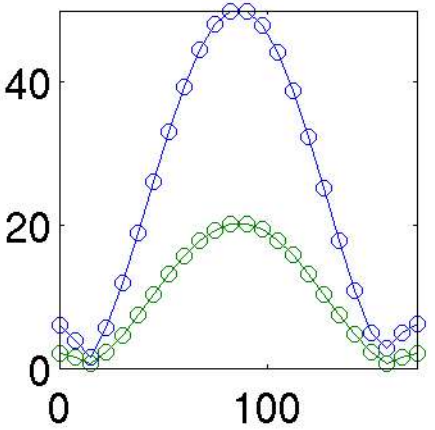
Weights



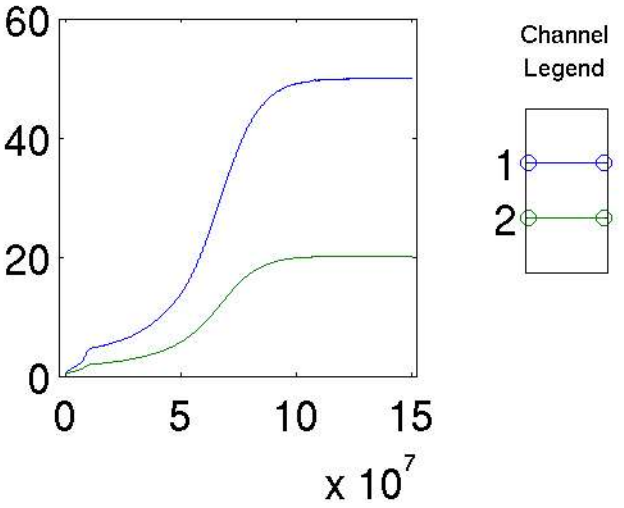
Thresholds (value vs. time)



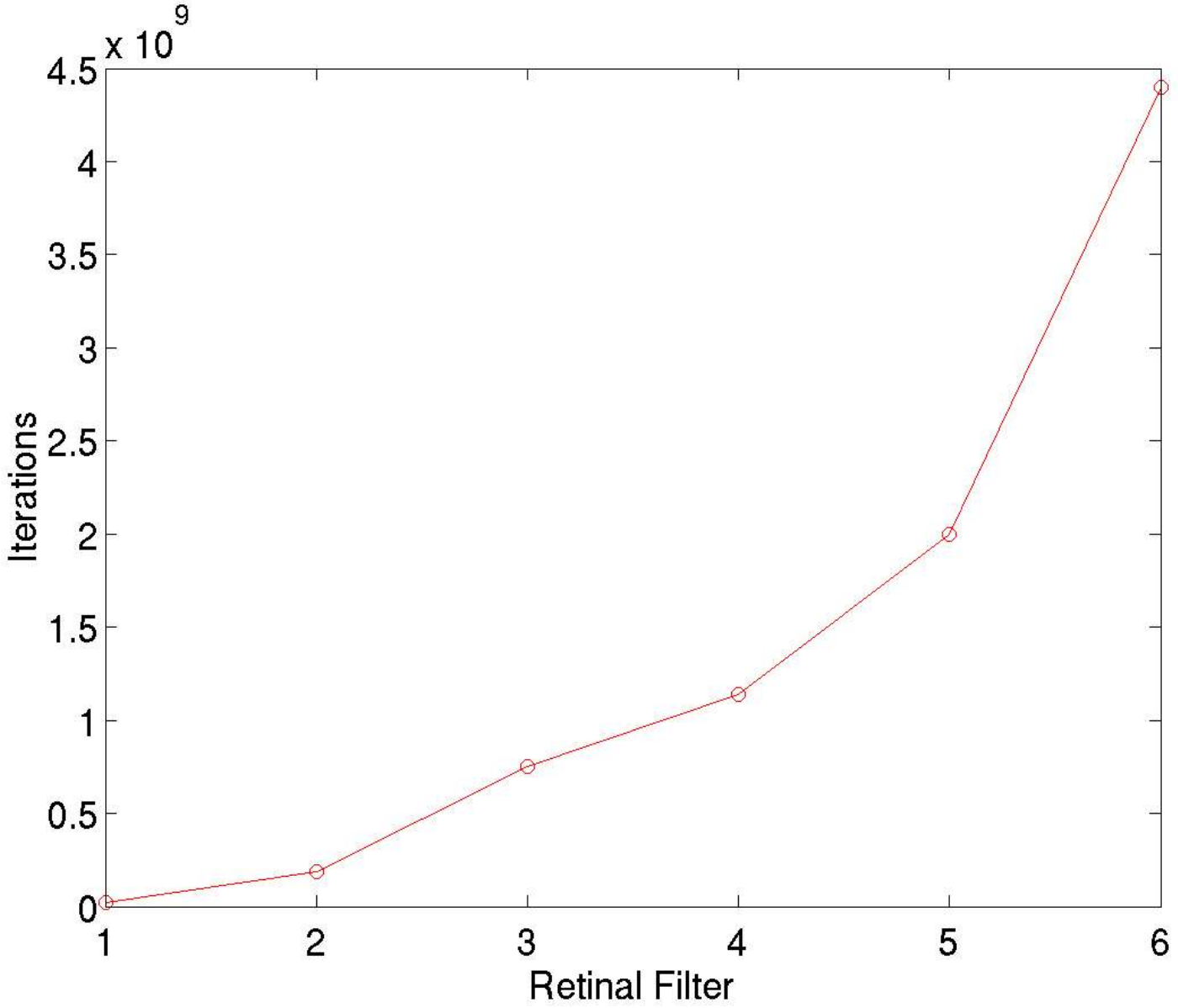
Tuning Curves (response vs. angle)



Responses (value vs. time)

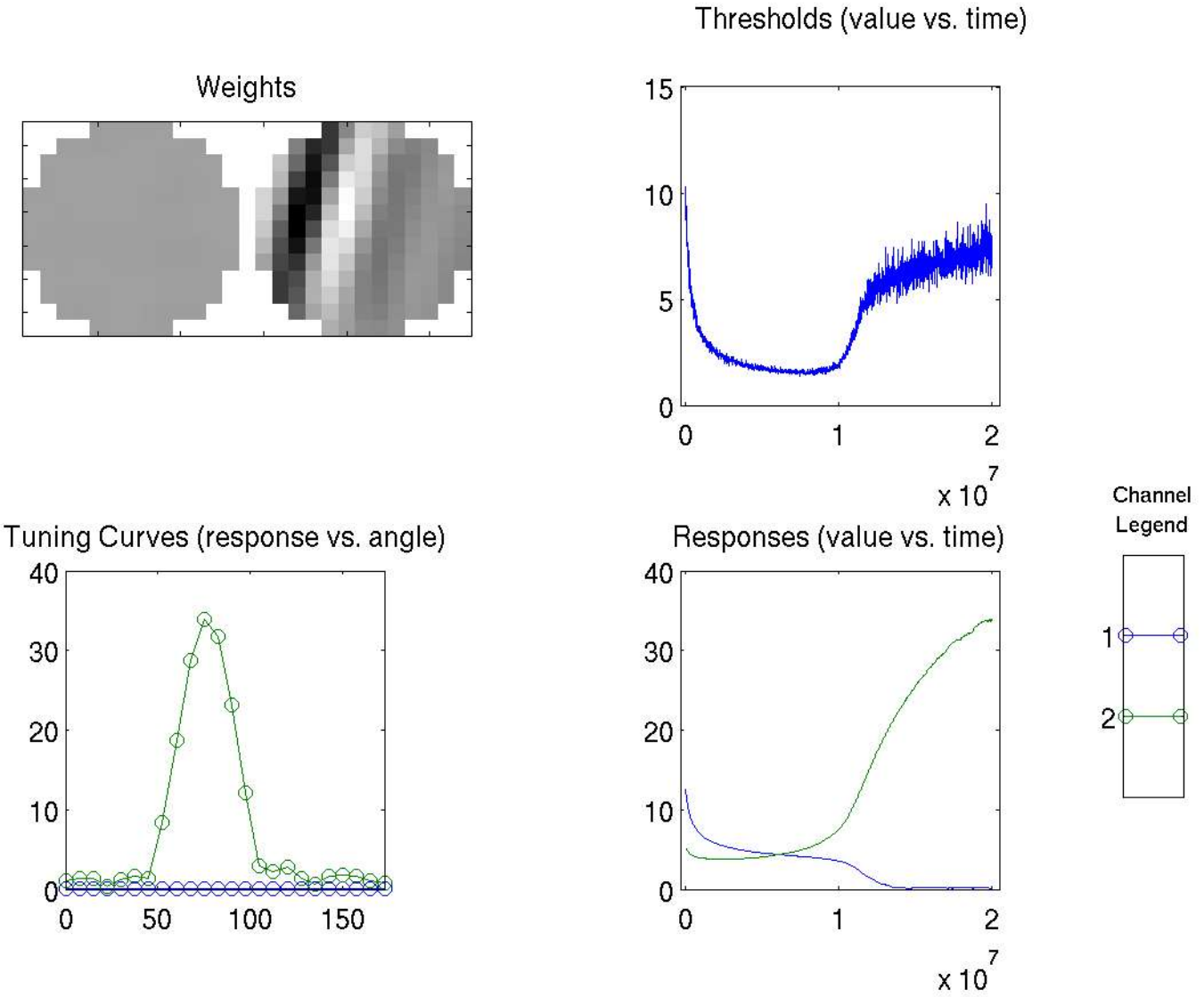


Effect of retinal filter (DoG) on required time for convergence



Cat with bias – Monocular Deprivation (MD), High noise (lid suture)

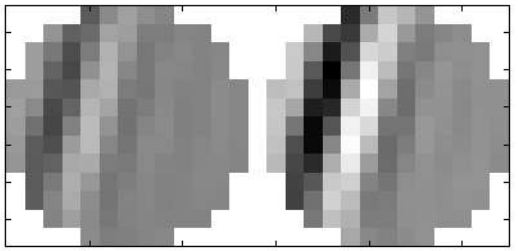
Gaussian SD = 0.8



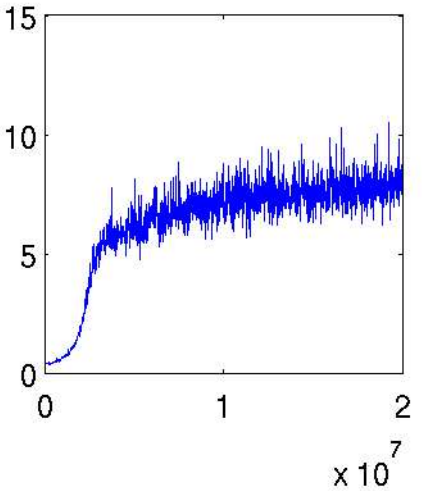
Cat with bias – MD, Low noise (TTX)

Gaussian SD = 0.01

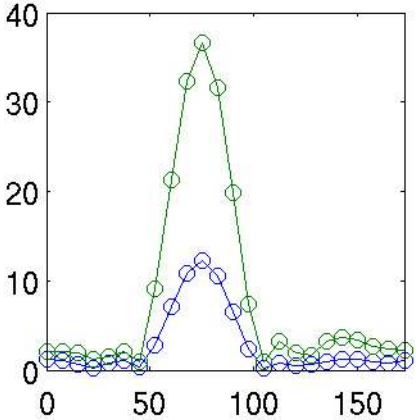
Weights



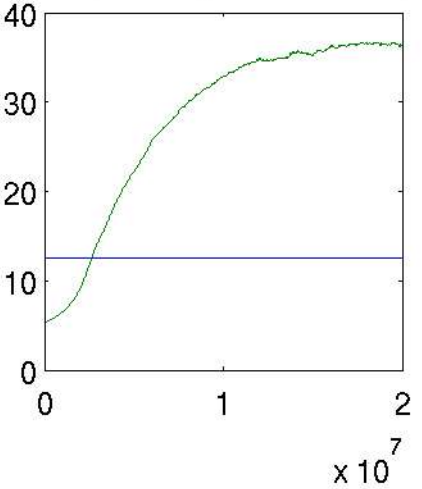
Thresholds (value vs. time)



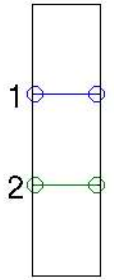
Tuning Curves (response vs. angle)



Responses (value vs. time)



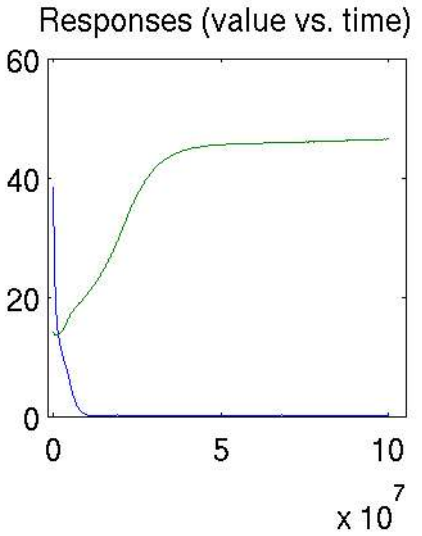
Channel Legend



MD noise dependency

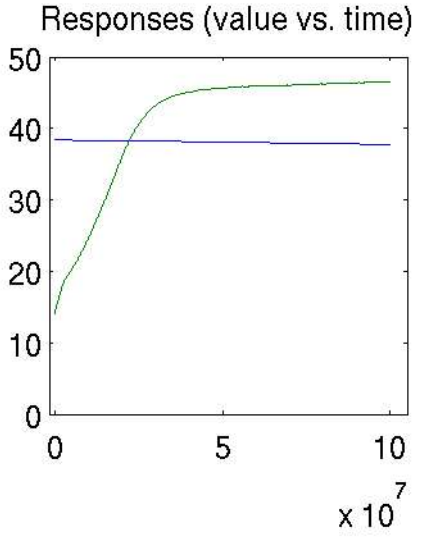
MD, High noise (lid suture):

- rapid response depression
- delayed response potentiation



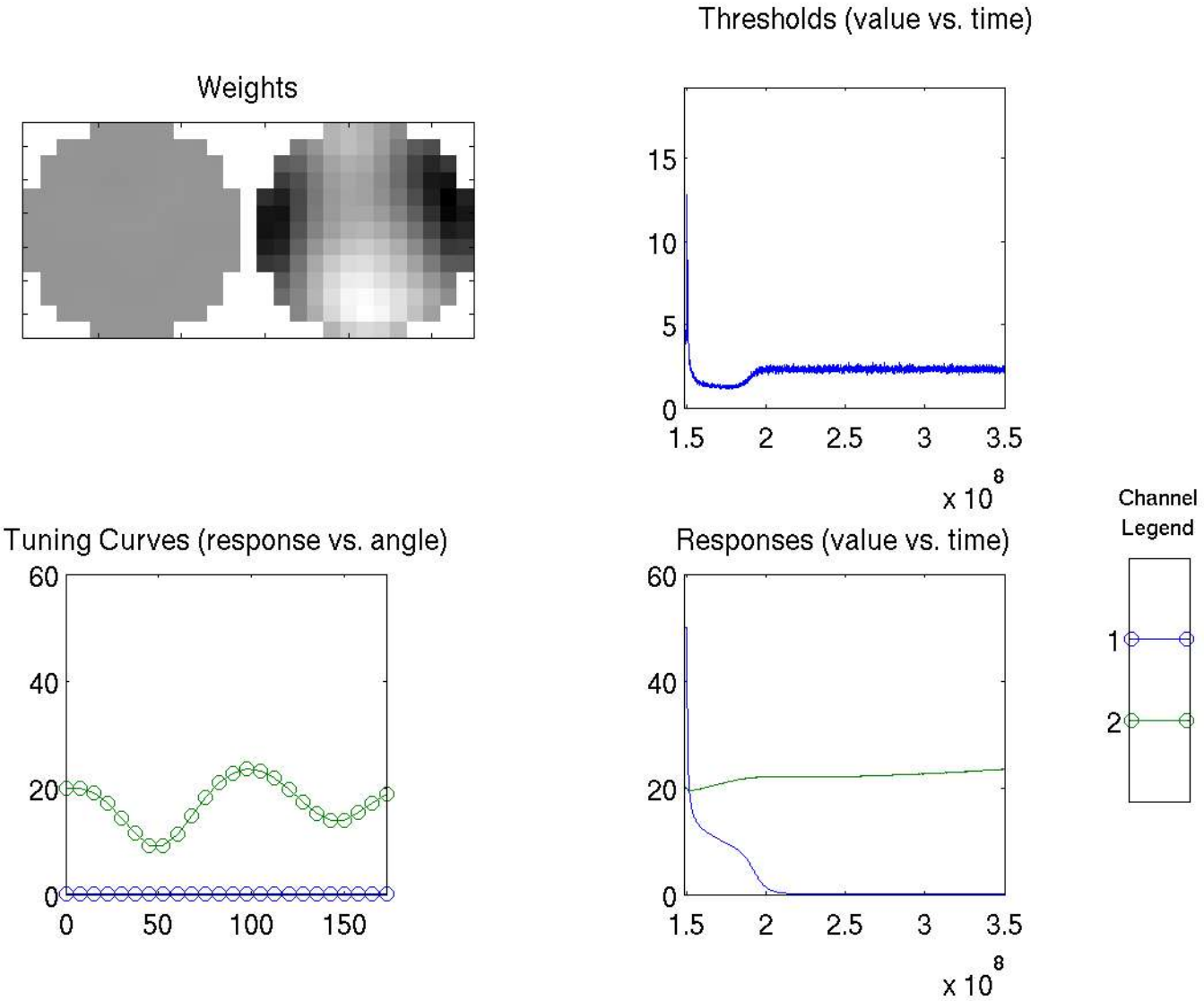
MD, Low noise (TTX):

- little or no response depression
- rapid response potentiation



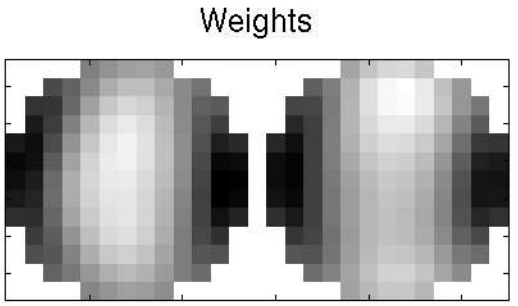
Mouse – MD, High noise (lid suture)

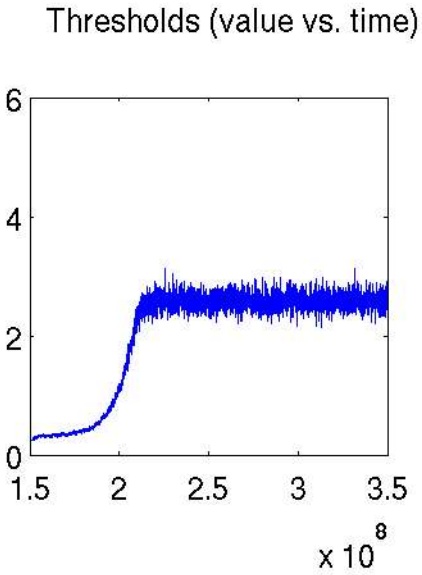
Gaussian SD = 0.8

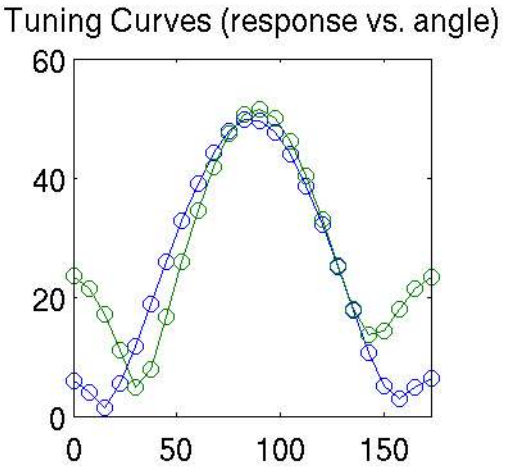


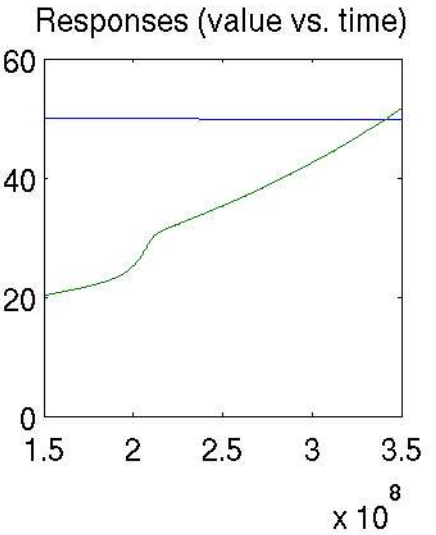
Mouse – MD, Low noise (TTX)

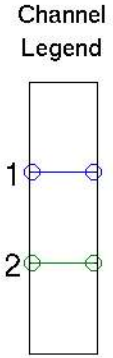
Gaussian SD = 0.01







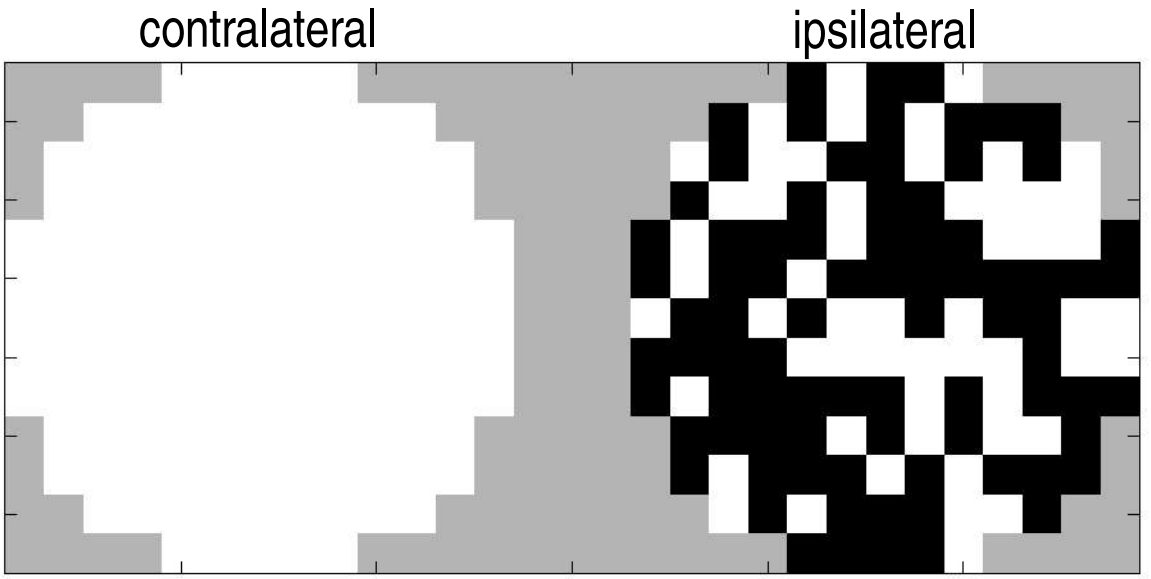




Two methods for contralateral bias

- Alter image intensity
- Reduce number of weights

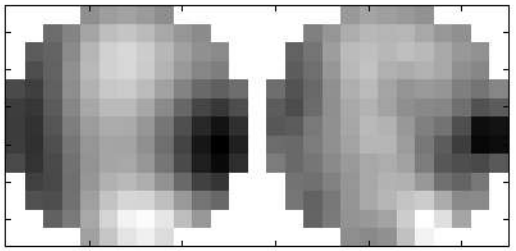
The number of weights in the right (ipsilateral) channel was reduced by setting a “dead” weight (weight of value 0) every 2.5 weights.



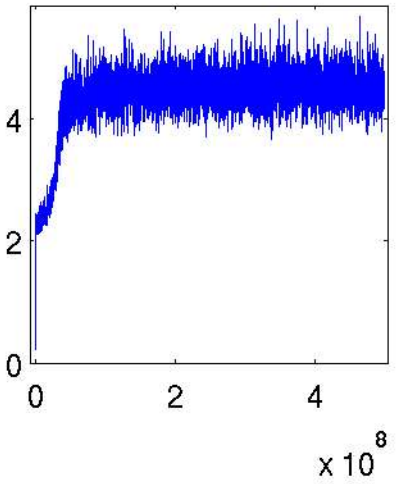
(dead weights are black)

Mouse – NR, Dead weights induced bias

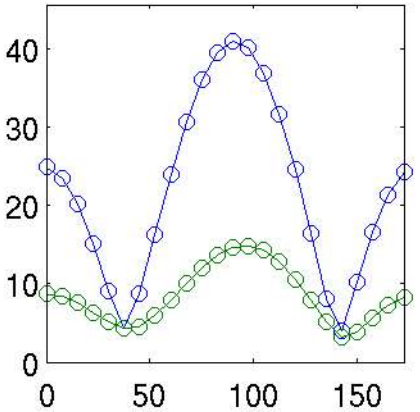
Weights



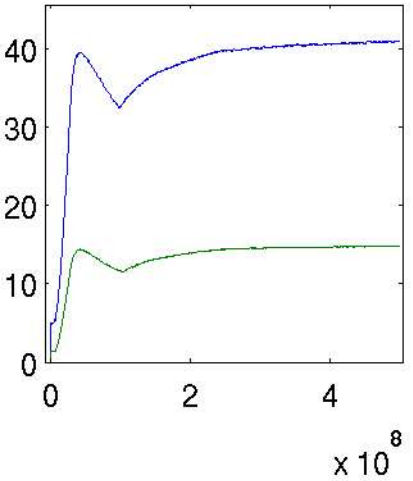
Thresholds (value vs. time)



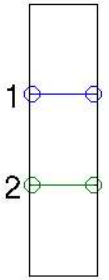
Tuning Curves (response vs. angle)



Responses (value vs. time)

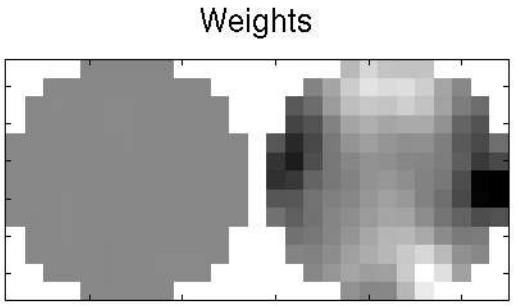


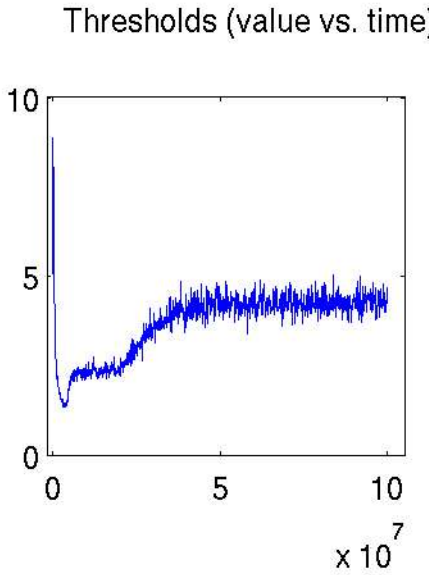
Channel Legend

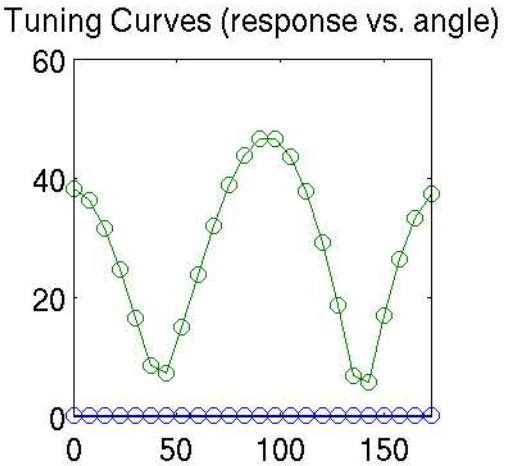


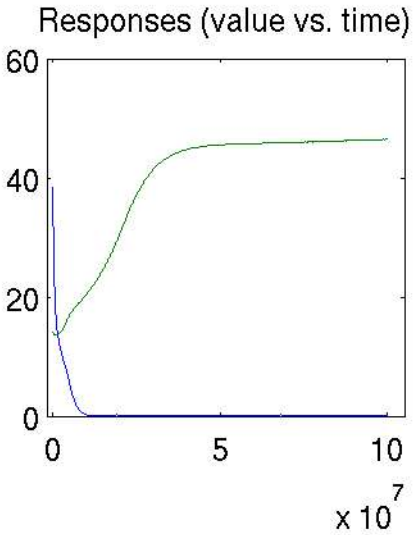
Mouse – MD, High noise (lid suture)

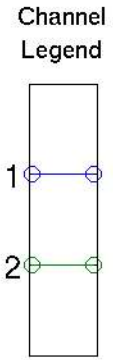
Gaussian SD = 0.8





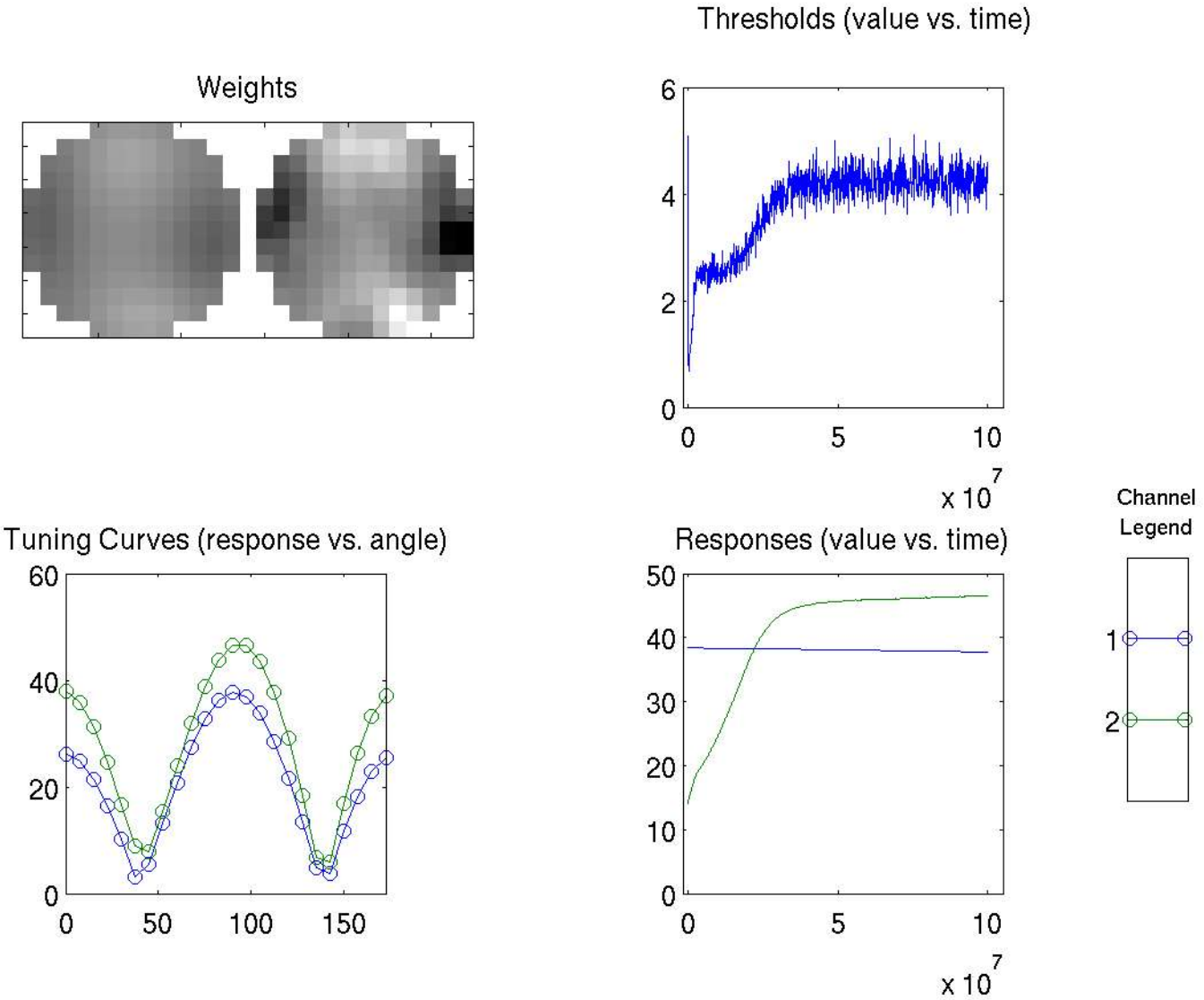






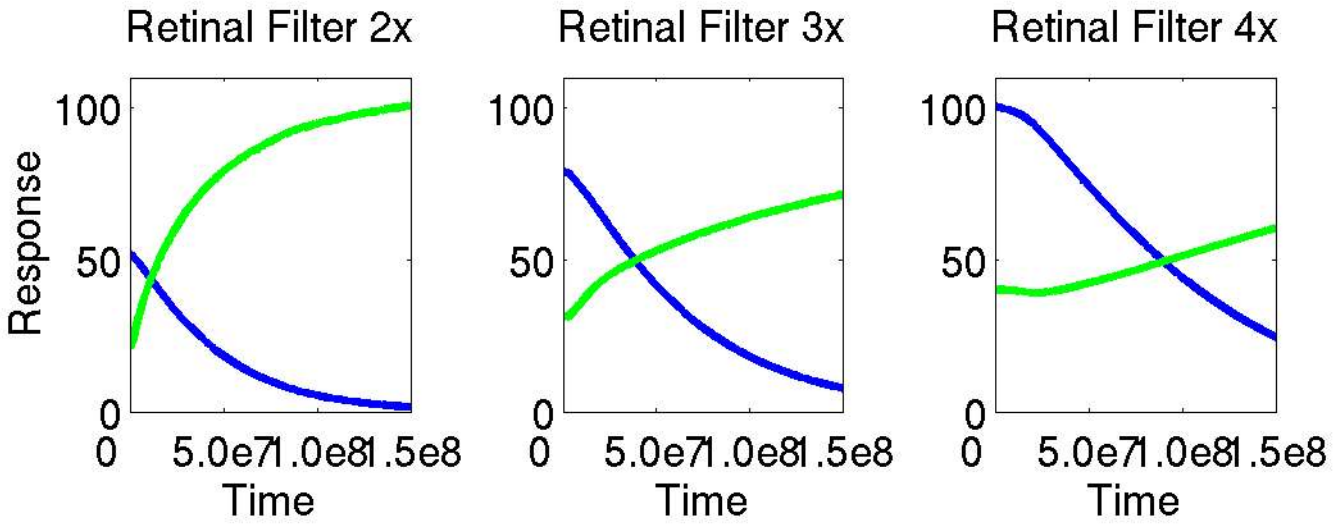
Mouse – MD, Low noise (TTX)

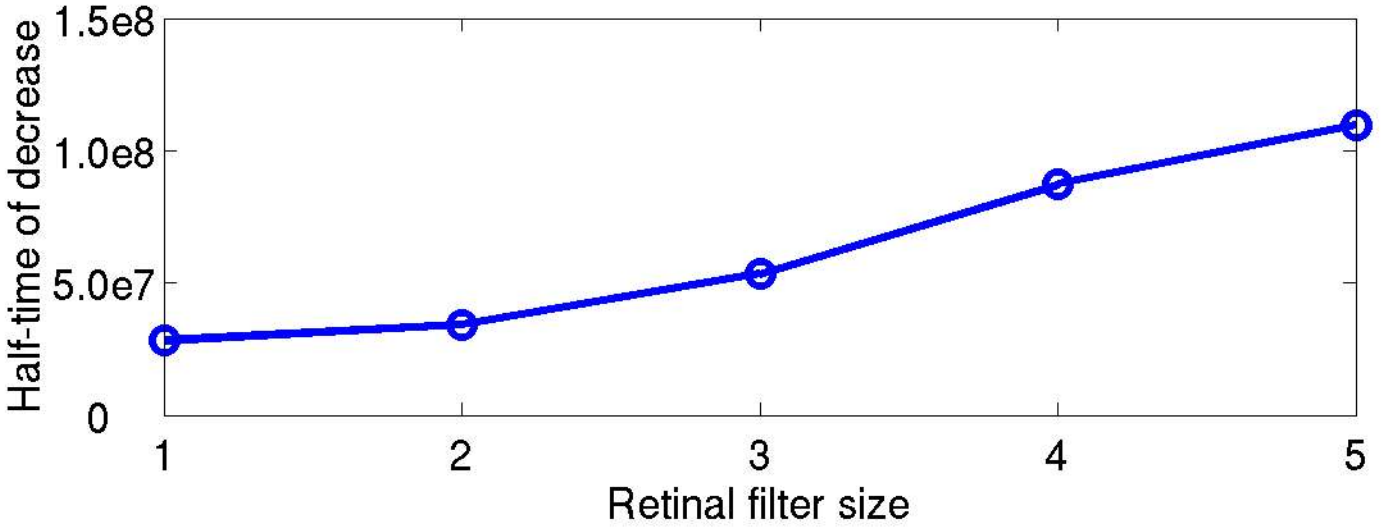
Gaussian SD = 0.01



Effects of retinal filter on MD dynamics

- Increasing retinal filter affects decay time similarly to decreasing noise level.

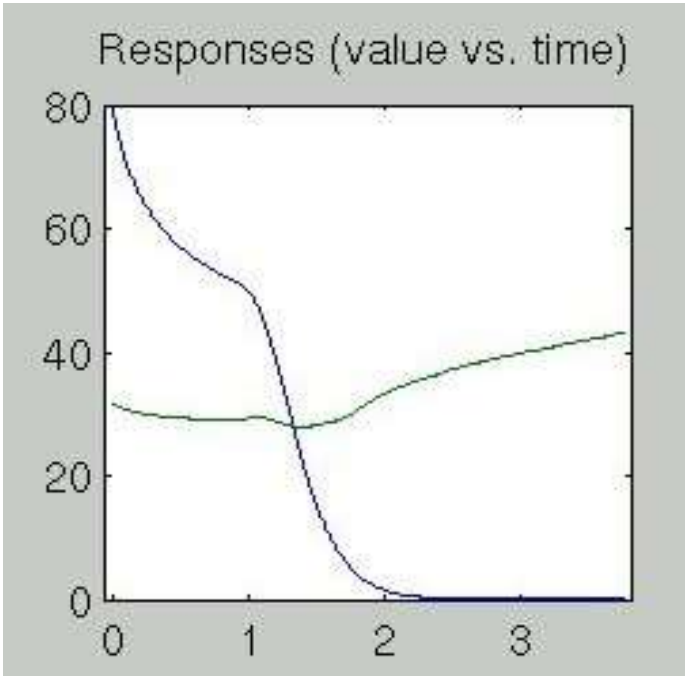




Mouse MD is similar to Cat RS

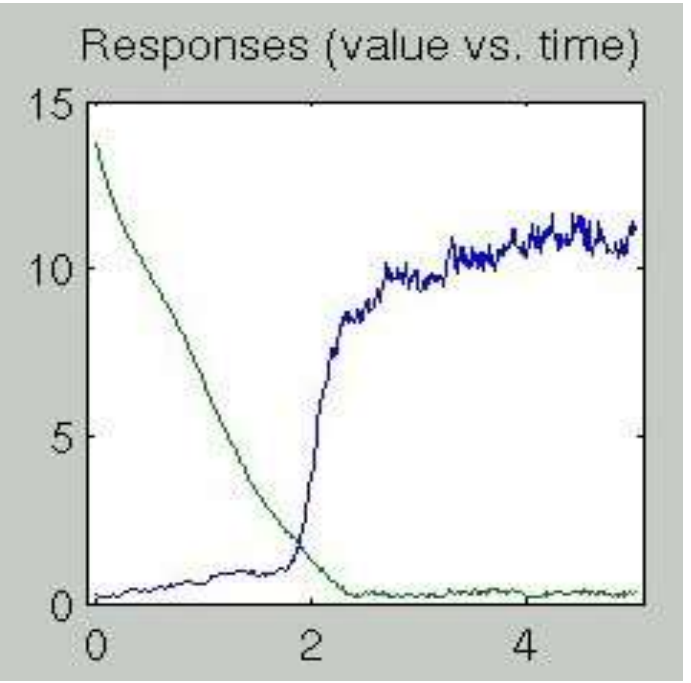
- Pattern input into weaker eye
- Noise input into stronger eye

Mouse MD



(intensity bias, DoG 3:9)

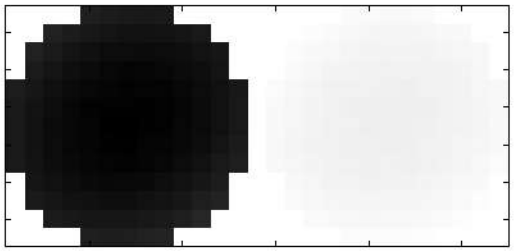
Cat RS



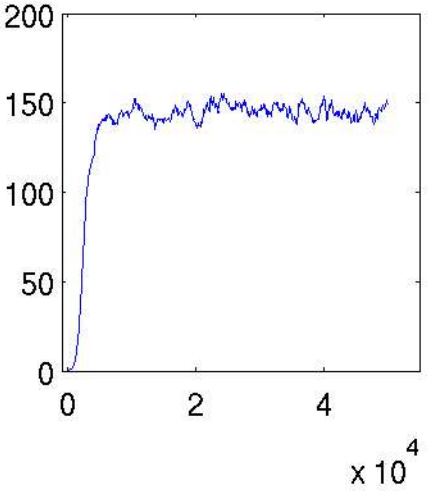
(no bias, DoG 1:3)

Mouse – NR, Hebbian Learning

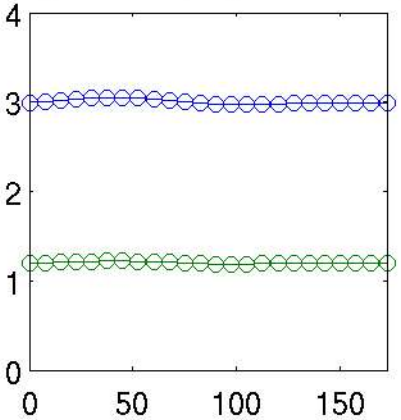
Weights



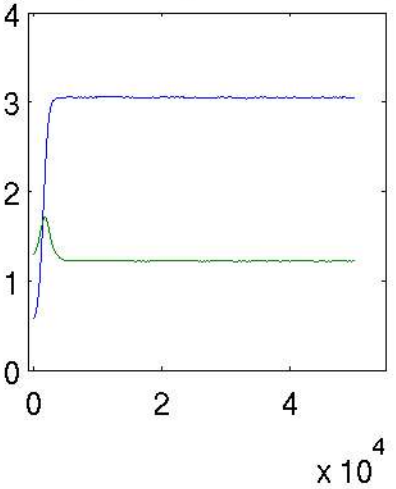
Thresholds (value vs. time)



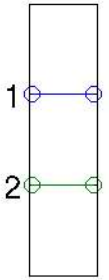
Tuning Curves (response vs. angle)



Responses (value vs. time)

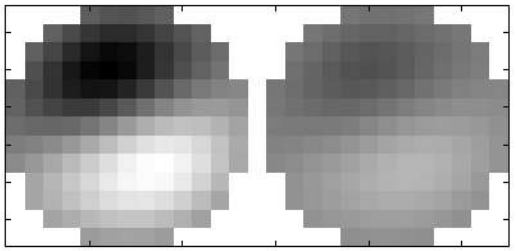


Channel Legend

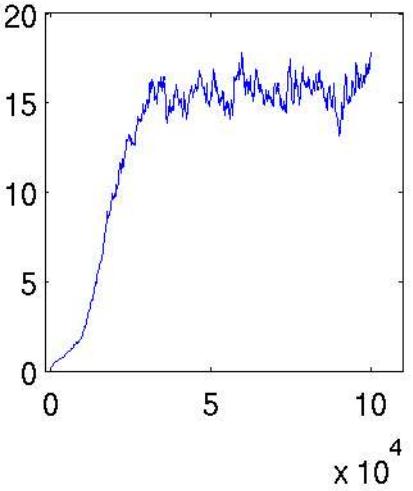


Cat with bias – NR, Hebbian Learning

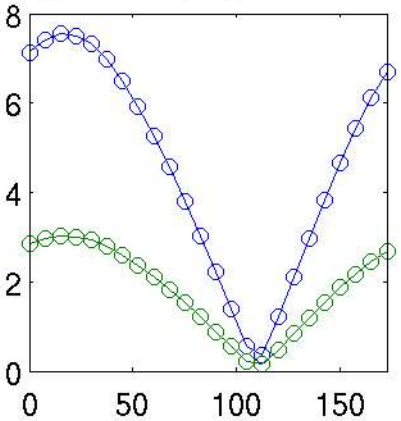
Weights



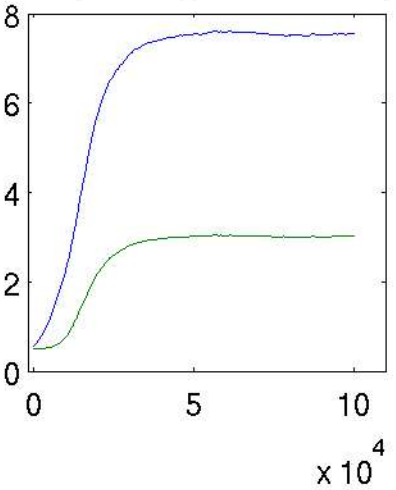
Thresholds (value vs. time)



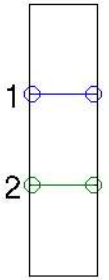
Tuning Curves (response vs. angle)



Responses (value vs. time)

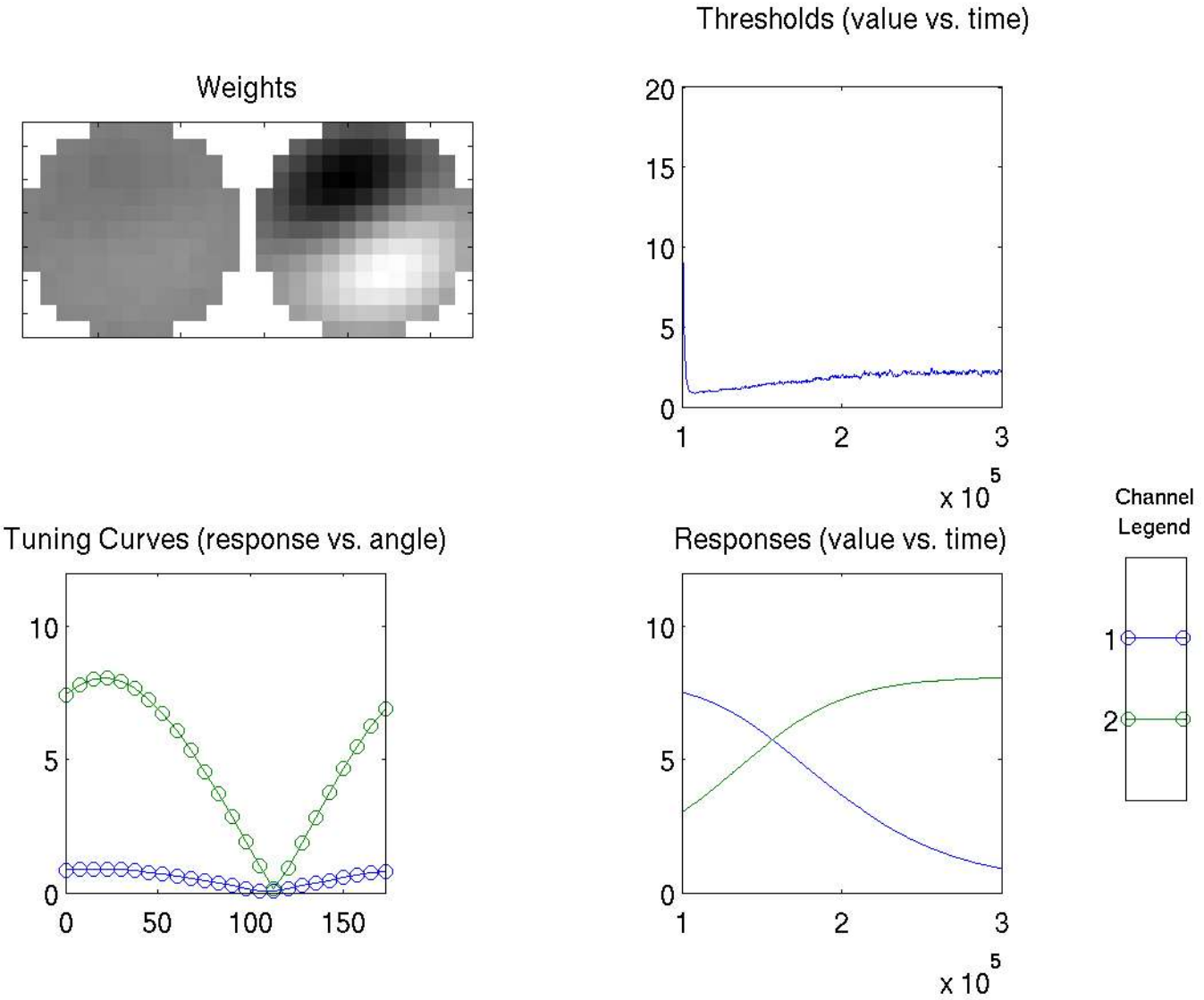


Channel Legend



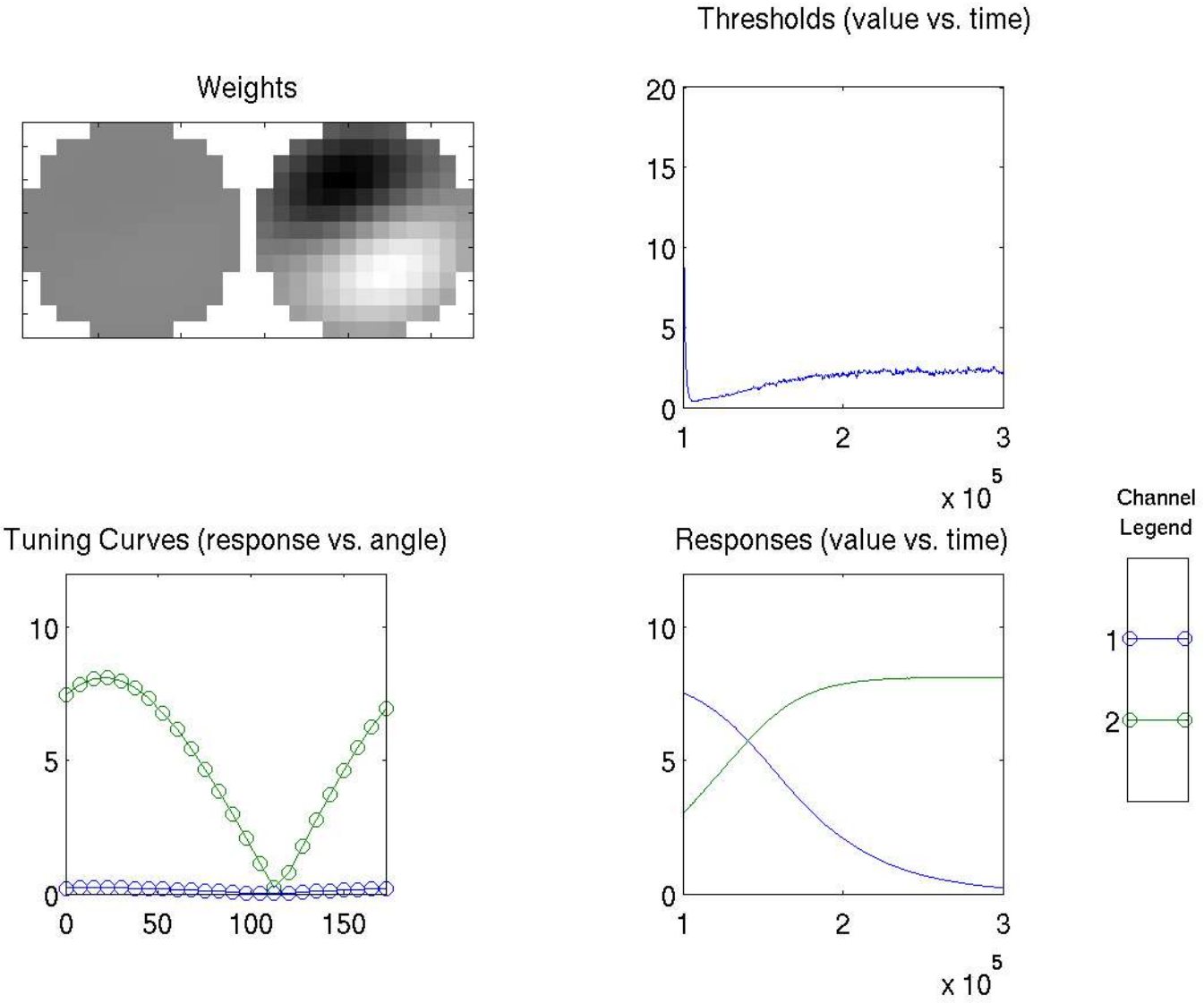
Cat with bias – MD, High noise, Hebbian Learning

Gaussian SD = 0.8



Cat with bias – MD, Low noise, Hebbian Learning

Gaussian SD = 0.01

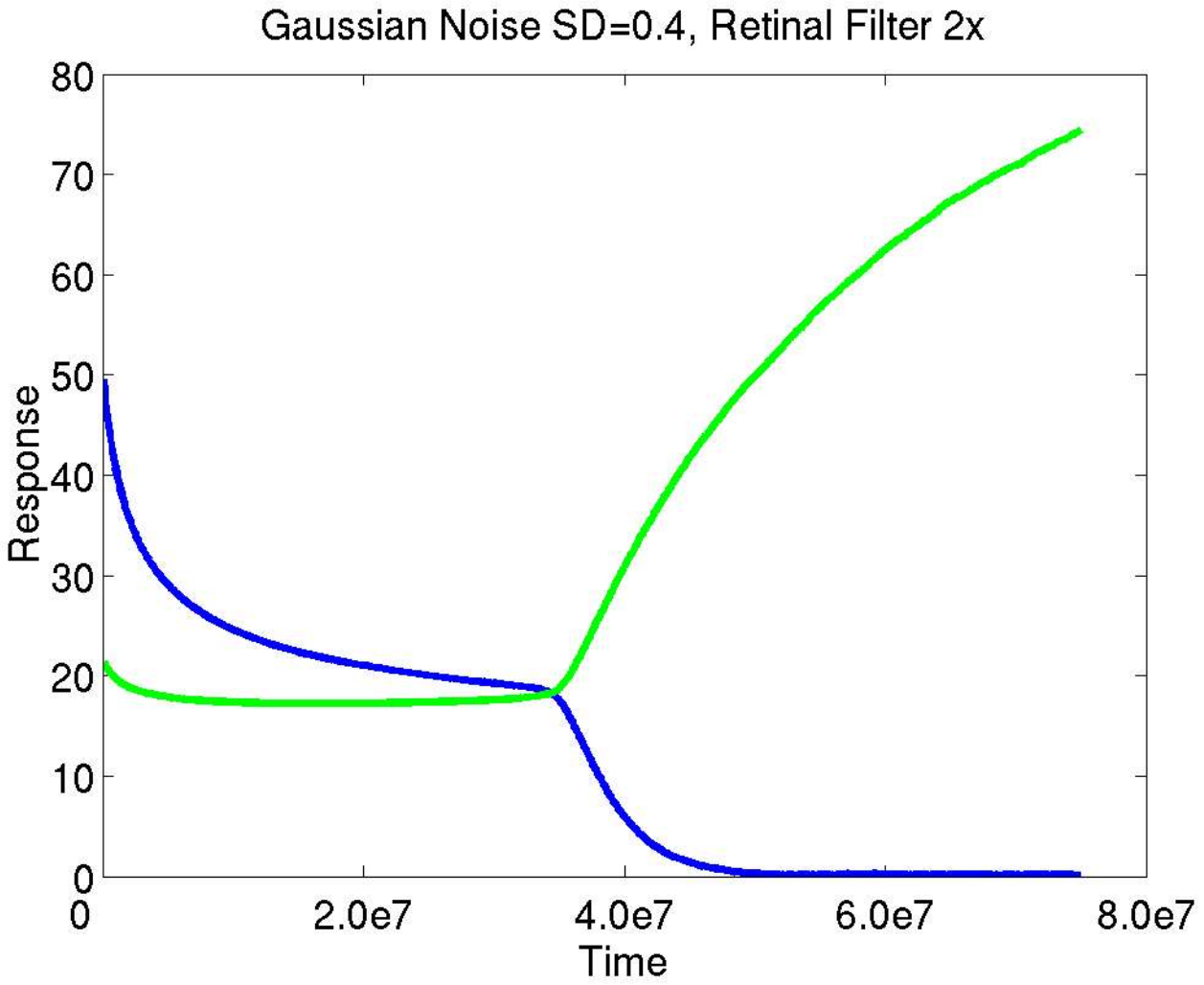


Some current problems with the BCM simulations

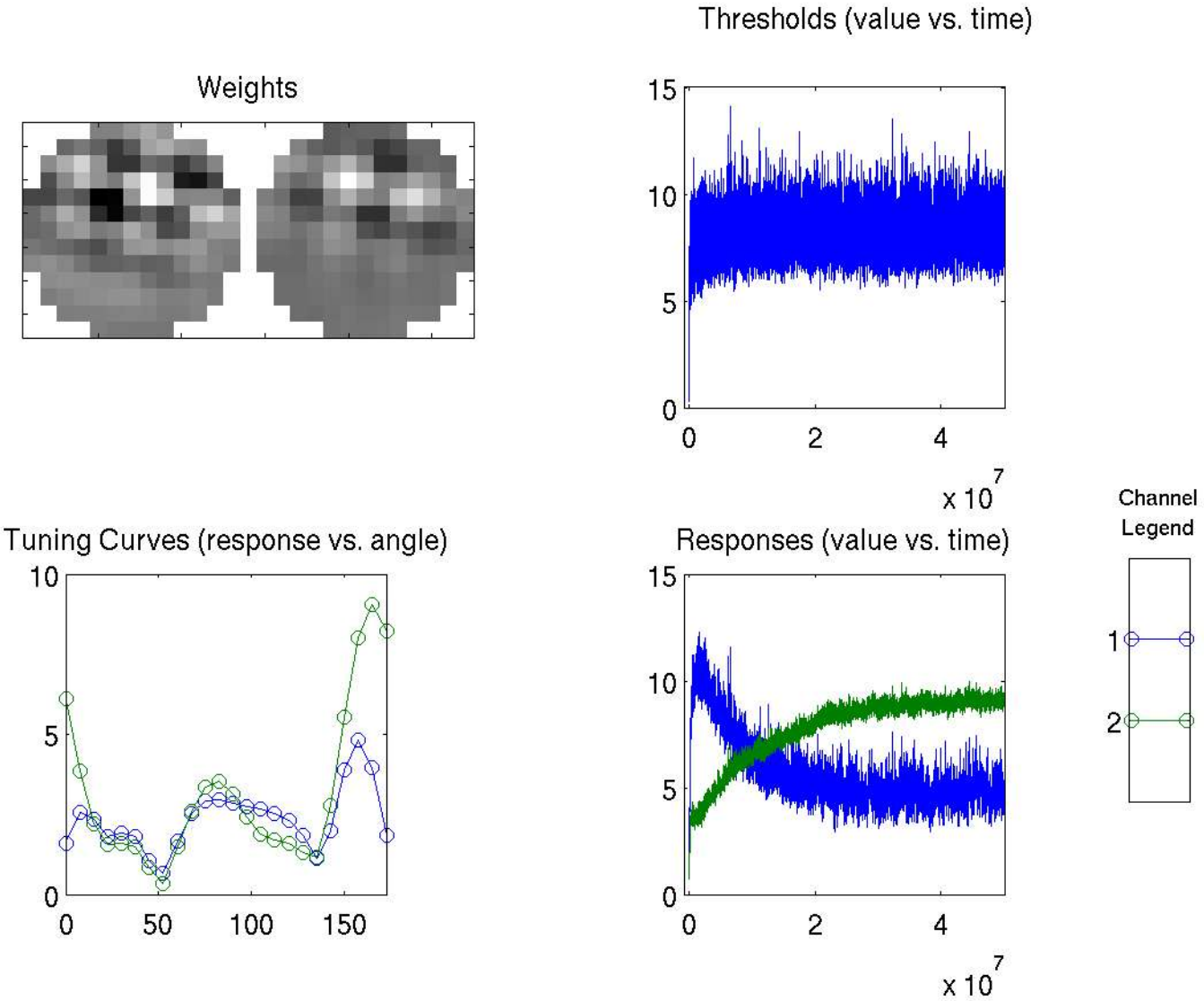
- Problem 1: How do we calculate the decay time?
- Problem 2: Dead weights bias instability

Problem 1: How do we calculate the decay time?

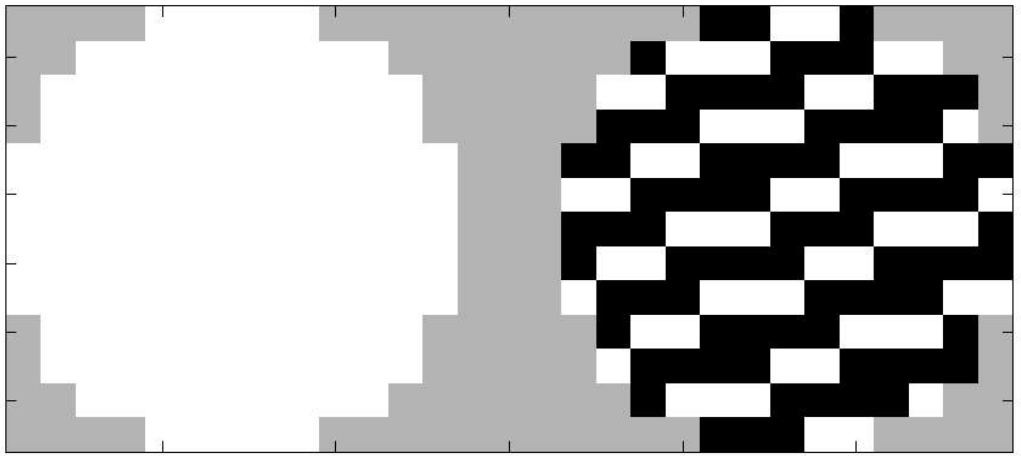
Mouse – NR, BCM

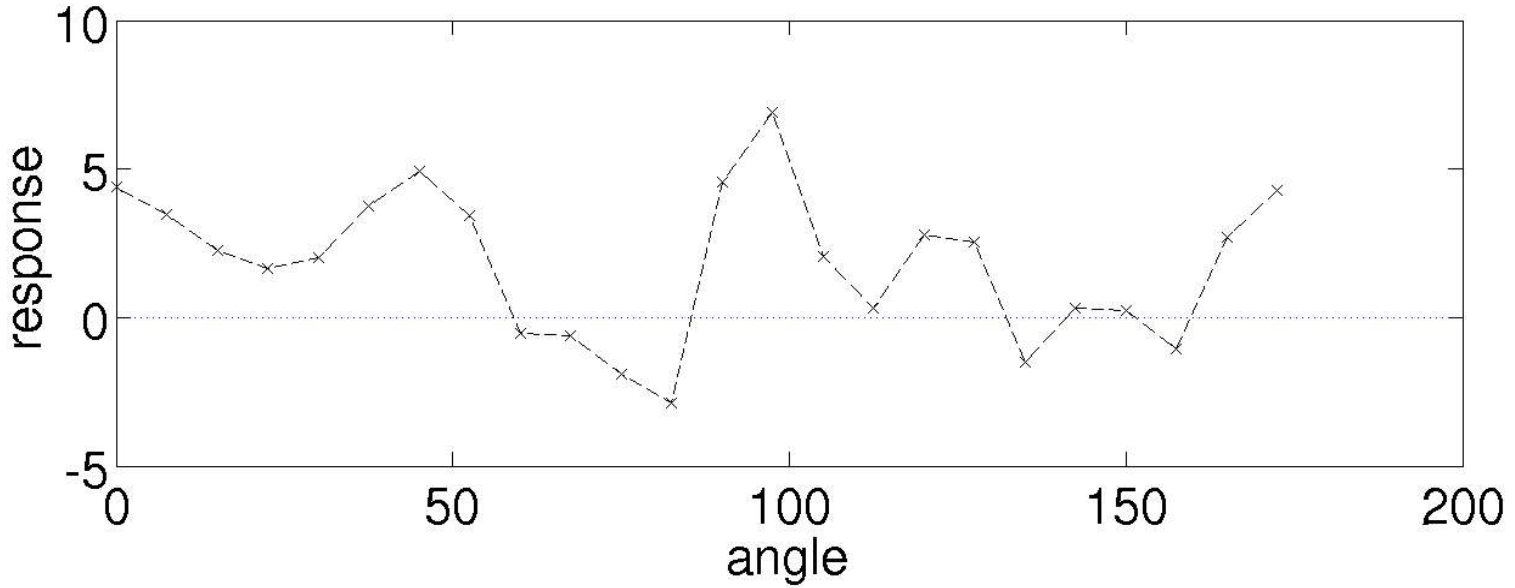


Problem 2: Dead weights instability: Cat with bias – NR

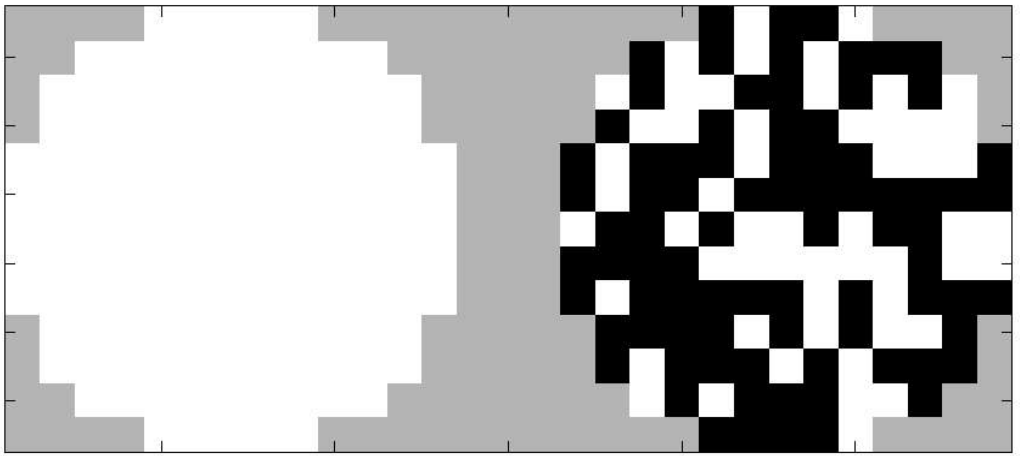


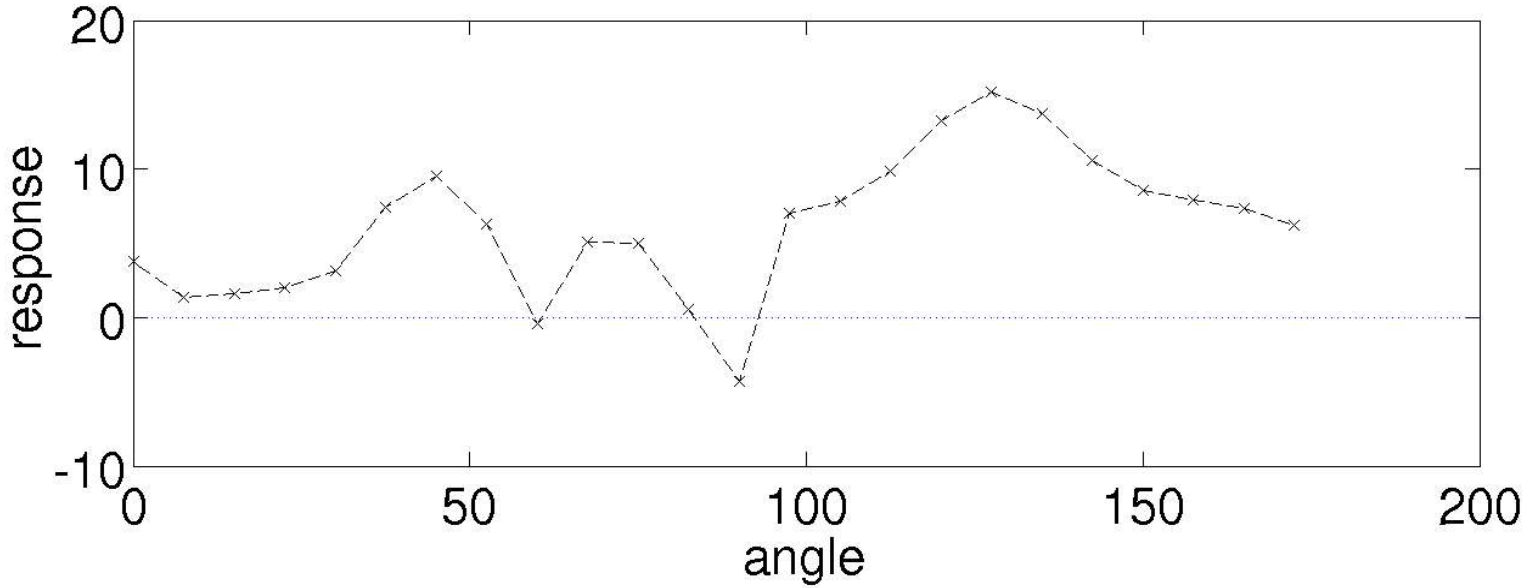
Dead weights method: Orientation problem





Dead weights method: Orientation problem



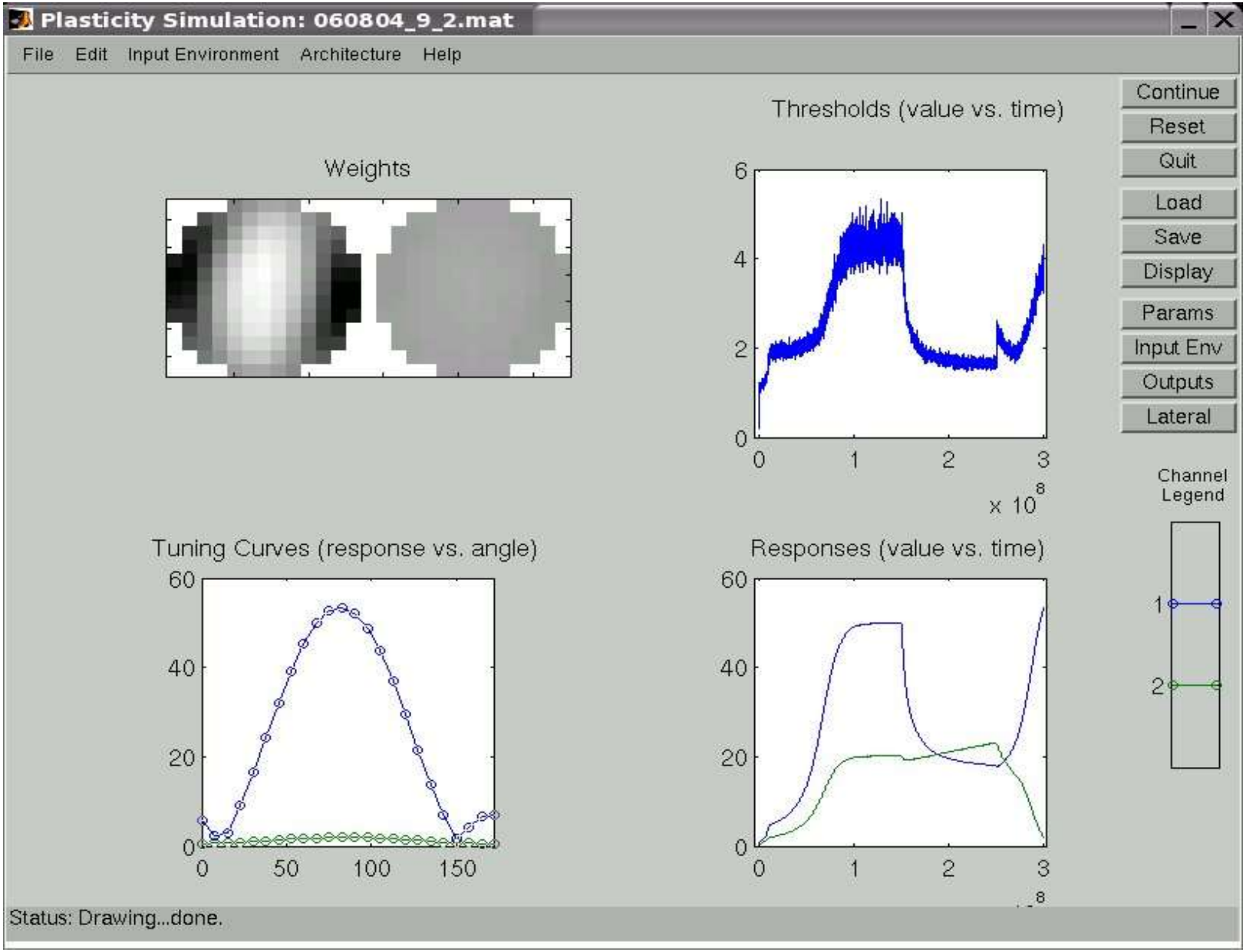


Conclusions

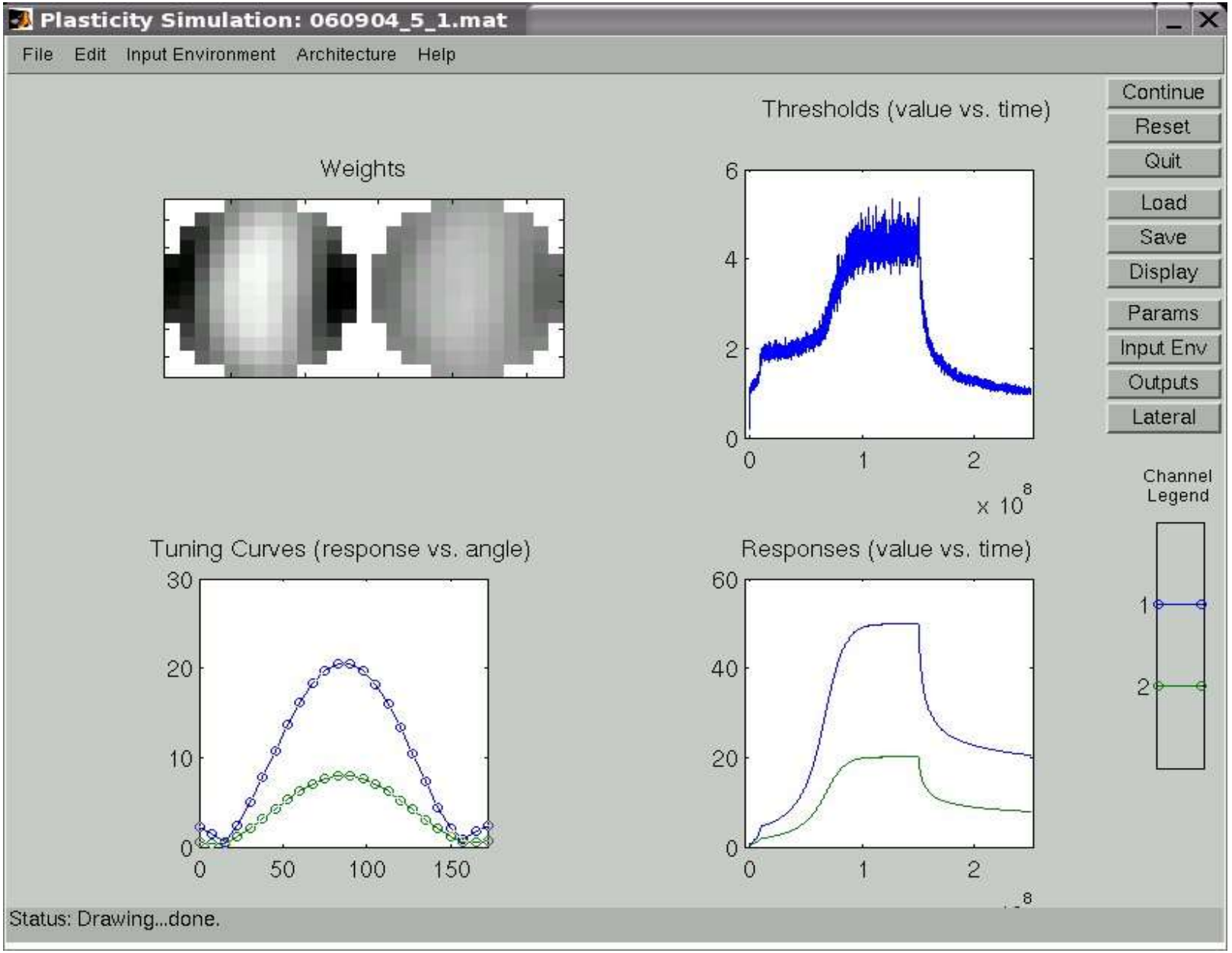
- Contralateral bias can effectively be implemented two ways:
  - Decreased image intensity
  - Decreased number of inputs
- Reproduce the results of Frenkel/Bear with BCM
  - Lid suture
    - Rapid response depression
    - Delayed response potentiation
  - TTX
    - Little or no response depression
    - Rapid response potentiation
- Cannot reproduce results using Hebbian or Kurtosis learning rules

Additional Slides

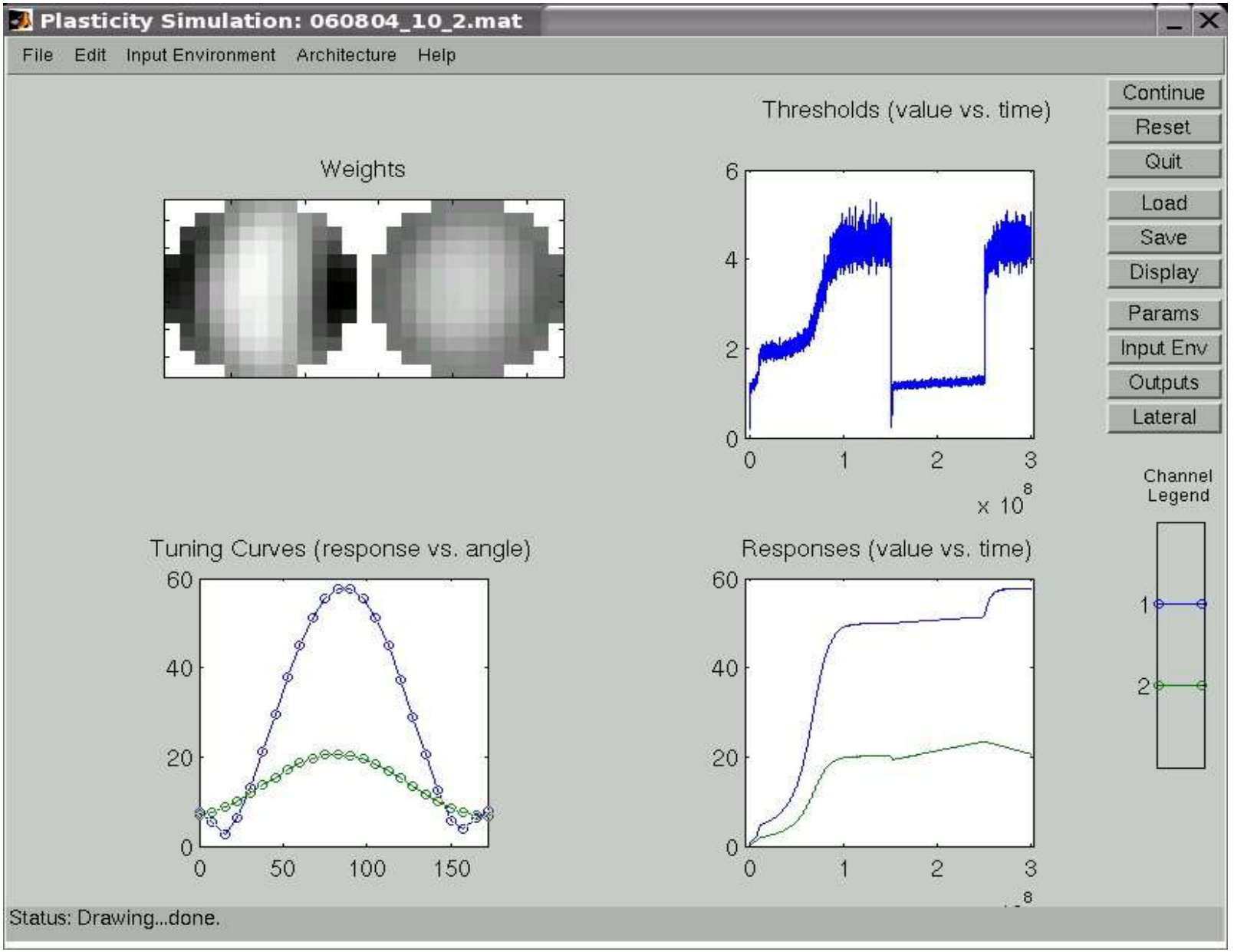
Reverse Suture
SD = 0.4



Binocular Deprivation
SD = 0.4



Reverse Suture
SD = 0.05



Binocular Deprivation
SD = 0.05