Amblyopia Research Update

June 1, 2023

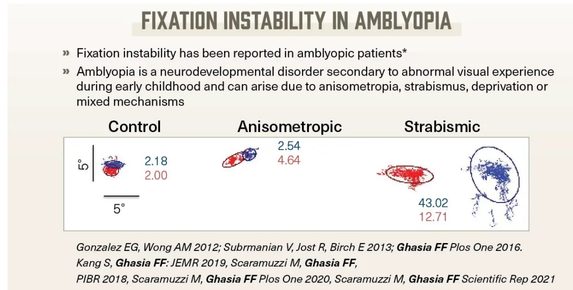
Brian Blais

Normal Vision Model

Normalization as a canonical neural computation

Matteo Carandini[1] and David J. Heeger[2]

NATURE REVIEWS | NEUROSCIENCE VOLUME 13 | JANUARY 2012 | 51

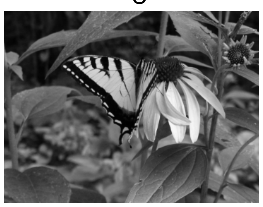


J Comp Neurol. 2010 June 1; 518(11): 2051–2070. doi:10.1002/cne.22321.

Receptive-field Properties of V1 and V2 Neurons in Mice and Macaque monkeys

Gert Van den Bergh[1,2], Bin Zhang[1], Lutgarde Arckens[2], and Yuzo M. Chino[1]

Images



Intensities: I

Mean and Std Dev: I_m, I_σ

→

Photoreceptors

the light adaptation of photoreceptors - responses reflect contrast (i.e. difference from the mean)

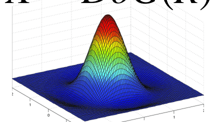
$$R = (I - I_m)/I_\sigma$$

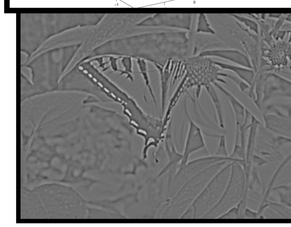
→

Ganglion Cells

contrast normalization effect of a suppressive field, e.g. difference of Gaussians

$$X \sim DoG(R)$$





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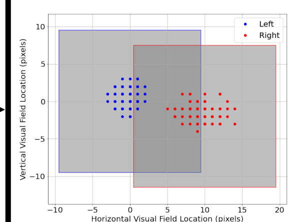
Jitter



→

Visual Cortex

Ghasia FF Plos One 2016.

Normal: variation ~ 2º + 2º

Amblyopic: variation ~ 2º + 4º

Bergh et al 2010

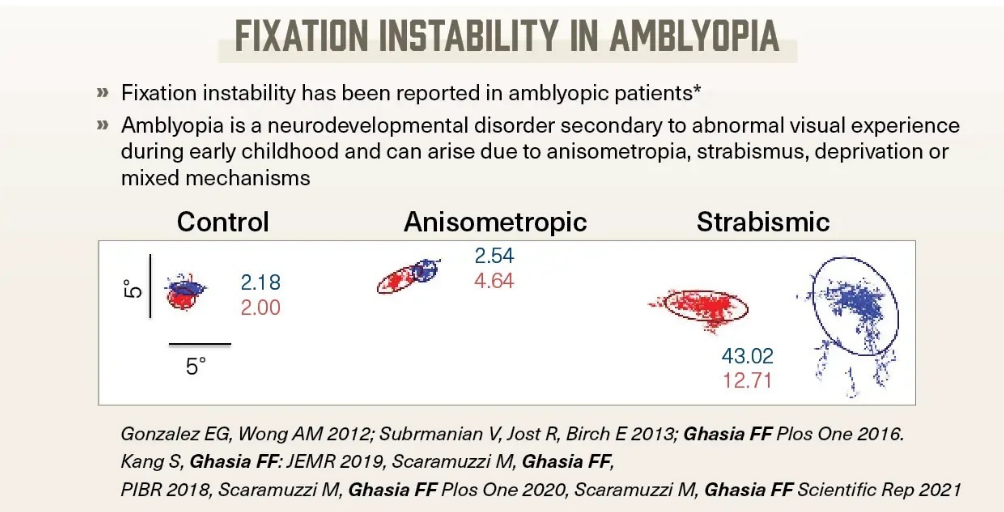
V1 RF size: ~ 8º

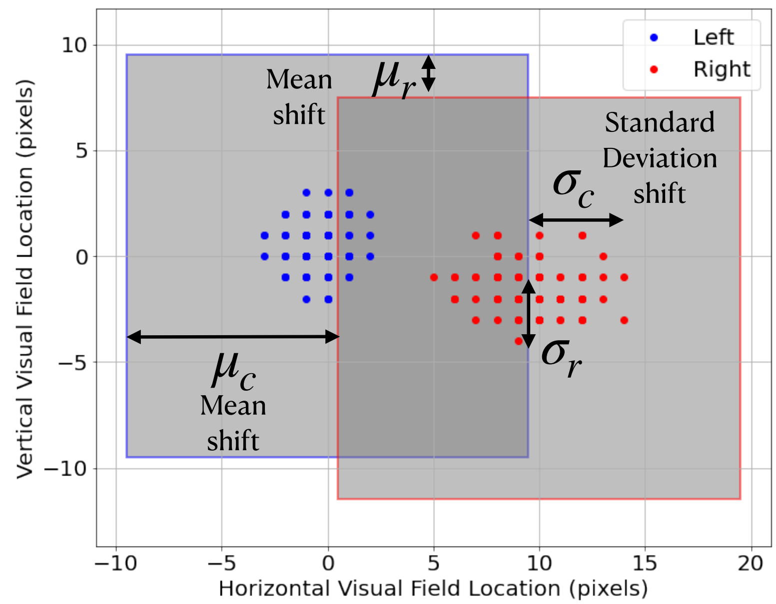
bblais

V1 RF size: 19px

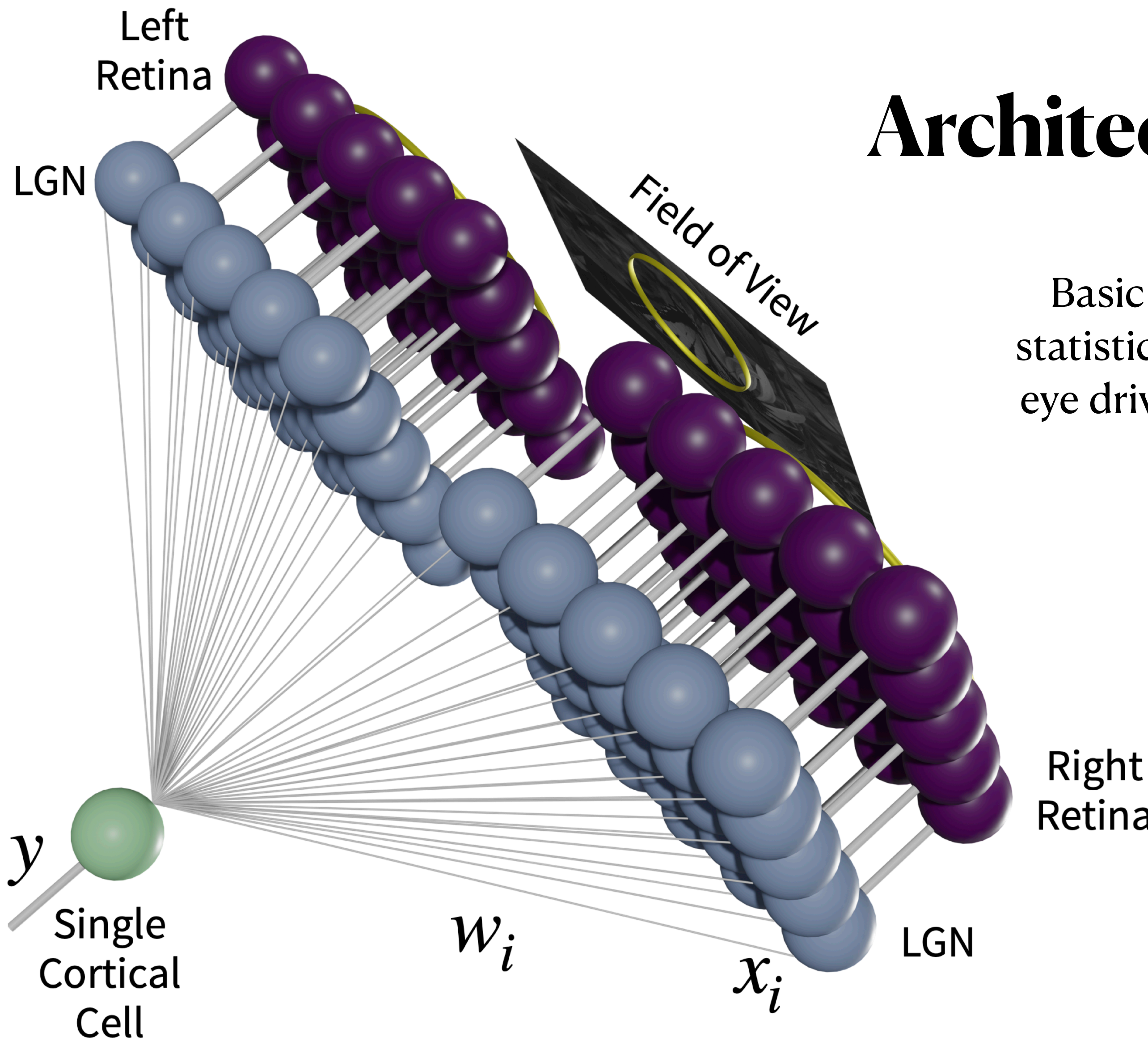
Jitter: $\mu = 7.5, \sigma = 2$

Strabismic Shift and Jitter



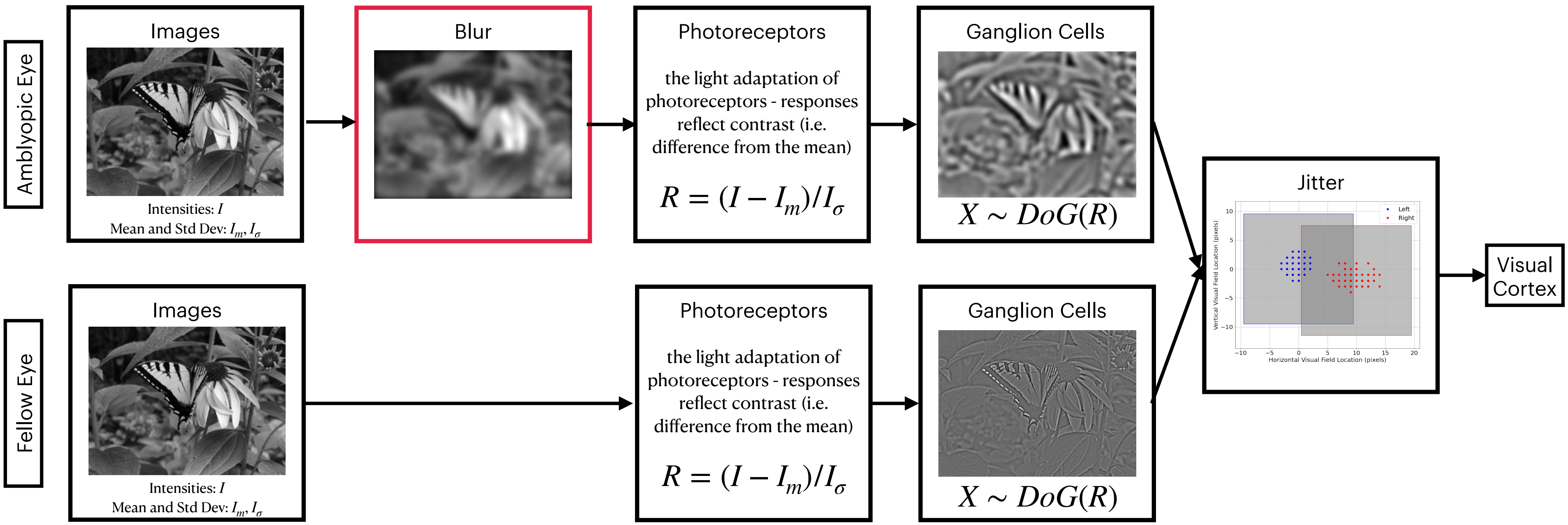


Architecture

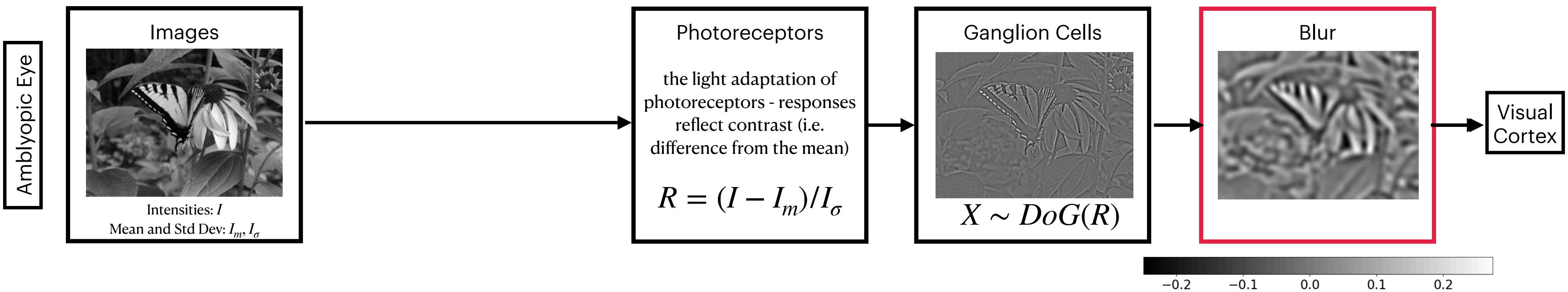


Basic idea: Differences in the statistics of the inputs from each eye drive the dynamics of deficit and recovery

Vision Deficit Model

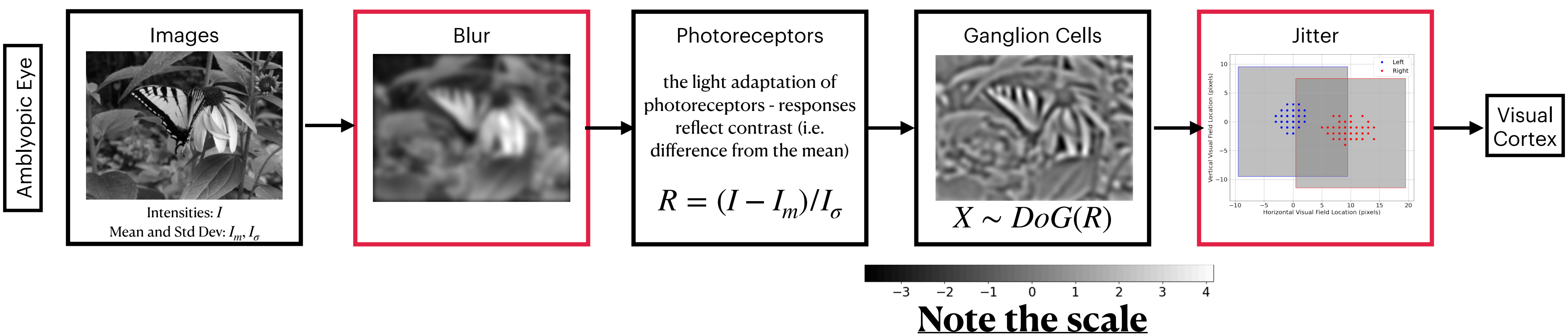


Old Deficit Model

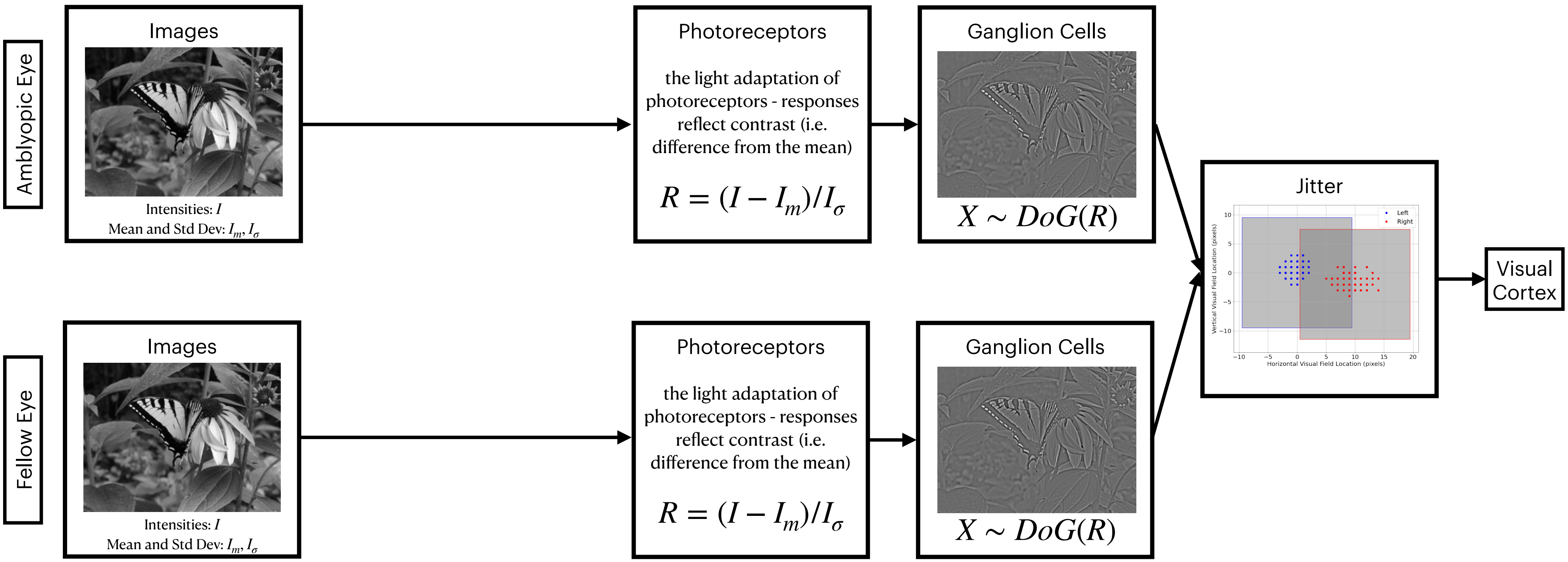


Note the scale

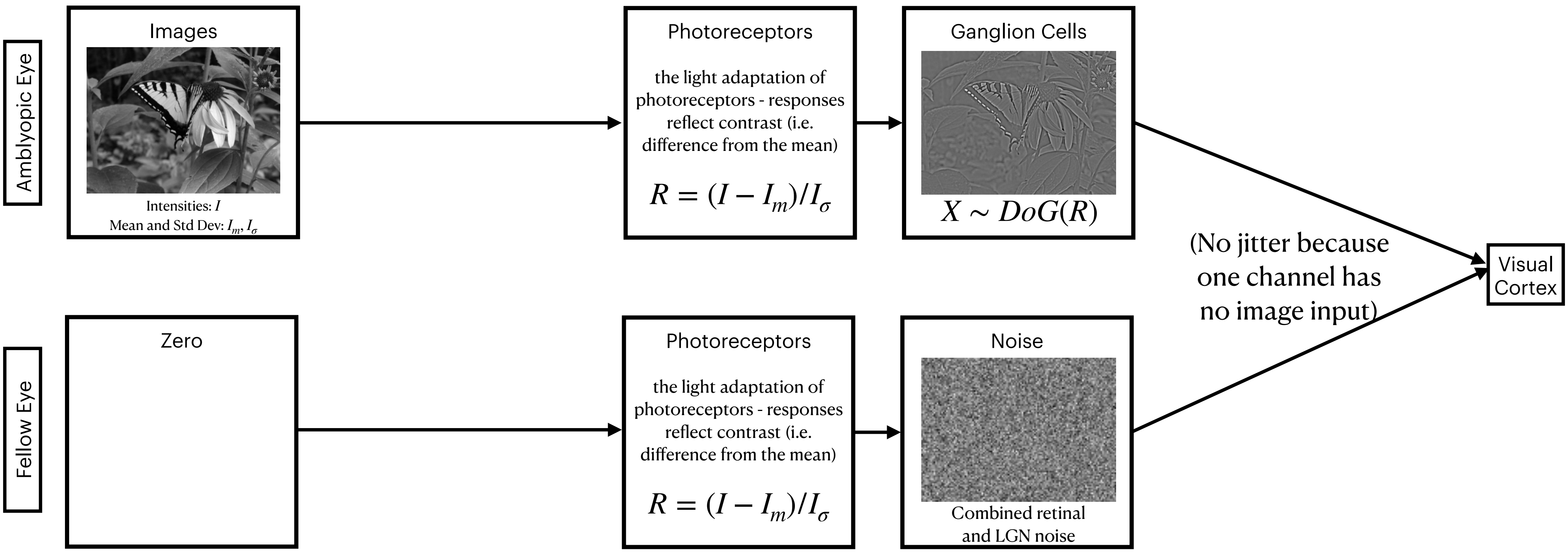
New Deficit Model



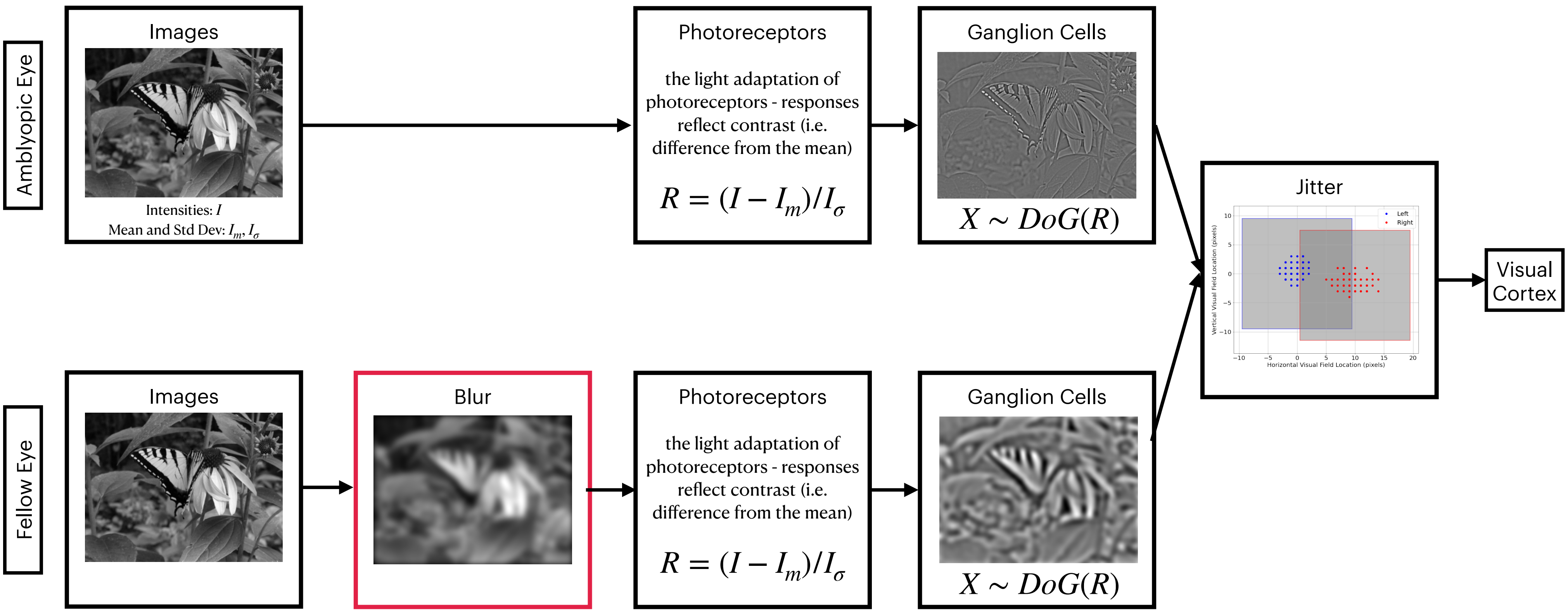
Optical Fix Model



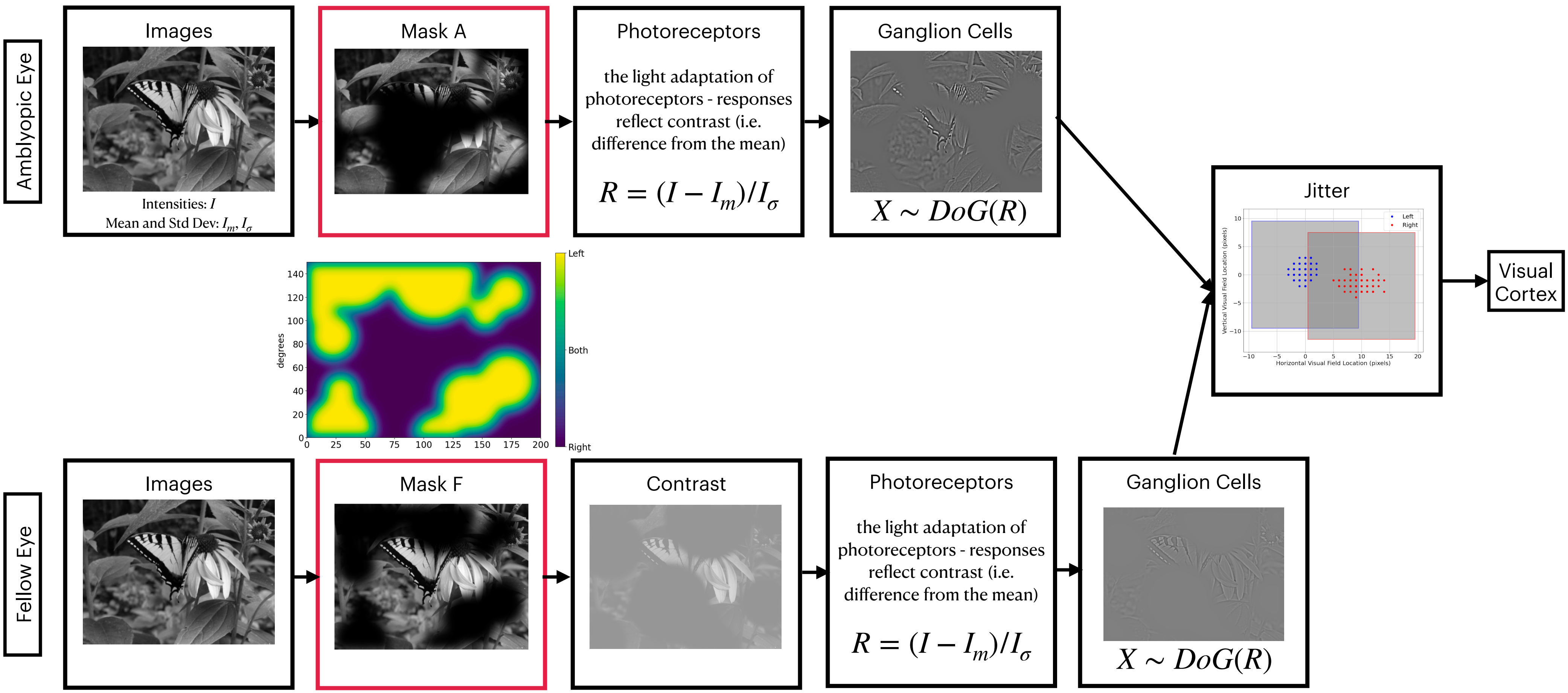
Patch Model


Amblyopic Eye
Images
Intensities: I
Mean and Std Dev: I_m, I_σ
Photoreceptors
the light adaptation of photoreceptors - responses reflect contrast (i.e. difference from the mean)
$R = (I - I_m)/I_\sigma$
Ganglion Cells
$X \sim DoG(R)$
(No jitter because one channel has no image input)
Visual Cortex
Fellow Eye
Zero
Photoreceptors
the light adaptation of photoreceptors - responses reflect contrast (i.e. difference from the mean)
$R = (I - I_m)/I_\sigma$
Noise
Combined retinal and LGN noise

Atropine Model



Contrast/Mask Model



Images

118 images 600 x 800 pixels



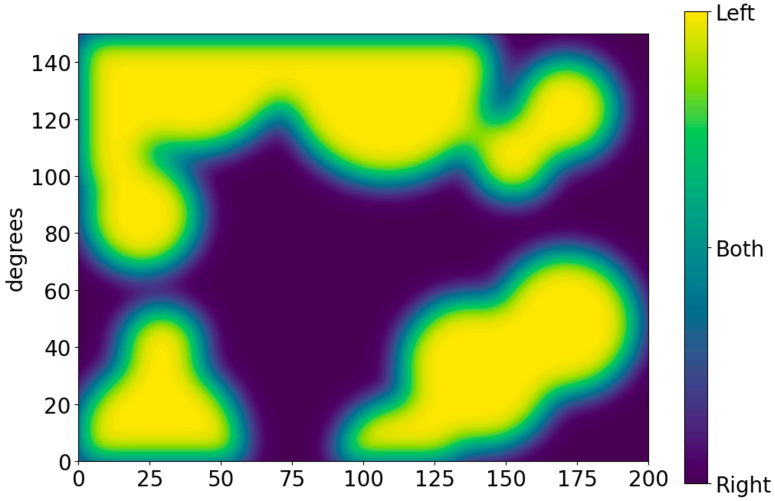




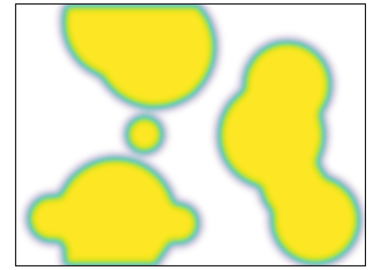





Masks



f=10



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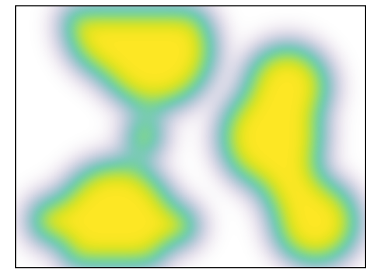

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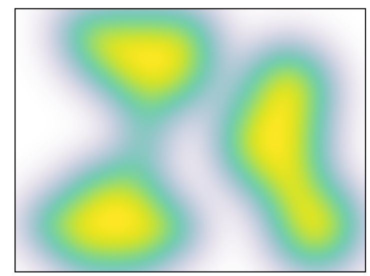
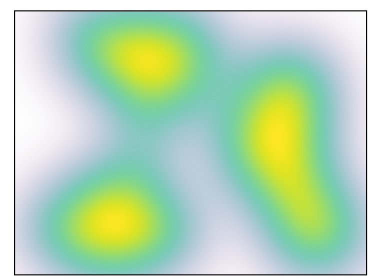


f=70

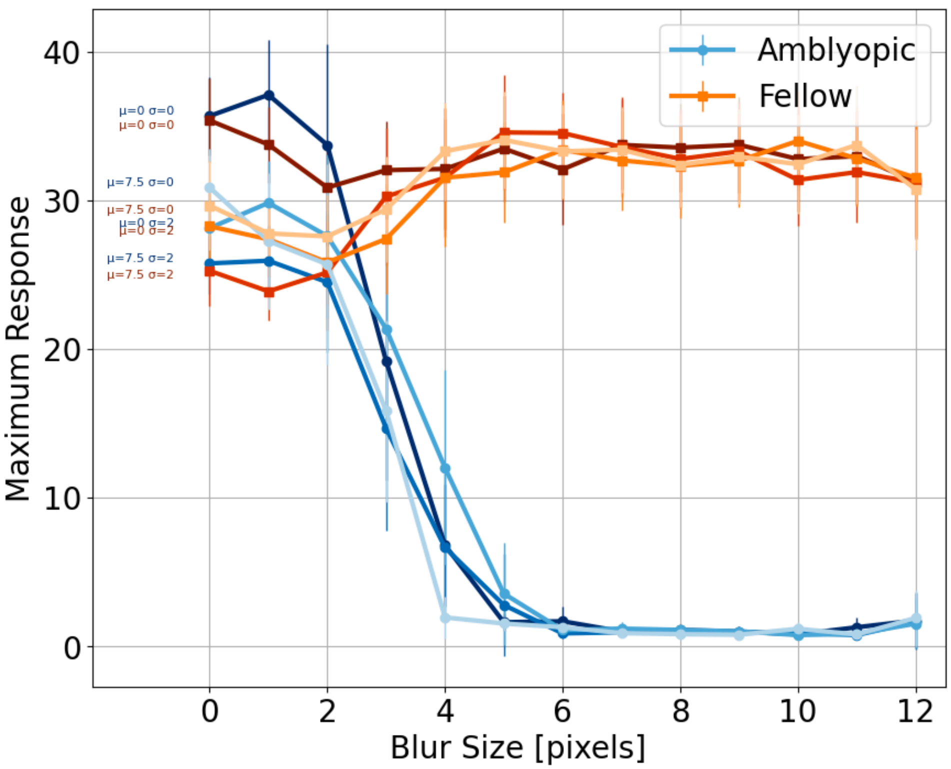


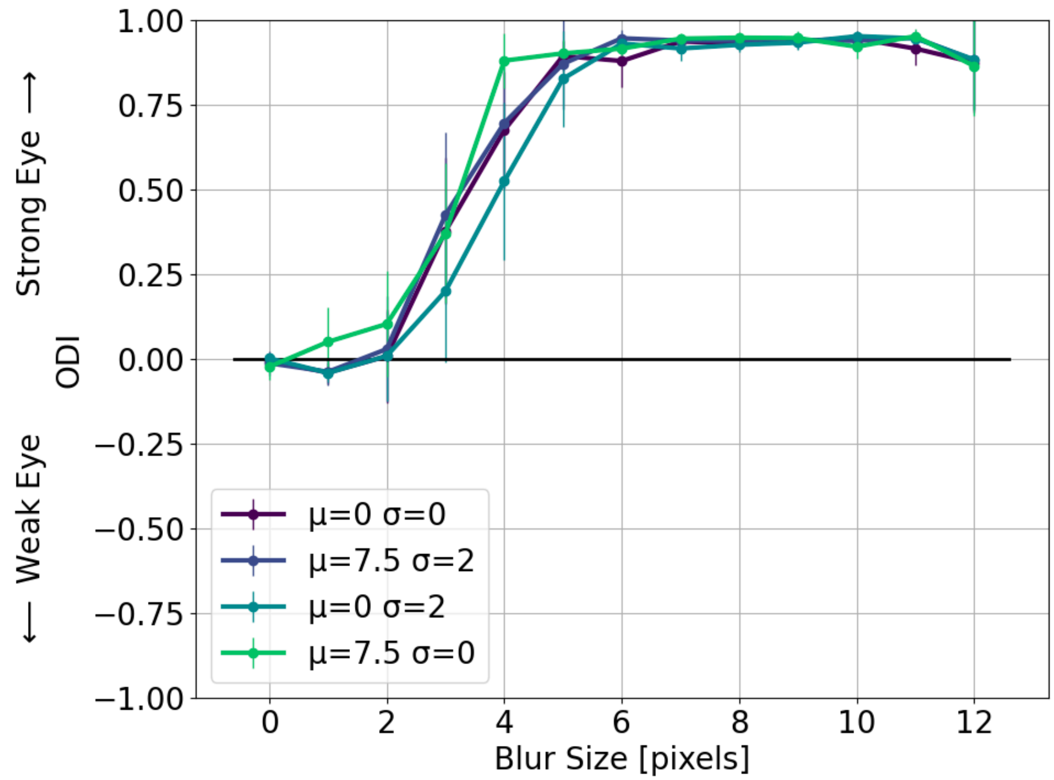
Results to Follow

- Comments and results will be formatted like this

☐ Open questions/things to explore will be formatted like this

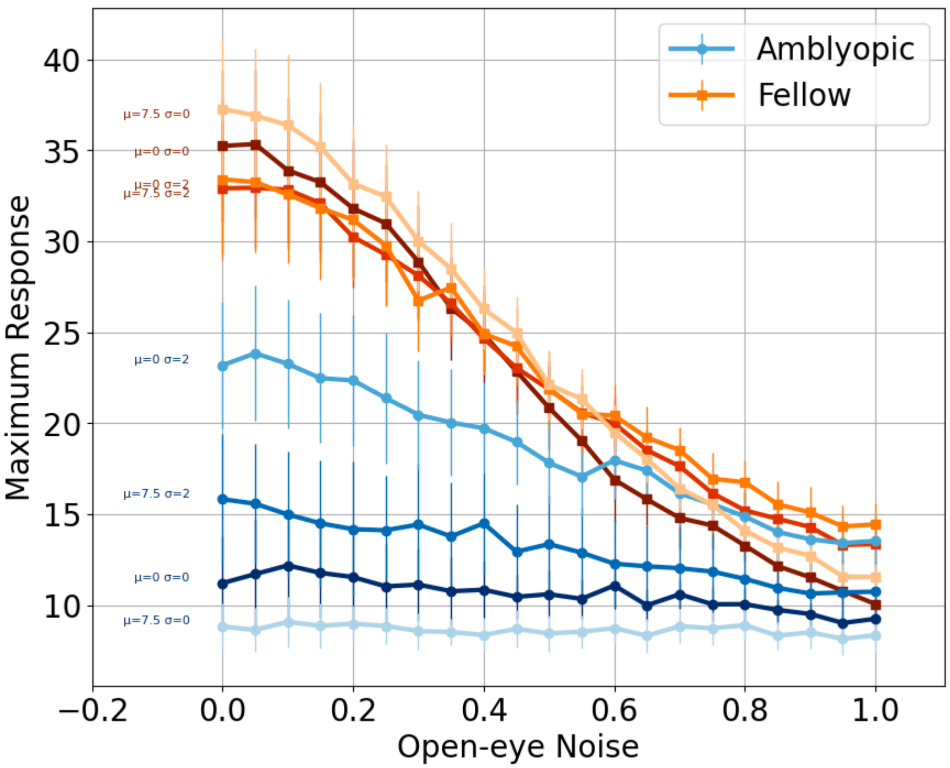
Deficit

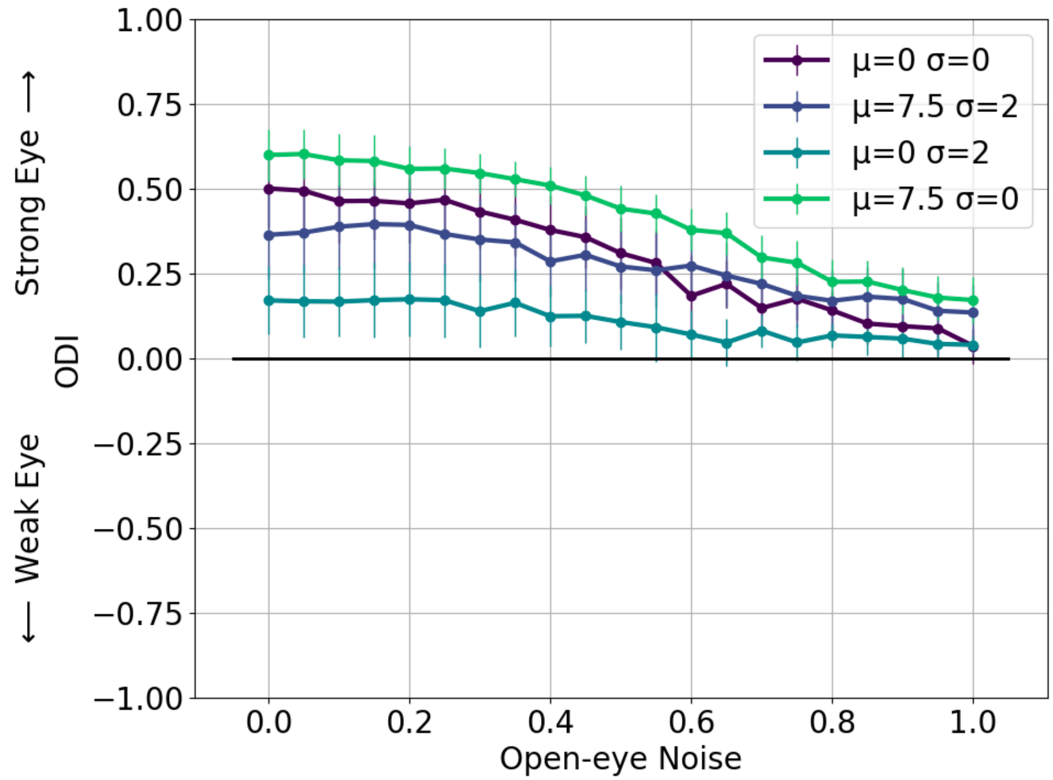




- Jitter does very little other than make the variation higher
- Choosing blur=4 for the subsequent simulations

Optical Fix



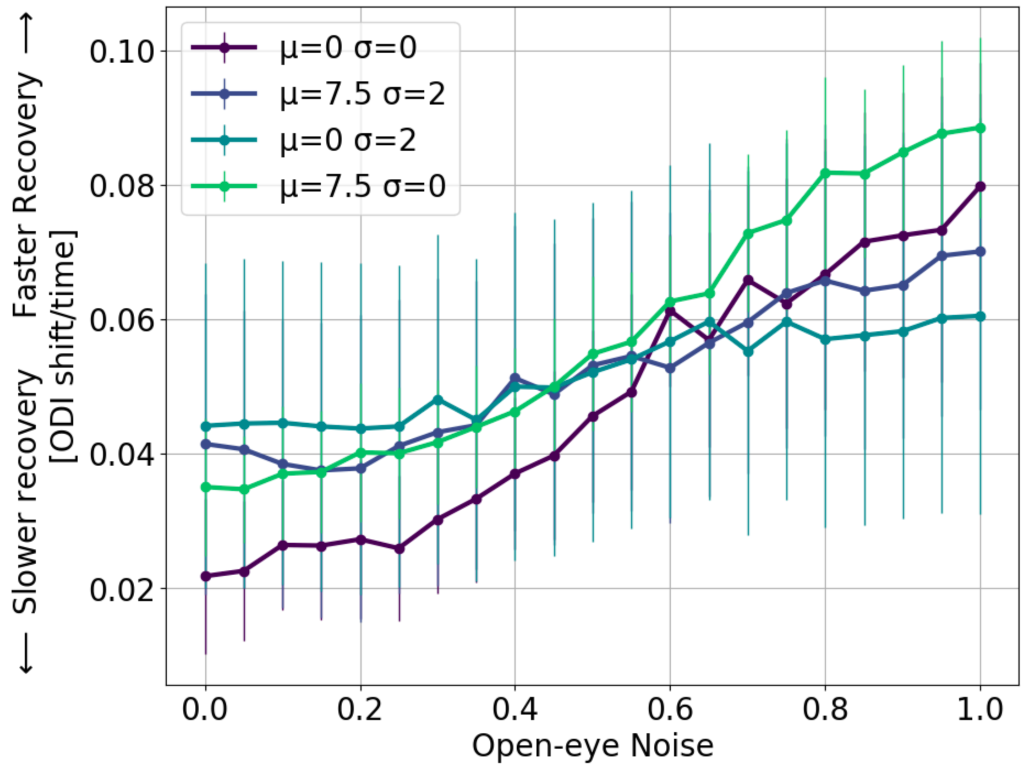


☐ Not sure how to interpret the effect on the optical fix from the jitter+noise

- Larger noise increases rate of recovery
- Choose open-eye noise = 0.1 for all simulations (other than these)

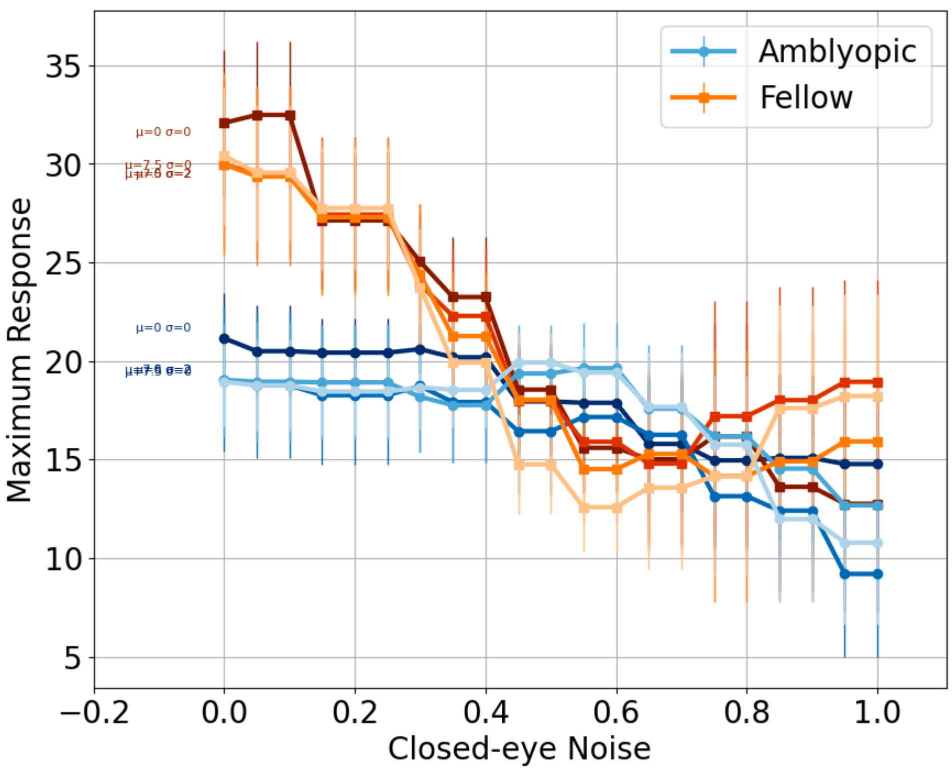
Optical Fix

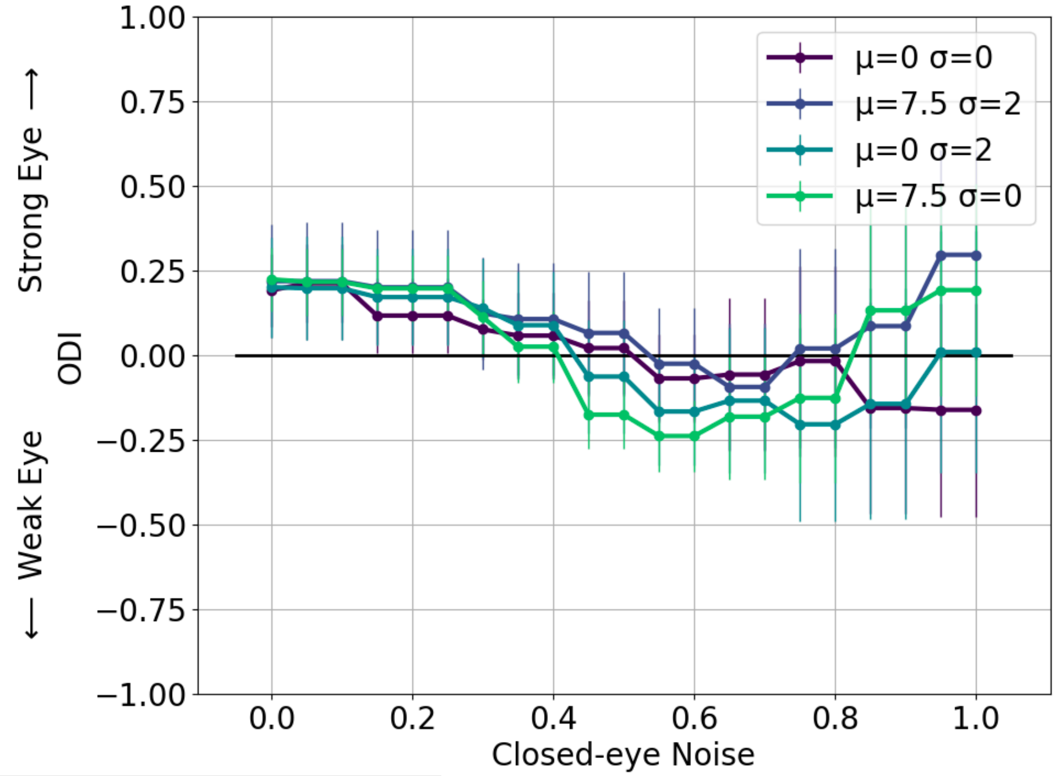
Rate of recovery



- Larger noise increases rate of recovery
- Choose open-eye noise = 0.1 for all simulations (other than these)

Patch Treatment

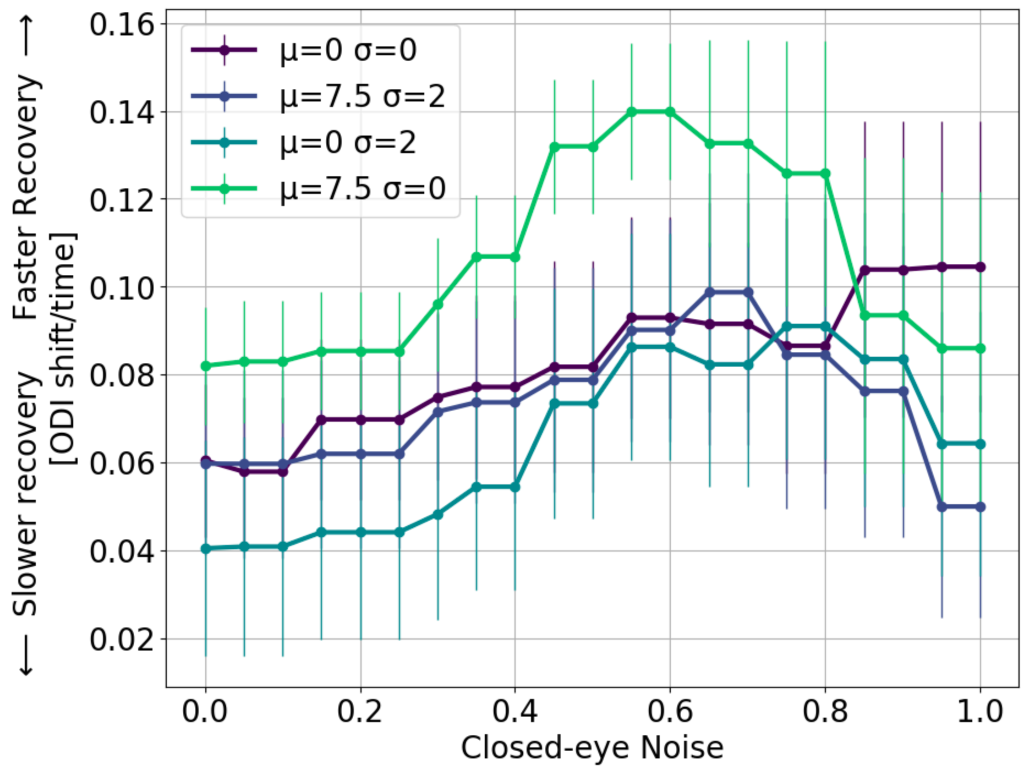




- Jitter does very little other than make the variation higher
- Larger noise yields much larger variation

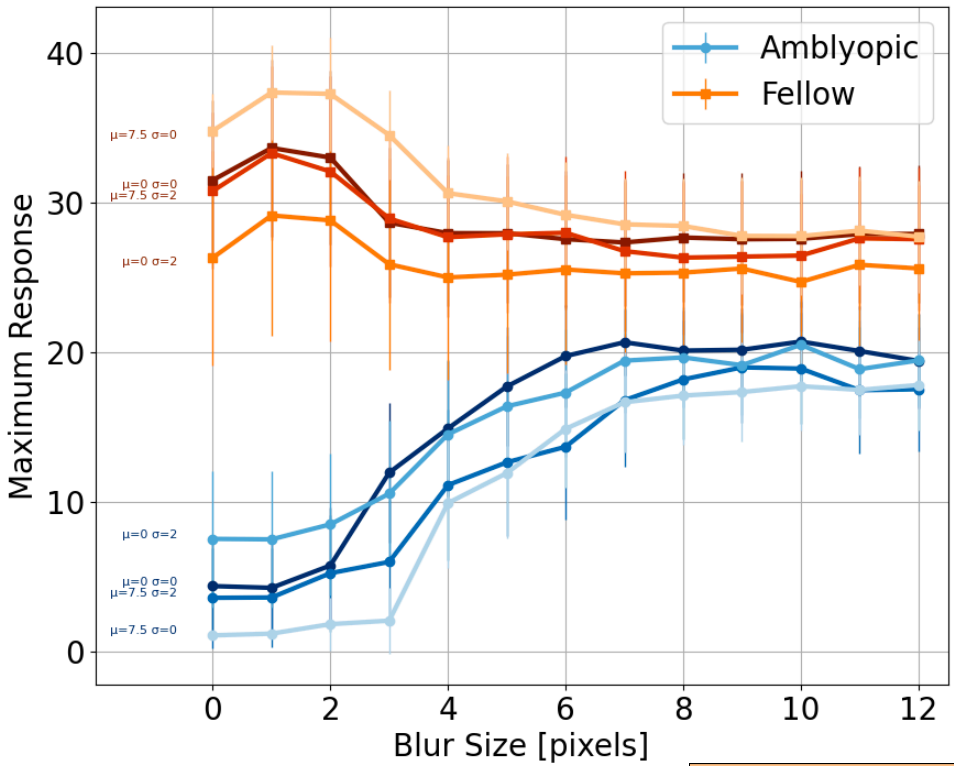
Patch Treatment

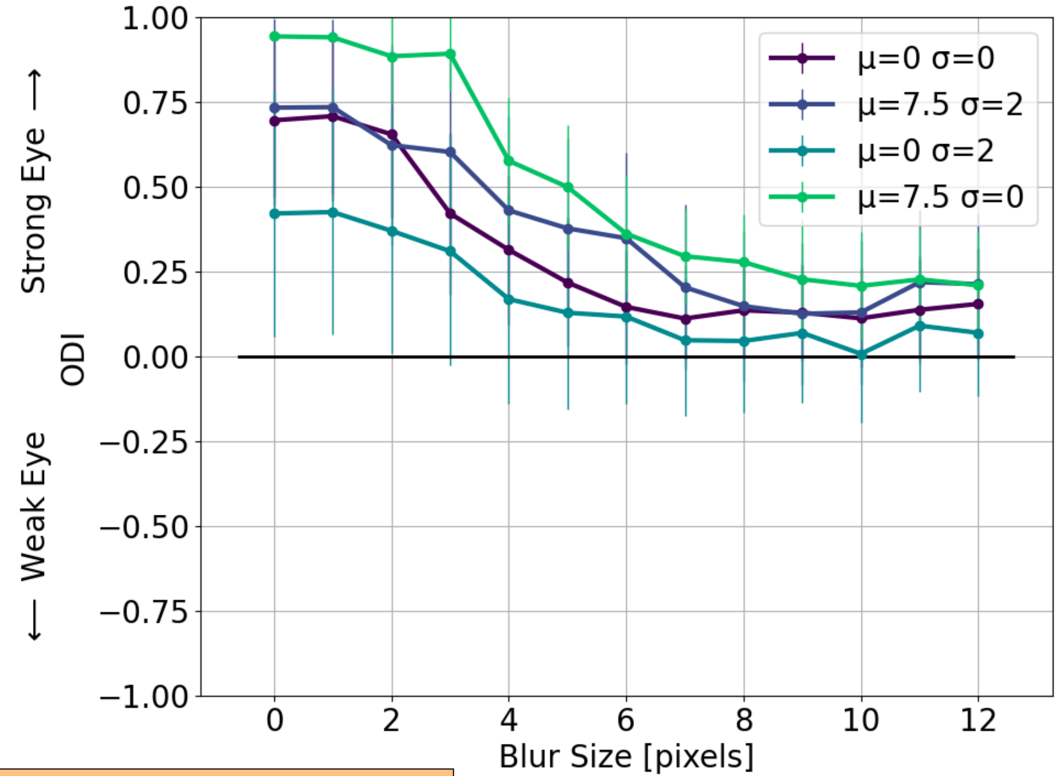
Rate of recovery



☐ Not sure why the rate reduces for large noise — even though the change may not be statistically significant

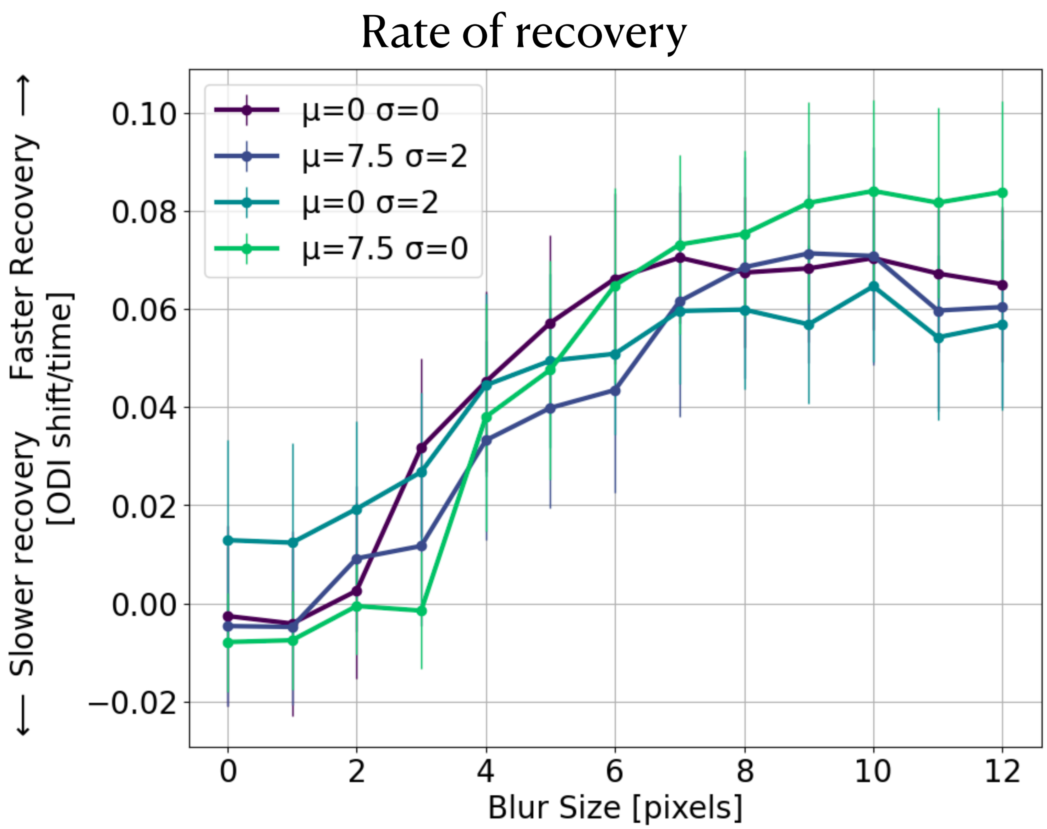
Atropine Treatment





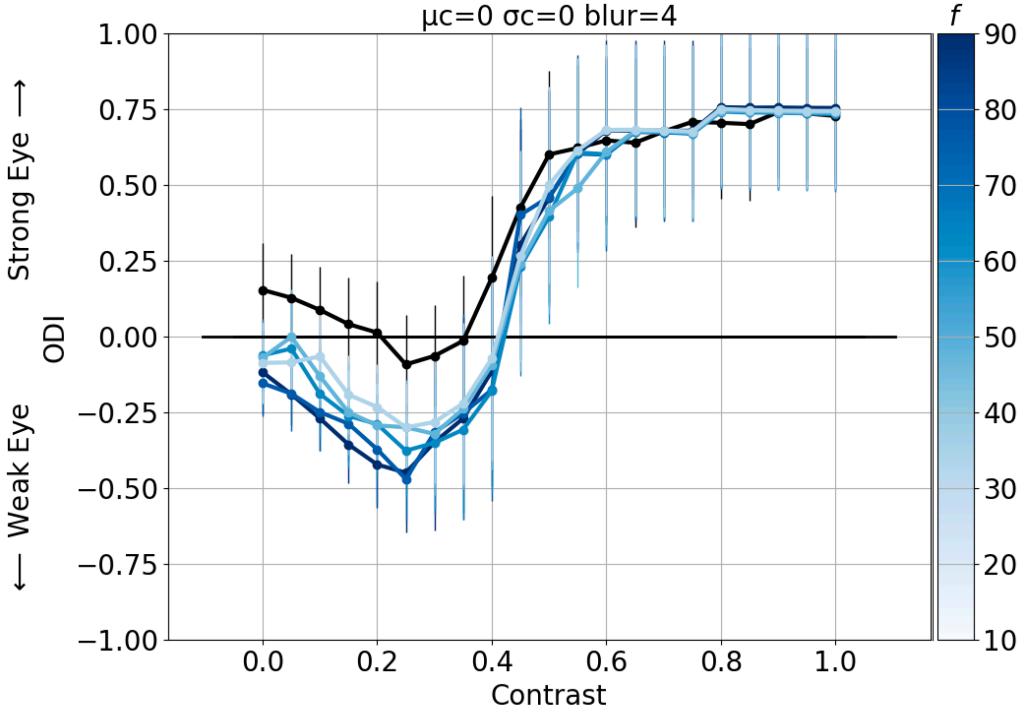
- Jitter does very little other than make the variation higher

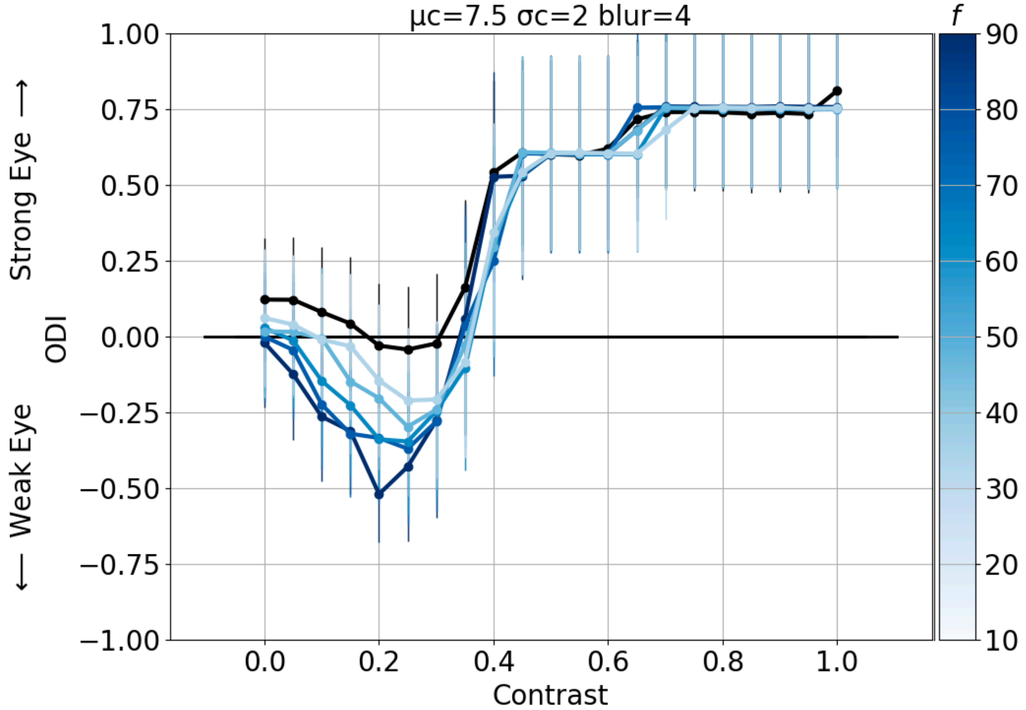
Atropine Treatment



- Recovery rate saturates for high blur value

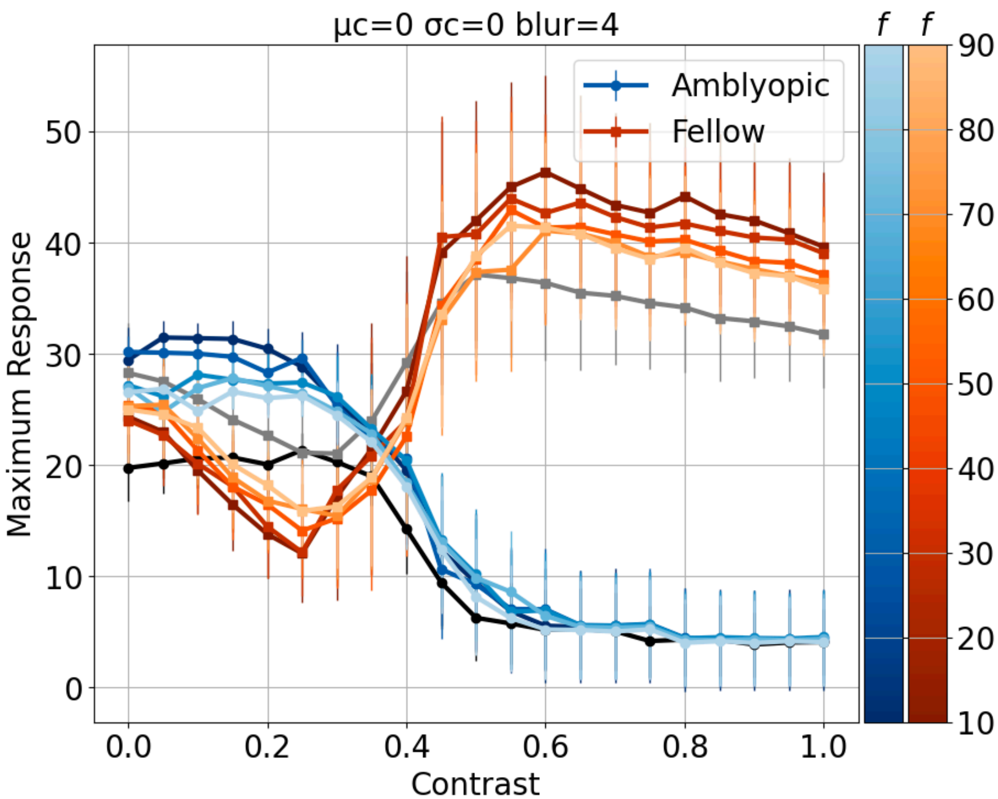
Contrast + Mask

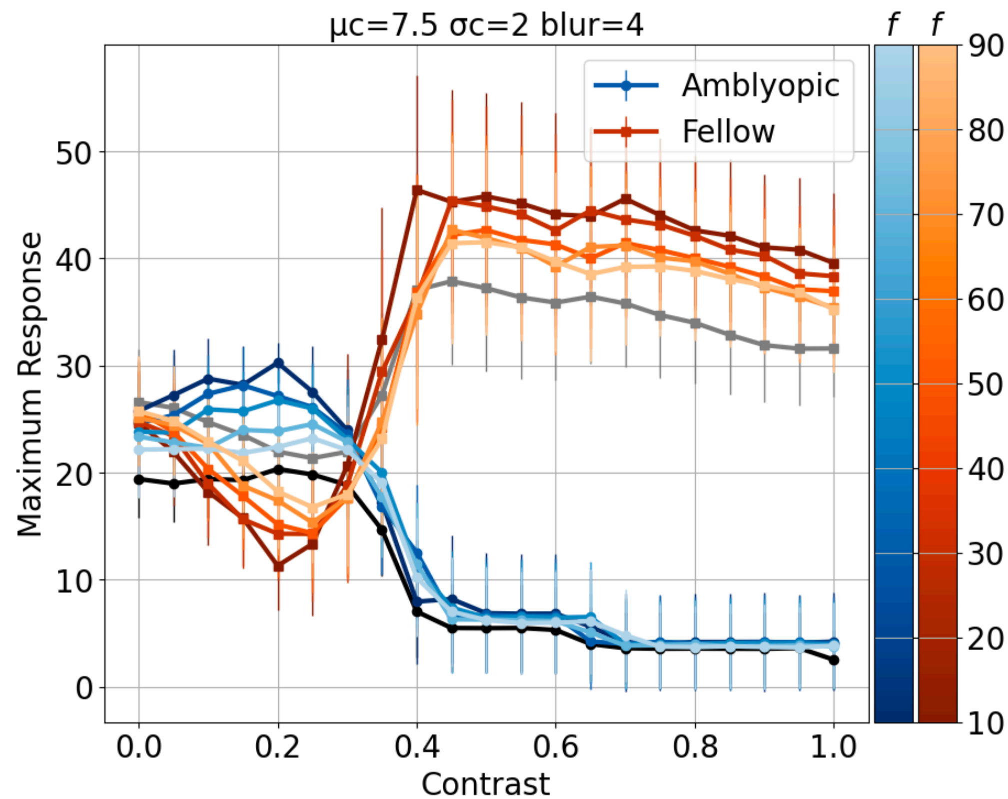




- Jitter does very little other than make the variation higher
- If the strong-eye contrast is too low (less than around 0.4) —> reverse amblyopia
- The mask fuzziness increases this effect —> the sharper the mask the faster the effect

Contrast + Mask

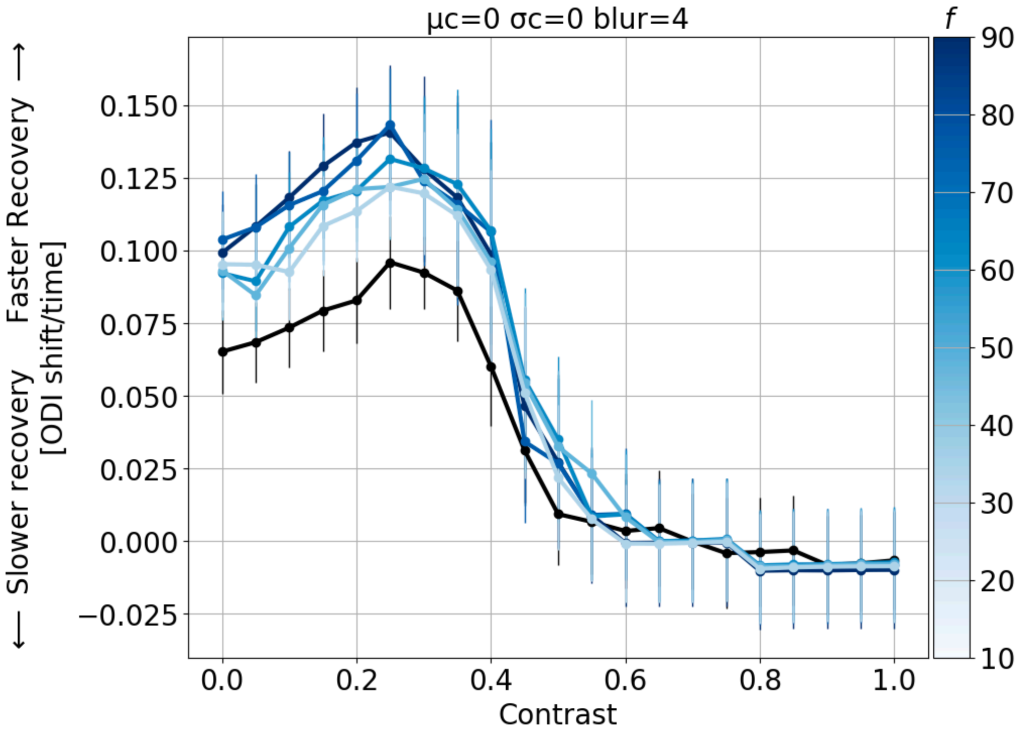


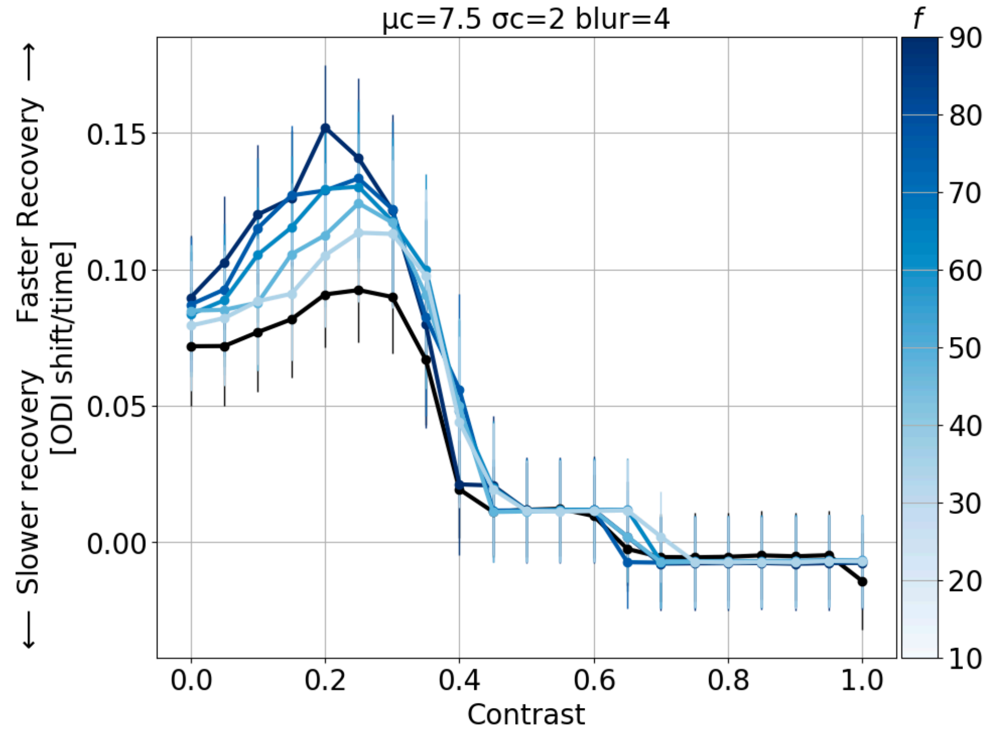


- Jitter does very little other than make the variation higher
- Suggests that one could reduce the speed of the recovery by making the masks fuzzier (i.e. more overlap)

Contrast + Mask

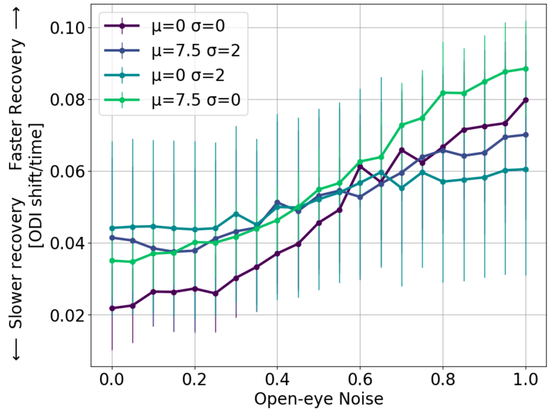
Rate of recovery



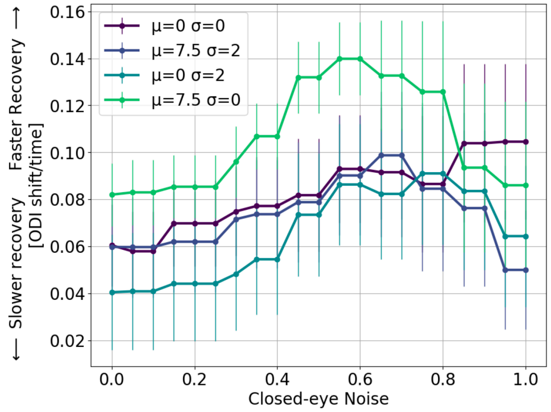


Rate of Recovery Summary

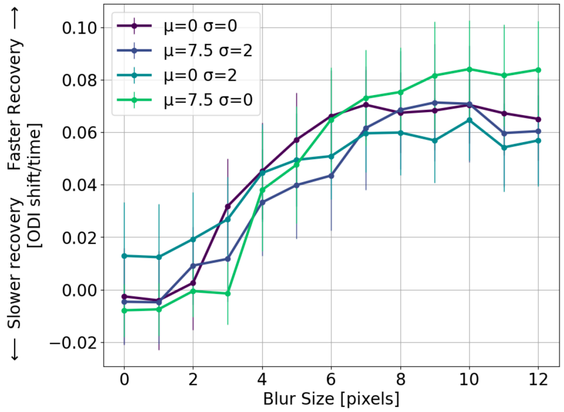
Optical Fix



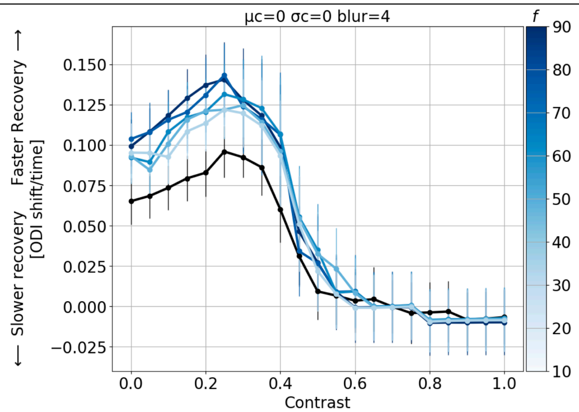
Patch Treatment



Atropine



Contrast+mask



Contrast+mask