Drift Gain Projects

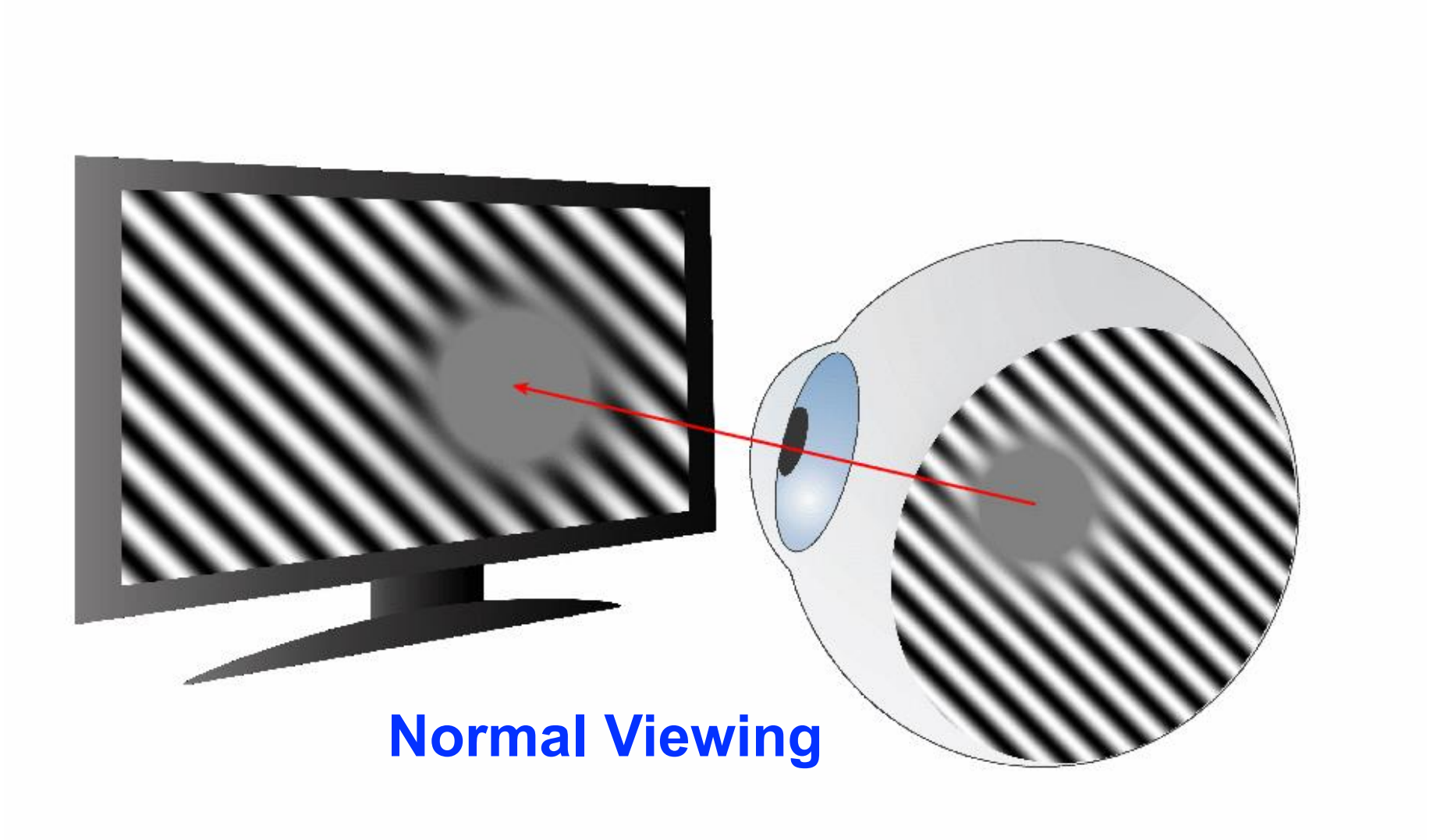
Drift Gain Projects

1. Free View at gains [0, .5, 1, 2, 3] (with and without scotoma)
2. 16cpd gratings at gains [0, .5, 1, 2, 3] (with scotoma)
3. 10cpd gratings at gains [.75, 1, 1.2] (with scotoma)

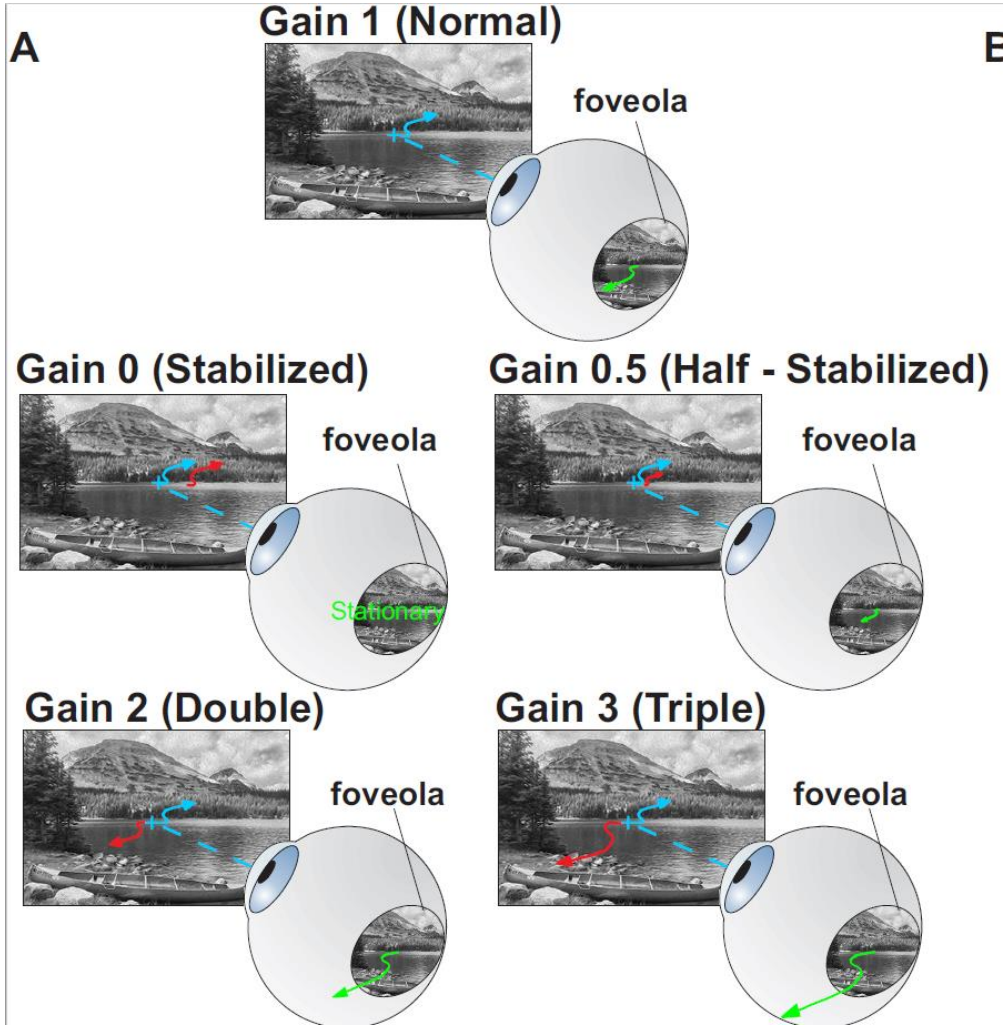
Objectives:

1. Do we change ocular drift characteristics to maintain a target amount of retinal image motion?
2. Do temporal modulations matter outside the foveola?
3. How much retinal image motion is optimal?

Artificial Scotoma

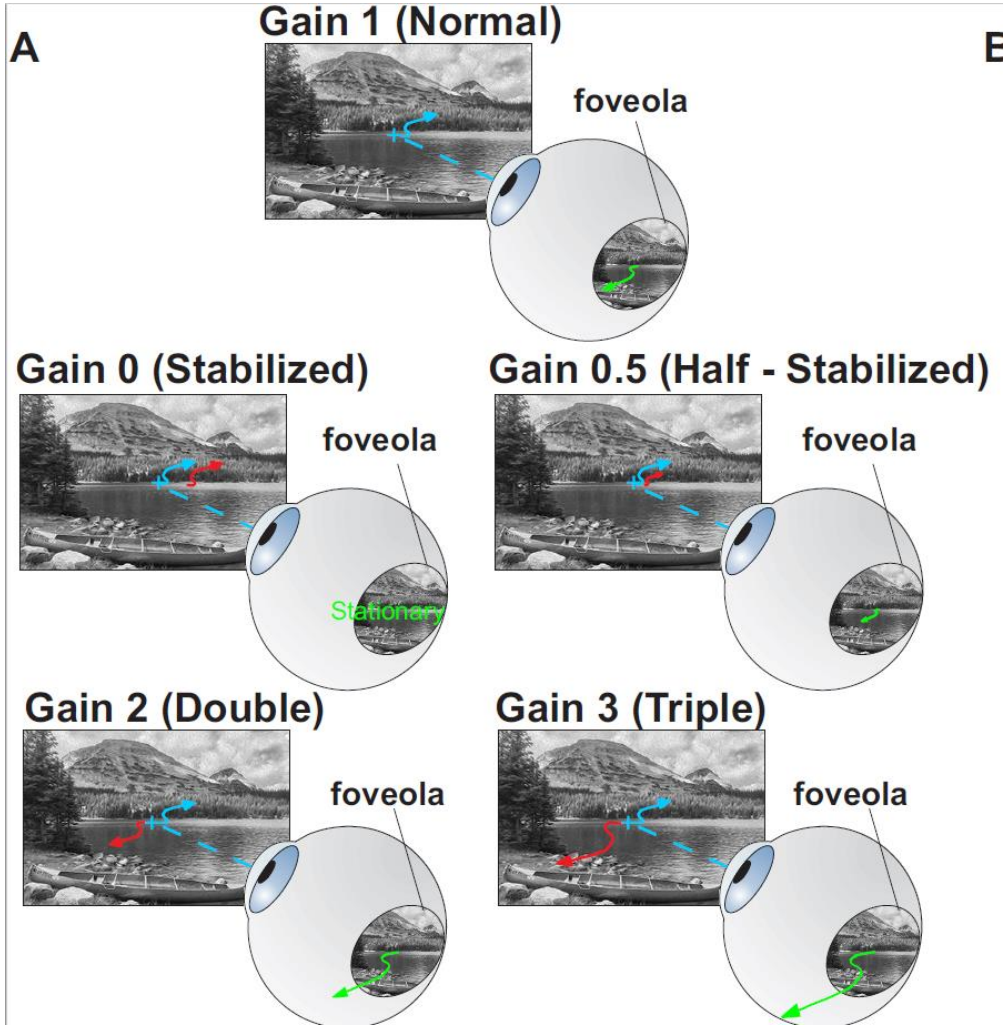


Free View



- How does drift change for various amounts of retinal image motion? With and without a scotoma?
- Speed of eccentric fixation is higher than foveal fixation in subjects with either simulated scotoma or maculopathy (Whittaker et al., 1988)

Free View

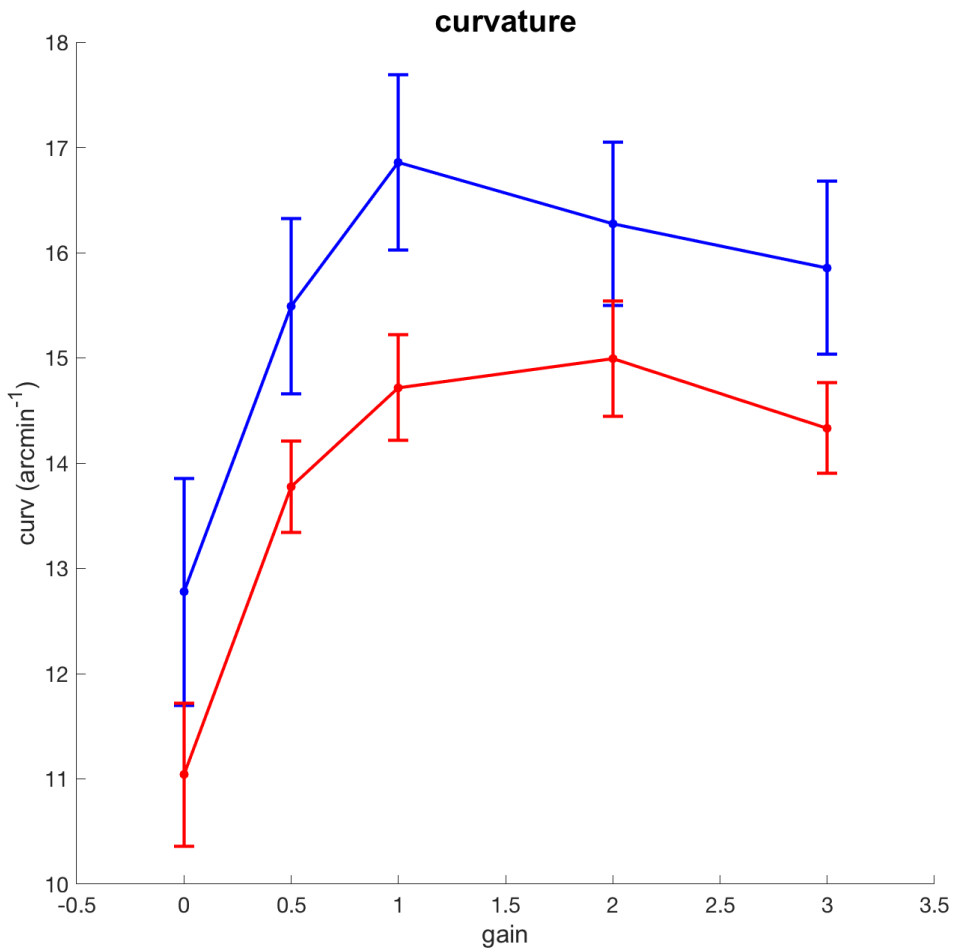


- N = 10 subjects
- Task: Memorize the images, indicate if the image was displayed before
- Trial consisted of 6 images each presented for 5 seconds (30s total)
- 30 trials each of scotoma / no scotoma
- Gain applied during drift periods only

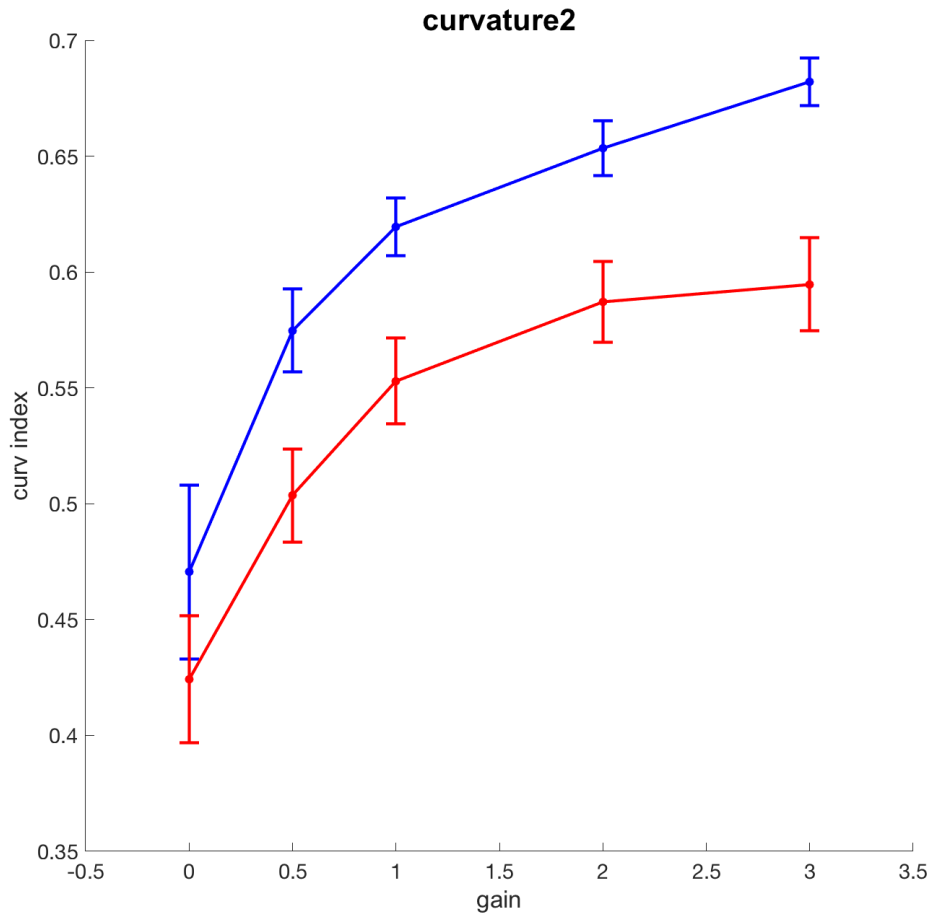
No Scotoma
Scotoma

Results

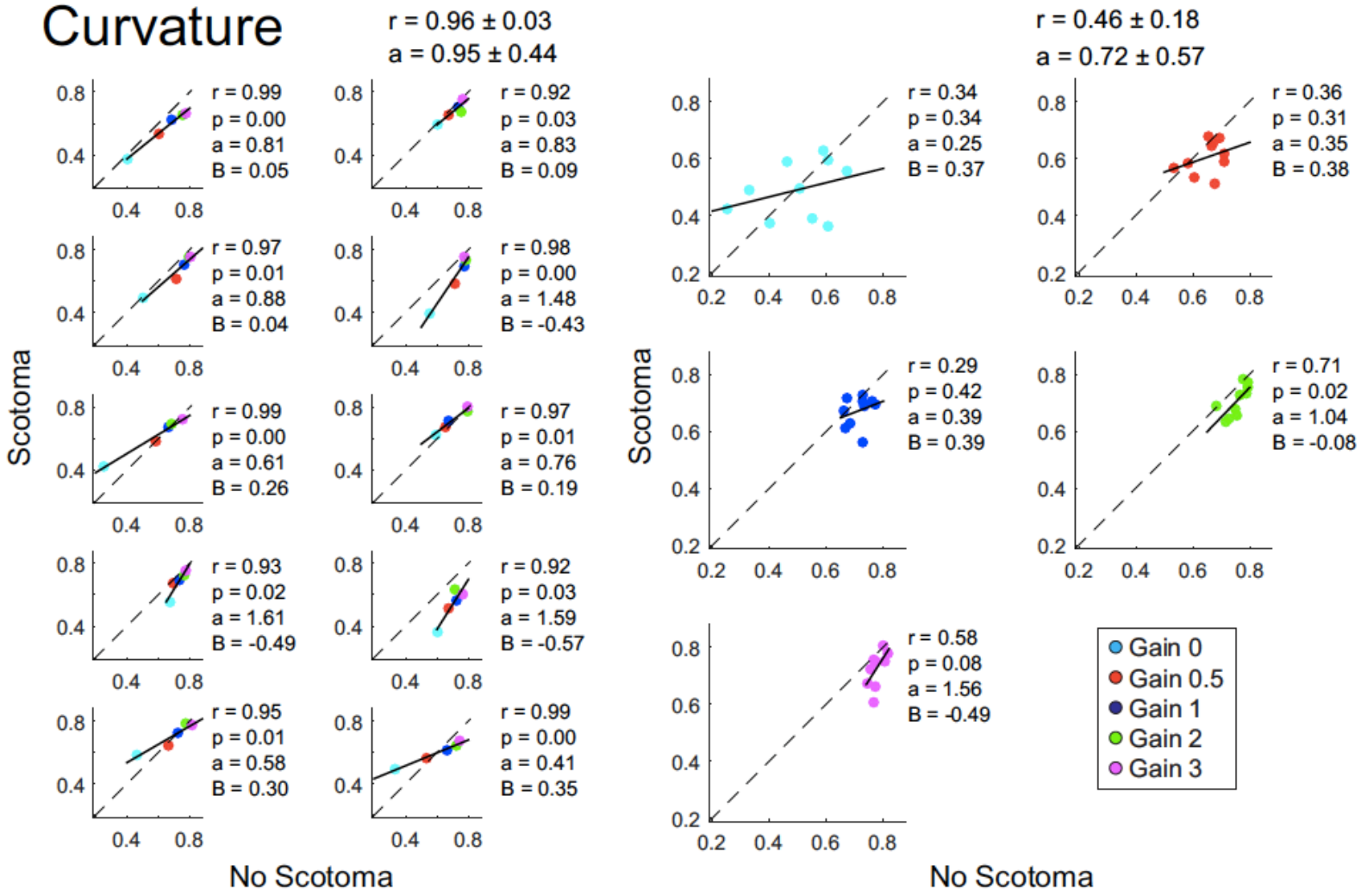
(inverse radius)



1 – amplitude/path length

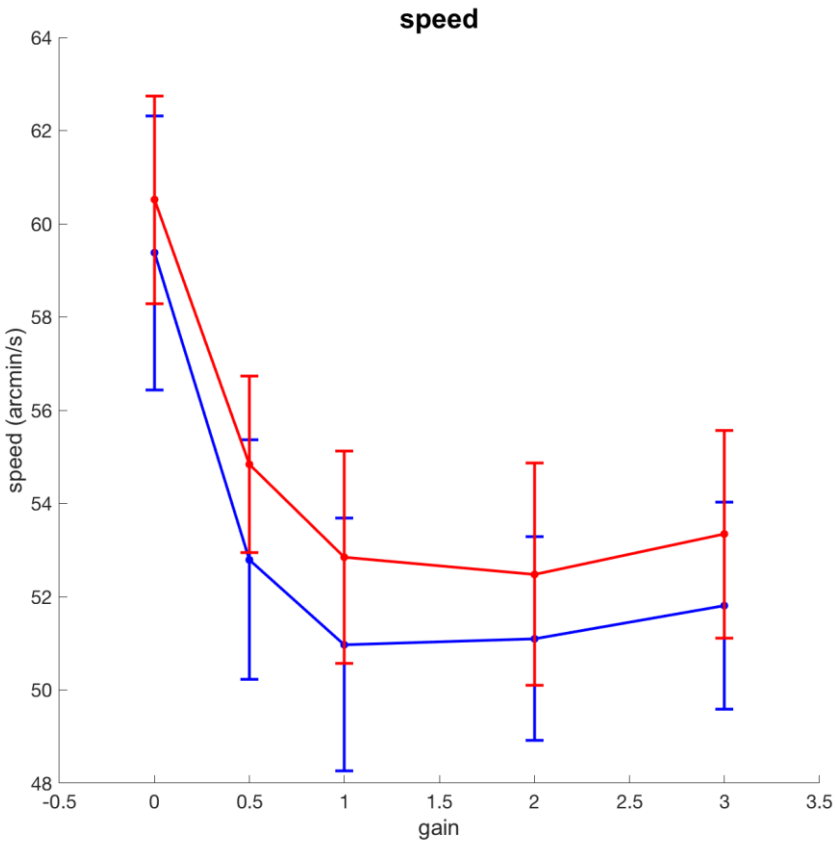


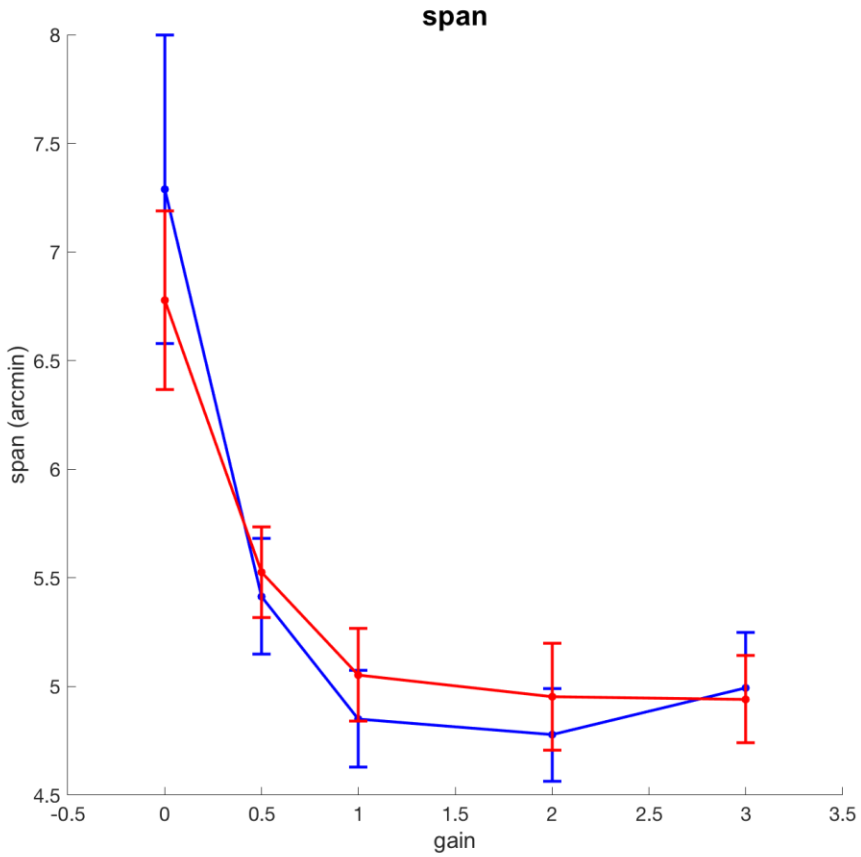
Curvature Index



No Scotoma
Scotoma

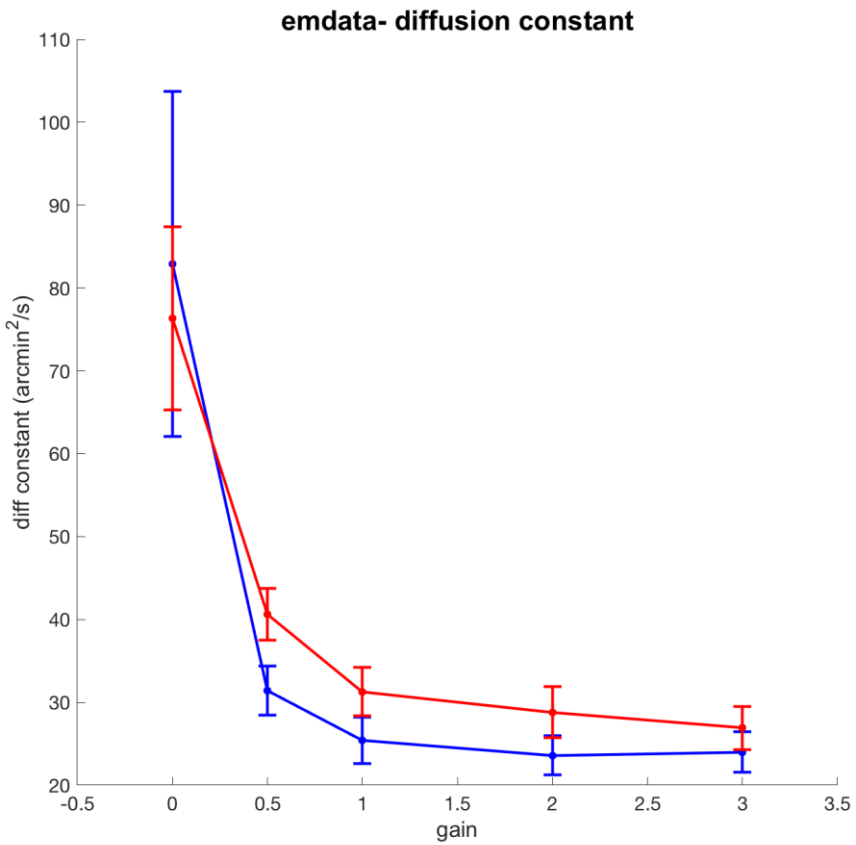
Results

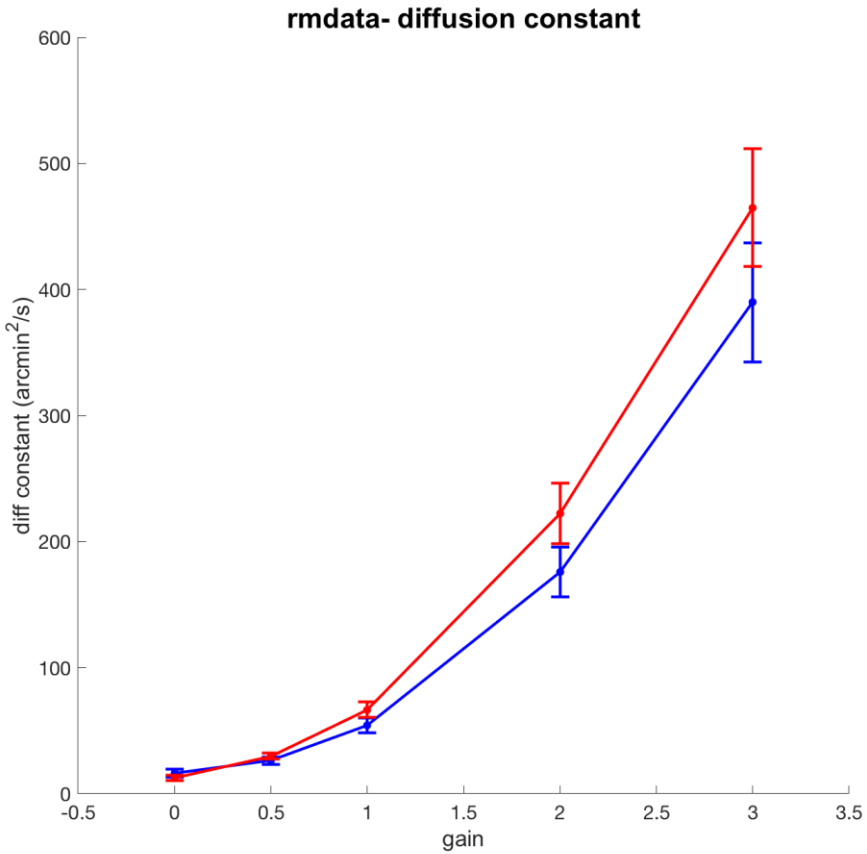




No Scotoma
Scotoma

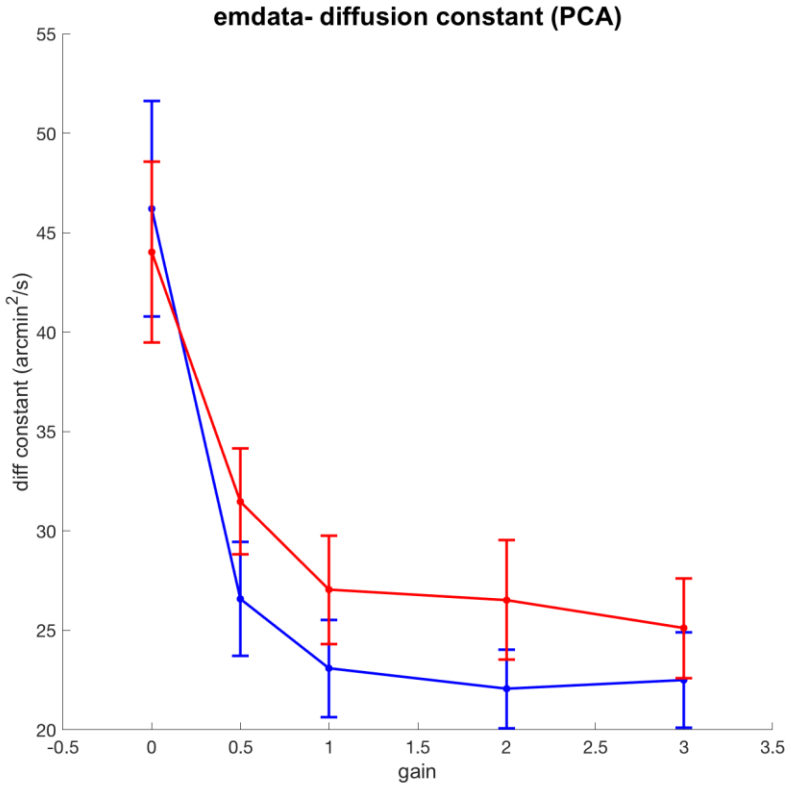
Results

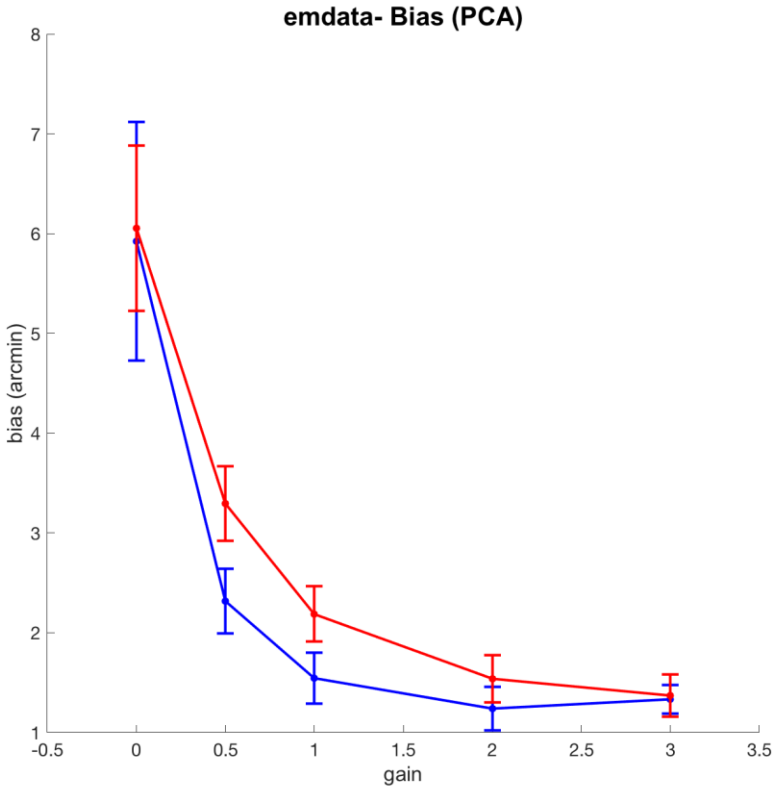




No Scotoma
Scotoma

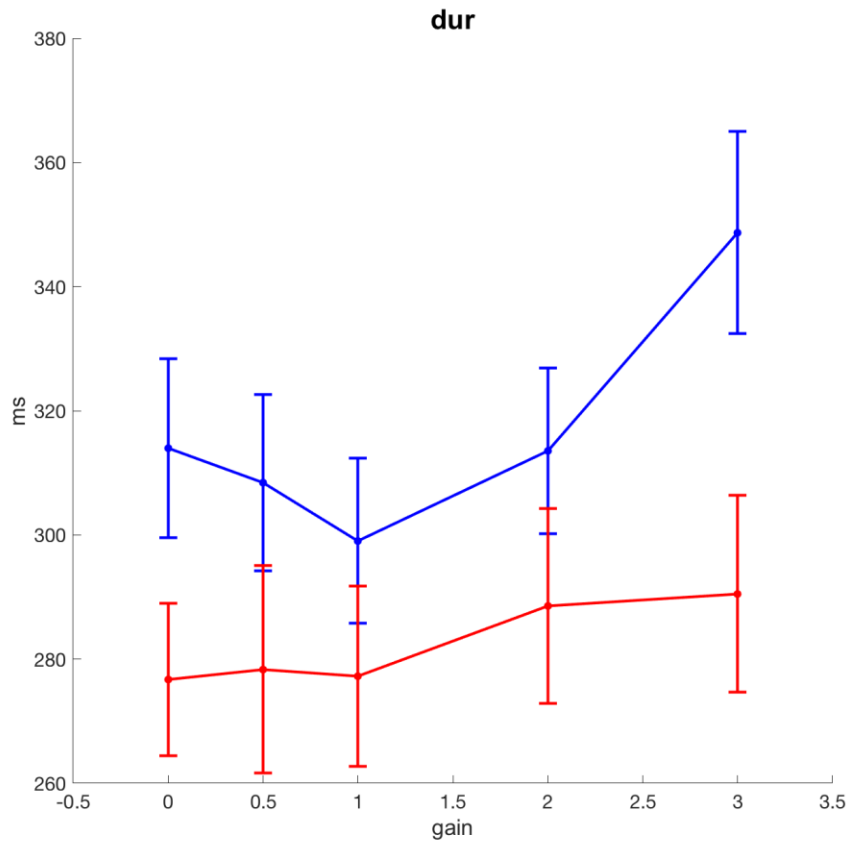
Results



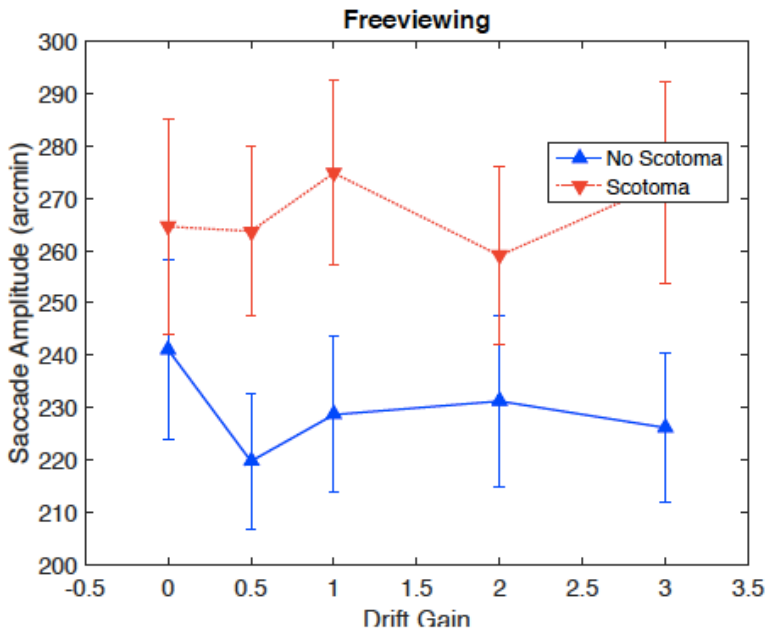


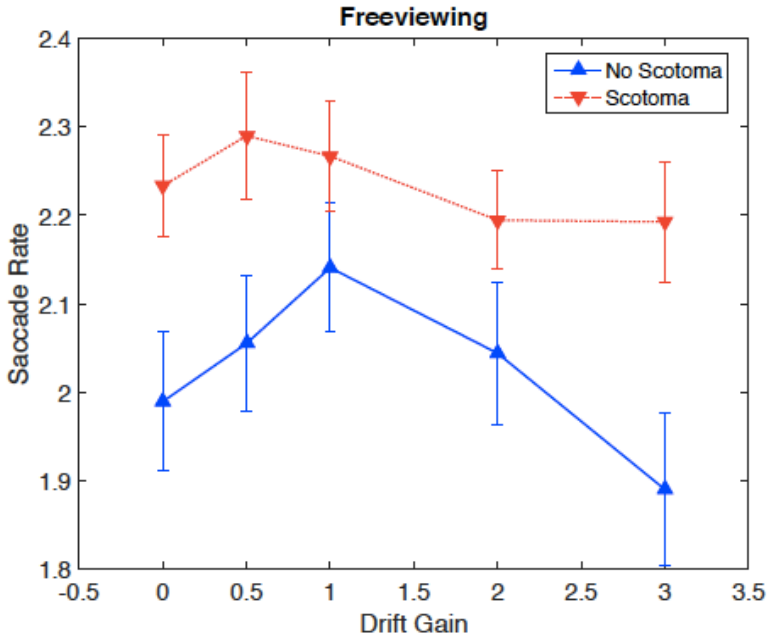
Results

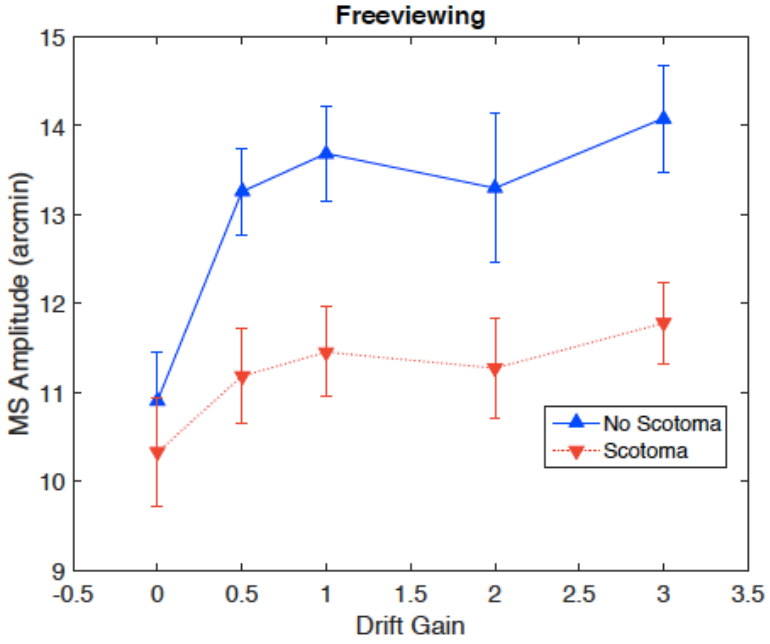
No Scotoma
Scotoma

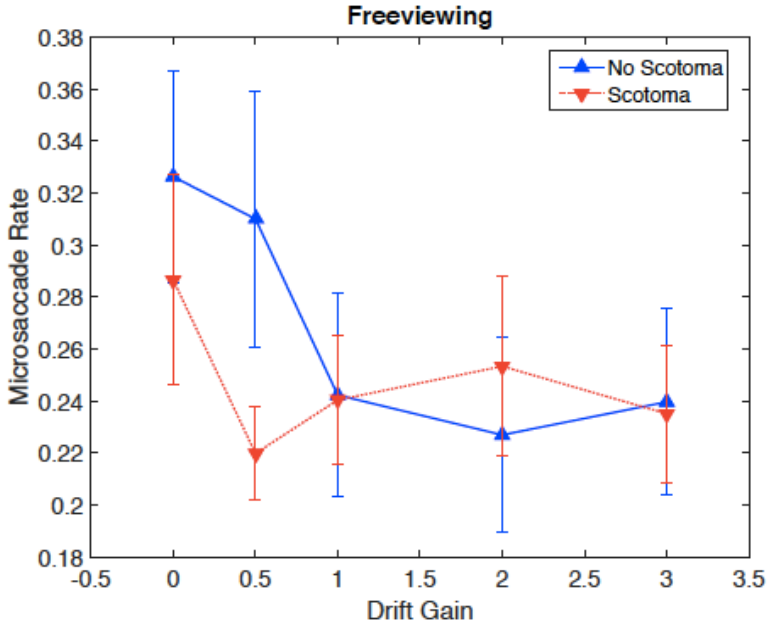


Results









No Scotoma

Scotoma

Free View Conclusions

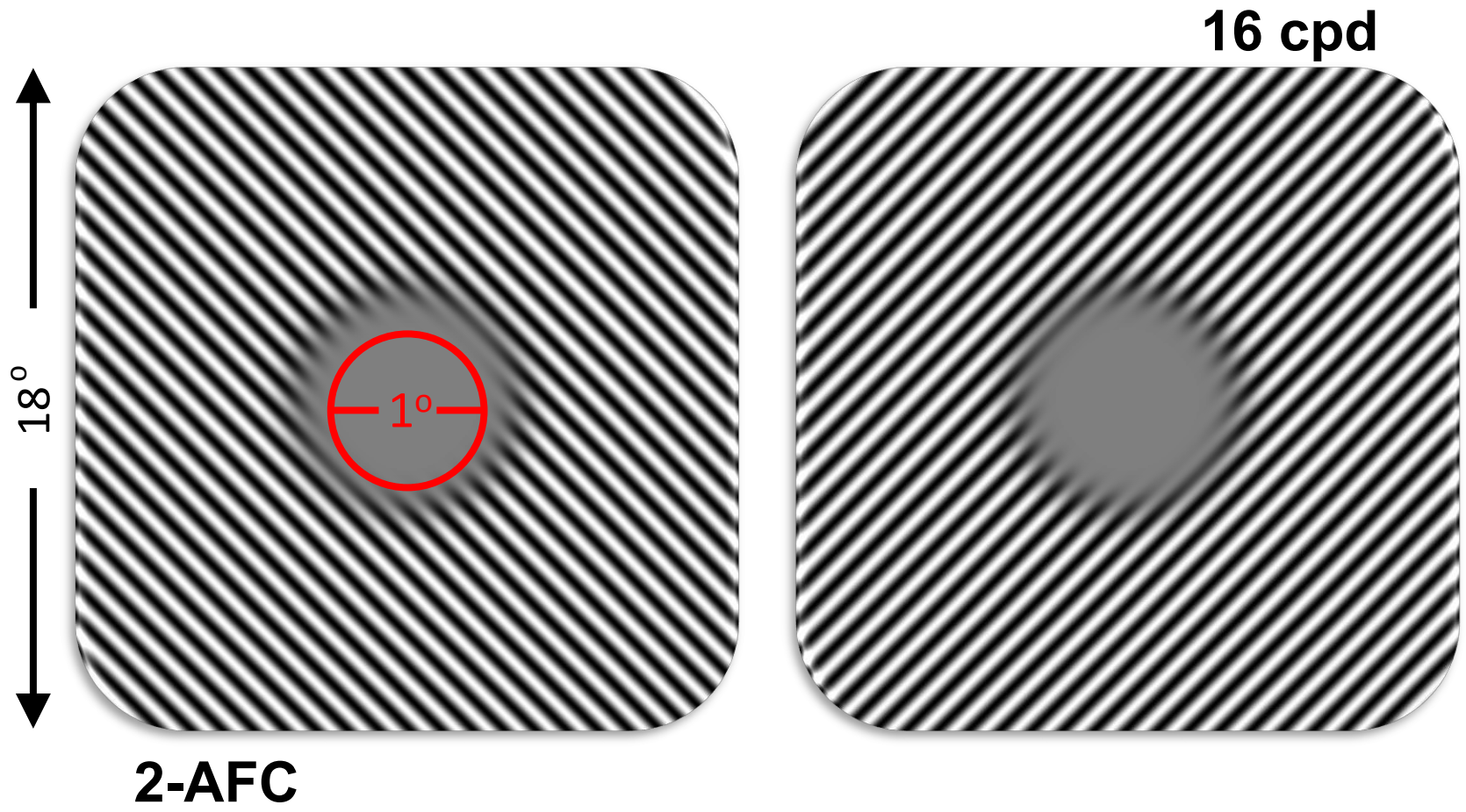
- Drift characteristics change when retinal image motion is reduced (curvature decreases; span, speed, diffusion, bias increase) – signs of smooth pursuit
- Drift characteristics similar with and without scotoma, suggesting that cues from drift are used outside of the foveola

16cpd gratings

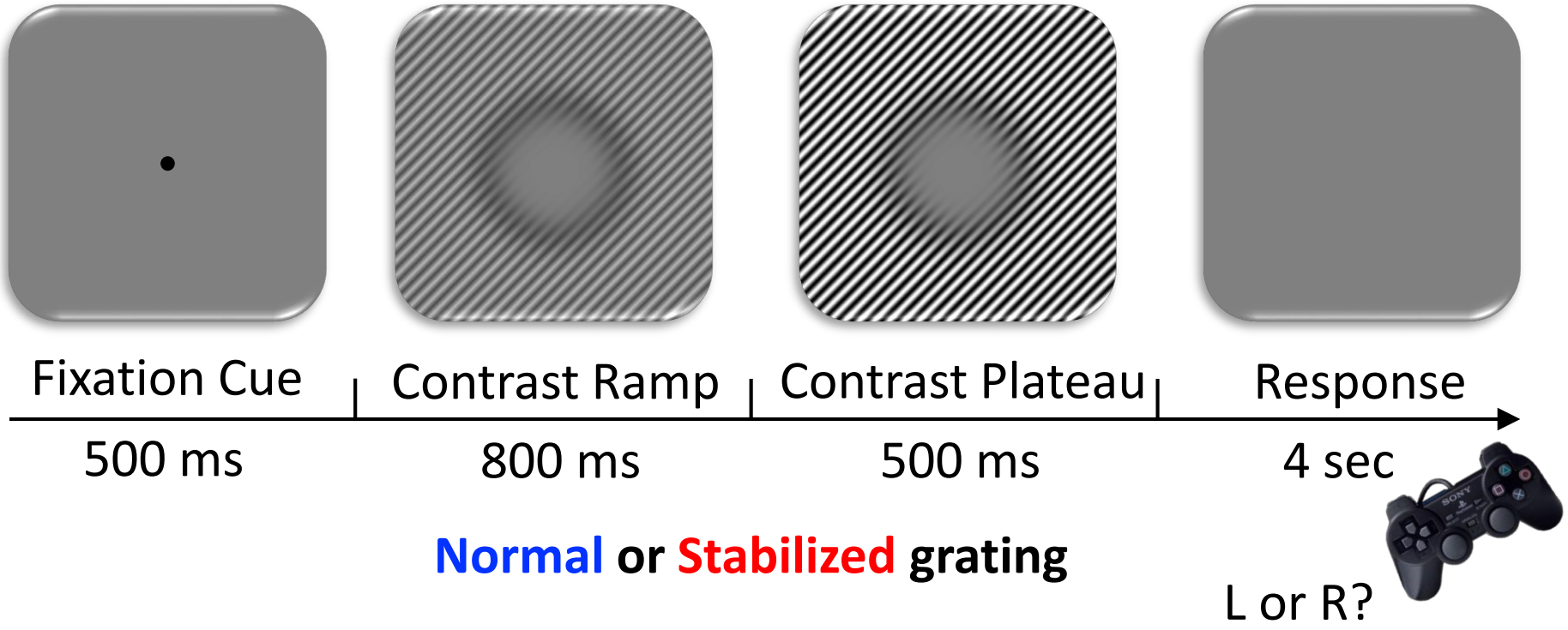
- **Retinal receptive field size increases with eccentricity** (Curcio et al. 1990; Dacey et al. 1993)
- **Prefer visual transients** (Finlay, 1982; McKee & Taylor, 1984; Snowden & Hess, 1992)

- Does ocular drift benefit vision outside the foveola?
- How do different amounts of retinal image motion from drift impact extrafoveal vision?

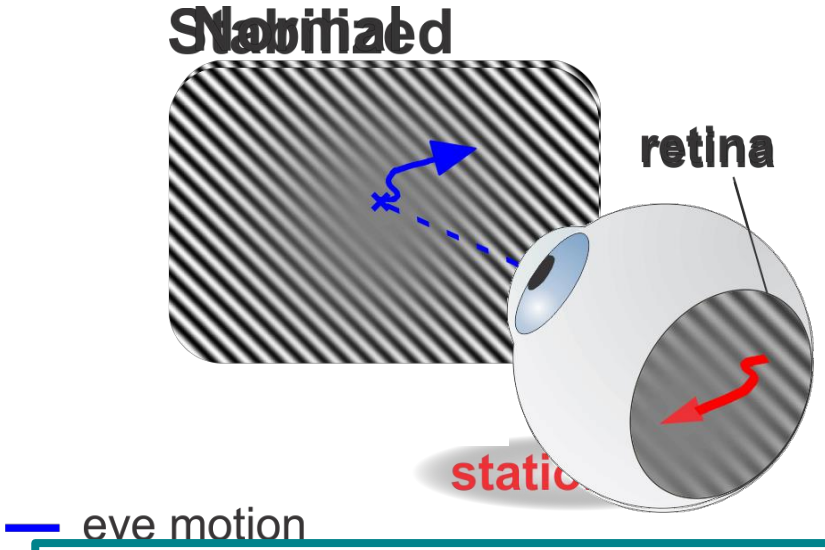
16cpd gratings



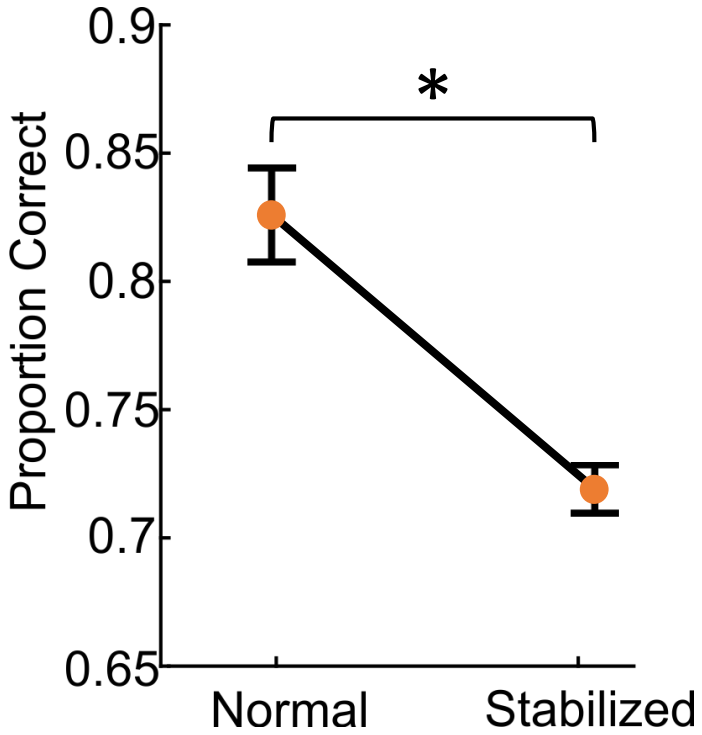
16cpd gratings



Contributions of Ocular Drift

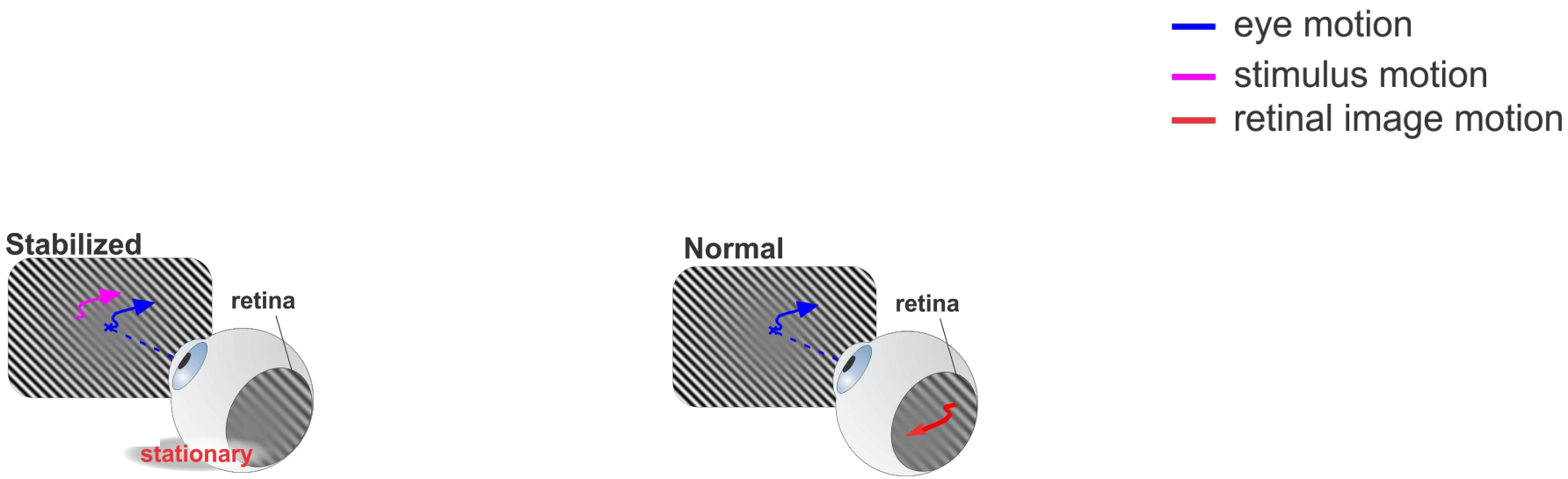


Temporal modulations from drift contribute to vision outside of the fovea.



* Wilcoxon signed-rank test test, $p = 0.031$

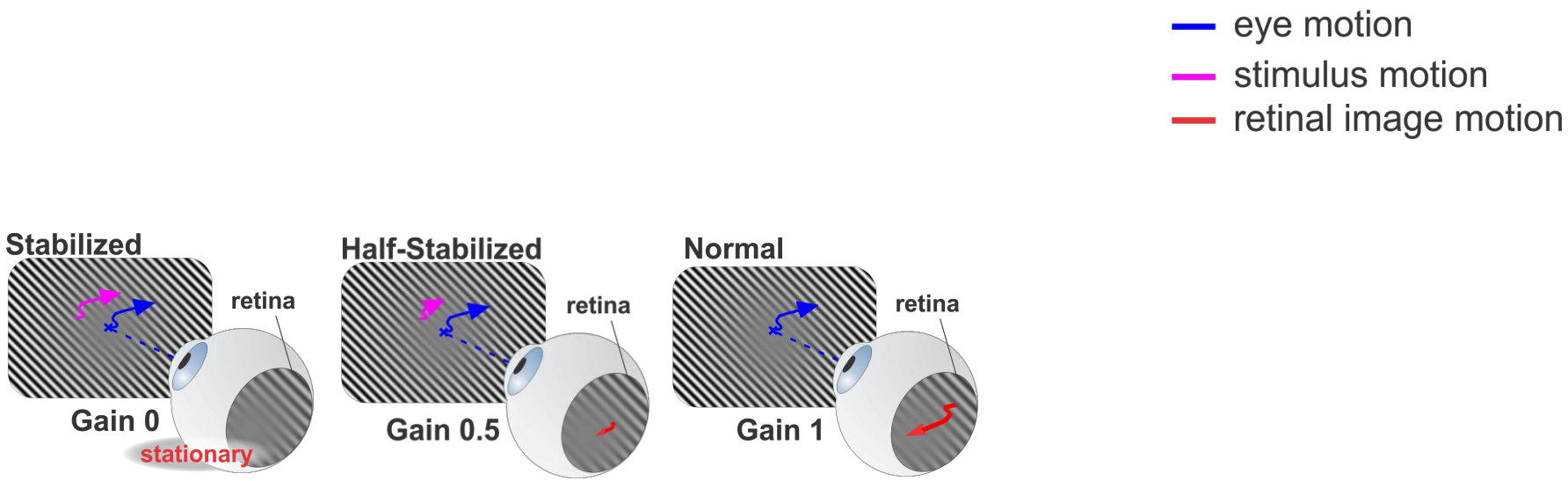
Manipulating retinal image motion



Less Retinal Image Motion from Drift

More Retinal Image Motion from Drift

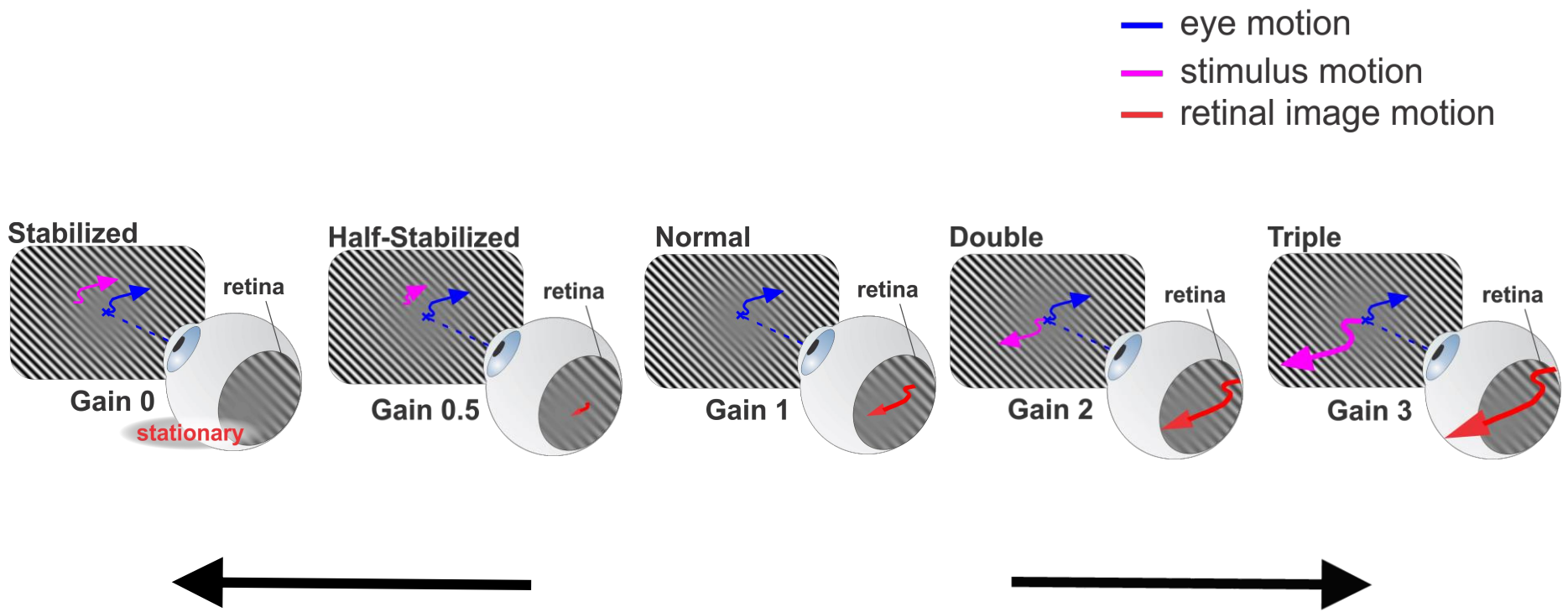
Manipulating retinal image motion



Less Retinal Image Motion from Drift

More Retinal Image Motion from Drift

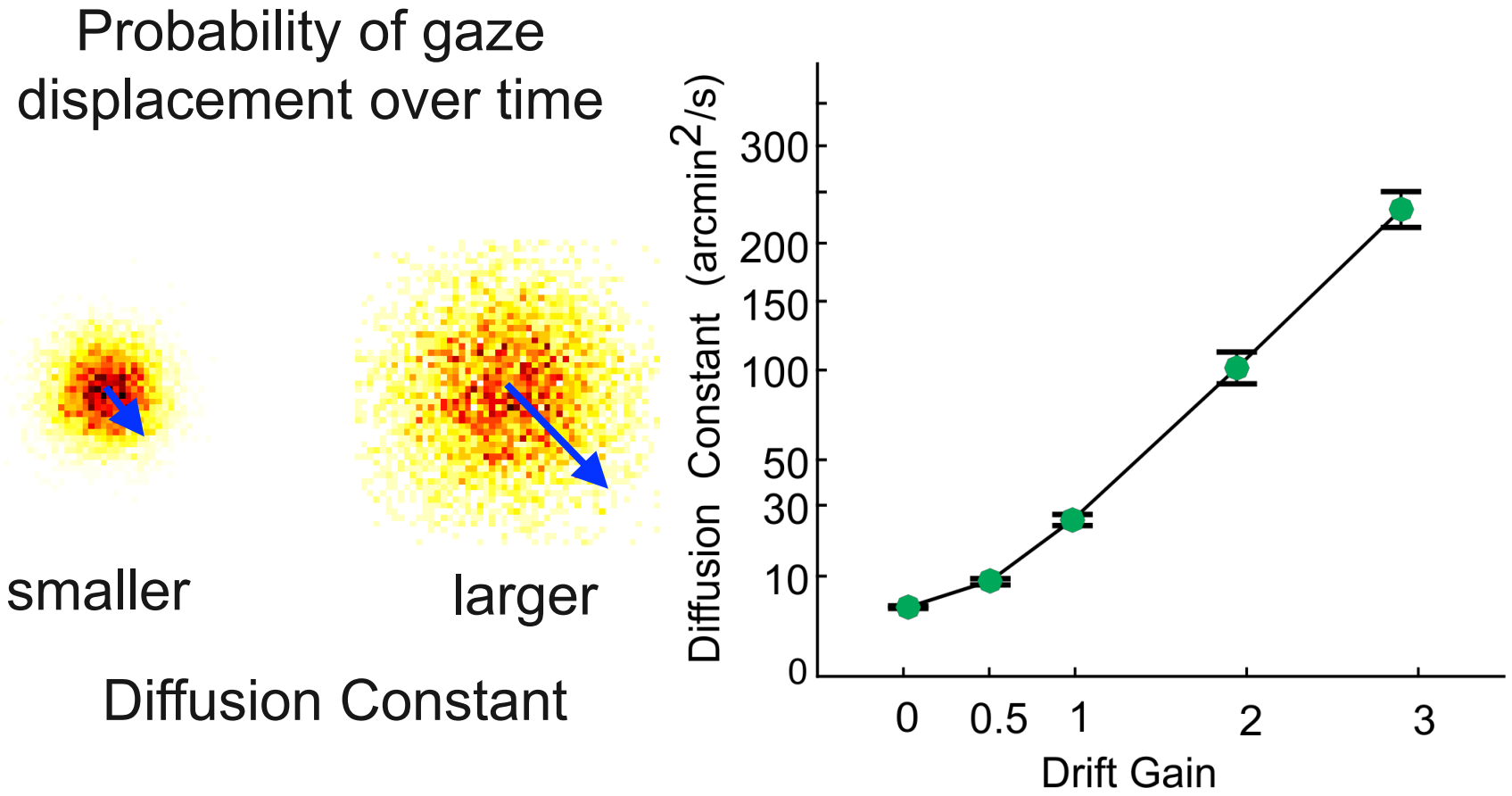
Manipulating retinal image motion



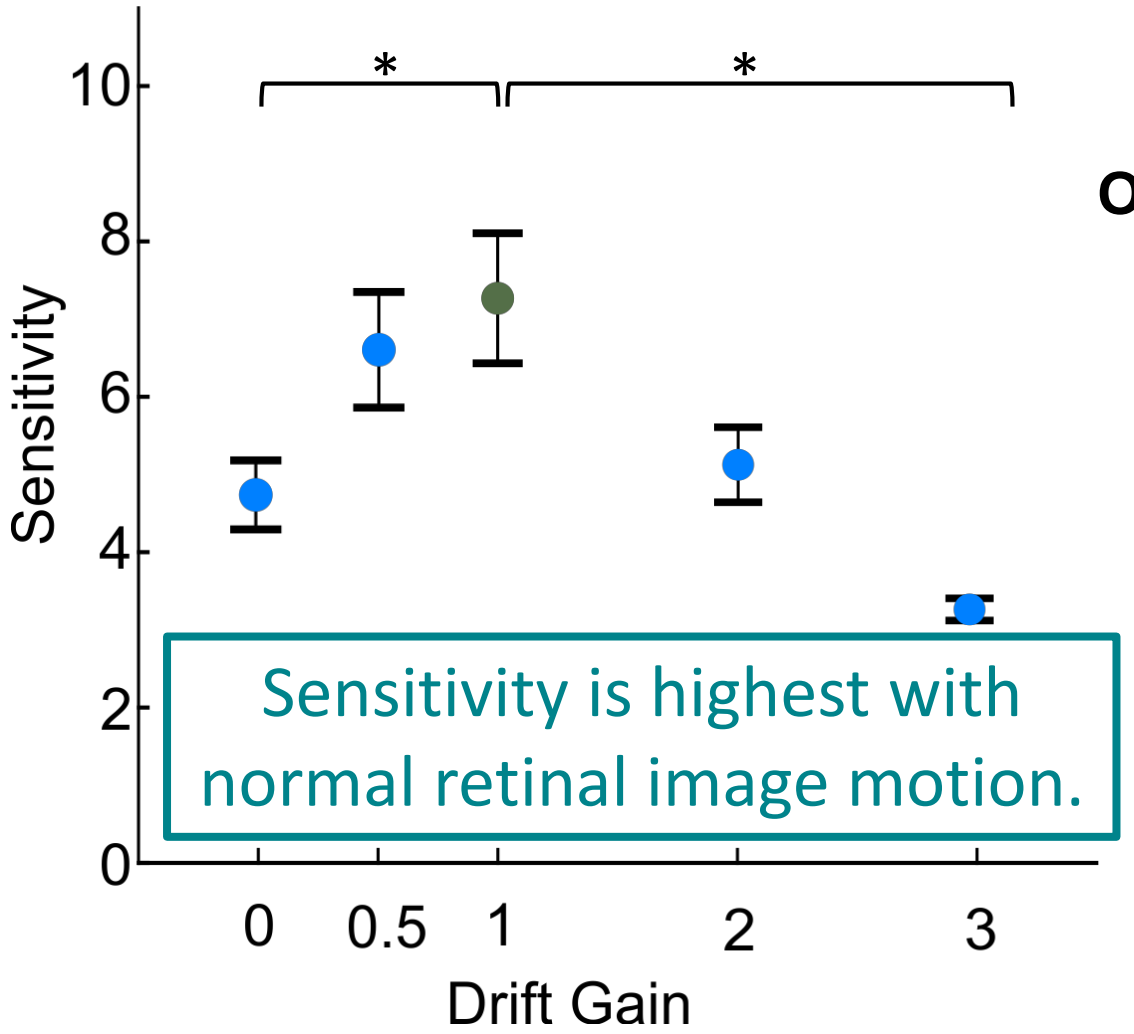
Less Retinal Image Motion from Drift

More Retinal Image Motion from Drift

Quantifying retinal image motion



Contrast Sensitivity

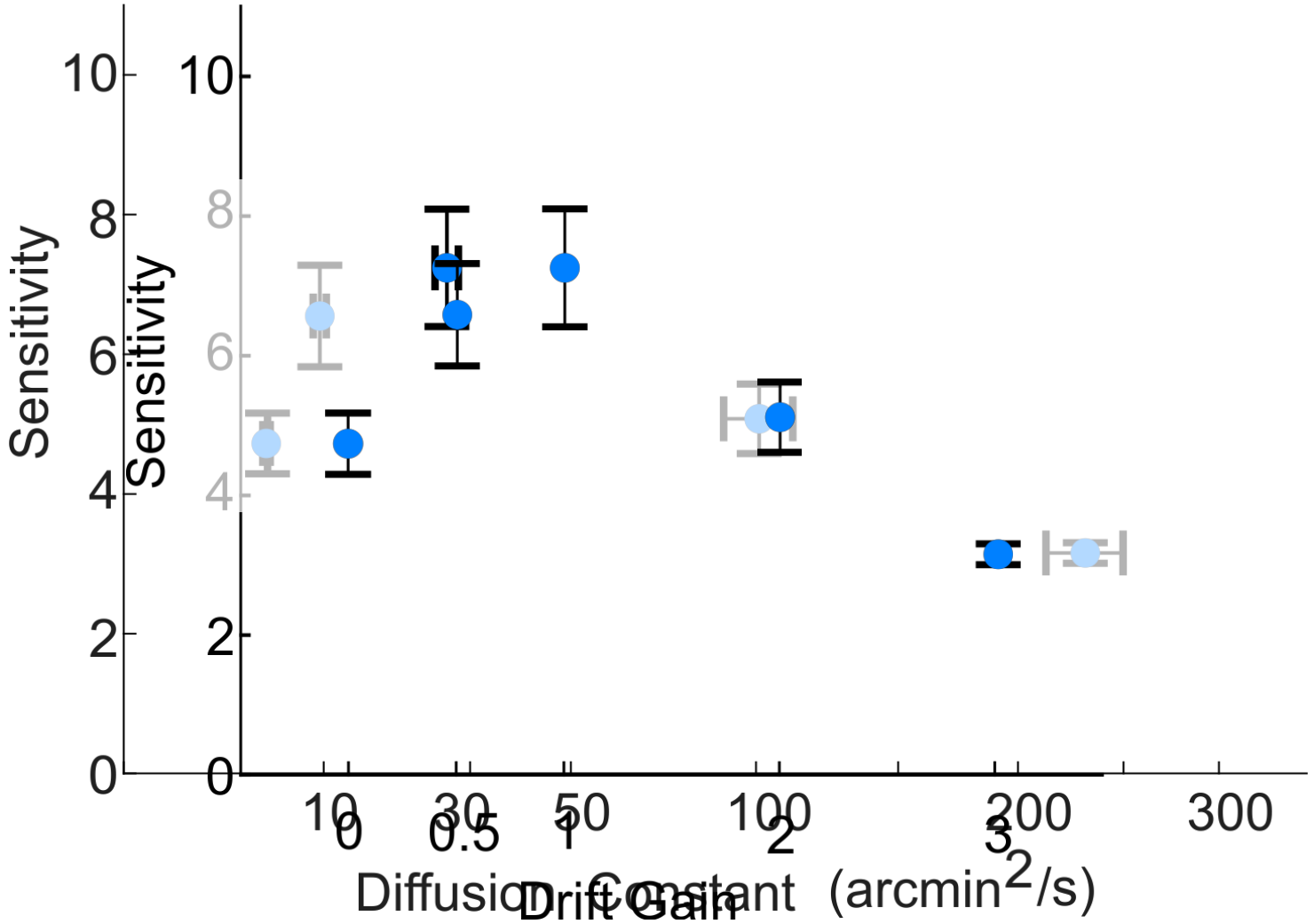


One-way ANOVA
$F(4, 6) = 7.59$
$p = 0.002$

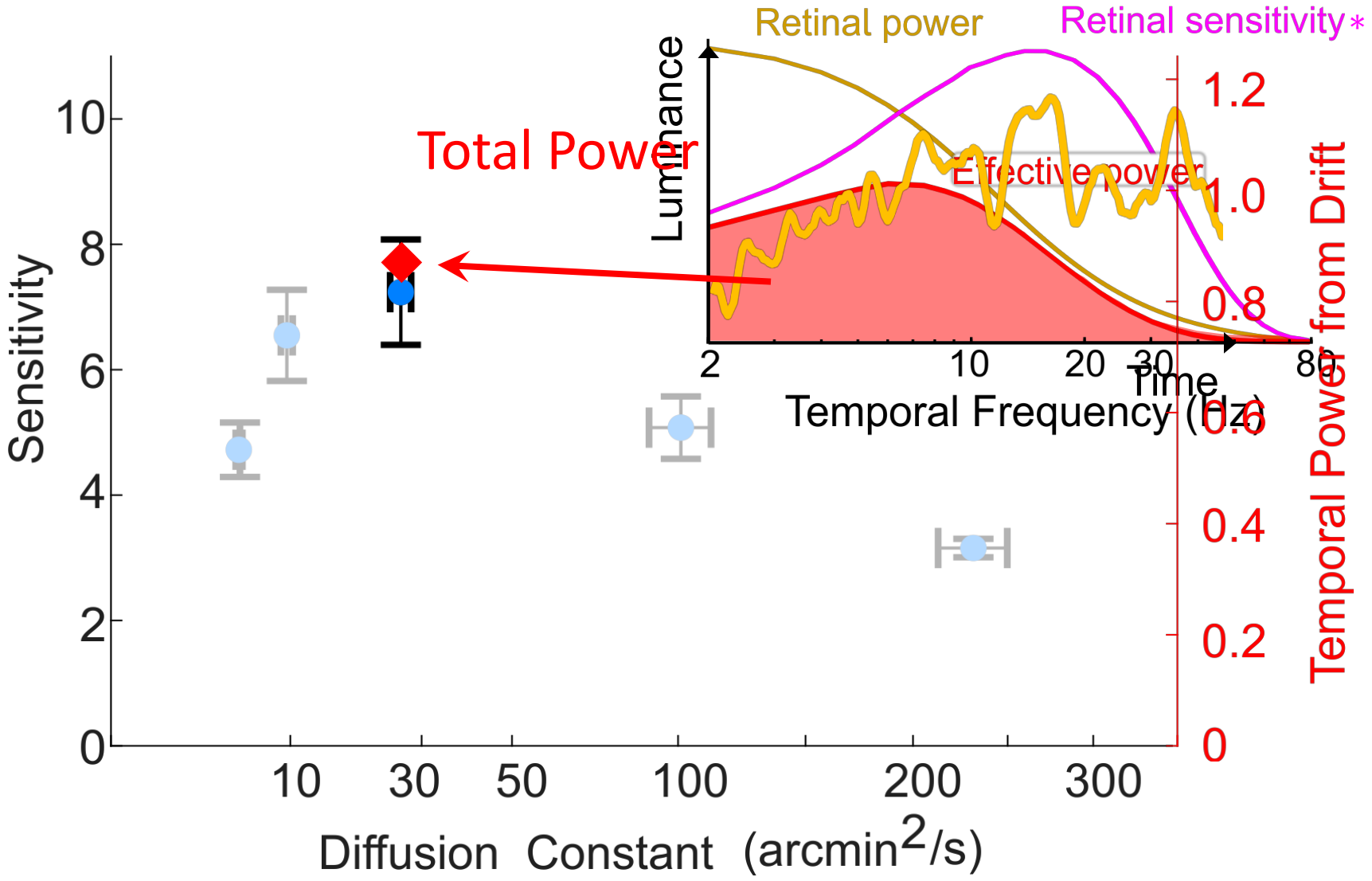
Tukey HSD test
$*p < 0.05$

Why does normal drift yield the highest sensitivity?

Temporal power from drift

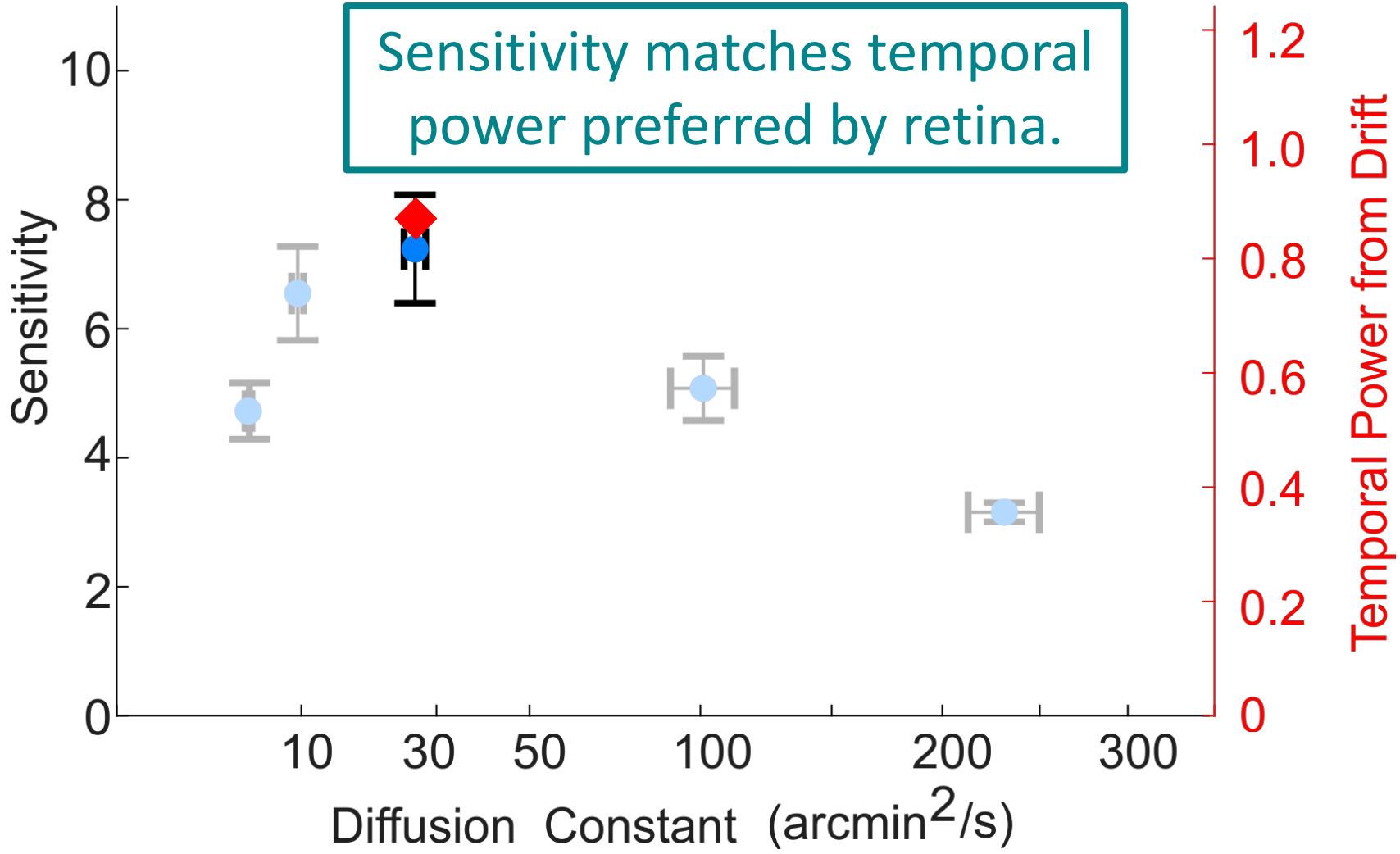


Temporal power from drift

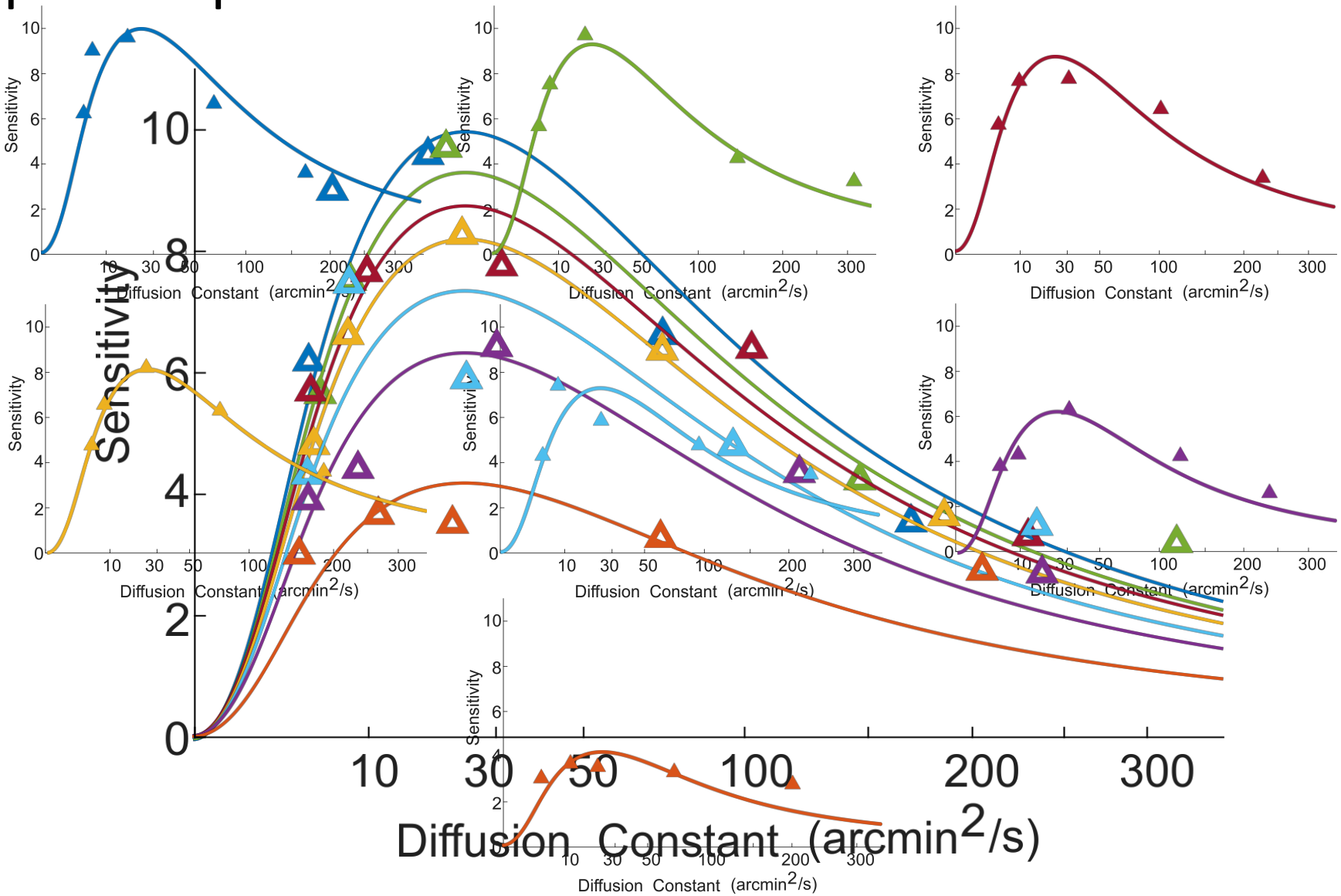


*Benardete & Kaplan (1999)

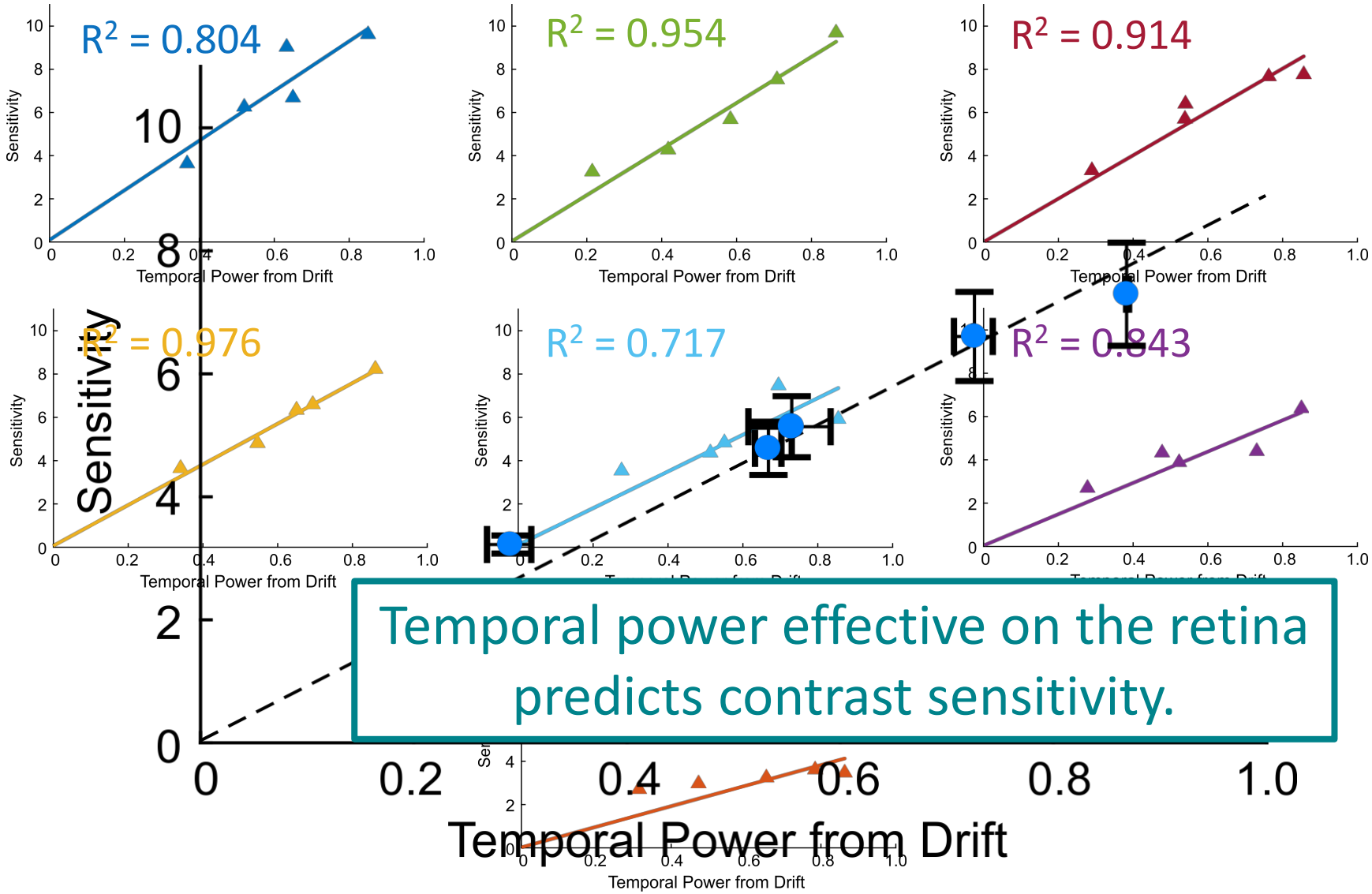
Temporal power from drift



Temporal power from drift



Temporal power from drift



Summary

- Ocular drift is beneficial outside the fovea.
- Increasing or decreasing ocular drift from its normal level impairs contrast sensitivity.
- The effect of manipulating ocular drift on contrast sensitivity is predicted by the change in temporal power on the retina.

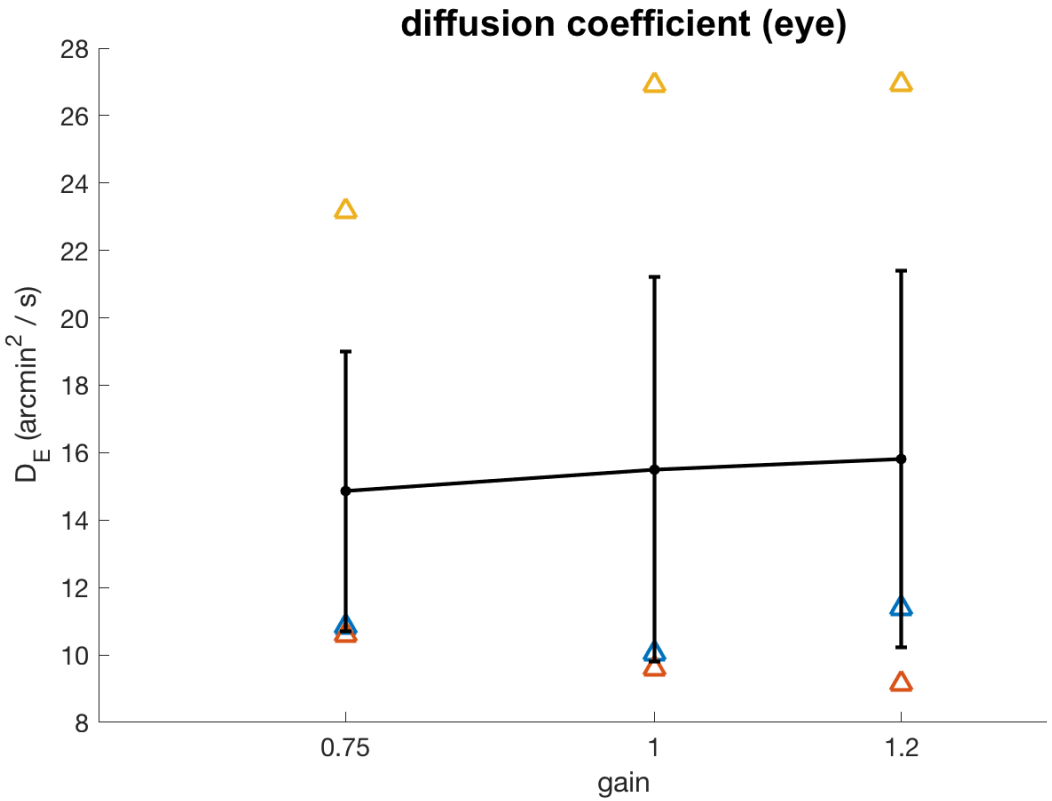
NIH R01 EY018363

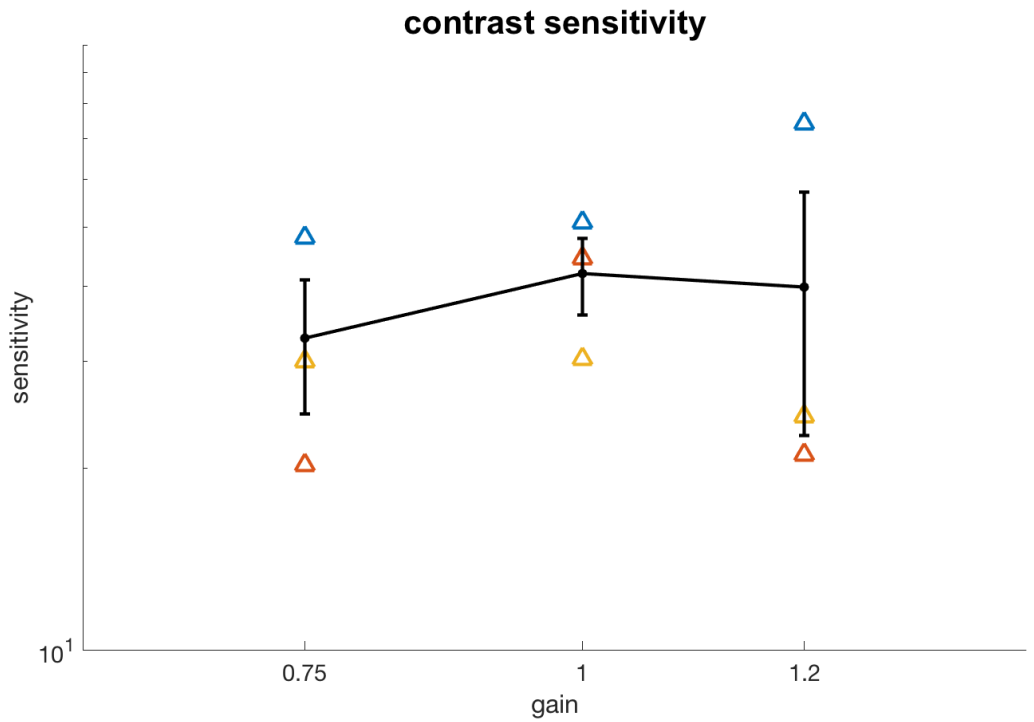
NSF BCS-1457283
and BCS-1420212

10cpd

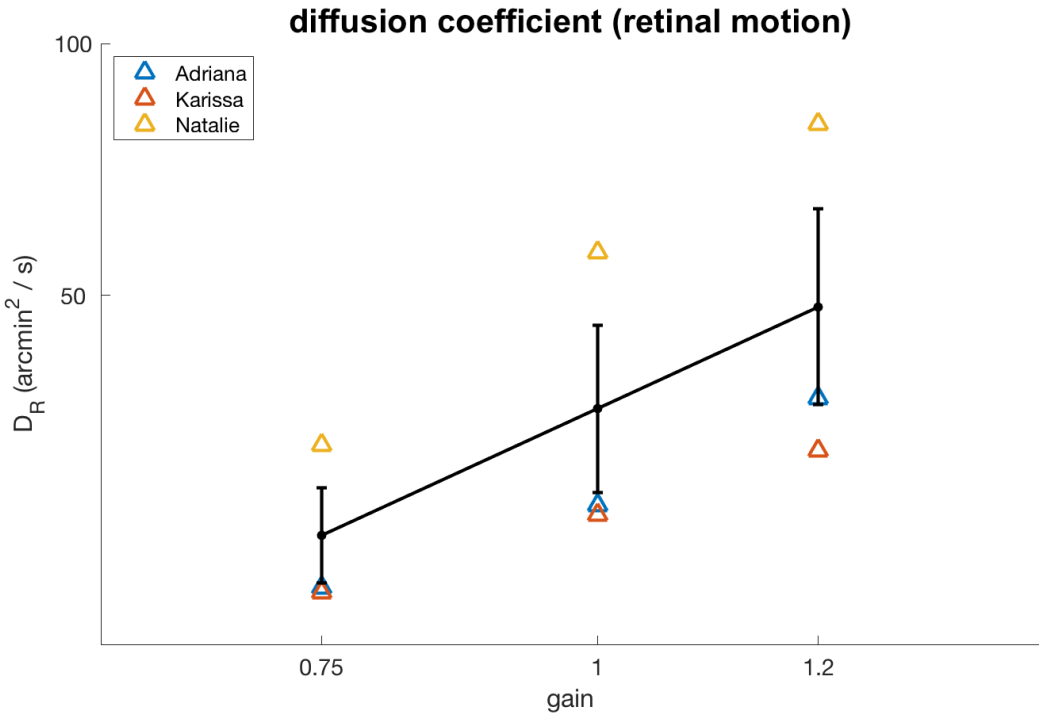
- Similar to previous experiment, but with 10cpd gratings at gains [0.75, 1, 1.2]

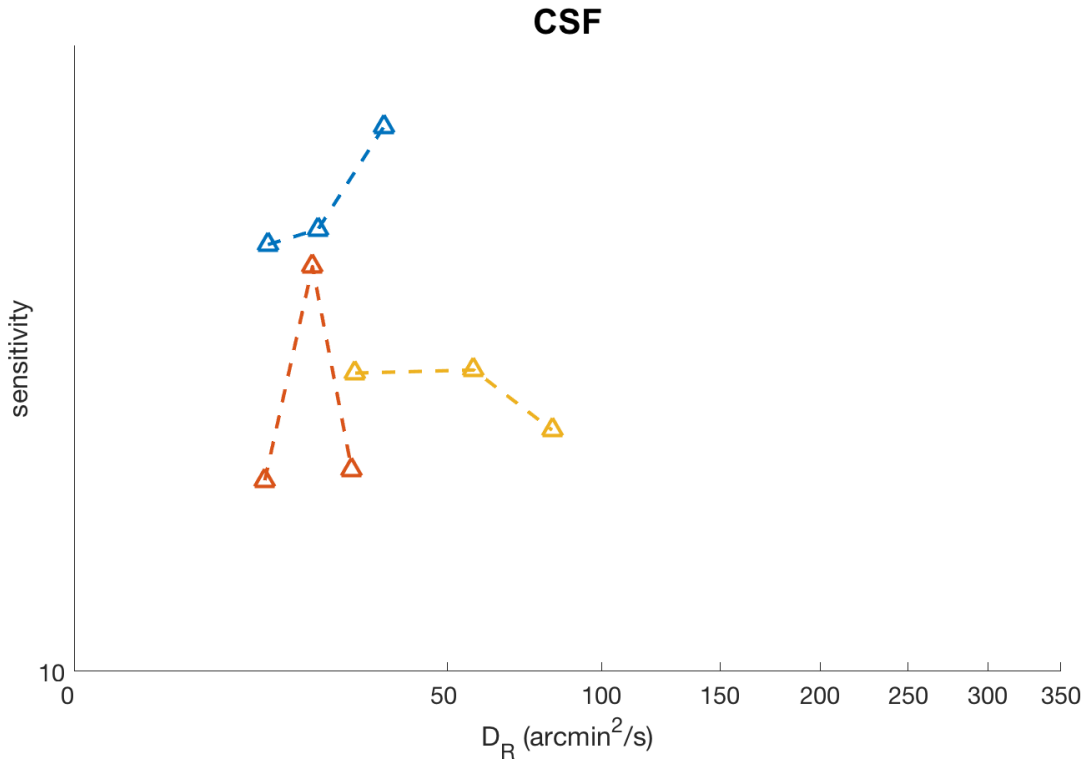
10cpd gratings



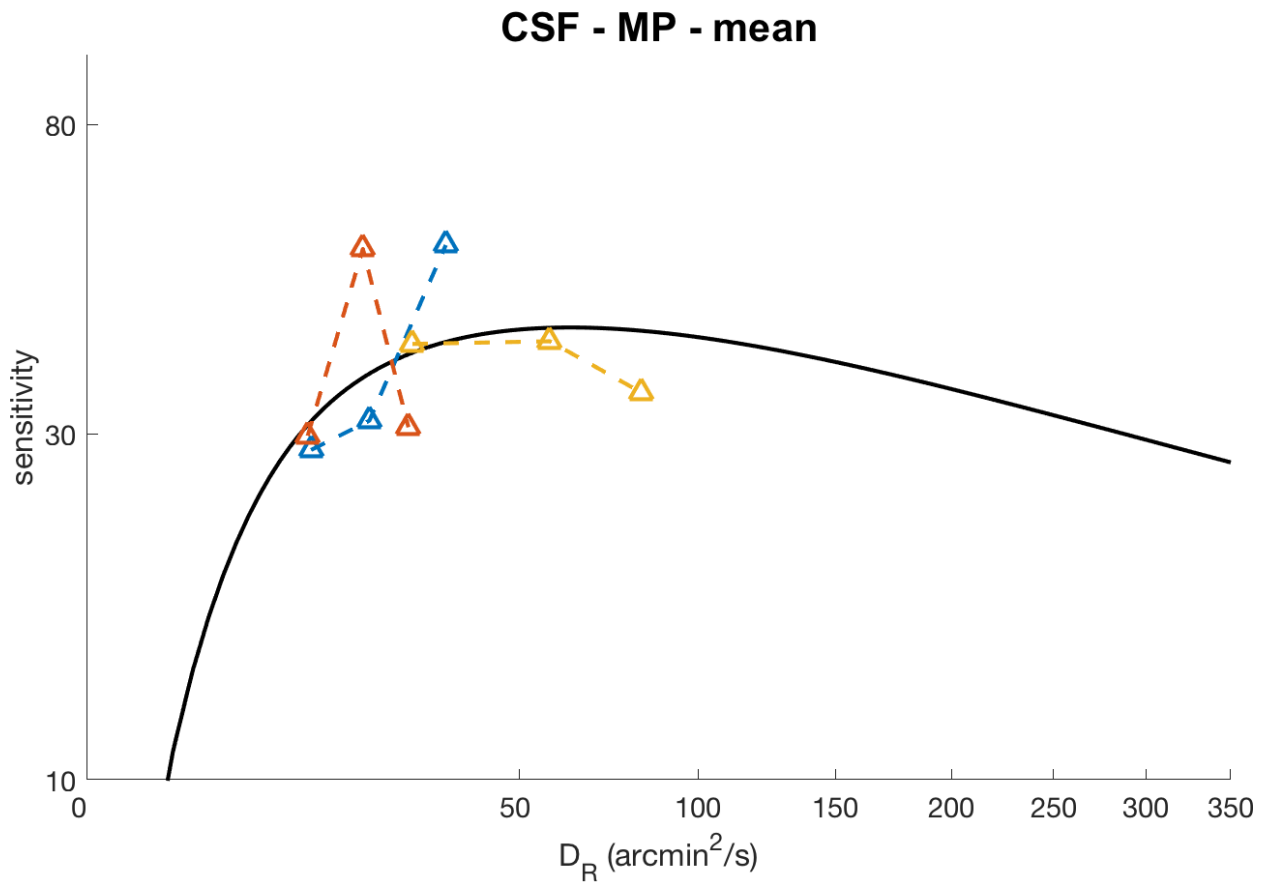


10cpd gratings





10cpd gratings



Next Steps

Questions

- How does drift contribute to vision across the retina?
- How much drift is optimal?
- Is drift controlled to modulate temporal power on the retina?

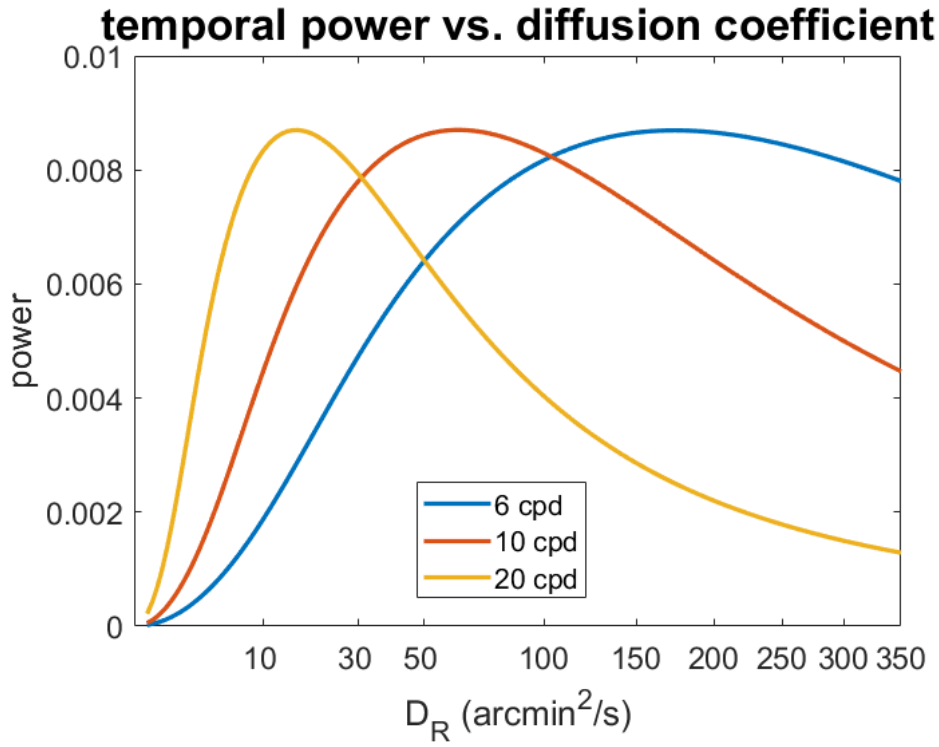
- Re-analysis of already collected data
  - Does drift bias change when the grating orientation is known?
  - Drift over gratings of various spatial frequencies

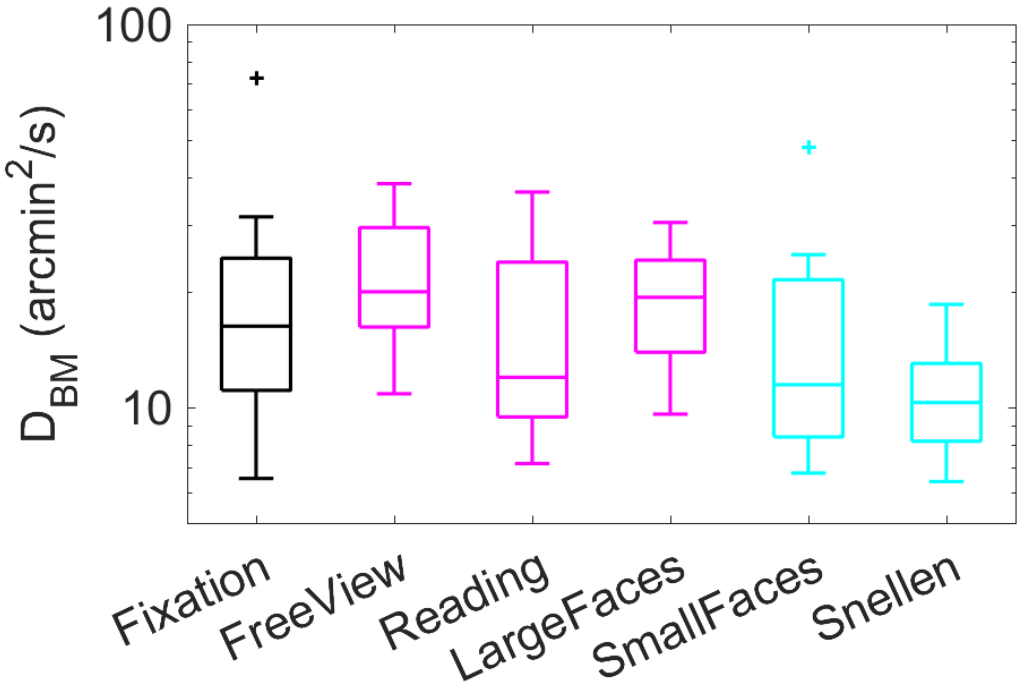
Next Steps

1. Test whether drift modulates power on the retina
2. Test if drift is optimal and whether retinal power predicts sensitivity
3. Measure individual temporal sensitivities – do these allow better predictions of sensitivity?
4. Measure temporal sensitivity across the retina

Is drift controlled to modulate temporal power on the retina?

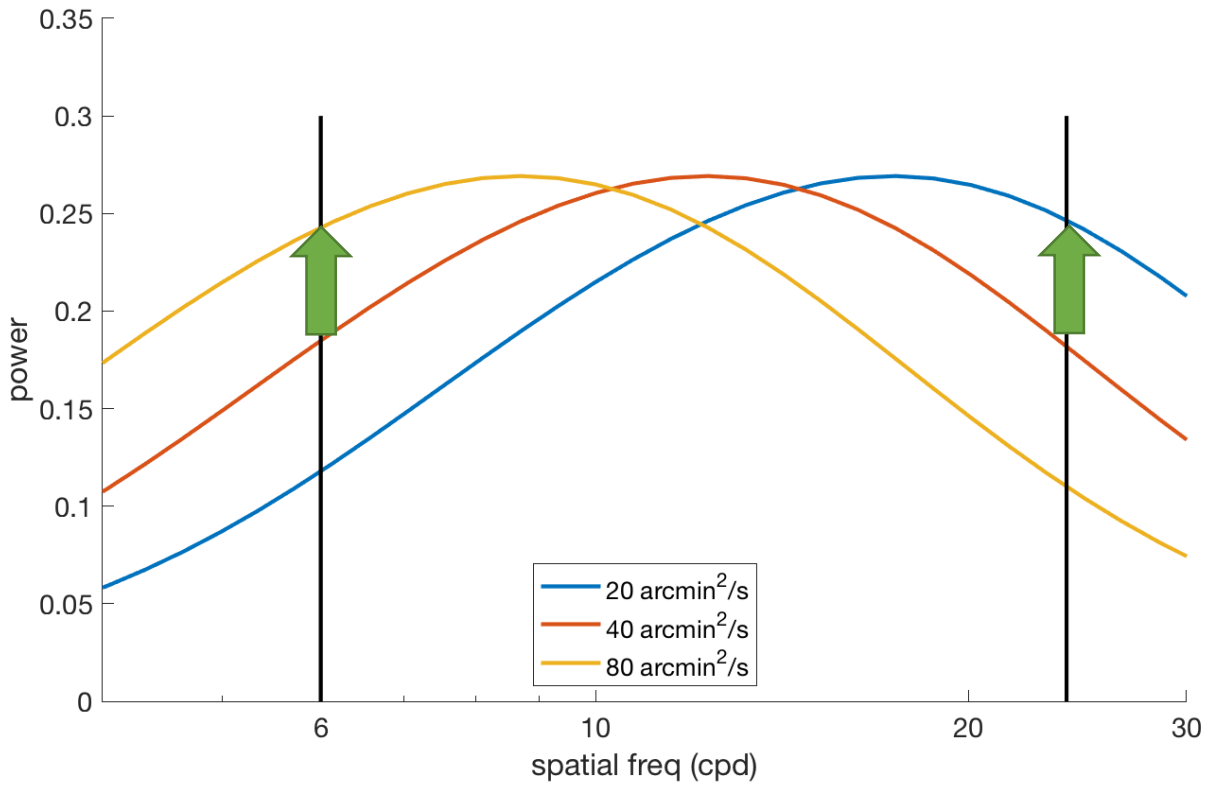
- Does drift change to enhance retinal power at relevant spatial frequencies?





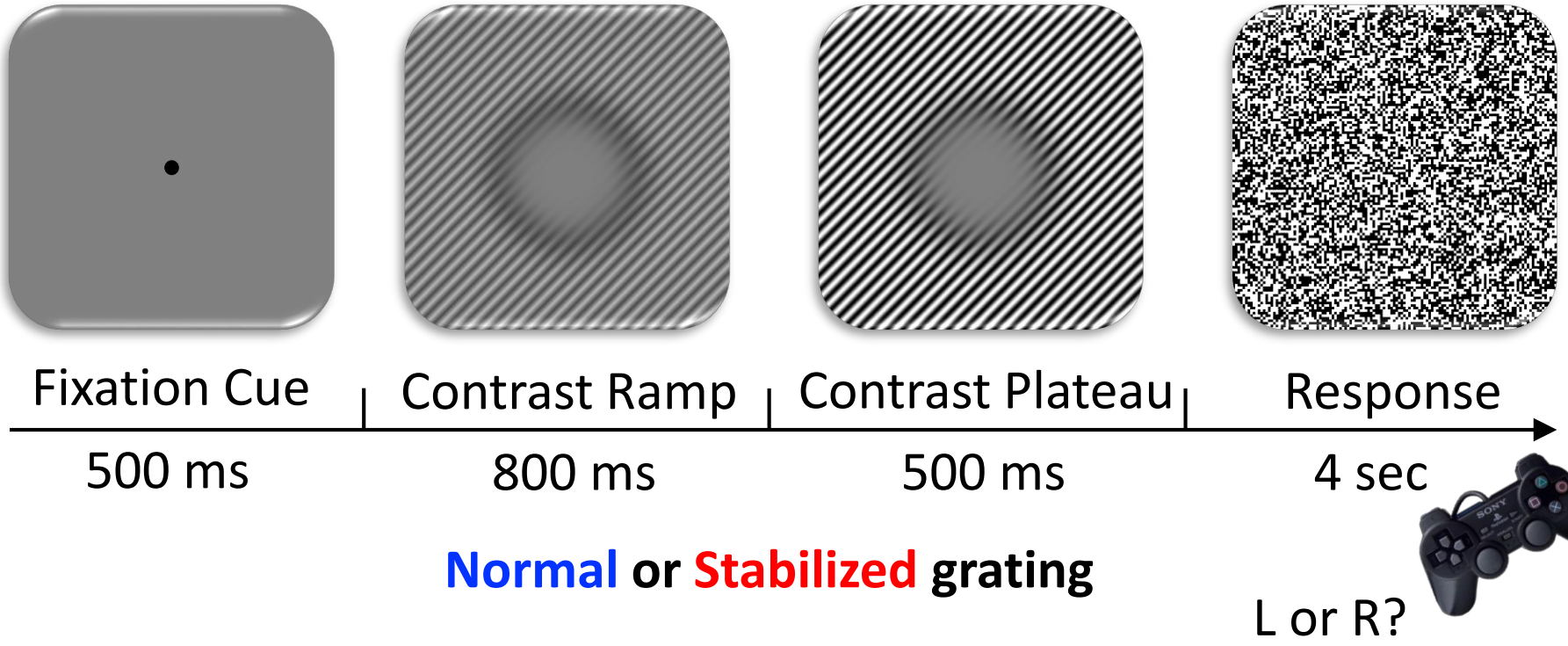
Is drift controlled to modulate temporal power on the retina?

- Changes in drift diffusion modulate retinal power
- **Hypothesis:** Drift changes to bring retinal power to a perceivable threshold
- i.e. tuned drift is needed for low contrast stimuli, not for high (when the stimulus provides enough power)

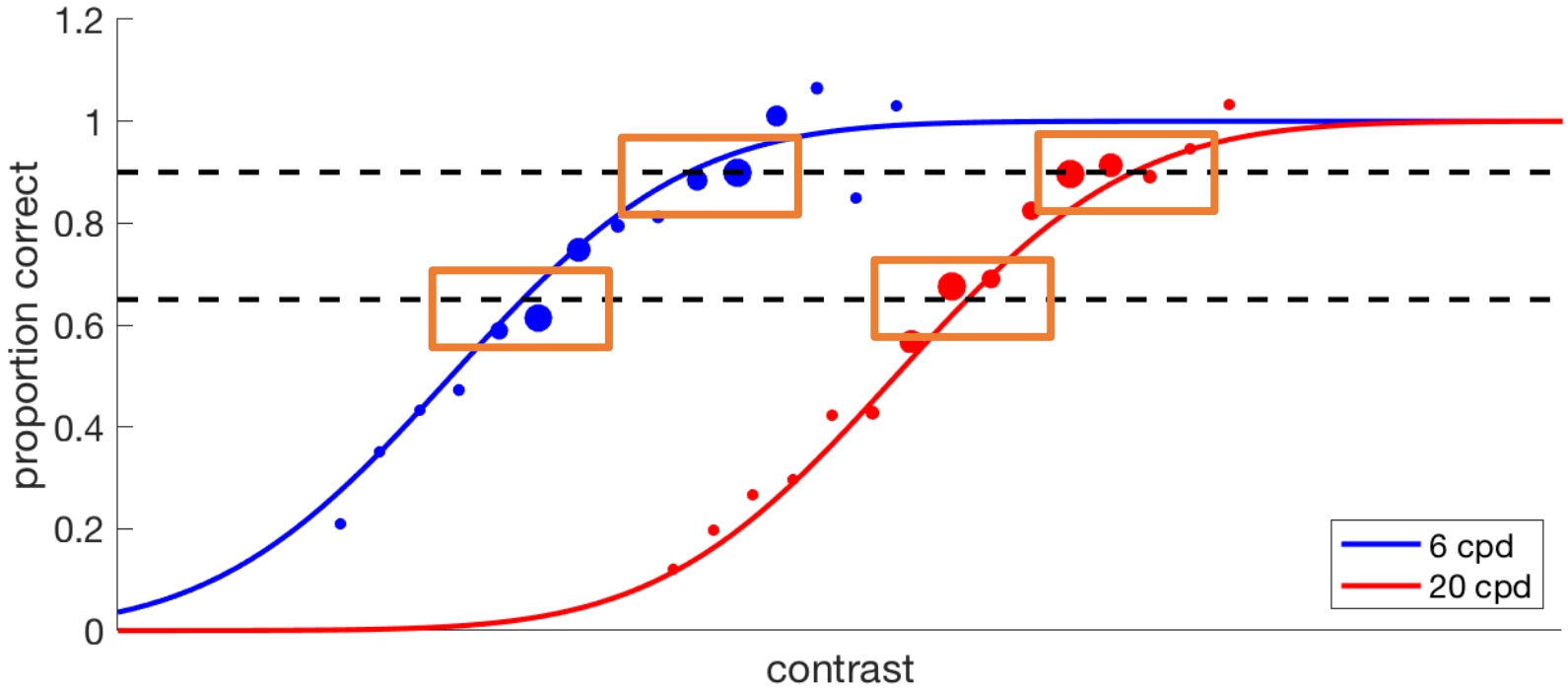


6 or 20 cpd gratings

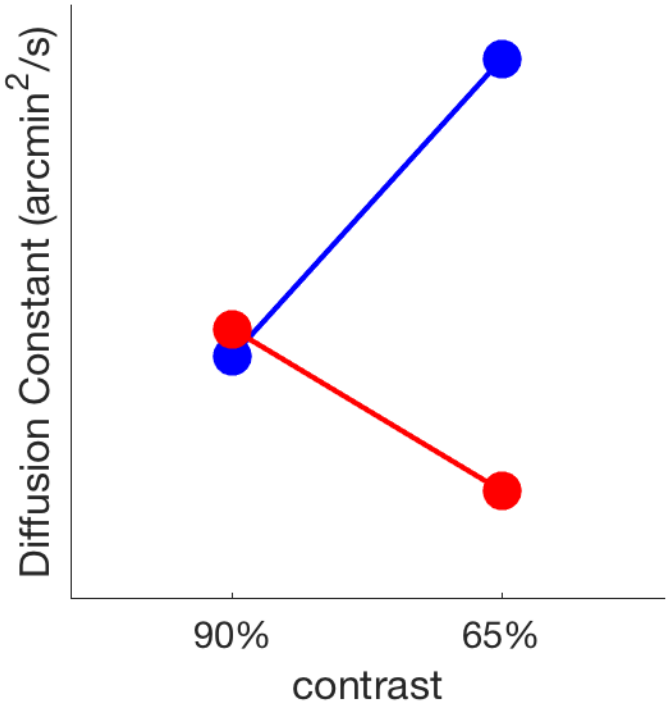
- Pest targets 65% or 90% performance in blocks (4 conditions total)



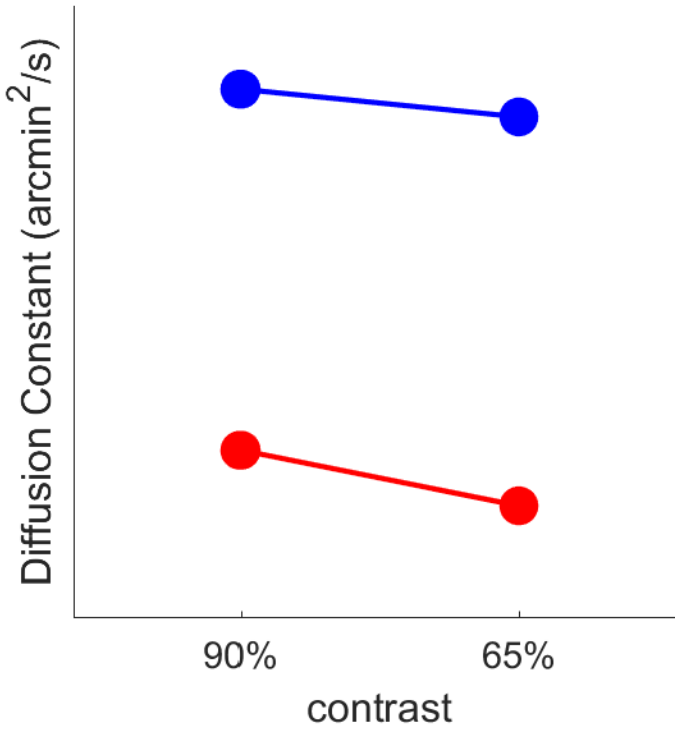
Is drift controlled to modulate temporal power on the retina?



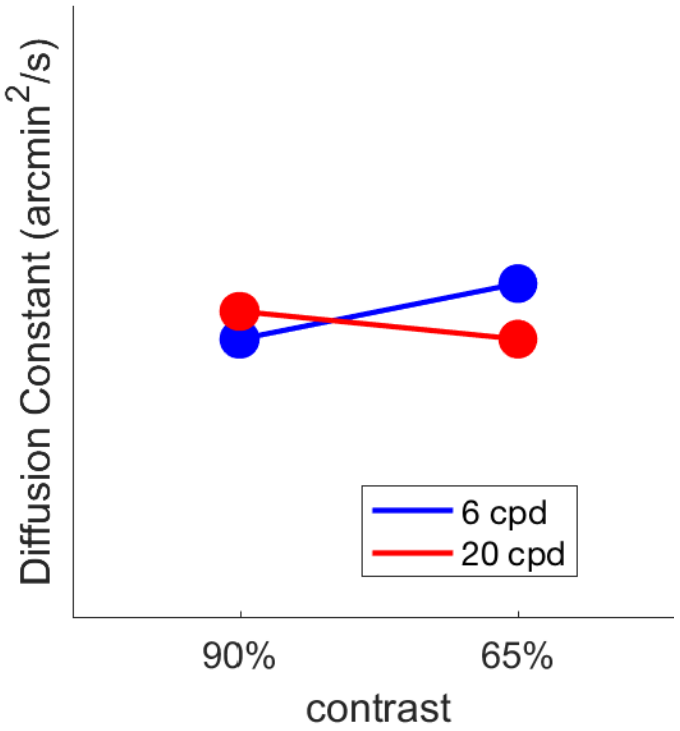
Is drift controlled to modulate temporal power on the retina?



Drift driven by power available on the retina?



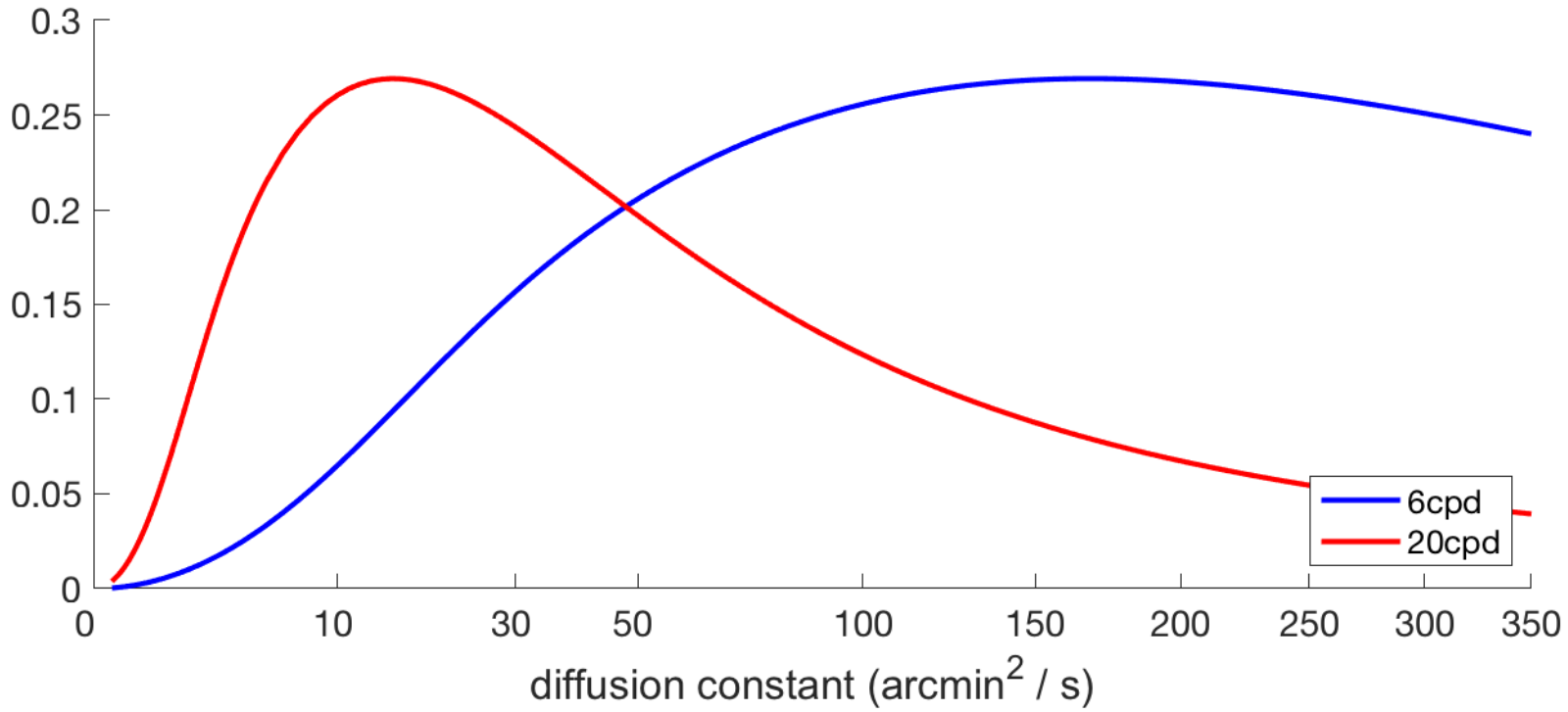
Drift driven by spatial frequency present in stimulus?



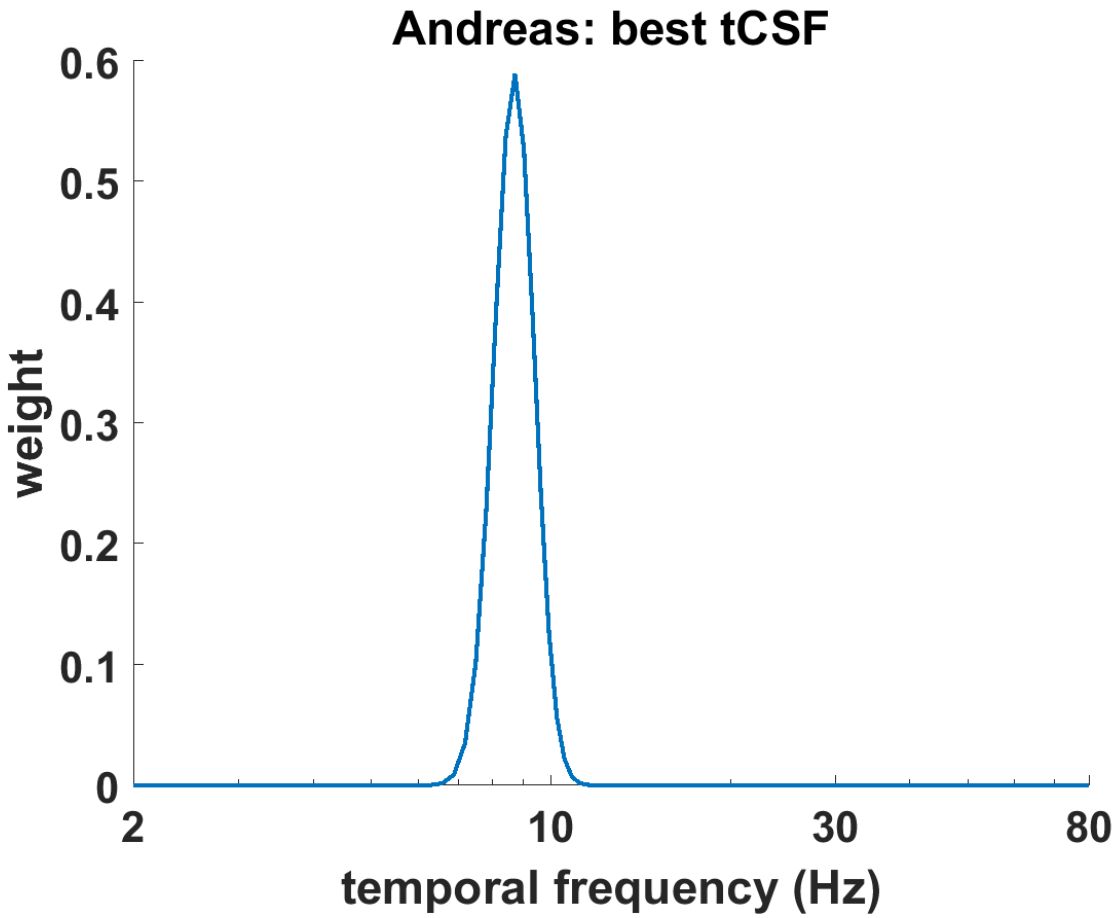
Drift is not tuned??? Or does not need tuning in these conditions

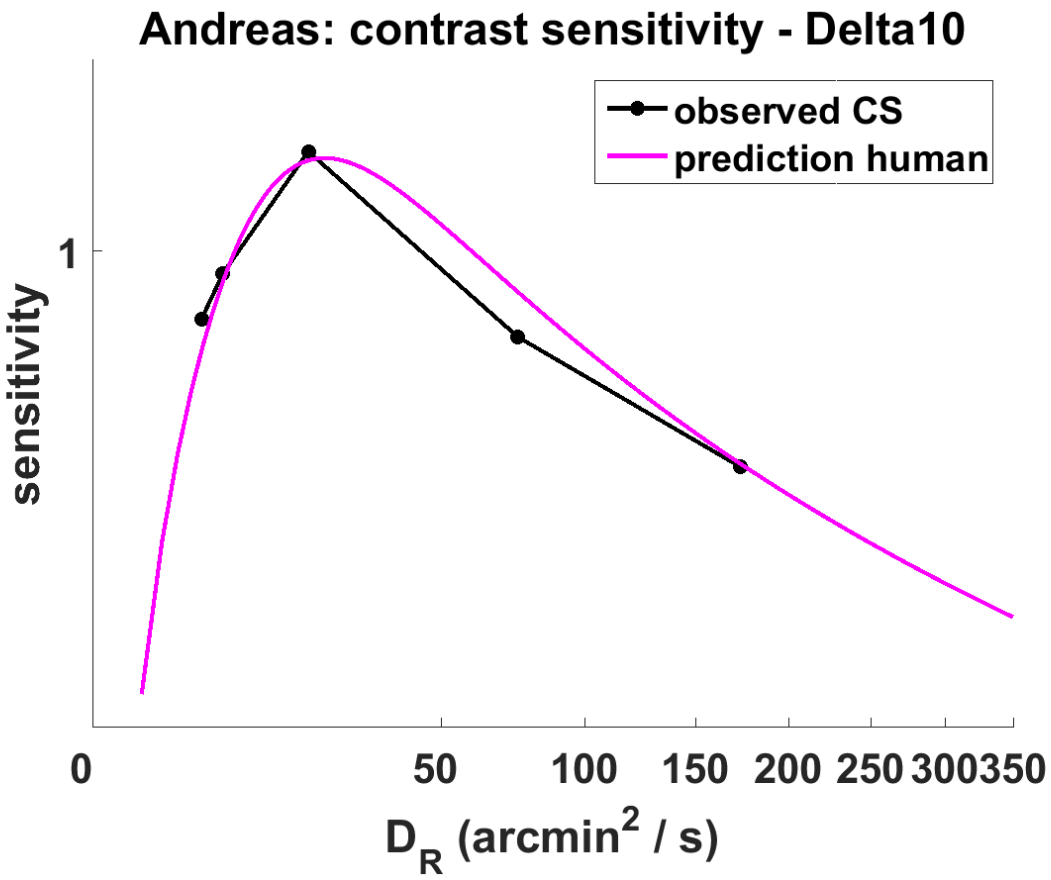
Is drift optimal?

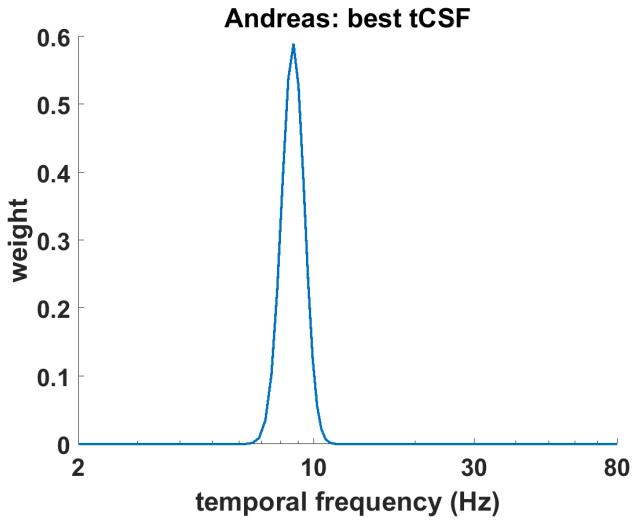
- Repeat sensitivity experiments at various gains

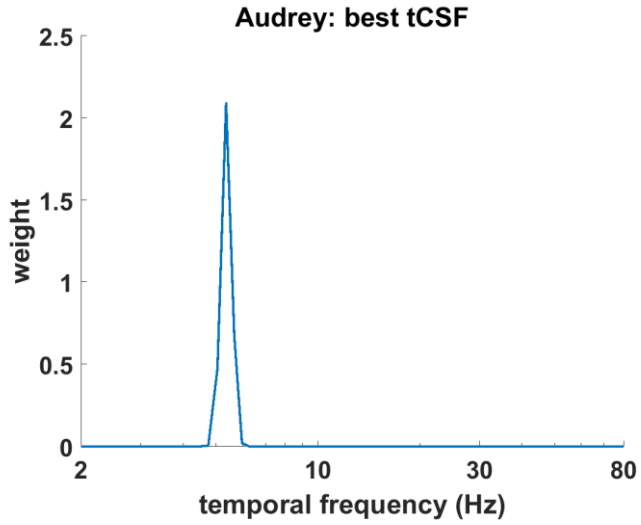


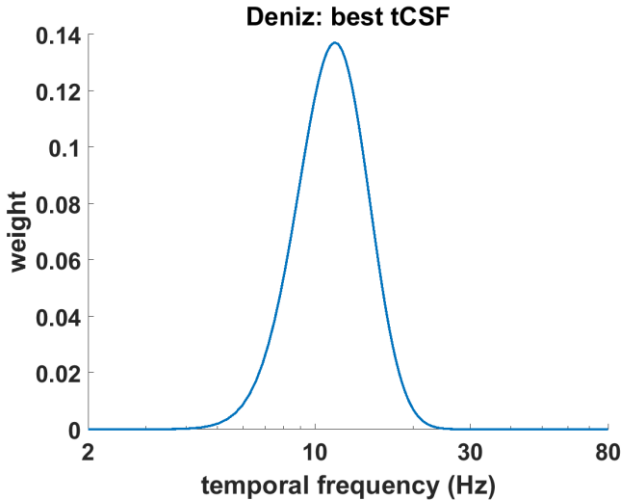
Improving predictions with individual temporal sensitivity

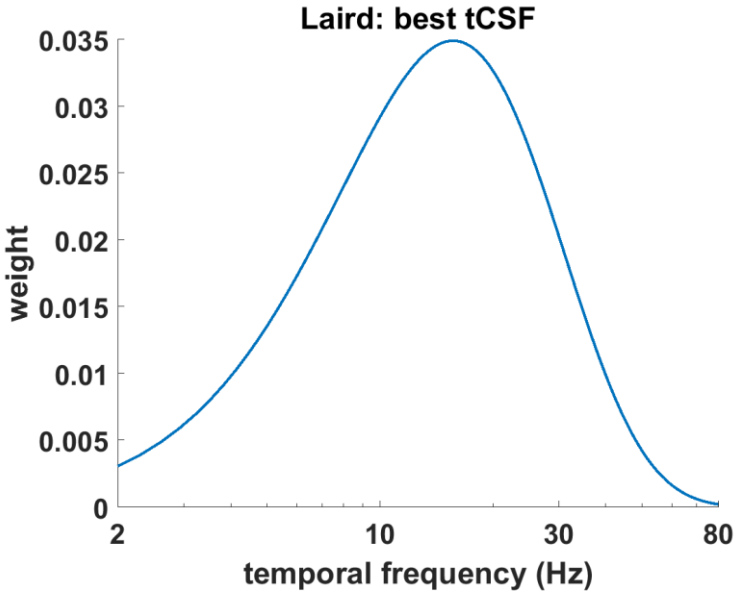


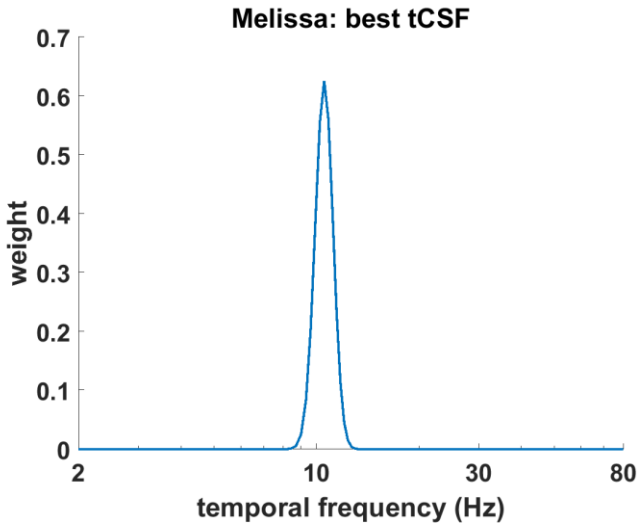


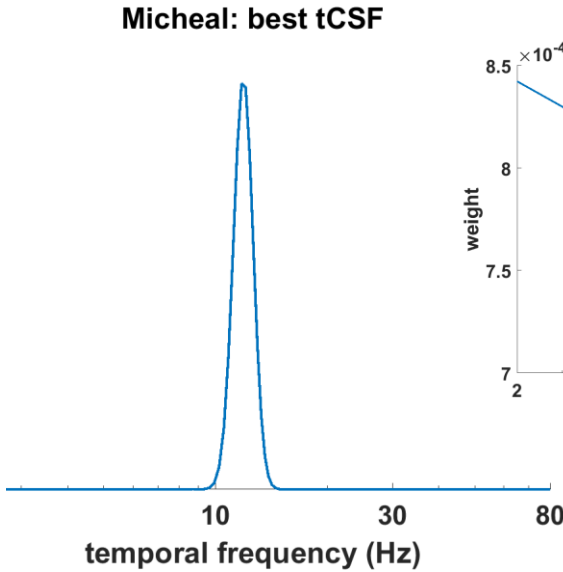

Andreas: best tCSF
weight
temporal frequency (Hz)
0
0.1
0.2
0.3
0.4
0.5
0.6
2
10
30
80

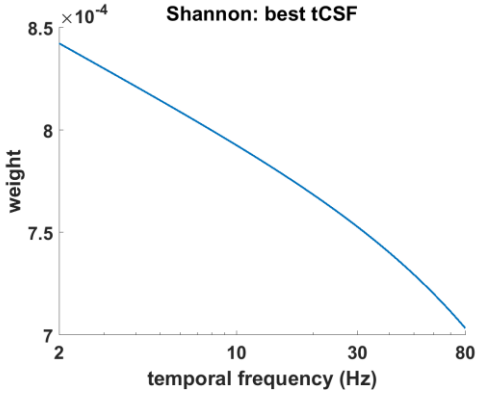

Audrey: best tCSF
weight
temporal frequency (Hz)
0
0.5
1
1.5
2
2.5
2
10
30
80

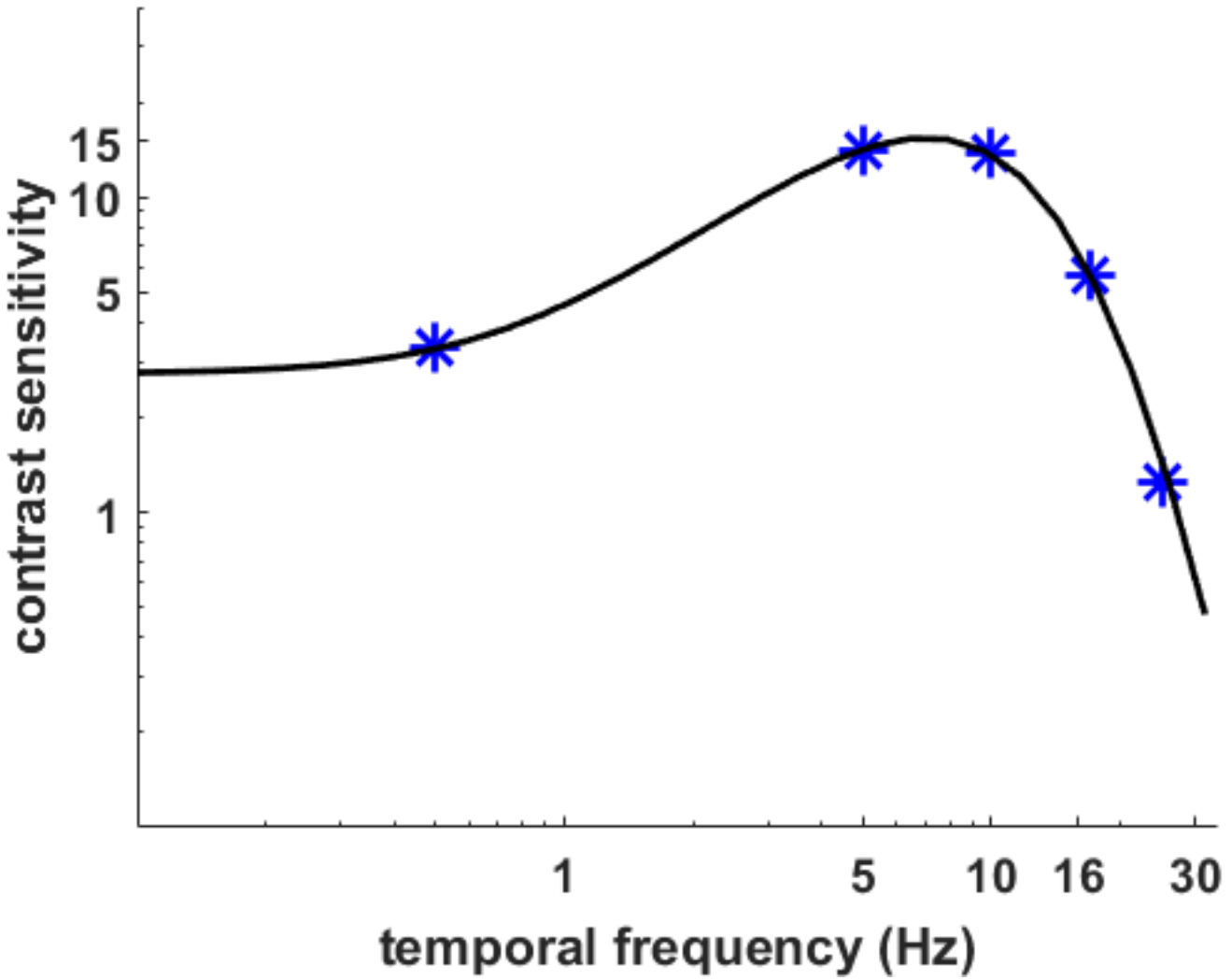

Deniz: best tCSF
weight
temporal frequency (Hz)
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
2
10
30
80


Laird: best tCSF
weight
temporal frequency (Hz)
0
0.005
0.01
0.015
0.02
0.025
0.03
0.035
2
10
30
80


Melissa: best tCSF
weight
temporal frequency (Hz)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
2
10
30
80

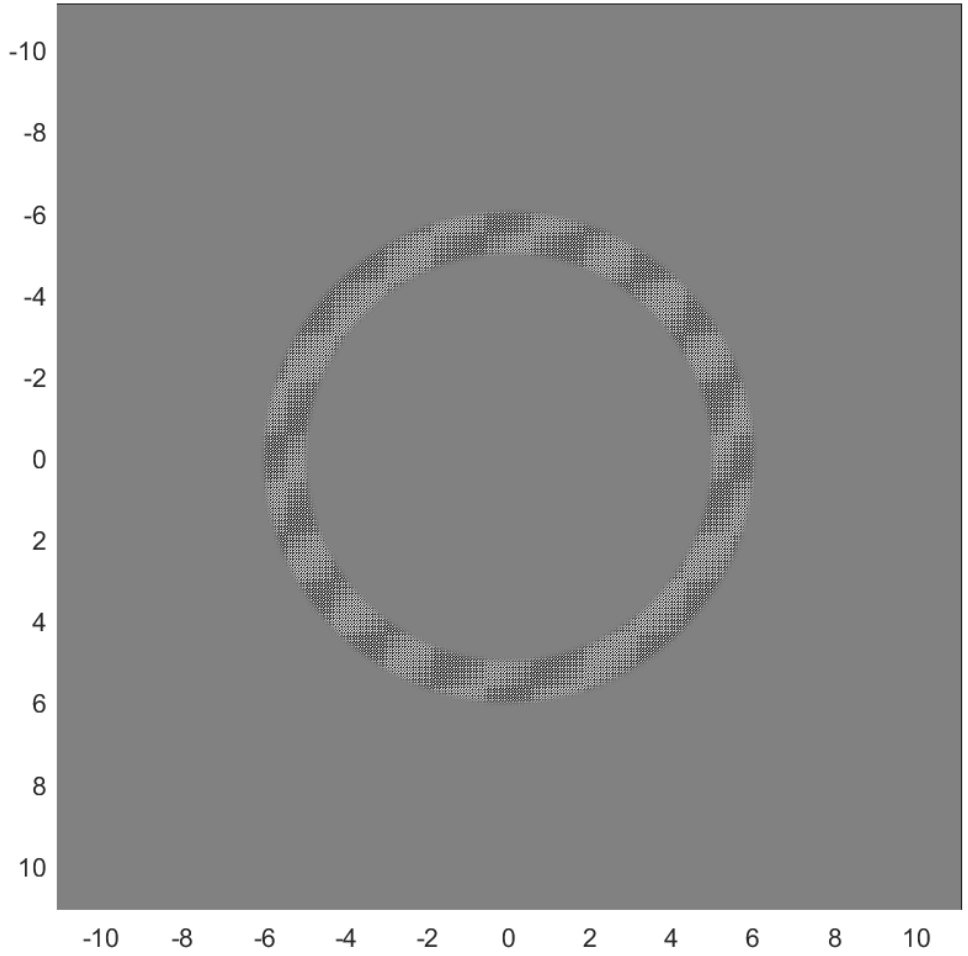

Micheal: best tCSF
temporal frequency (Hz)
10
30
80


Shannon: best tCSF
×10-4
weight
temporal frequency (Hz)
7
7.5
8
8.5
2
10
30
80



6 cpd grating, fully stabilized

Measuring spatiotemporal sensitivity across the retina



- Grating annulus stabilized at fixed eccentricity
- Measure spatial and temporal sensitivities to relate to known properties of retina