Temporal Sensitivity

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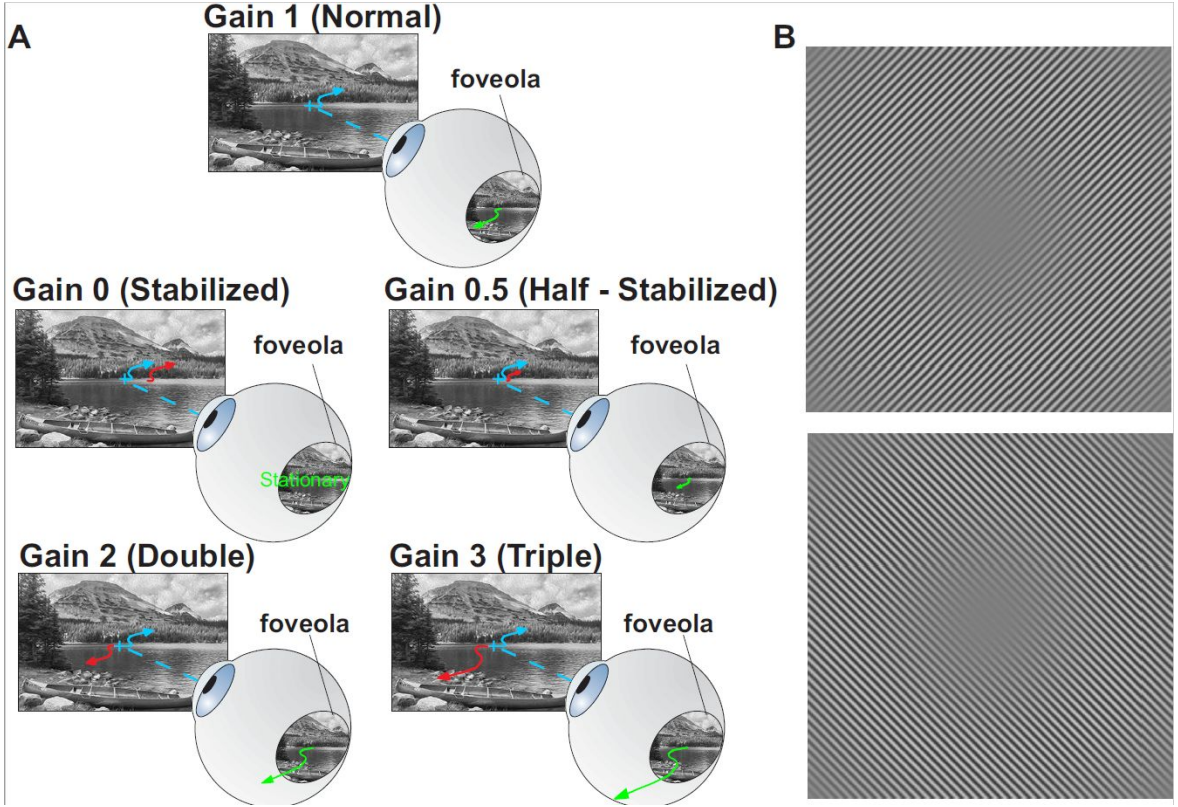
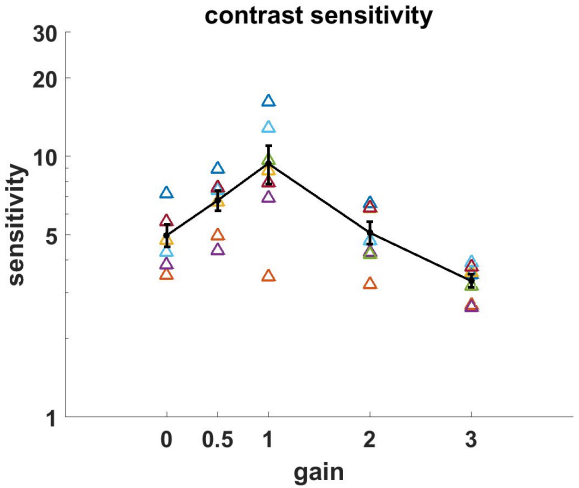
Overview

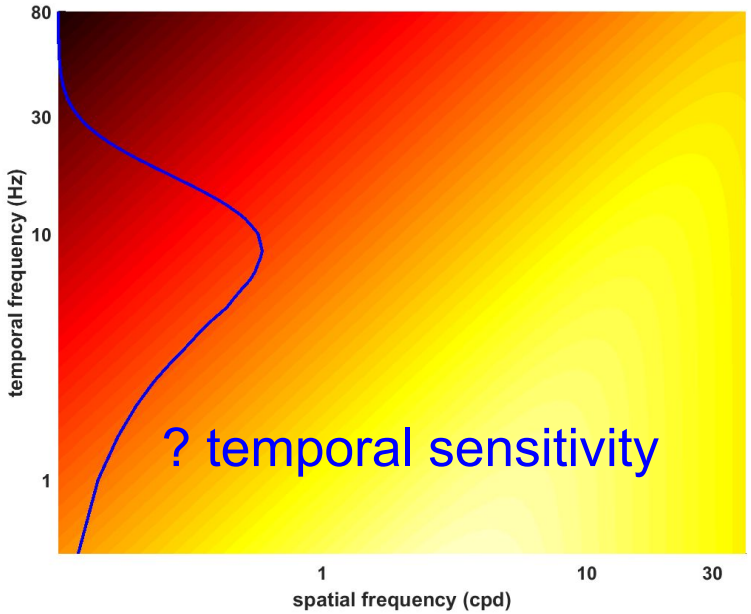
- Improve understanding of temporal sensitivity
- Predict contrast sensitivity results for Drift Gain - Grating data
  - Evaluate predictions using well known temporal sensitivity profiles (psychophysically estimated tCSF, neurophysiologically estimated temporal profiles)
  - Determine the optimal temporal sensitivity profile given the drift gain - grating data
- Ideal case: Estimate tCSF in conditions as similar as possible to drift gain for individualized predictions

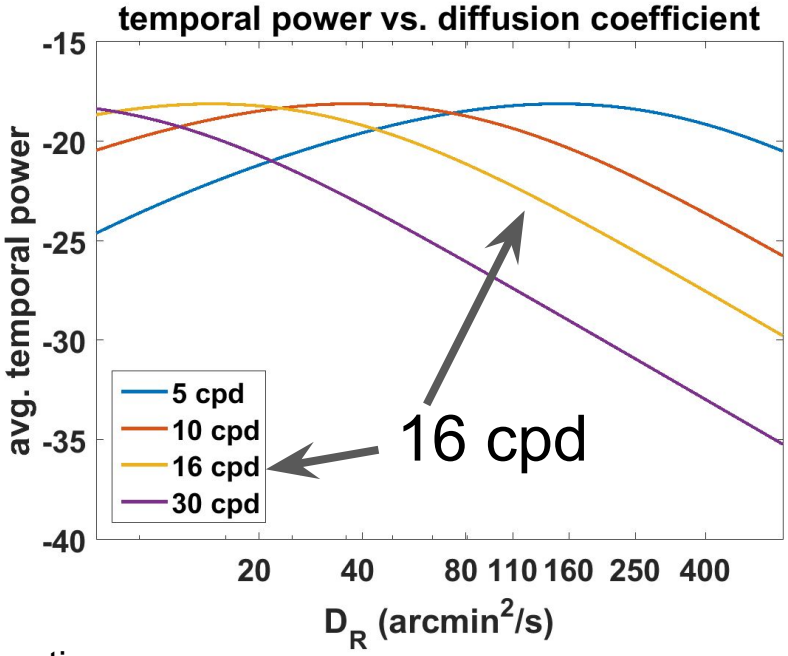
Quick Overview of Drift Gain - Grating data





Quick Overview of Drift Gain - Grating model





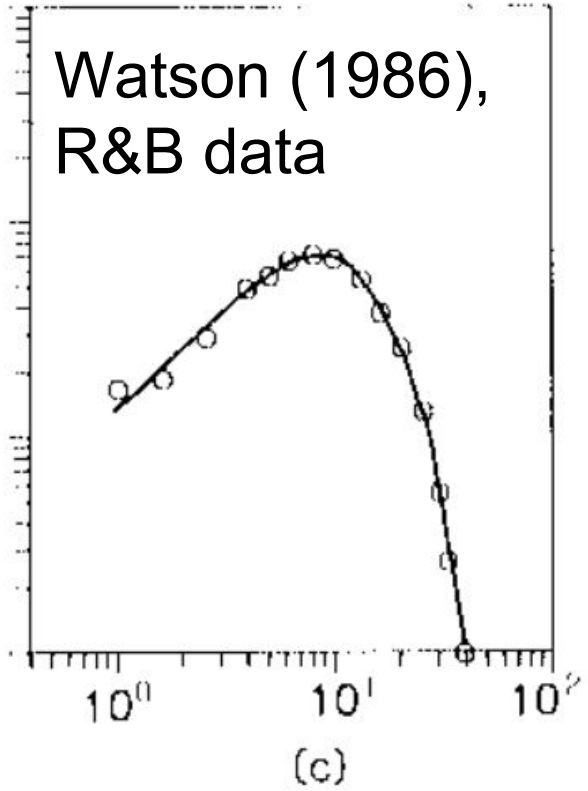
Brownian motion of spatiotemporal frequency content on retina

$$Q(\xi, f; D_R) = \frac{2D_R\xi^2}{4\pi^2 D_R^2 \xi^4 + f^2}$$

Review of tCSF from literature

- Human temporal sensitivity
  - Watson (1986) fit to Roufs & Blommaert (1981) data - flickering 1-deg disk
  - Robson (1966) - sinusoidally modulated grating (collected our own data)
- Stabilized human temporal sensitivity
  - Kelly (1979) series in JOSA - standing or traveling gratings
- M and P ganglion cell profiles
  - M: Benardete & Kaplan, 1999 (Visual Neuroscience)
  - P: Benardete & Kaplan, 1999 (Journal of physiology)
  - Inferred from recordings in LGN; disk or grating stimuli with sum of sinusoids temporal modulation(M) or drifting gratings (P) (near preferred spatial frequency)

Human Temporal Sensitivity Profiles



Robson (1966)

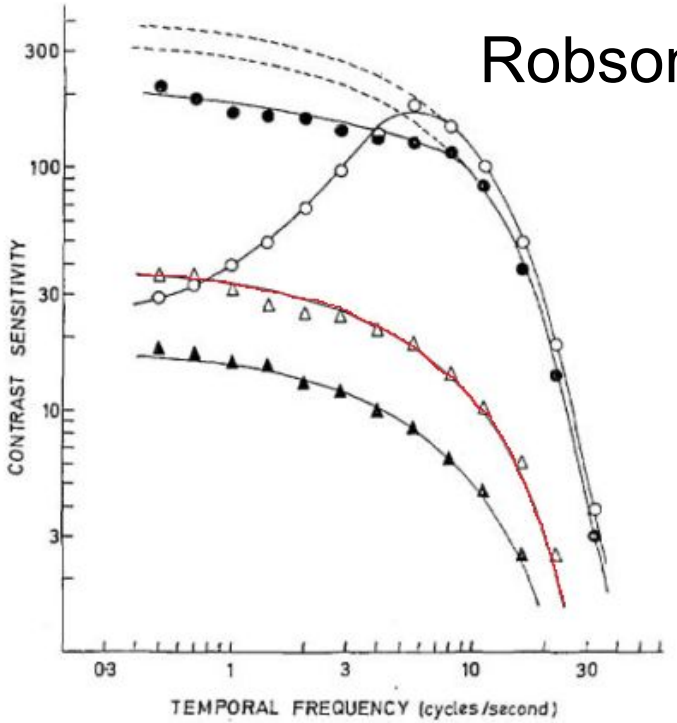
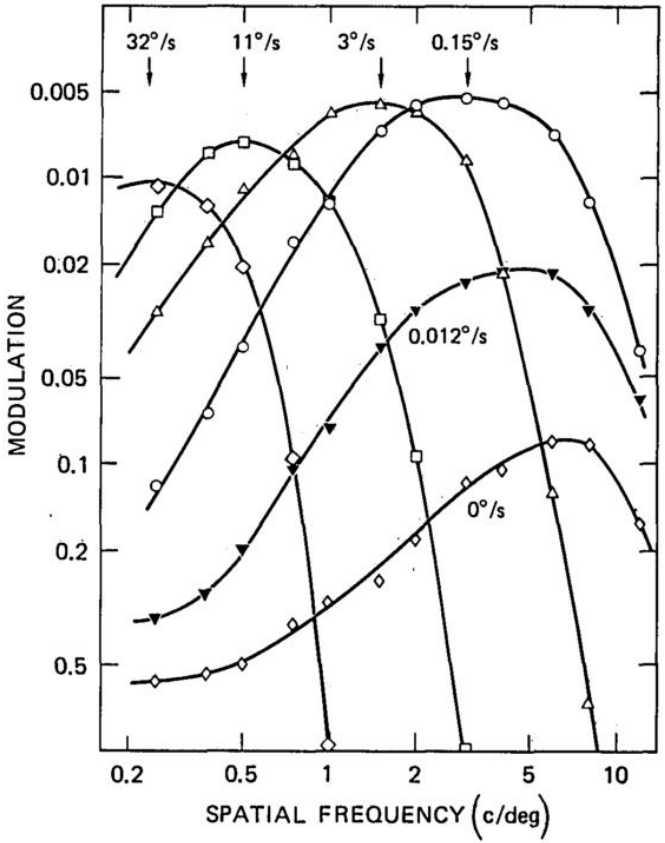


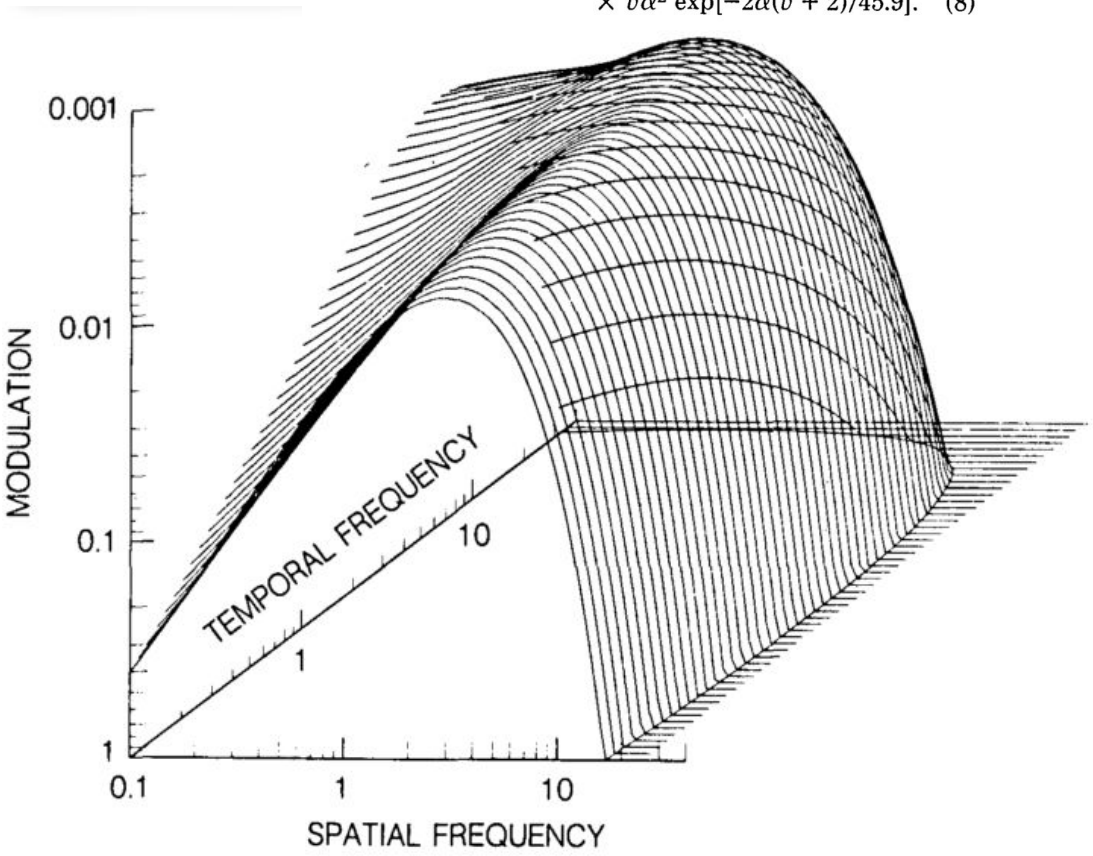
FIG. 2. Temporal contrast-sensitivity (reciprocal of threshold contrast) functions for different spatial frequencies. The points are the means of four measurements and the curves (two with dashed low-frequency sections) differ only in their positions along the contrast-sensitivity scale, ○ 0.5 cycle per degree, ● 4, △ 16, ▲ 22 cycles per degree.

Human Stabilized tCSF

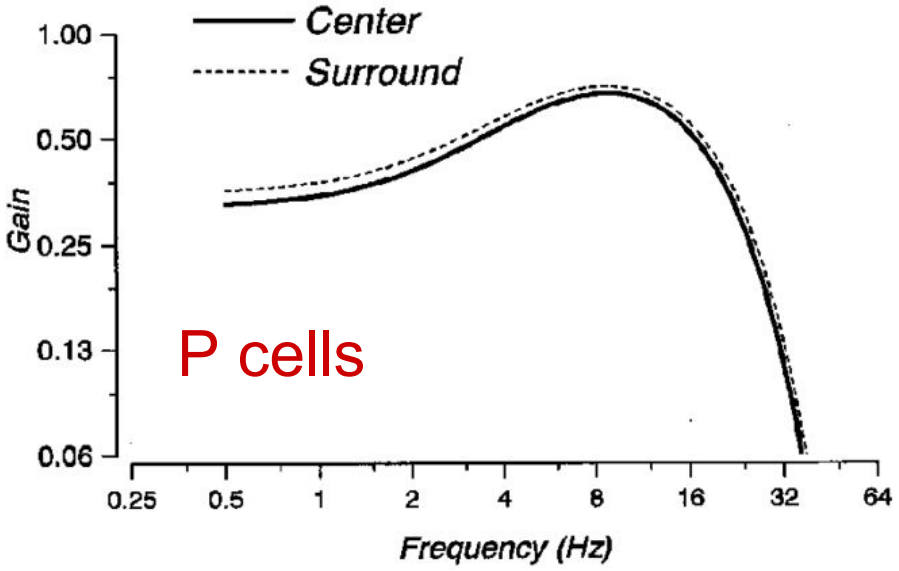
Kelly (1979)

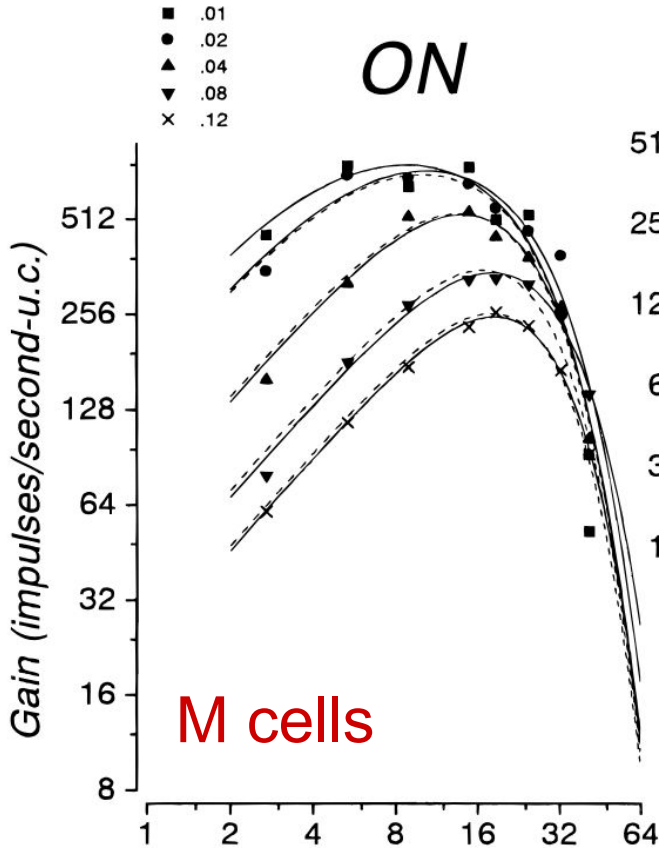
$$G(\alpha,v) = [6.1 + 7.3|\log(v/3)|^3] \times v\alpha^2 \exp[-2\alpha(v+2)/45.9]. \quad (8)$$





Ganglion Cell Temporal Sensitivity Profiles

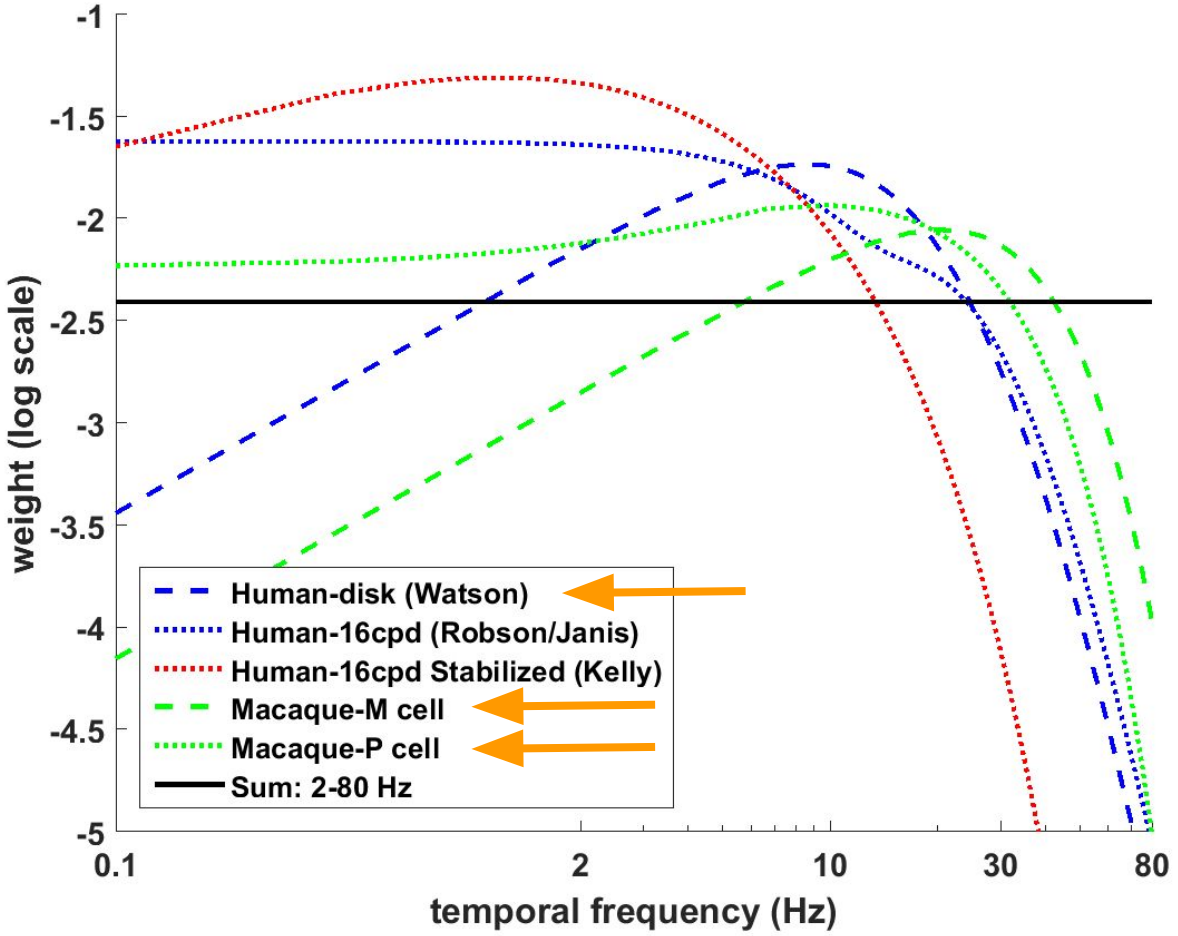




Benardete & Kaplan (1999a,b)

tCSF summary

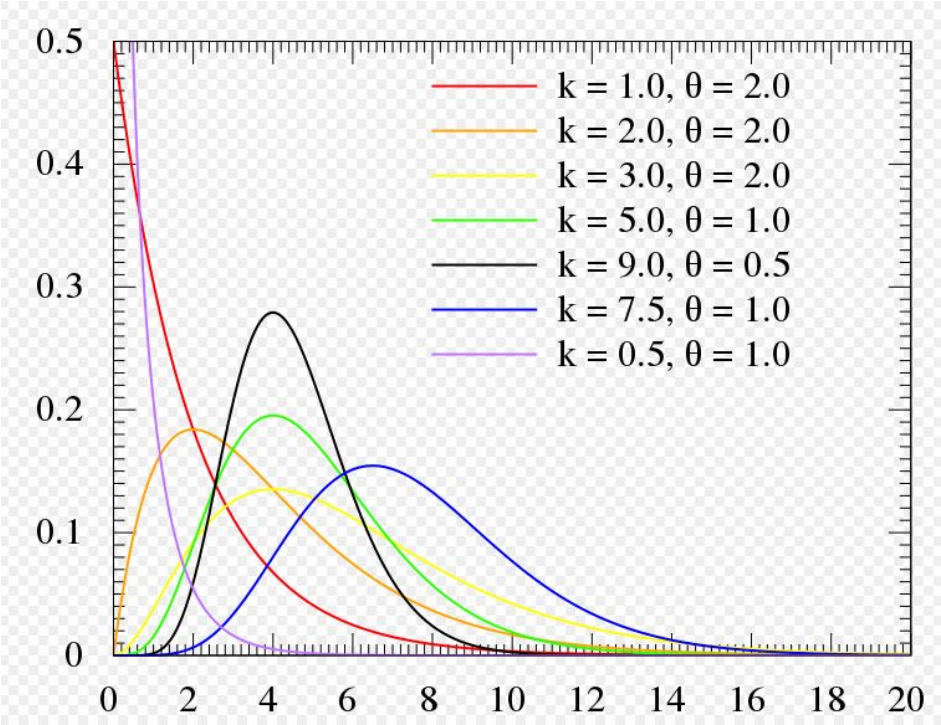
Cutoff at 2Hz or 0.1Hz



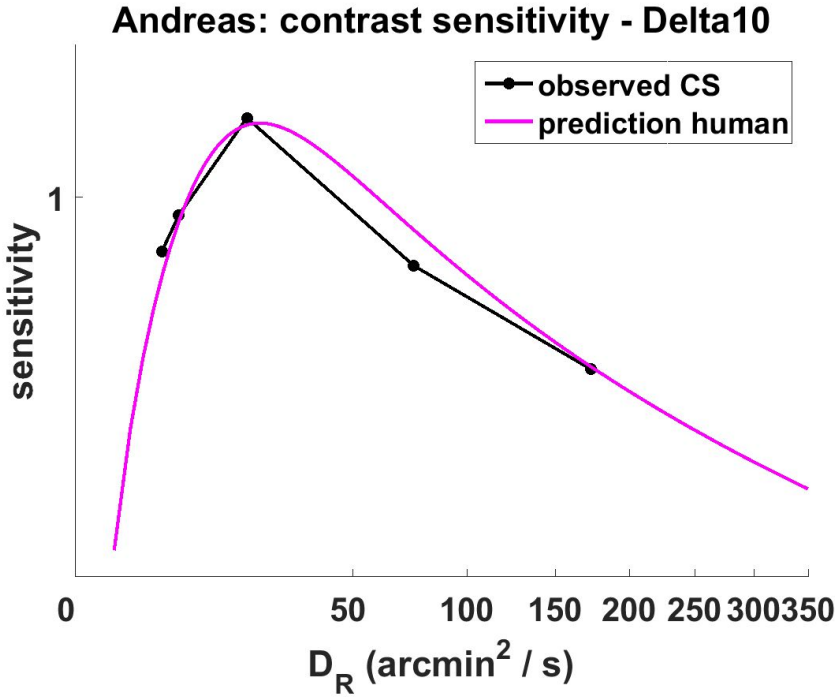
Optimal temporal sensitivity profile

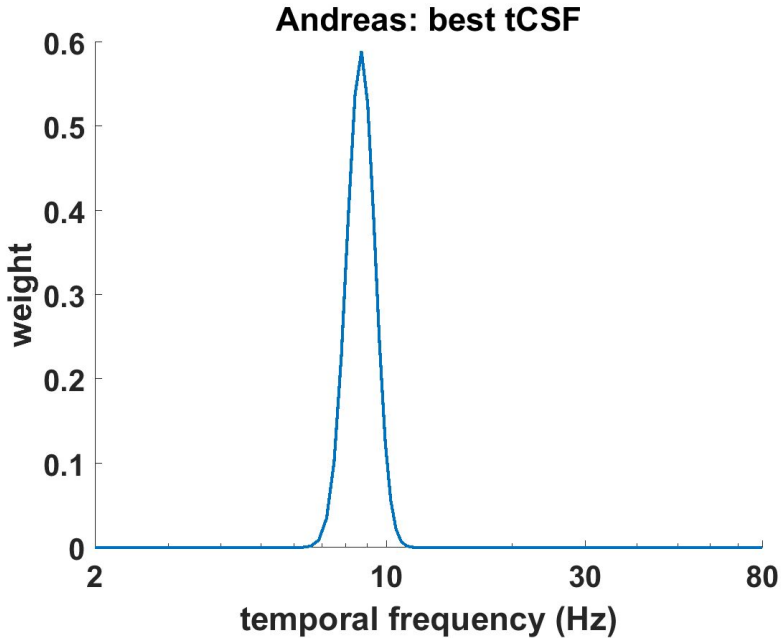
Model temporal filter as gamma distribution

Find gamma distribution parameters that minimize error between data and prediction for each subject

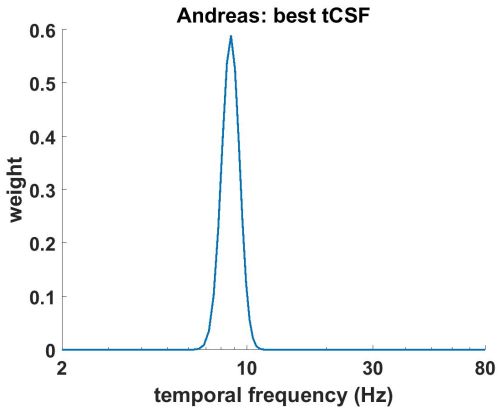


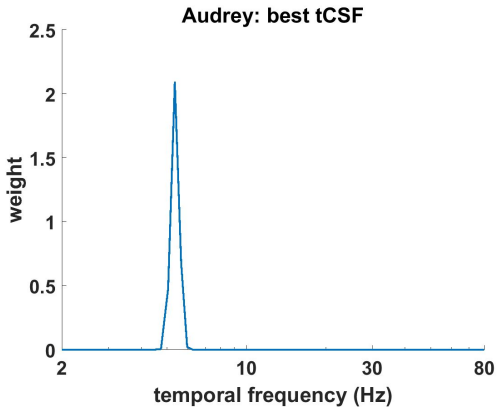
Optimal temporal sensitivity profiles

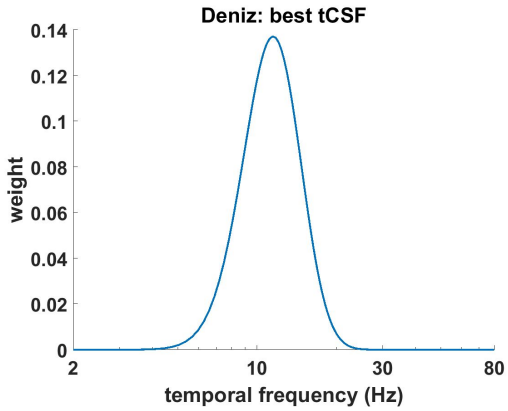


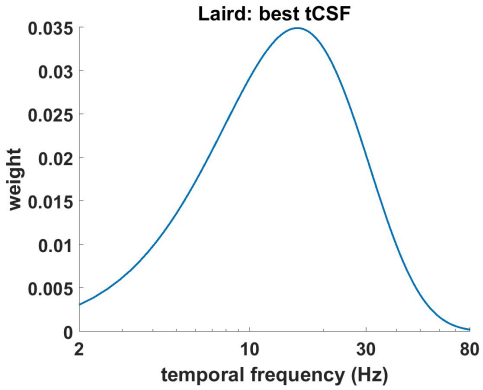


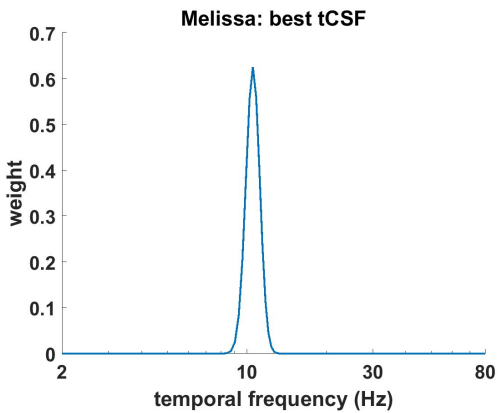
We'll also look at predictions which include only the 10Hz frequency band ('Delta10')

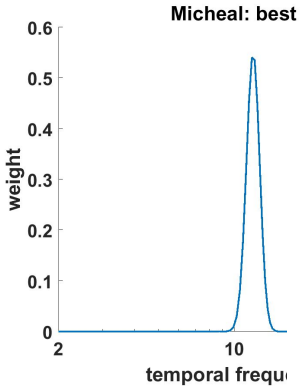

Andreas: best tCSF
weight
temporal frequency (Hz)

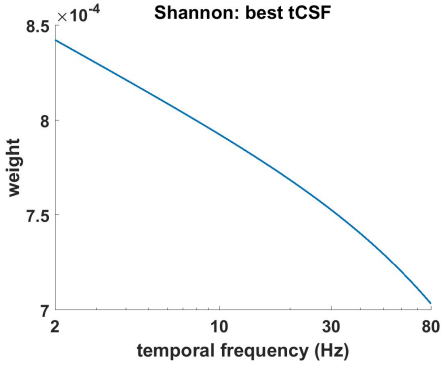

Audrey: best tCSF
weight
temporal frequency (Hz)


Deniz: best tCSF
weight
temporal frequency (Hz)


Laird: best tCSF
weight
temporal frequency (Hz)

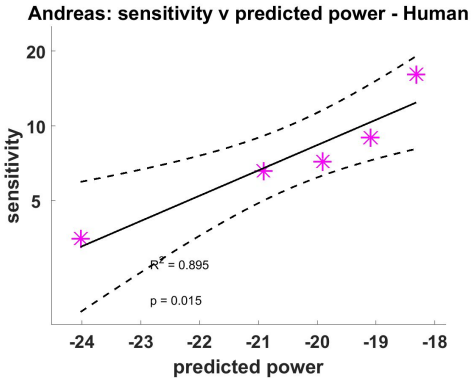

Melissa: best tCSF
weight
temporal frequency (Hz)

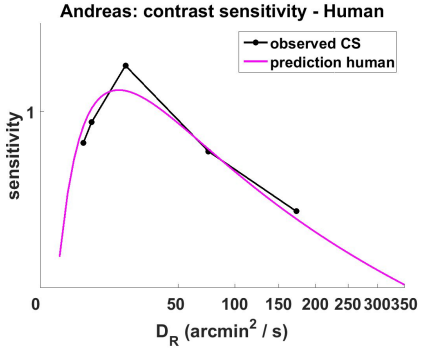

Micheal: best tCSF
weight
temporal frequ

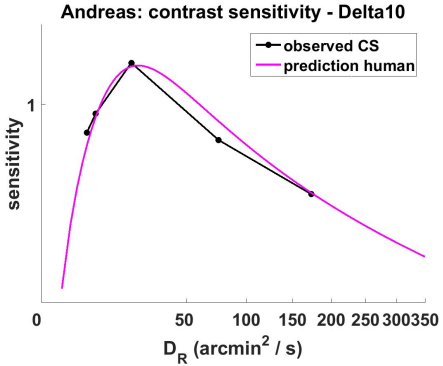

Shannon: best tCSF
×10-4
weight
temporal frequency (Hz)

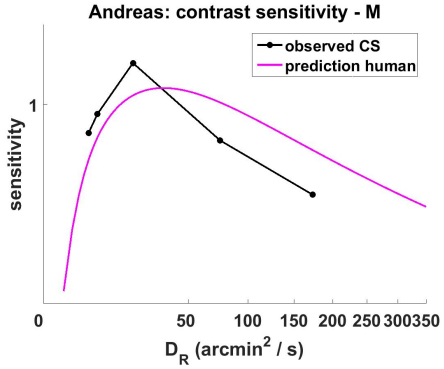
Predictions and data

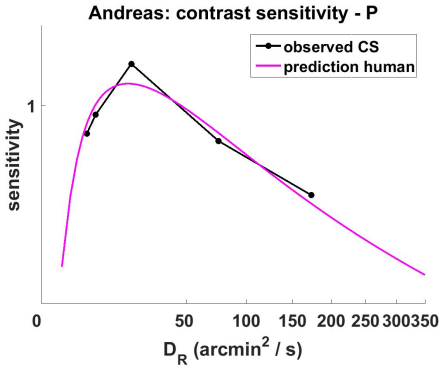
- One prediction curve for each temporal filter and each low cutoff frequency (2Hz and 0Hz)
- Individual subject data is scaled and vertically translated to minimize error between prediction and data







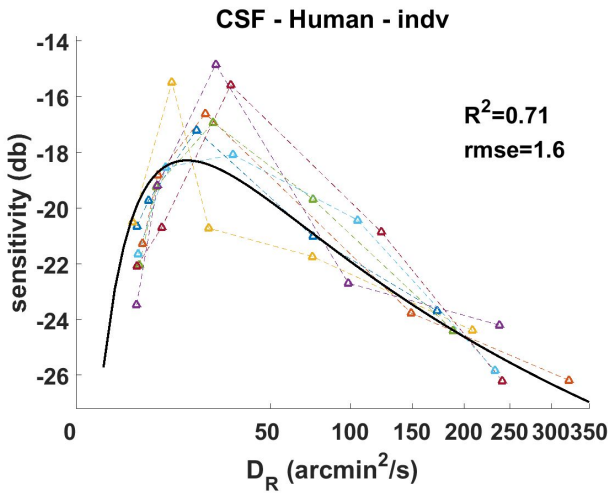


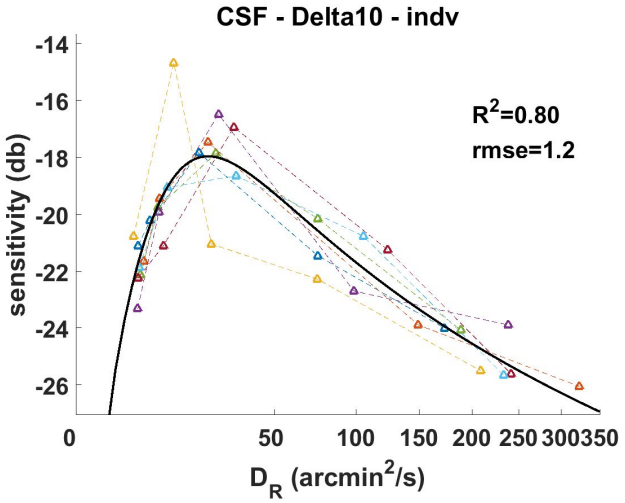


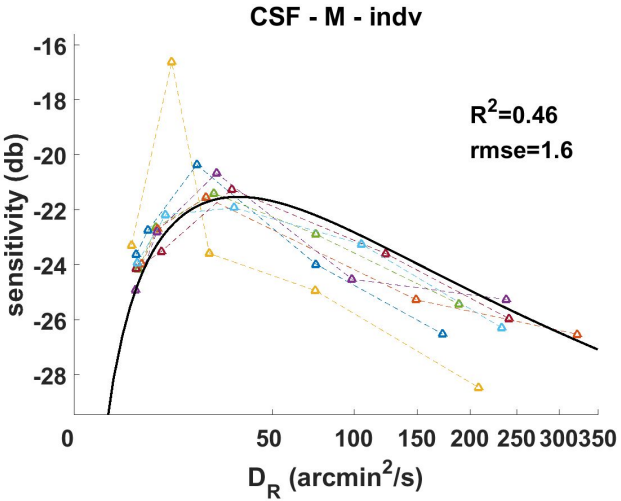
>= 2Hz

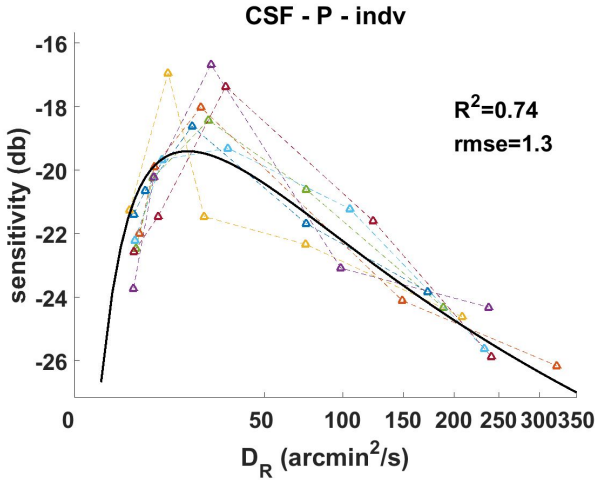
>= 2Hz

Assumption:
no sensitivity to temporal frequencies < 2Hz

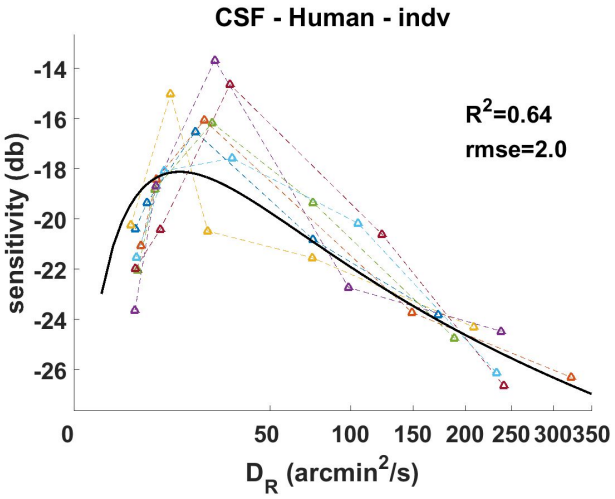


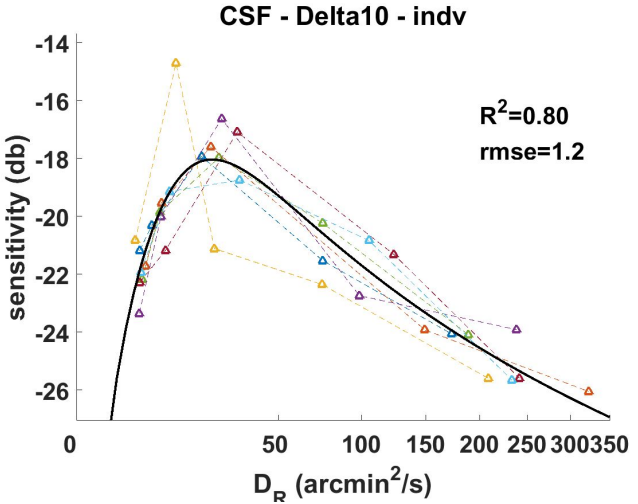


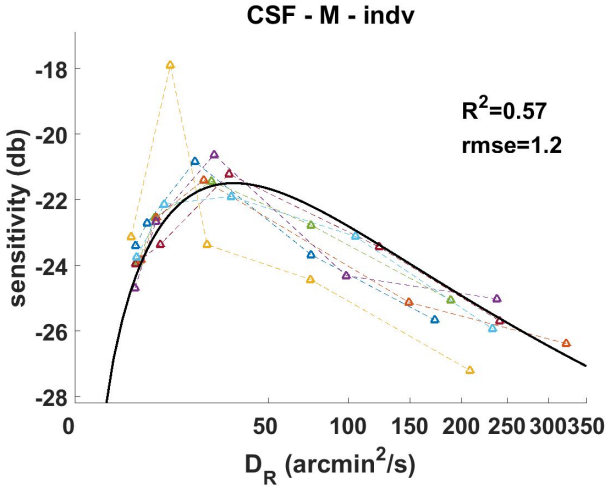


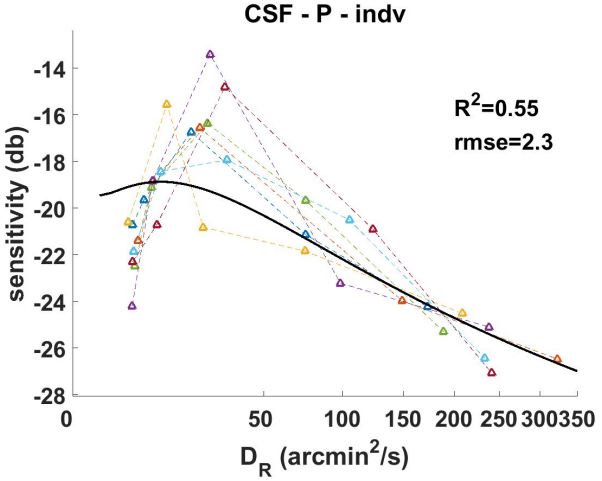


> 0Hz


CSF - Human - indv
R^2=0.64
rmse=2.0
sensitivity (db)
-14
-16
-18
-20
-22
-24
-26
0
50
100
150
200
250
300
350
D_R (arcmin^2/s)


CSF - Delta10 - indv
R^2=0.80
rmse=1.2
sensitivity (db)
-14
-16
-18
-20
-22
-24
-26
0
50
100
150
200
250
300
350
D_R (arcmin^2/s)


CSF - M - indv
R^2=0.57
rmse=1.2
sensitivity (db)
-18
-20
-22
-24
-26
-28
0
50
100
150
200
250
300
350
D_R (arcmin^2/s)


CSF - P - indv
R^2=0.55
rmse=2.3
sensitivity (db)
-14
-16
-18
-20
-22
-24
-26
-28
0
50
100
150
200
250
300
350
D_R (arcmin^2/s)

R^2 values by subject

	> 2Hz **Human** > 0Hz		> 2Hz **M** > 0Hz		> 2Hz **P** > 0Hz		**10Hz**
1	**.895**	**.821**	.363	.486	**.918**	.705	**.939**
2	.653	.654	.159	.220	.622	.612	.489
3	.702	.604	**.822**	**.895**	.769	.491	**.966**
4	.589	.517	**.910**	**.947**	.649	.442	**.818**
5	**.883**	**.849**	**.855**	**.883**	**.892**	**.797**	**.973**
6	.528	.445	.709	.717	.560	.339	**.789**
7	**.816**	.747	**.837**	**.912**	**.868**	.667	**.947**

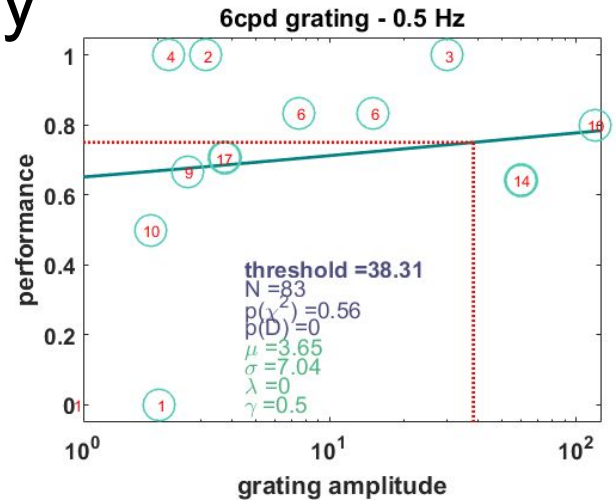
*Values in **bold** have $p < 0.05$

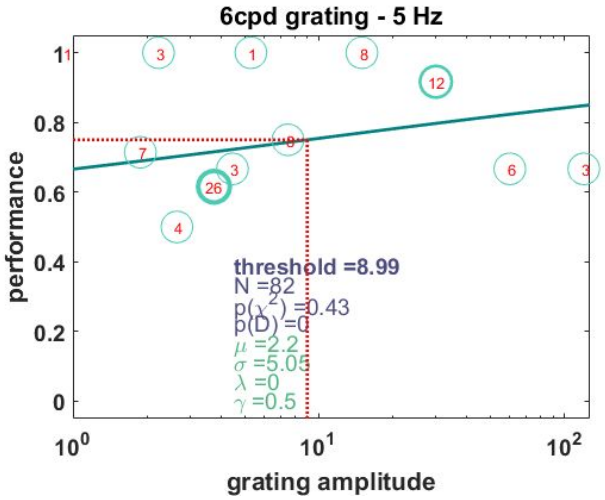
Data Collection

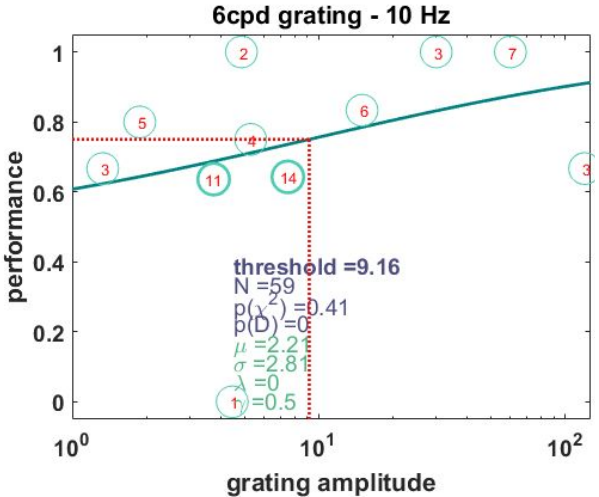
- Data was collected from a naive subject (CS) using a 6cpd grating with temporal frequencies 0.5, 5, 10, 17 and 25Hz.
- Presentation time was 1300ms with a gaussian envelope to ramp the stimulus both in and out.
- A 6cpd grating was used instead of 16cpd because the 16cpd gratings were too difficult to see and stabilization is better.

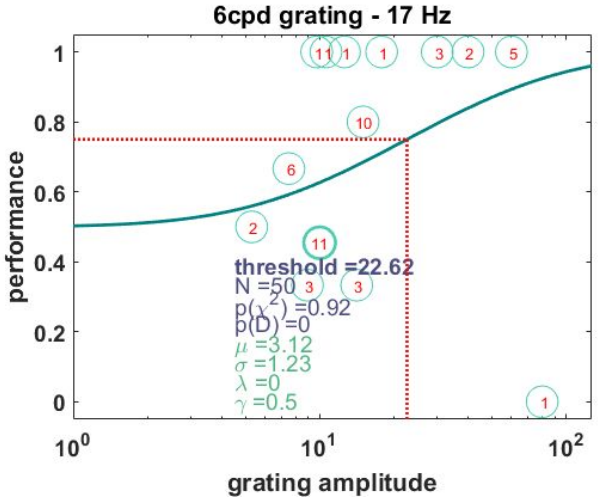
CS Data: Drift Only

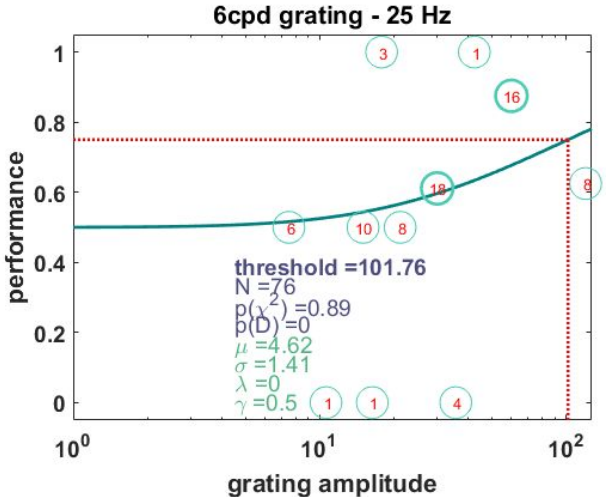
- Total Trials: 1450
- Saccade Trials: 935
- MS Trials: 201
- B/NT/ND: 72
- Valid Trials: 350





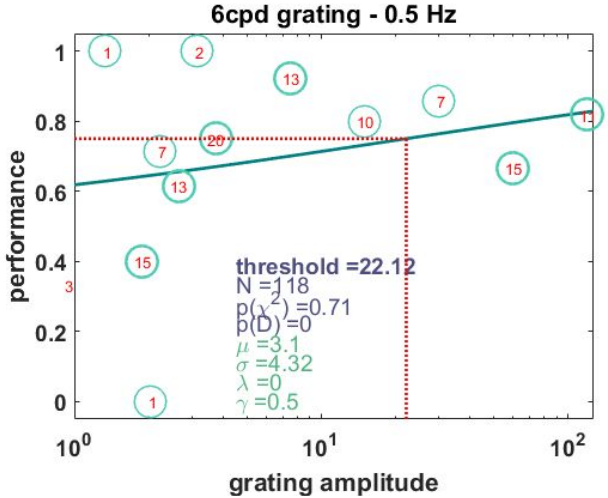


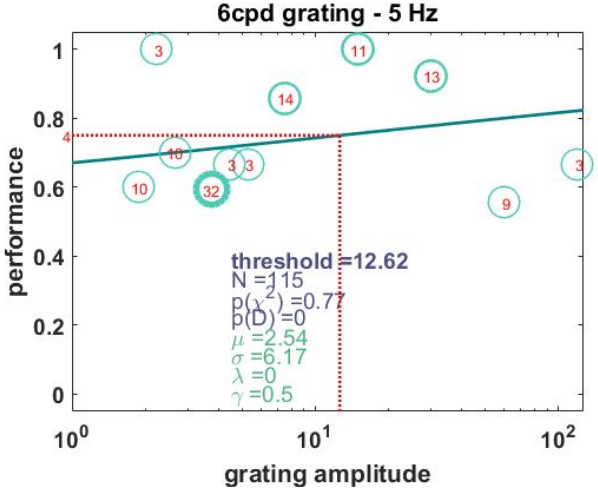


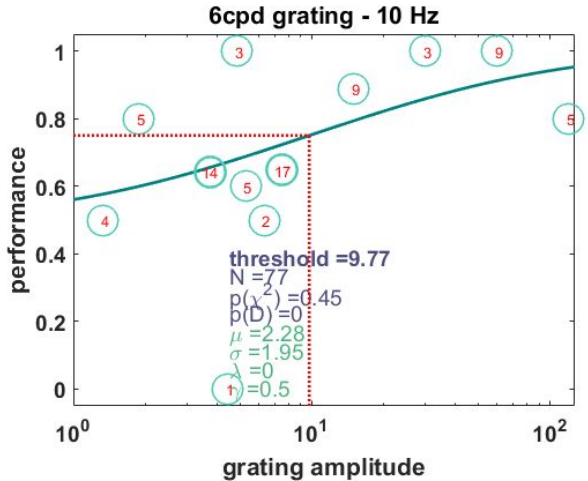


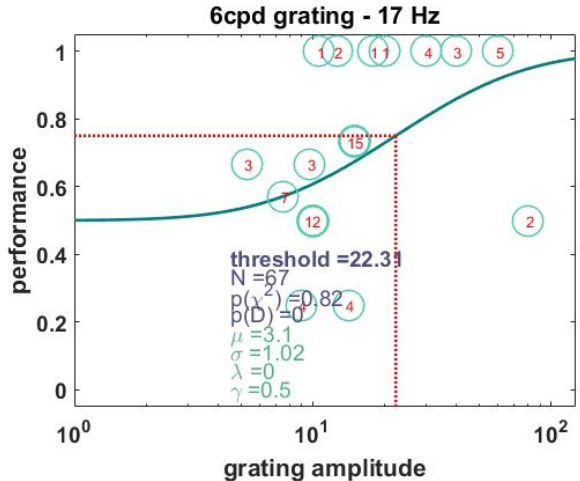
CS Data: MS Included

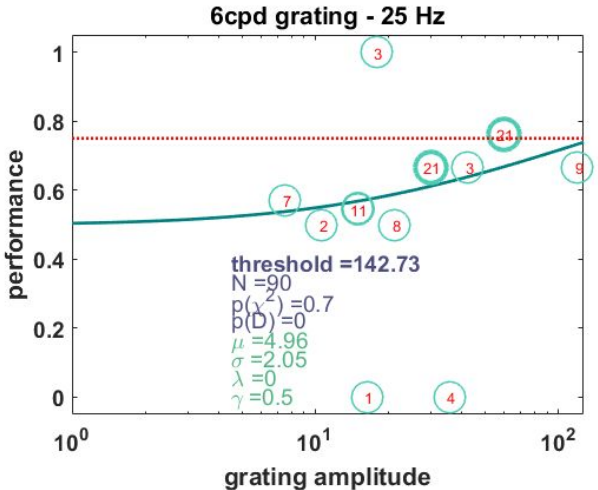
- Total Trials: 1450
- Saccade Trials: 935
- MS Trials: 0
- B/NT/ND: 72
- Valid Trials: 476



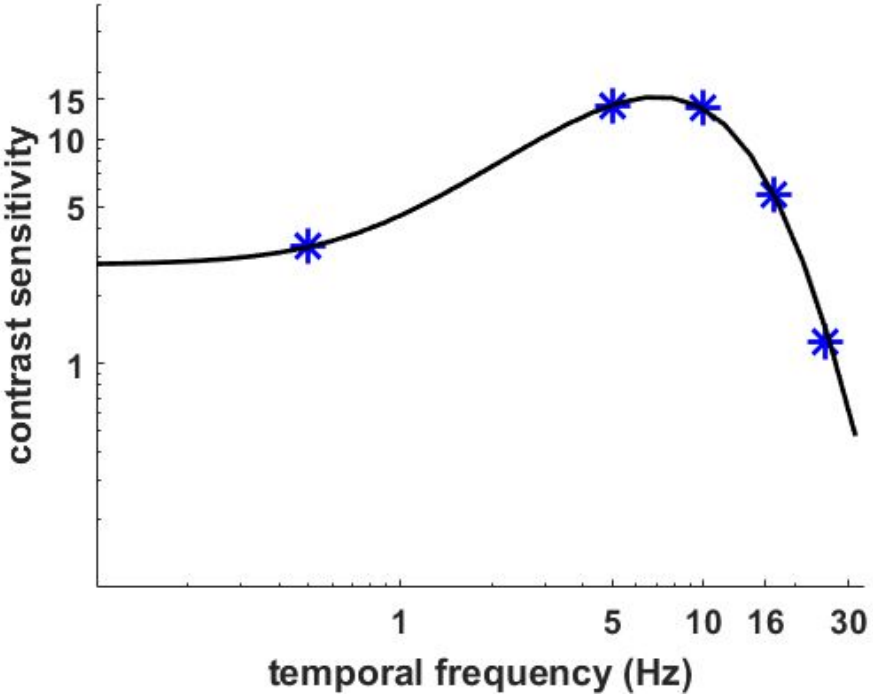




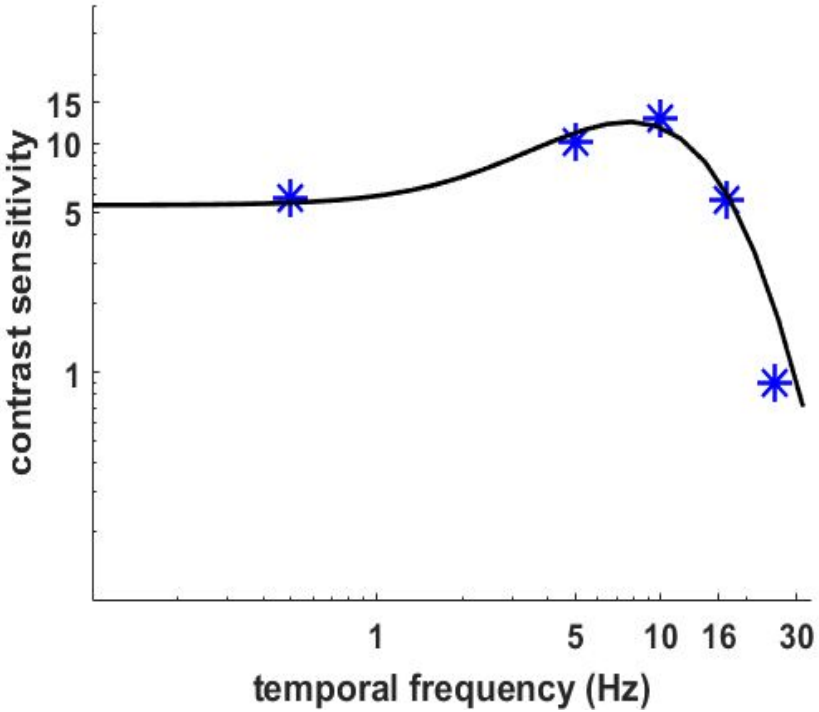




Temporal Contrast Sensitivity Functions



Drift Only



MS Included

Difficulties

- Data collection is slow. Only 135 trials collected per session.
- In the higher frequency conditions (17Hz and 25Hz) eyeris takes a long time to generate stimulus.
- A spatial frequency of 6cpd was used instead of 16cpd because

Ways to speed up tCSF estimation process?

- Method of adjustment is faster but less accurate

Next Steps

- Suggestions for current data and model?
- Follow up study: estimate individual tCSF and generate individualized predictions for drift gain study (without scotoma)
- Temporal sensitivity map of retina?