Dynamics of Visual Processing

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APLAB Meeting

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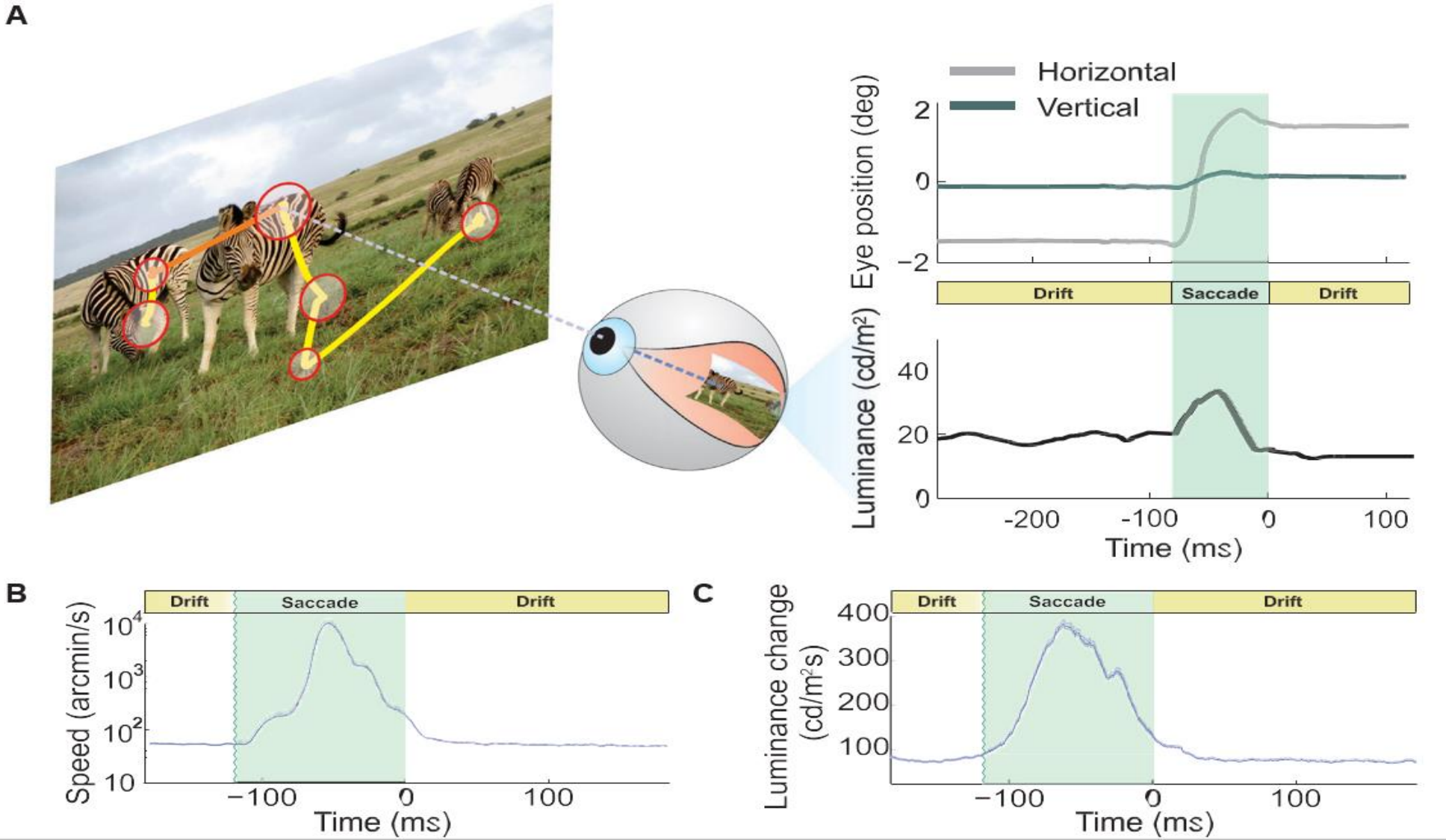
Background

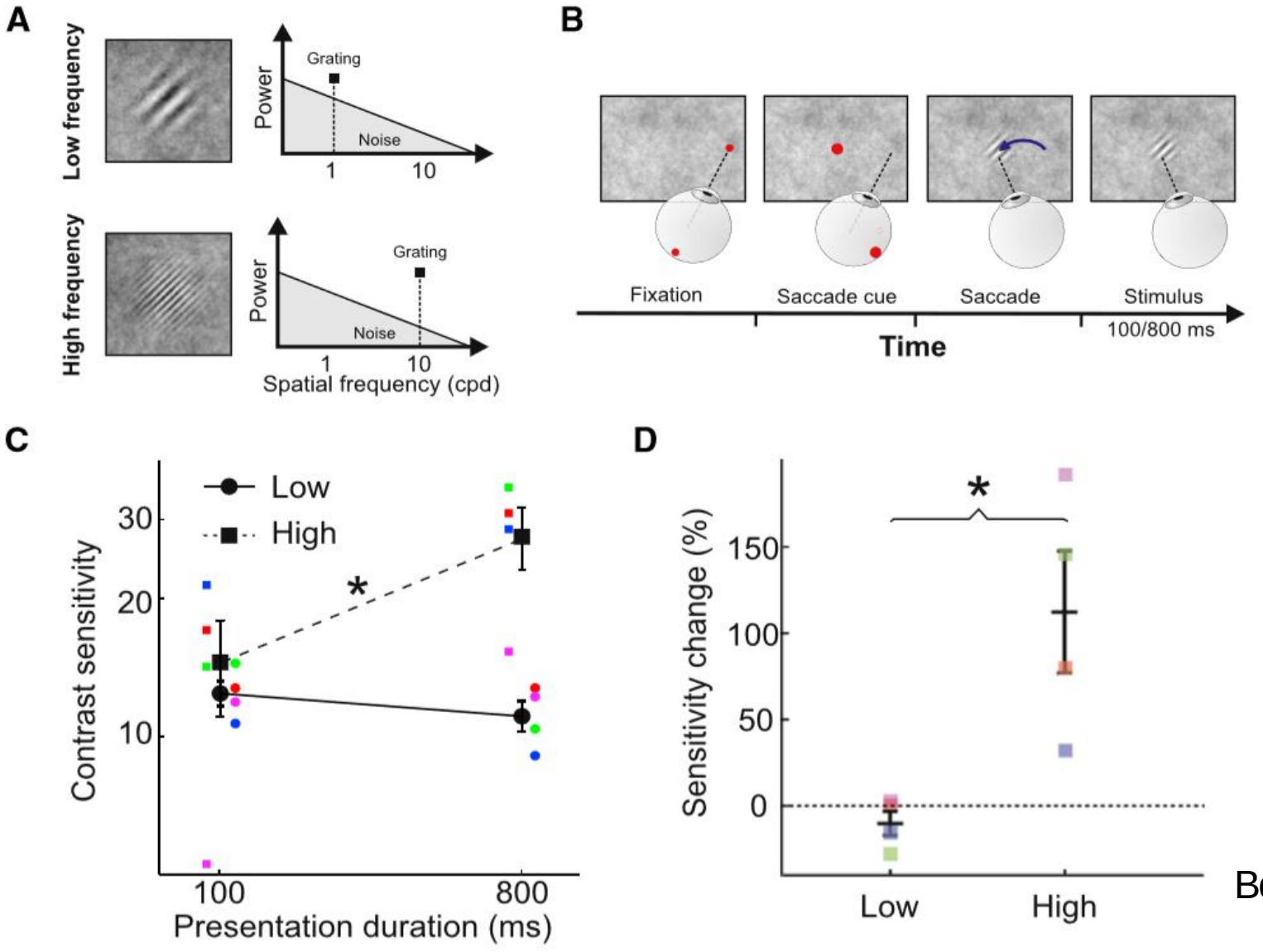
- Eye movements play a critical role for visual dynamics.
- Low and high spatial frequencies processing rely on different types of luminance transients, from saccades and drift, respectively.
- As shown by Boi et al, 2017

Natural Input to Retina



Boi et al, 2017

Post-saccadic Dynamics

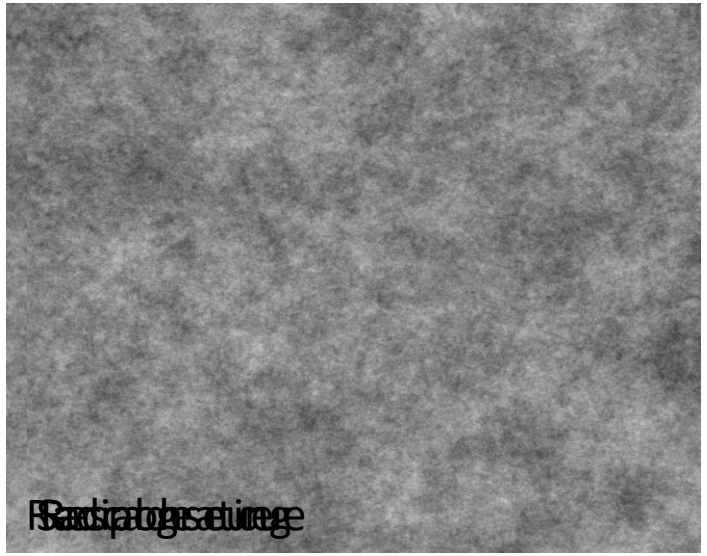


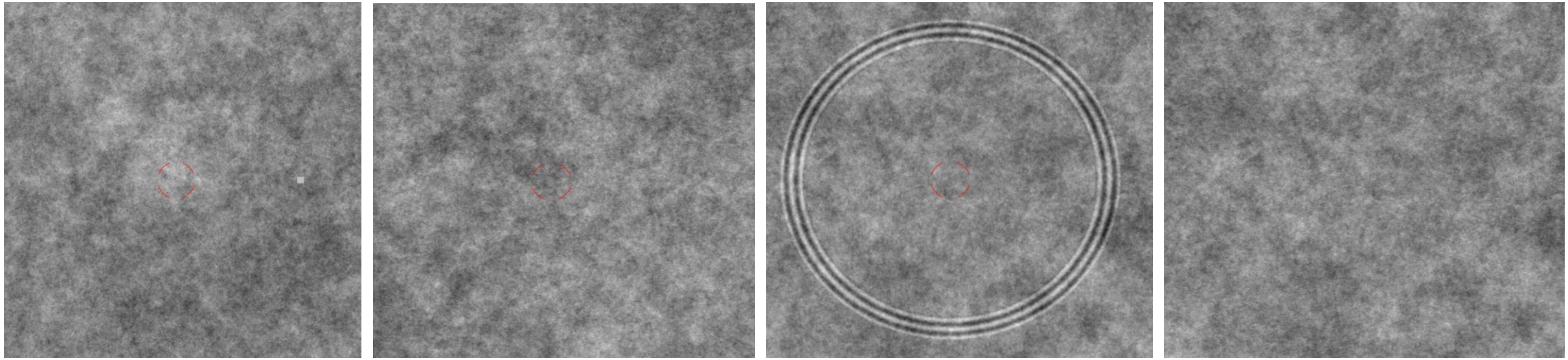
Boi et al, 2017

Overview

- Expanding on work done by Boi et al, 2017
- How do spatiotemporal response properties vary with eccentricity
- How the processing dynamics of fundamental visual features varies across eccentricity, time and spatial frequency
- Direct engineering consequences, as knowledge of these dynamics enables optimal use of visual displays.

Paradigm





Fixation

Saccade cue

Stimulus turns on

Stimulus

Eccentricity – 0, 4, 8

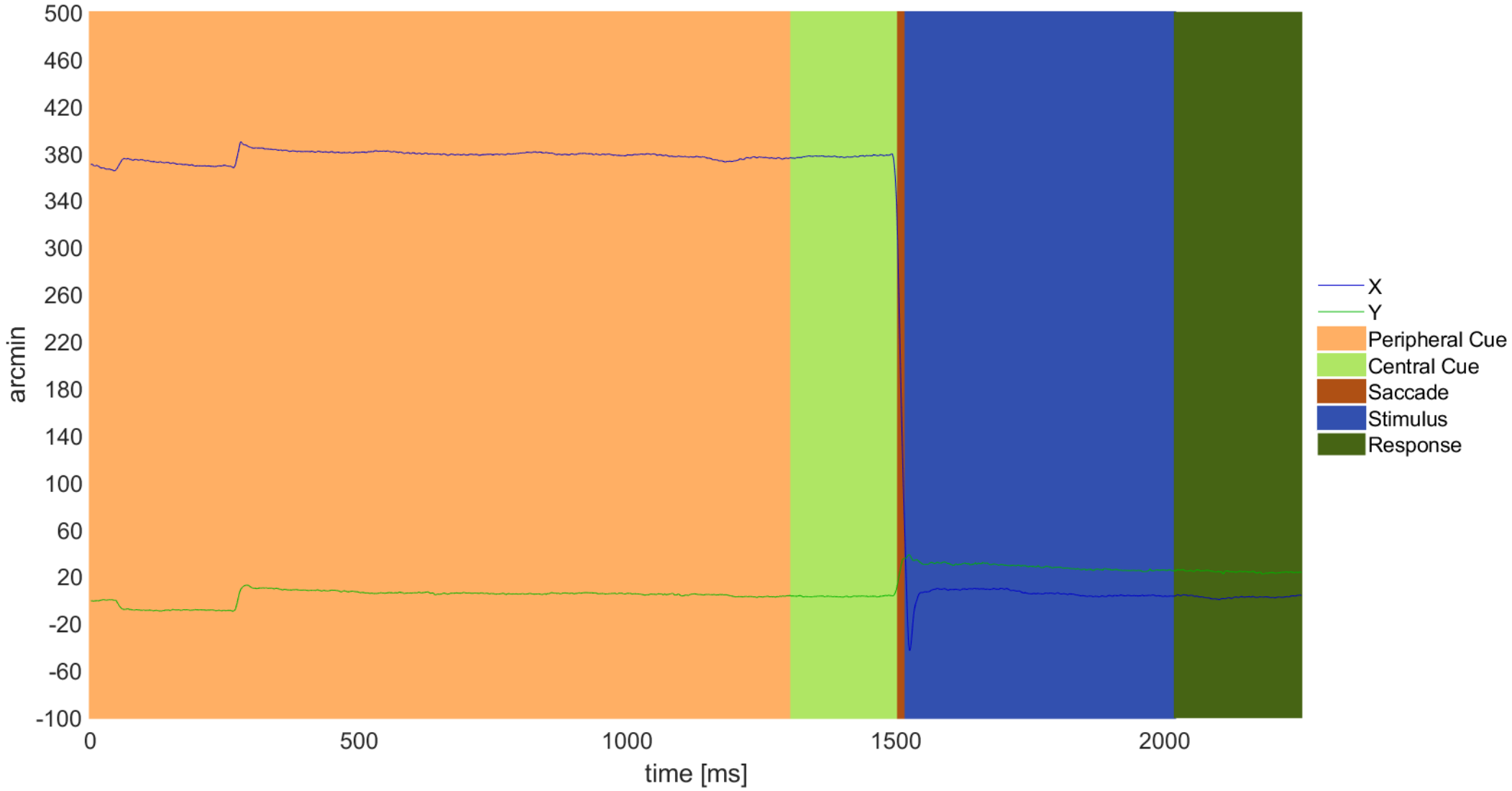
Presentation – 50, 500

Spatial Freq – 2, 10

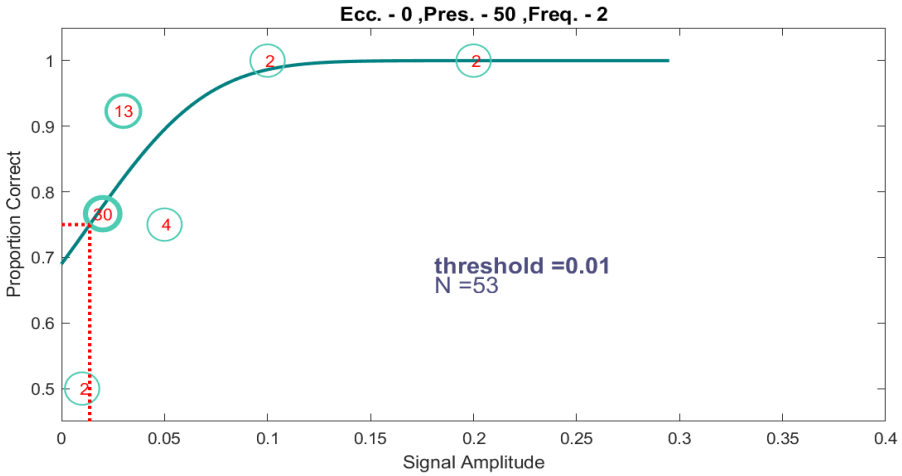
Catch trials (No stimulus)

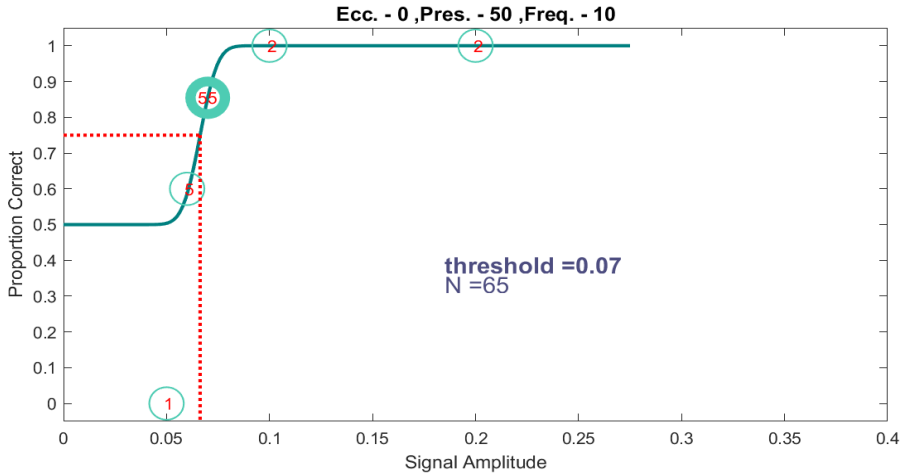
Response

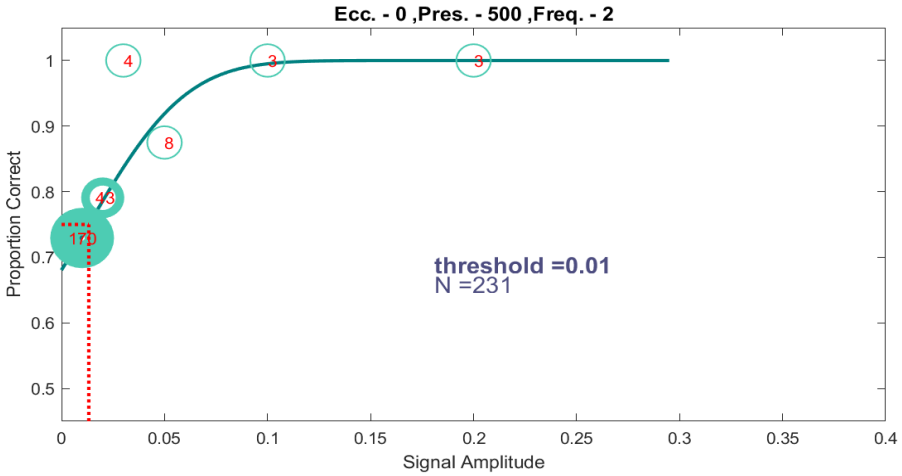
Eye Movement

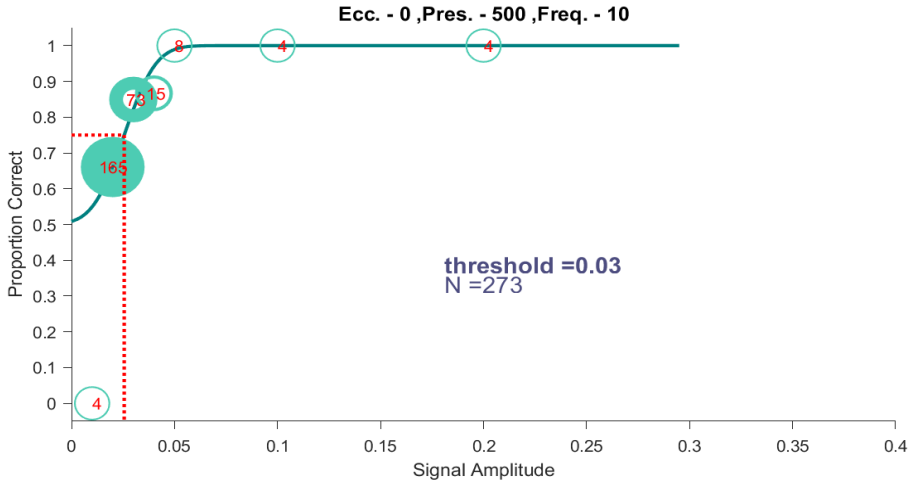


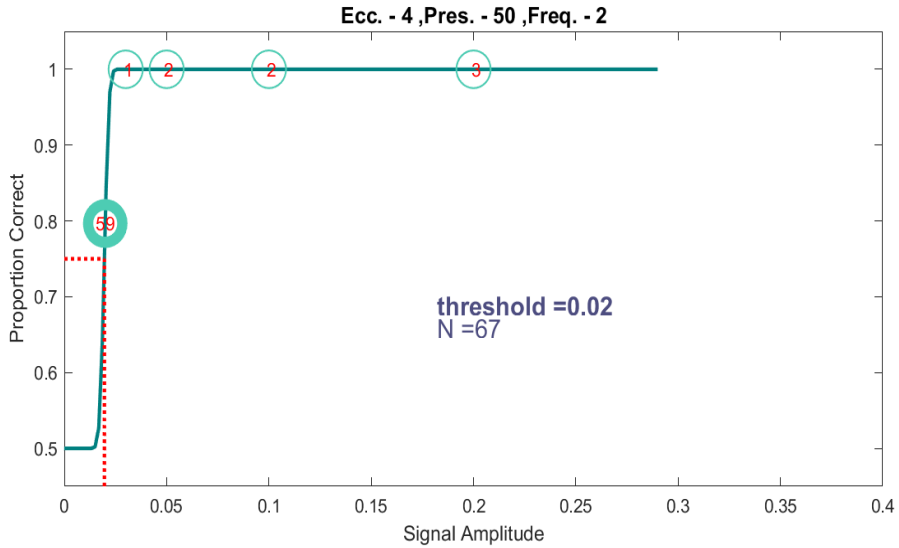
Analysis

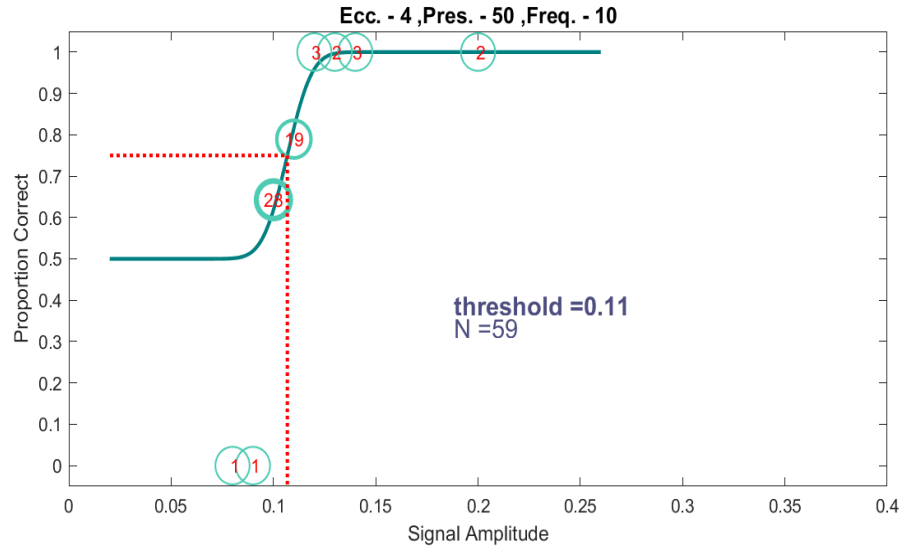

Ecc. - 0 ,Pres. - 50 ,Freq. - 2
Proportion Correct
Signal Amplitude
threshold =0.01
N =53

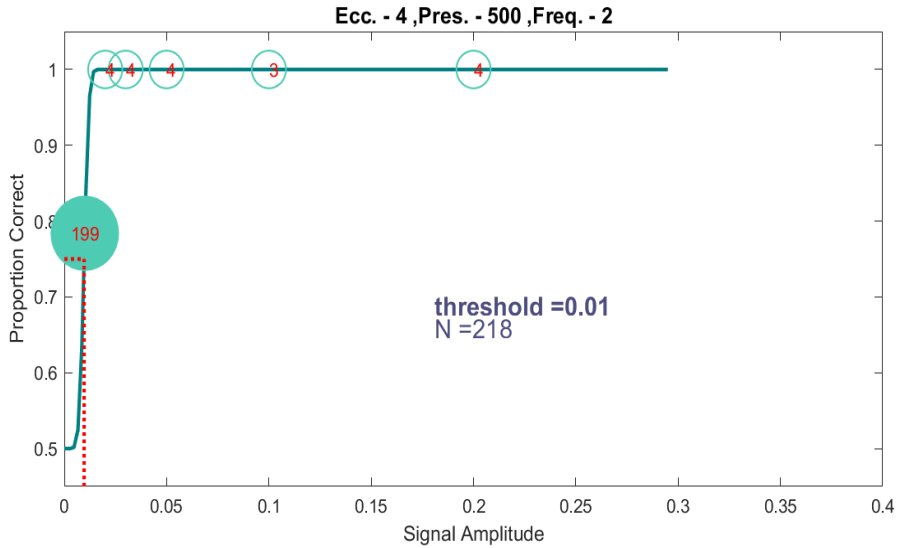

Ecc. - 0 ,Pres. - 50 ,Freq. - 10
Proportion Correct
Signal Amplitude
threshold =0.07
N =65

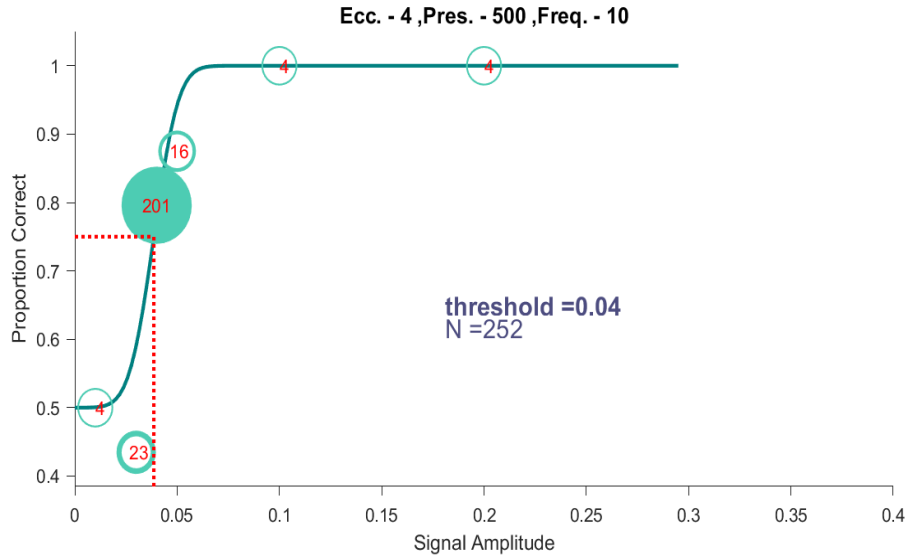

Ecc. - 0 ,Pres. - 500 ,Freq. - 2
Proportion Correct
Signal Amplitude
threshold =0.01
N =231

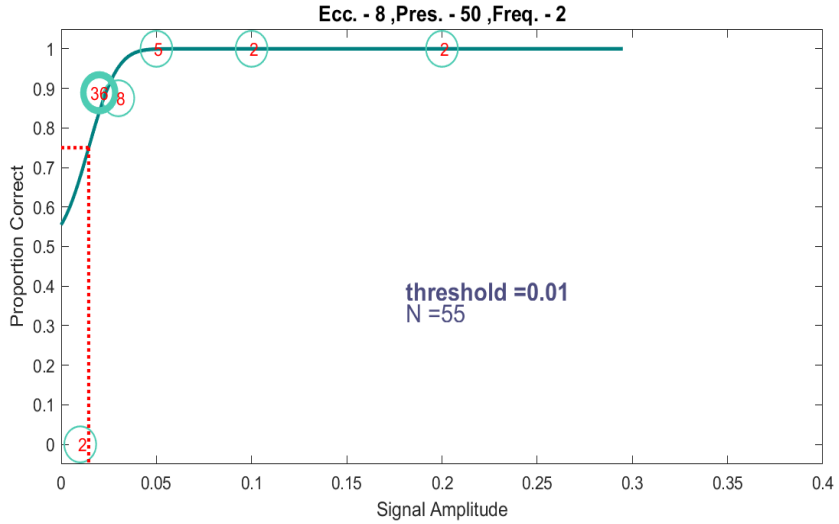

Ecc. - 0 ,Pres. - 500 ,Freq. - 10
Proportion Correct
Signal Amplitude
threshold =0.03
N =273

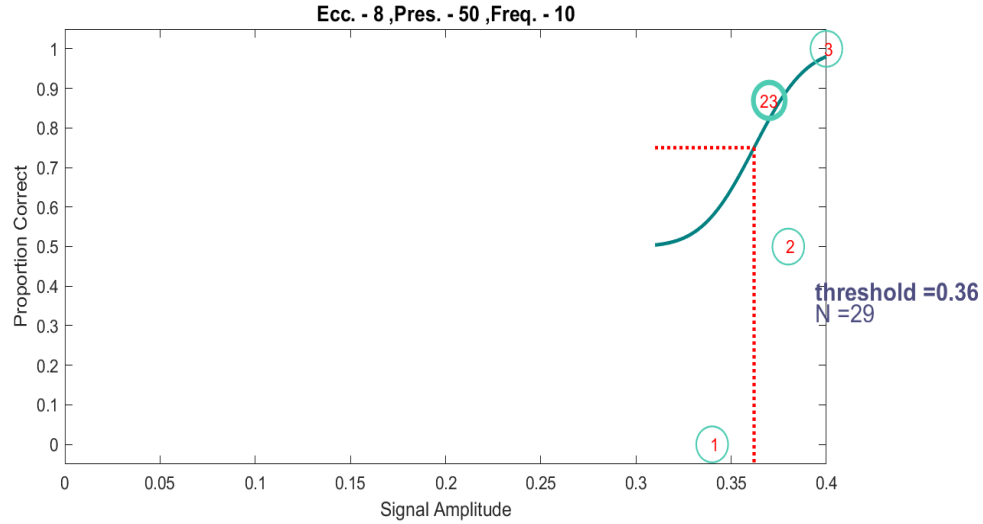

Ecc. - 4 ,Pres. - 50 ,Freq. - 2
Proportion Correct
Signal Amplitude
threshold =0.02
N =67

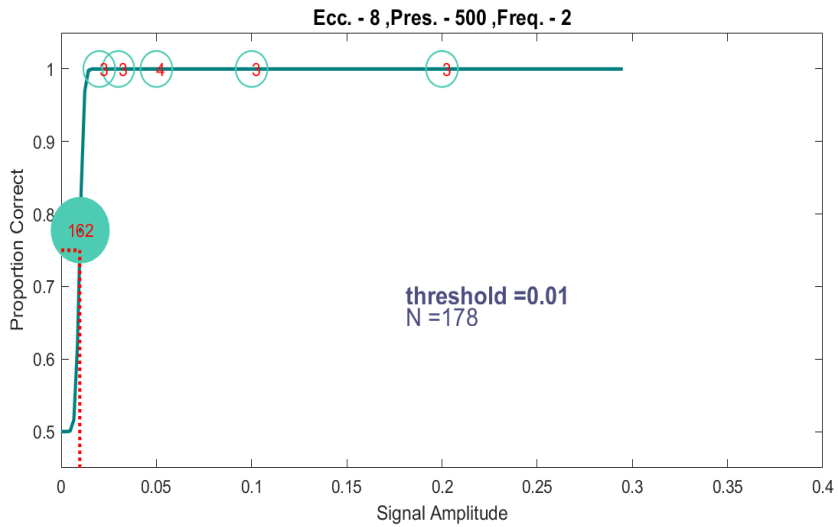

Ecc. - 4 ,Pres. - 50 ,Freq. - 10
Proportion Correct
Signal Amplitude
threshold =0.11
N =59

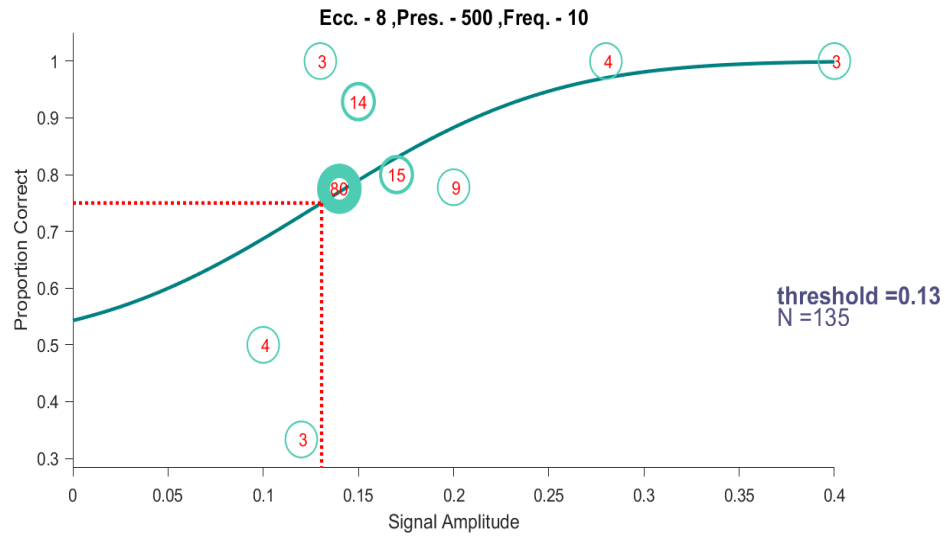

Ecc. - 4 ,Pres. - 500 ,Freq. - 2
Proportion Correct
Signal Amplitude
threshold =0.01
N =218


Ecc. - 4 ,Pres. - 500 ,Freq. - 10
Proportion Correct
Signal Amplitude
threshold =0.04
N =252


Ecc. - 8 ,Pres. - 50 ,Freq. - 2
Proportion Correct
Signal Amplitude
threshold =0.01
N =55


Ecc. - 8 ,Pres. - 50 ,Freq. - 10
Proportion Correct
Signal Amplitude
threshold =0.36
N =29


Ecc. - 8 ,Pres. - 500 ,Freq. - 2
Proportion Correct
Signal Amplitude
threshold =0.01
N =178

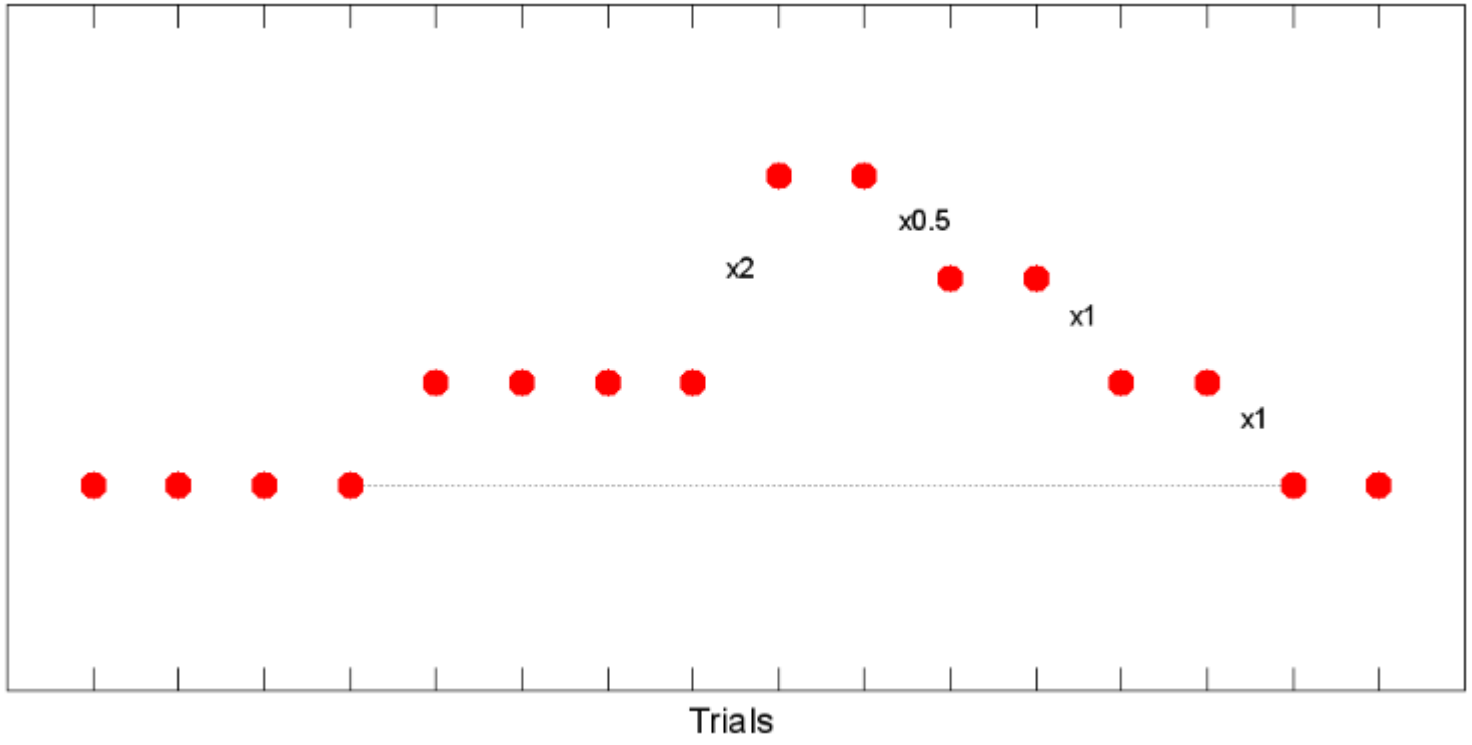

Ecc. - 8 ,Pres. - 500 ,Freq. - 10
Proportion Correct
Signal Amplitude
threshold =0.13
N =135

Number of trials

Total Trials	**4600**
Blink	35
No Track	178
Micro/Saccade only	**1689**
Drift only	134
Discarded	83
Valid	**2481**

PEST (parameter estimation by sequential testing)

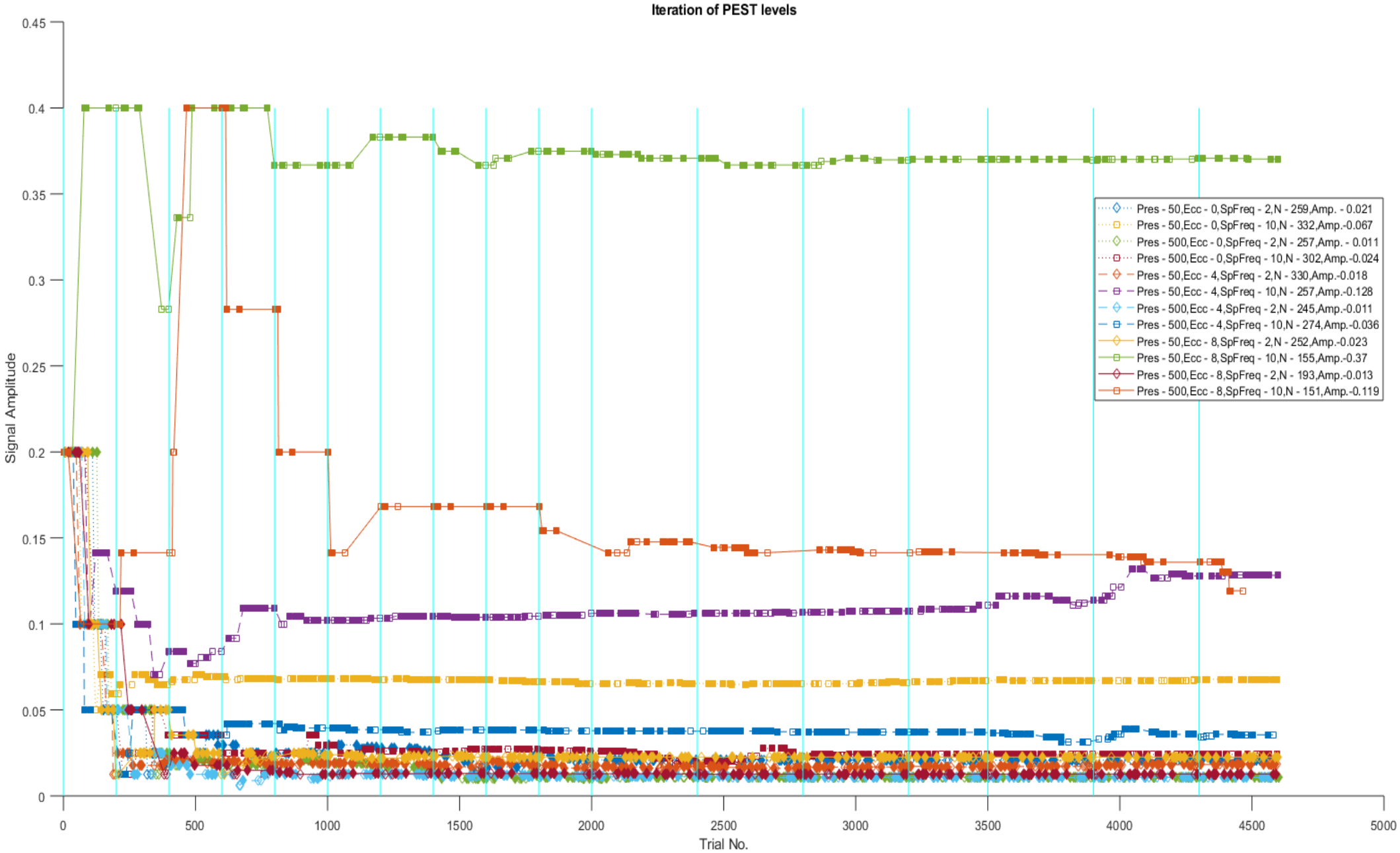
- Set of rules to adjust difficulty of a task to quickly find the point at which performance reaches a predefined level
- Change in ‘step-size’



- Individual PEST is run on each of the 12 conditions

- Stepsizes in PEST are not of fixed size. Generally, stepsizes tend to decrease as the run proceeds.

- The relative contribution of each additional trial to the overall fit becomes smaller, given that the fit is based on all of the preceding trials.


Iteration of PEST levels
Signal Amplitude
Trial No.
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Pres - 50,Ecc - 0,SpFreq - 2,N - 259,Amp. - 0.021
Pres - 50,Ecc - 0,SpFreq - 10,N - 332,Amp.-0.067
Pres - 500,Ecc - 0,SpFreq - 2,N - 257,Amp. - 0.011
Pres - 500,Ecc - 0,SpFreq - 10,N - 302,Amp.-0.024
Pres - 50,Ecc - 4,SpFreq - 2,N - 330,Amp.-0.018
Pres - 50,Ecc - 4,SpFreq - 10,N - 257,Amp.-0.128
Pres - 500,Ecc - 4,SpFreq - 2,N - 245,Amp.-0.011
Pres - 500,Ecc - 4,SpFreq - 10,N - 274,Amp.-0.036
Pres - 50,Ecc - 8,SpFreq - 2,N - 252,Amp.-0.023
Pres - 50,Ecc - 8,SpFreq - 10,N - 155,Amp.-0.37
Pres - 500,Ecc - 8,SpFreq - 2,N - 193,Amp.-0.013
Pres - 500,Ecc - 8,SpFreq - 10,N - 151,Amp.-0.119

Ideas/suggestions

- PEST doesn’t get trials at contrast levels other than the threshold
- Could add additional 10% trials whose contrast is generated by preset levels.
- Percentage of catch trials considering 12 different conditions.

THANK YOU!