How Blink Transient Affects Visual Acuity

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08.17.2018

Background

Although usually unnoticed, we blink every several seconds, in order to:

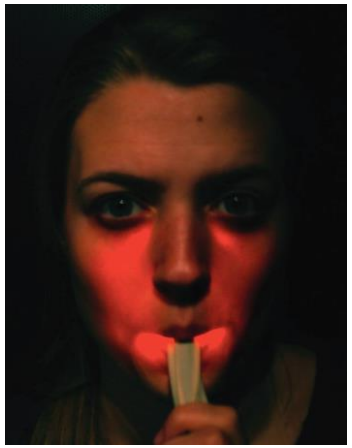
- Lubricate eye balls,
- Maintain a humid environment for the eye,
- Clean the surface of the eye
- Protect the eye from injuries
- ...

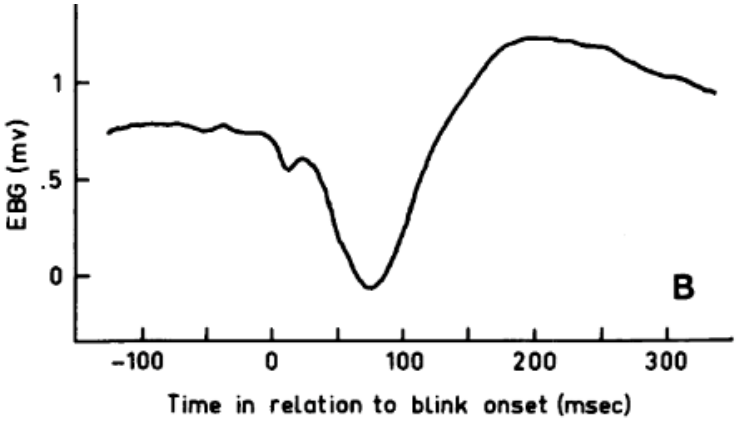
Side effect:

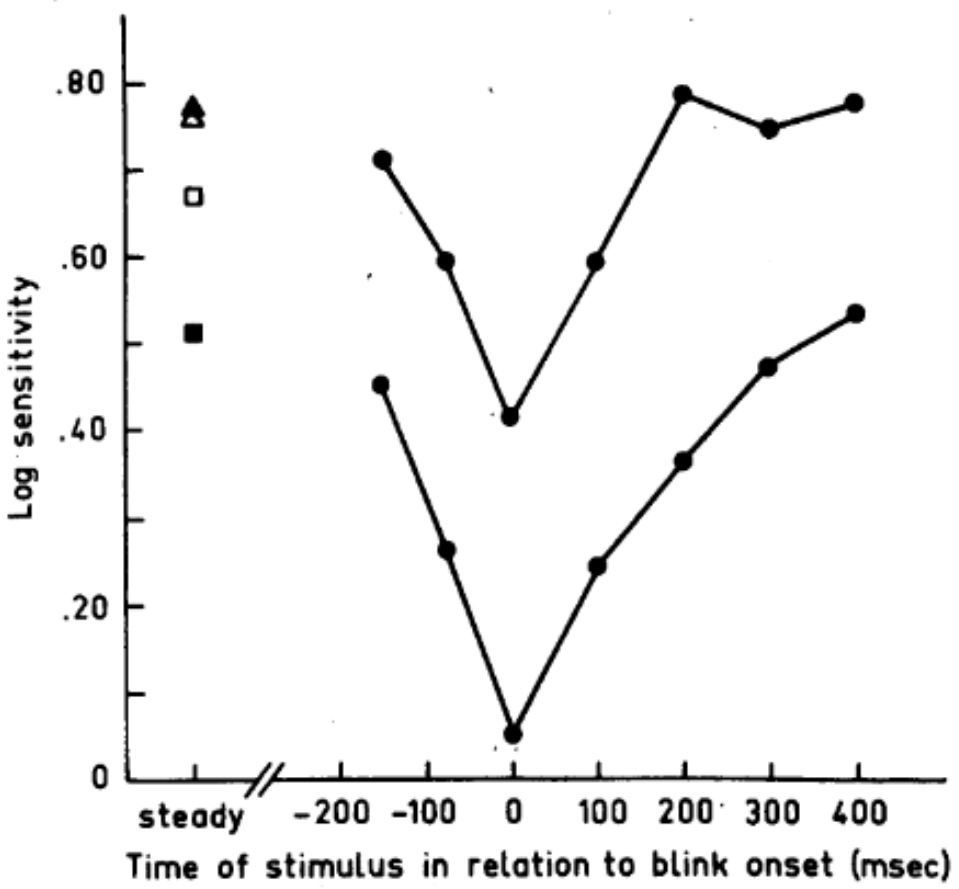
- Visual suppression

Background Visual Suppression by Blinks

Visual suppression due to internal signal related to blink







Volkmann *et al*, *Science*, 1980

Background Question & Hypothesis

Question:

Despite the visual suppression during blinks, is there any contribution to visual perception by blinks?

Clues:

- Drifts and saccades redistribute spatial power into the temporal domain and hence modulate visual sensitivity.
- Blinks are accompanied by eyelid and eye movements.

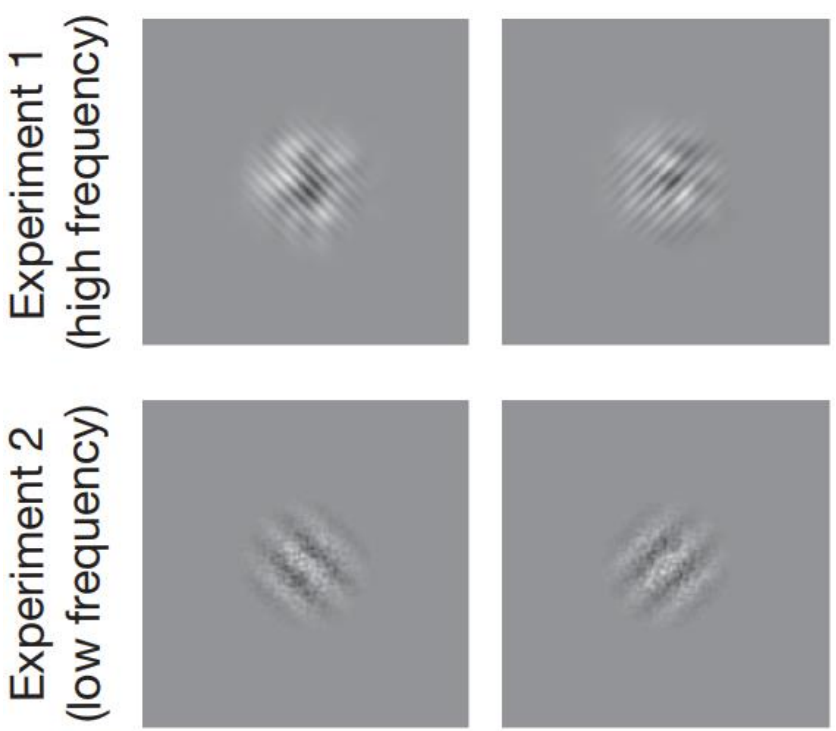
Hypothesis:

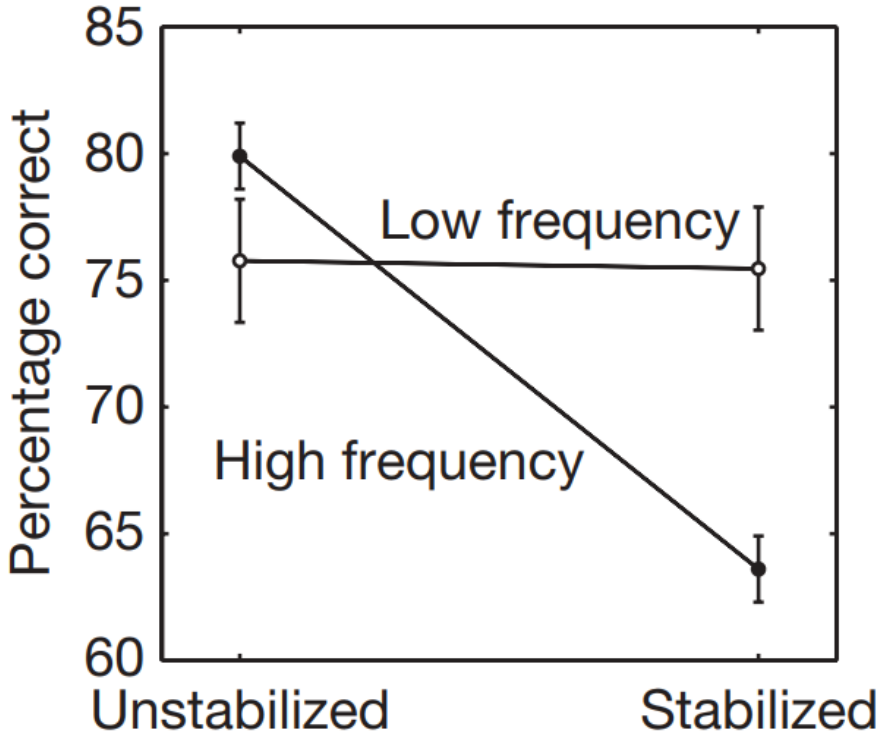
- Visual transient introduced by eyelid and eye movements accompanying blinks redistributes spatial power into the temporal domain.
- This redistribution is more significant for low spatial frequencies, and therefore would enhance visual sensitivity for low spatial frequencies.

Background

Drifts for High Spatial Frequency

Drifts enhance contrast sensitivity of high spatial frequency



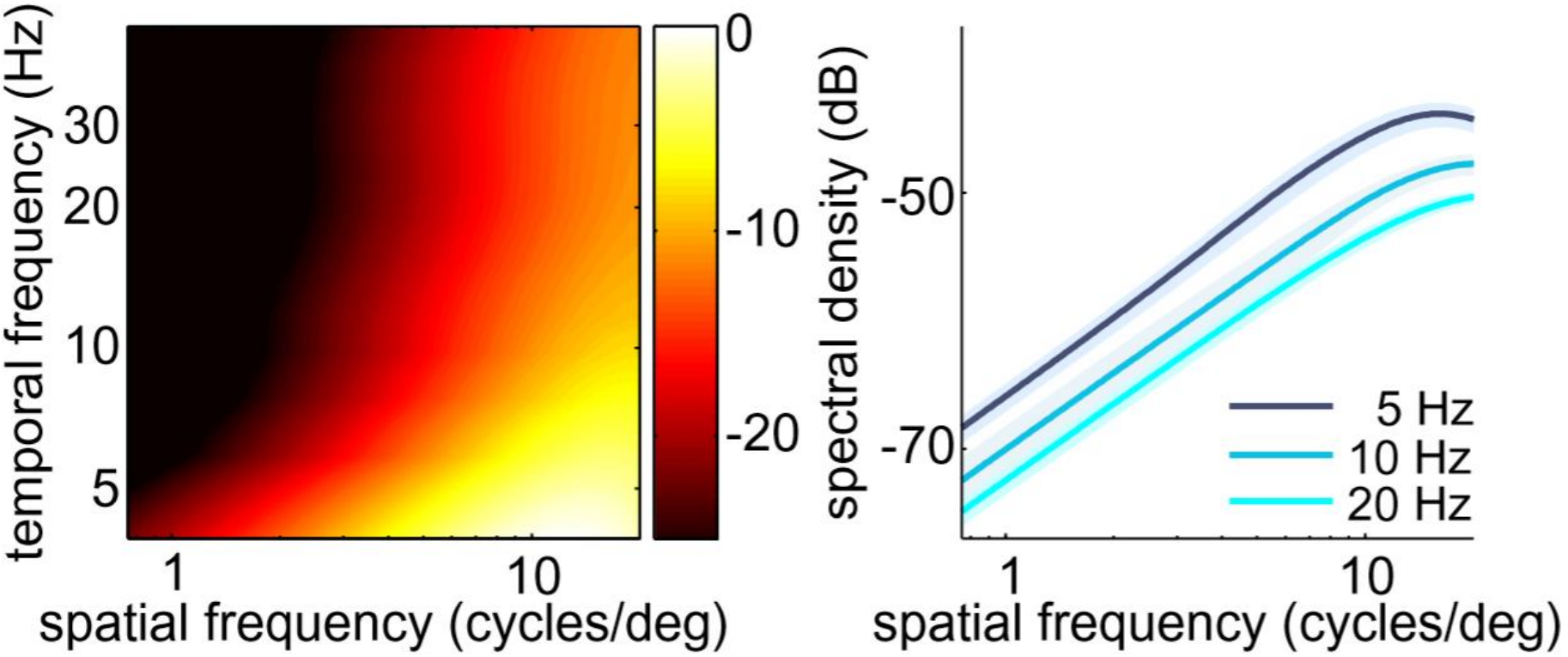


Rucci *et al*, *Nature*, 2007

Background

Drifts for High Spatial Frequency

Because drifts redistribute more power into temporal domain for high spatial frequencies

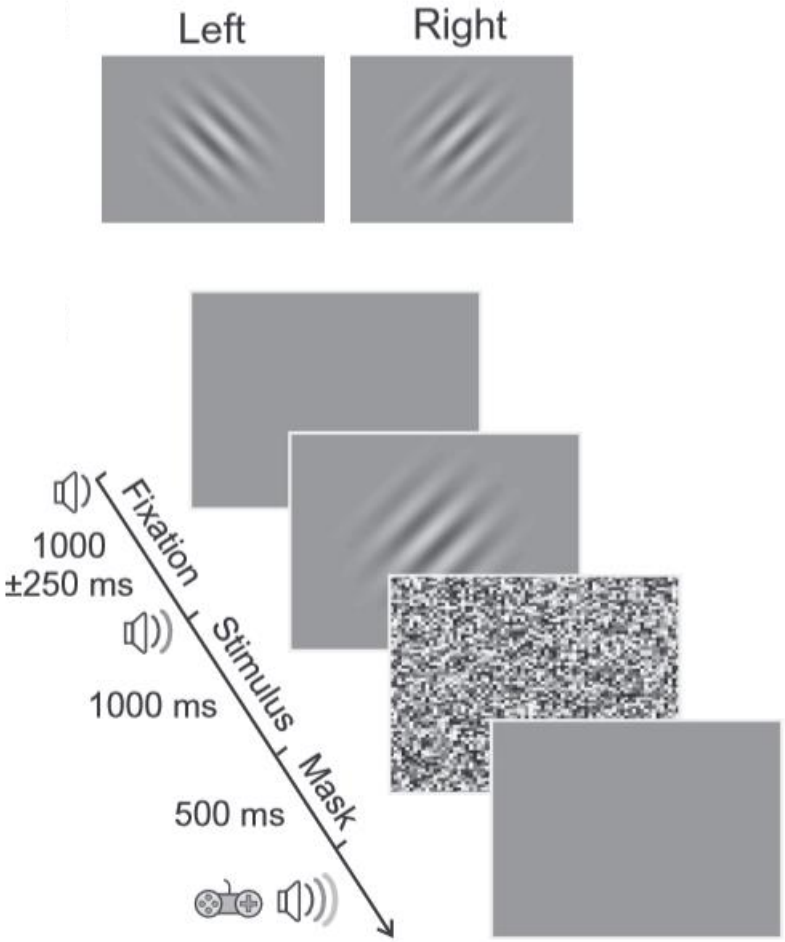


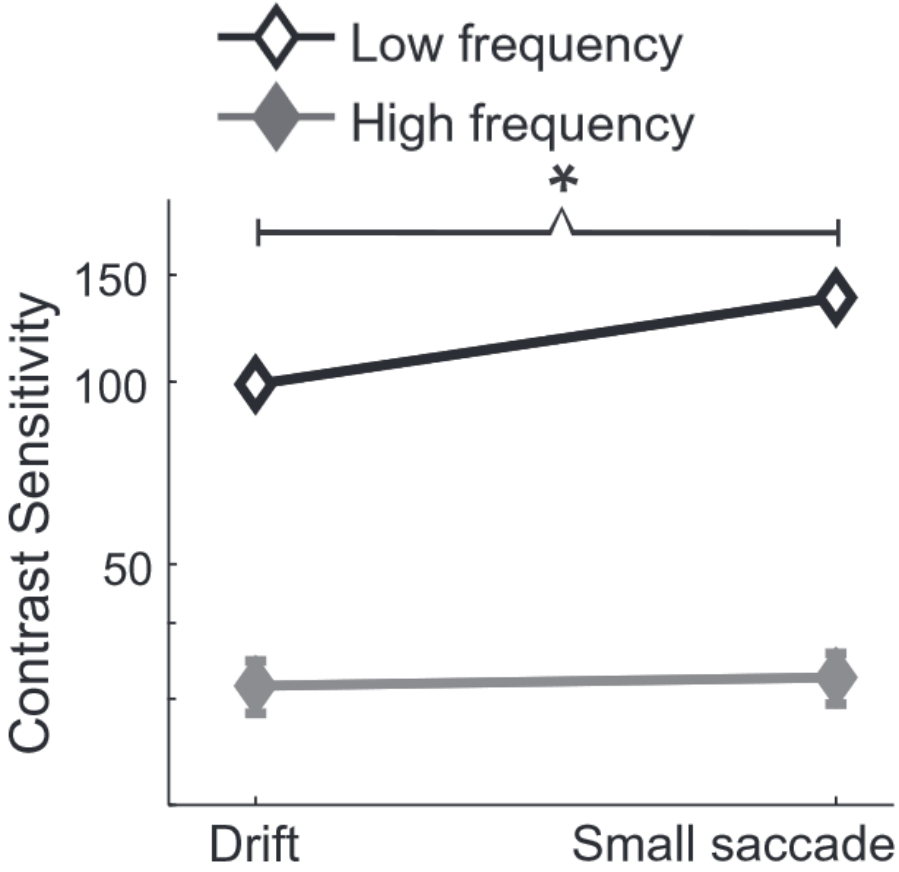
Naghmeh *et al*, *Vision Research*, 2015

Background

Small Saccades for Low Spatial Frequency

Small saccades enhance contrast sensitivity of low spatial frequency



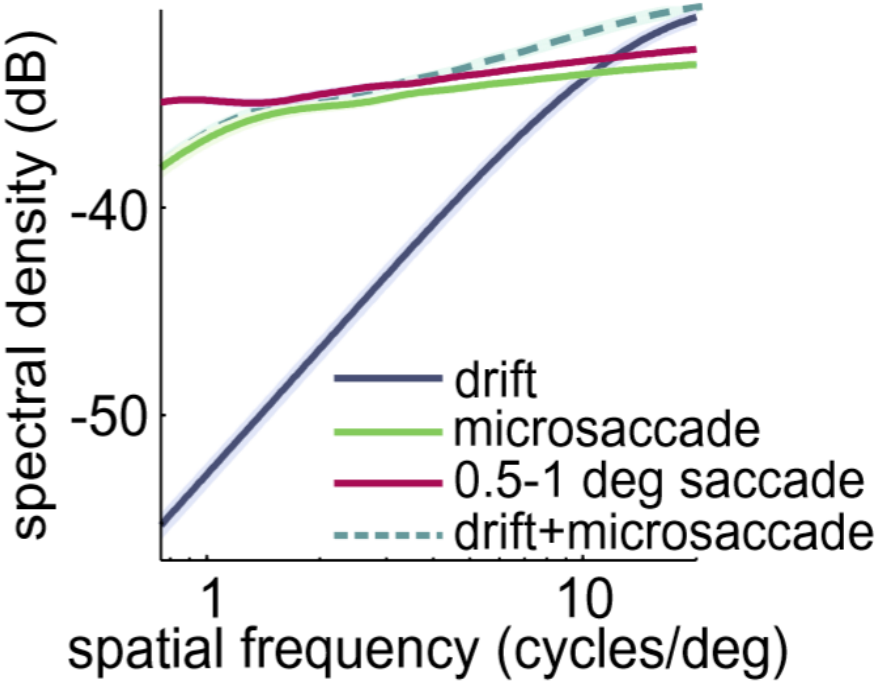


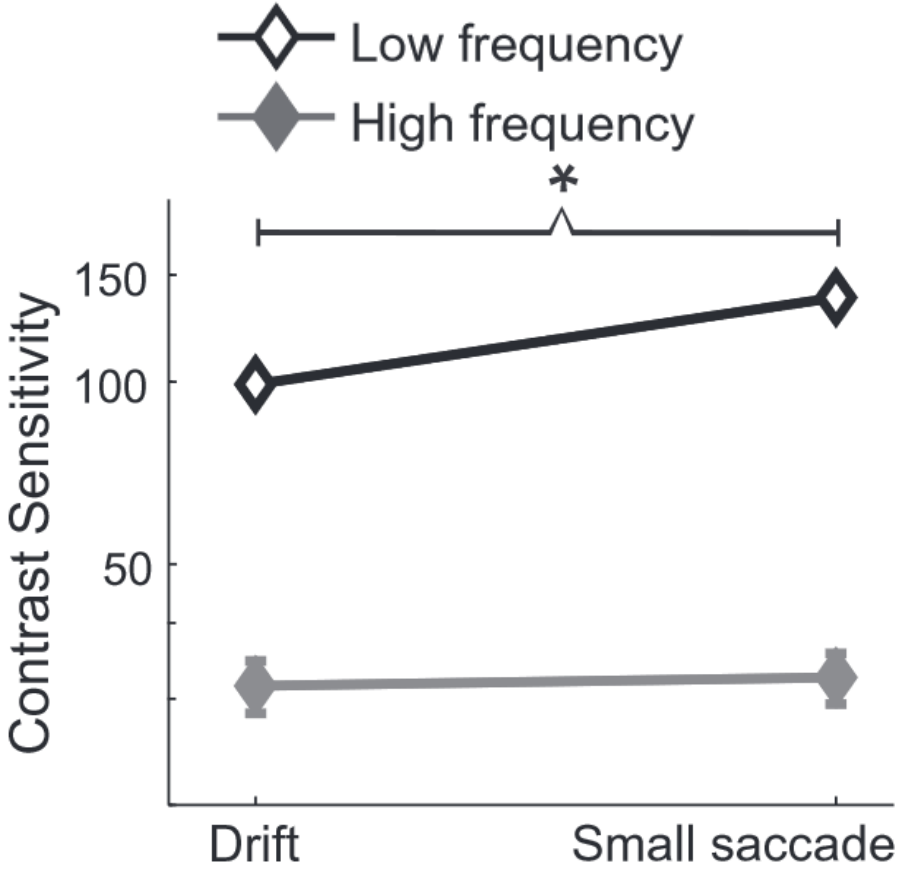
Naghmeh *et al*, *Vision Research*, 2015

Background

Small Saccades for Low Spatial Frequency

Because small saccades redistribute more power into temporal domain for low spatial frequencies than drifts do



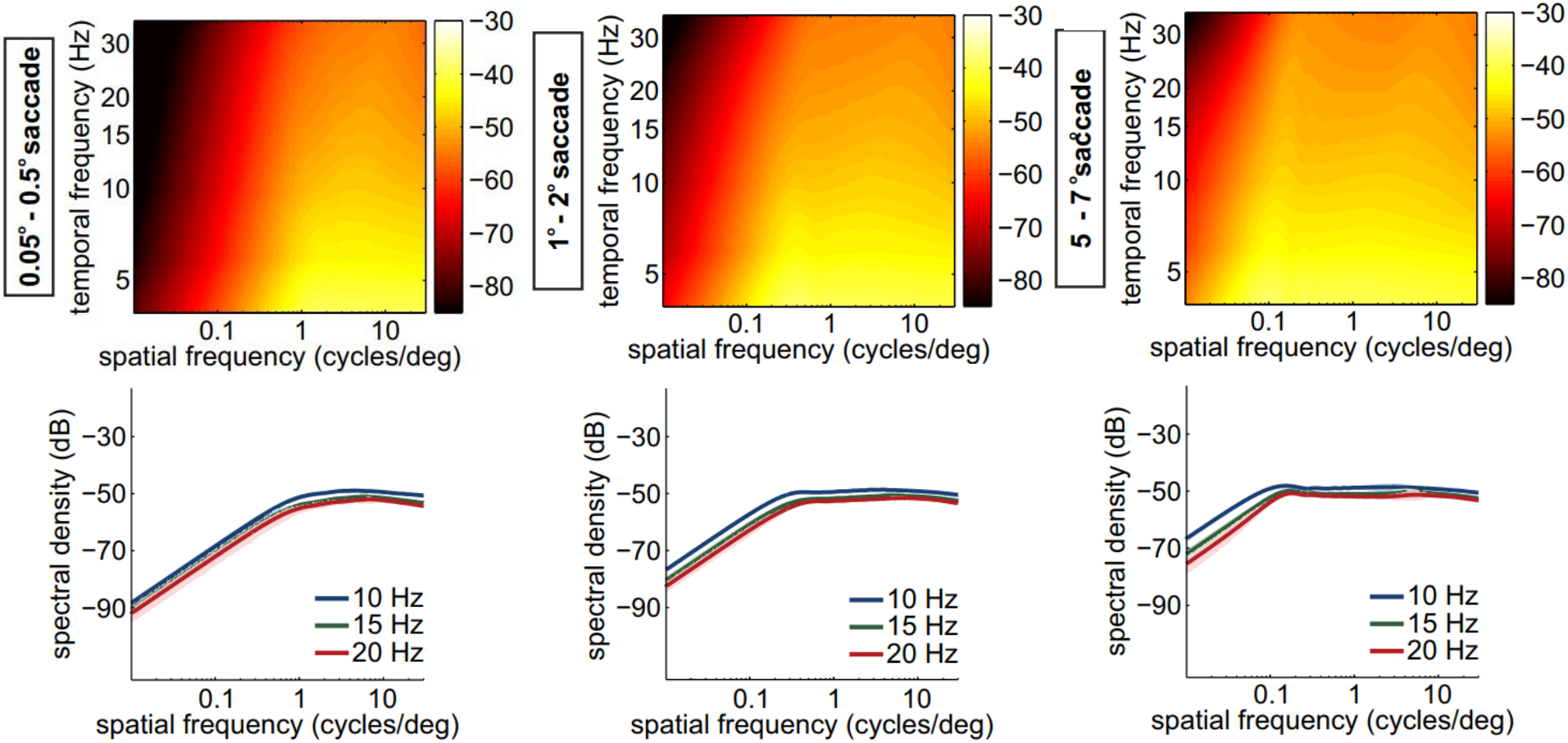


Naghmeh *et al*, *Vision Research*, 2015

Background

Larger Saccades for Lower Spatial Frequency

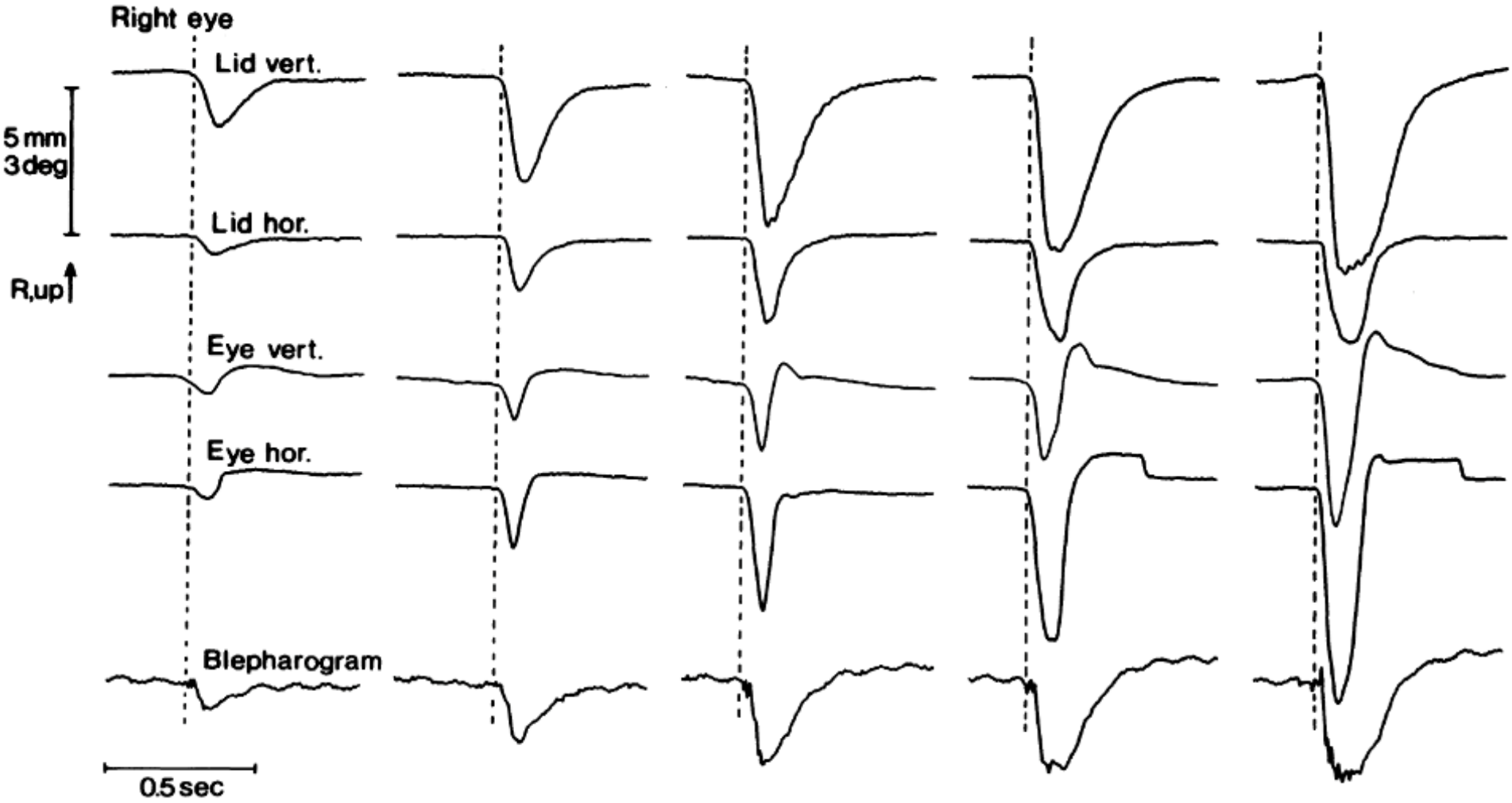
The larger the saccades amplitude, the more the temporal power for low spatial frequencies



Naghmeh *et al*, *Draft*

Background

Eye Moves Together with Eyelid

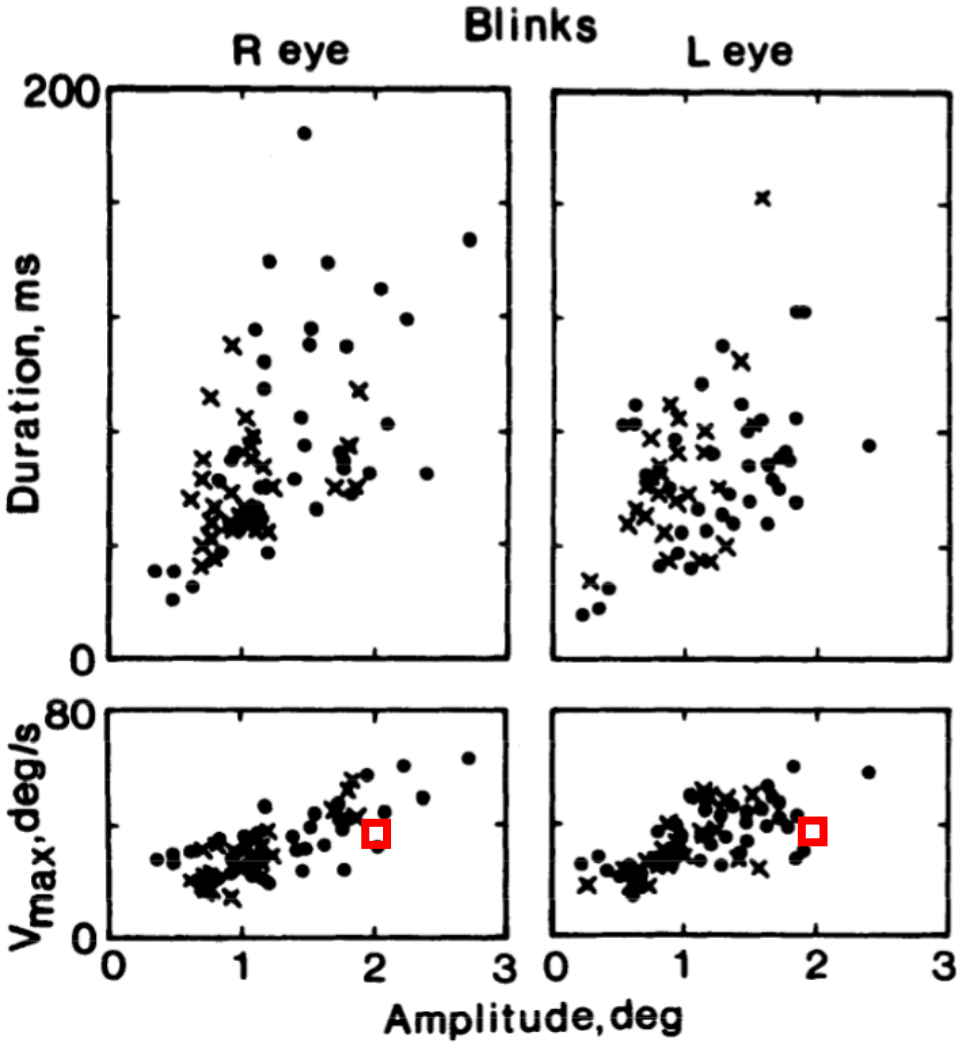


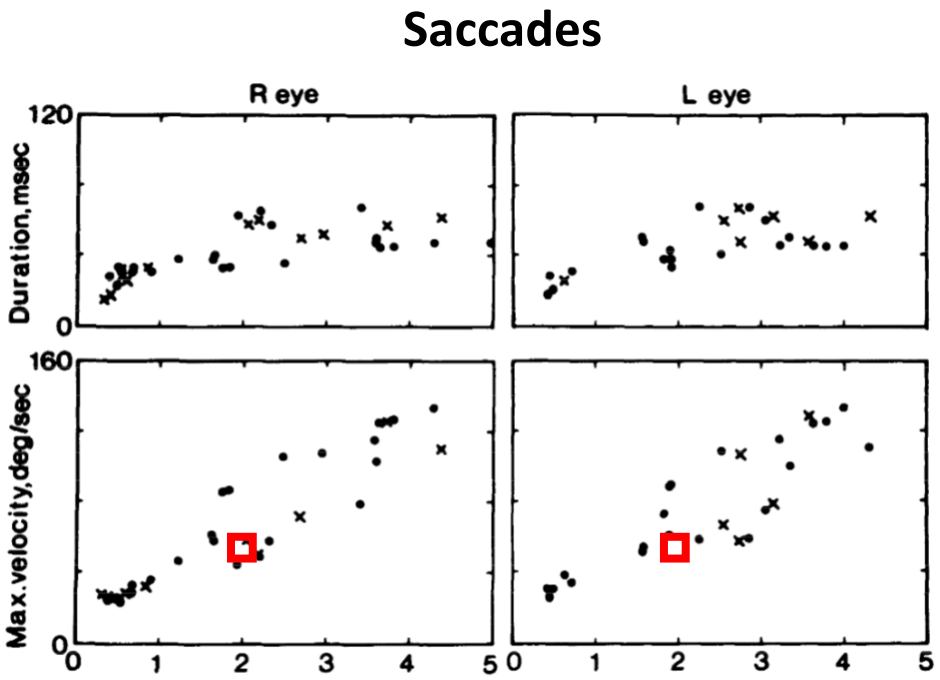
Collewijn *et al*, *JNP*, 1985

Background

Eye Movements During Blinks

Eye movements during blinks are only slightly slower than saccades





Collewijn *et al*, *JNP*, 1985

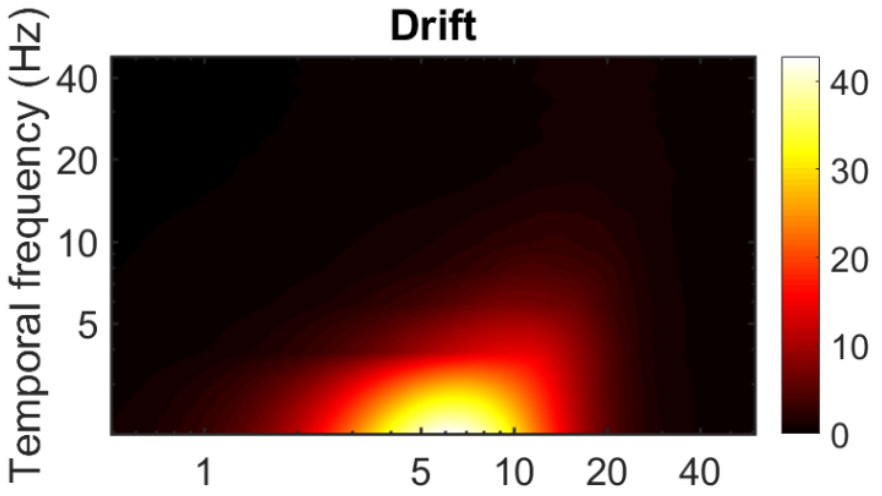
Blink Transient

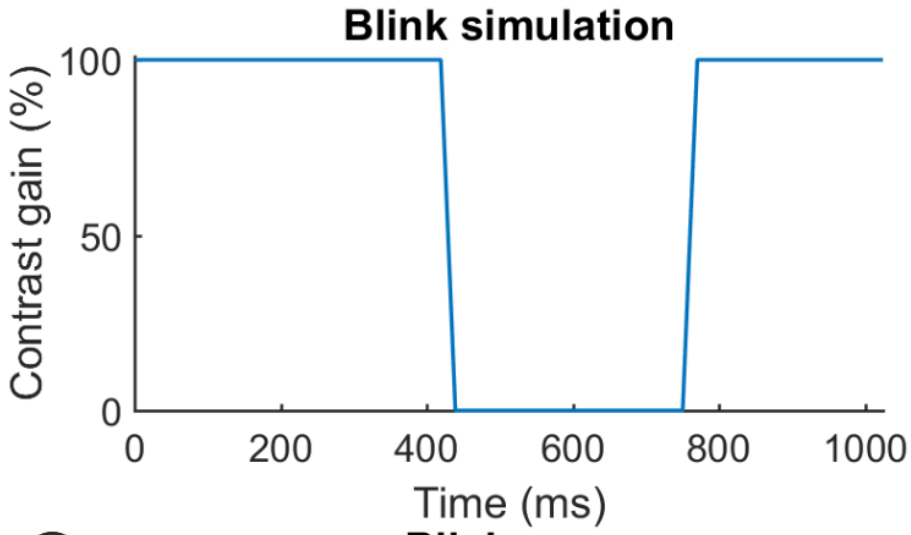
Power Spectrum Analysis

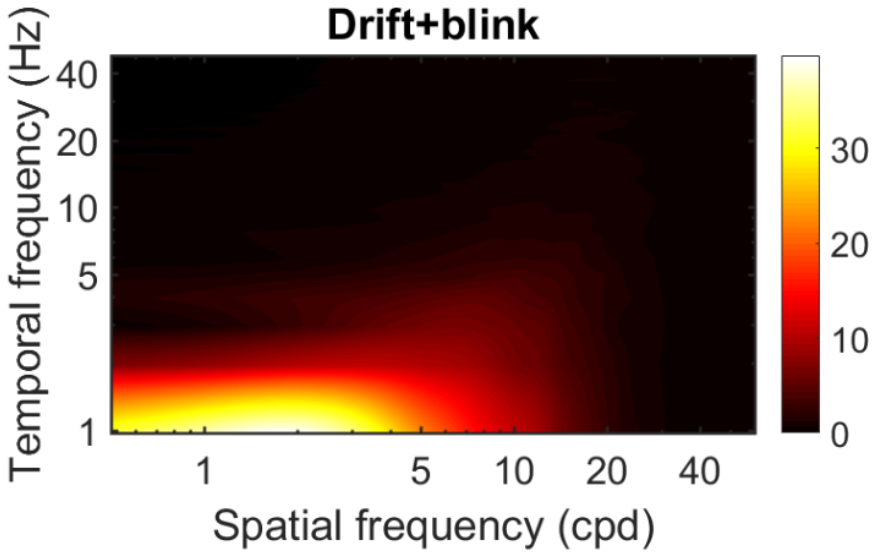
How does blink redistribute spatial power into the temporal domain?

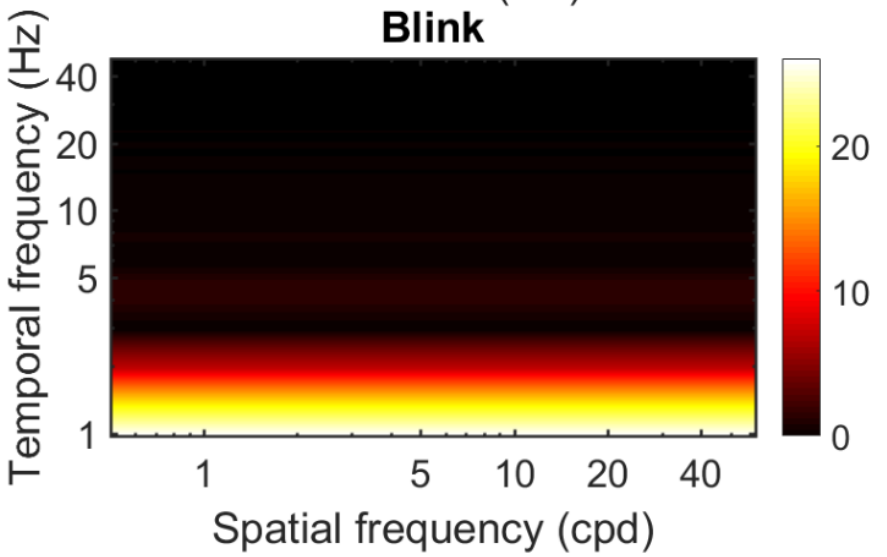
Blink Transient

Power Spectrum Analysis



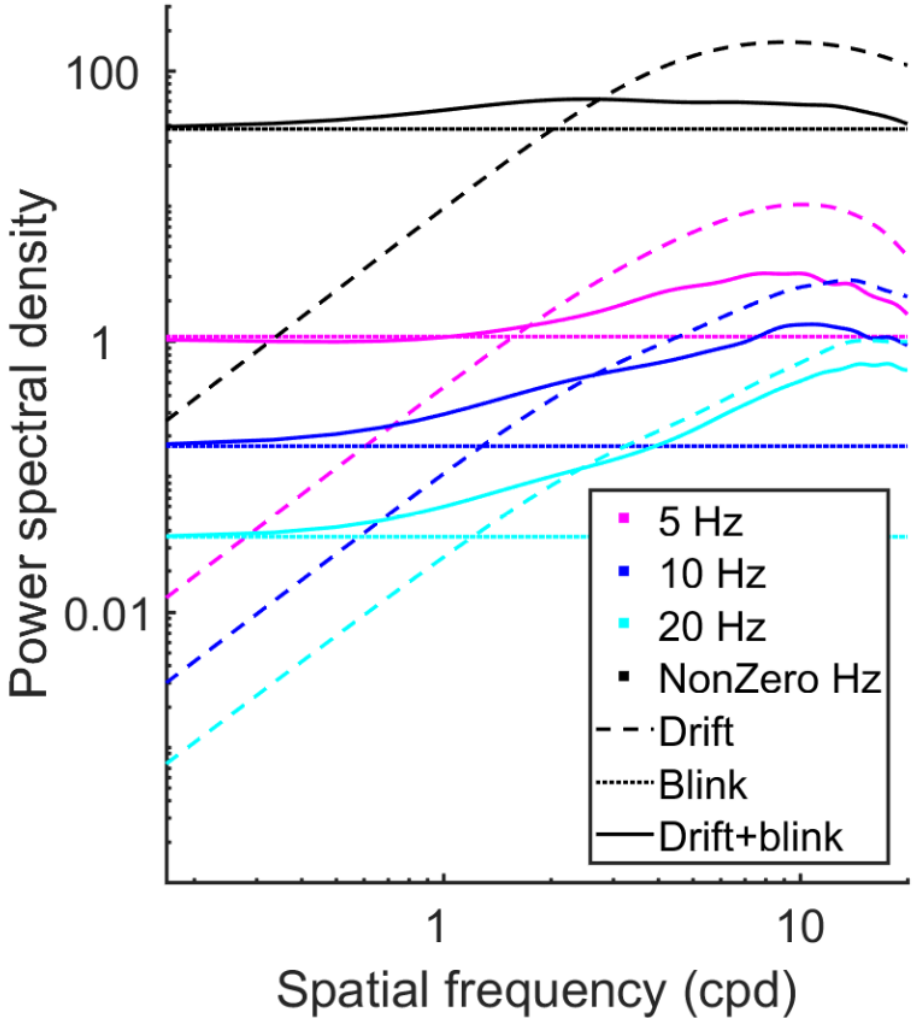






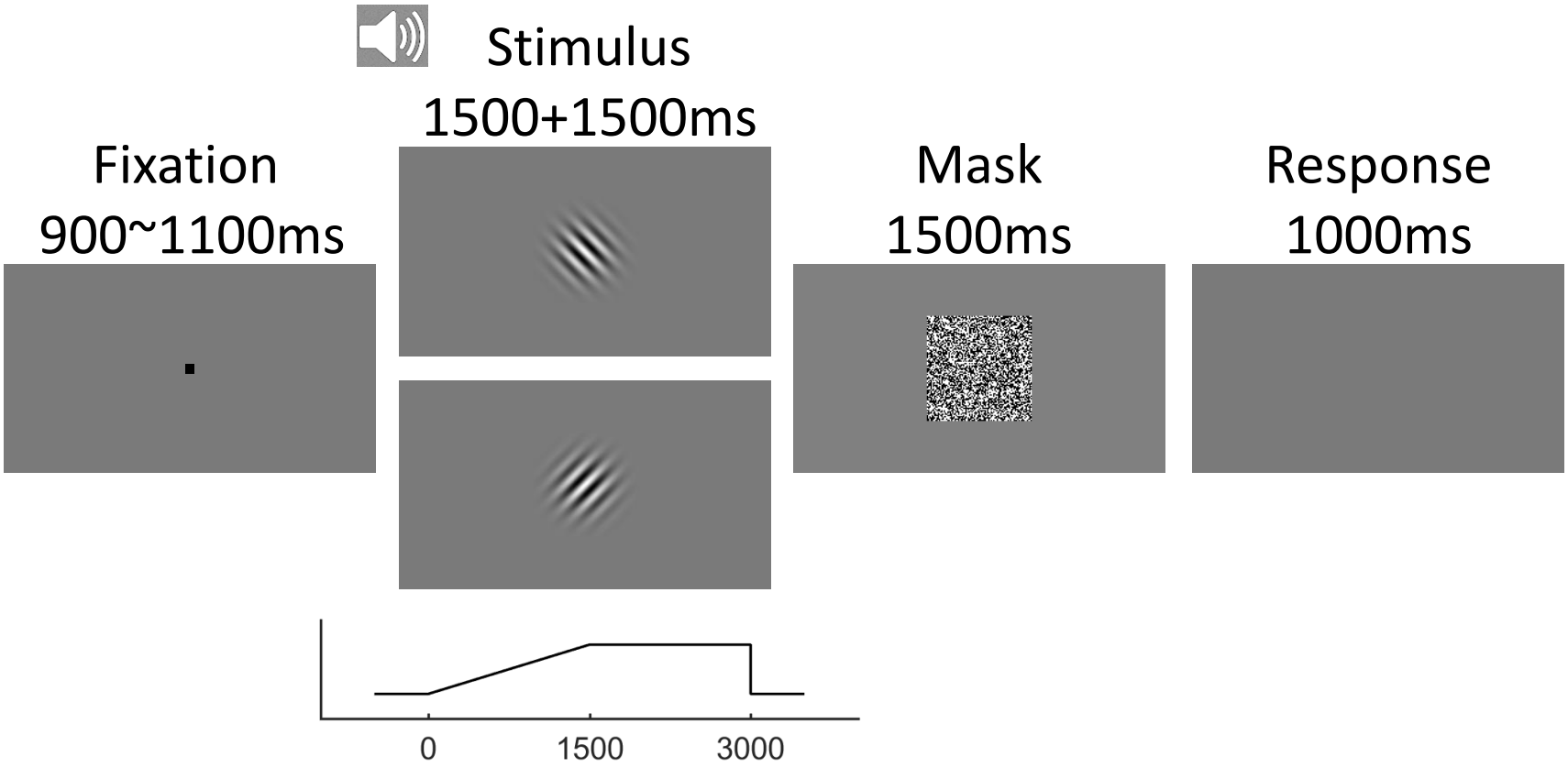
Blink Transient Power Spectrum Analysis

Together with drift, blink should be able to enhance contrast sensitivity for low spatial frequency



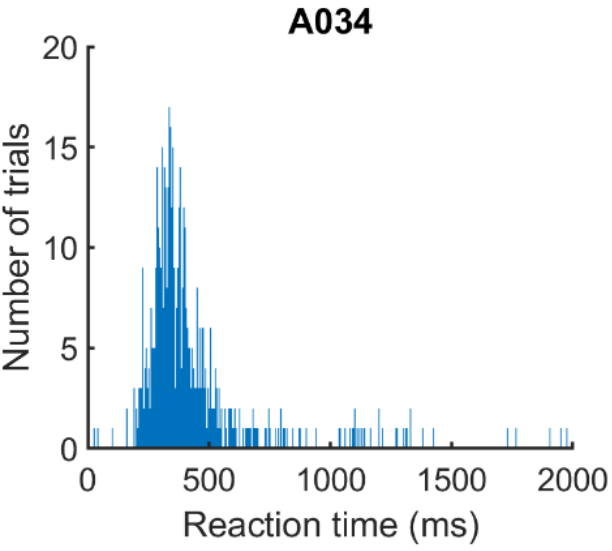
Method

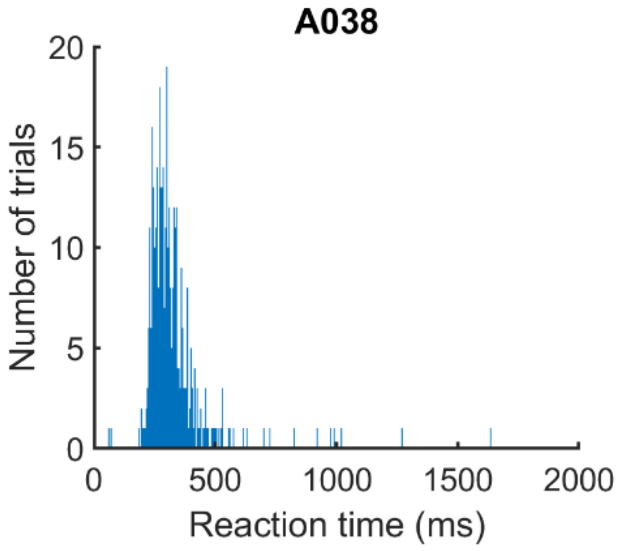
Paradigm

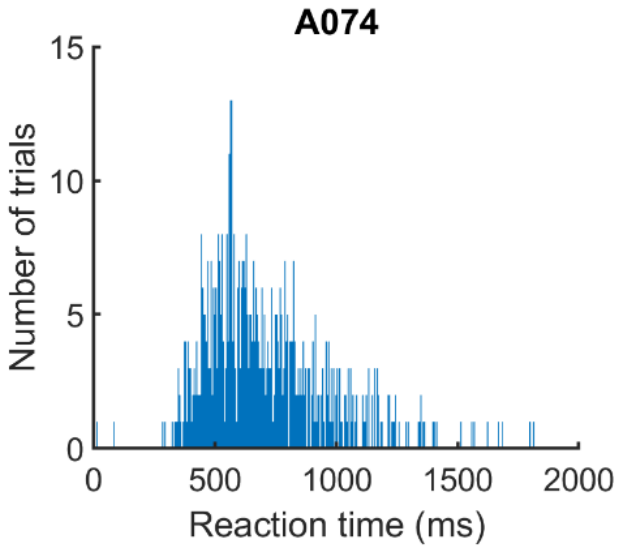


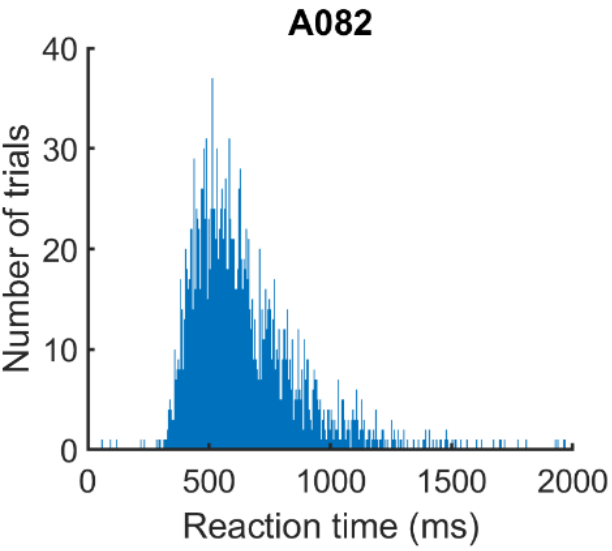
Results

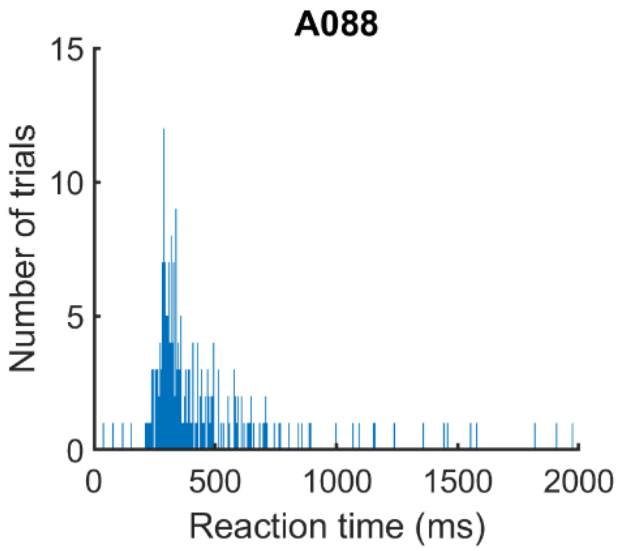
Blink Reaction Time



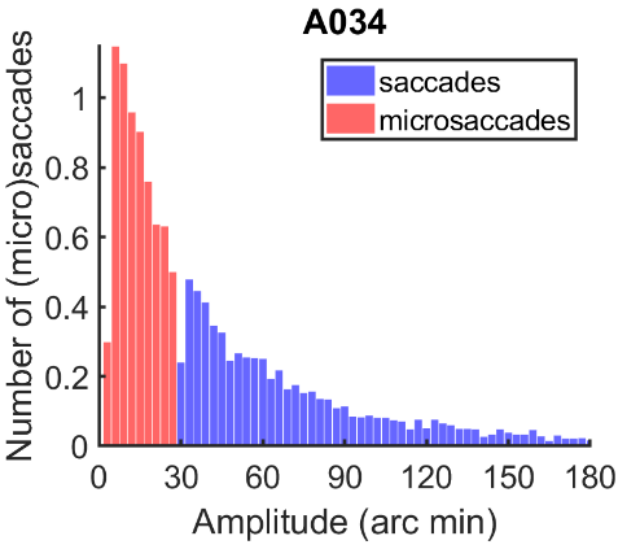


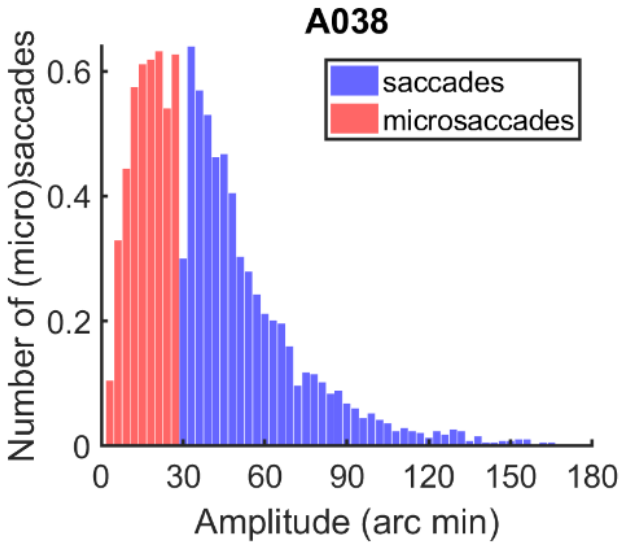






Results


A034
saccades
microsaccades
Number of (micro)saccades
0
0.2
0.4
0.6
0.8
1
0
30
60
90
120
150
180
Amplitude (arc min)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microsaccades
Number of (micro)saccades
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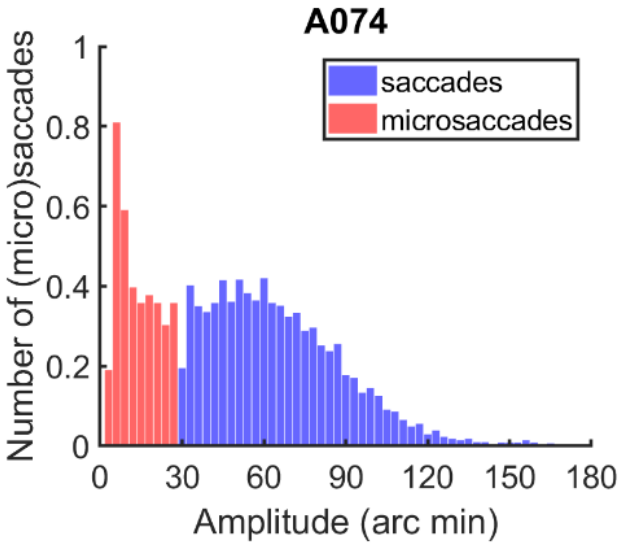
90
120
150
180
Amplitude (arc min)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microsaccades
Number of (micro)saccades
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0.8
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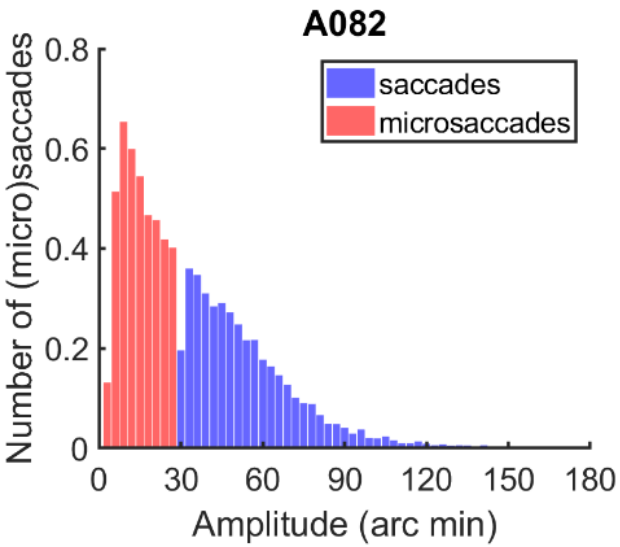
0
30
60
90
120
150
180
Amplitude (arc min)


A082
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microsaccades
Number of (micro)saccades
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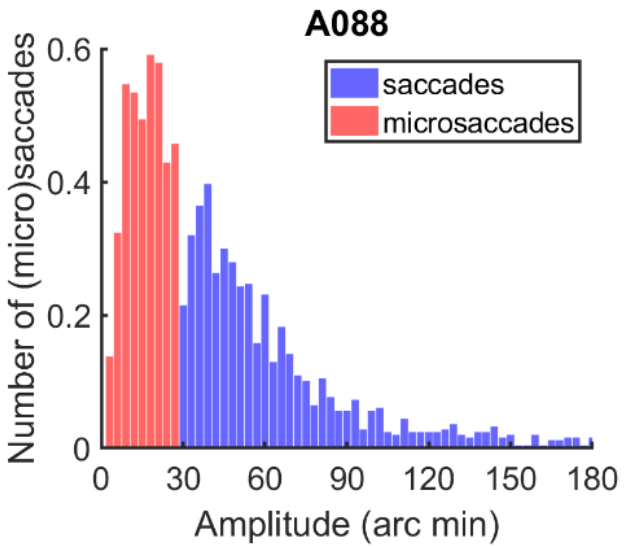
150
180
Amplitude (arc min)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saccades
microsaccades
Number of (micro)saccades
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0.6
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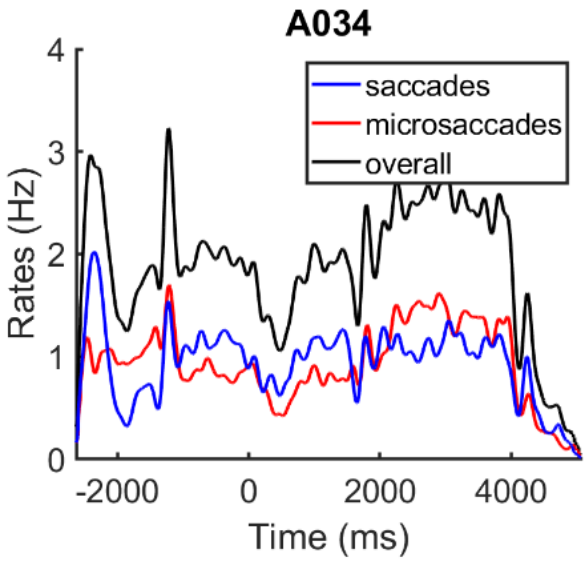
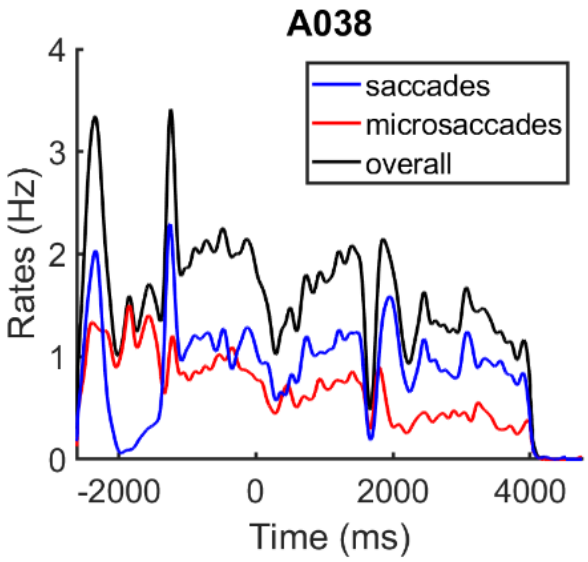
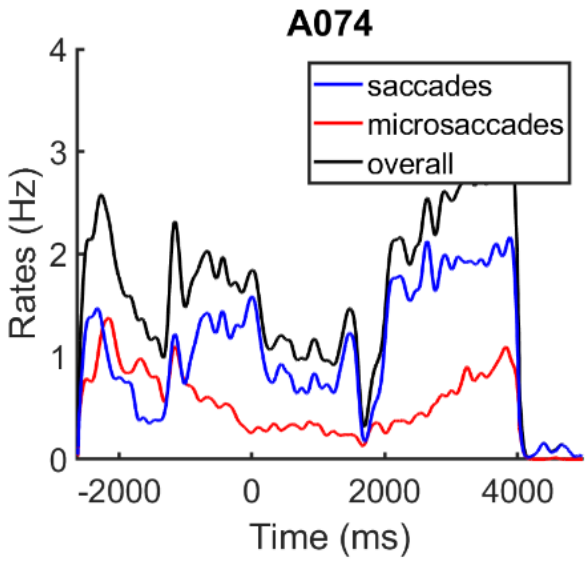
30
60
90
120
150
180
Amplitude (arc min)

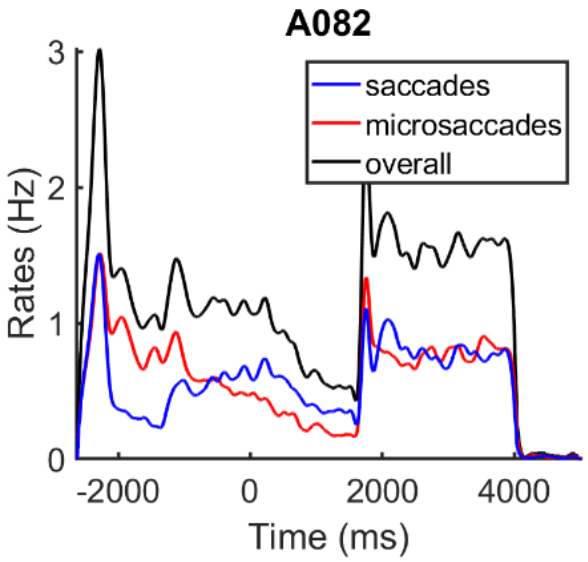
Results

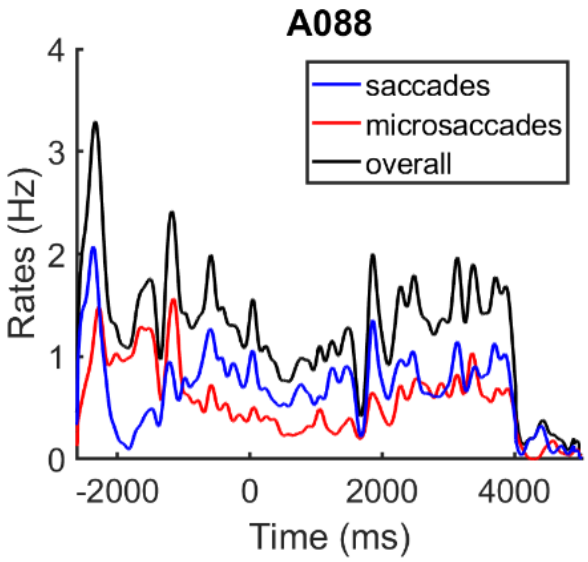
Fixational Saccades Rate





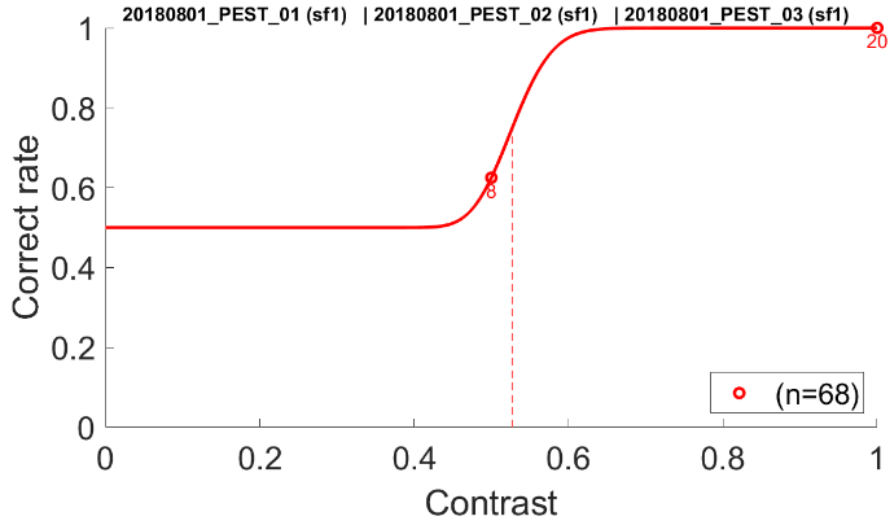


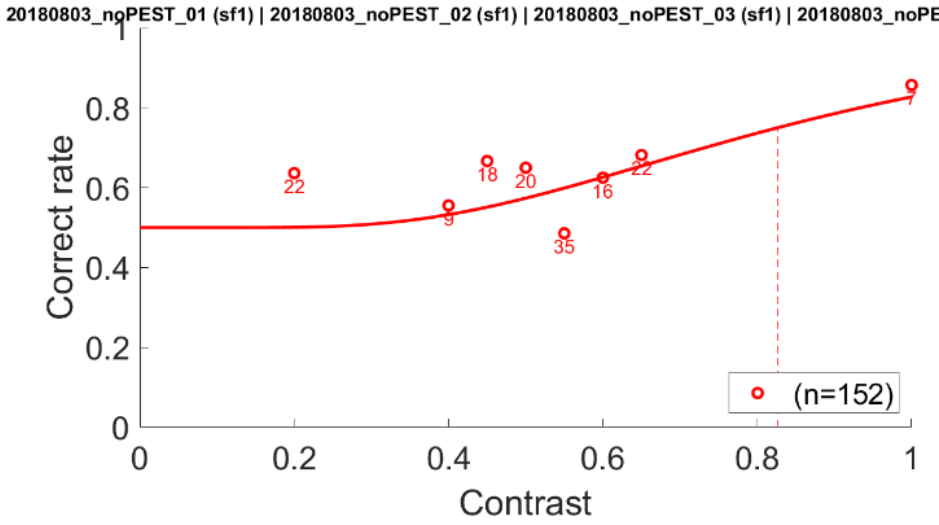


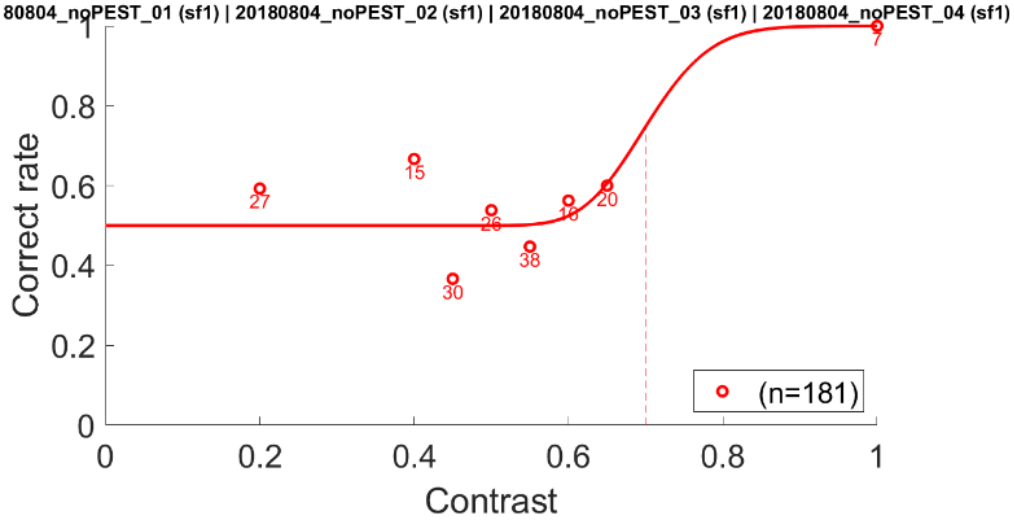


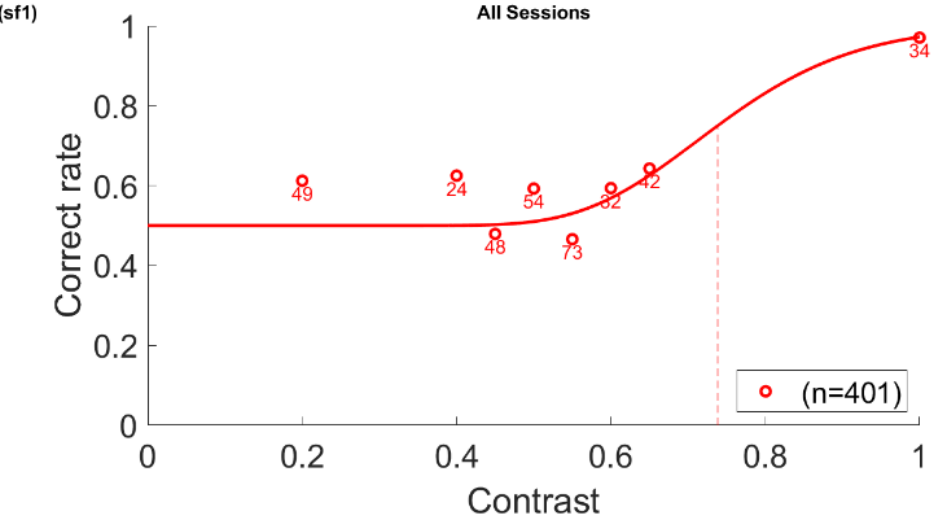
Results

A034. Overall Psych Curve



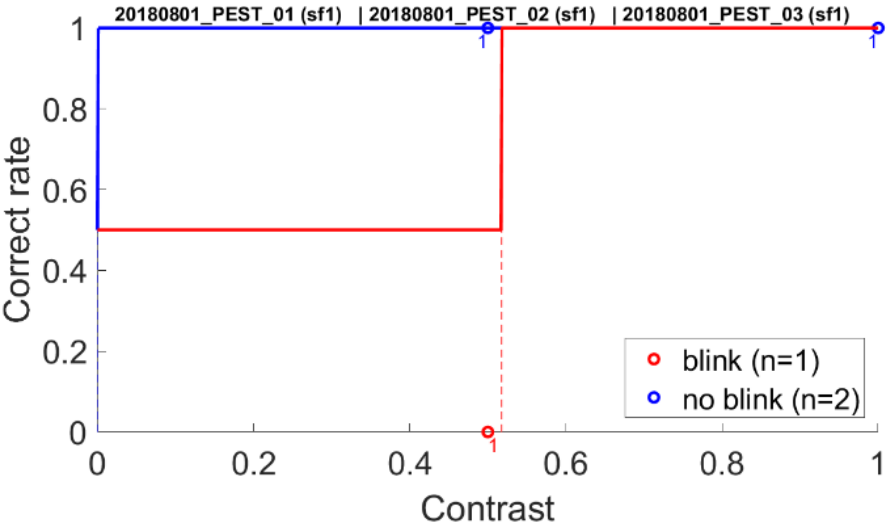


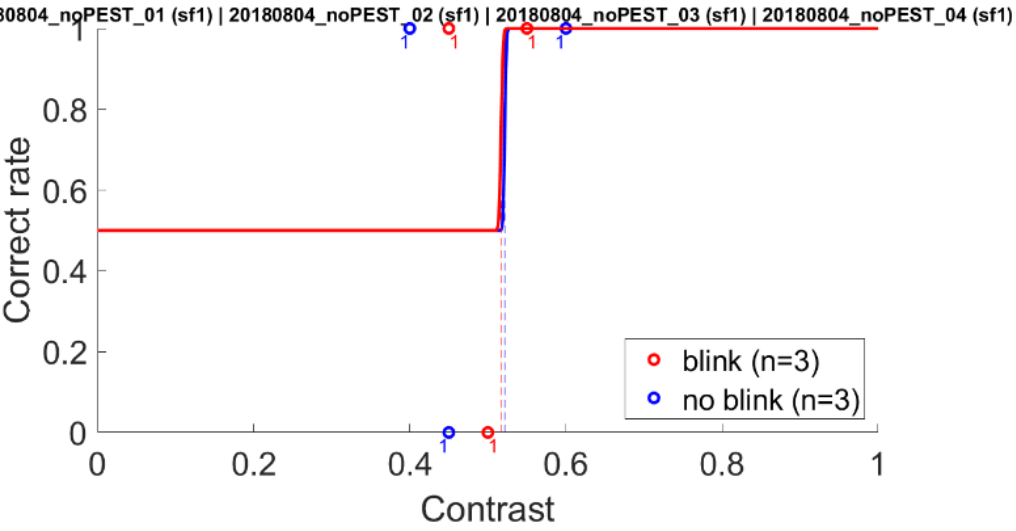


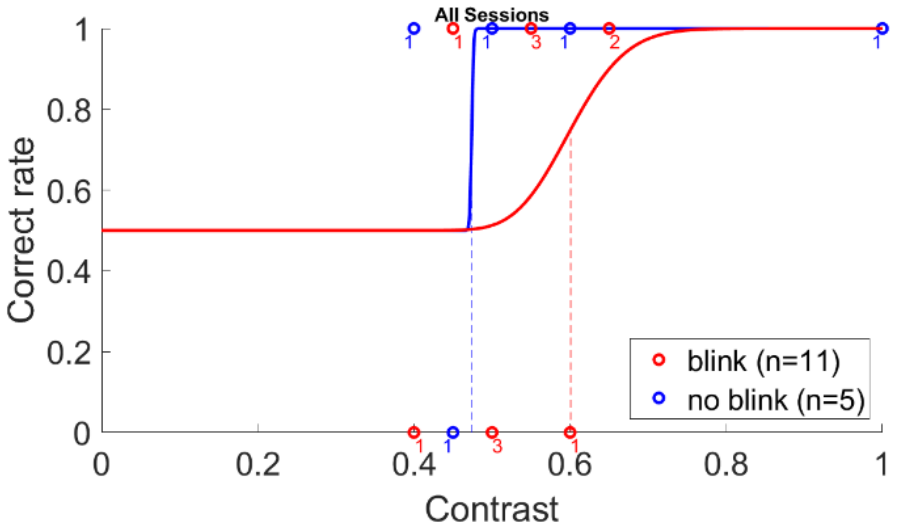


Results

A034. Blink Effect

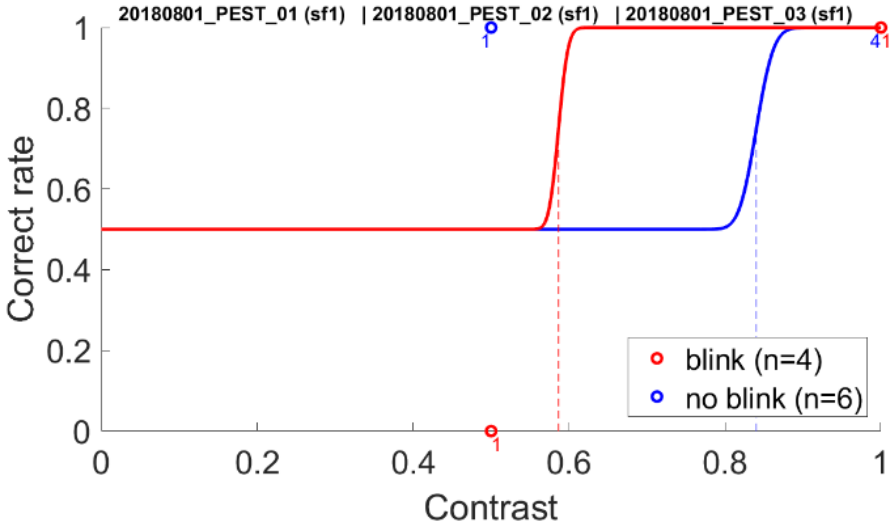


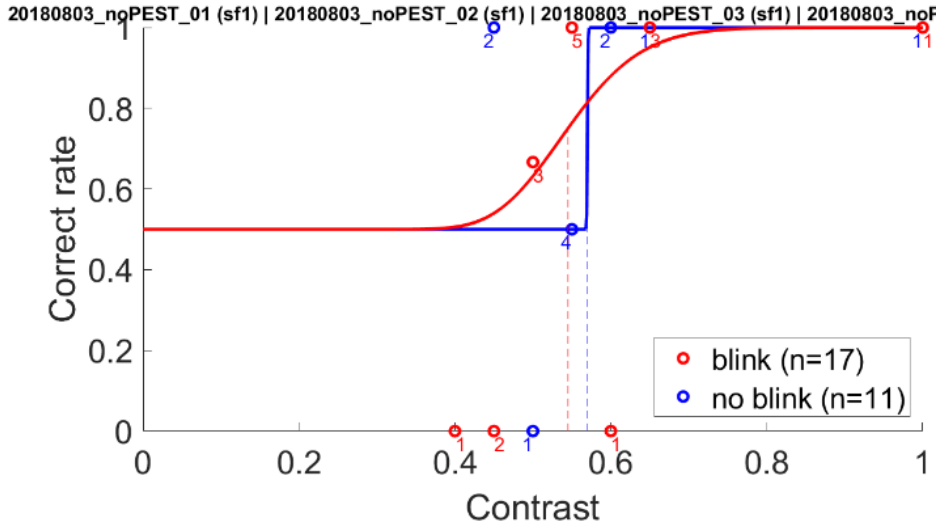


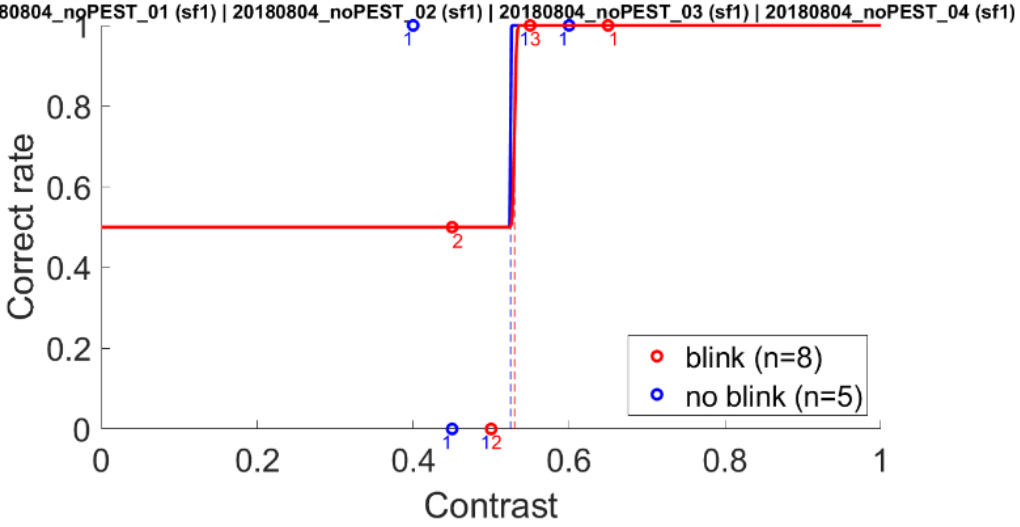


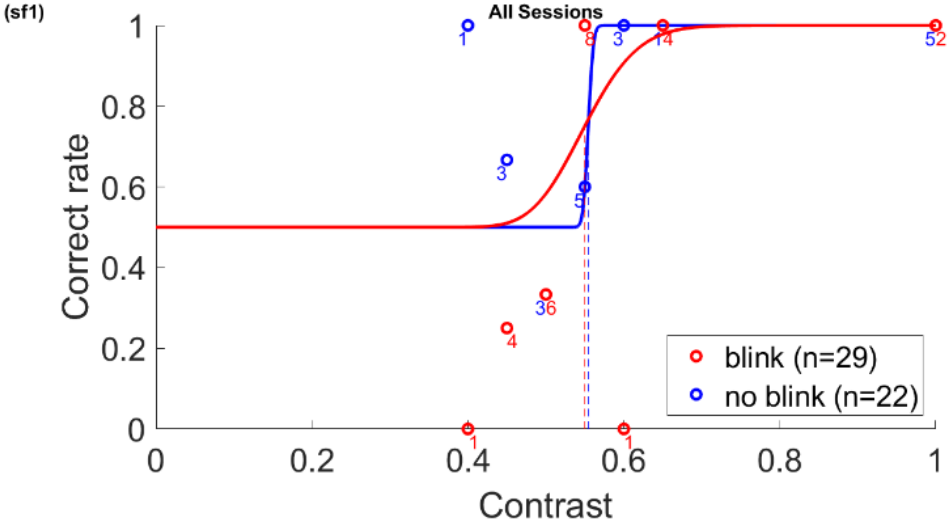
Results

A034. Blink Effect. With Microsacs



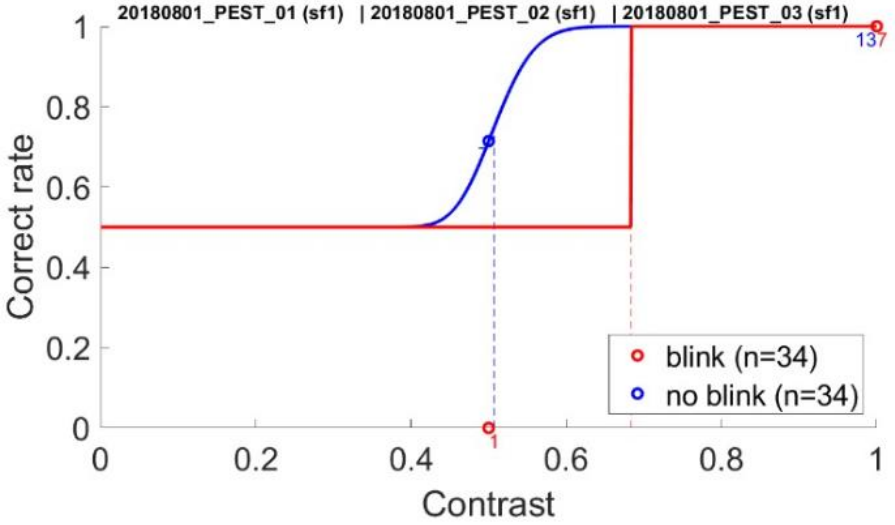


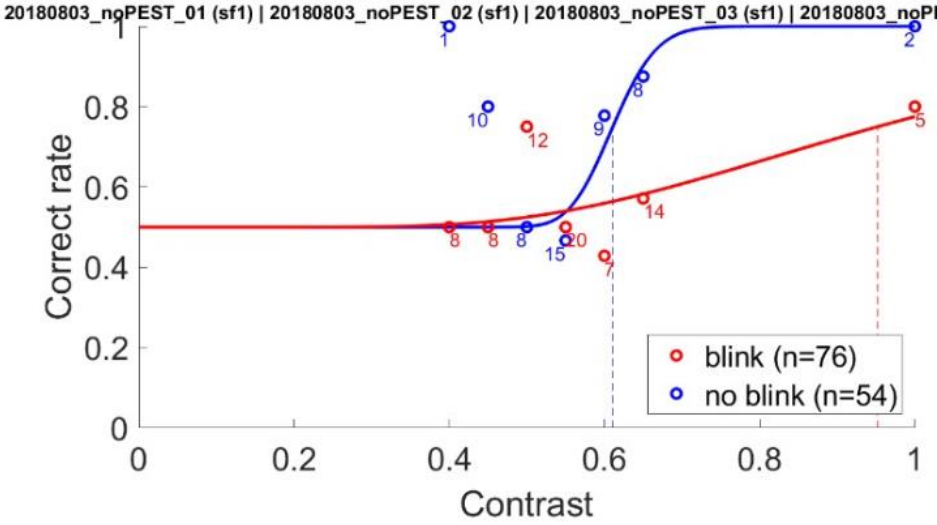


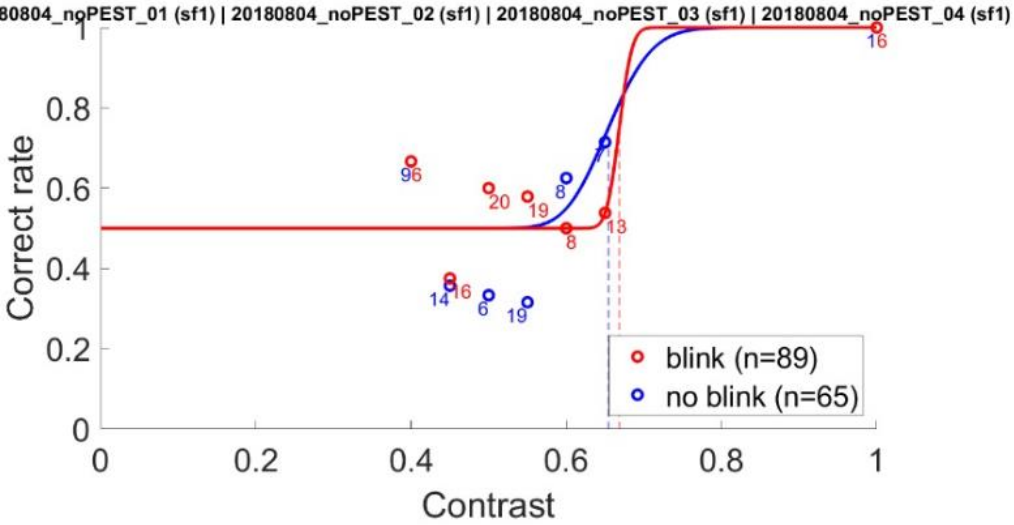


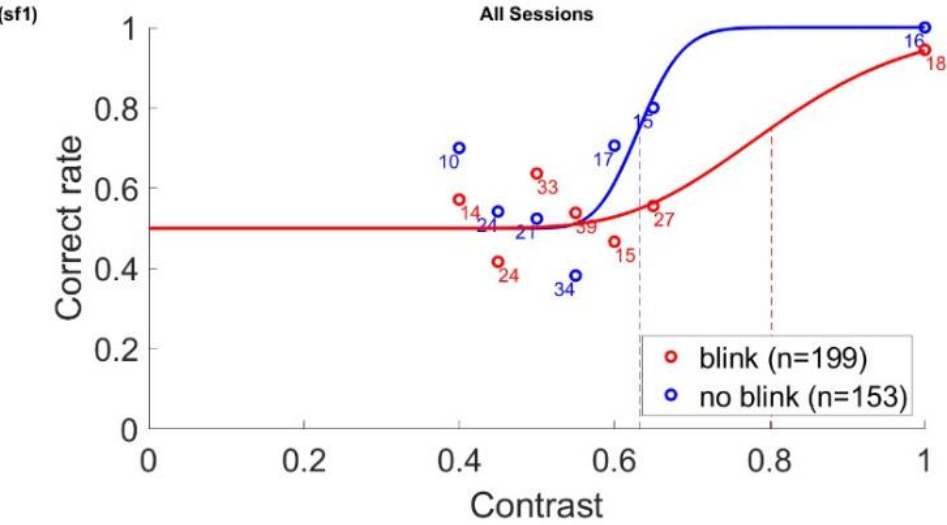
Results

A034. Blink Effect. With All Sacs



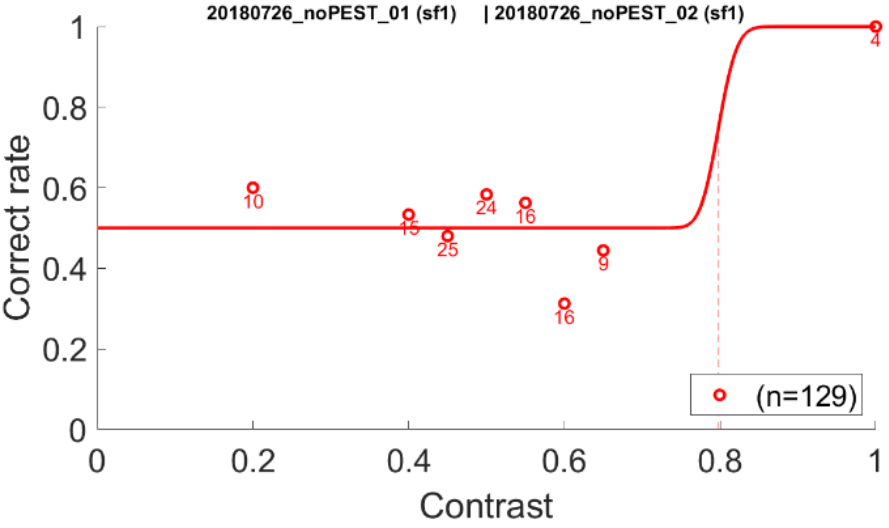


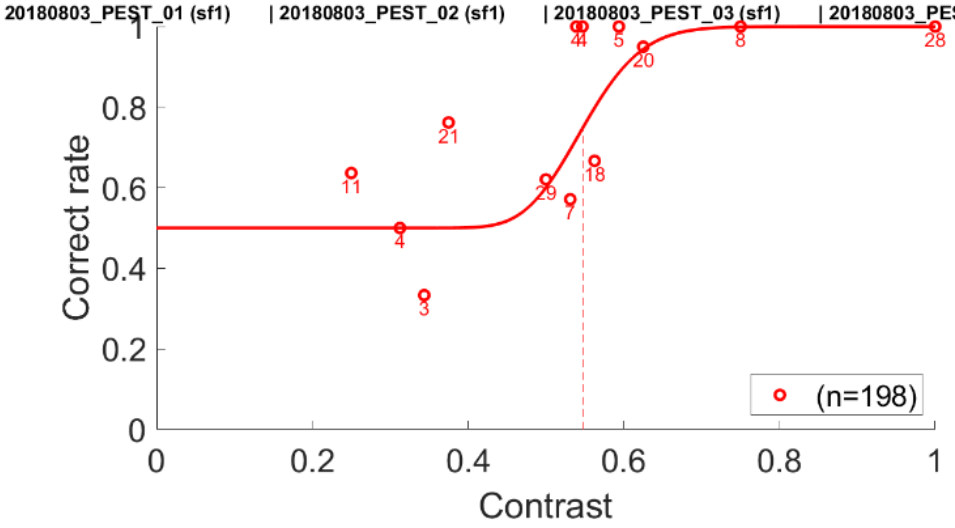


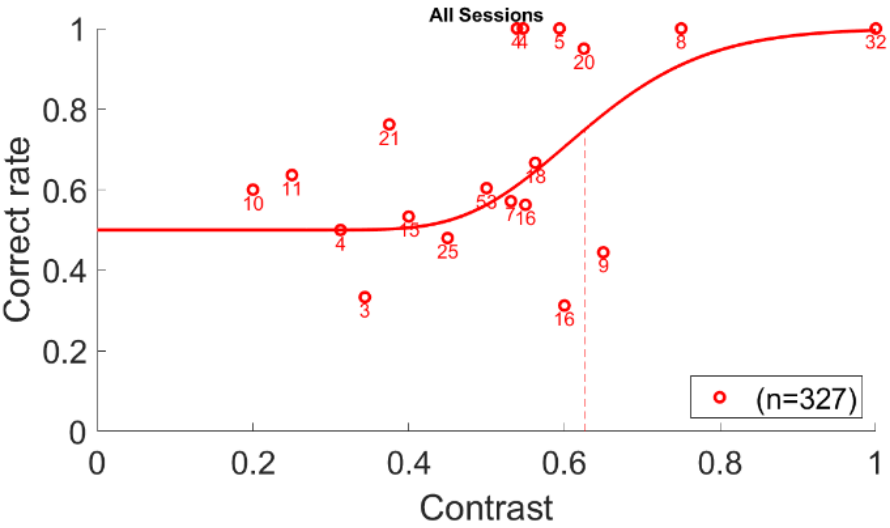


Results

A038. Overall Psych Curve

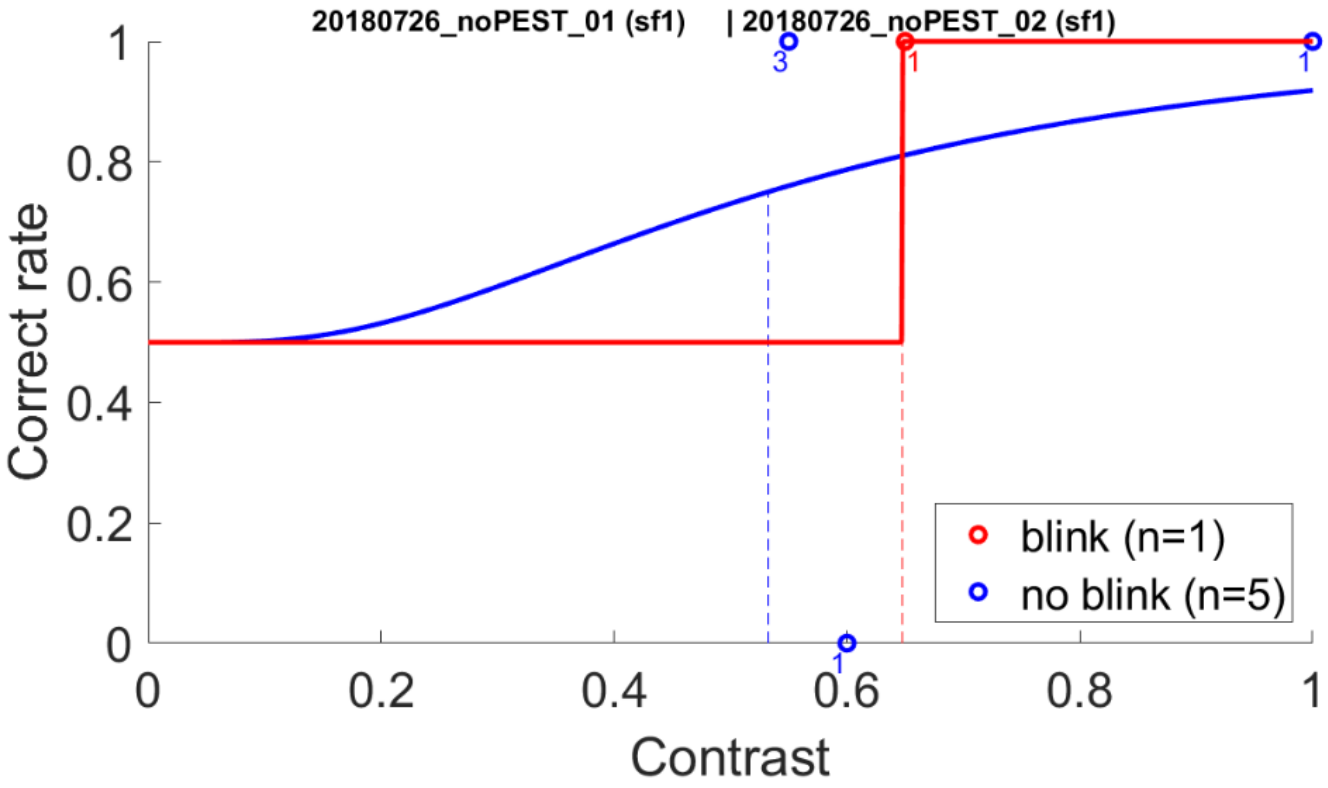






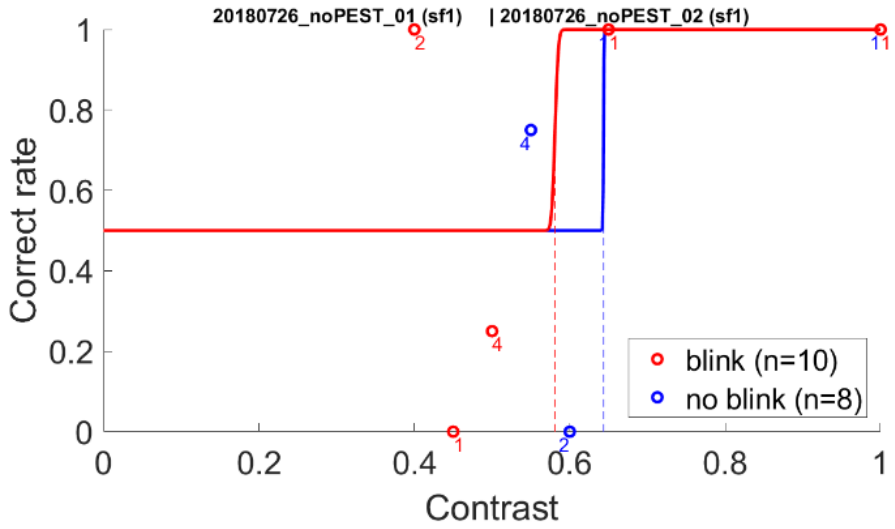
Results

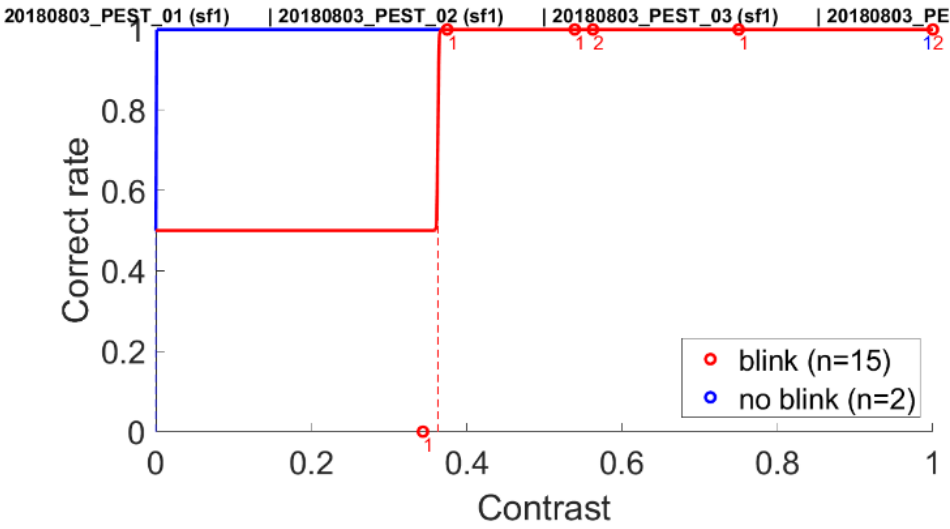
A038. Blink Effect

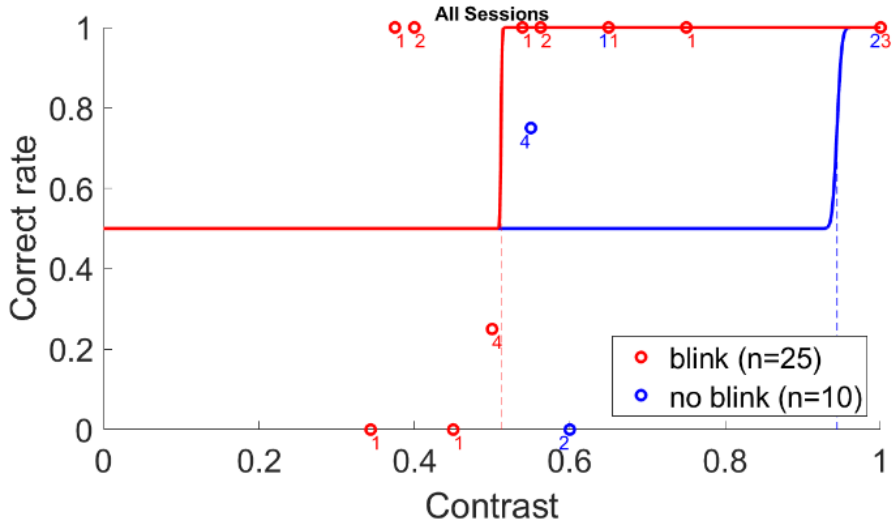


Results

A038. Blink Effect. With Microsacs

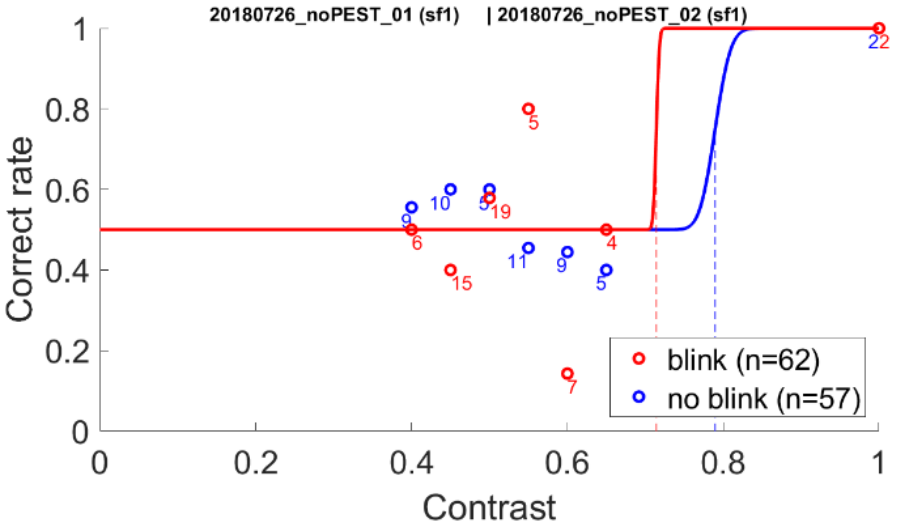


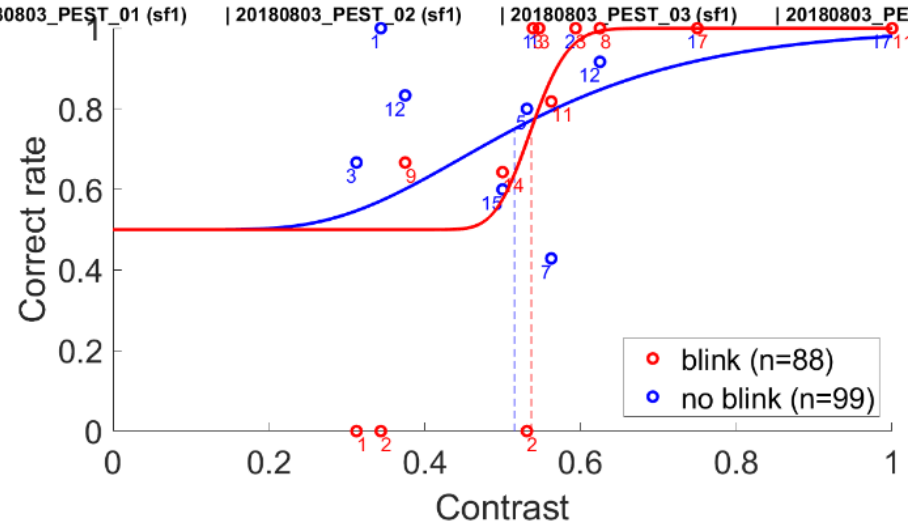


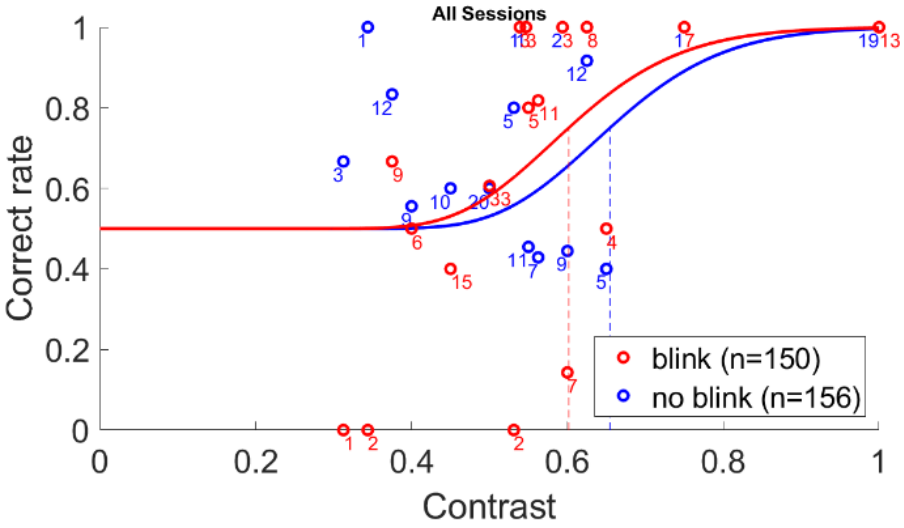


Results

A038. Blink Effect. With All Sacs

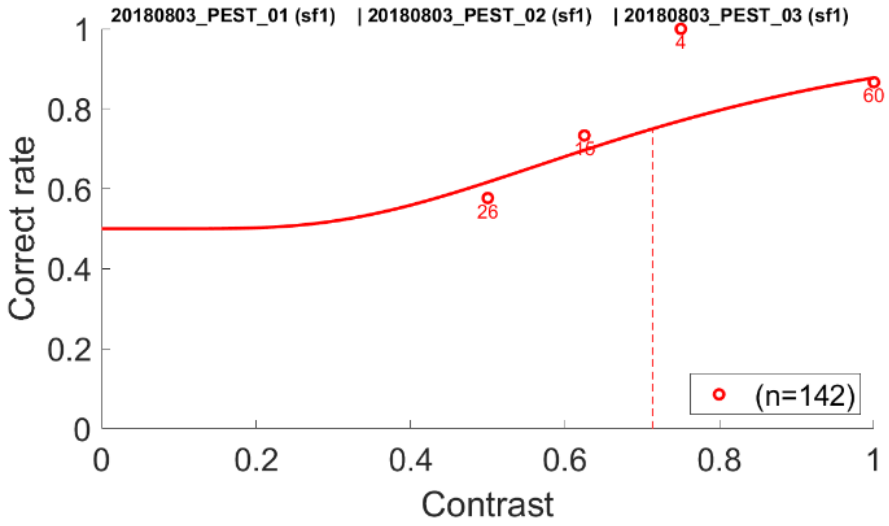


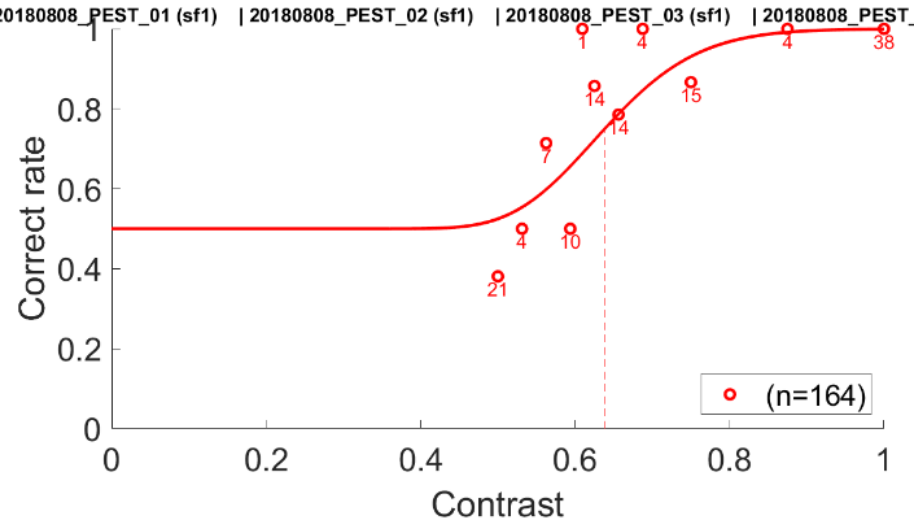


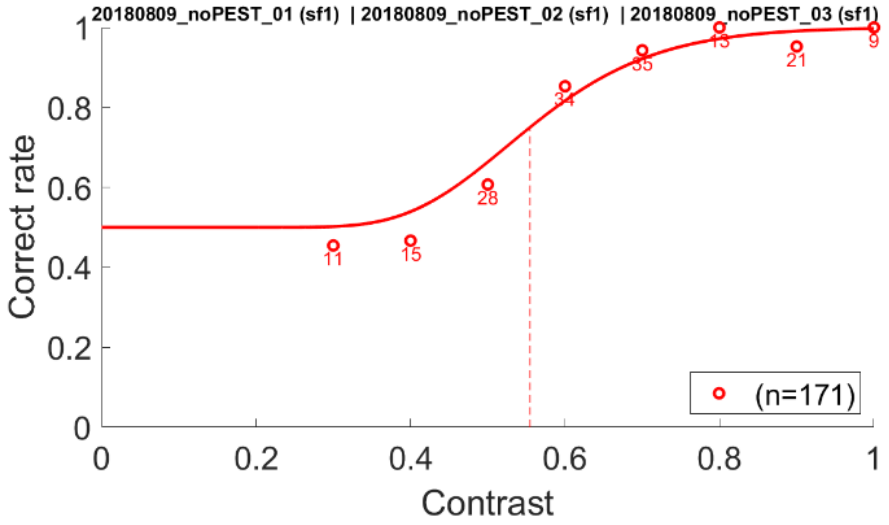


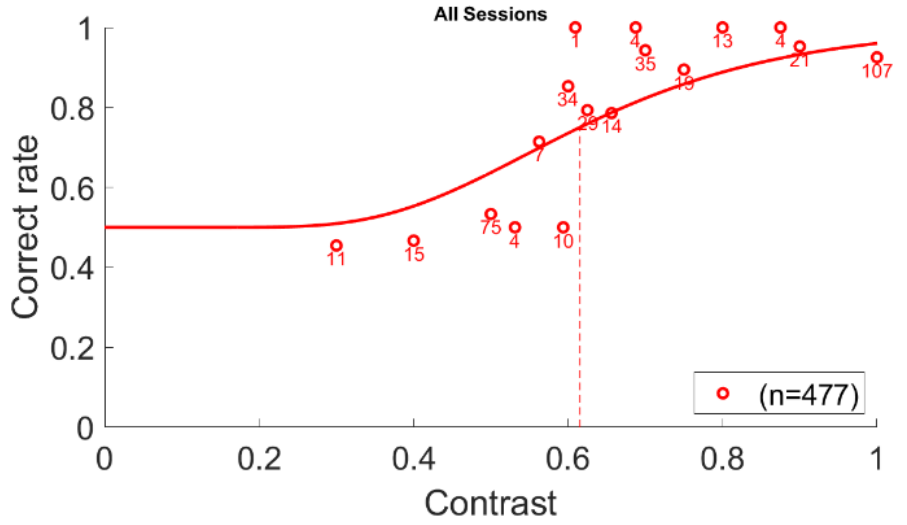
Results

A074. Overall Psych Curve



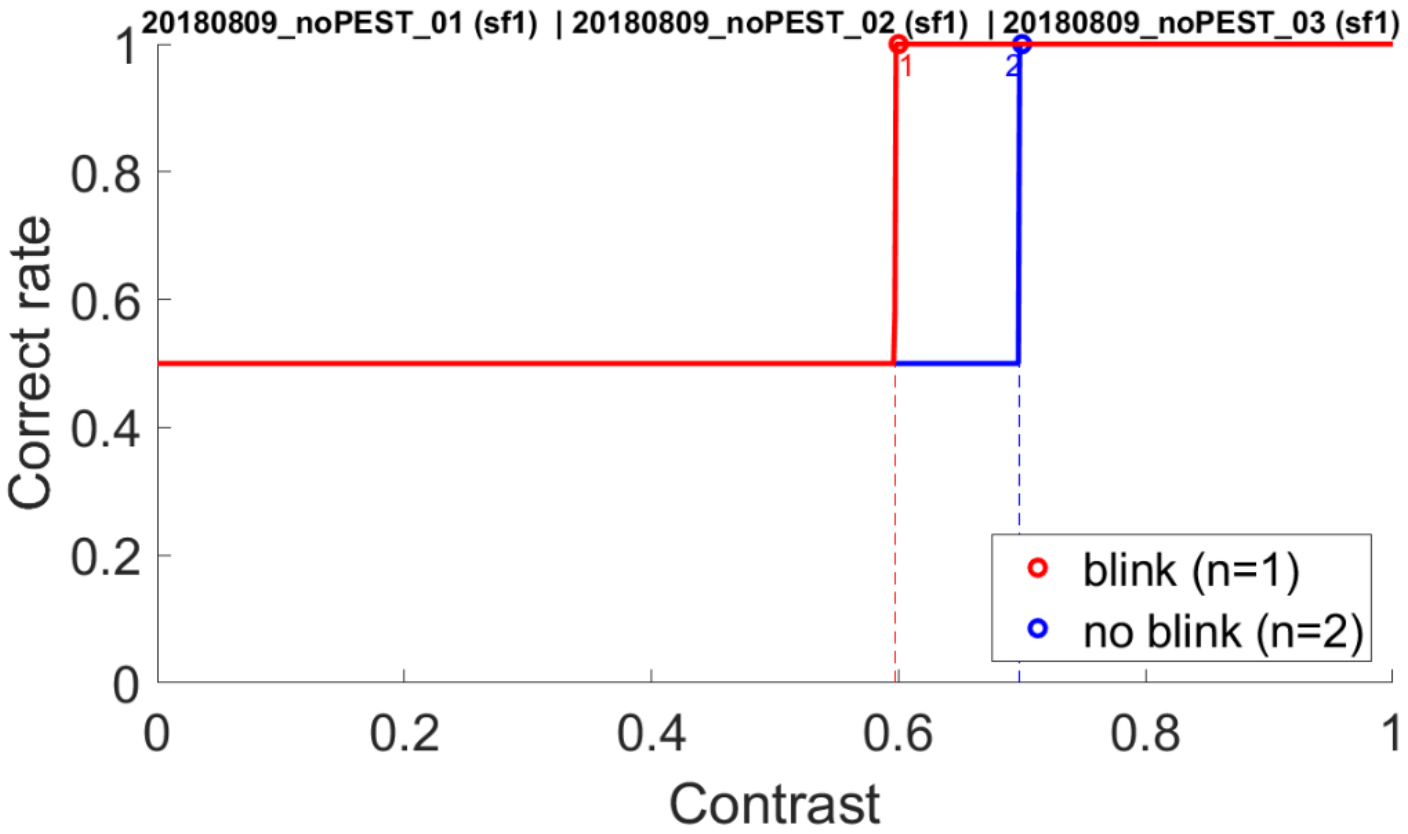






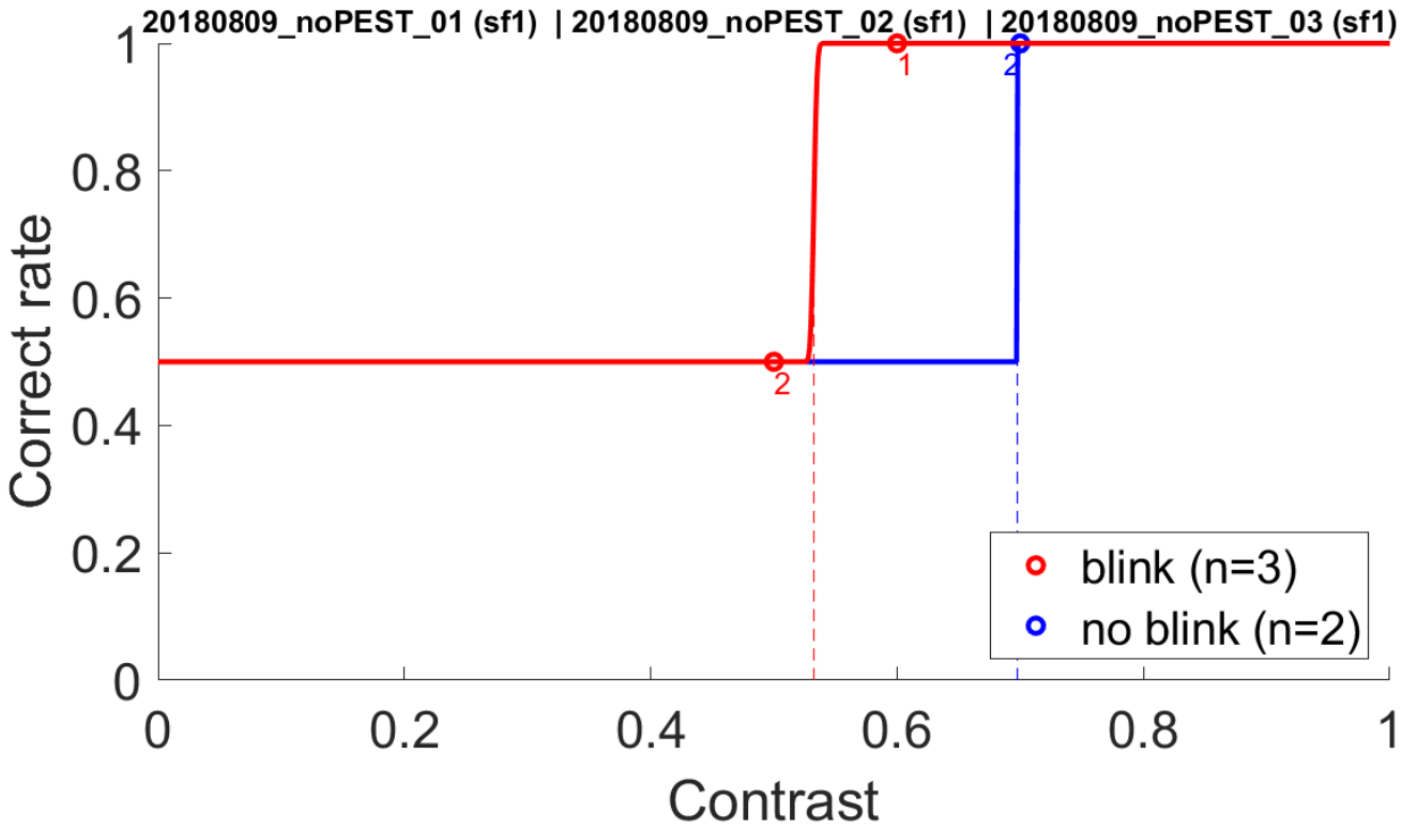
Results

A074. Blink Effect



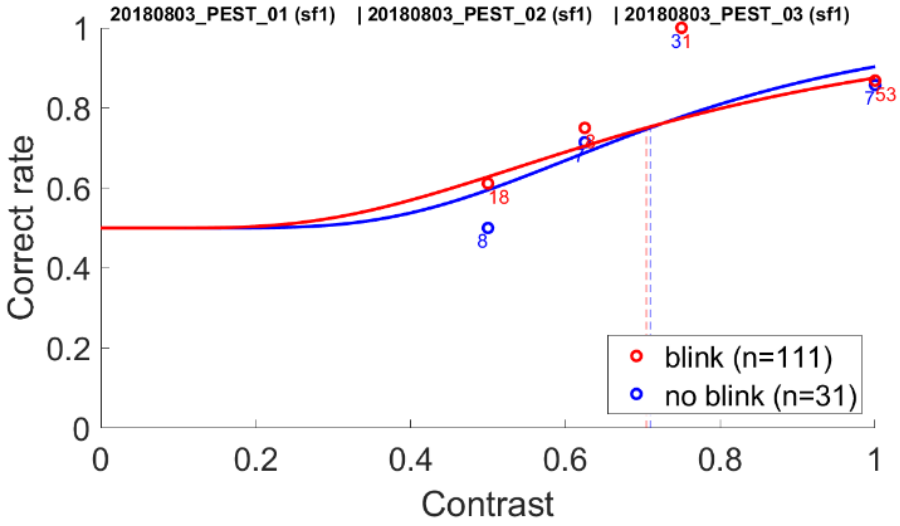
Results

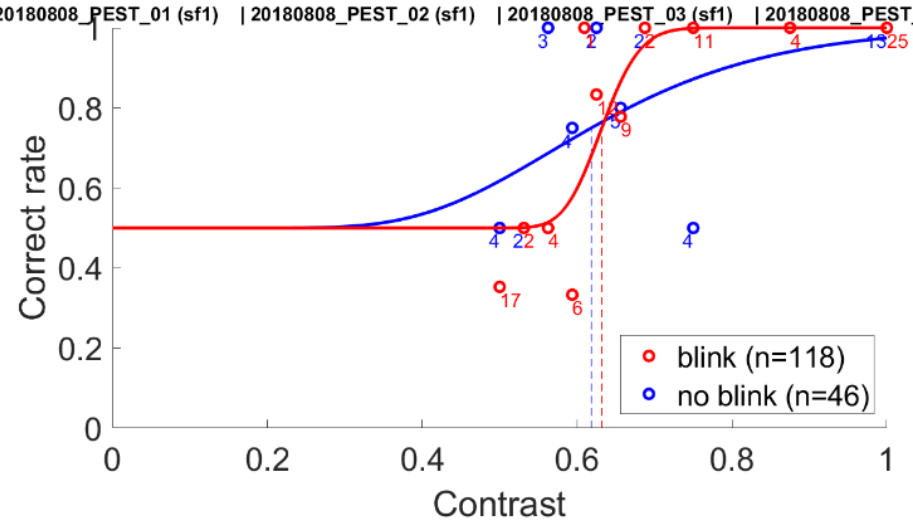
A074. Blink Effect. With Microsacs

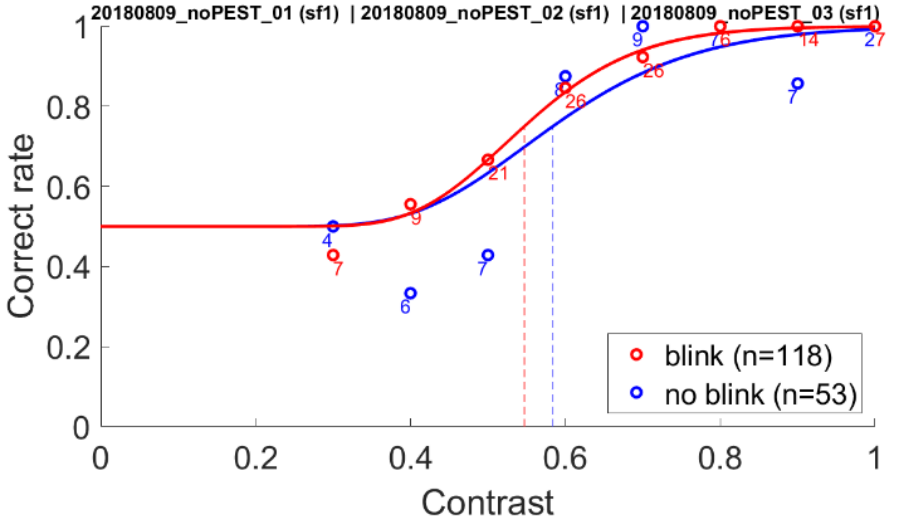


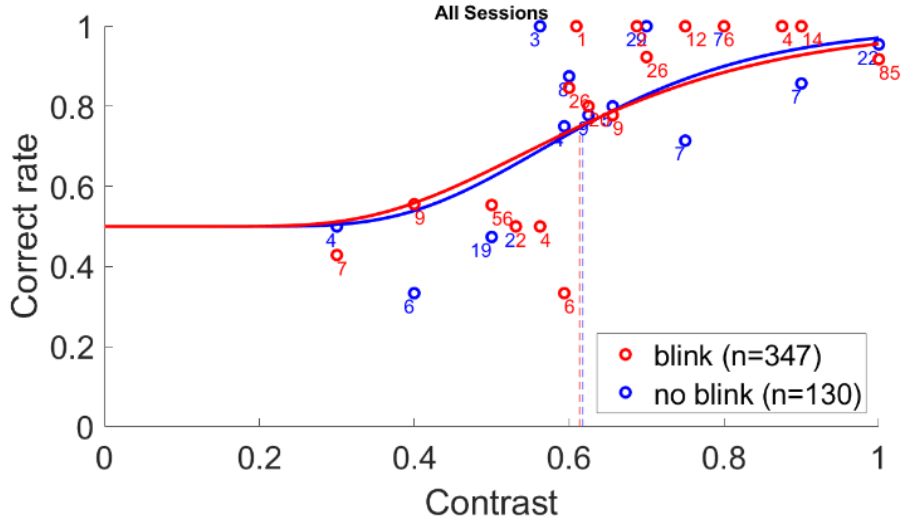
Results

A074. Blink Effect. With All Sacs



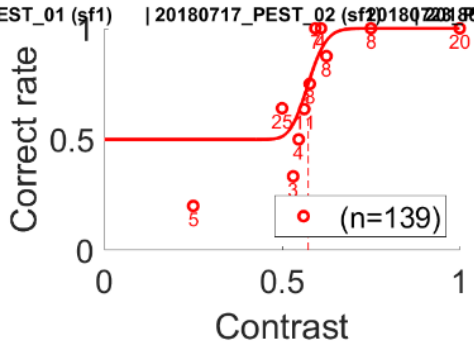


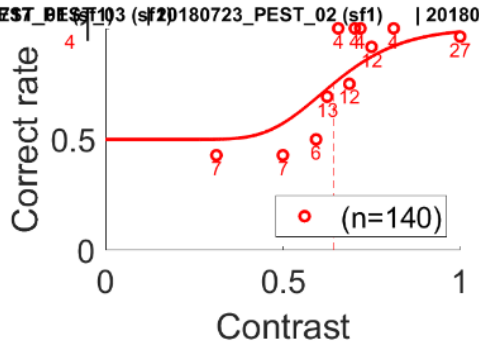


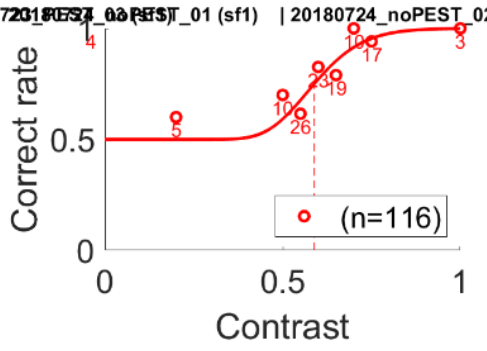


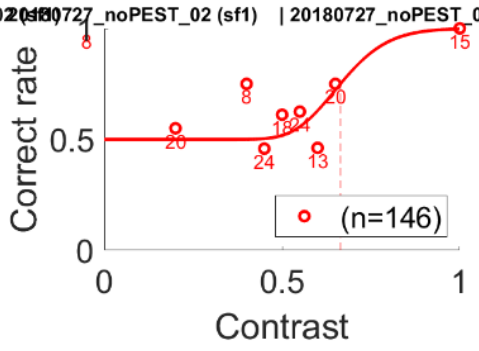
Results

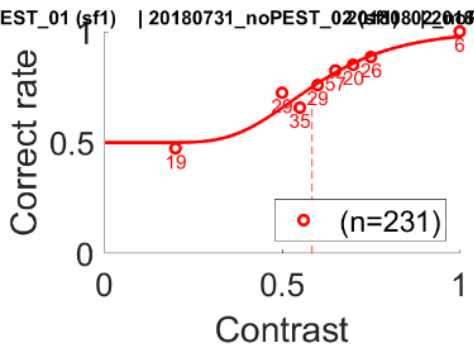
A082. Overall Psych Curve

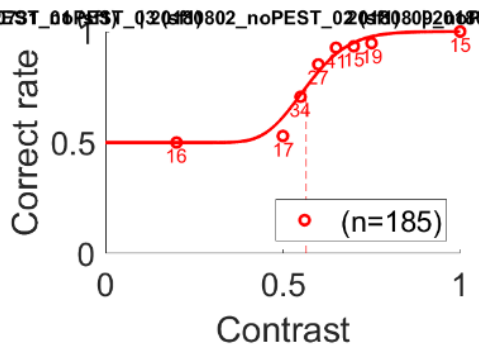


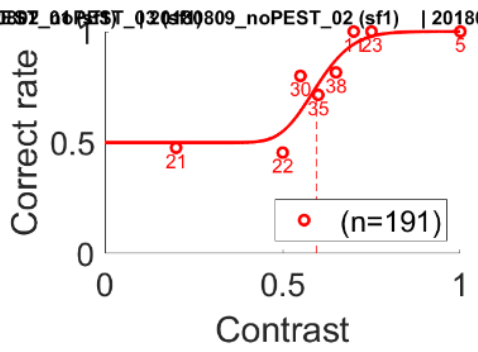


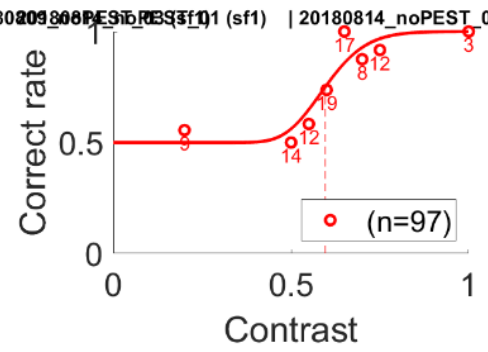


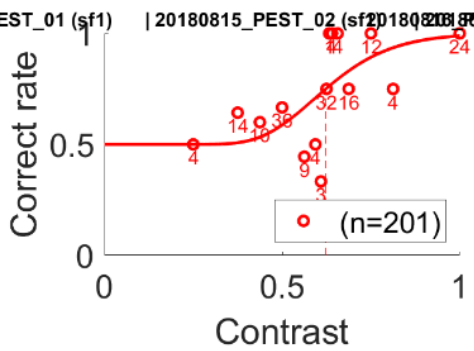


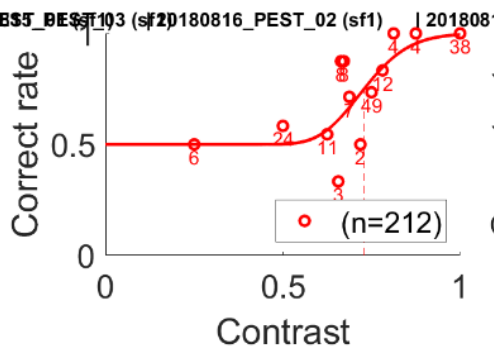


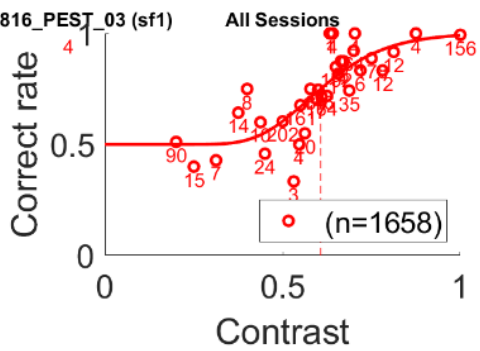






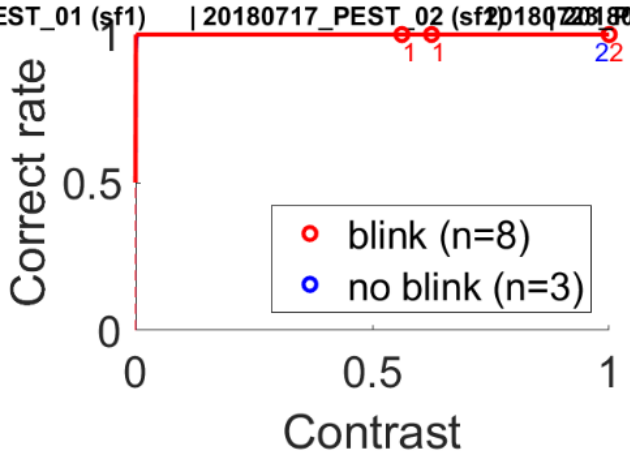


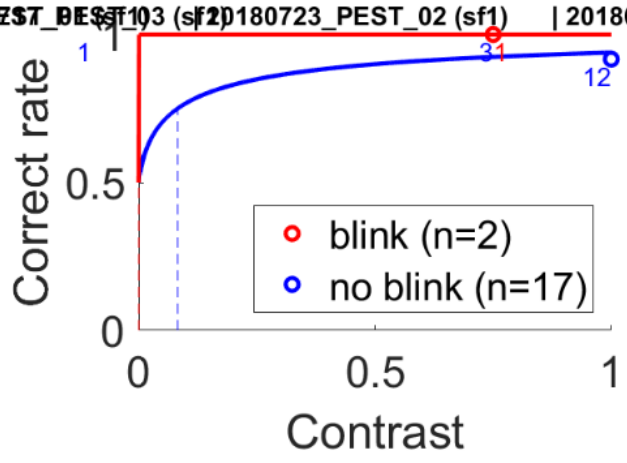


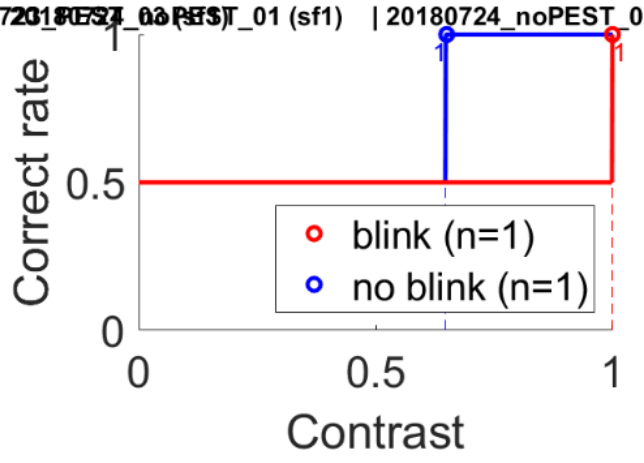


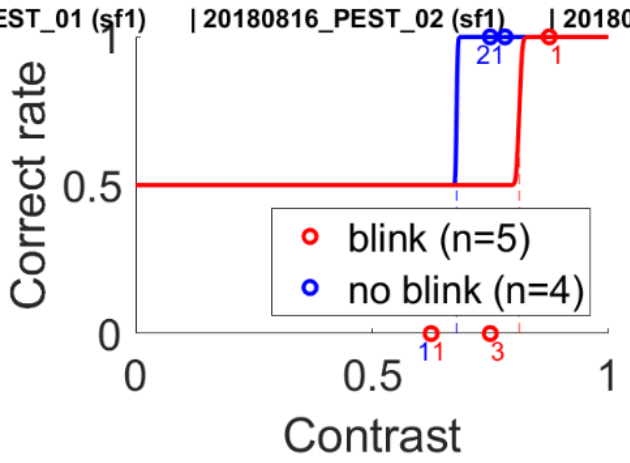
Results

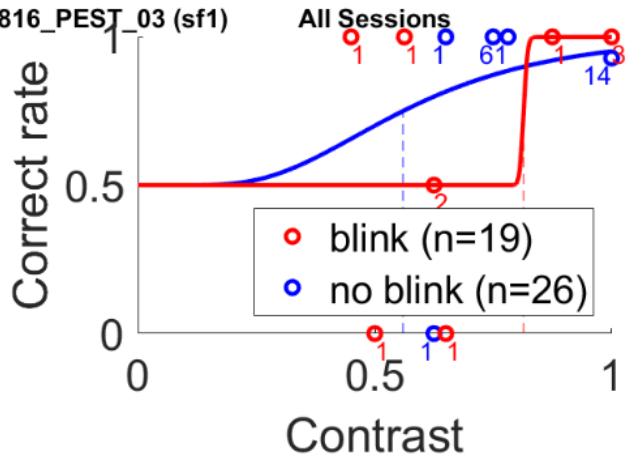
A082. Blink Effect





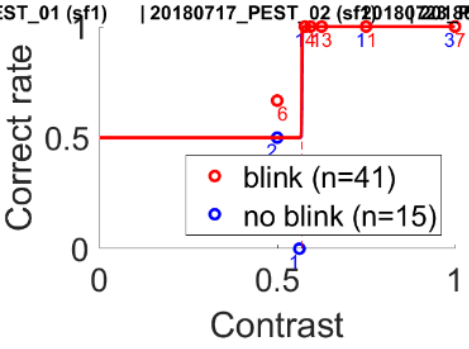


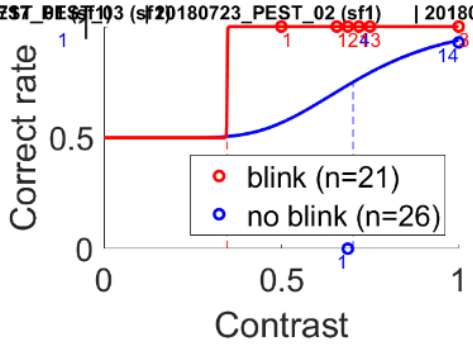


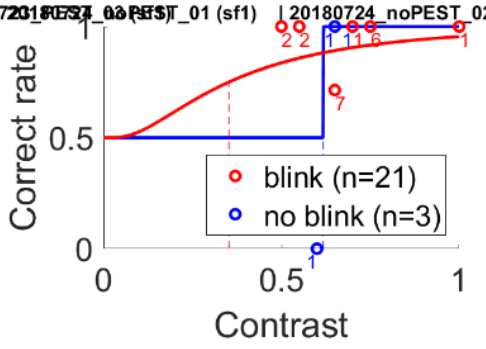


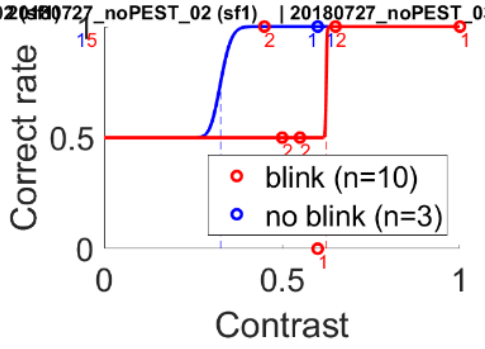
Results

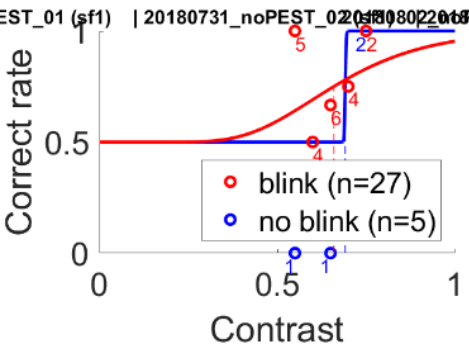
A082. Blink Effect. With Microsacs

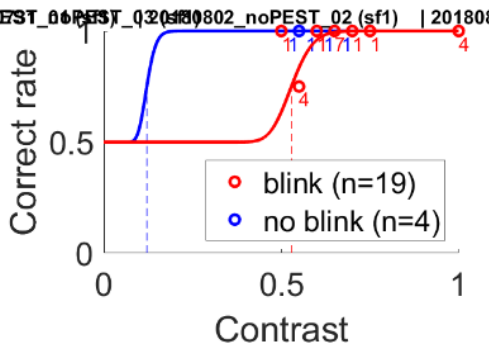


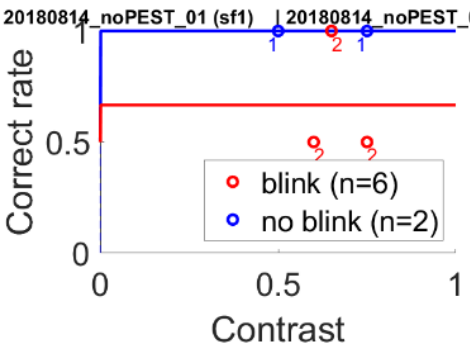


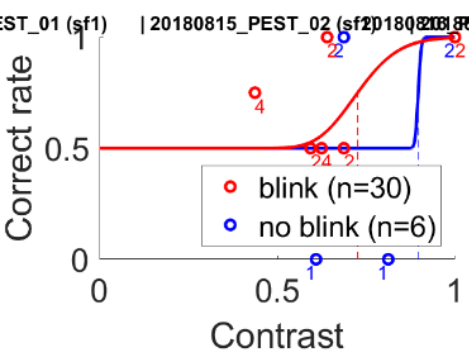


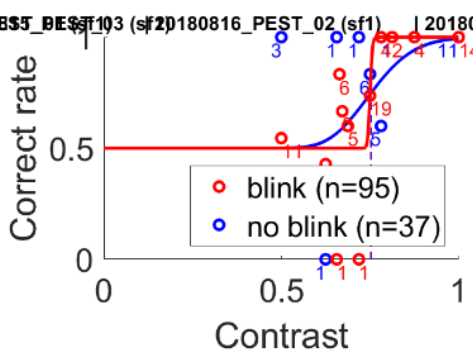


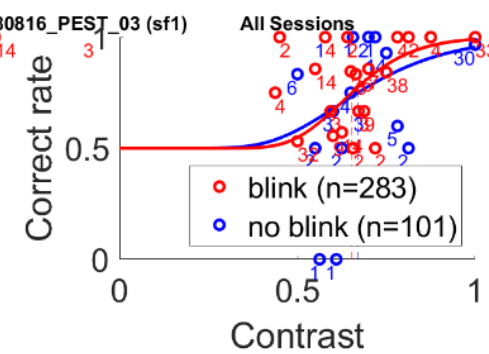






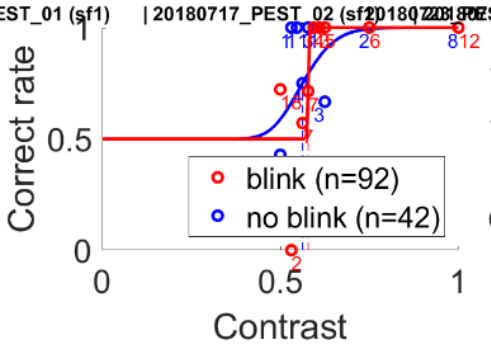


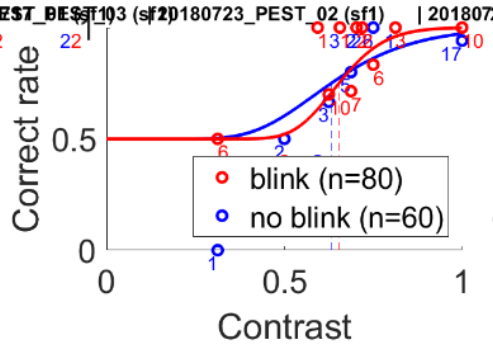


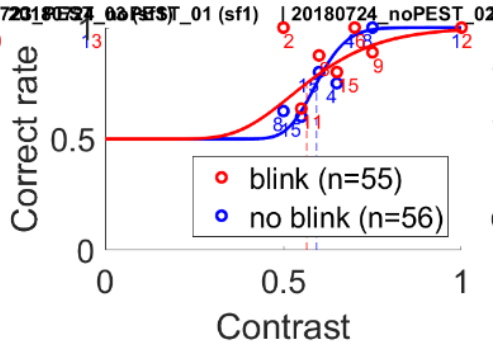


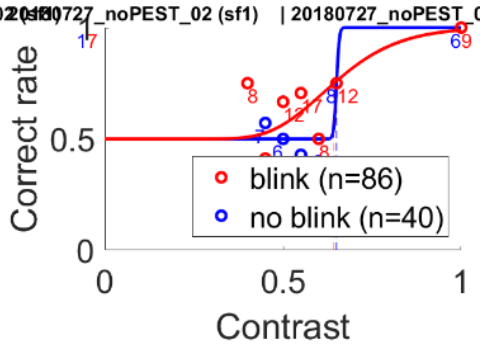
Results

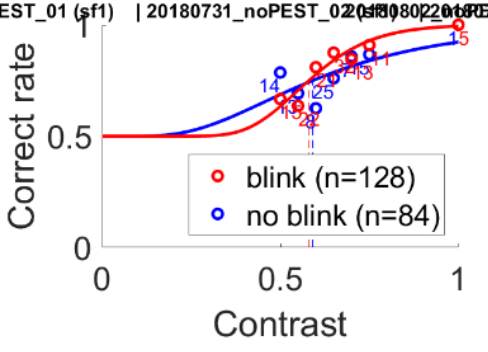
A082. Blink Effect. With All Sacs

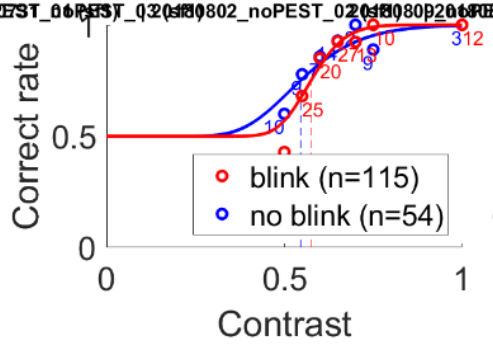


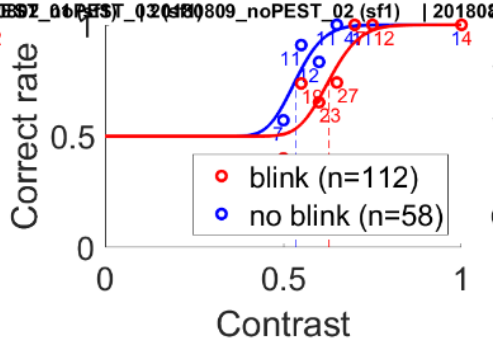


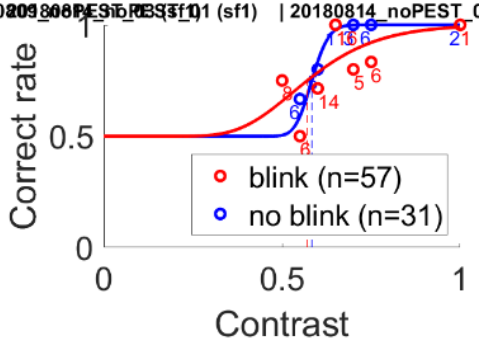


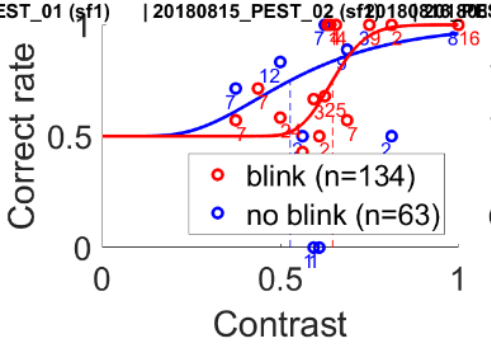


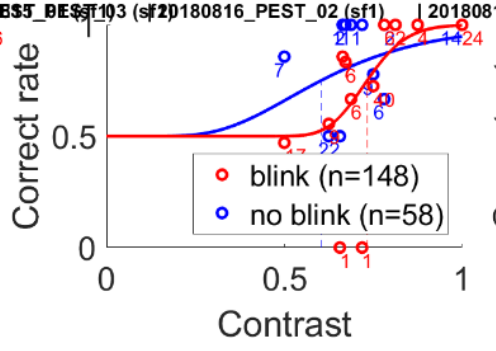


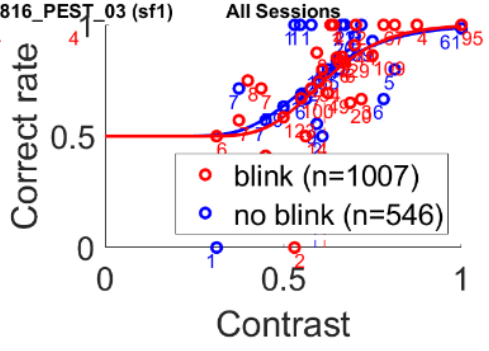






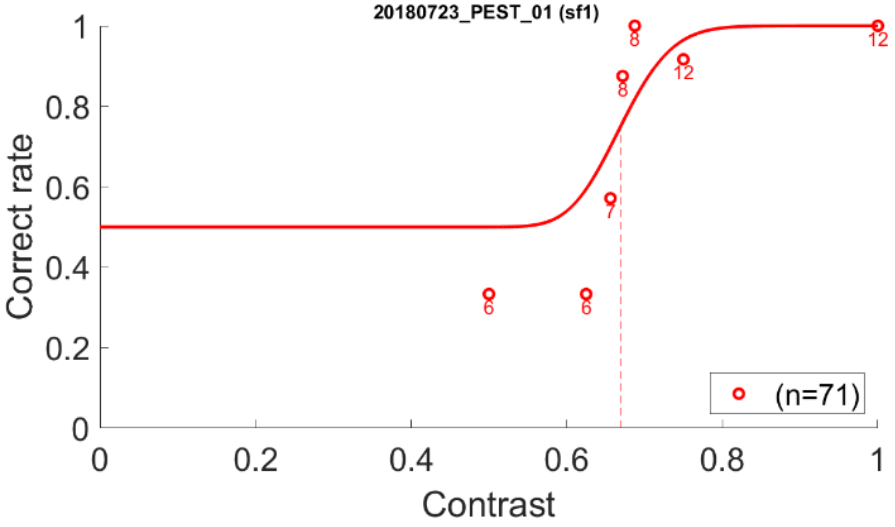


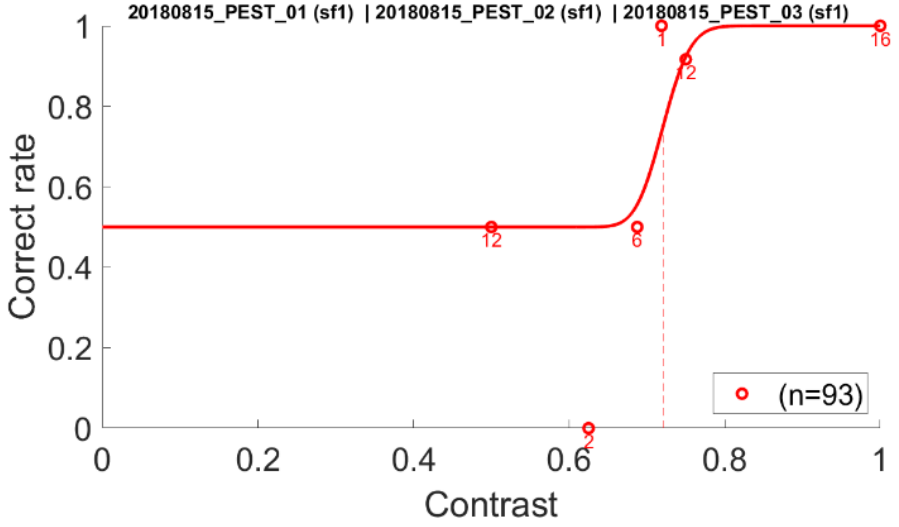


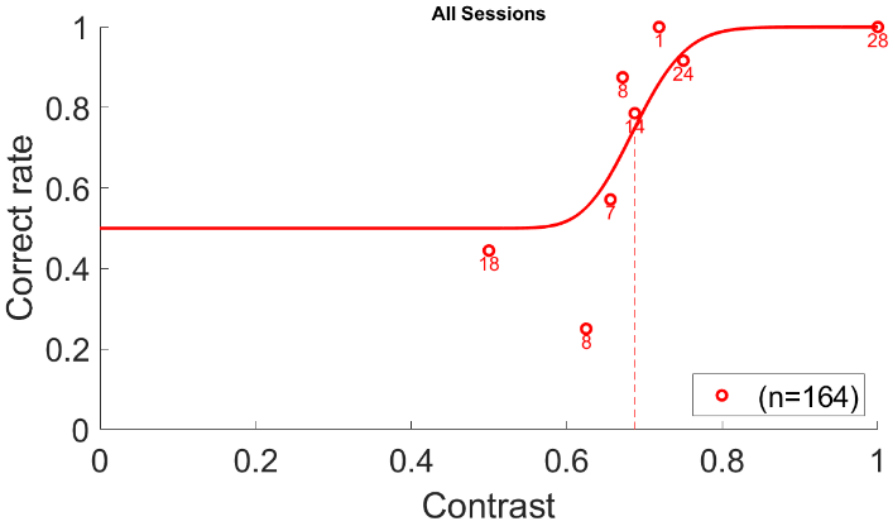


Results

A088. Overall Psych Curve

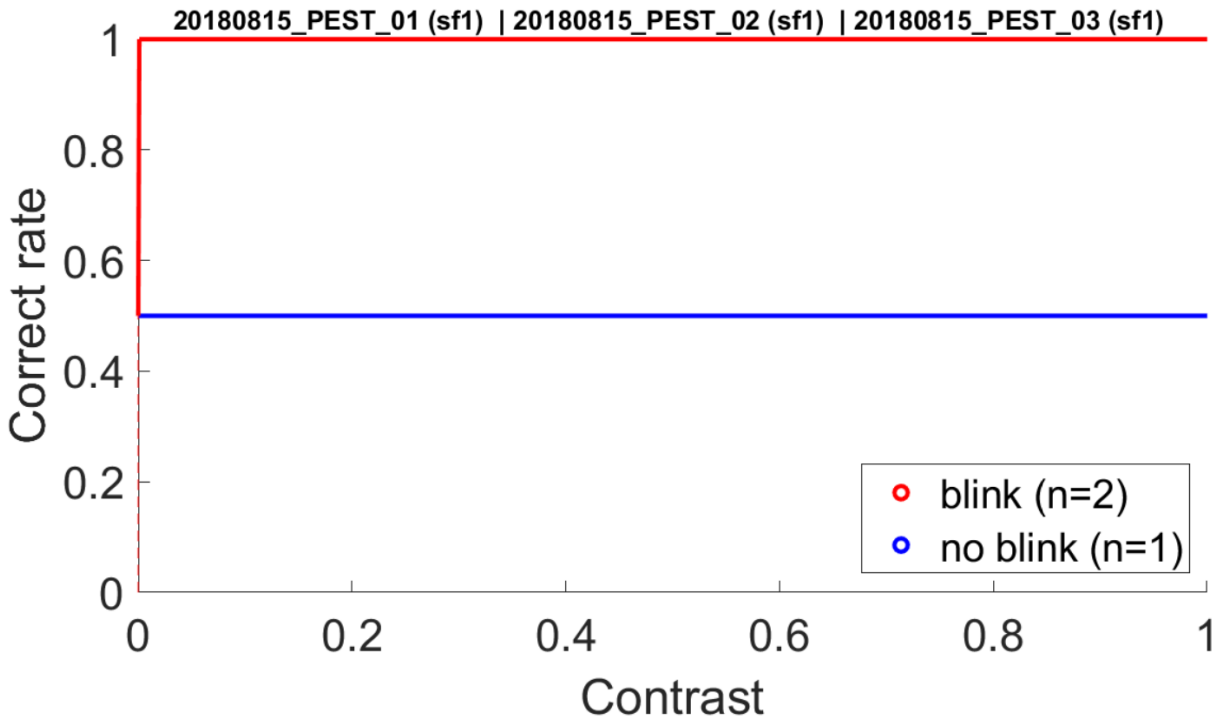






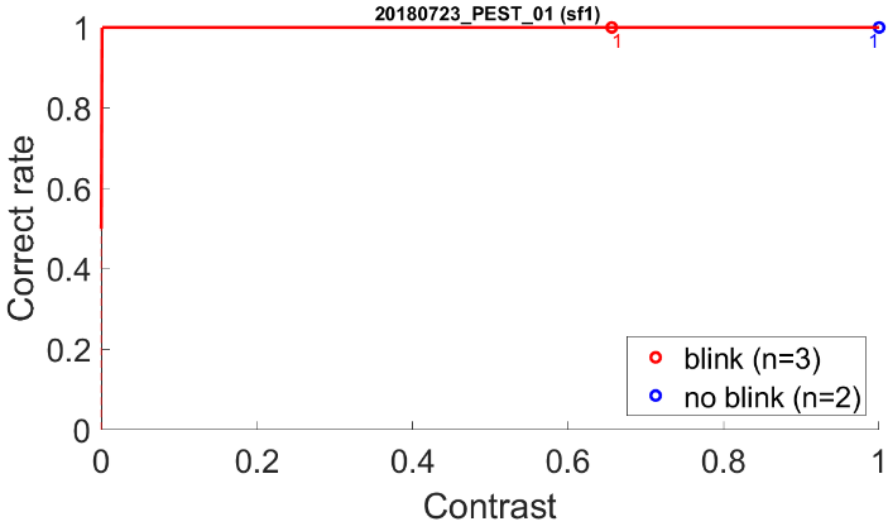
Results

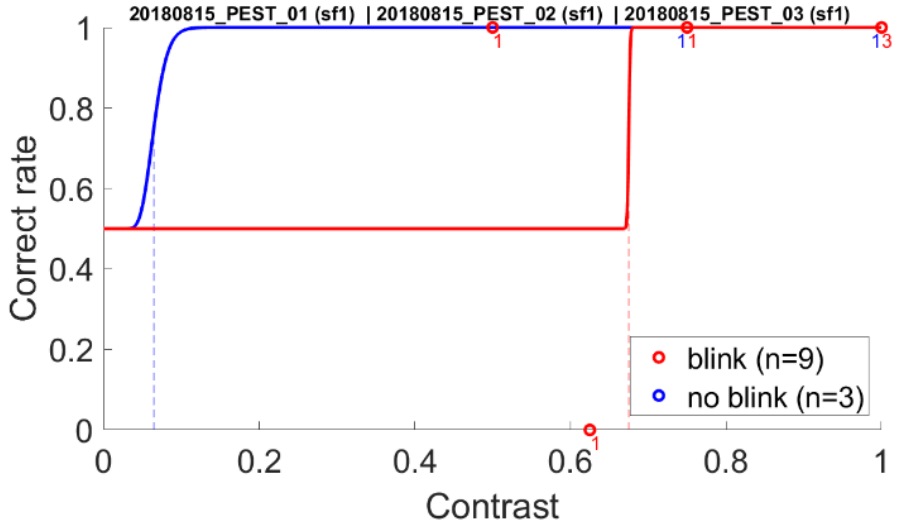
A088. Blink Effect

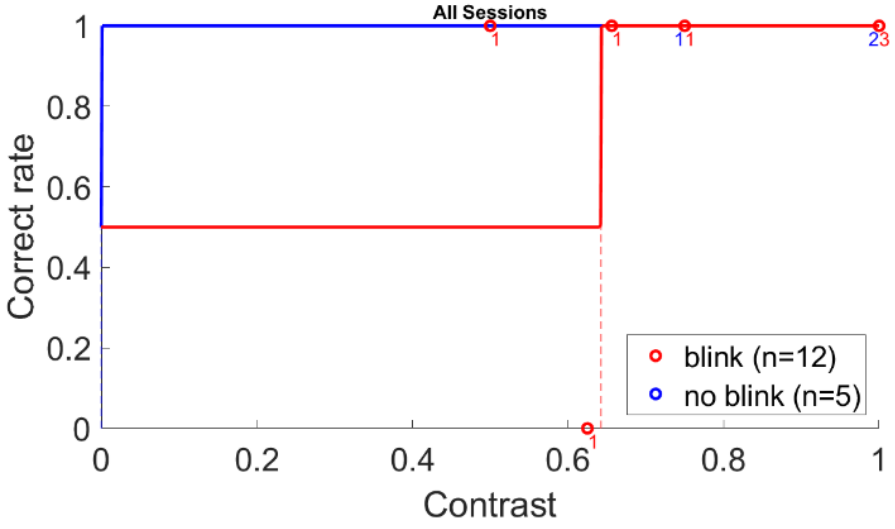


Results

A088. Blink Effect. With Microsacs

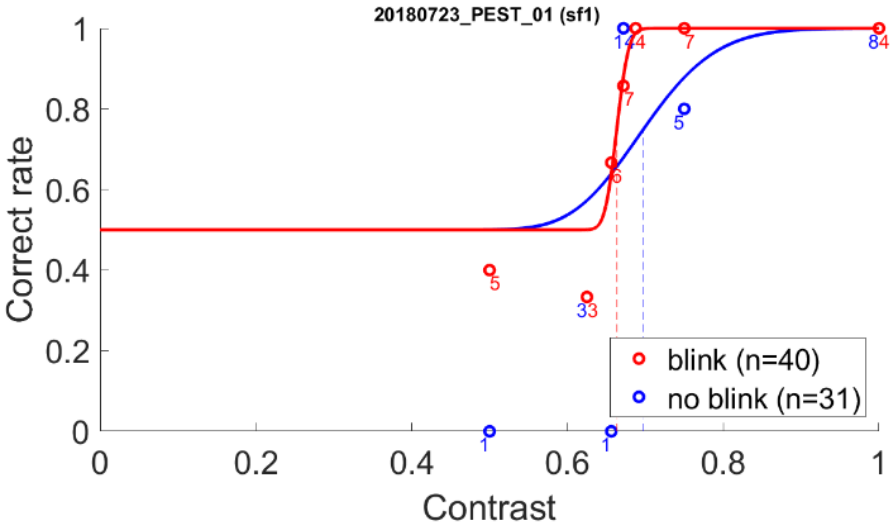


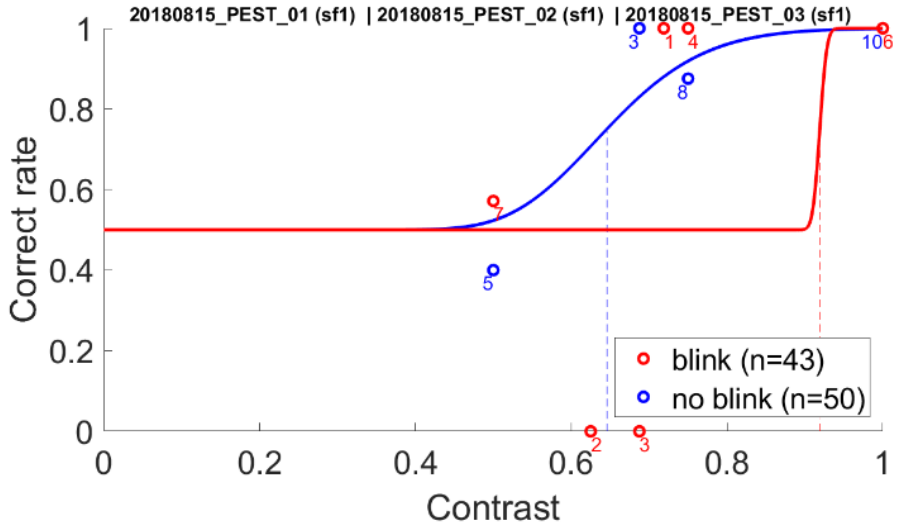


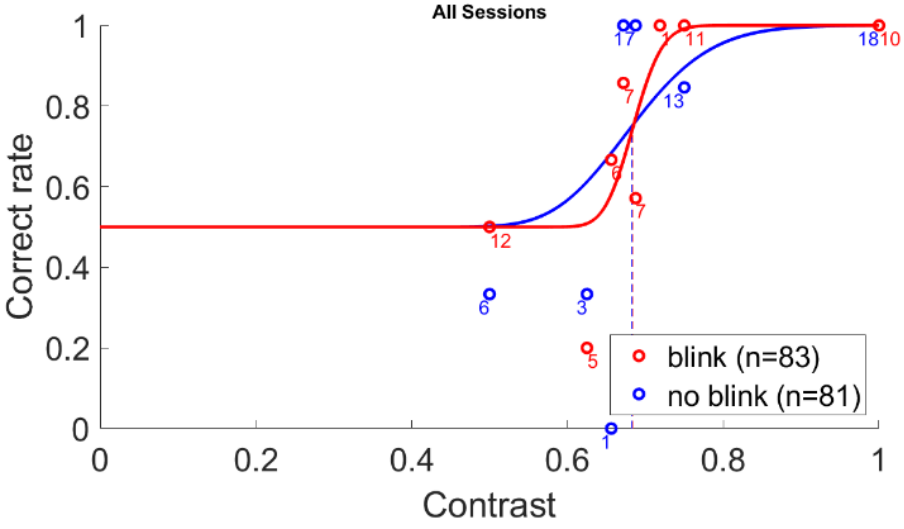


Results

A088. Blink Effect. With All Sacs

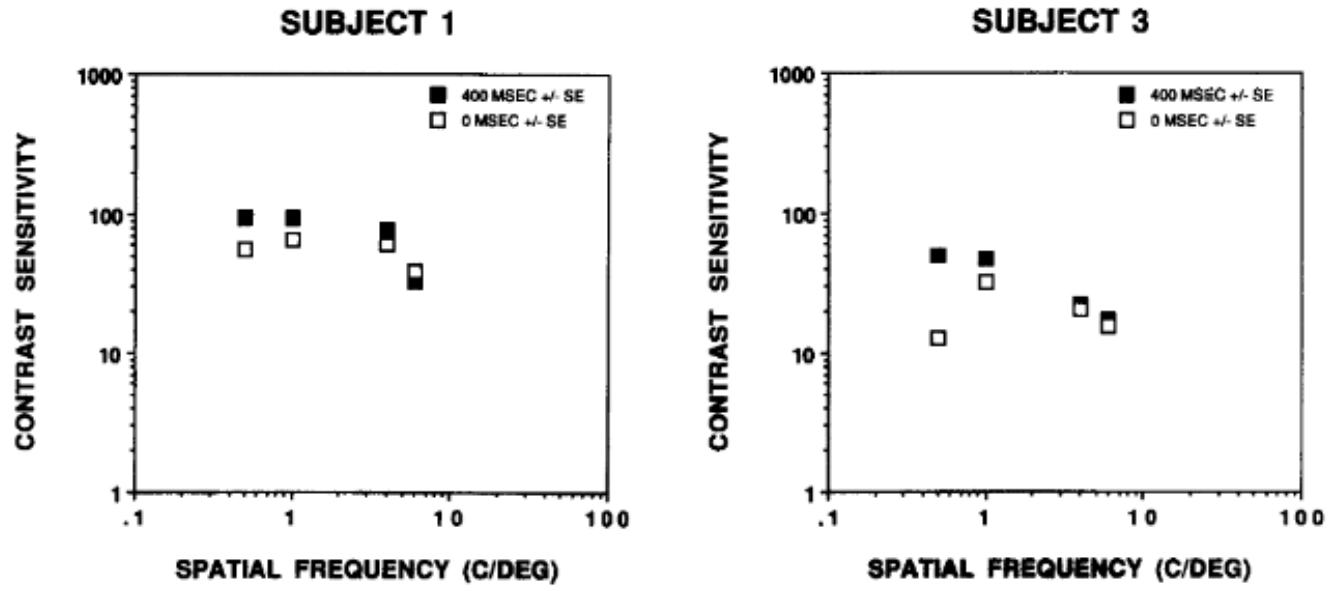


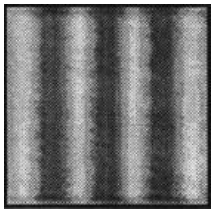




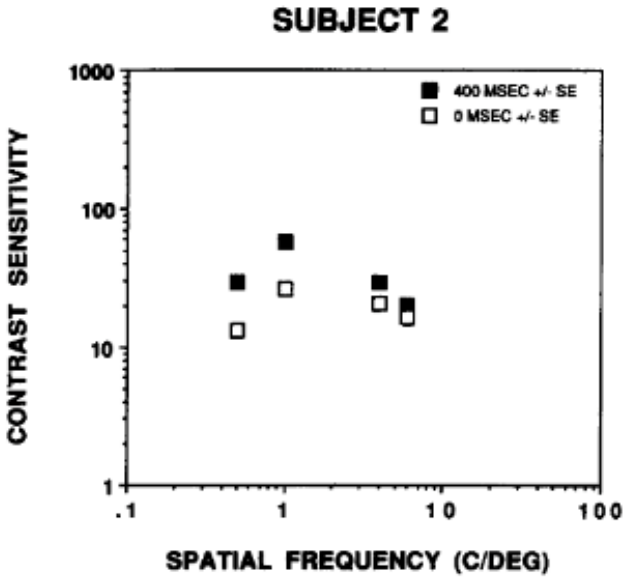
Collect More Data

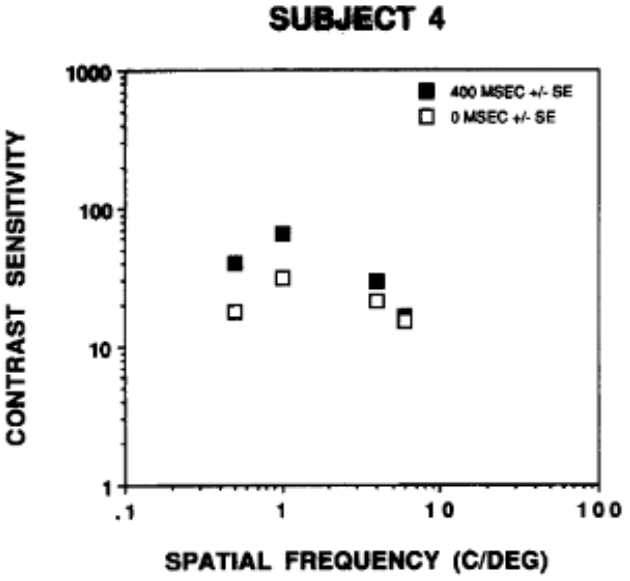
Collect more data!!!



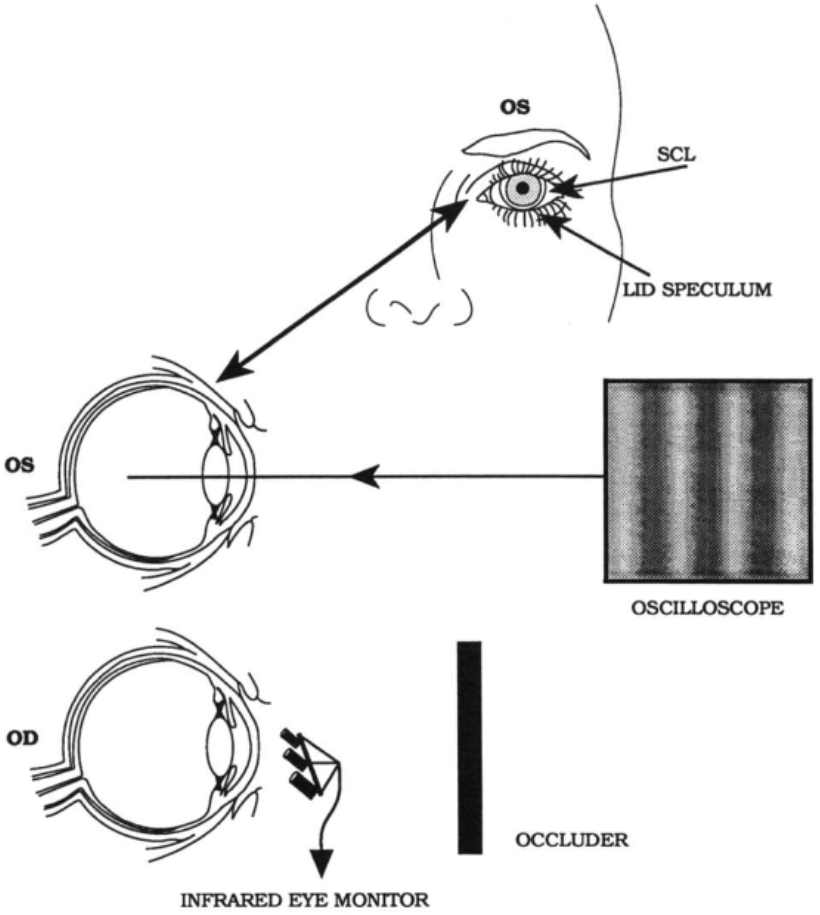


Low spatial frequency suppressed more





Ridder & Tomlinson, *Vision Research*, 1993



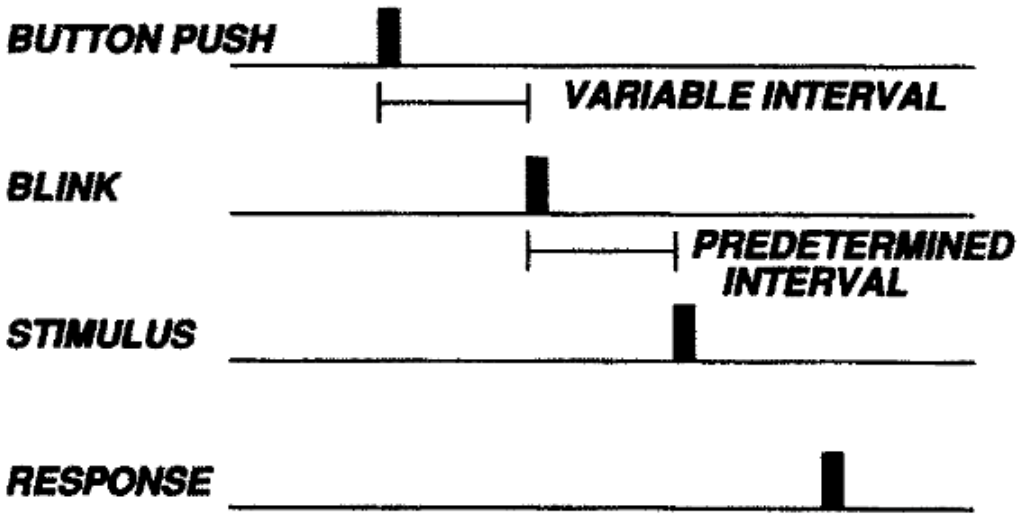
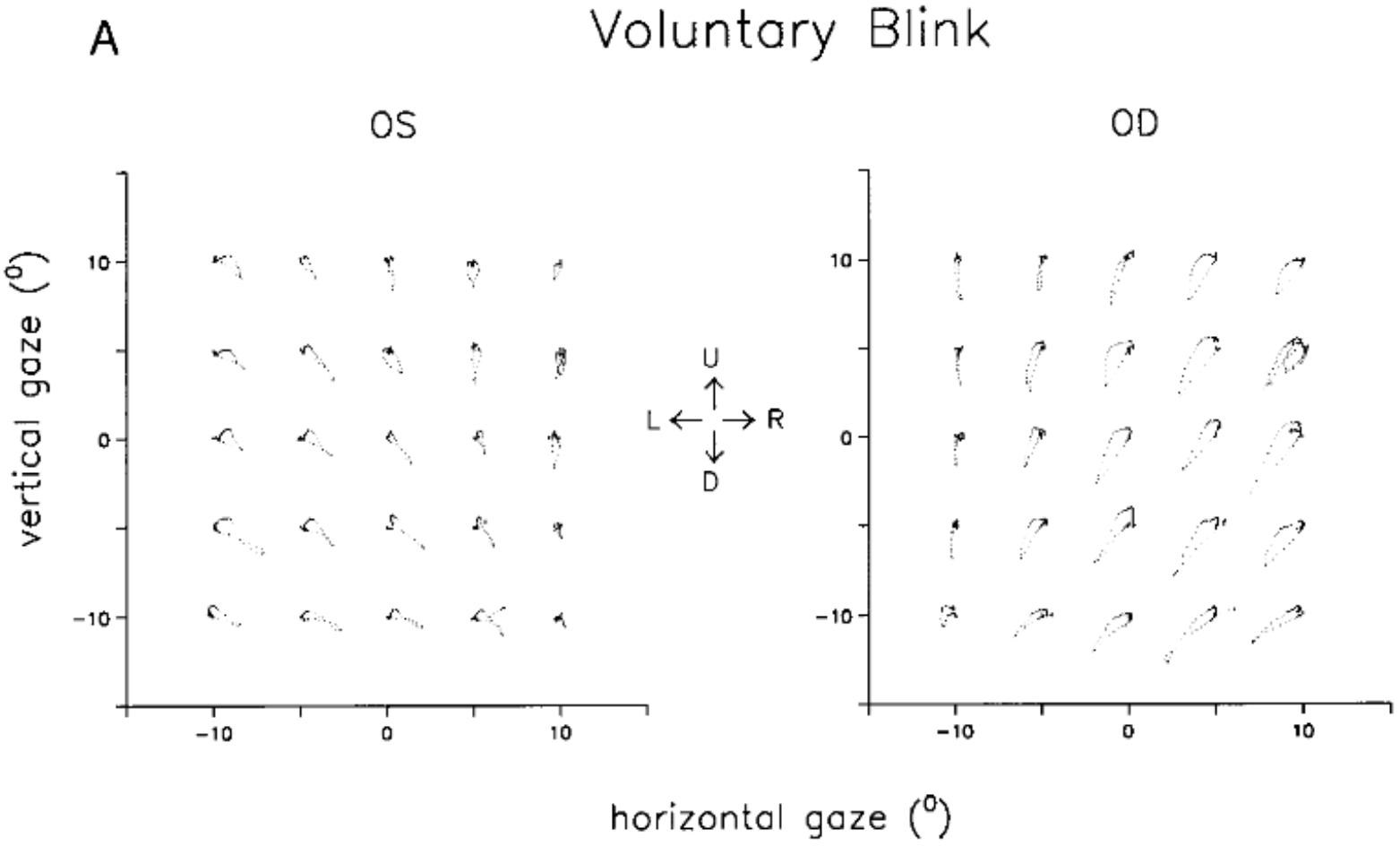


FIGURE 2. Flow chart of the events for a single stimulus trial. The subject initiates the trial with a button push. The next blink then initiates a variable duration period after which the stimulus is presented.

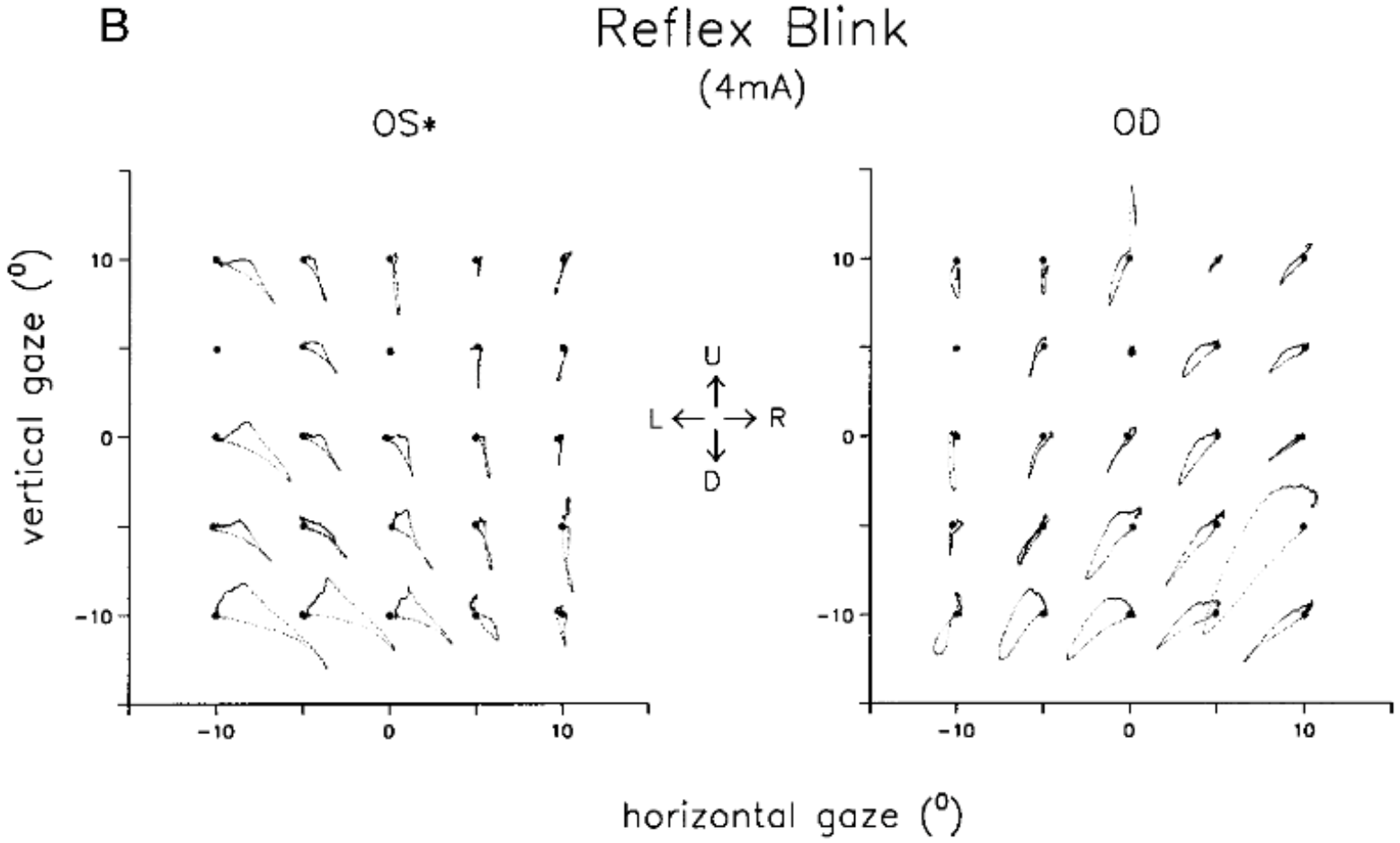
Ridder & Tomlinson, *Vision Research*, 1993

On the other hand, blink is always accompanied by fast eye movements



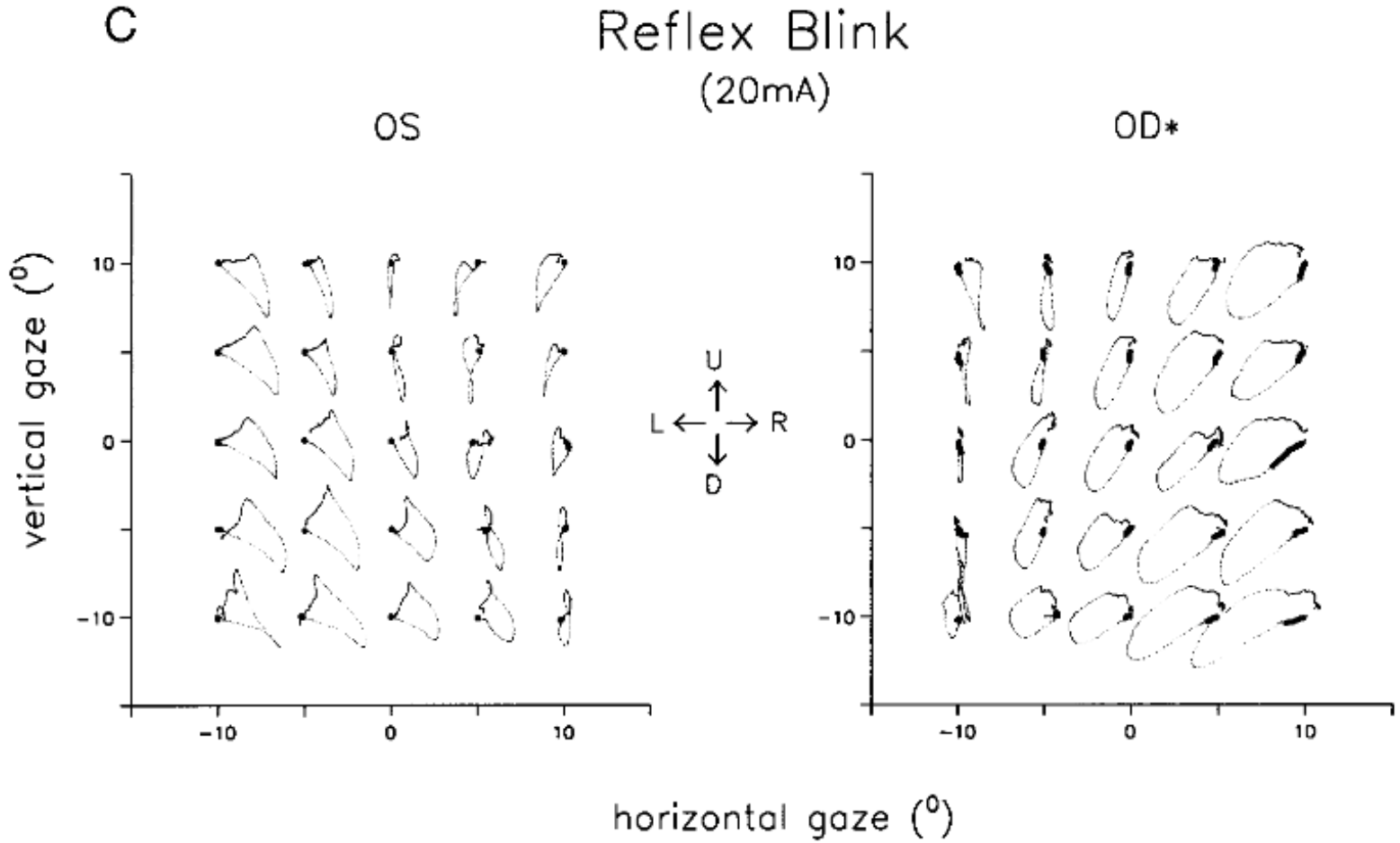
Bour *et al*, *JNP*, 2000

On the other hand, blink is always accompanied by fast eye movements



Bour *et al*, *JNP*, 2000

On the other hand, blink is always accompanied by fast eye movements



Bour *et al*, *JNP*, 2000