Binocular Snellen

Characteristics of eye movements during the Snellen visual acuity test

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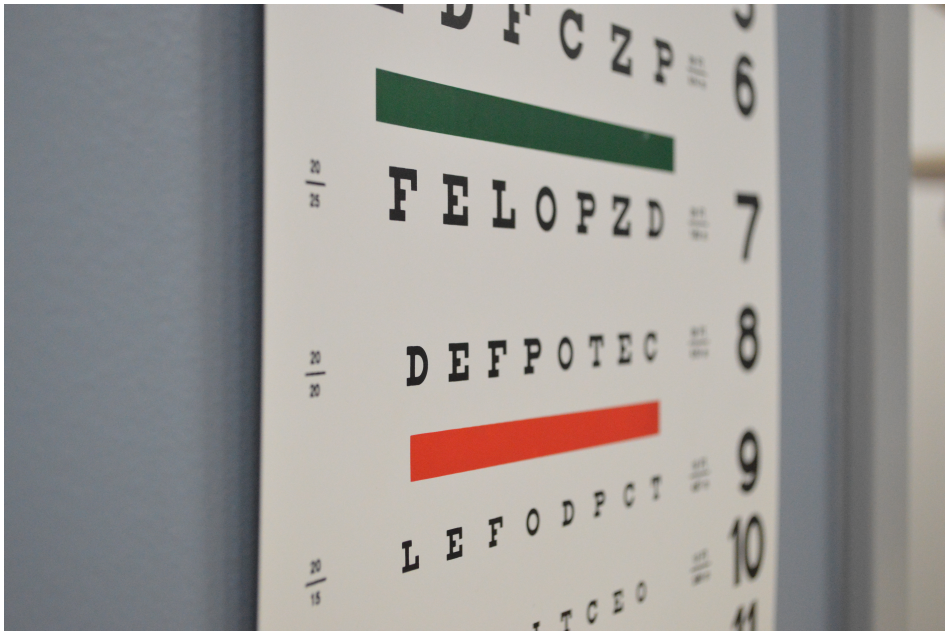
APLAB

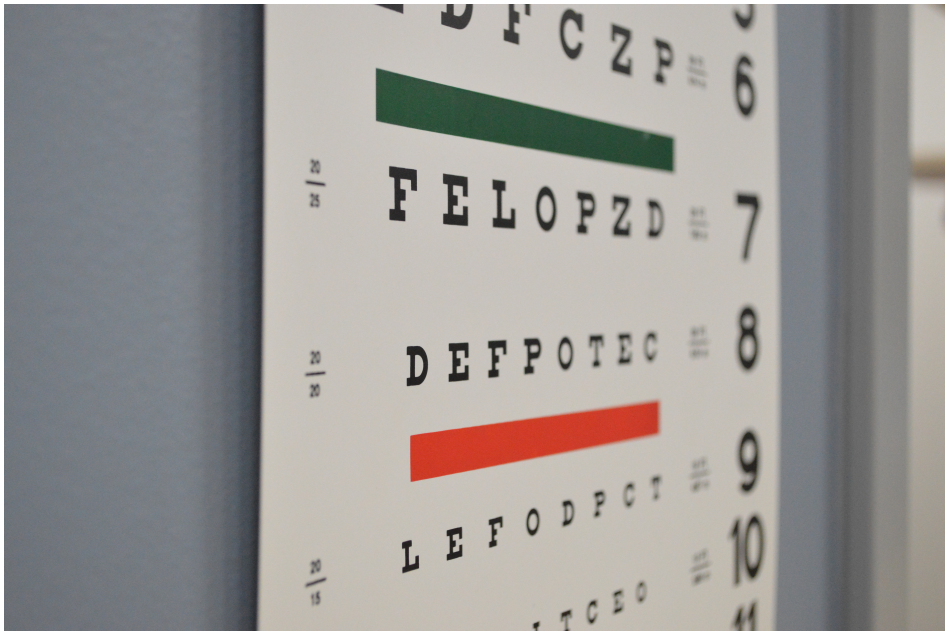
November 20, 2018

Questions



1. How do the eyes move when acquiring detailed visual information?

Questions



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2. How does binocular coordination change during a high acuity task?

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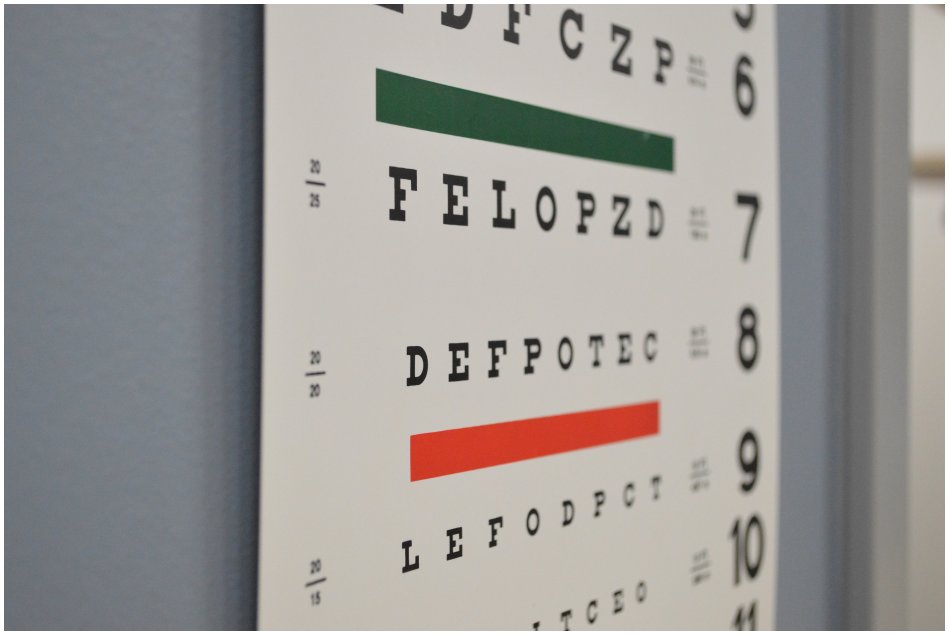

1. How do the eyes move when acquiring detailed visual information?
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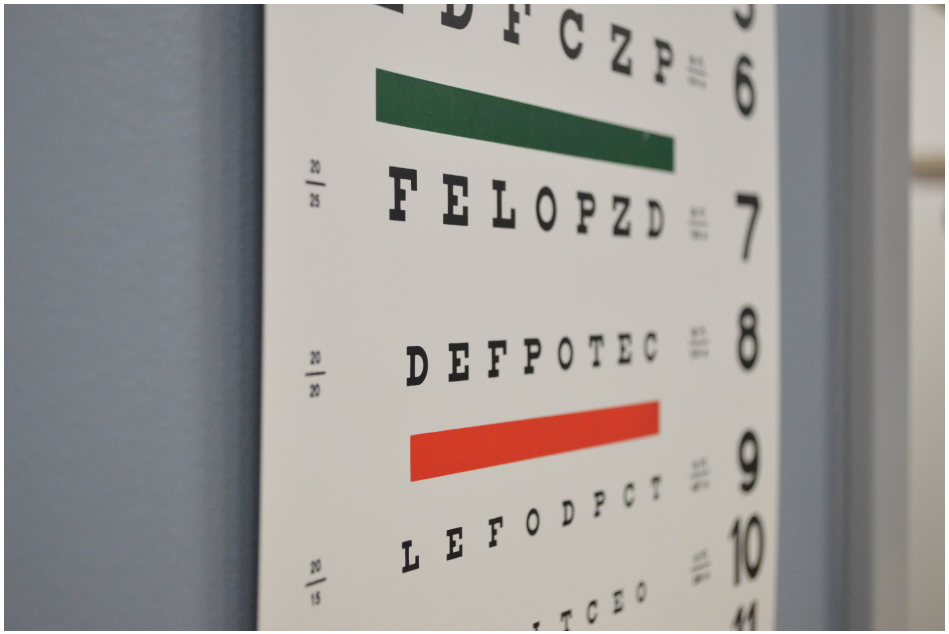
   - Does the degree of conjugacy increase?

Questions



1. How do the eyes move when acquiring detailed visual information?
2. How does binocular coordination change during a high acuity task?
   - Does the degree of conjugacy increase?
   - Are the eyes more synchronized?

Method: Measuring Eye Movements

- measure changes, not absolute position of gaze

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- measure changes, not absolute position of gaze
- assumption that vergence during initial fixation is on the plane of fixation

Method: Gaze Localization

1 Binocular automatic calibration

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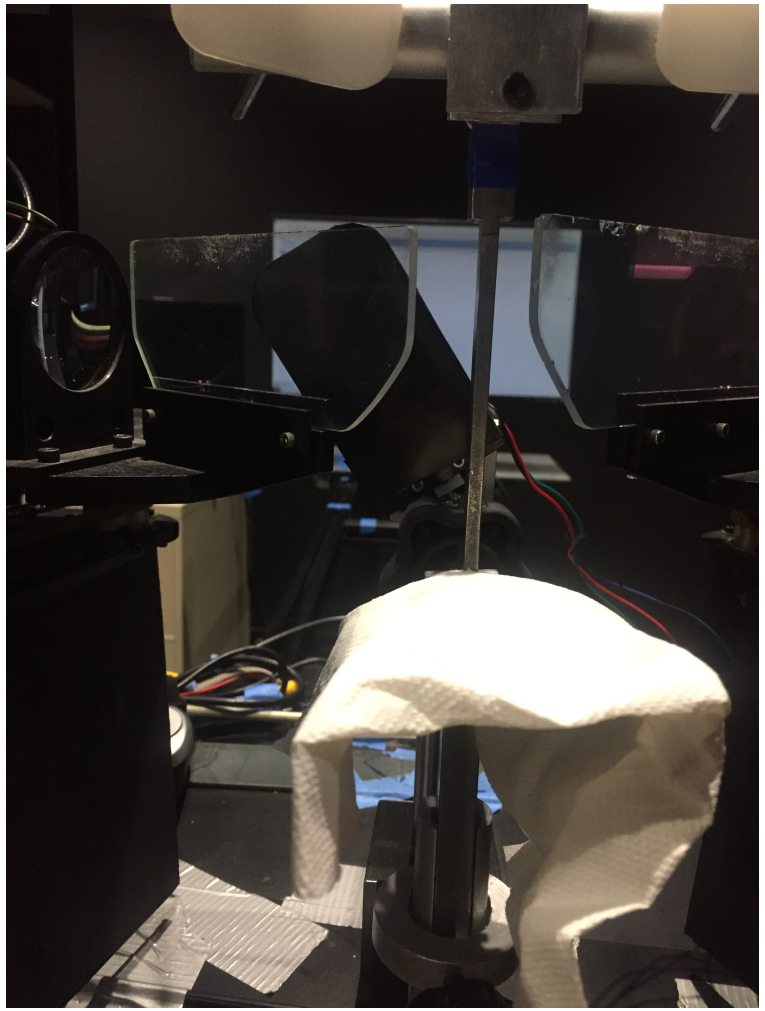
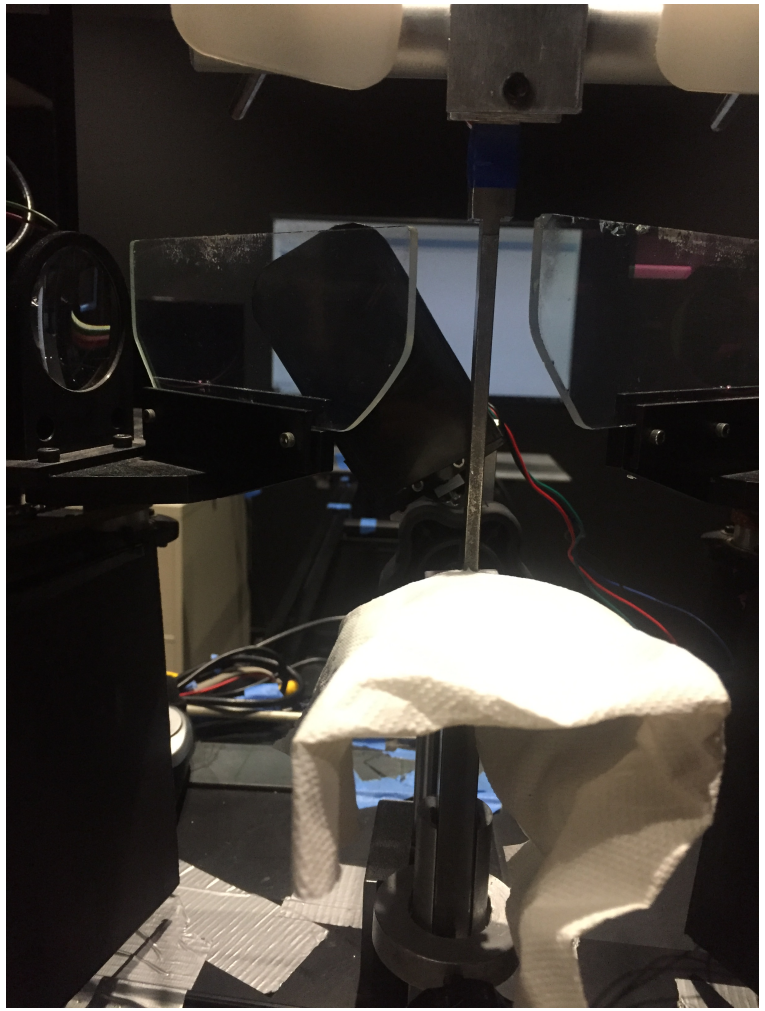
2. Monocular manual calibrations of each eye with occluder

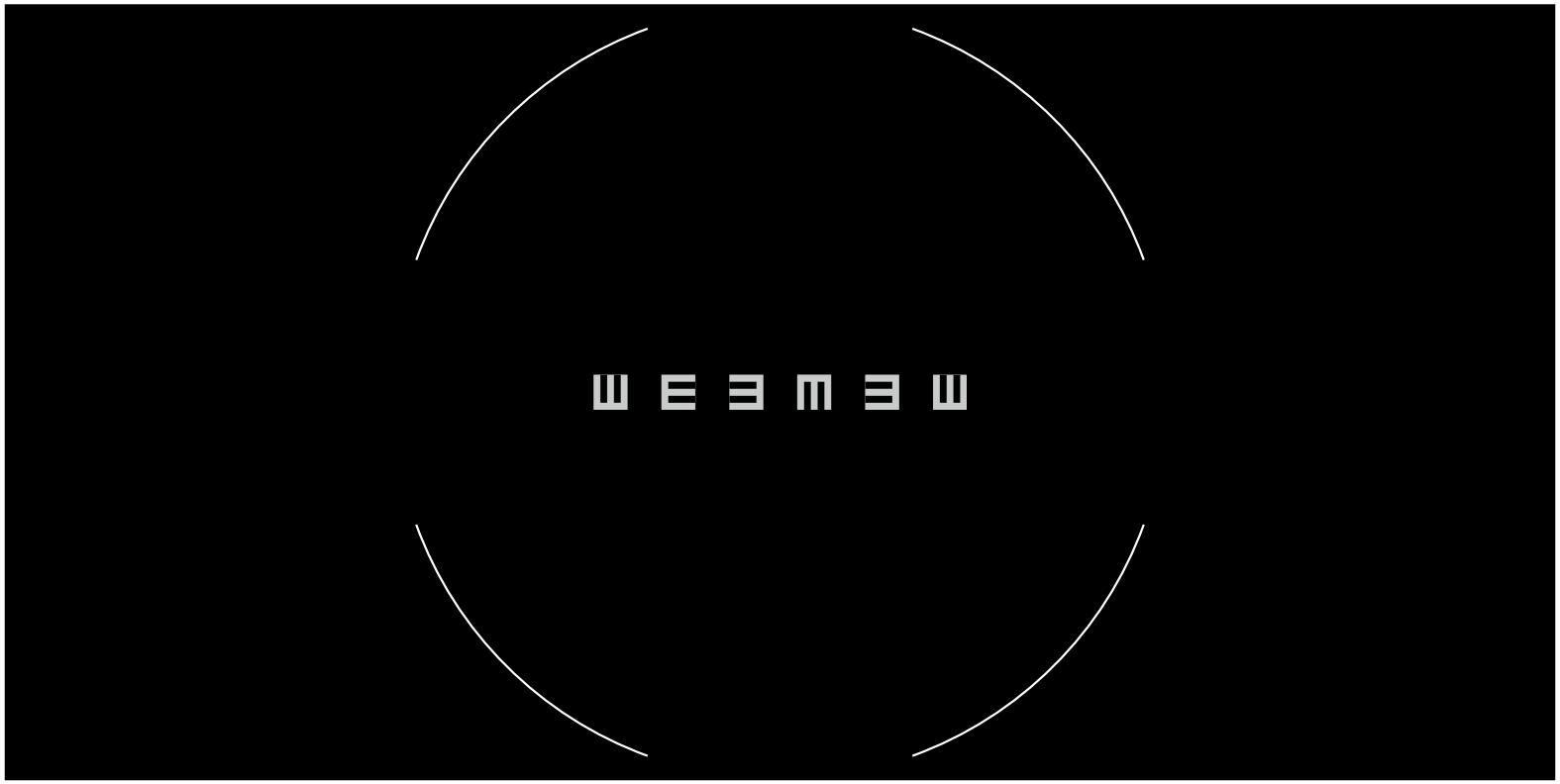


Method: Gaze Localization

1. Binocular automatic calibration
2. Monocular manual calibrations of each eye with occluder
3. Monocular recalibrations of each eye with occluder

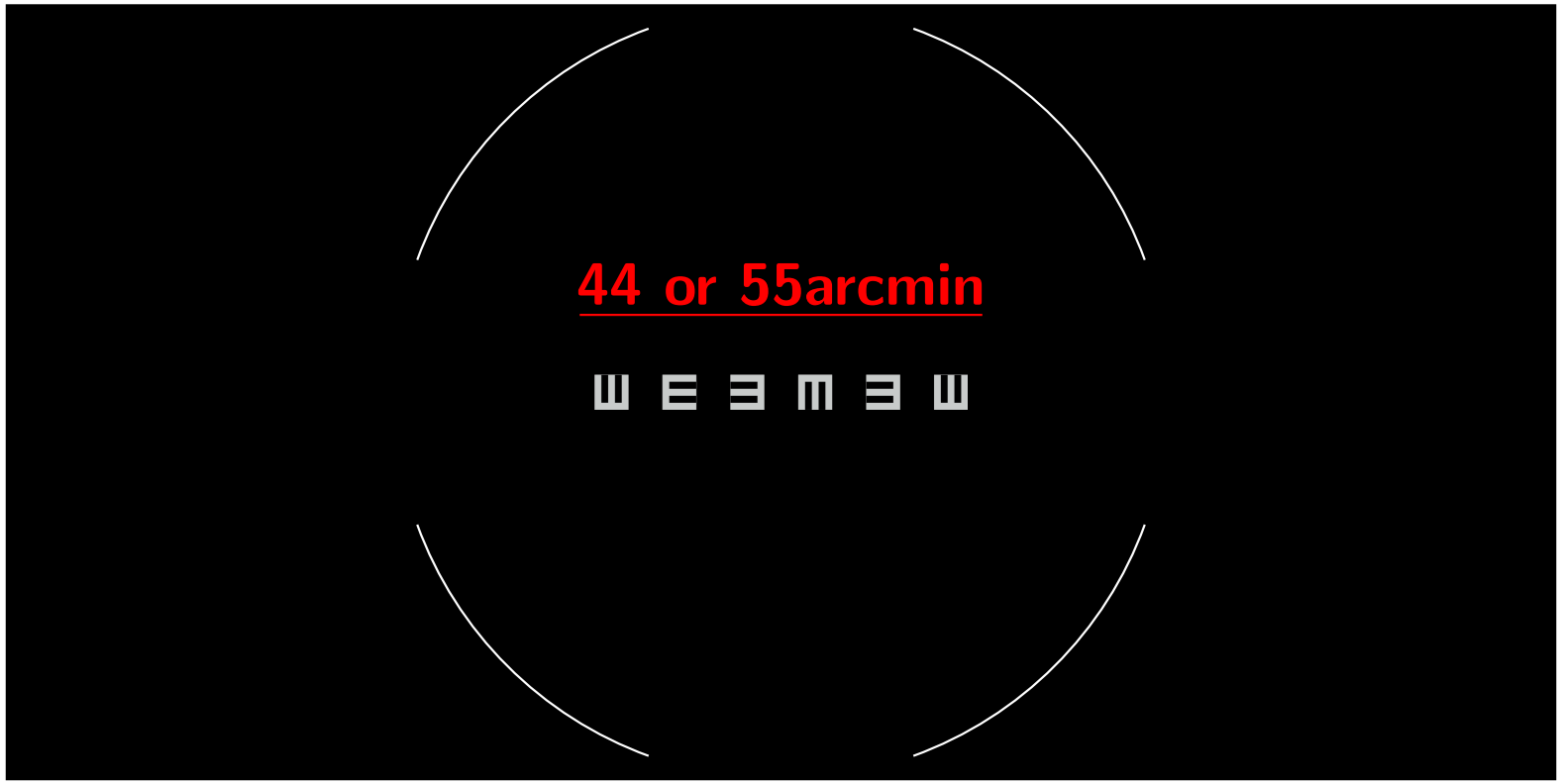


Method: Stimulus and Task



Strokewidth of 0.8 (20/16 line) or 1.0 (20/20 line)

Method: Stimulus and Task



Strokewidth of 0.8 (20/16 line) or 1.0 (20/20 line)

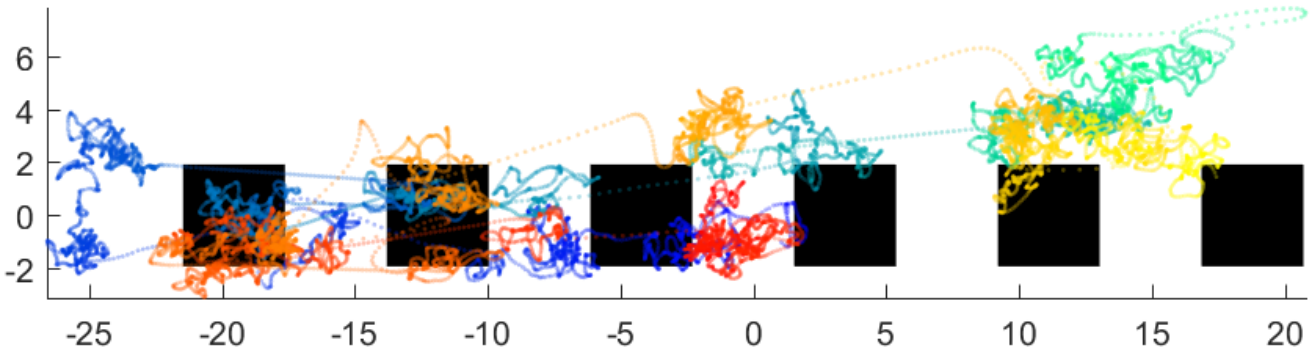
Data Collection

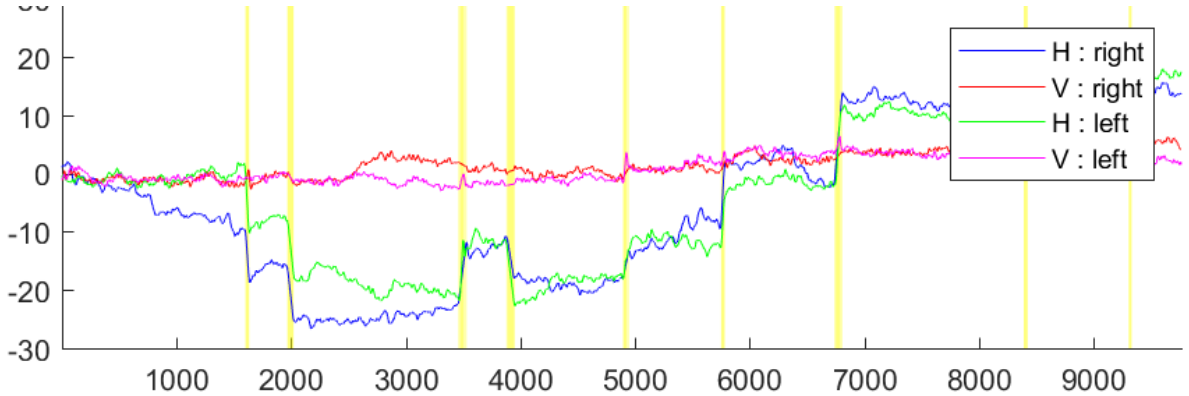
Subject	Total	(S)	(T)	Correct	Avg Dur (s)	# Sacc
MAC[1]	134	89	121	85.5%	7.6 ± 2.1	1536
A068	221	89	131	87.5%	9.1 ± 2.1	1378
Anne[2]	108	67	69	81%	10.6 ± 4.06	783

- Trials with more than 500ms of blink/no track excluded from analysis.
- Trials following incomplete manual calibration were excluded from spatial (S) analysis, but included in temporal analysis (T).

1. 20/20 line stimuli. 2. Did not have monocular occluder for calibration.

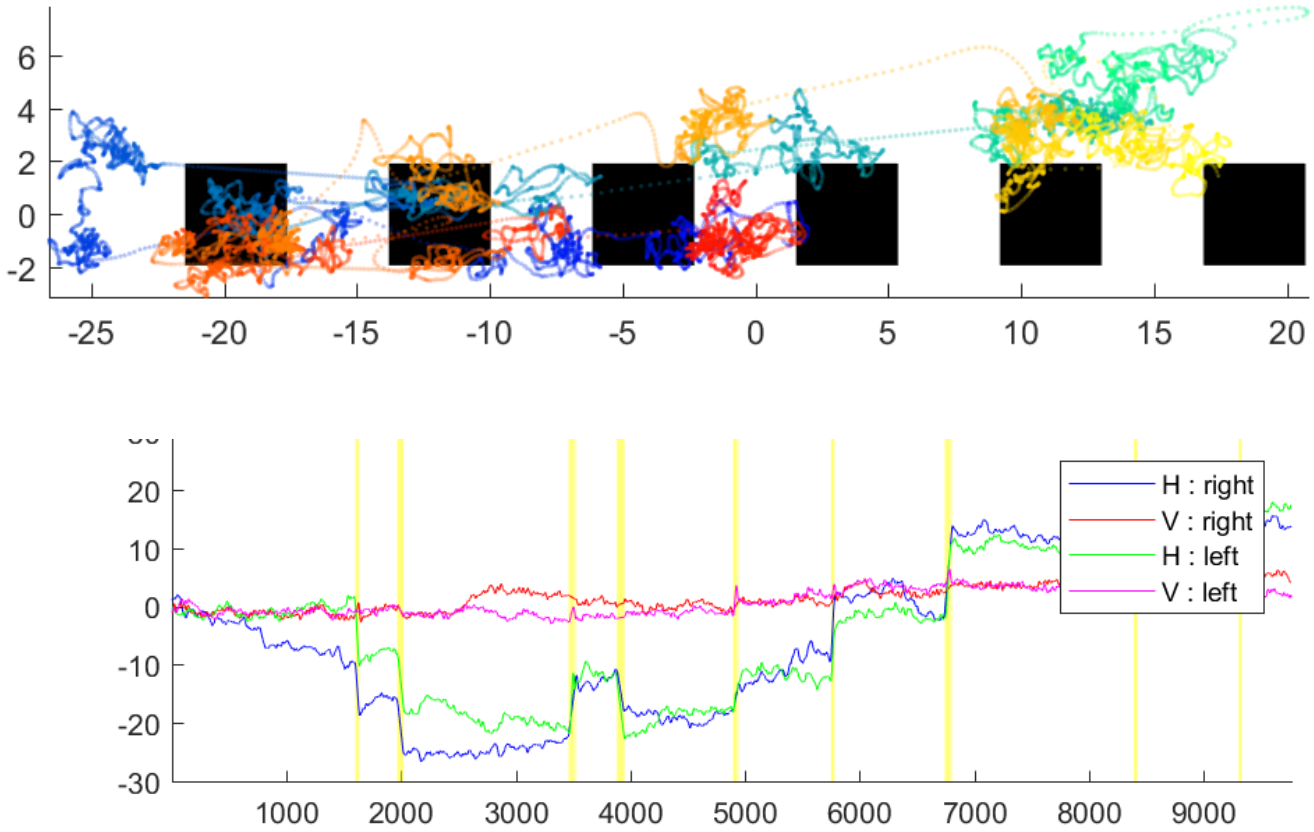
Outline


6
4
2
0
-2
-25
-20
-15
-10
-5
0
5
10
15
20


20
10
0
-10
-20
-30
1000
2000
3000
4000
5000
6000
7000
8000
9000
H : right
V : right
H : left
V : left

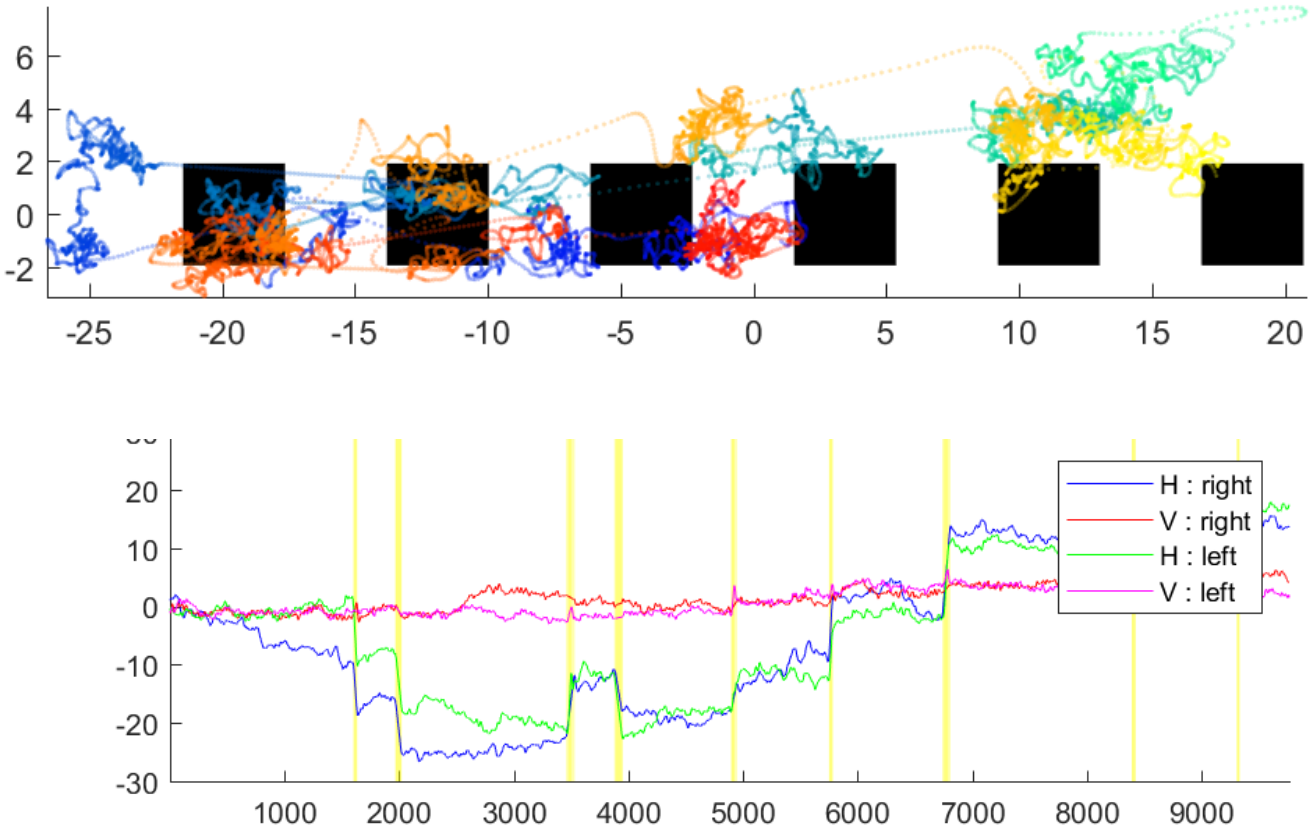
Outline

1 Characteristics and correlations of left and right eye movements

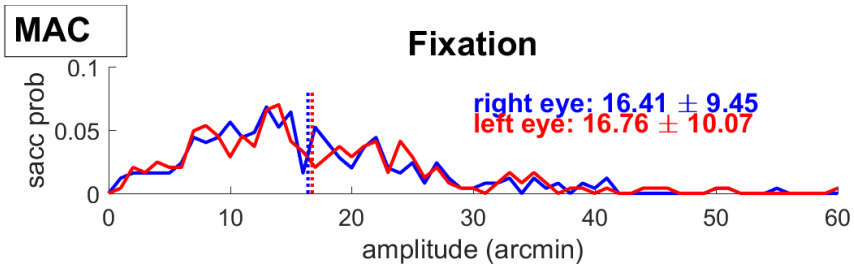


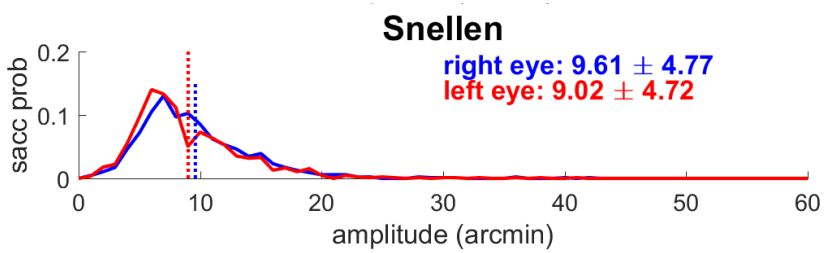
Outline

1. Characteristics and correlations of left and right eye movements
2. Differences between left and right eye movements



Microsaccade Characteristics: Amplitude





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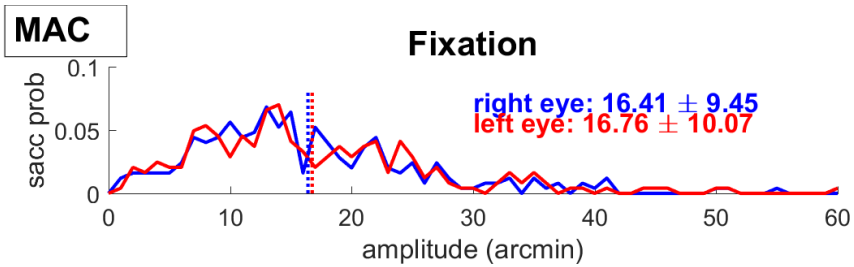
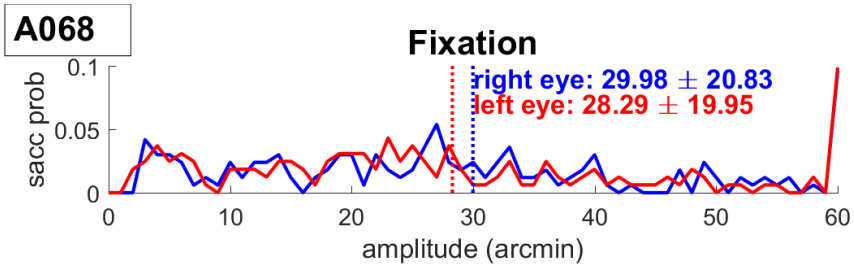
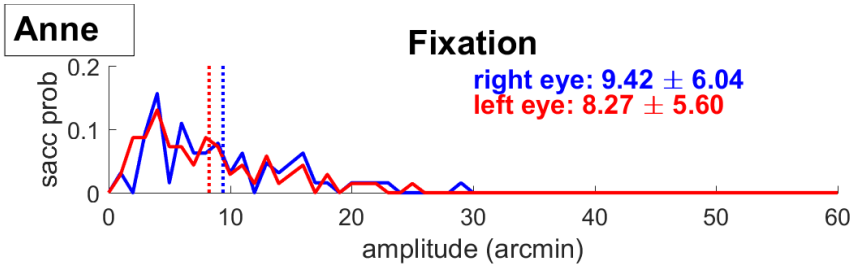
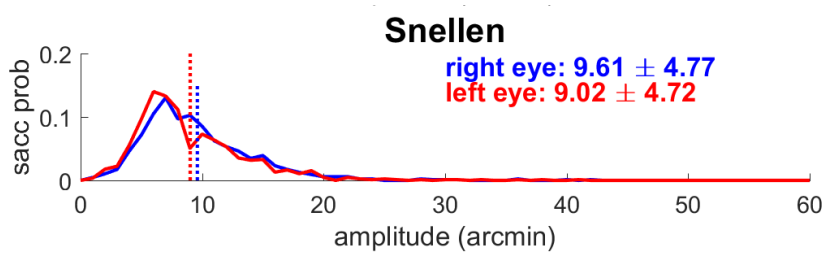
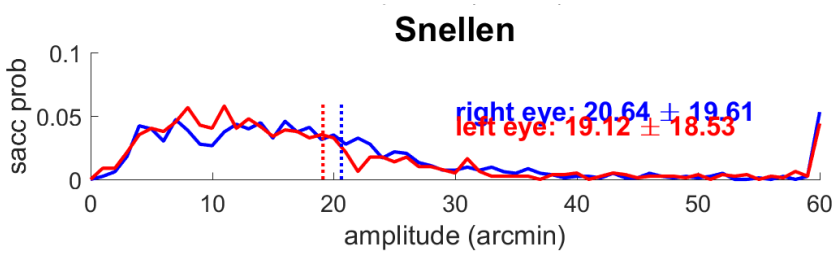
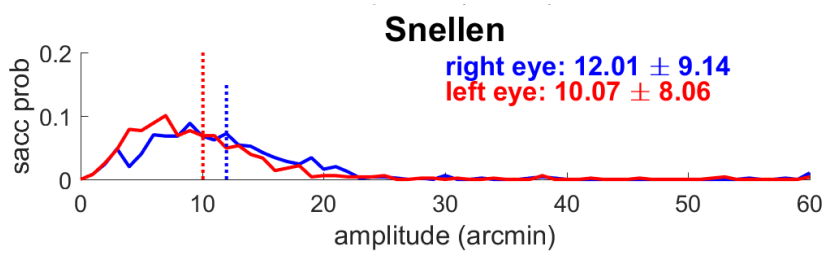






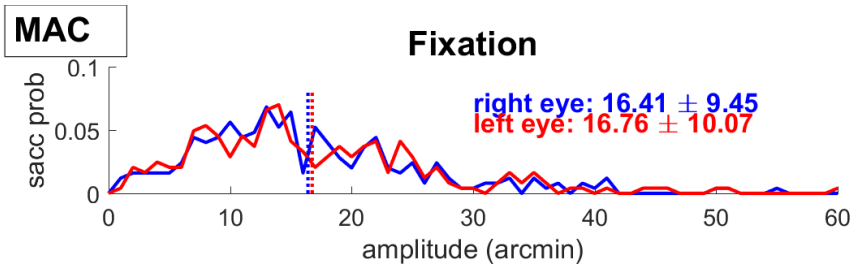


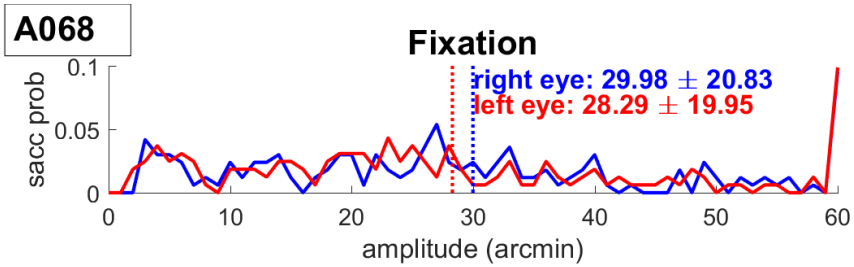


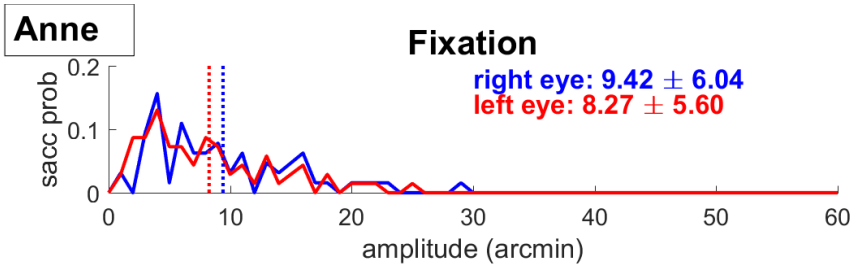


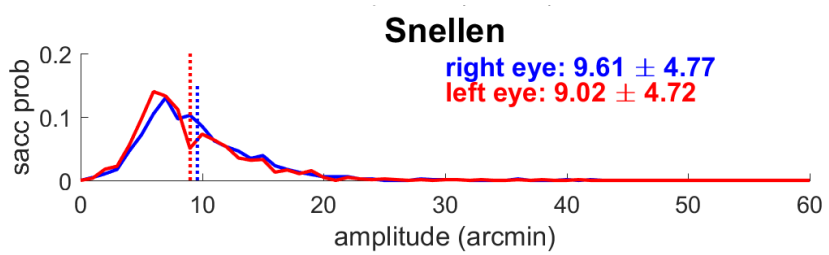
Microsaccade Characteristics: Amplitude

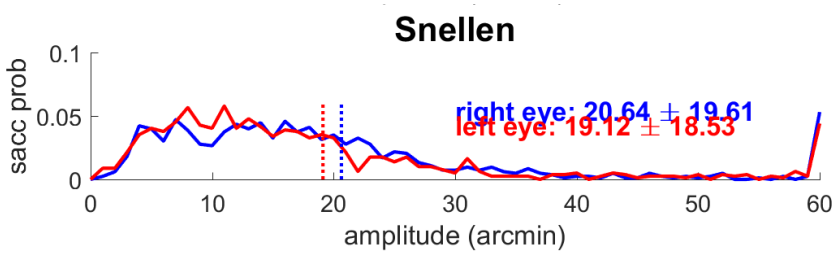
Distribution of microsaccade amplitudes during Snellen task peak around 8-10 arcmin, the center to-centering spacing between optotypes.

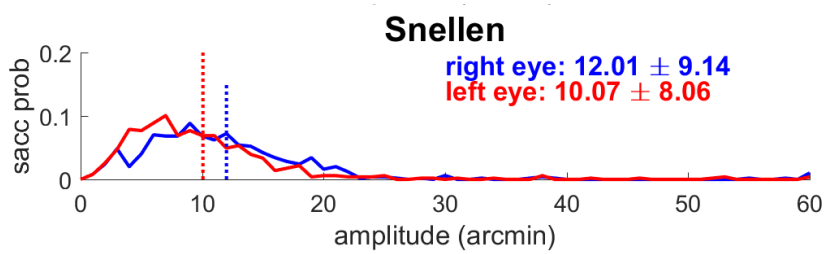




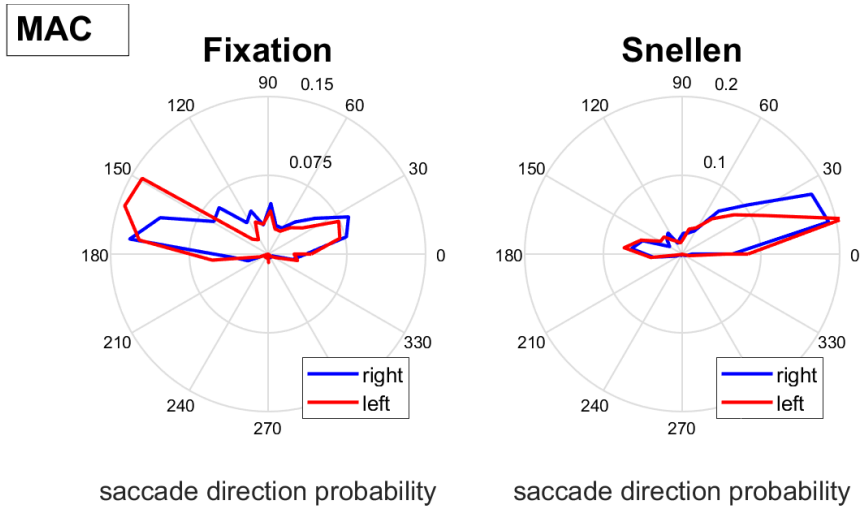






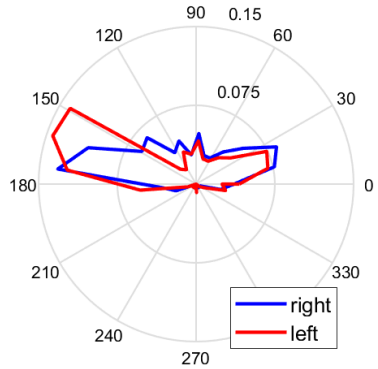


Microsaccade Characteristics: Direction

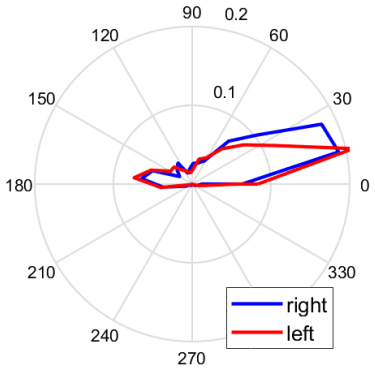


Microsaccade Characteristics: Direction

MAC

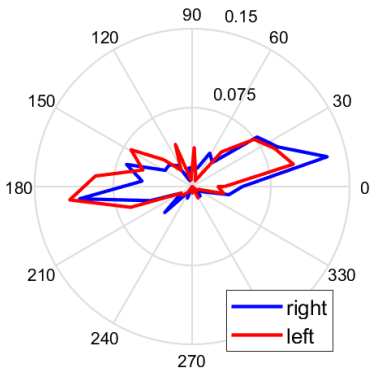


saccade direction probability



saccade direction probability

A068



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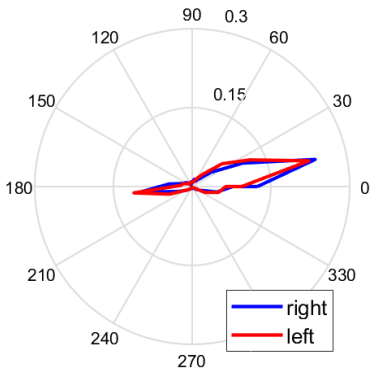
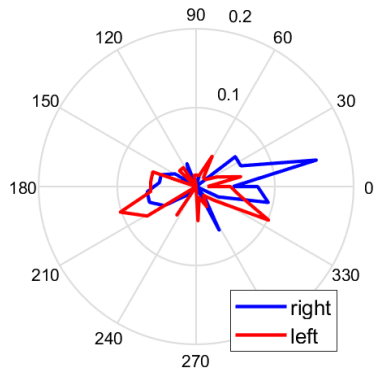
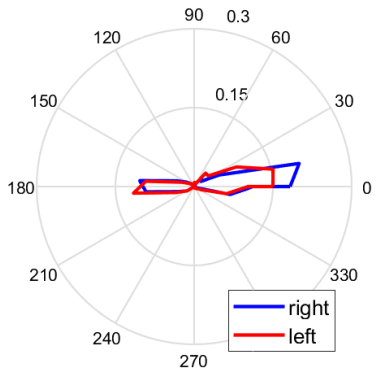


saccade direction probability

Anne



saccade direction probability

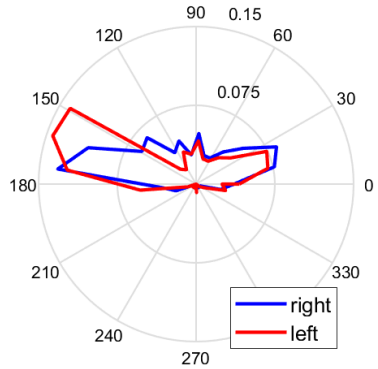


saccade direction probability

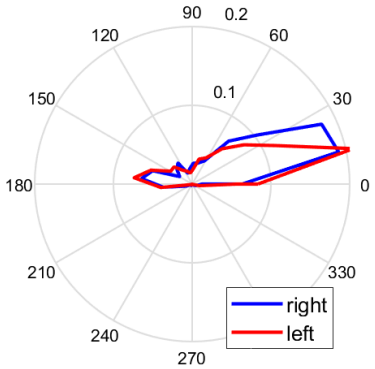
Microsaccade Characteristics: Direction

Microsaccades during the Snellen test shift gaze to the right.

MAC



saccade direction probability



saccade direction probability

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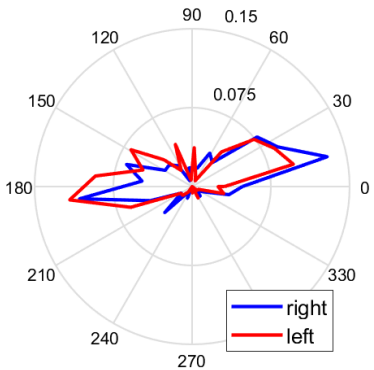
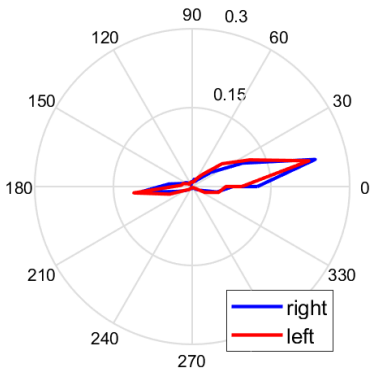
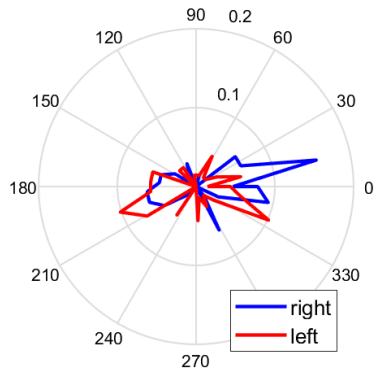


saccade direction probability

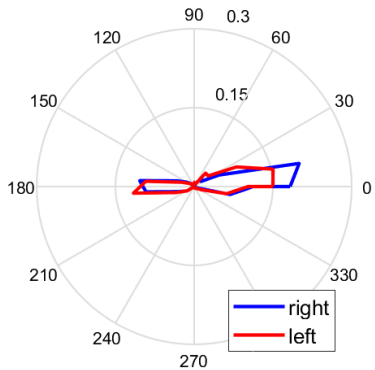


saccade direction probability

Anne

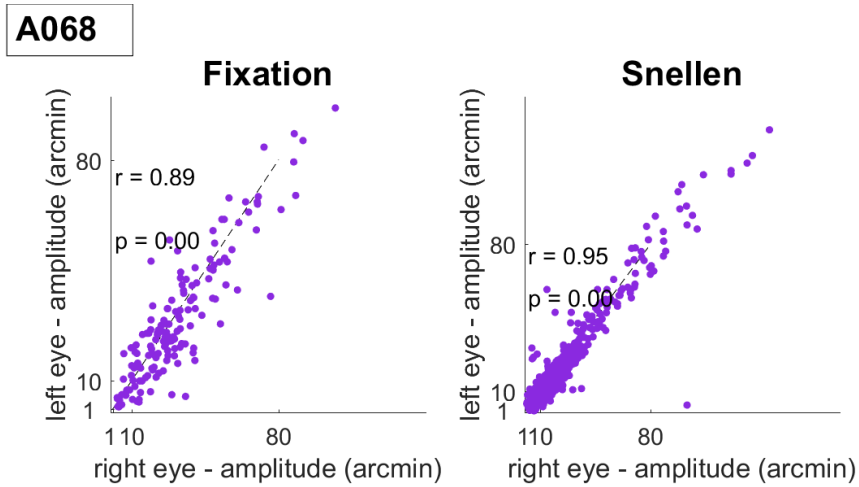


saccade direction probability



saccade direction probability

Microsaccades characteristics are correlated



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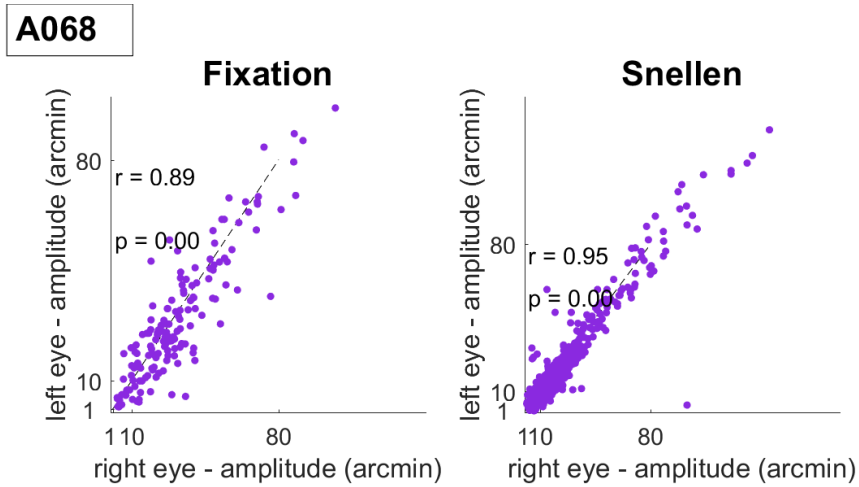

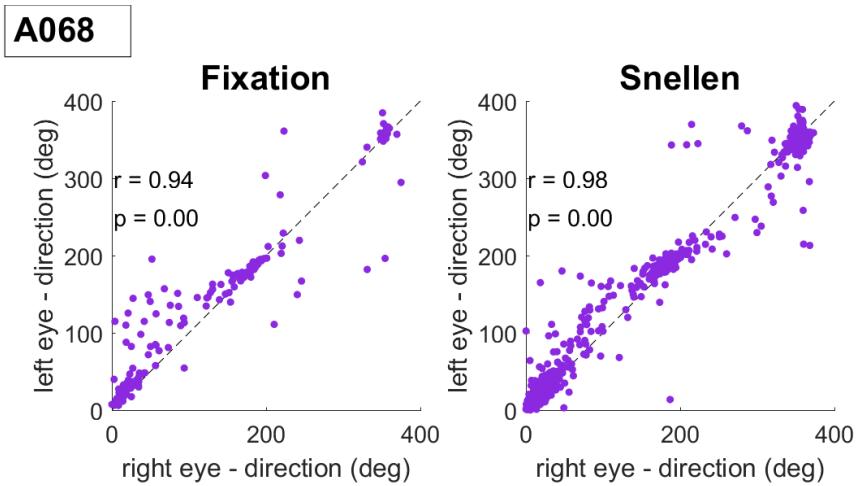

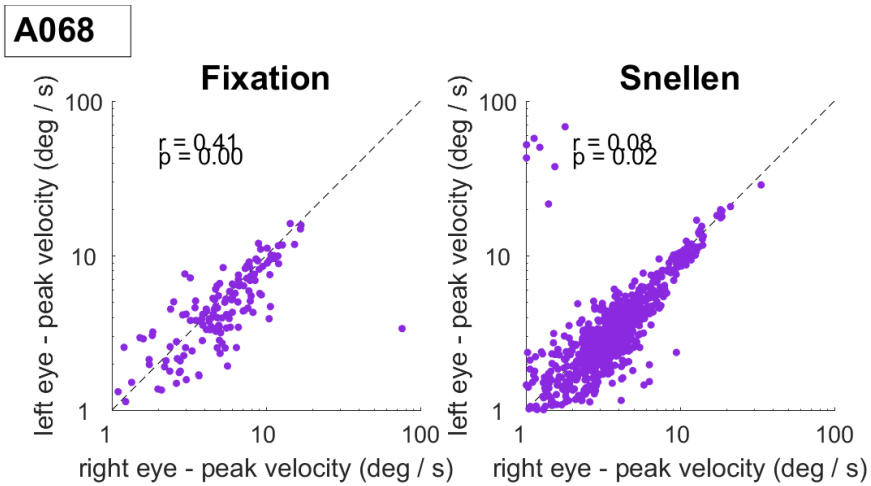

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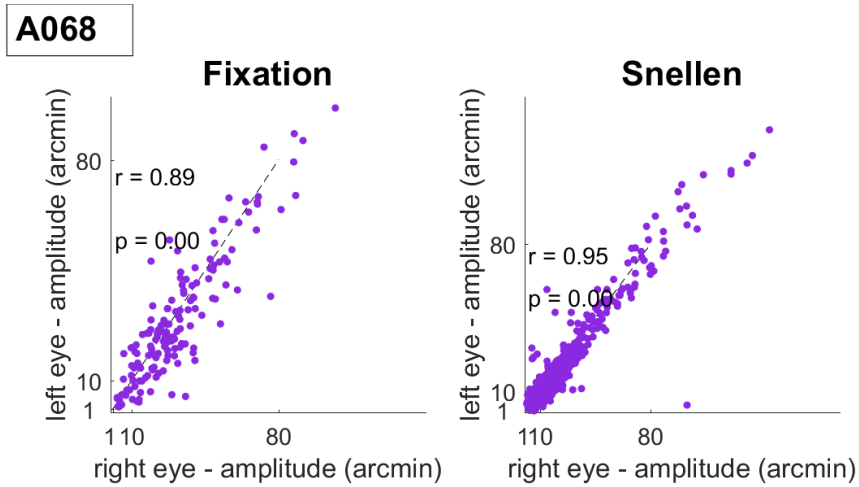
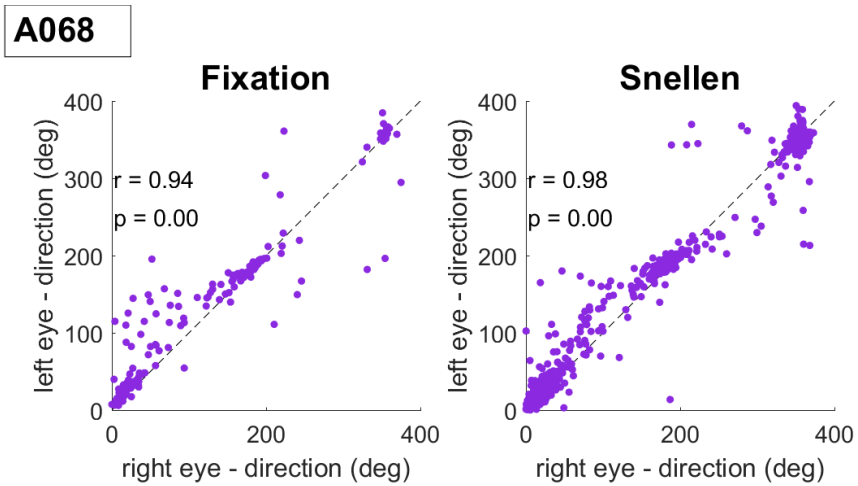
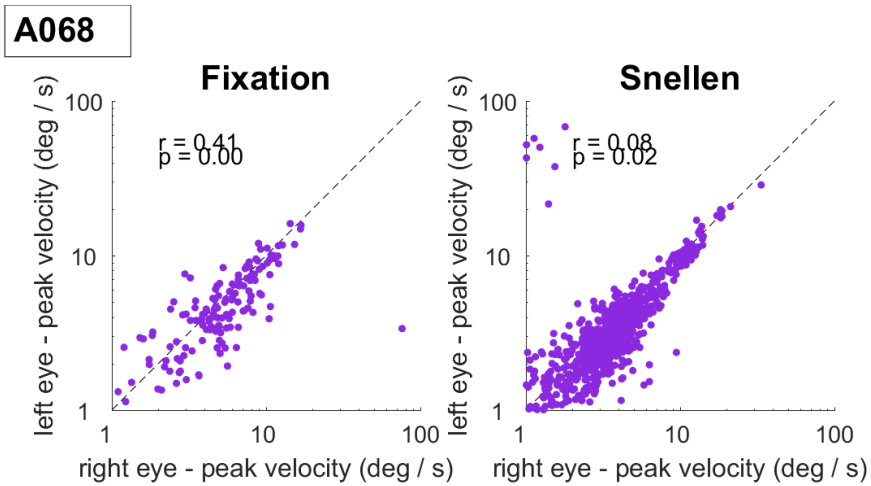
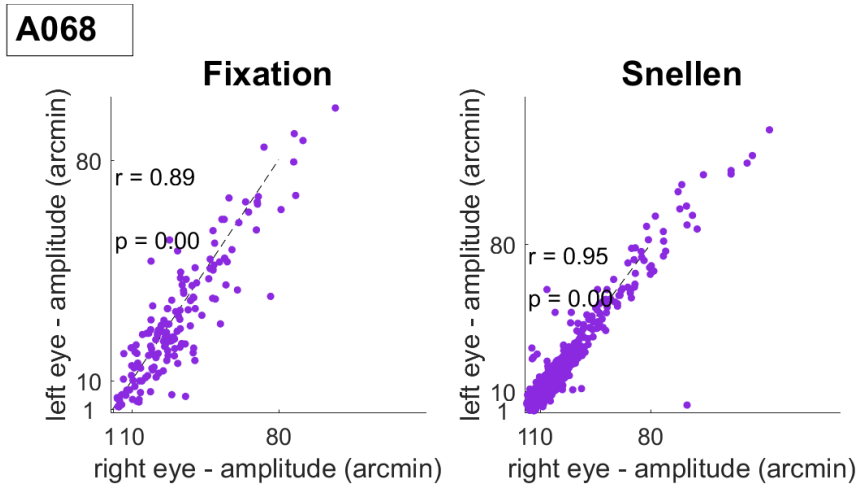


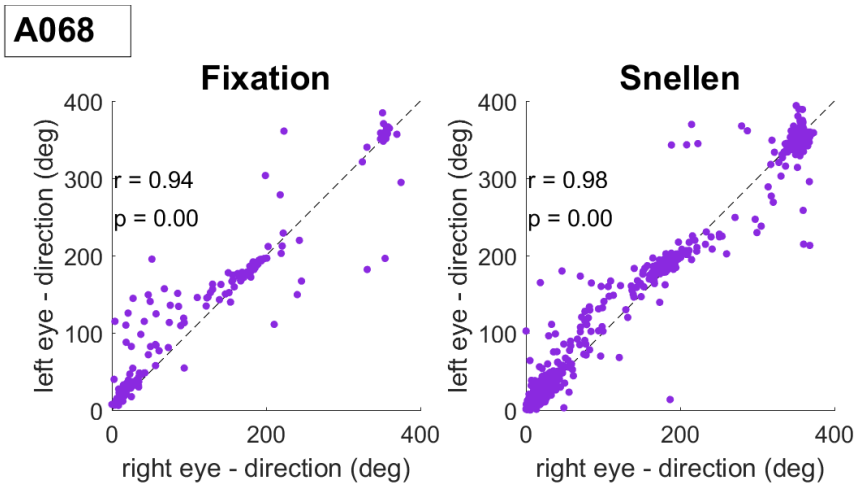


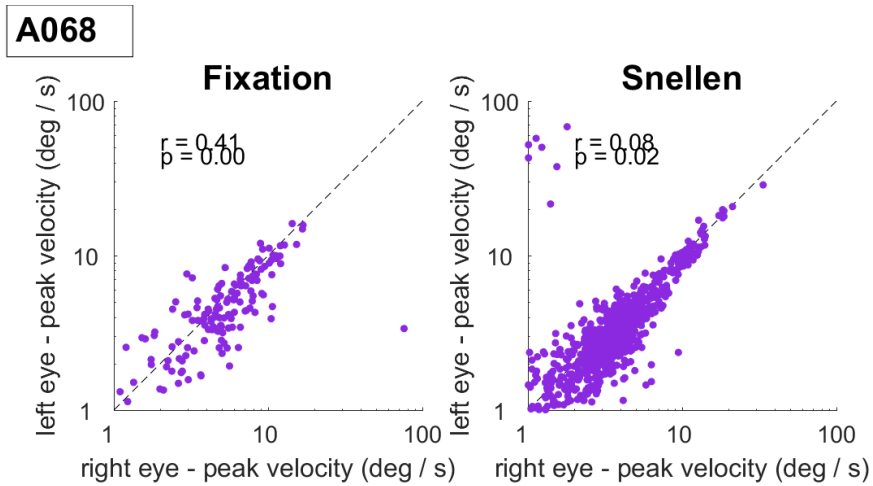


Microsaccades characteristics are correlated

Microsaccade amplitudes, directions, and peak velocities are highly correlated in the two eyes.







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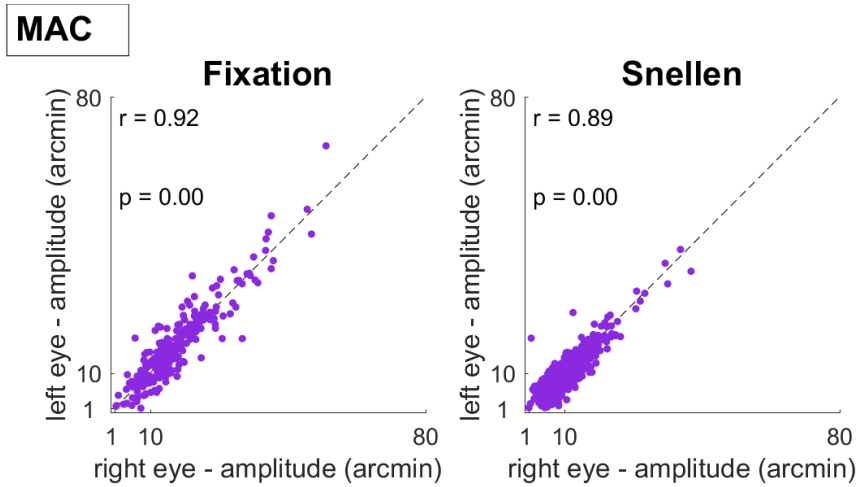

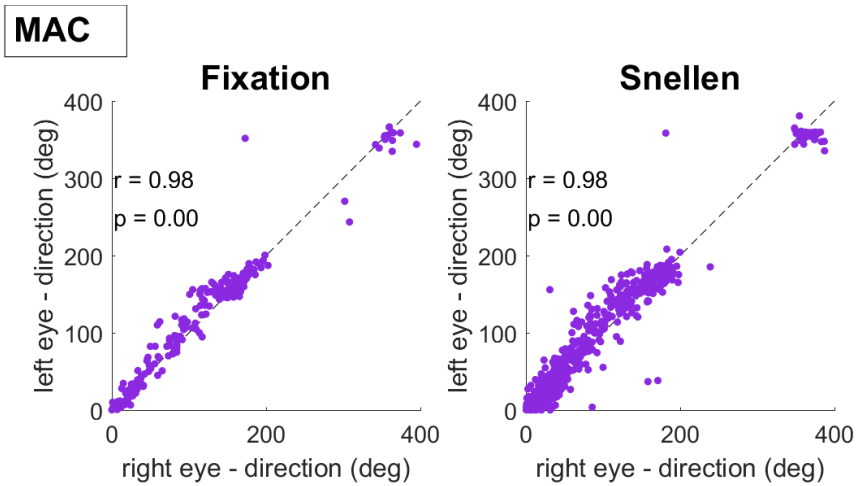

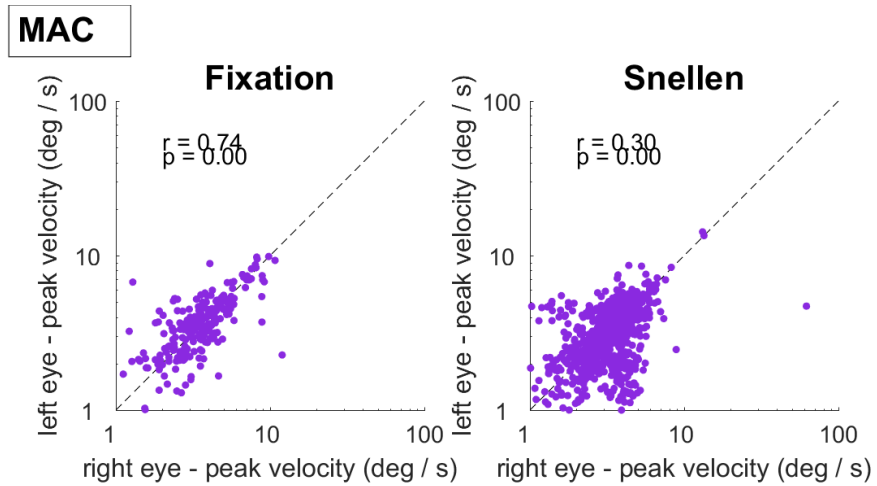

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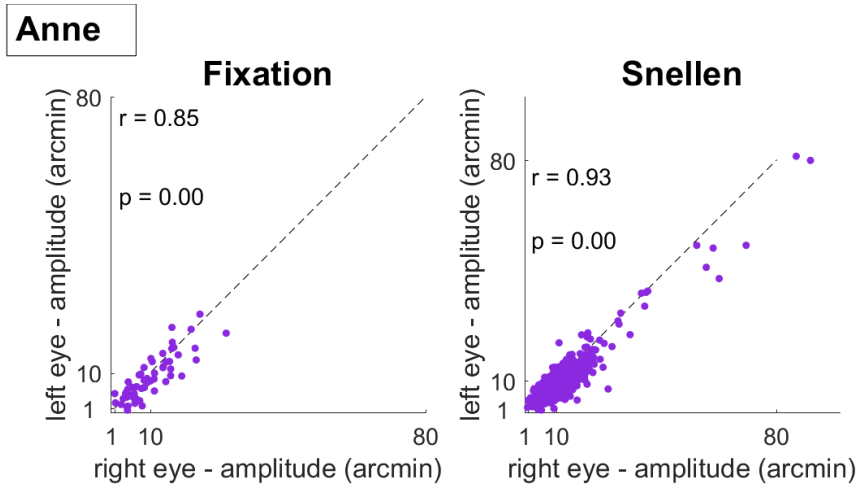
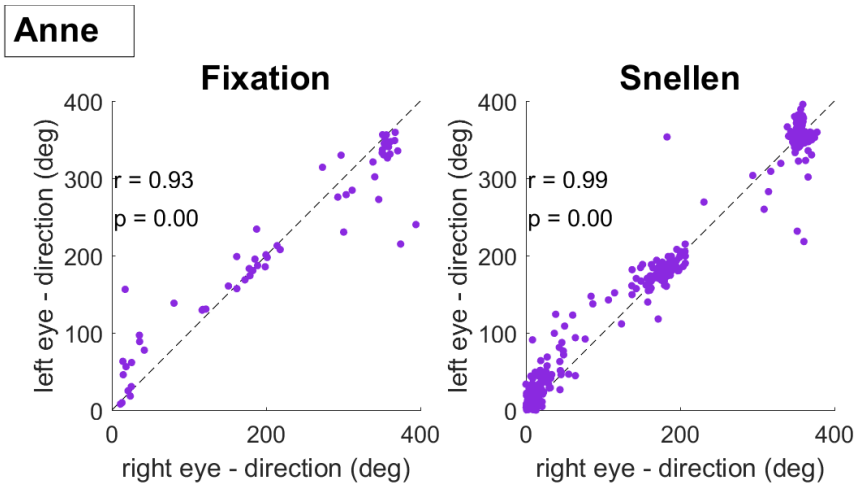
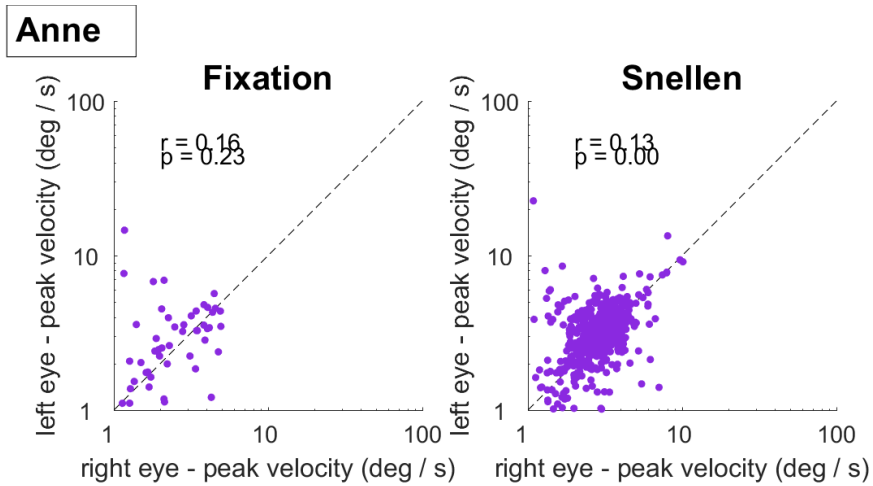






Microsaccades: Summary of characteristics and correlations

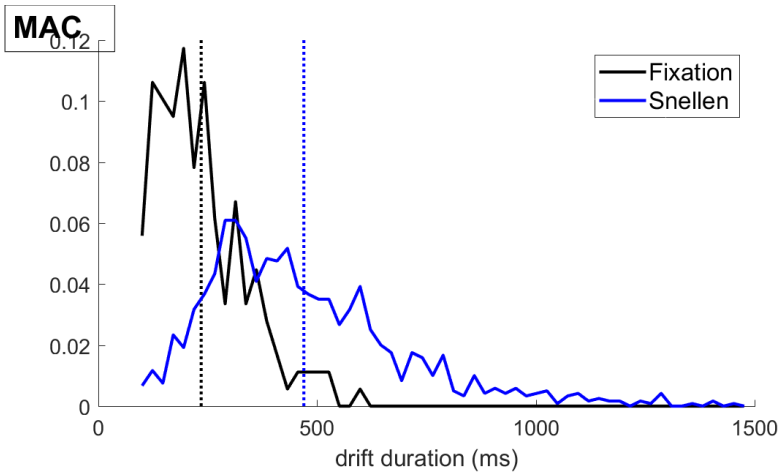
1. Microsaccades shift both lines of sight across the optotypes.

Microsaccades: Summary of characteristics and correlations

1. Microsaccades shift both lines of sight across the optotypes.
2. Microsaccade characteristics are highly correlated in the two eyes.

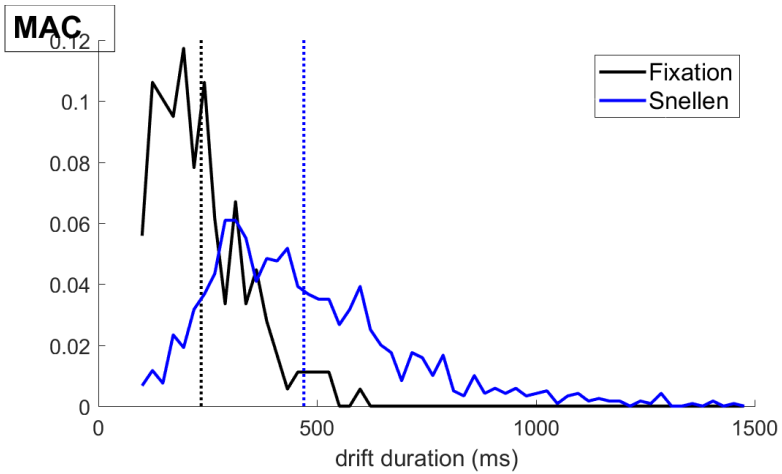
Drift Characteristics: Duration

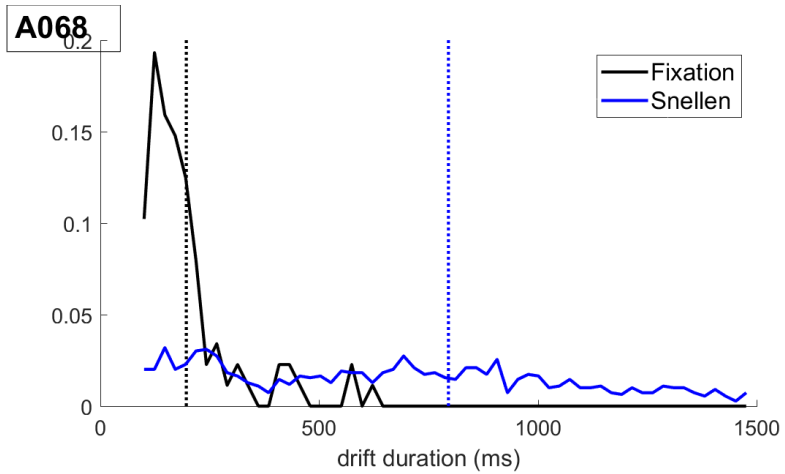
Drifts are longer in Snellen than during Fixation.

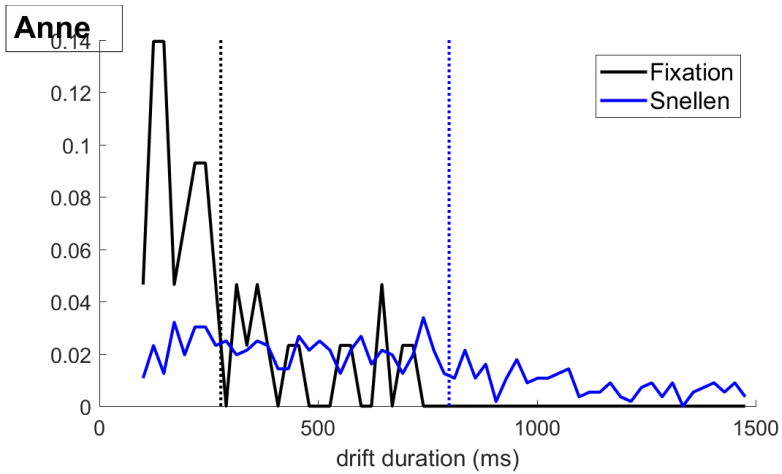


Drift Characteristics: Duration

Drifts are longer in Snellen than during Fixation.

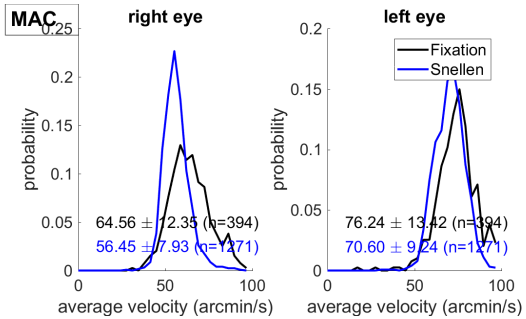






Drift Characteristics

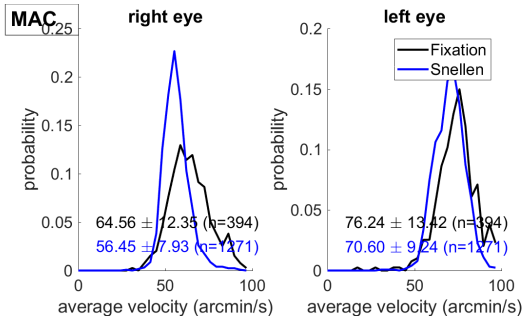
Velocity



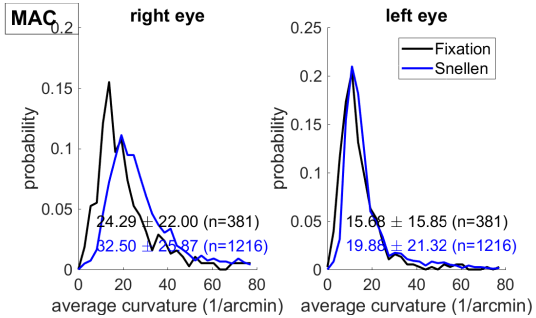
Curvature

Drift Characteristics

Velocity

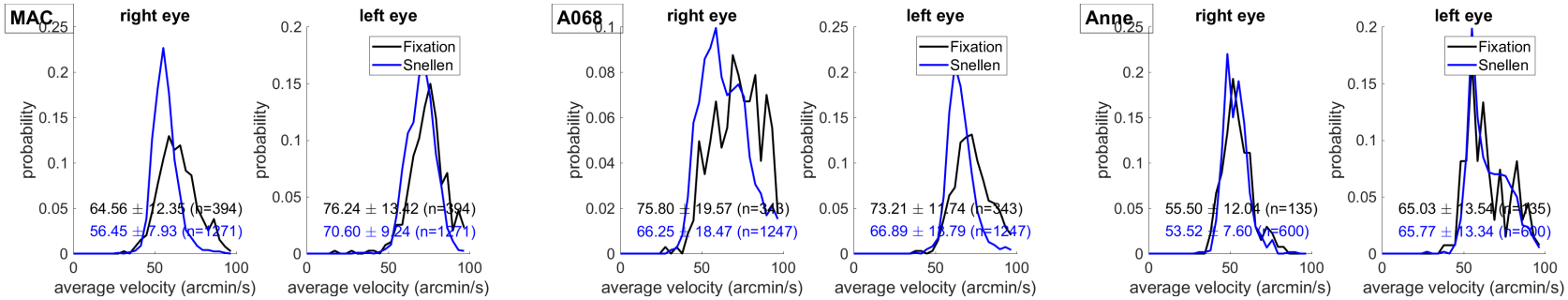


Curvature

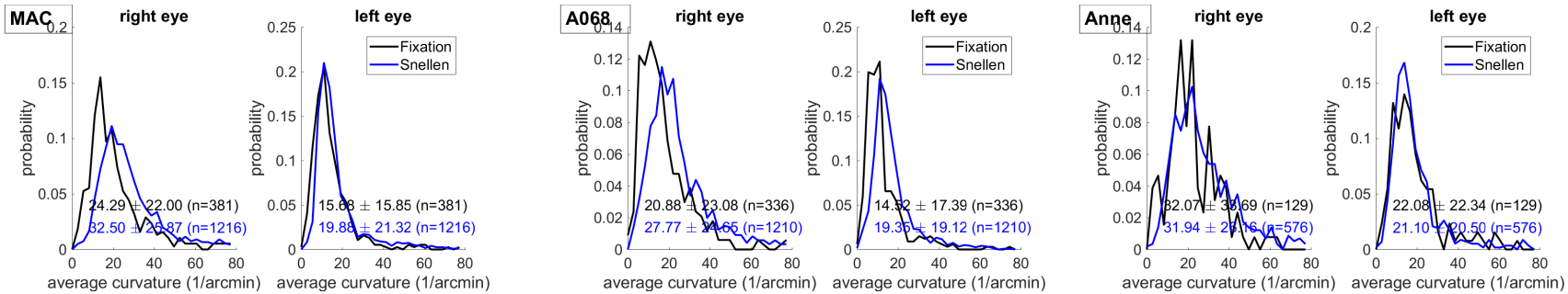


Drift Characteristics

Velocity

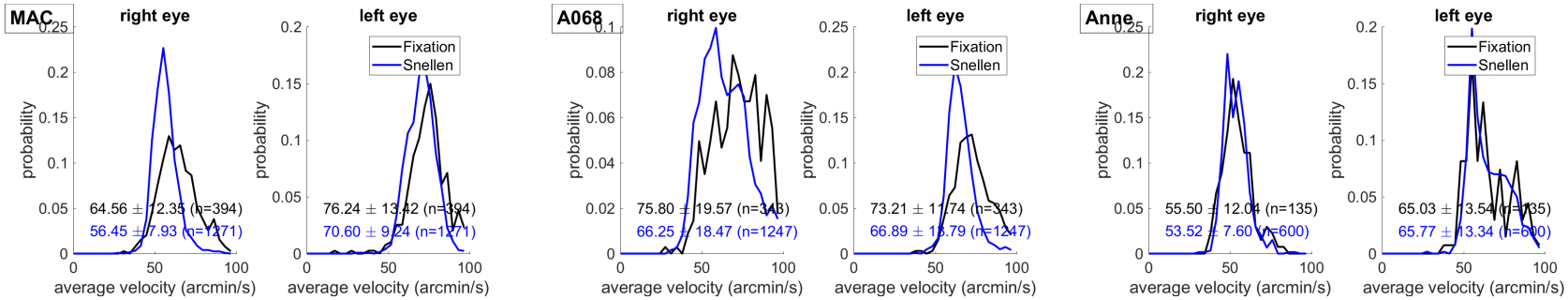


Curvature

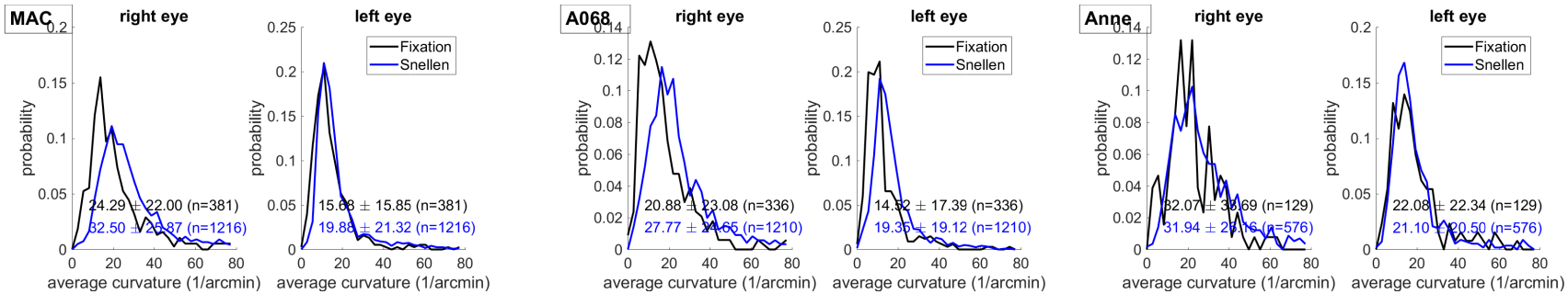


Drift Characteristics

Velocity

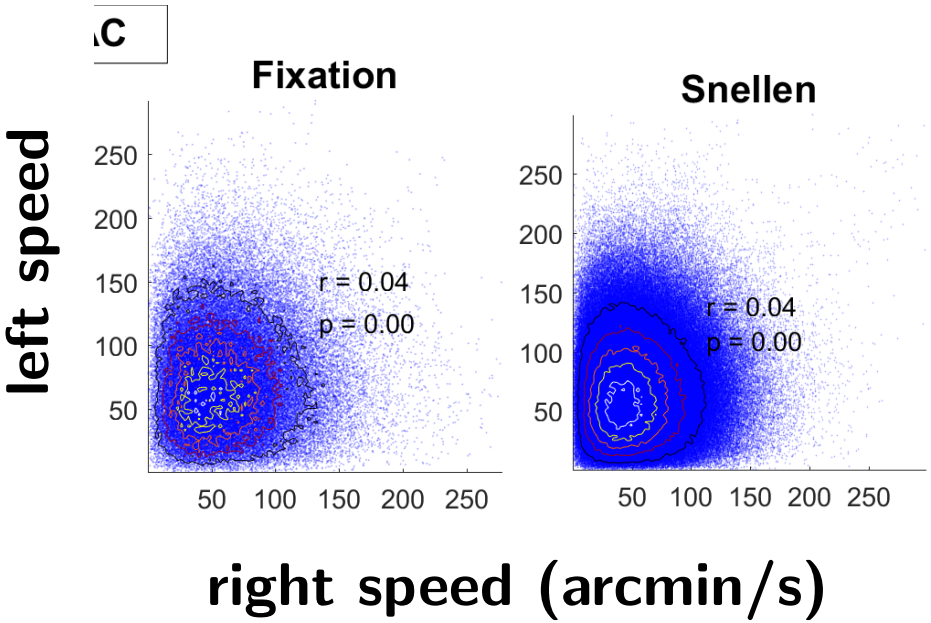


Curvature

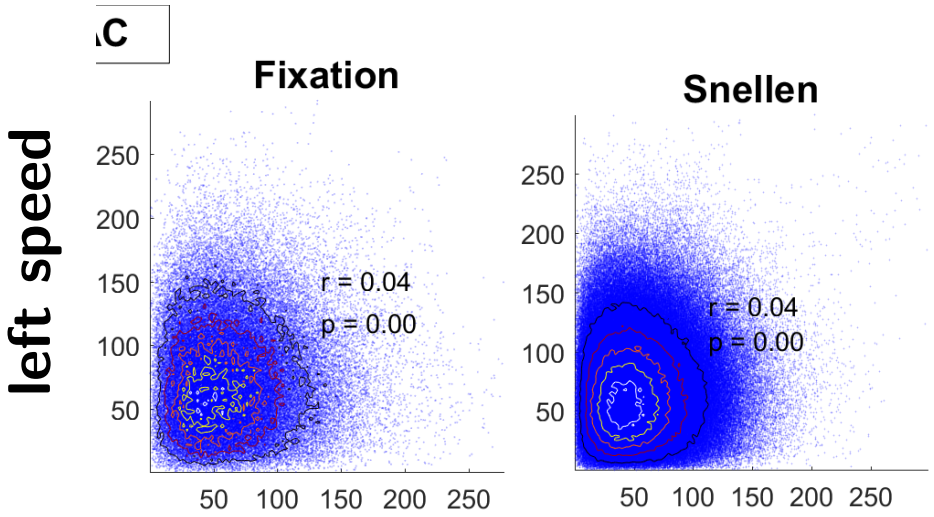


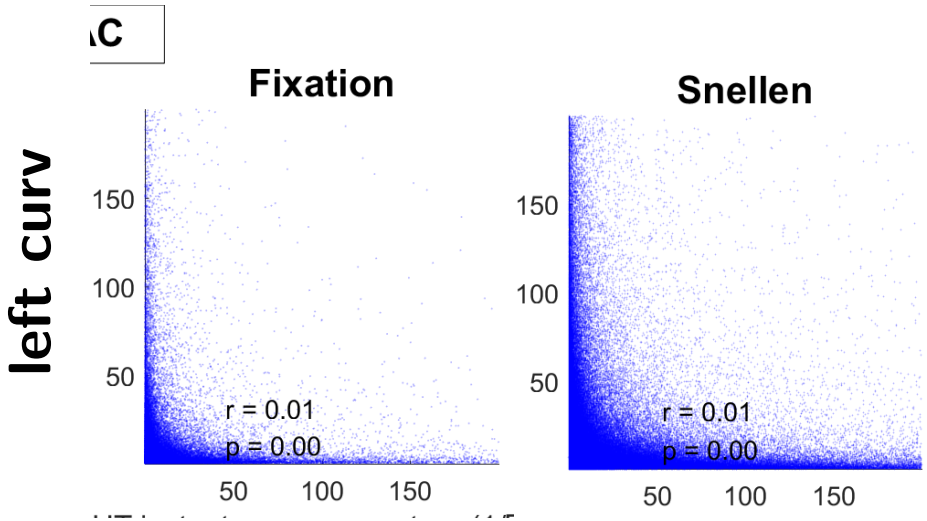
Drift is slower and more curved during the Snellen test.

Instantaneous drift characteristics are not correlated in the two eyes

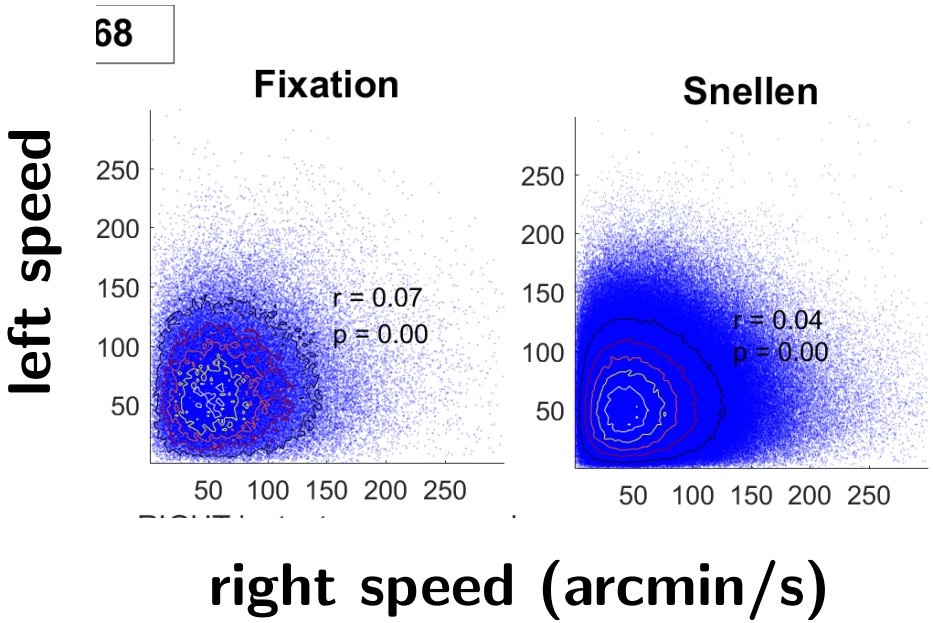


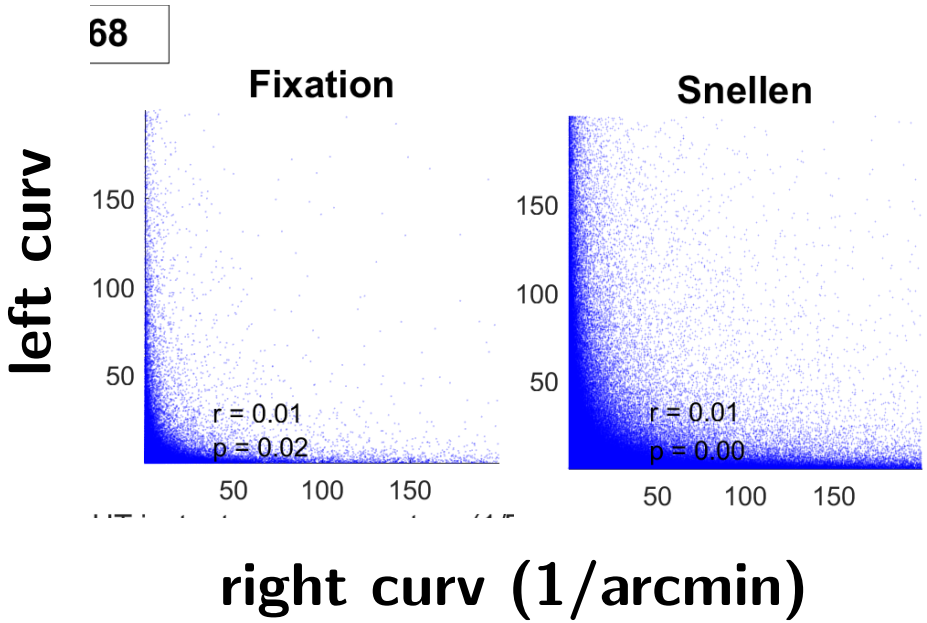
Instantaneous drift characteristics are not correlated in the two eyes



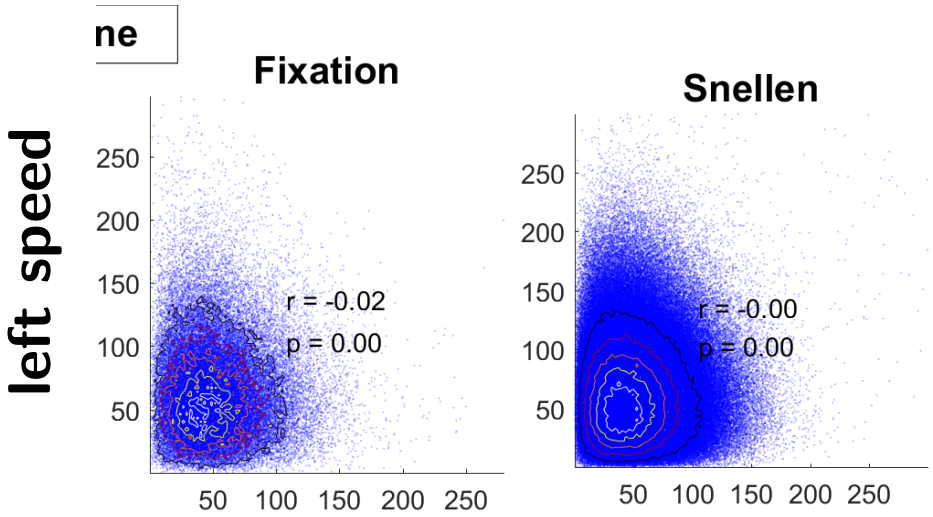


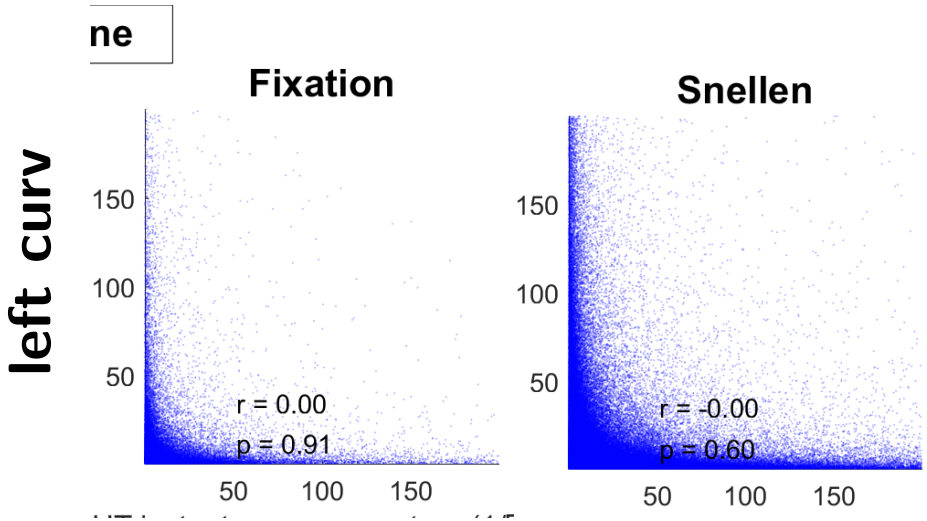
Instantaneous drift characteristics are not correlated in the two eyes



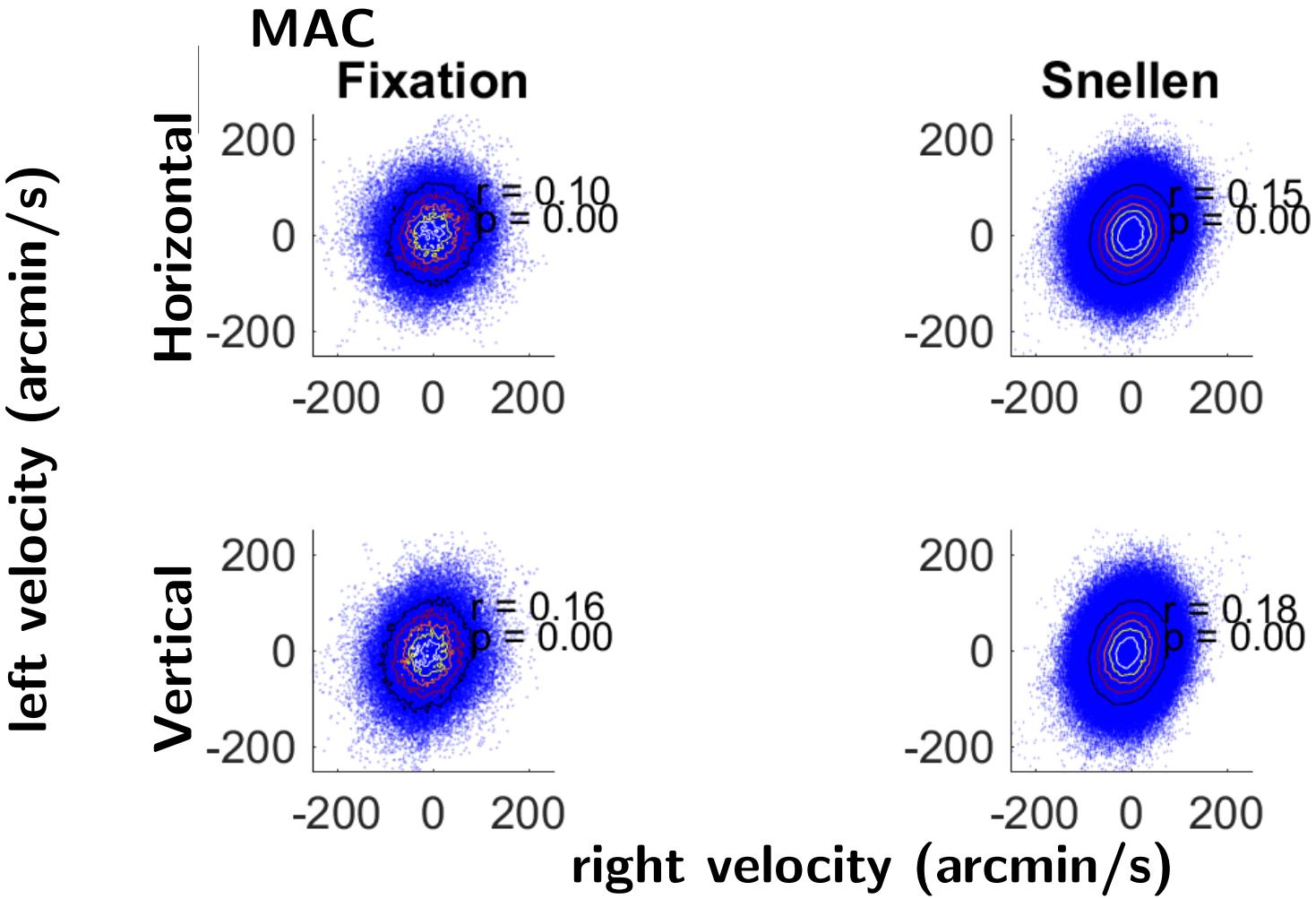


Instantaneous drift characteristics are not correlated in the two eyes

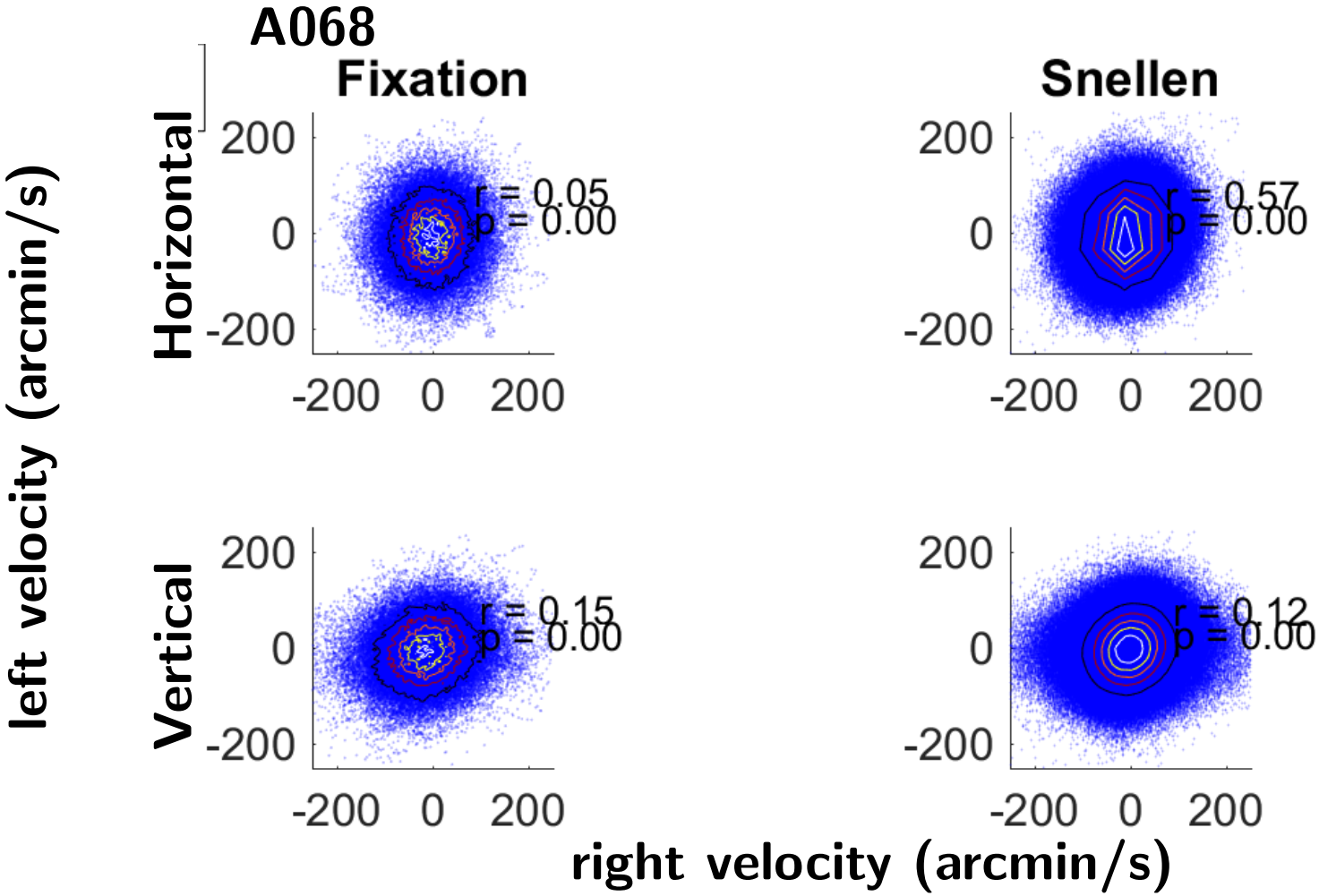




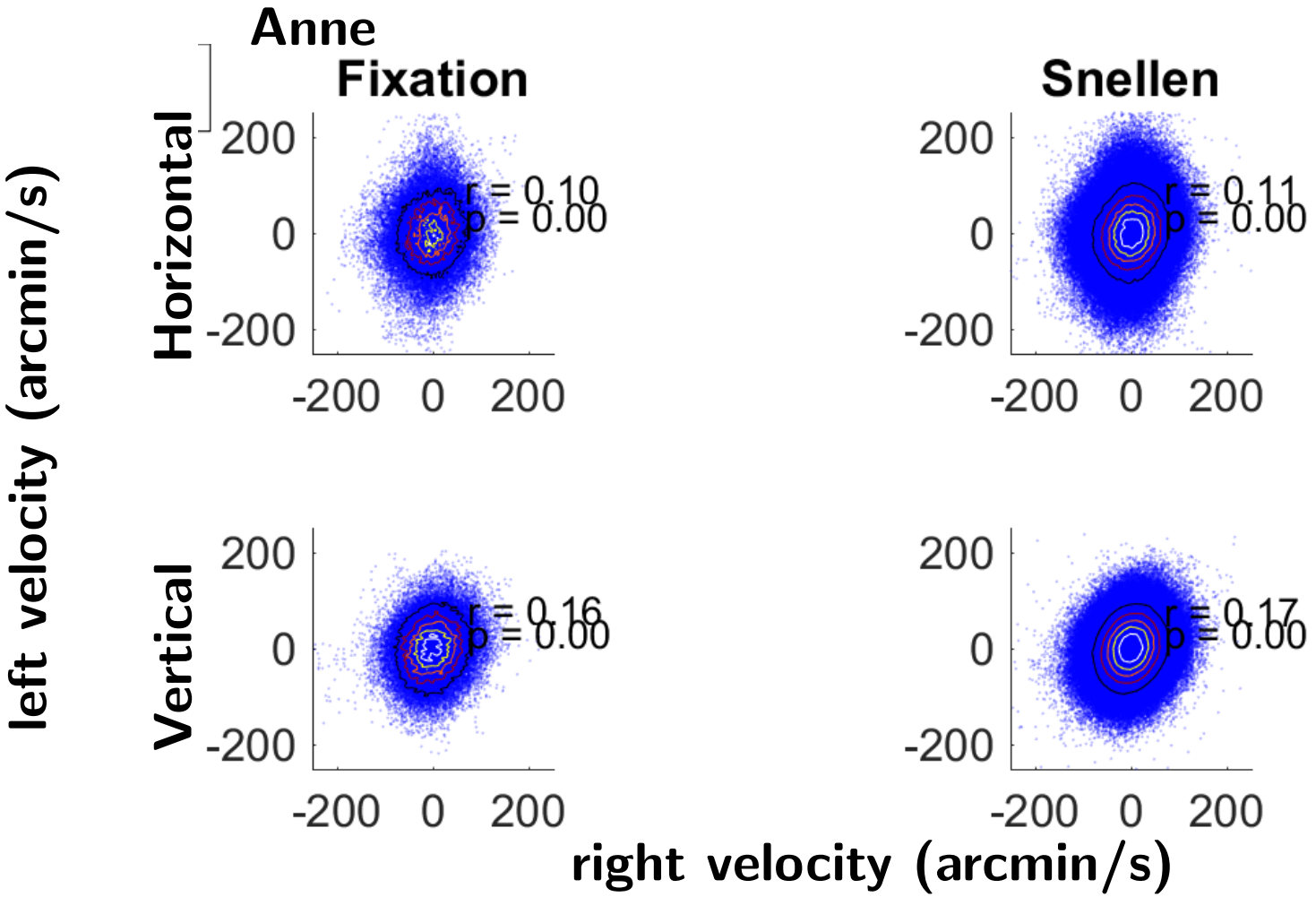
Instantaneous drift characteristics are not correlated in the two eyes



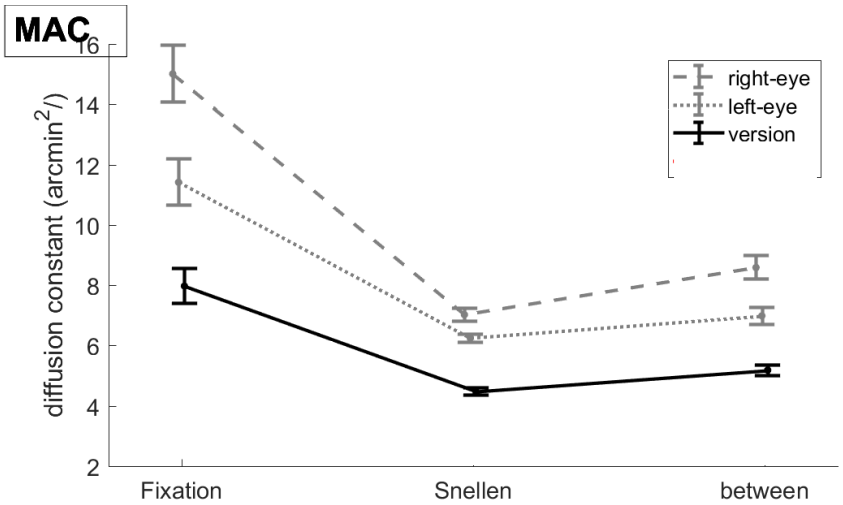
Instantaneous drift characteristics are not correlated in the two eyes



Instantaneous drift characteristics are not correlated in the two eyes



Drift diffuses less during Snellen



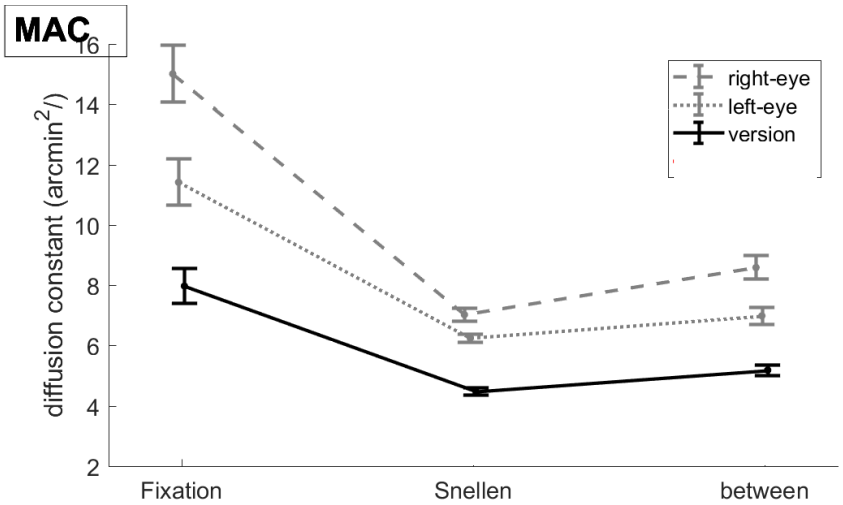
Version: average movement of the eyes

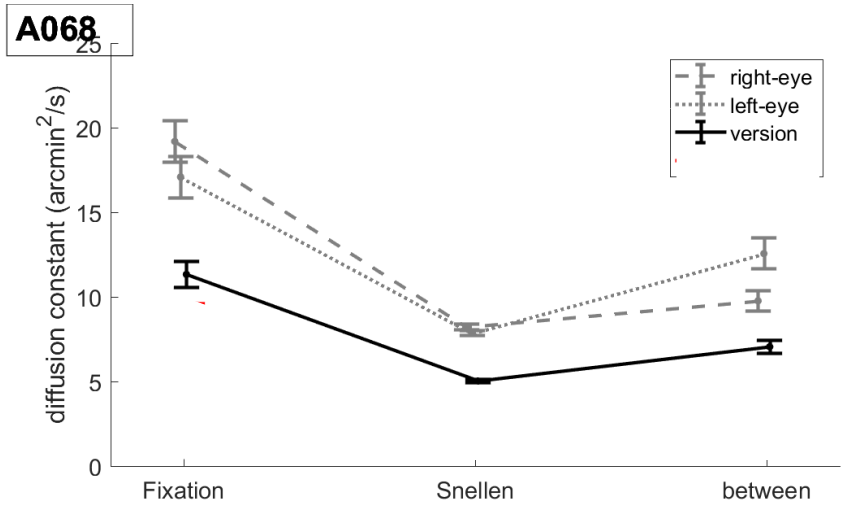
$$x = (x_R + x_L)/2$$

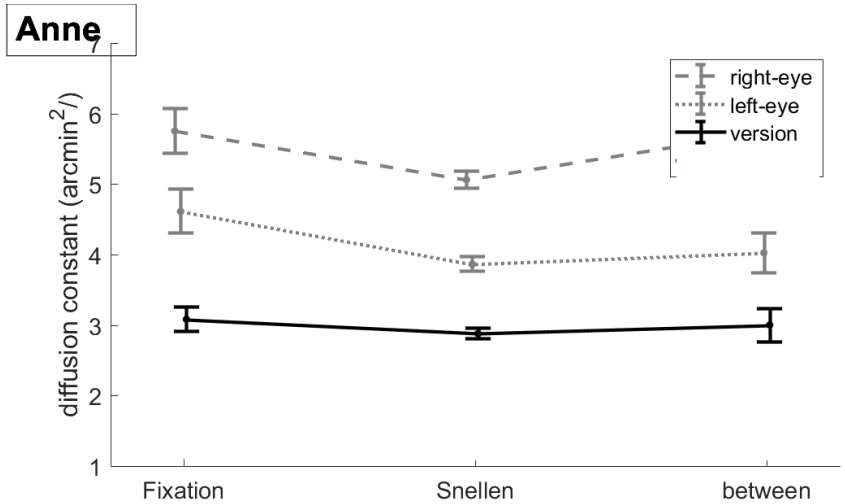
$$y = (y_R + y_L)/2$$

Between: period following fixation before first response

Drift diffuses less during Snellen







Version: average movement of the eyes

$$x = (x_R + x_L)/2$$

$$y = (y_R + y_L)/2$$

Between: period following fixation before first response

Drifts: Summary of characteristics and correlations

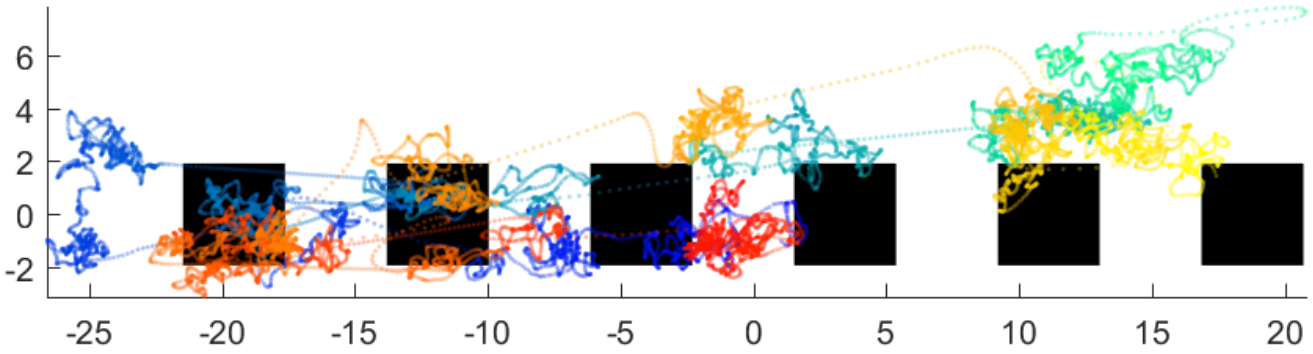
1. Each eye drifts less during the Snellen test than during sustained fixation.

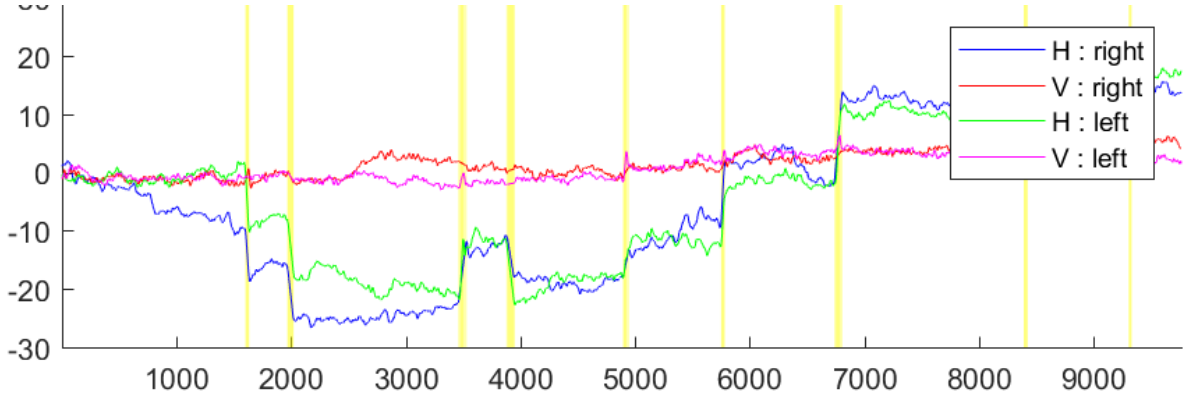
Drifts: Summary of characteristics and correlations

1. Each eye drifts less during the Snellen test than during sustained fixation.
2. In these experimental conditions, the instantaneous drift properties are not correlated.

Outline

1. Characteristics and correlations of left and right eye movements
2. Differences between left and right eye movements



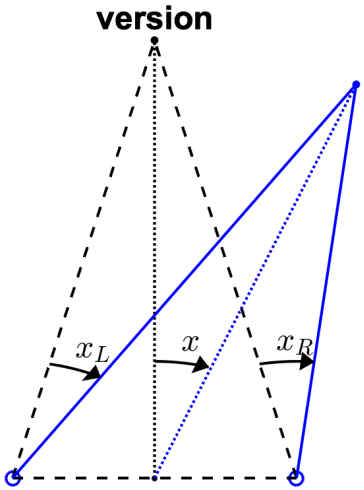


Version and Vergence Components

Version: avg movement of the eyes

$$x = (x_R + x_L)/2$$

$$y = (y_R + y_L)/2$$

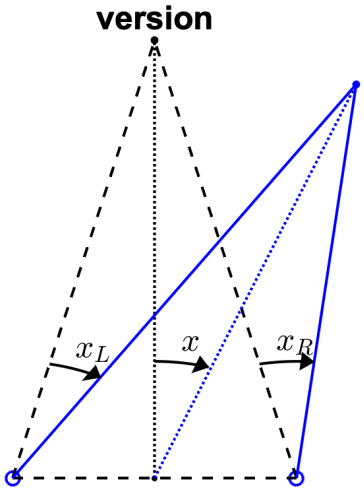


Version and Vergence Components

Version: avg movement of the eyes

$$x = (x_R + x_L)/2$$

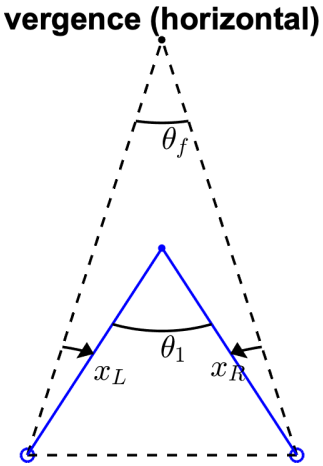
$$y = (y_R + y_L)/2$$



Vergence: diff. in the movements of the eyes*

$$V_x = (x_R - x_L)/2$$

$$V_y = (y_R - y_L)/2$$

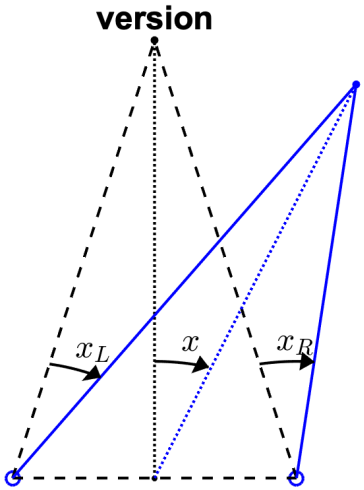


Version and Vergence Components

Version: avg movement of the eyes

$$x = (x_R + x_L)/2$$

$$y = (y_R + y_L)/2$$



Vergence: diff. in the movements of the eyes*

$$V_x = (x_R - x_L)/2$$

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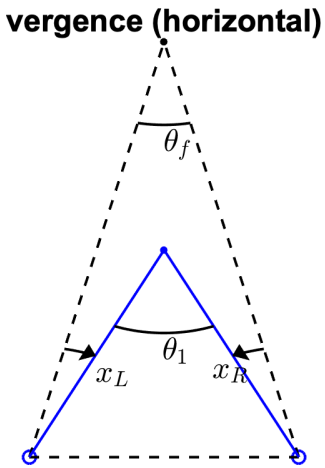
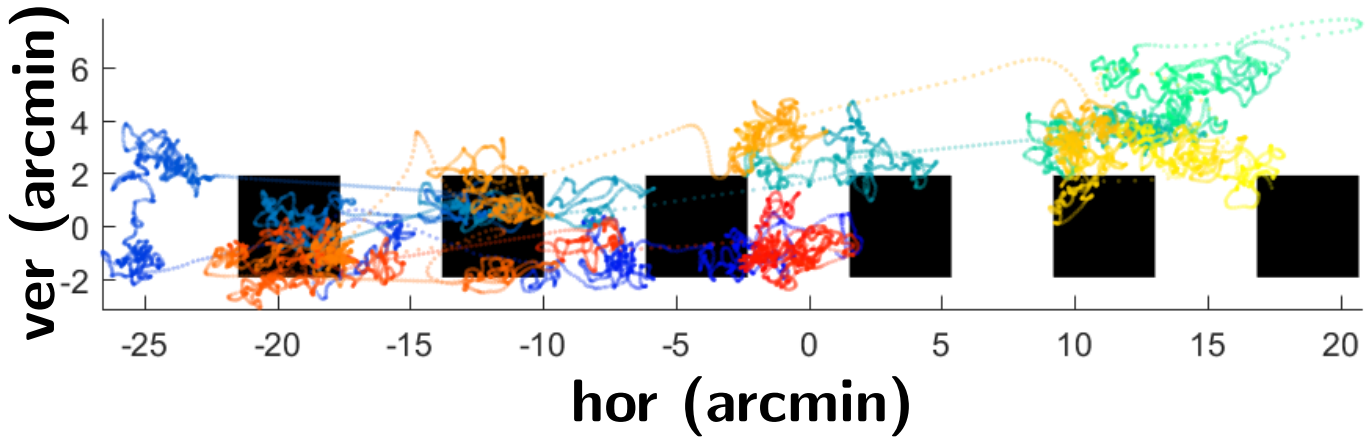
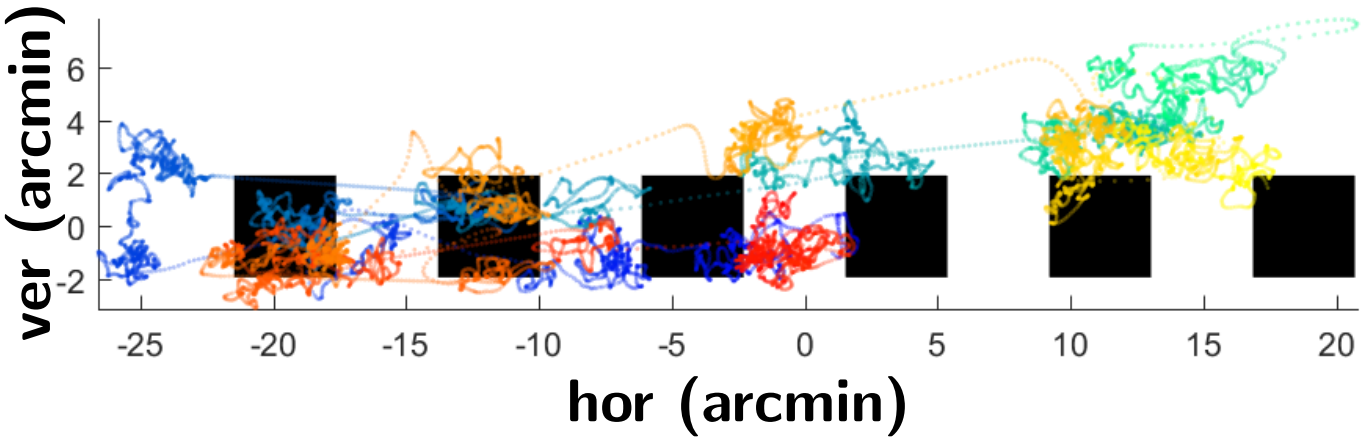


* **1.** $V_x > 0$: uncrossed. $V_x < 0$: crossed **2.** Vergence is measured relative to the fixation point, which we assume is located at (0, 0) on the monitor.

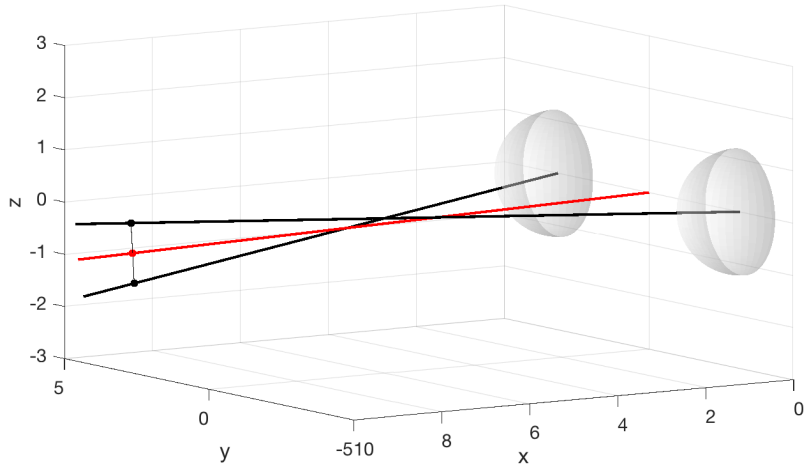
Binocular Gaze Point



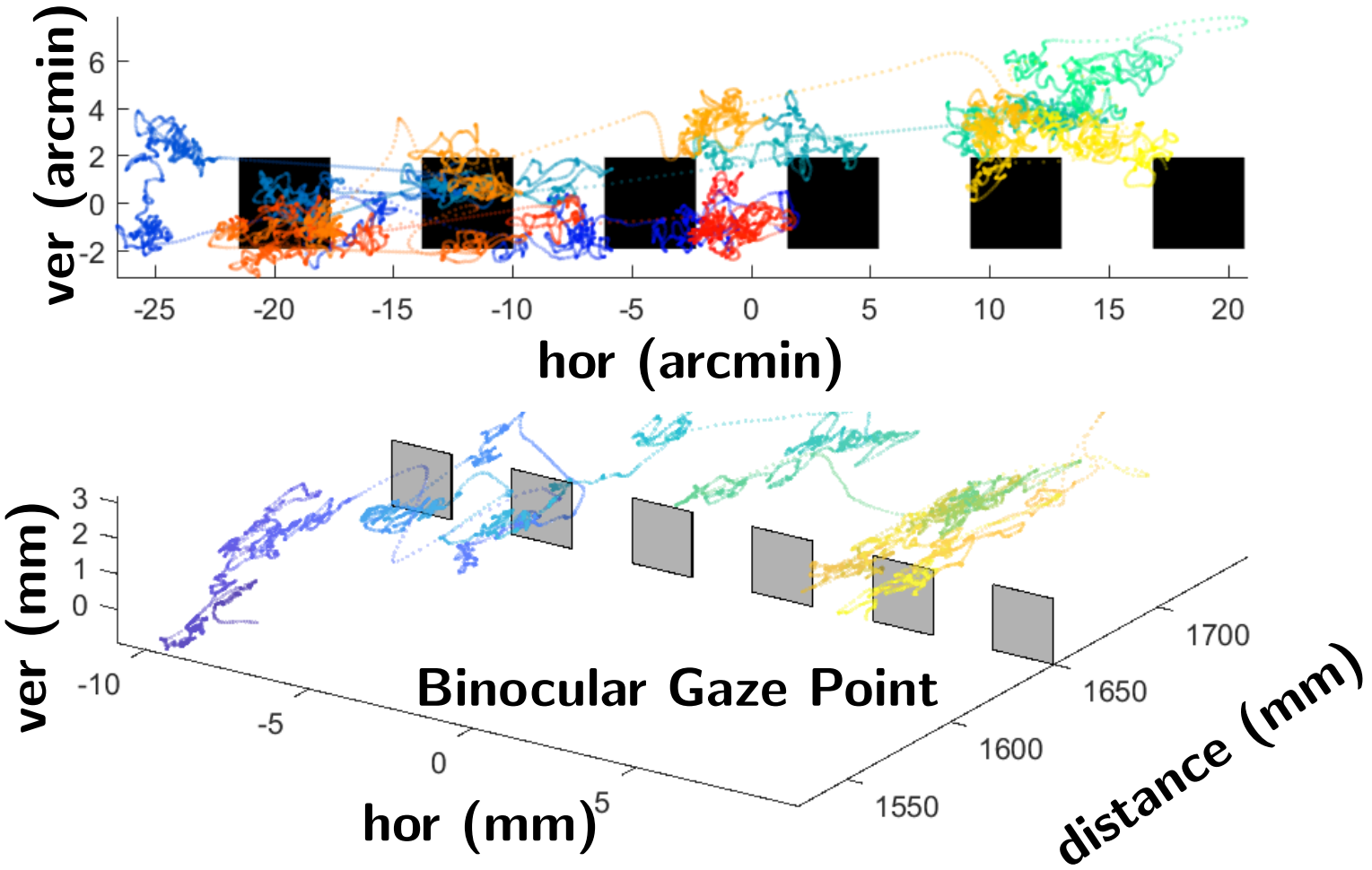
Binocular Gaze Point



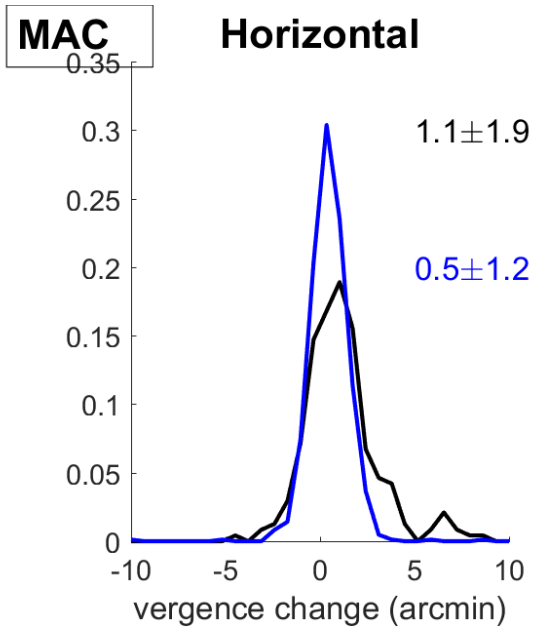
BGP = midpoint of line of closest approach



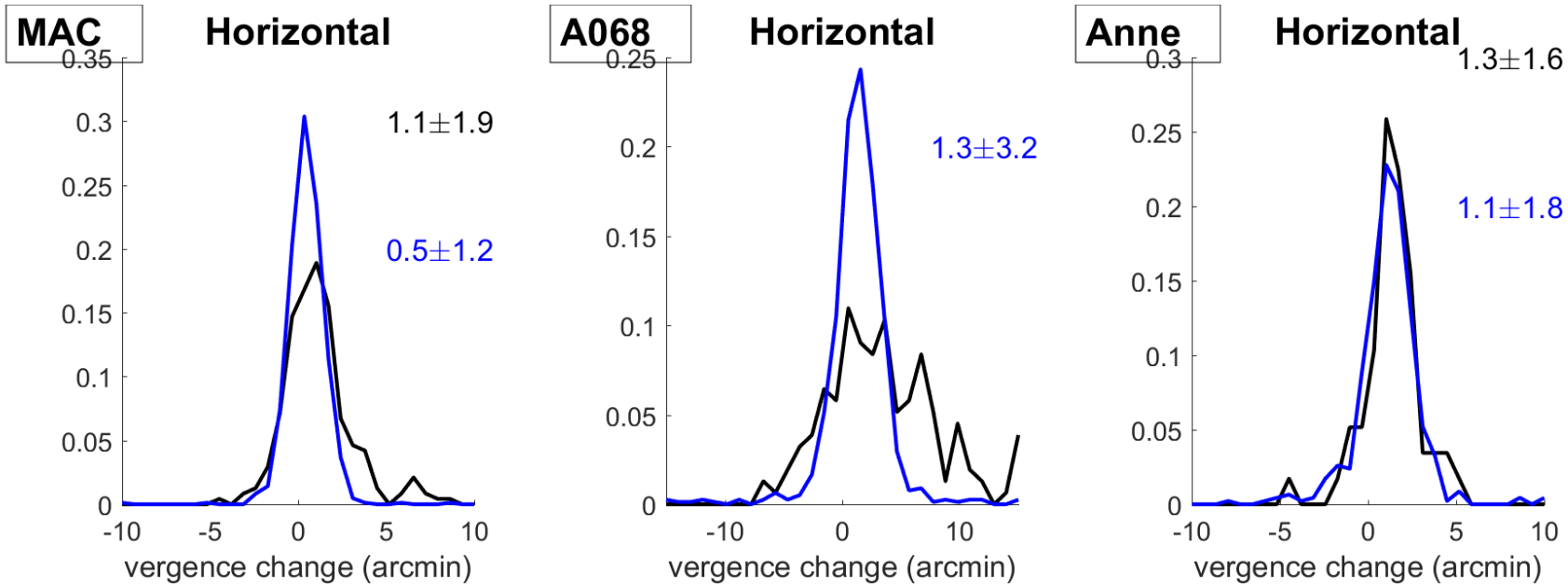
Binocular Gaze Point



Microsaccades change horizontal vergence

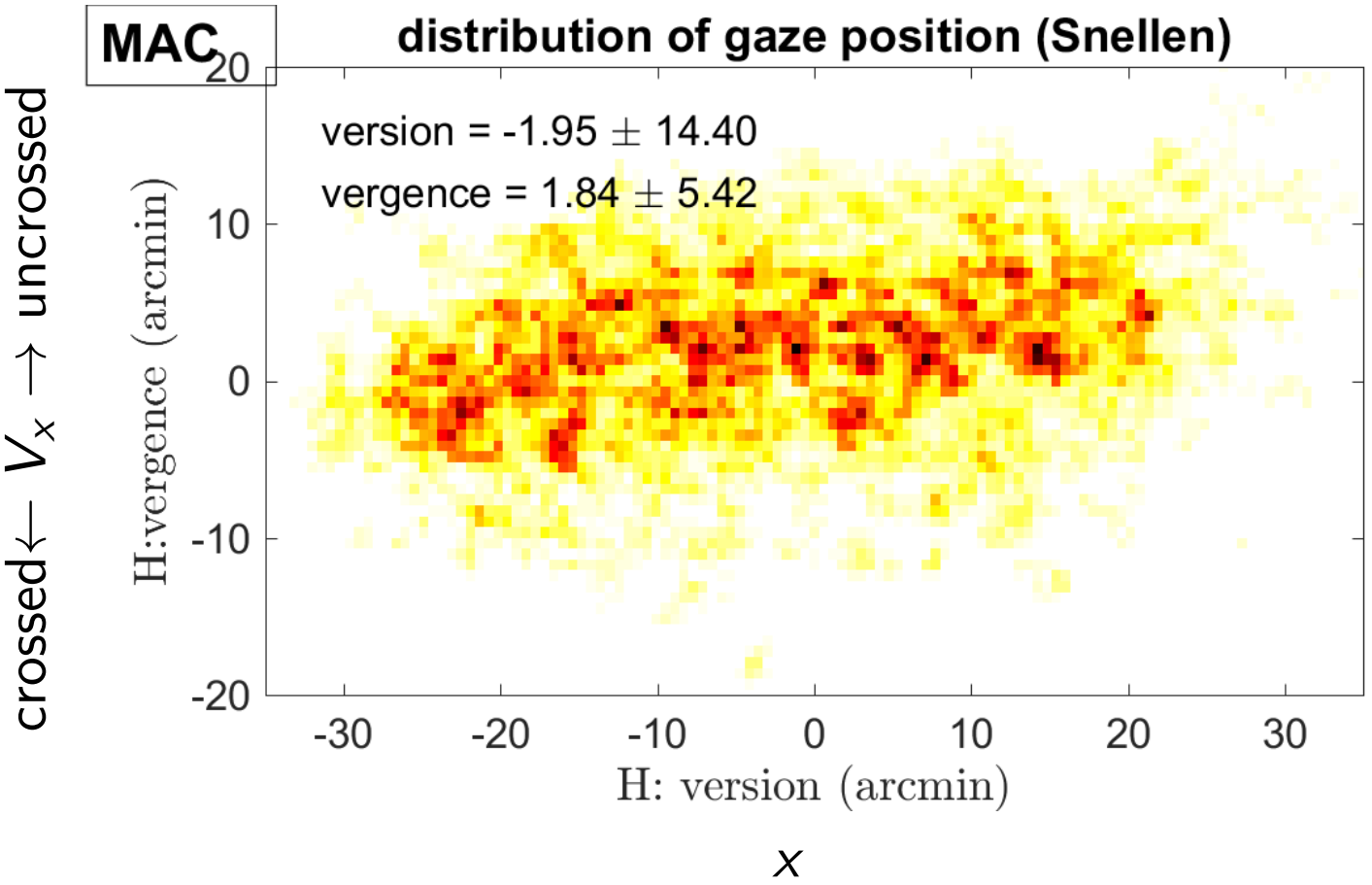


Microsaccades change horizontal vergence



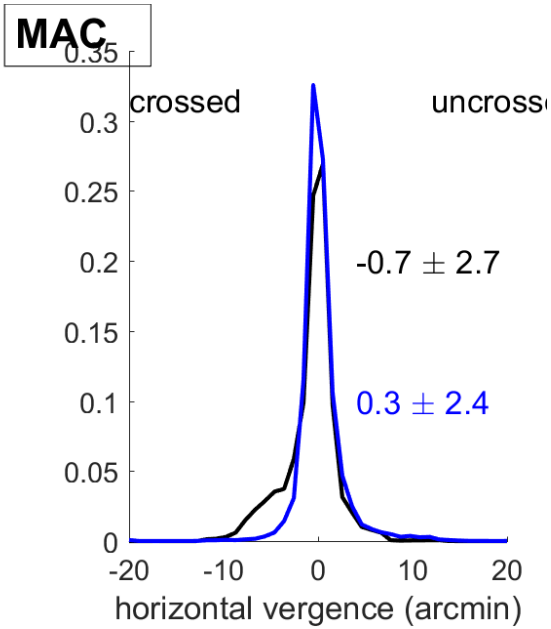
BGP across stimulus

Go to 3D figures in Matlab.



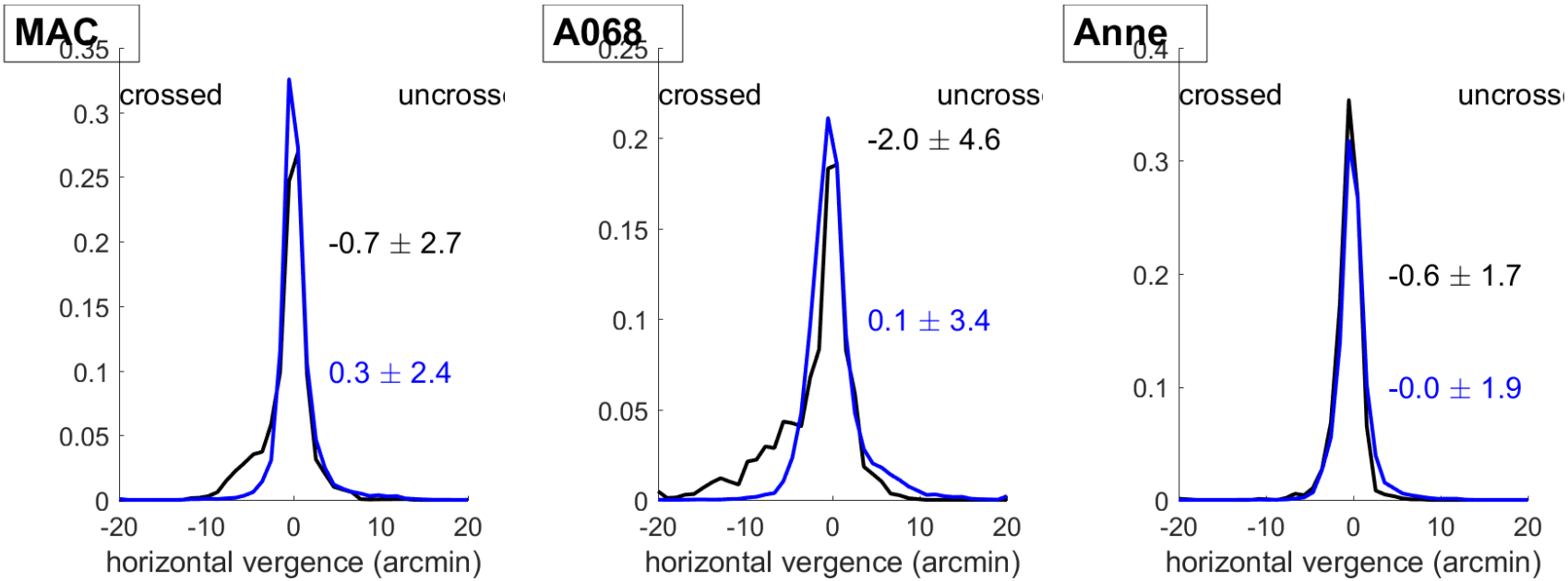
Drifts don't change horizontal vergence

Change in vergence from start of drift.



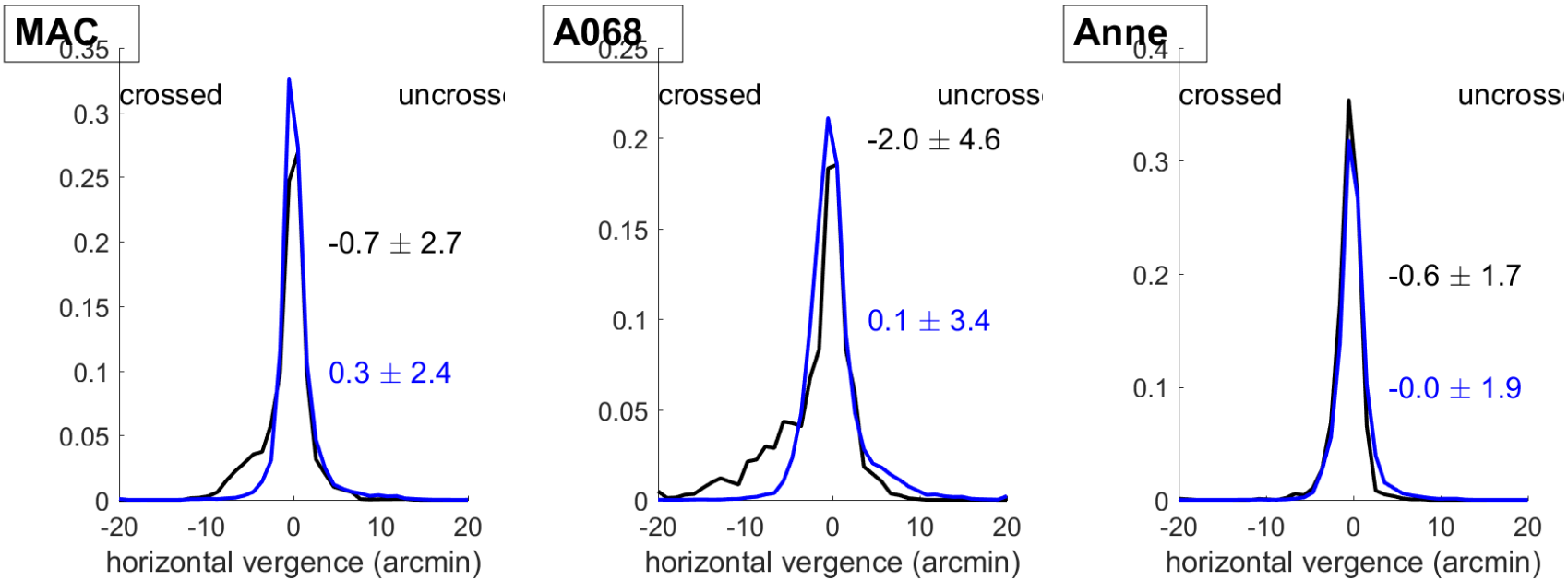
Drifts don't change horizontal vergence

Change in vergence from start of drift.



Drifts don't change horizontal vergence

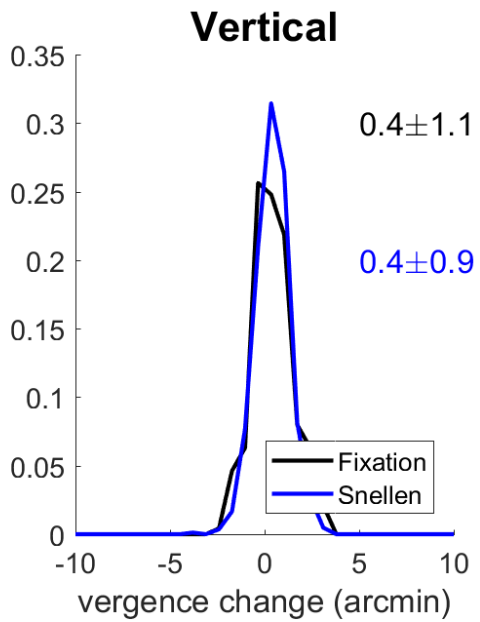
Change in vergence from start of drift.



Microsaccades tend to uncross the eyes while drift on average does not change vergence. Next: Do drifts show tendencies to correct or amplify the vergence change from the previous microsaccade?

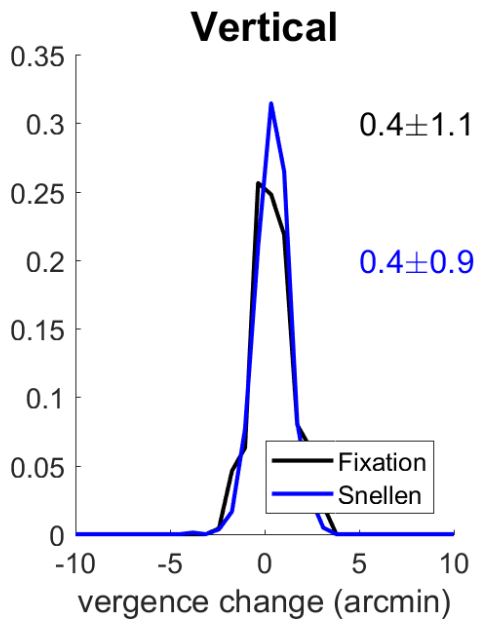
Microsaccades don't change vertical vergence

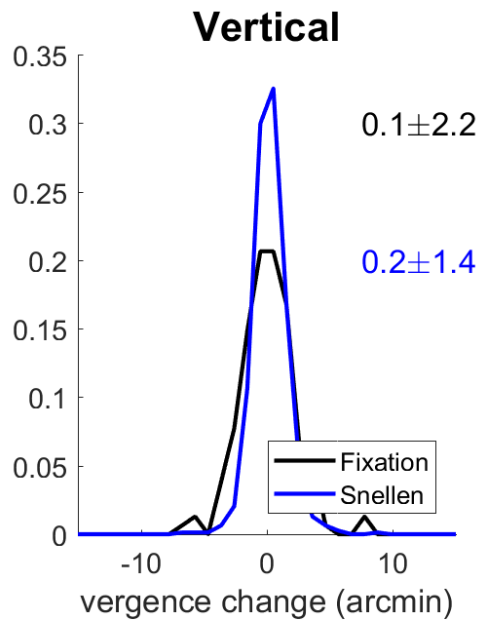
Change in vergence from start of drift.

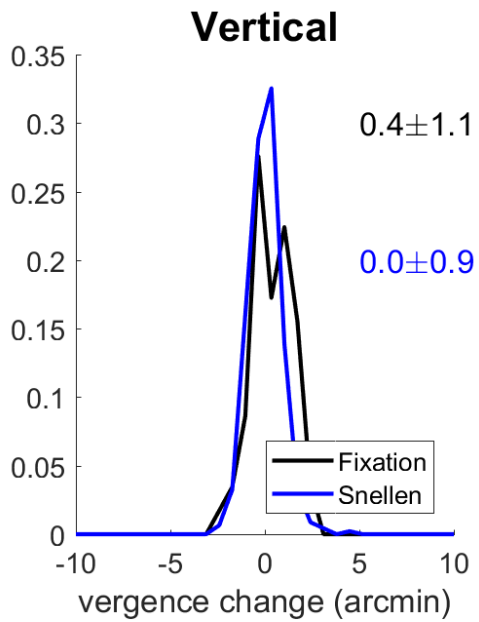


Microsaccades don't change vertical vergence

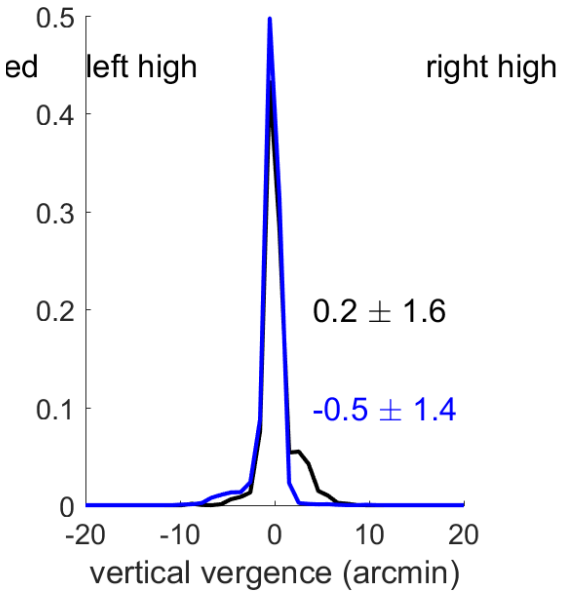
Change in vergence from start of drift.



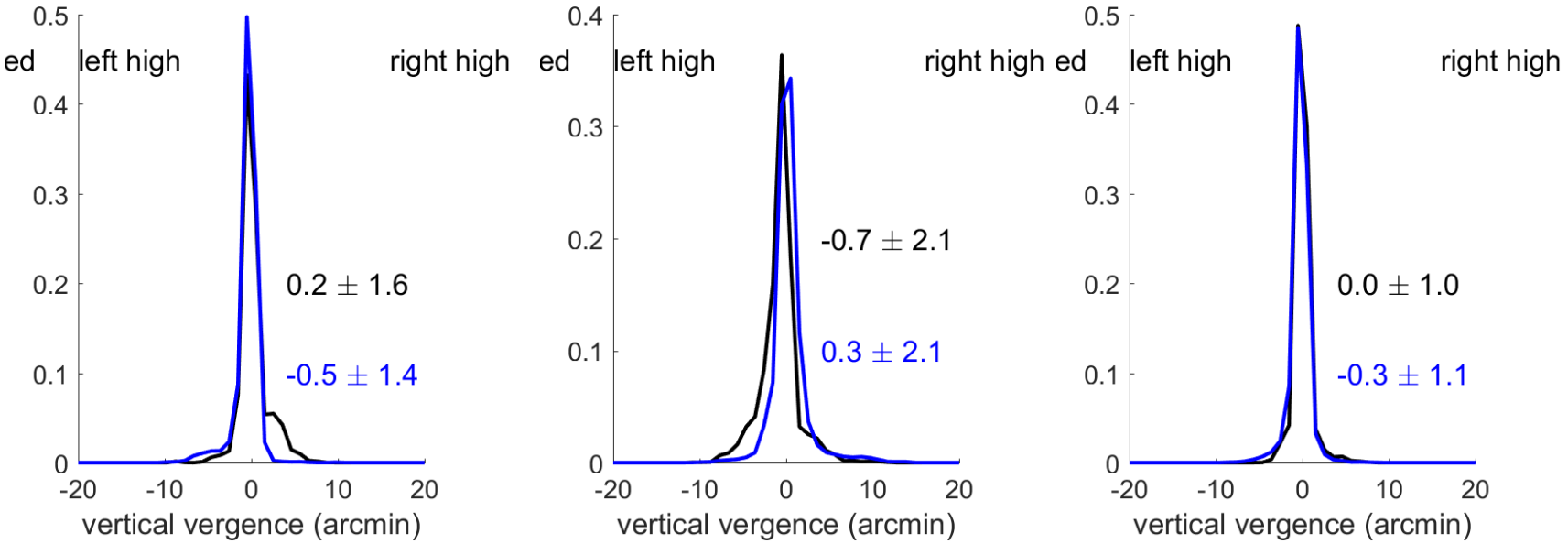




Drifts don't change vertical vergence

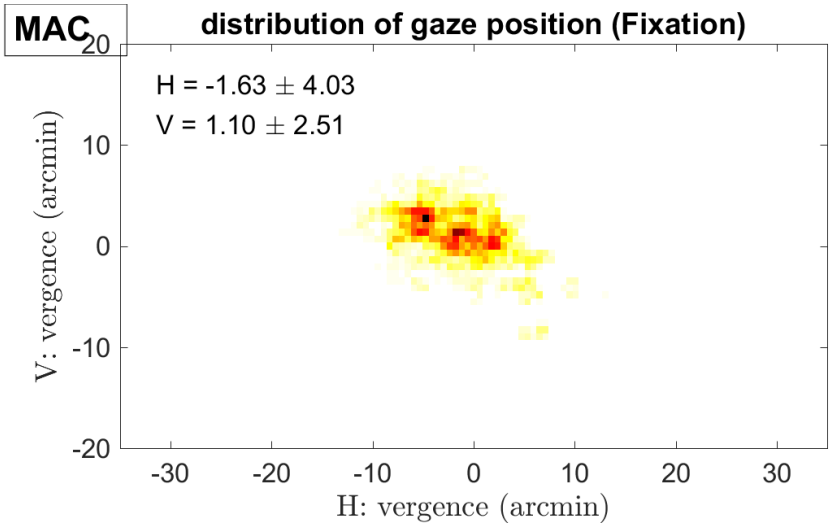


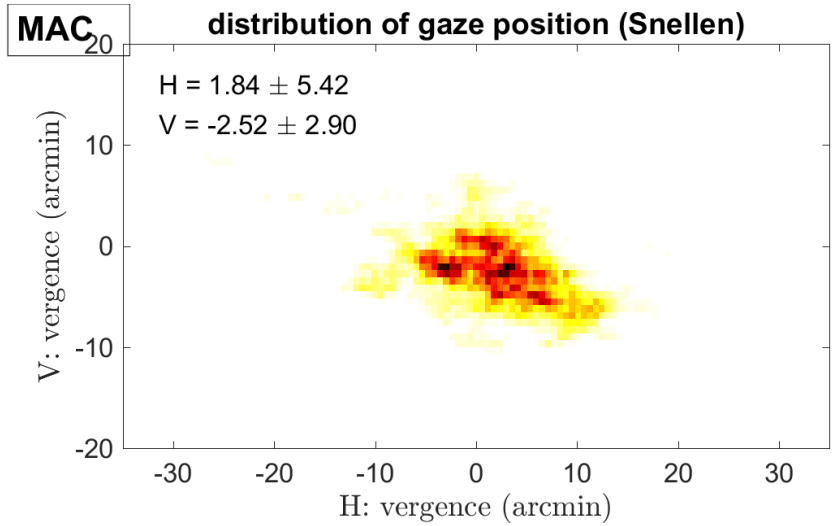
Drifts don't change vertical vergence



Positional offset of gaze

left high$\leftarrow V_y \rightarrow$ right high

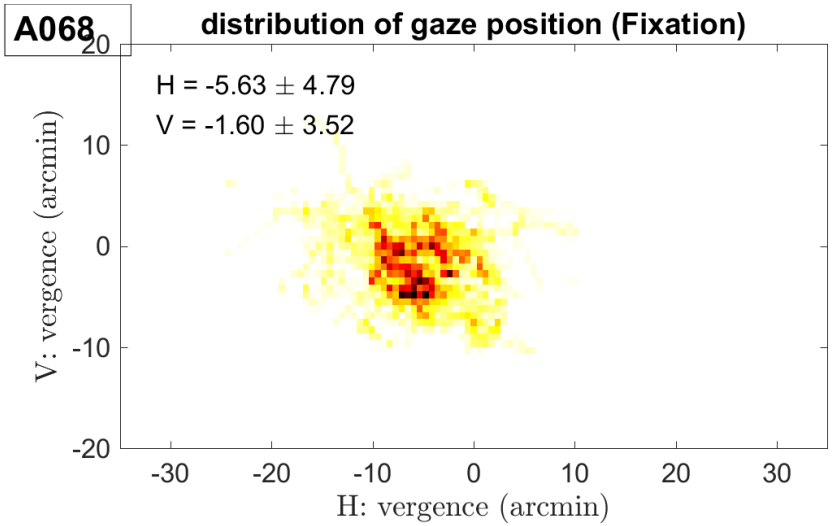


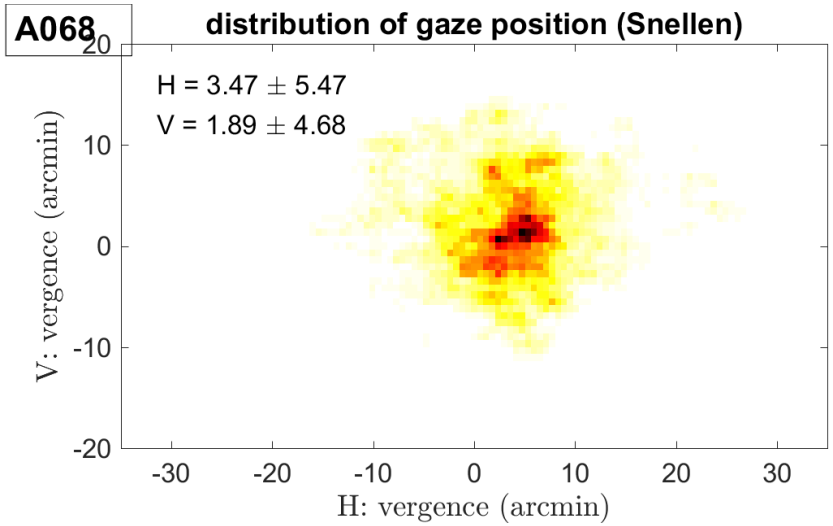


crossed$\leftarrow V_x \rightarrow$ uncrossed

Positional offset of gaze

left high$\leftarrow V_y \rightarrow$ right high

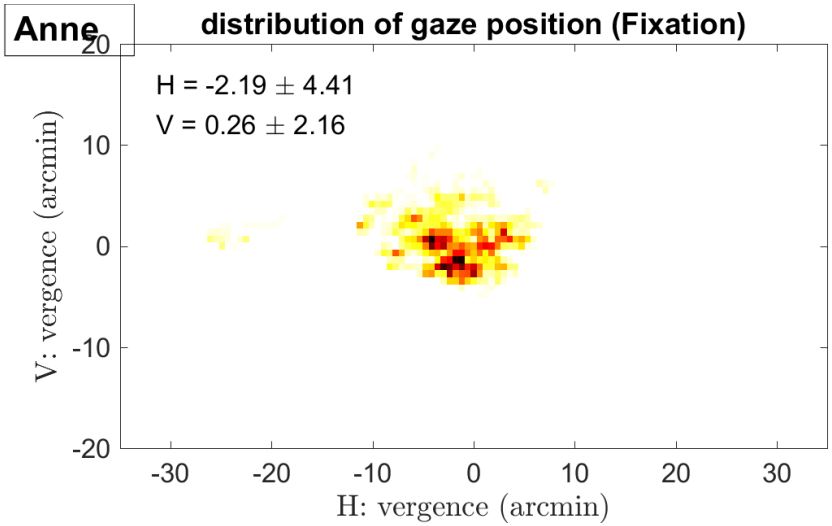


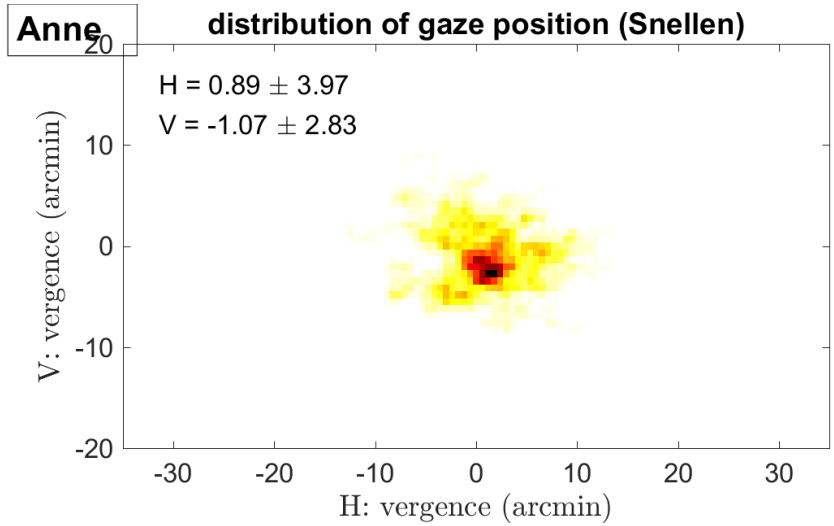


crossed$\leftarrow V_x \rightarrow$ uncrossed

Positional offset of gaze

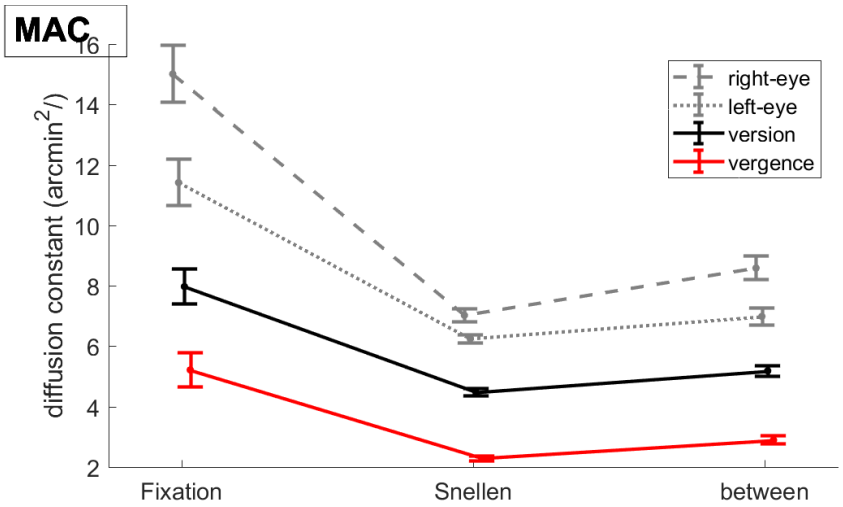
left high$\leftarrow V_y \rightarrow$ right high





crossed$\leftarrow V_x \rightarrow$ uncrossed

Positional offset diffuses less in Snellen



Vergence: difference between eyes

$$x = (x_R - x_L)/2$$

$$y = (y_R - y_L)/2$$

Between: period following fixation before first response

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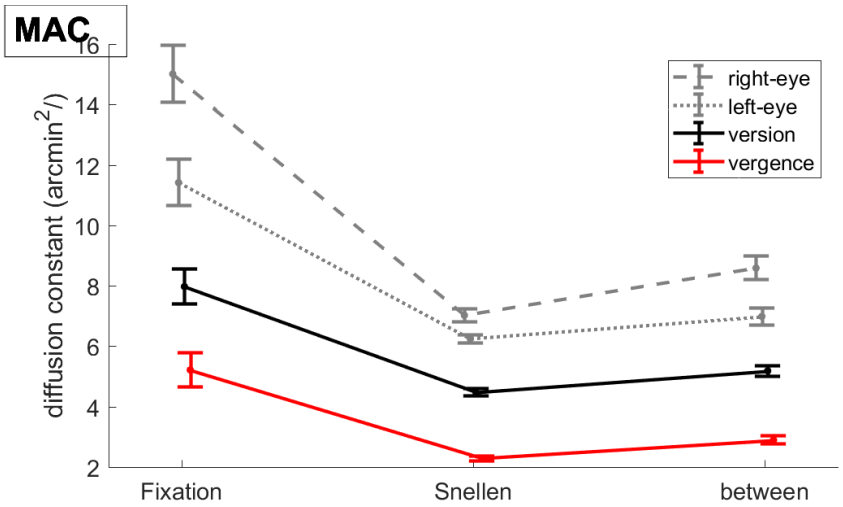

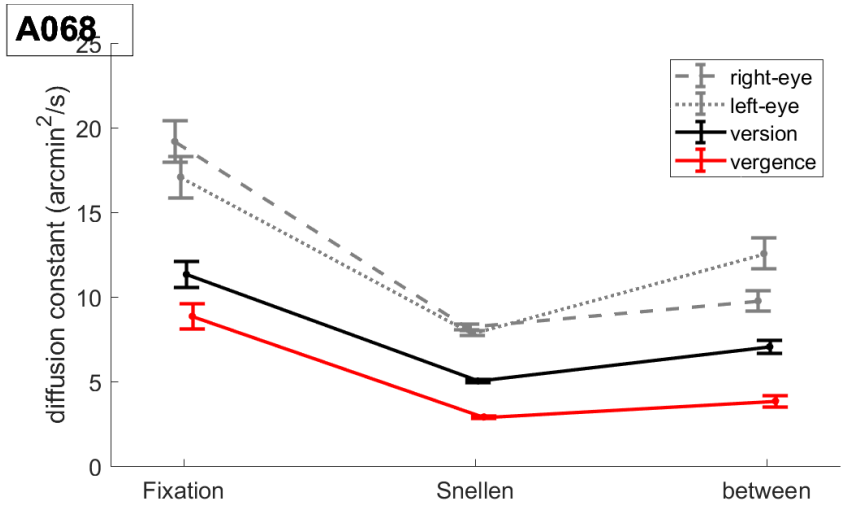

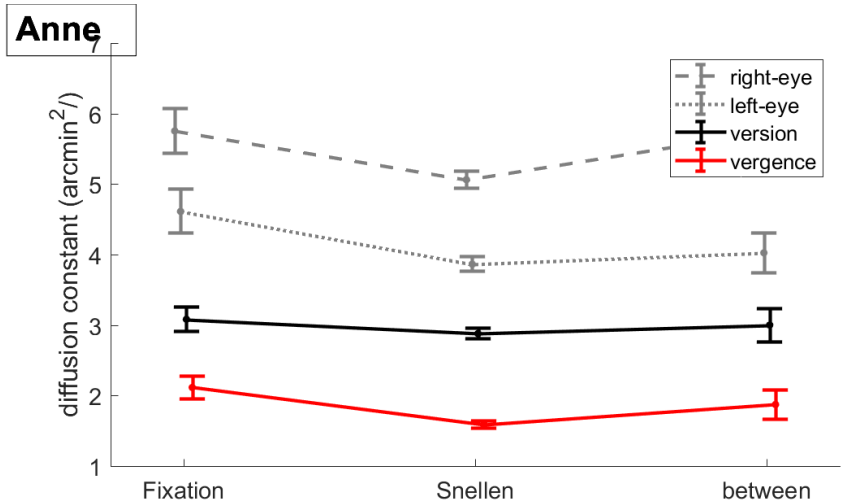

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   - Microsaccades seem to constantly uncross gaze. Why?
   - Though drifts in the eyes do not exhibit synchronous speeds or direction in these conditions, the decrease in the diffusion rate during Snellen results in slower changes in retinal disparity.