Binocular Snellen

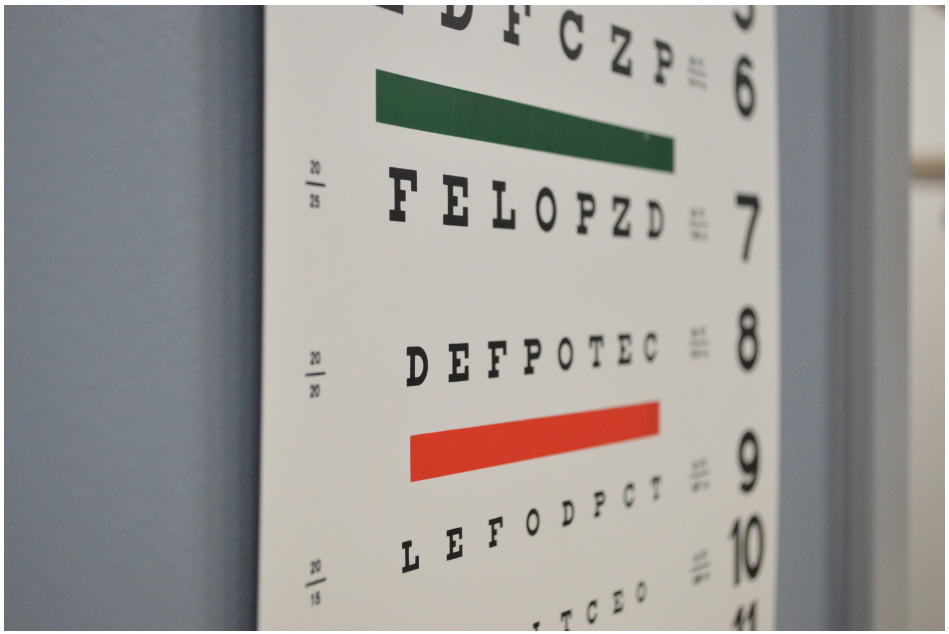
Characteristics of eye movements during the Snellen visual acuity test

Janis Intoy

APLAB

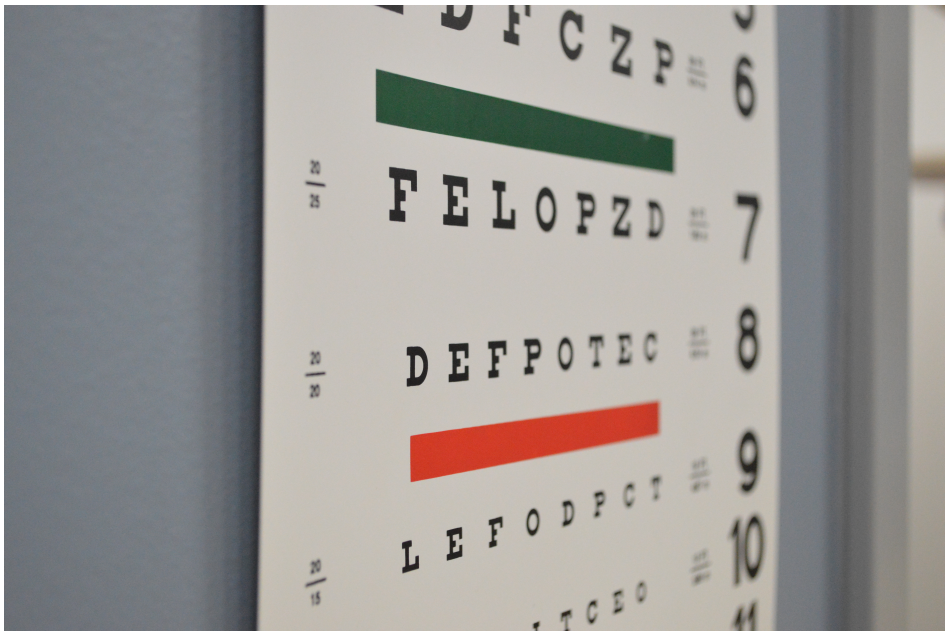
October 13, 2020

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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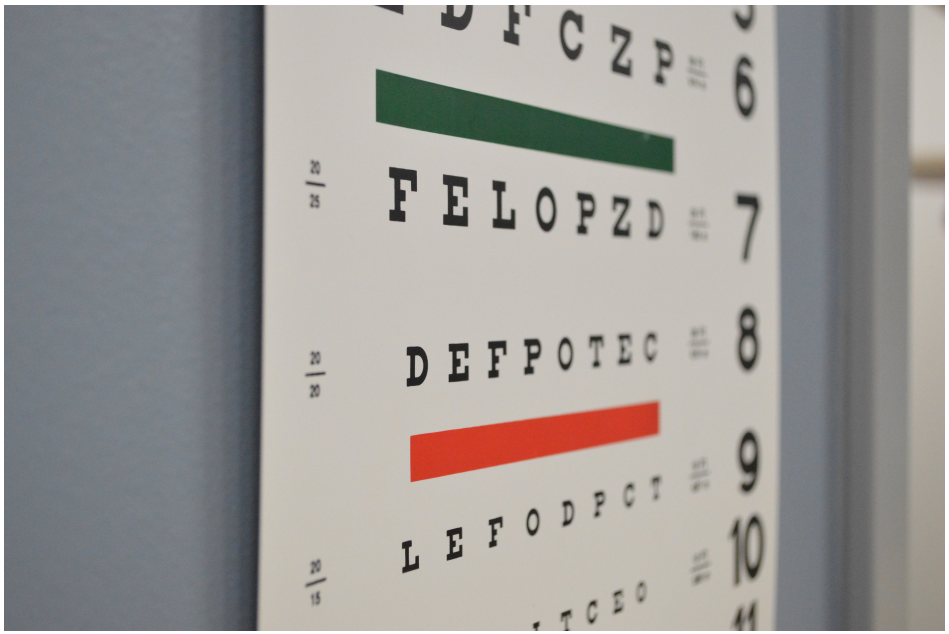

1. How do the eyes move when acquiring detailed visual information?
2. How does binocular coordination change during a high acuity task?
   - Does the degree of conjugacy increase?

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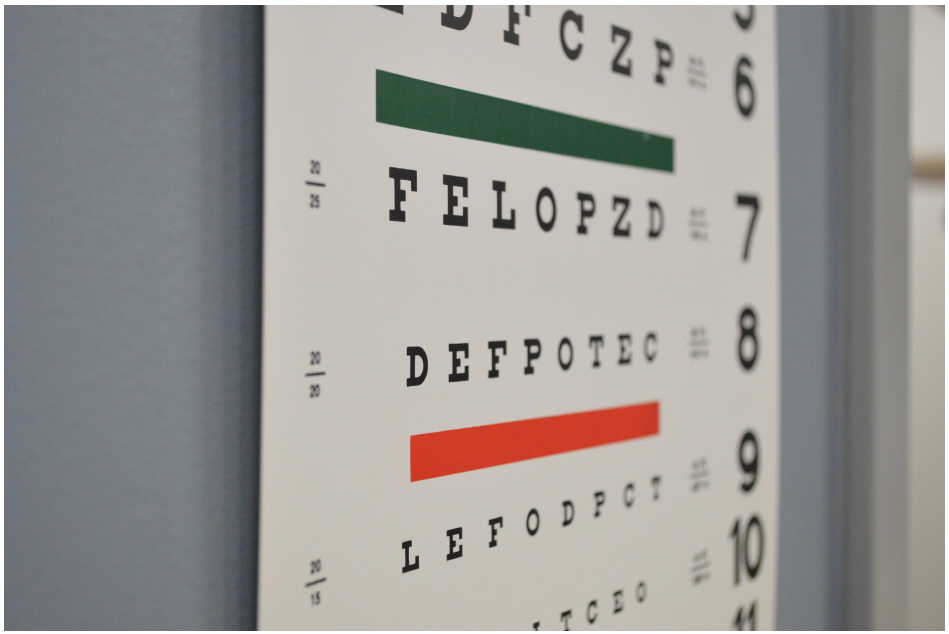

1. How do the eyes move when acquiring detailed visual information?
2. How does binocular coordination change during a high acuity task?
   - Does the degree of conjugacy increase?
   - Are the eyes more synchronized?

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

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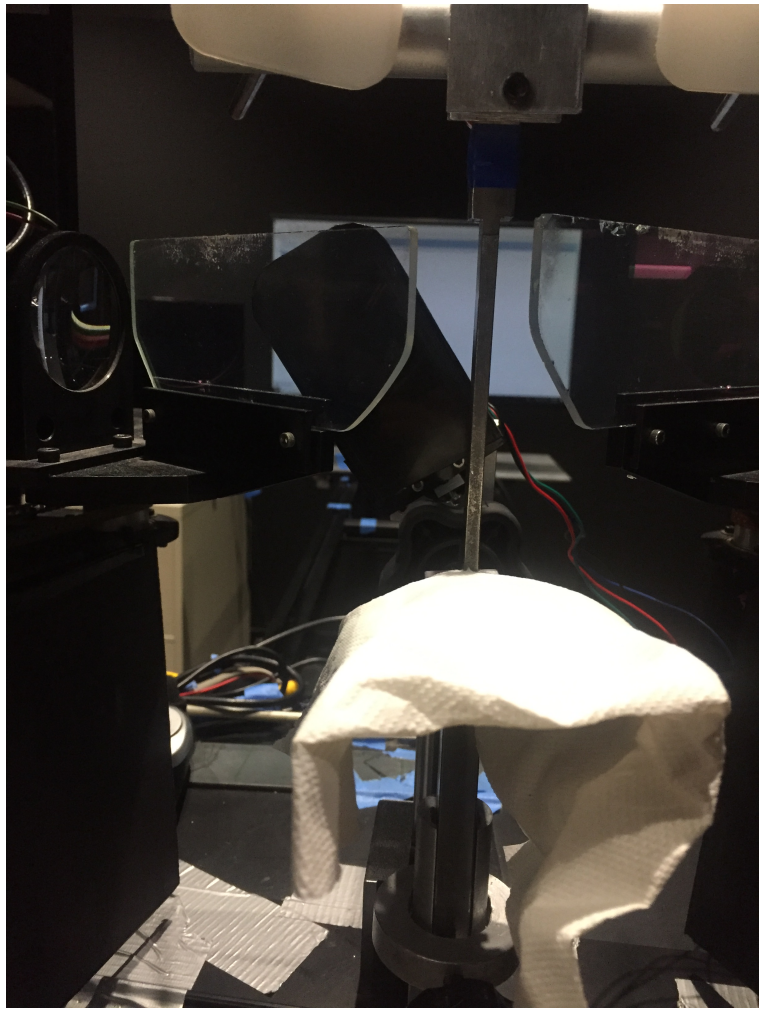
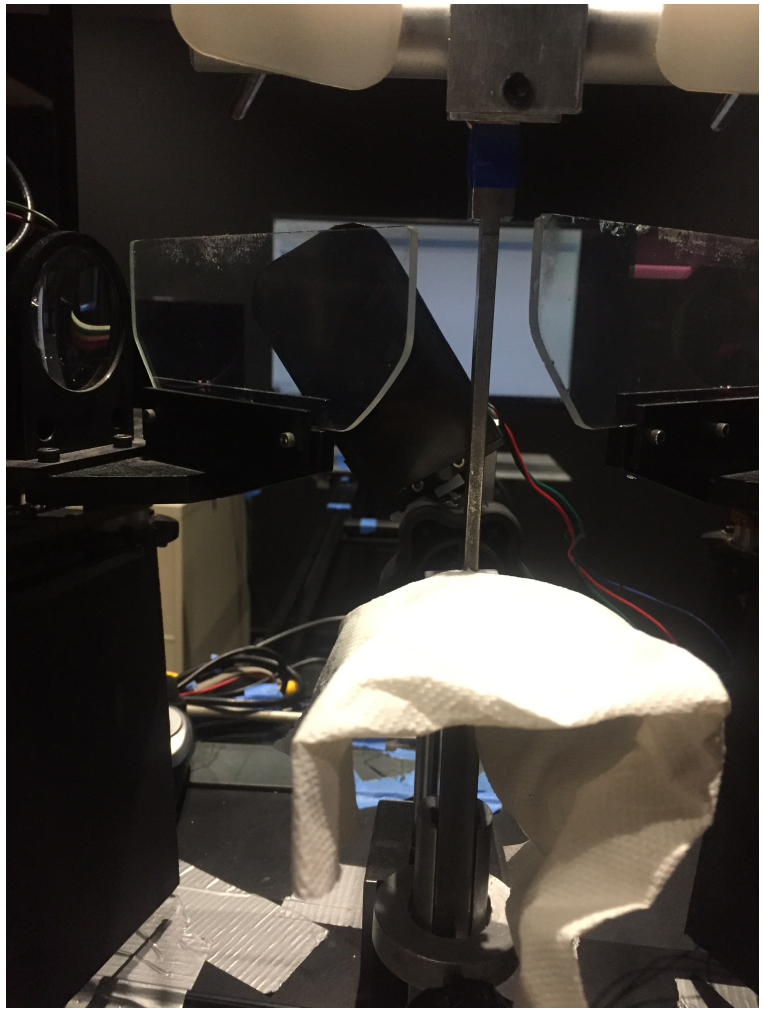
2. Monocular manual calibrations of each eye with occluder

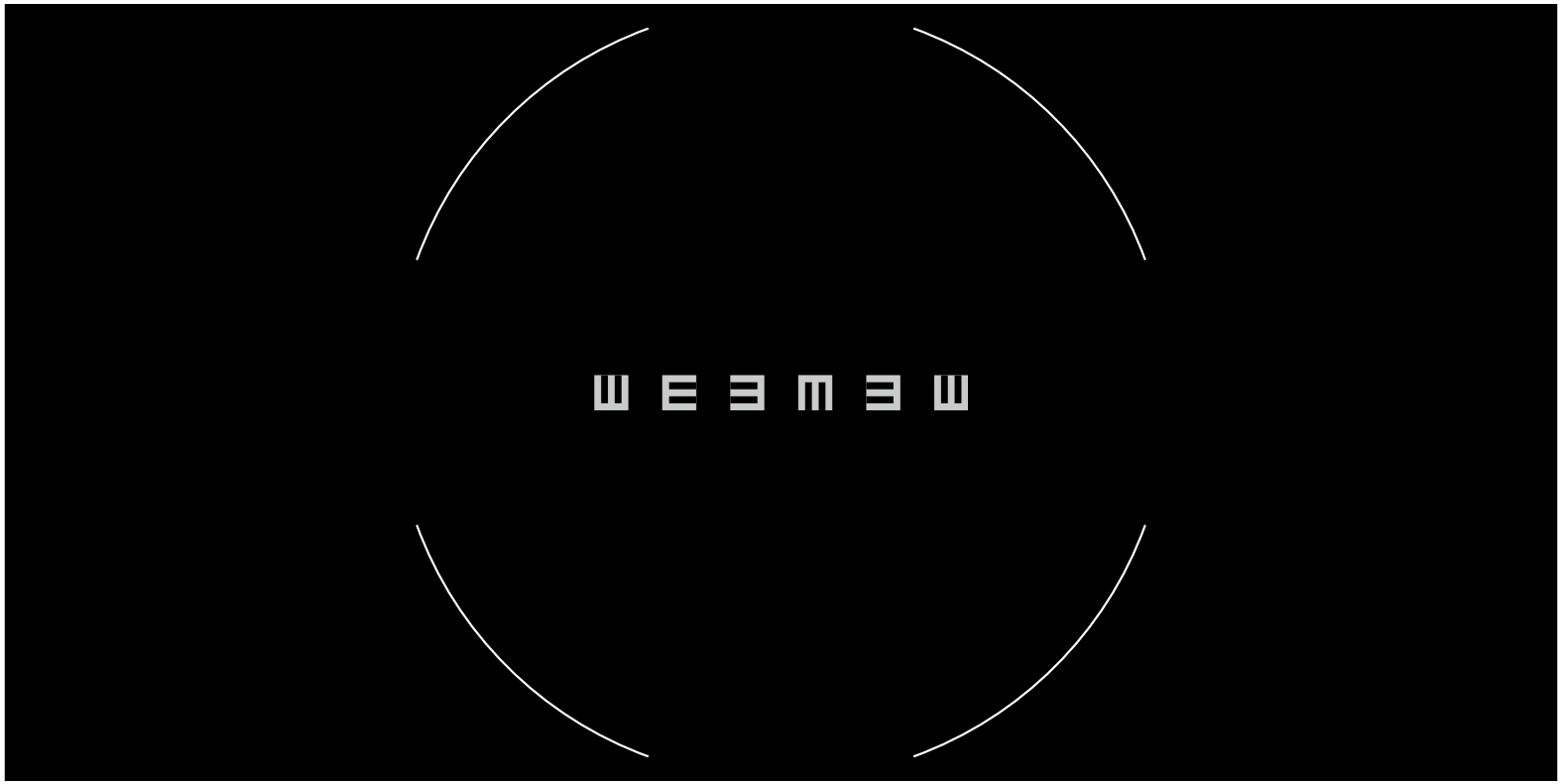


Method: Gaze Localization

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)

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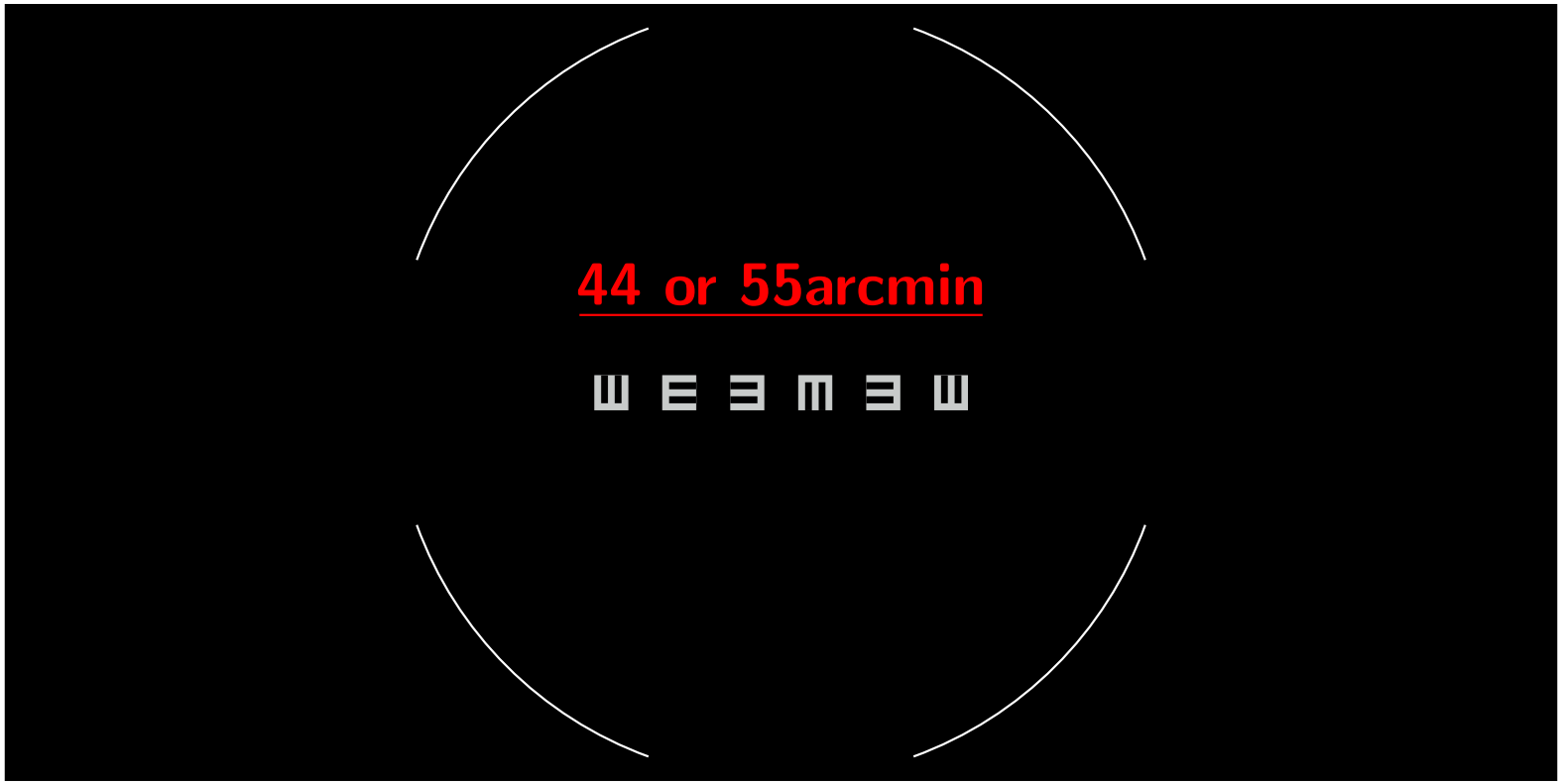


Strokewidth of 0.8 (20/16 line) or 1.0 (20/20 line)

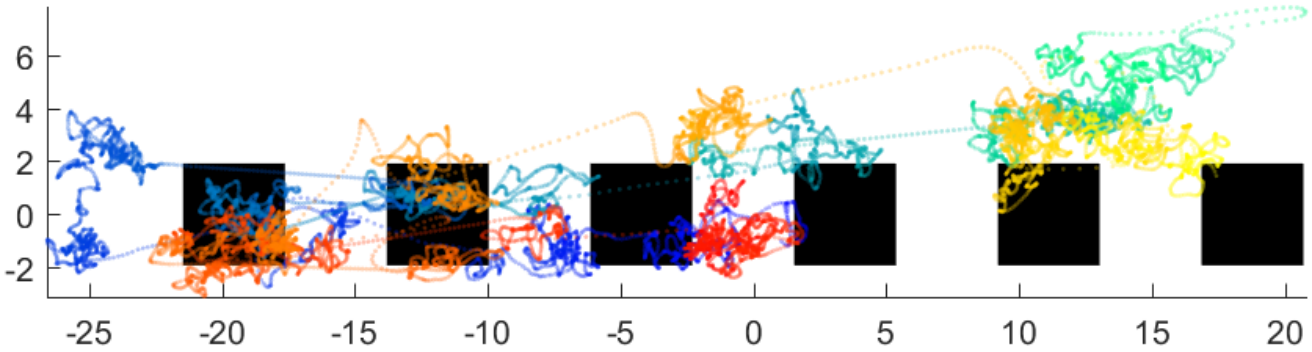
Data Collection

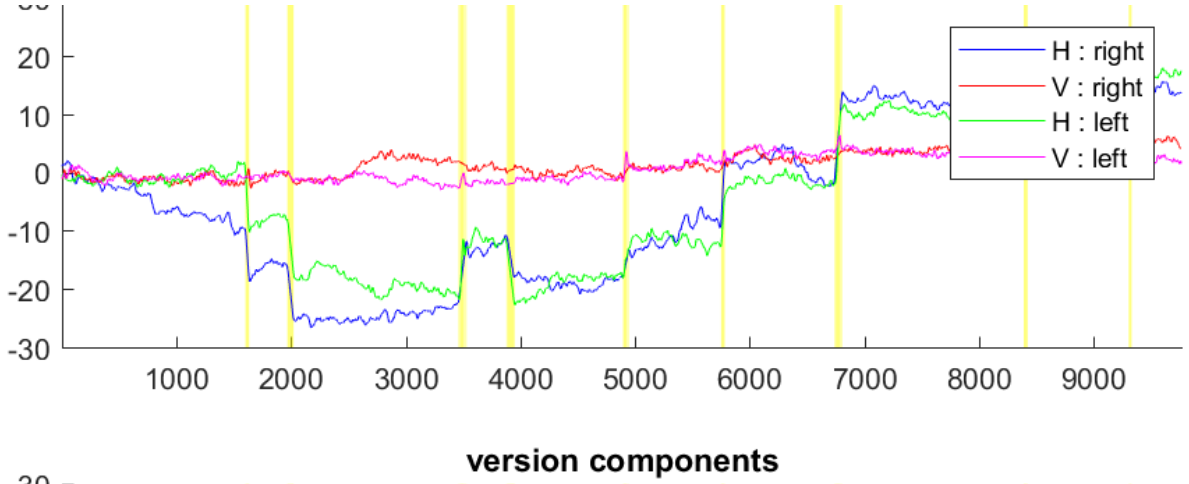
Subject	Total	S	T	Perf.	Avg Dur (s)	# Sacc	# Mon.
MAC[1]	134	87	117	85.3%	7.6 ± 2.1	1462	8
A024	96	22	55	69.4%	9.7 ± 2.2	312	0
A068	221	64	122	87.3%	9.1 ± 2.1	1037	0
A084	108	34	73	84.2%	11.0 ± 3.4	871	8
Anne[2]	108	64	66	81.6%	8.6 ± 3.3	658	23

- S = good tracking, good recalibration; T = good tracking, bad recalibration
- 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

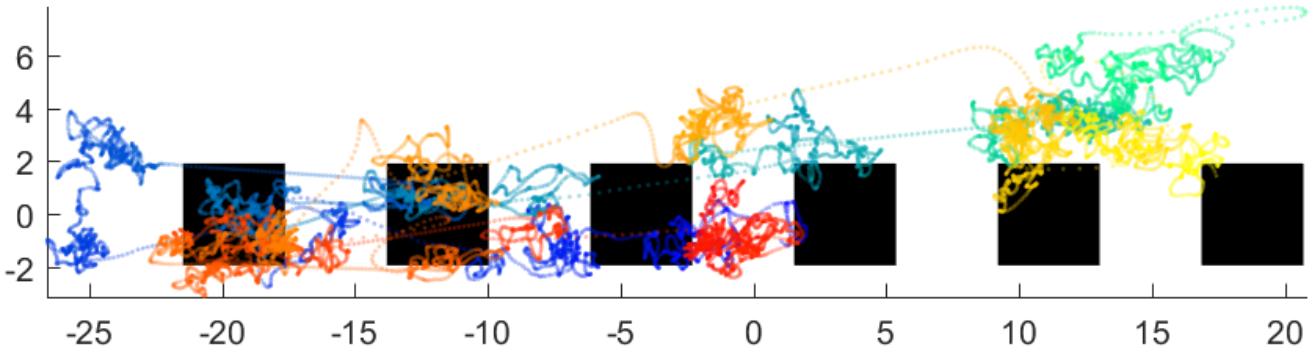


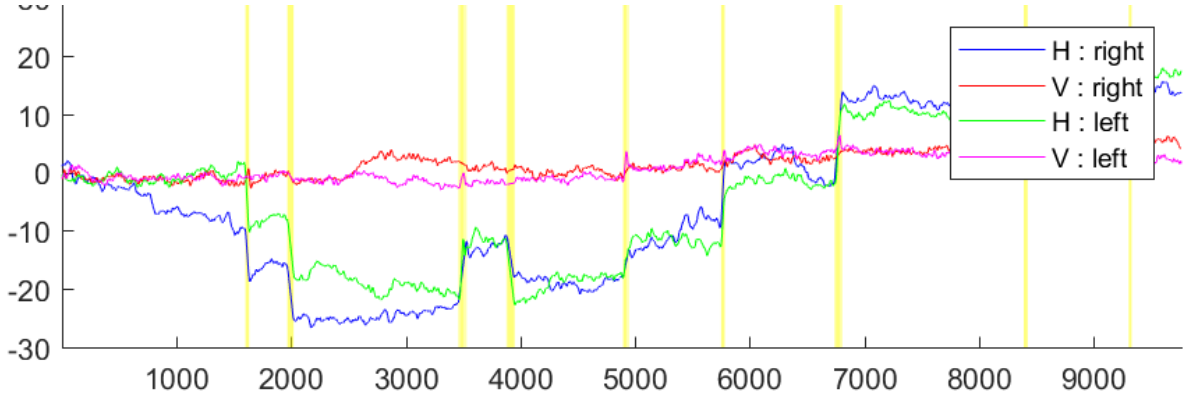


version components

Outline

1 Characteristics and correlations of left and right eye movements

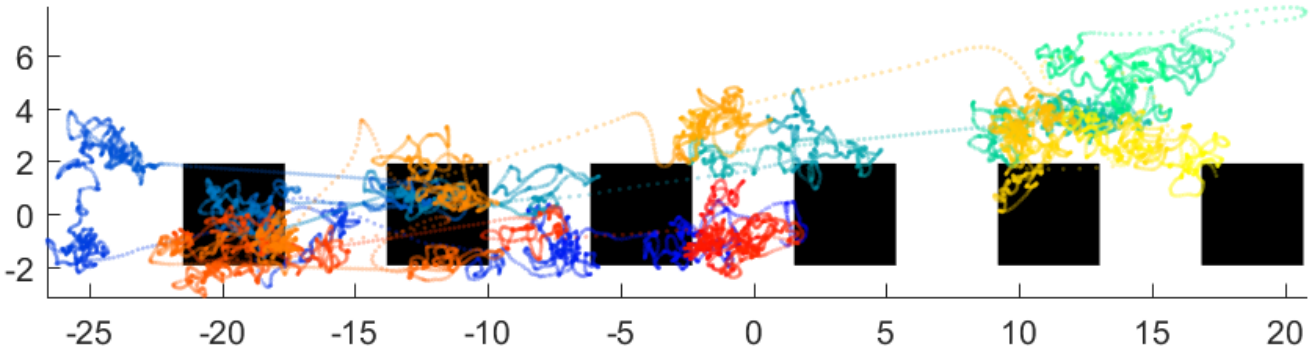


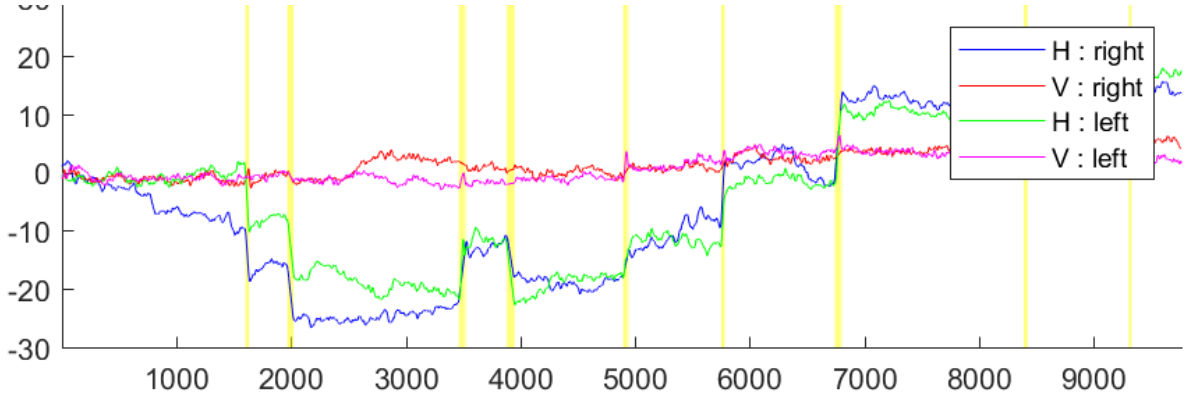


version components

Outline

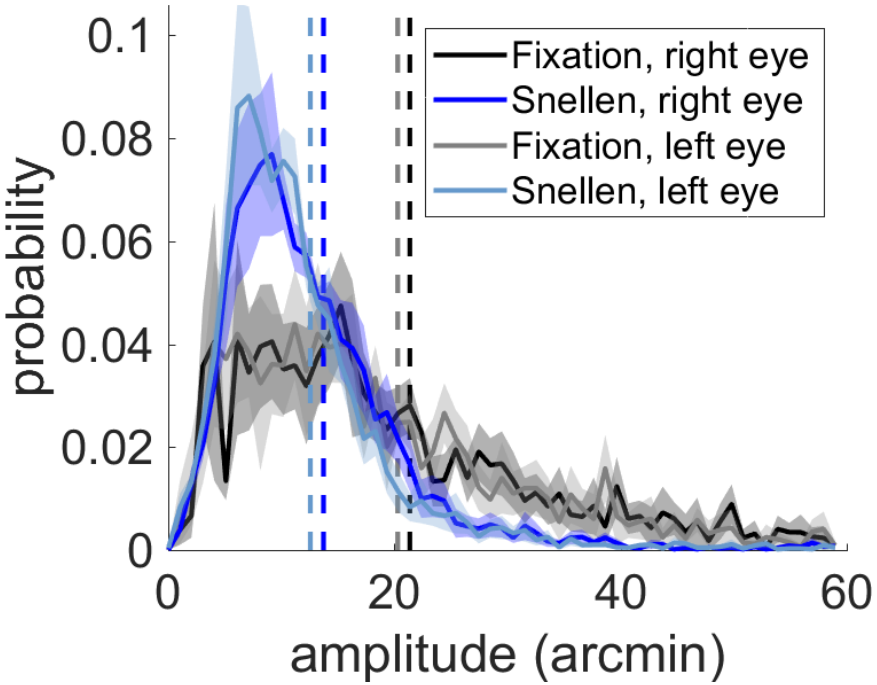
1. Characteristics and correlations of left and right eye movements
2. Differences between left and right eye movements





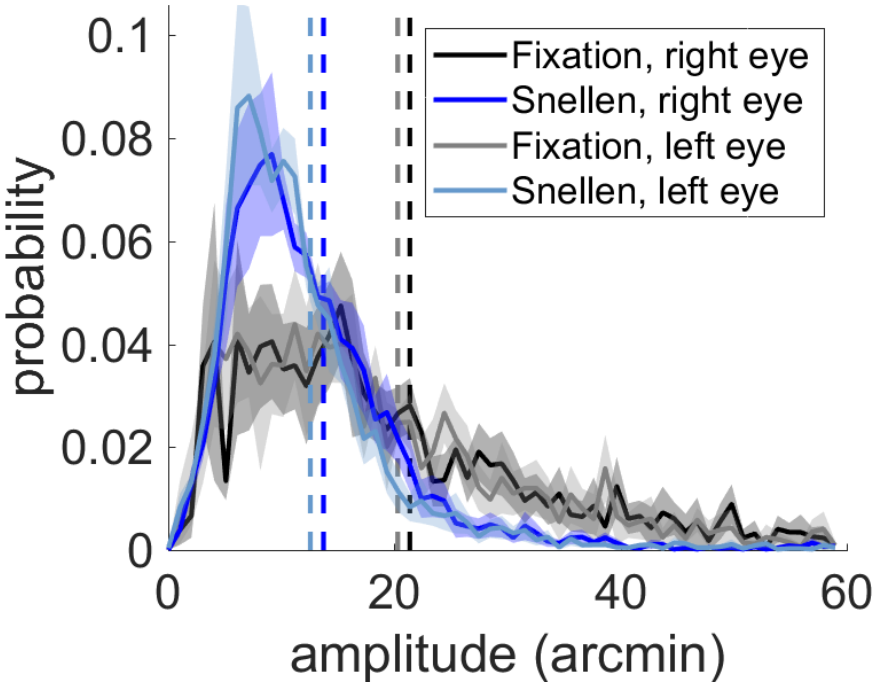
version components

Microsaccade Characteristics: Amplitude



Microsaccade Characteristics: Amplitude

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



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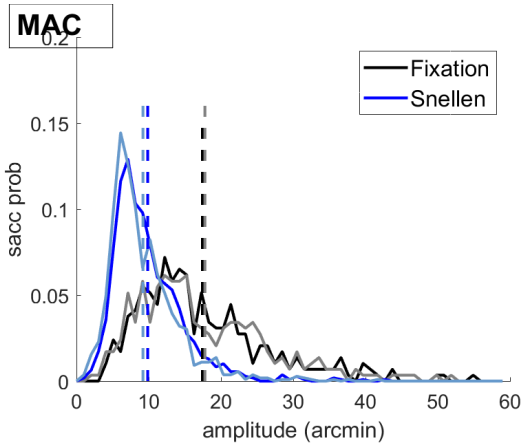

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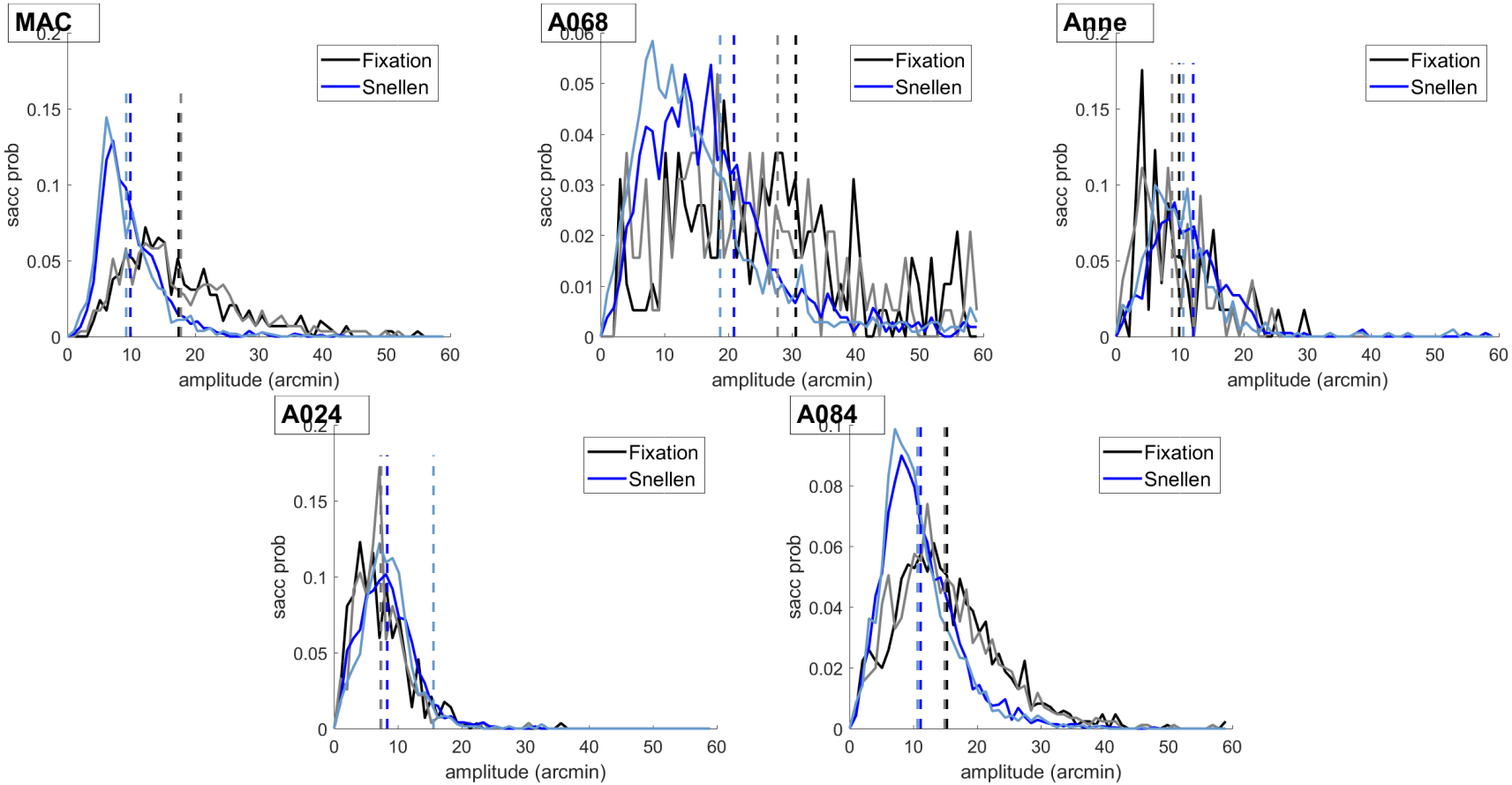
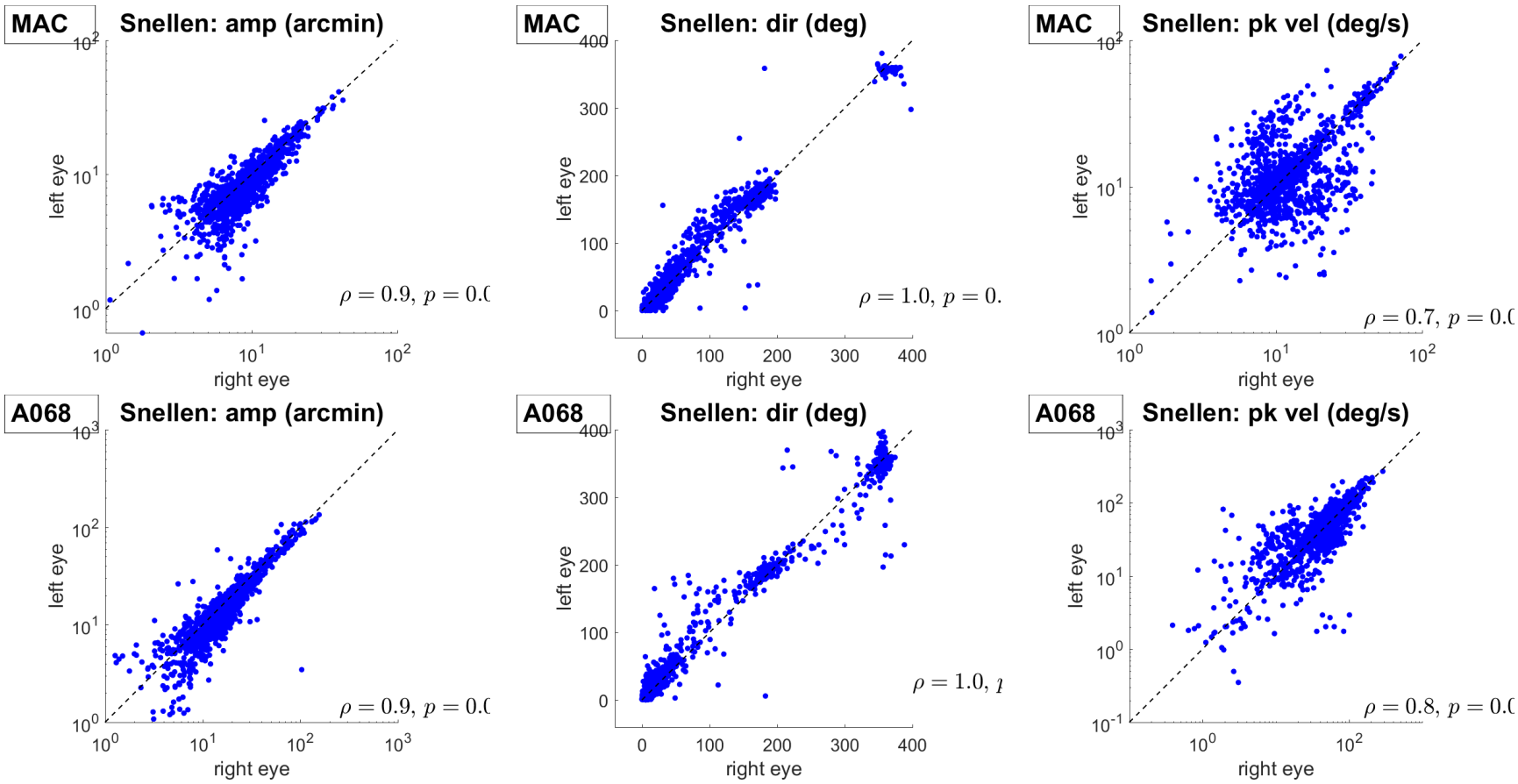


Microsaccades characteristics are correlated

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



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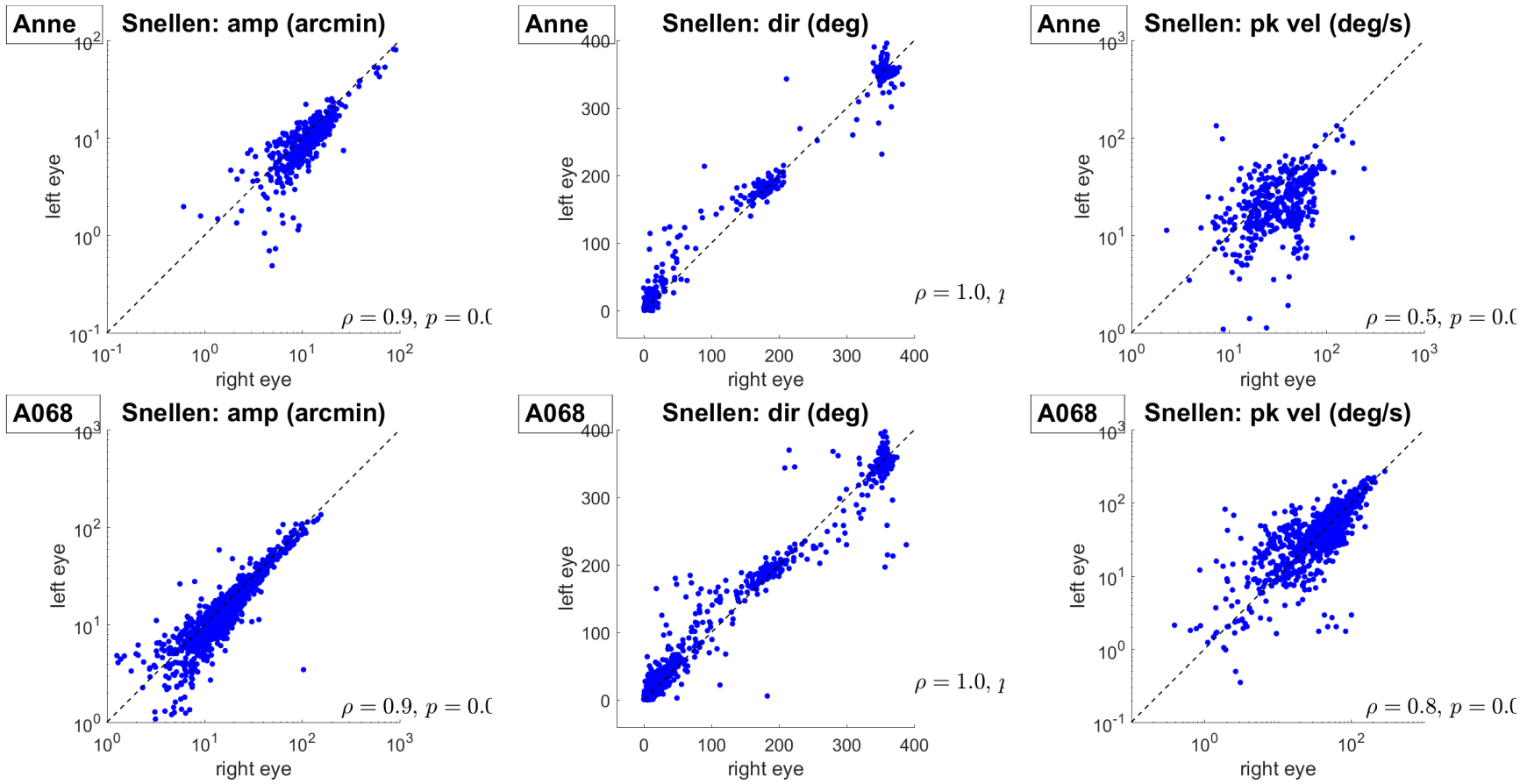

Microsaccades: Summary of characteristics and correlations

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

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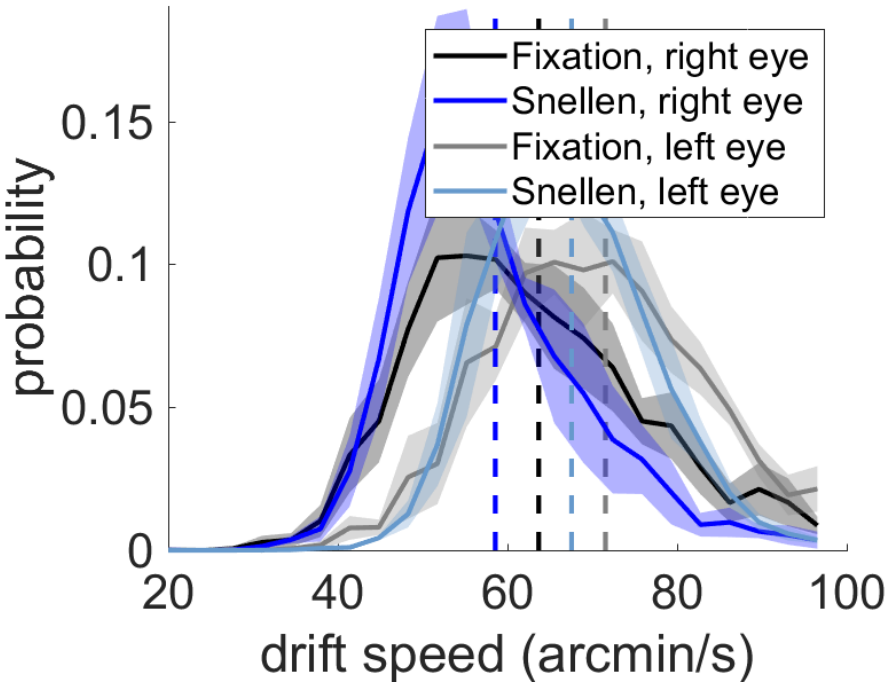
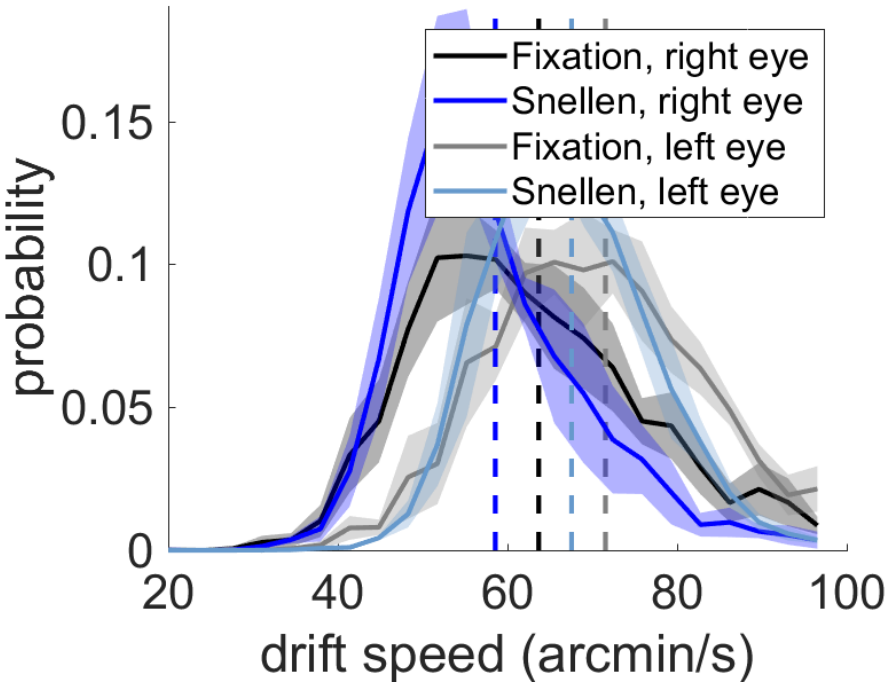
1. Microsaccades shift both lines of sight across the optotypes.
2. Microsaccade characteristics are highly correlated in the two eyes.

Drift Characteristics: Amplitude

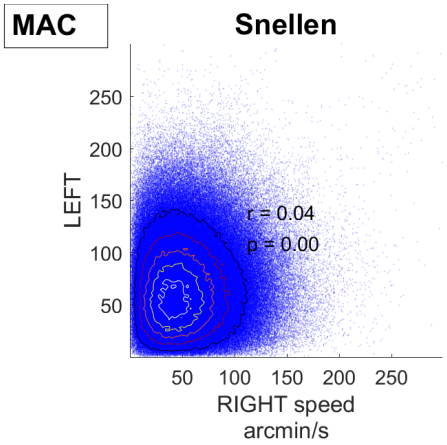


Drift Characteristics: Amplitude

Drift is slower during the Snellen test. .

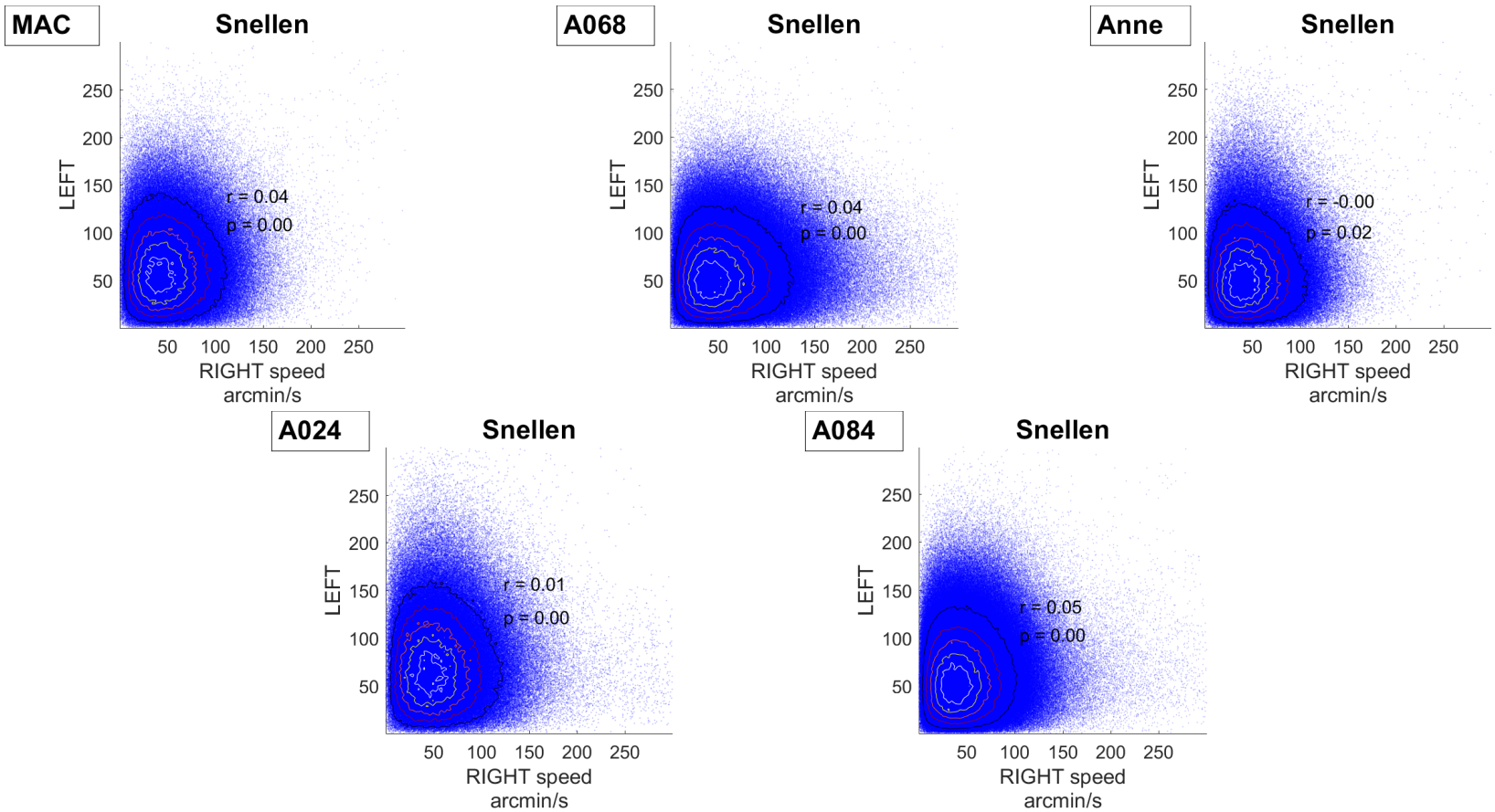


Drift Characteristics: Instantaneous Speed

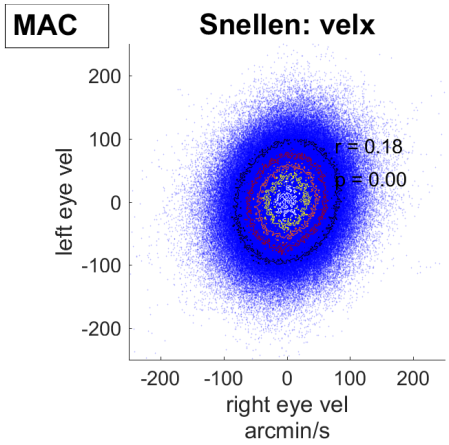


Drift Characteristics: Instantaneous Speed

Instantaneous drift speed is uncorrelated in the two eyes.



Drift Characteristics: Instantaneous Horizontal Velocity



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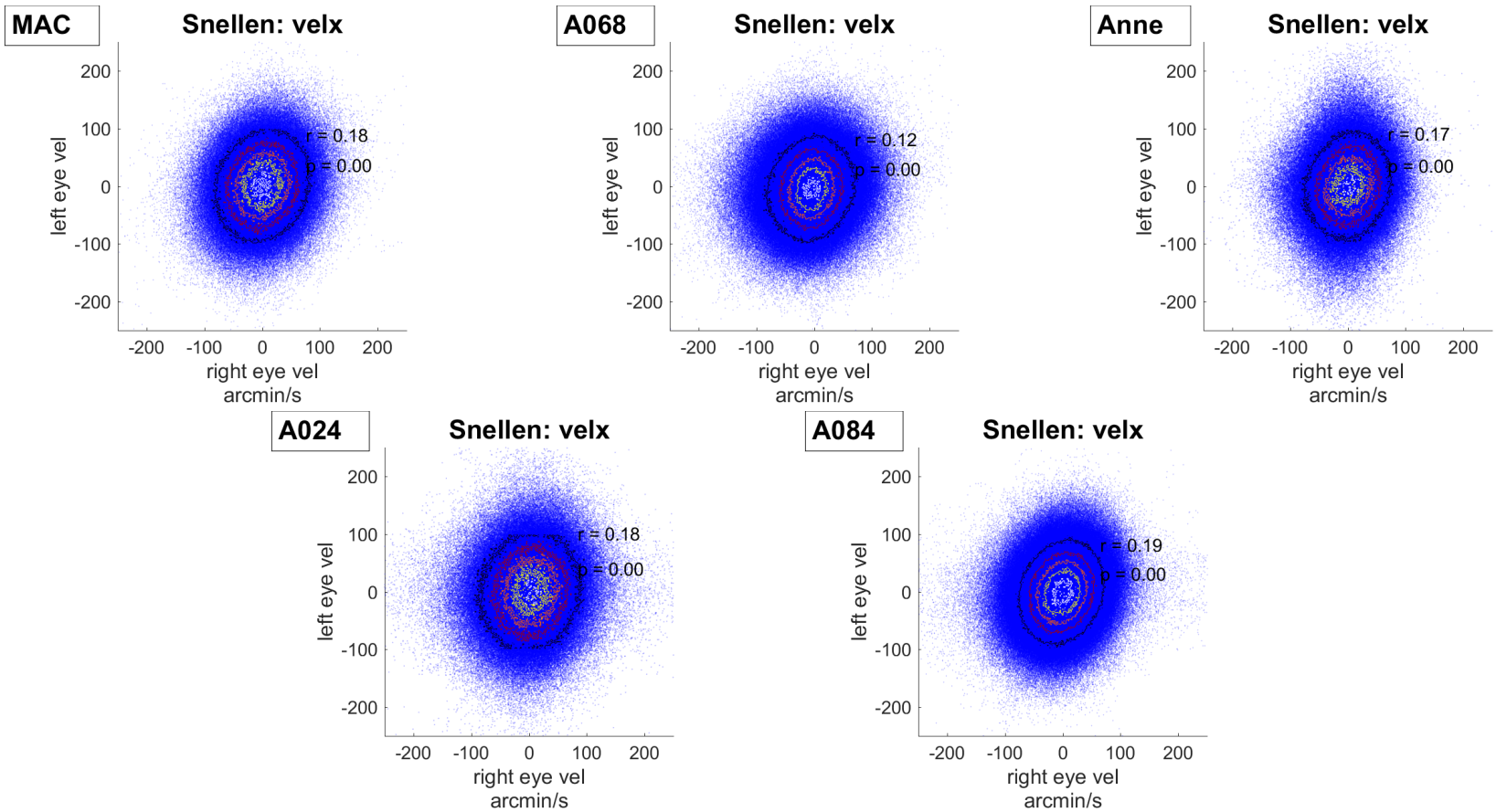
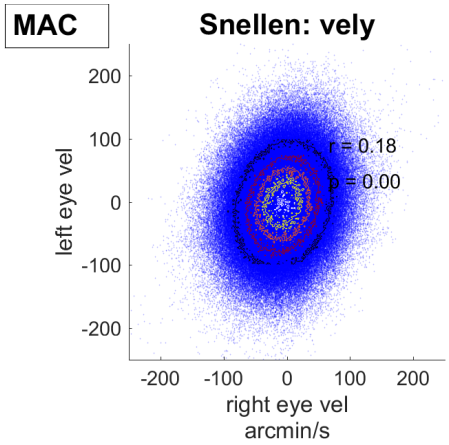


Drift Characteristics: Instantaneous Vertical Velocity



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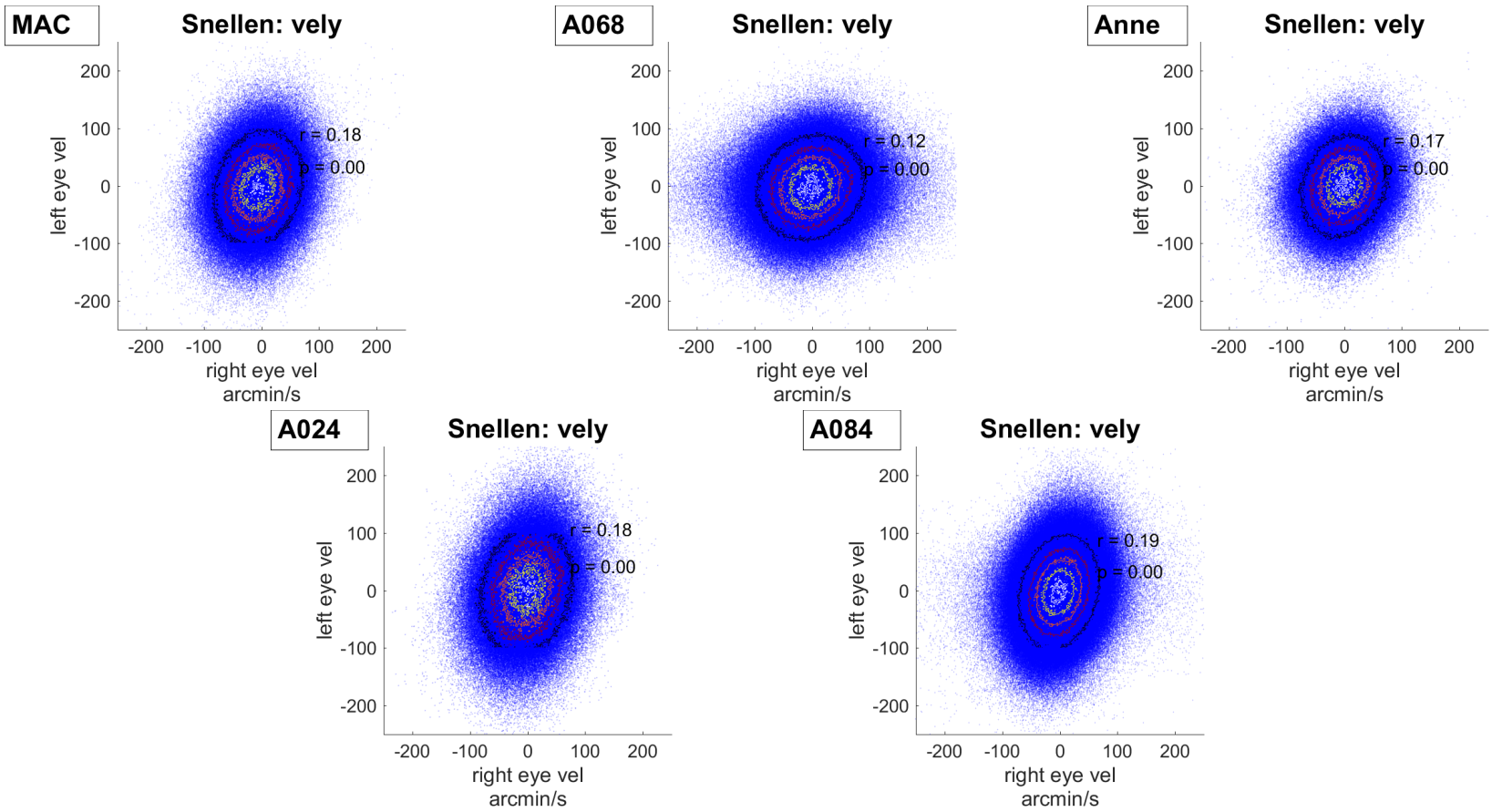
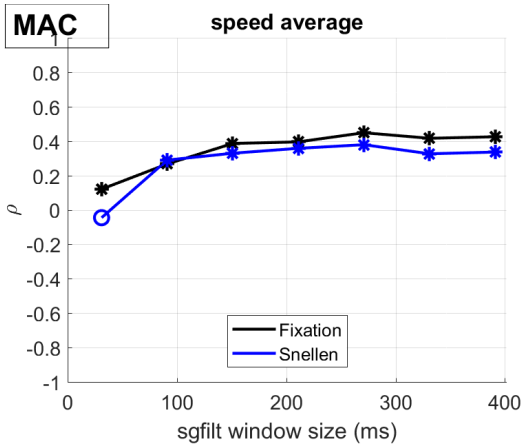
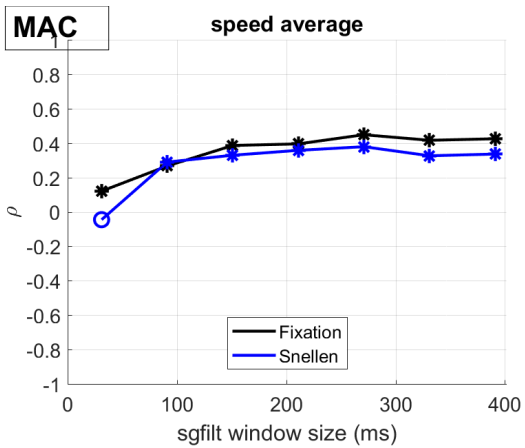


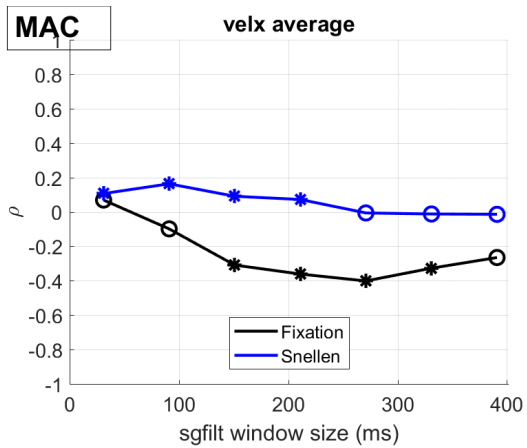
Drift Characteristics: Correlation by time scale

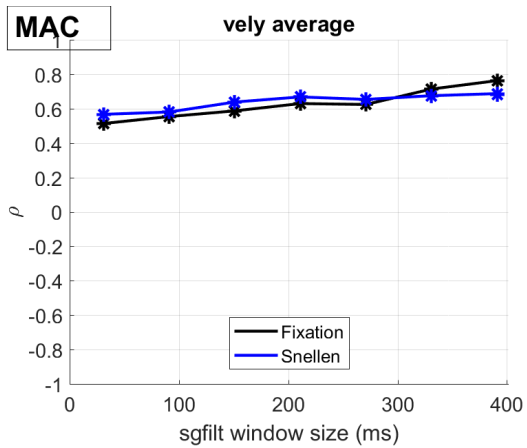


Drift Characteristics: Correlation by time scale

Speed becomes more correlated over longer time periods, driven primarily by increased correlation in vertical eye velocity.







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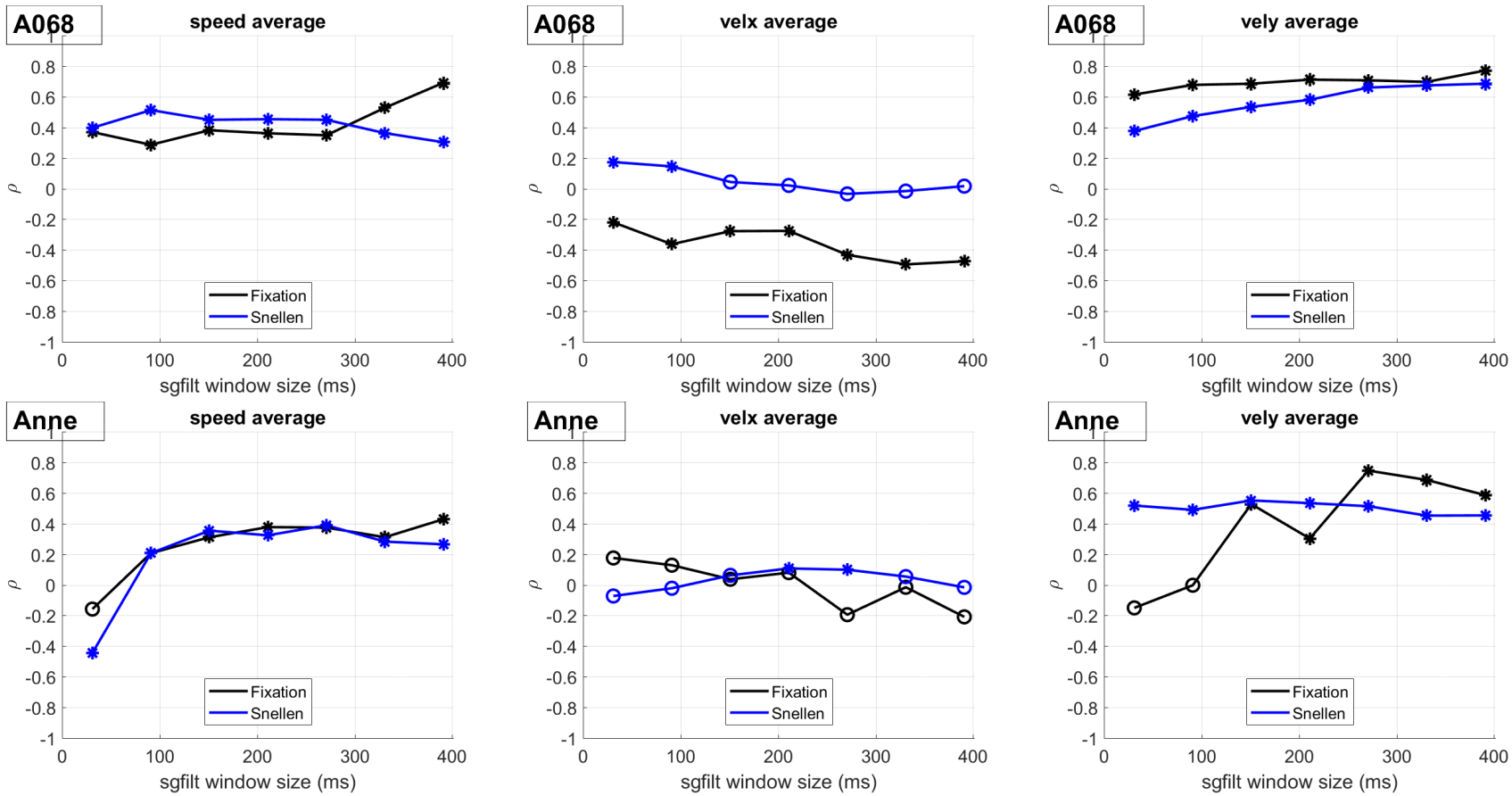

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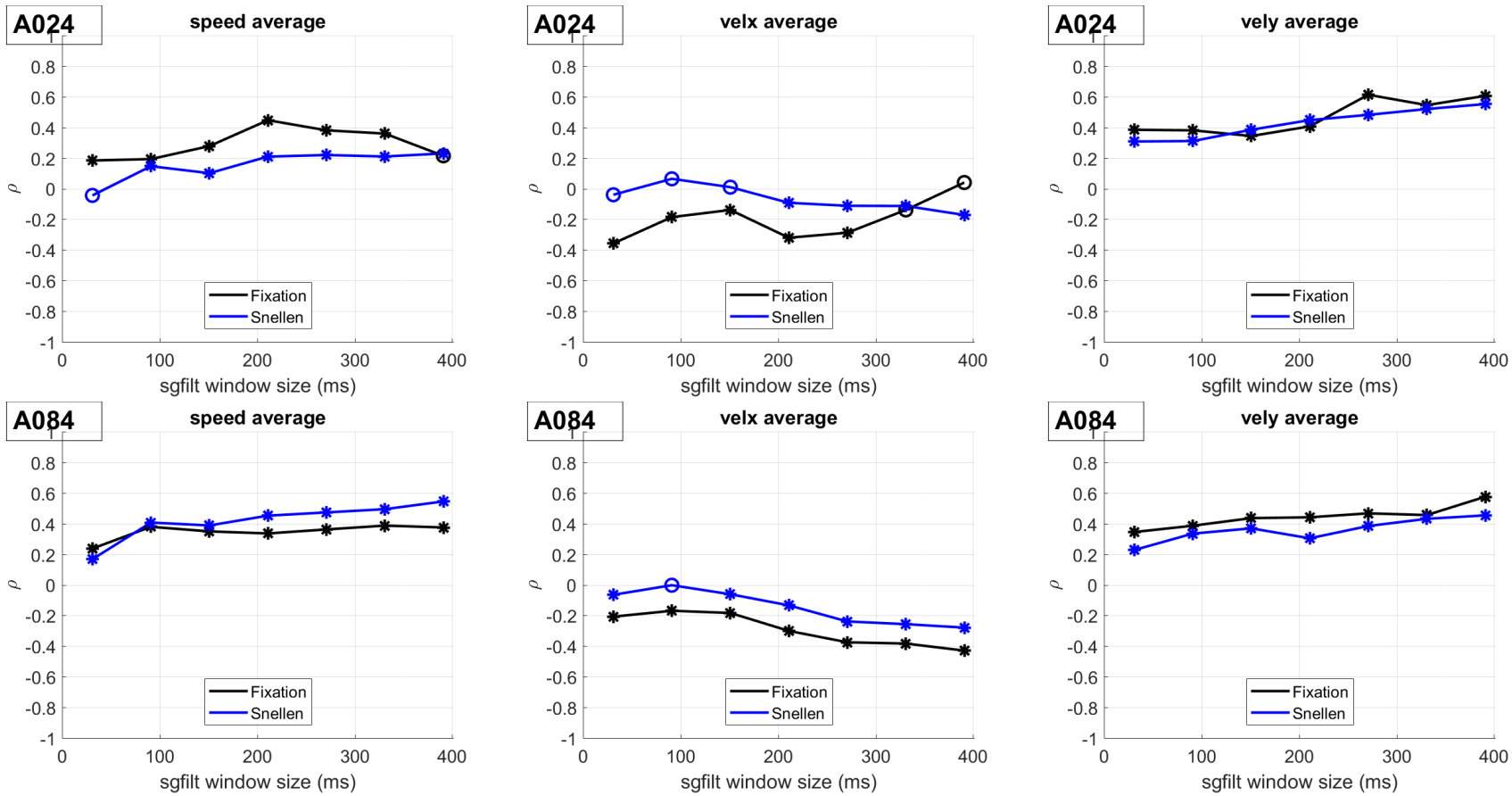


Drifts: Summary of characteristics and correlations

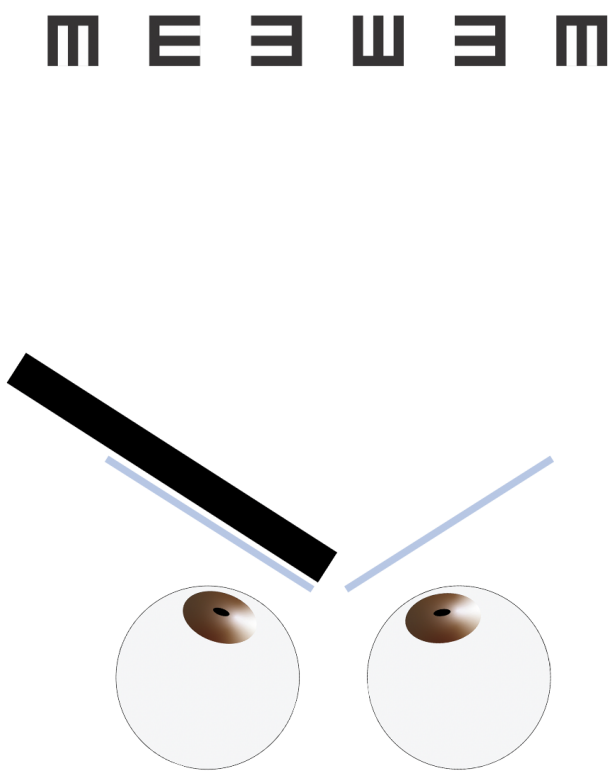
1. Each eye drifts less during the Snellen test than during sustained fixation.

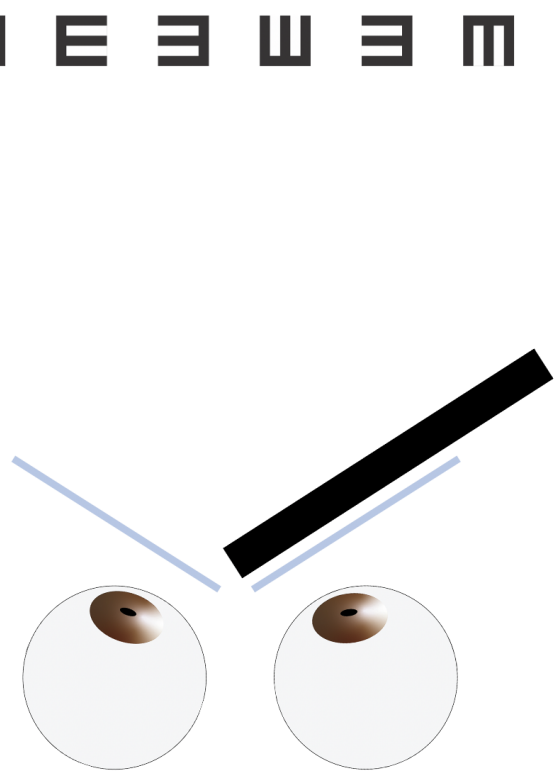
Drifts: Summary of characteristics and correlations

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.

Binocular coordination with one occluded eye

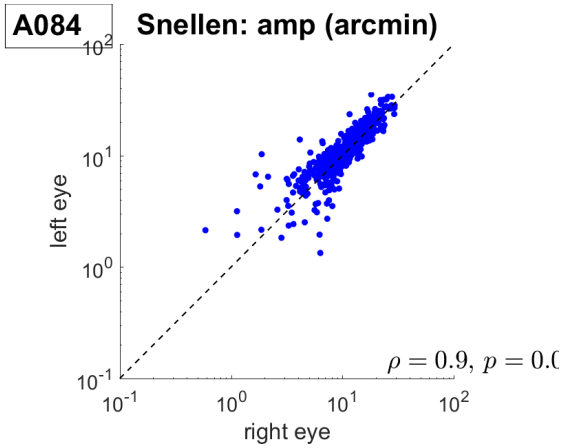
Does binocular coordination arise from similar retinal input to each eye?

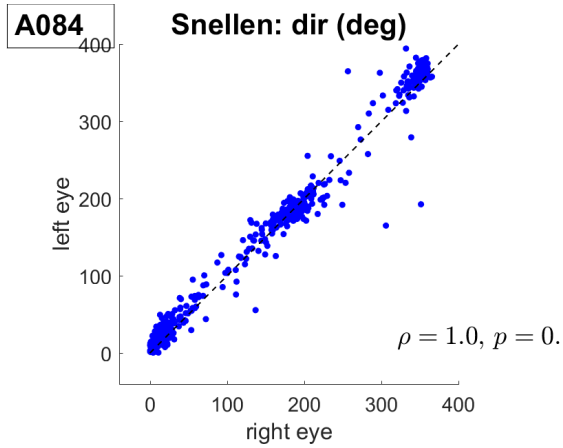


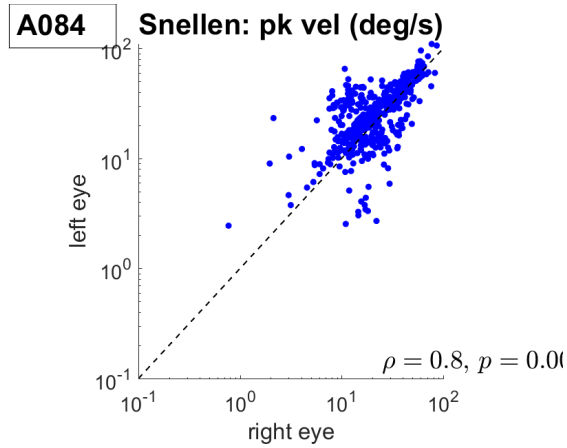


Binocular coordination with one occluded eye

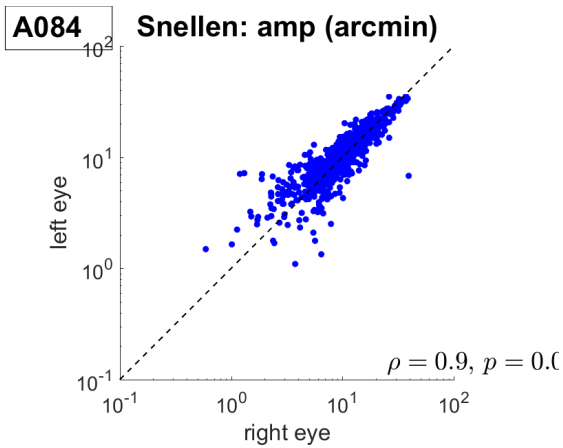
Right eye occluded:

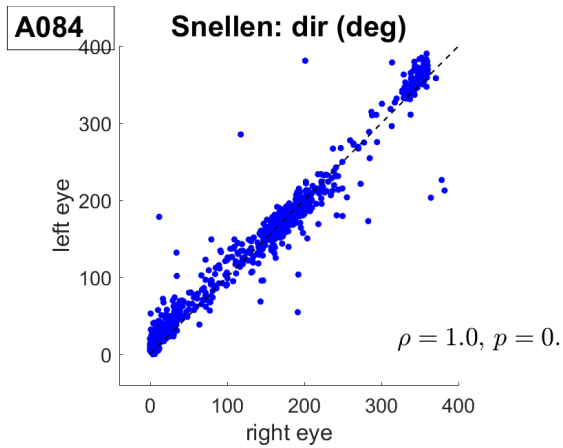


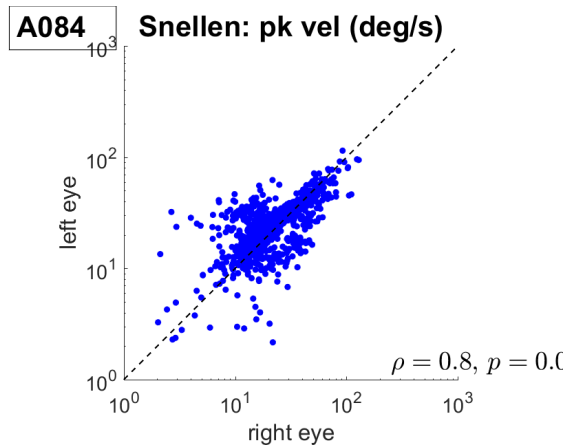




Left eye occluded:







Drift Characteristics: Instantaneous Speed

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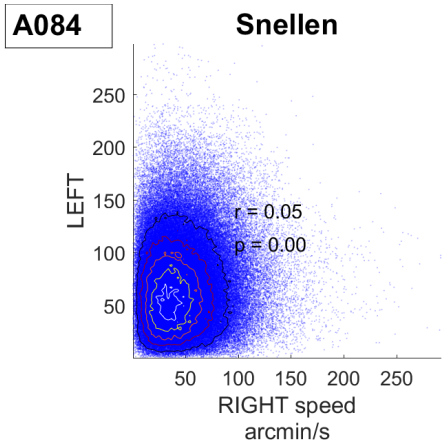
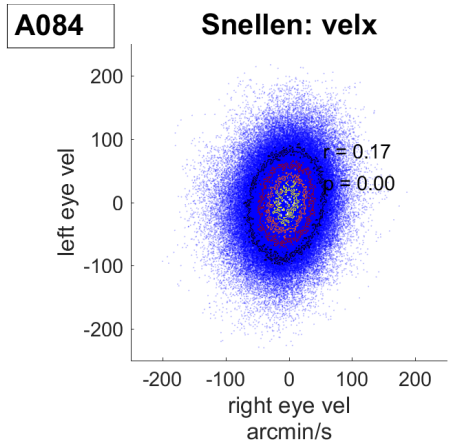
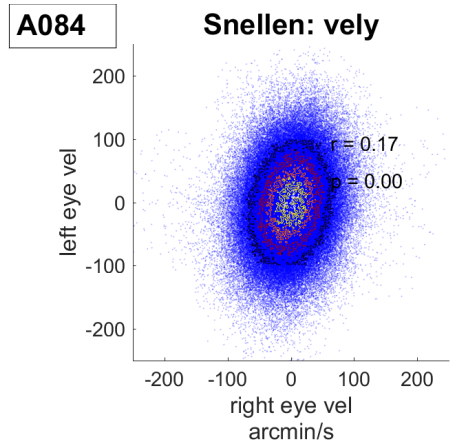
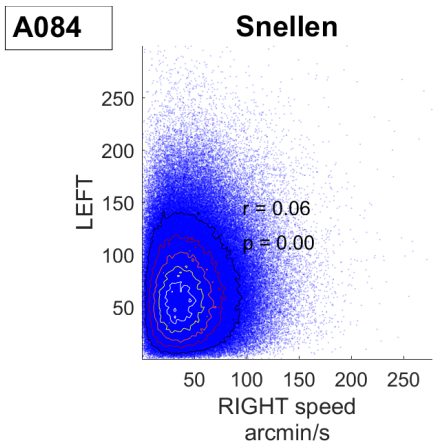
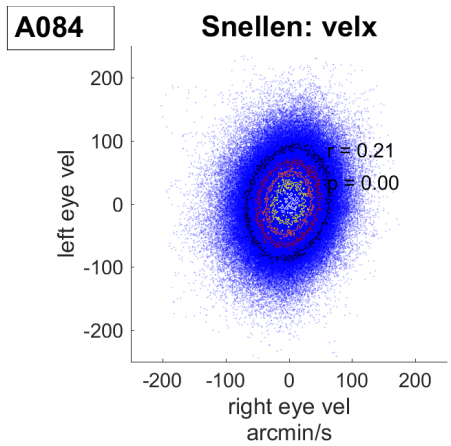


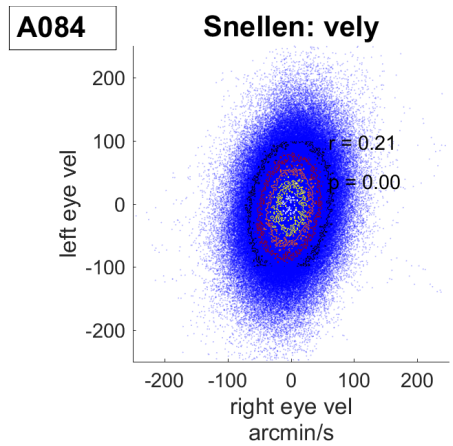




Left eye occluded:





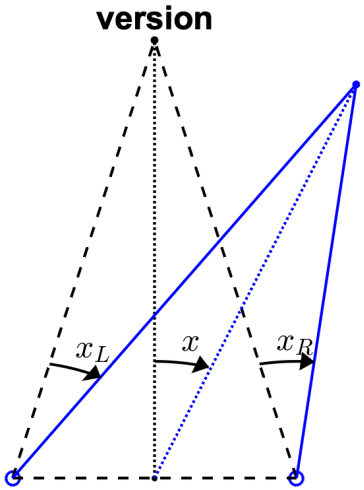


Version and Vergence Components

Version: avg movement of the eyes

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

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



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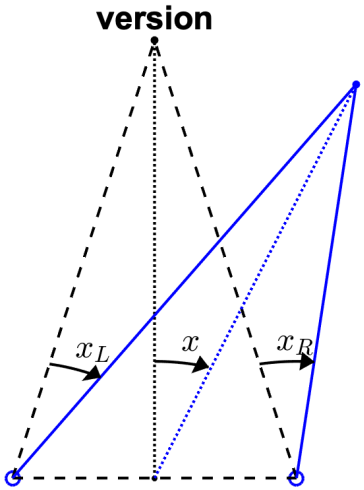
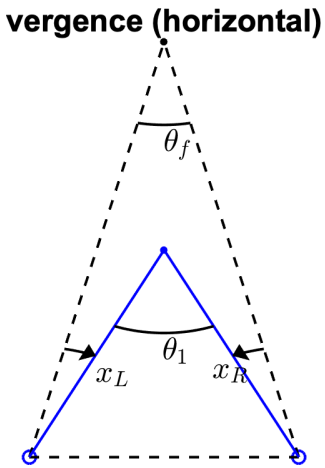


Vergence: diff. in the movements of the eyes*

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

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



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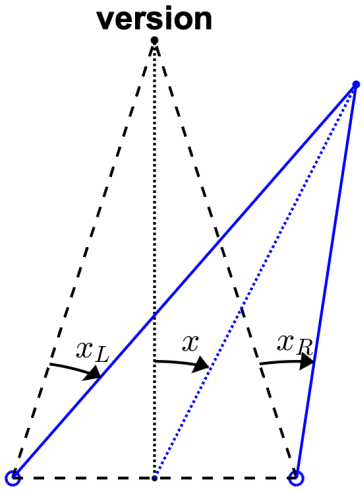
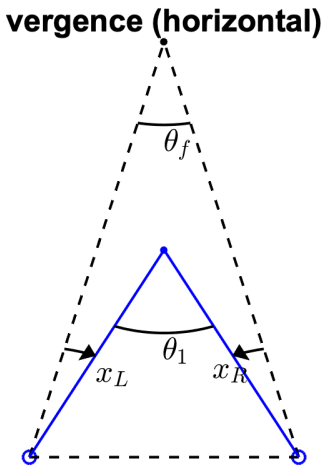


Vergence: diff. in the movements of the eyes*

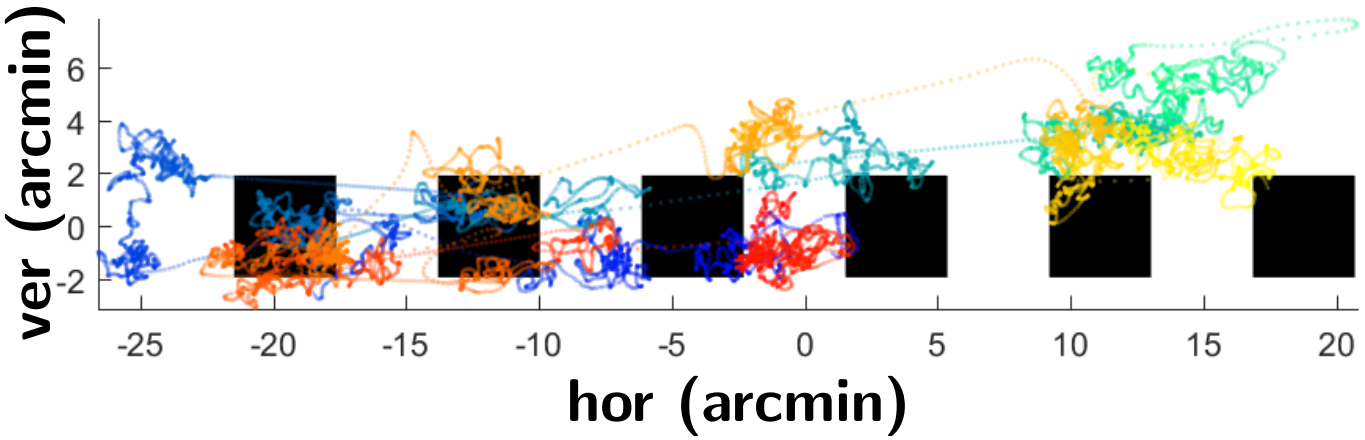
$$V_x = (x_R - x_L)/2$$

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

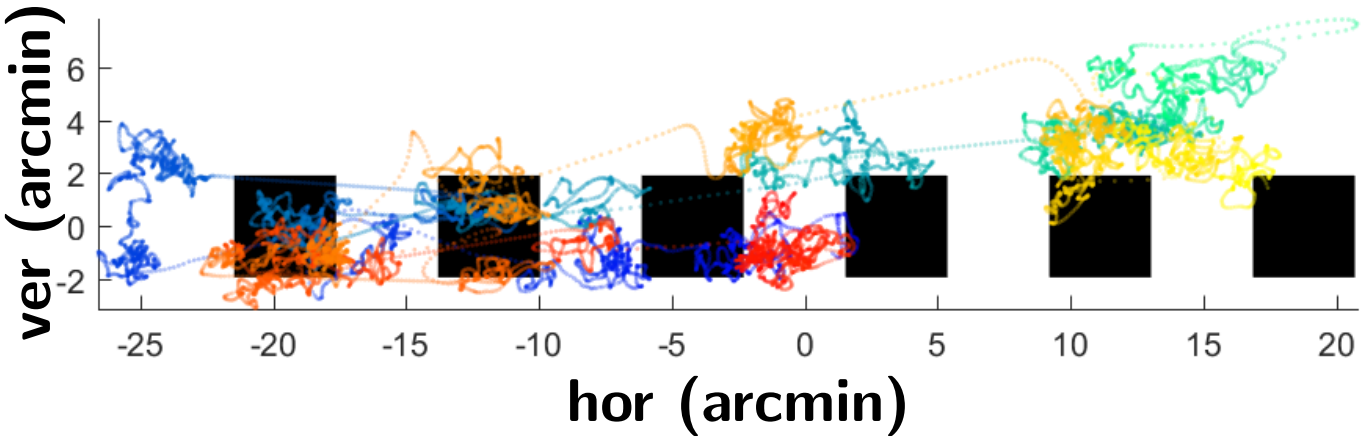


* **1.** $V_x > 0$: uncrossed. $V_x < 0$: crossed **2.** Vergence is measured relative to the fixation point, which we assume is located at (0, 0) on the monitor.

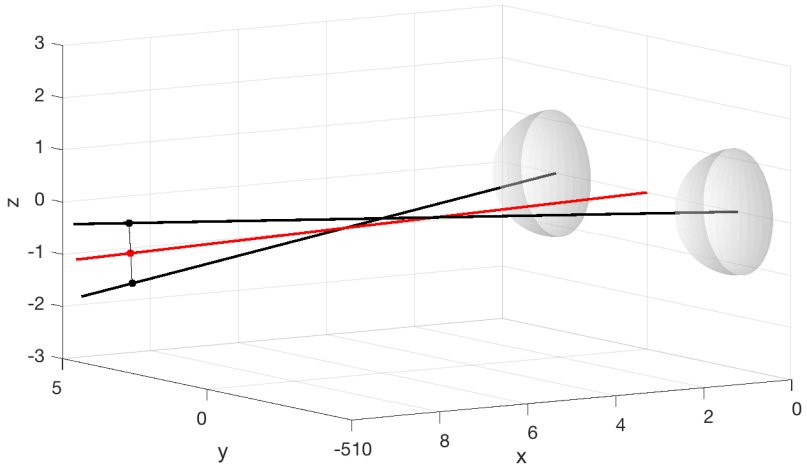
Binocular Gaze Point



Binocular Gaze Point



BGP = midpoint of line of closest approach



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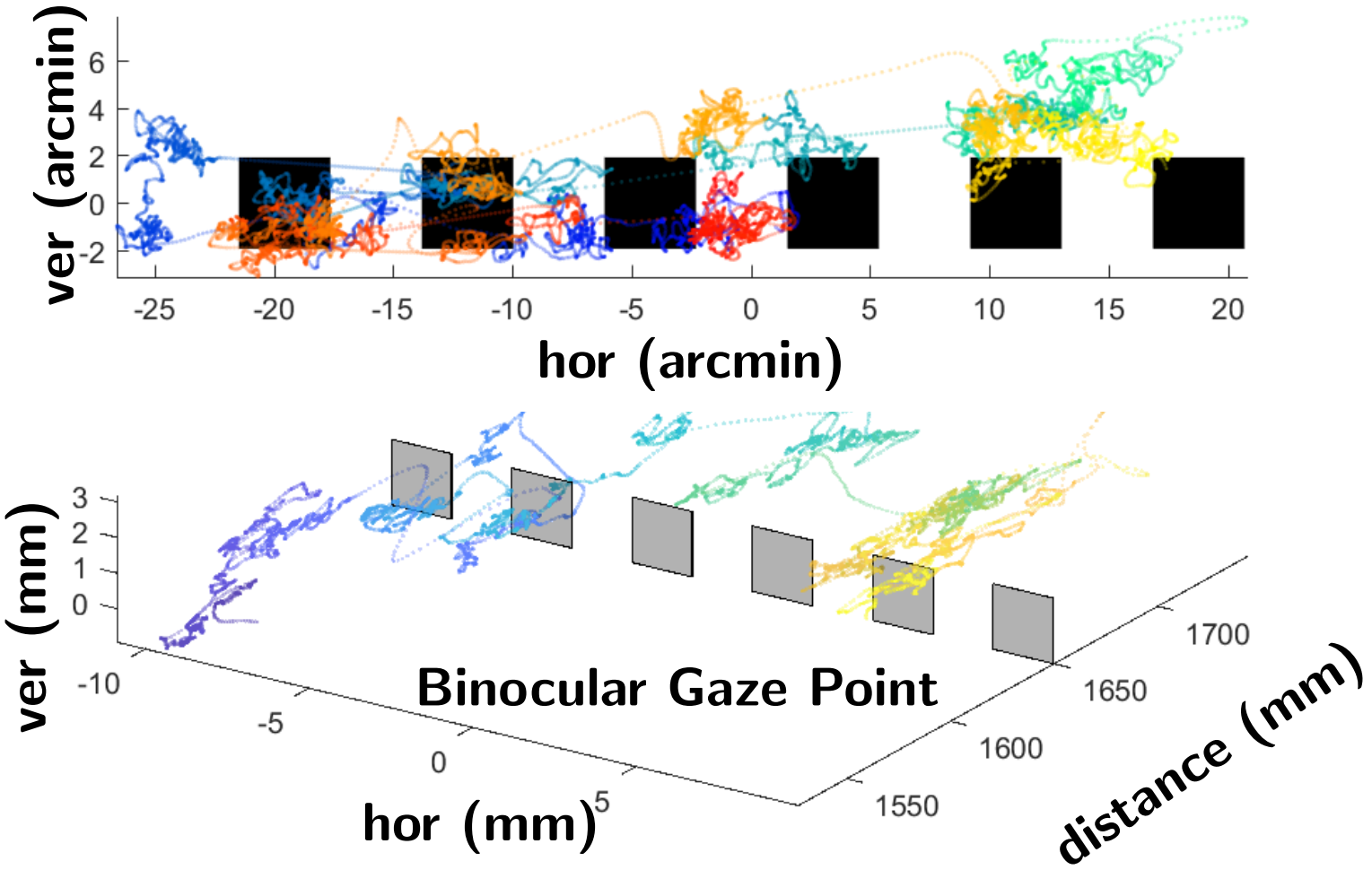
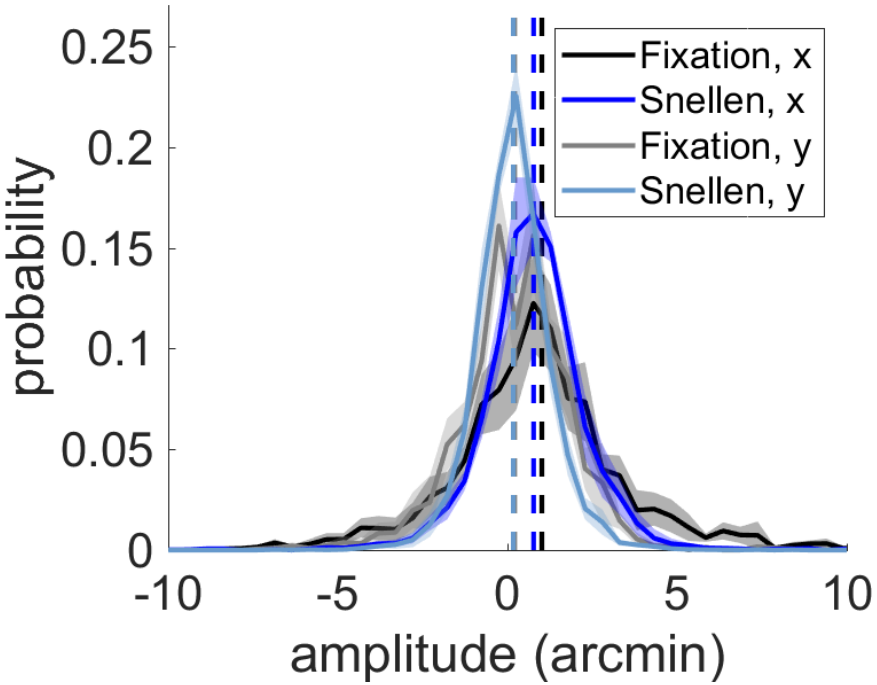
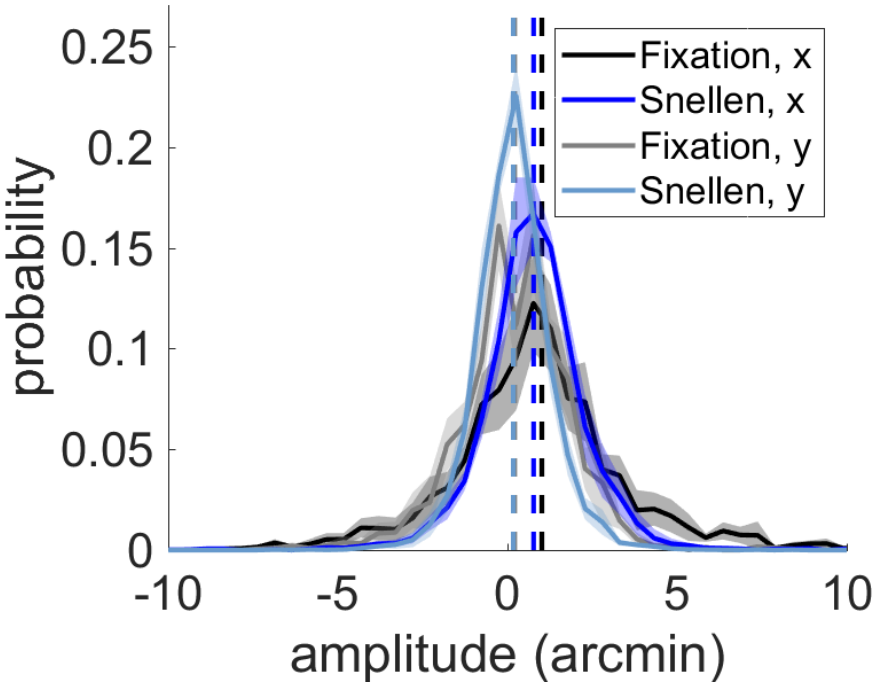


Microsaccades change horizontal vergence



Microsaccades change horizontal vergence

Microsaccades are on average uncrossing gaze (horizontally) but not changing vertical vergence.



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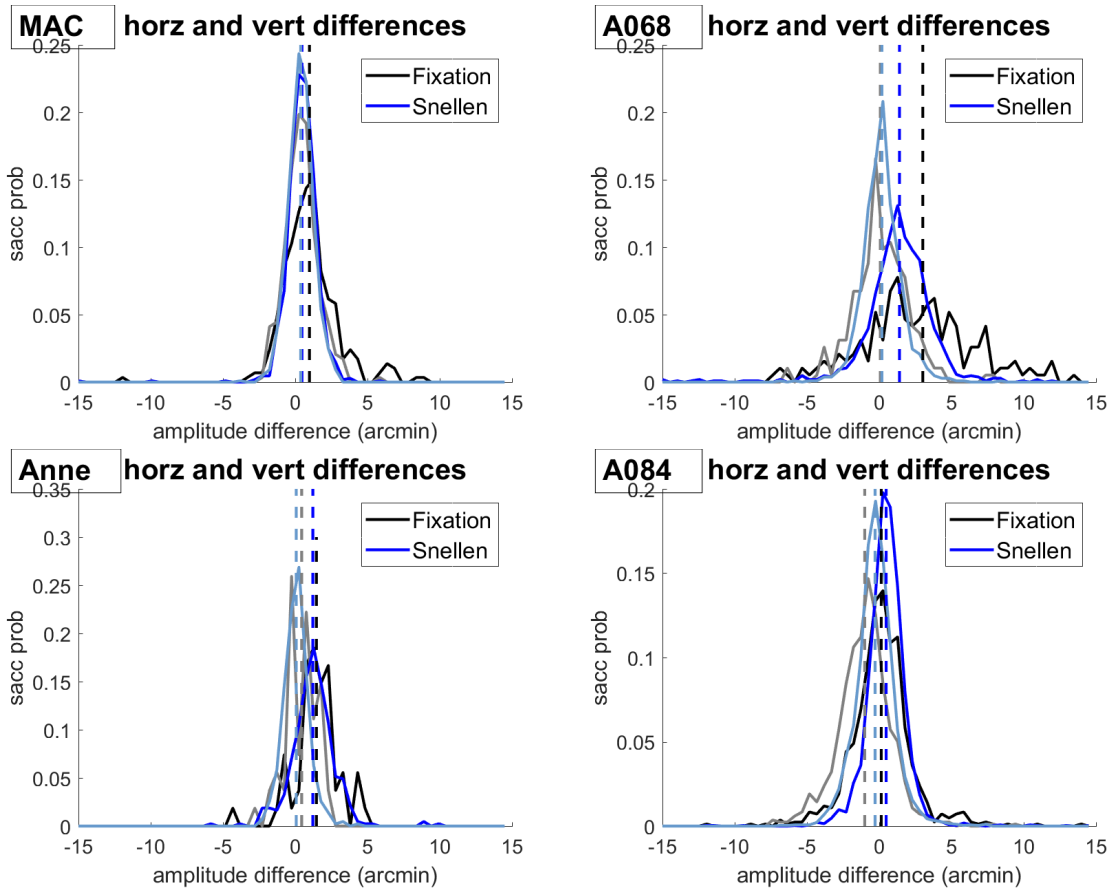
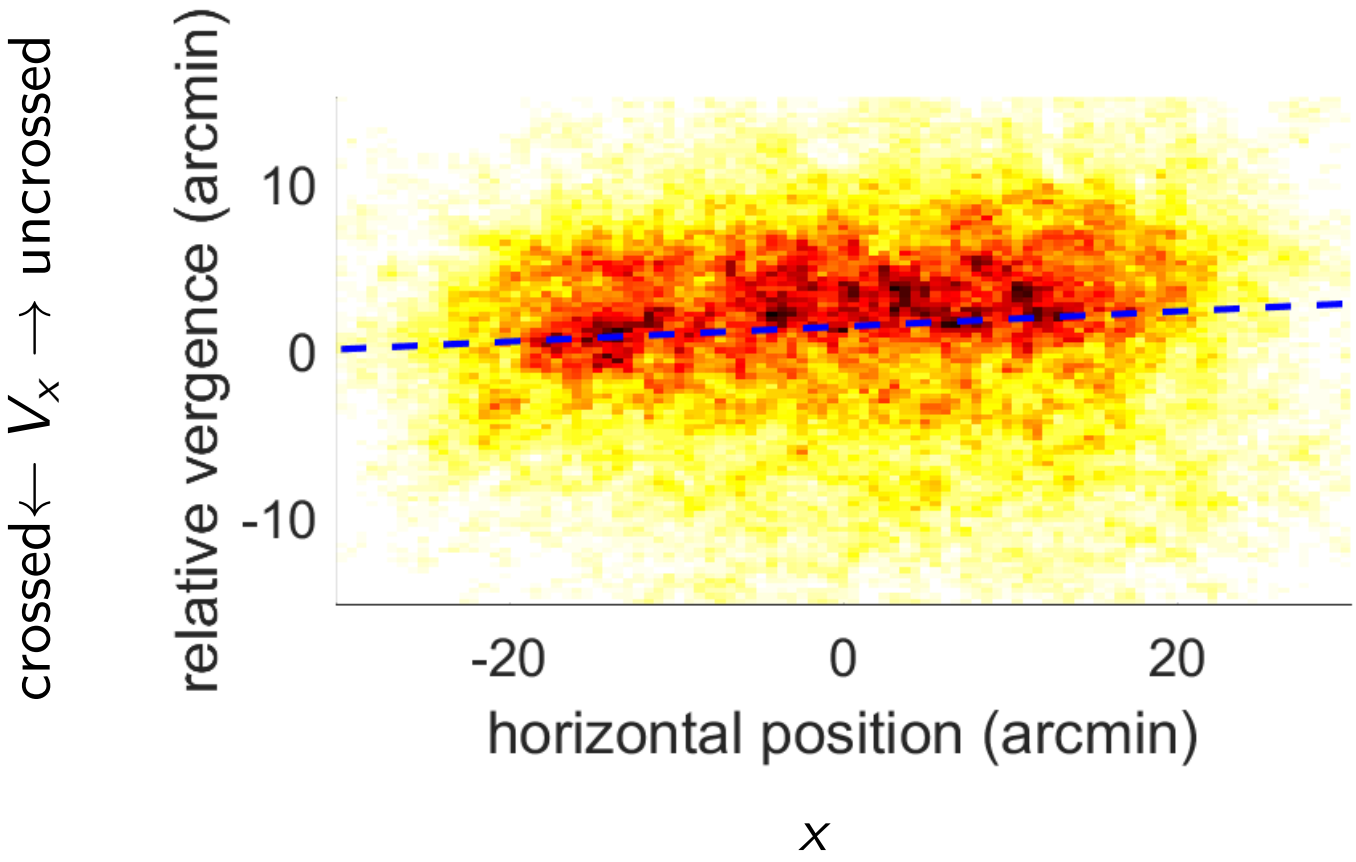


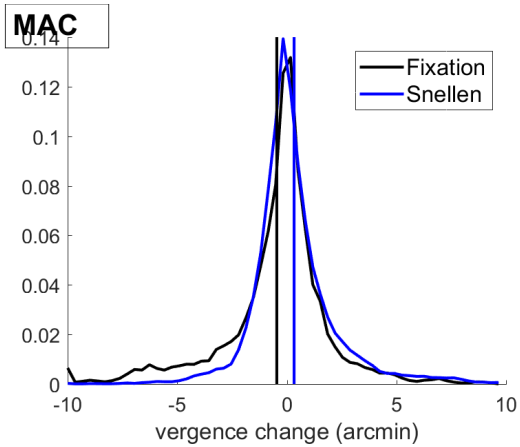
BGP across stimulus

Go to 3D figures in Matlab.



Drifts do not change horizontal vergence

Change in vergence from start of drift.



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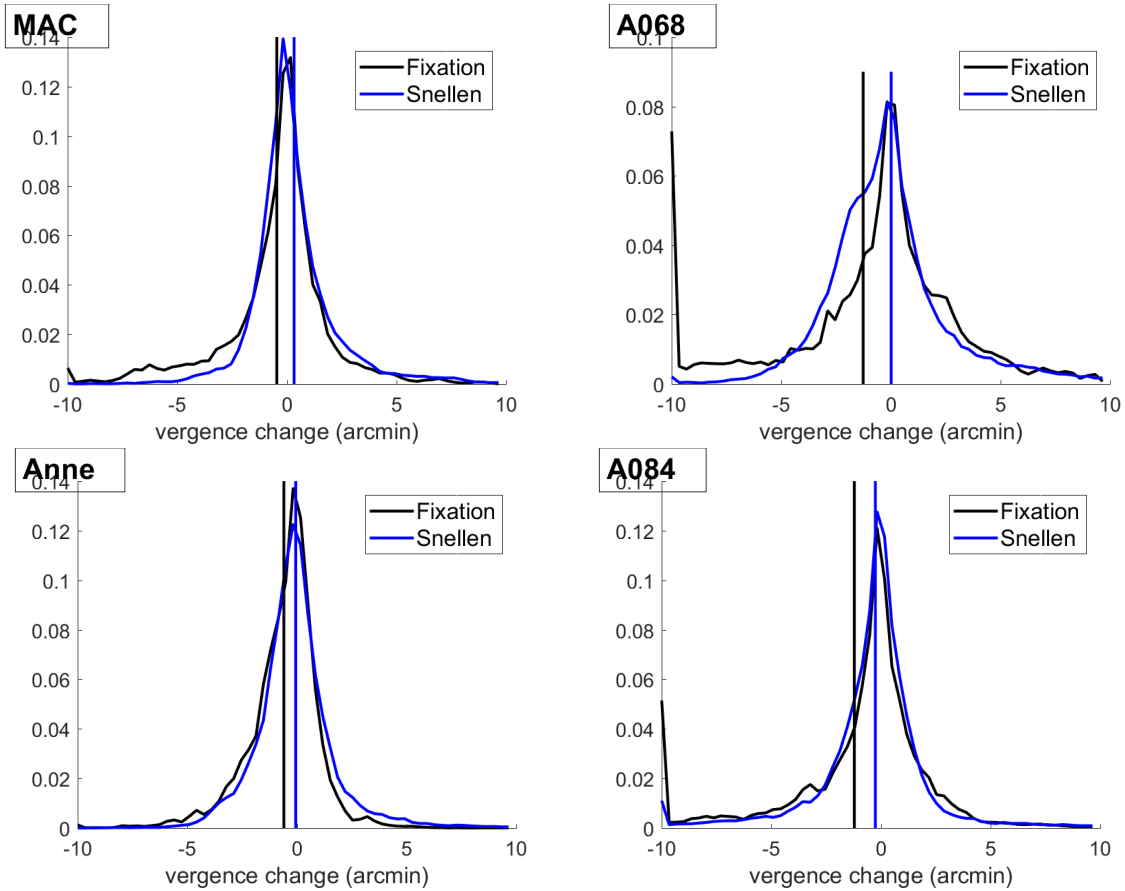

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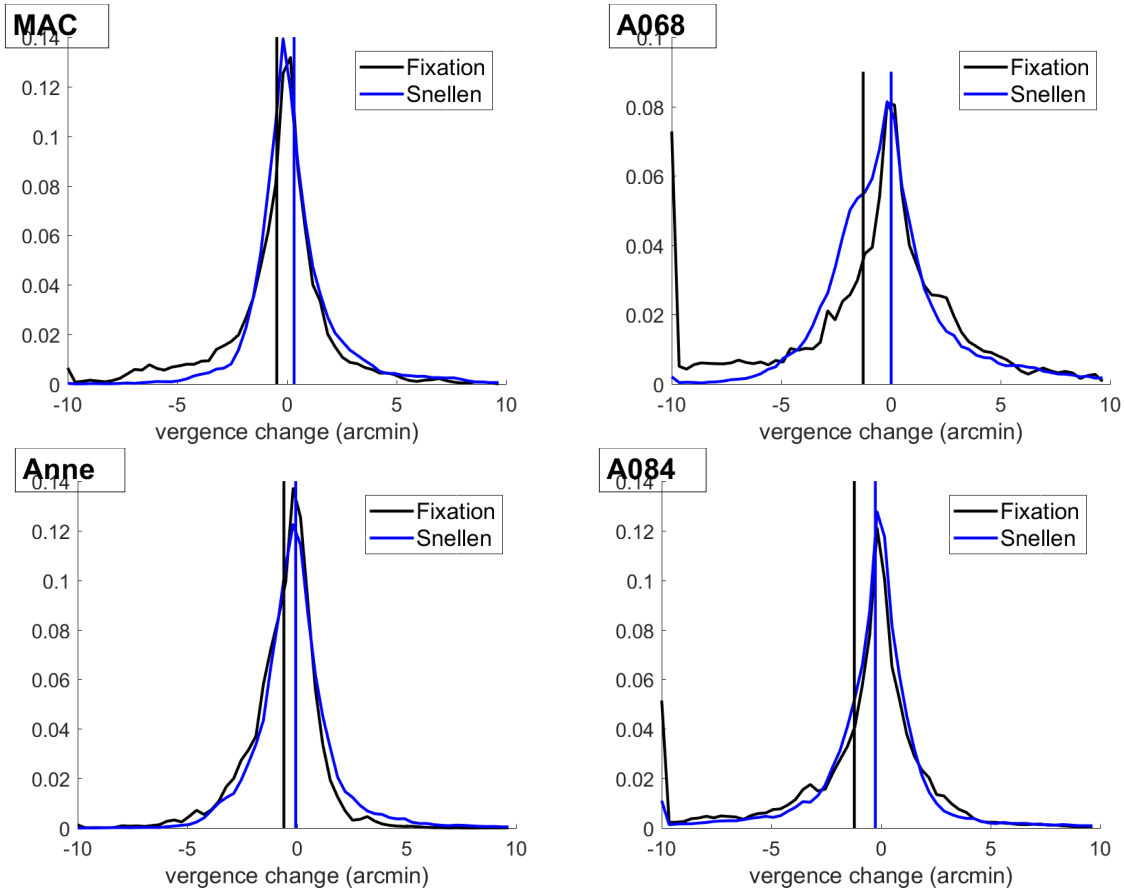
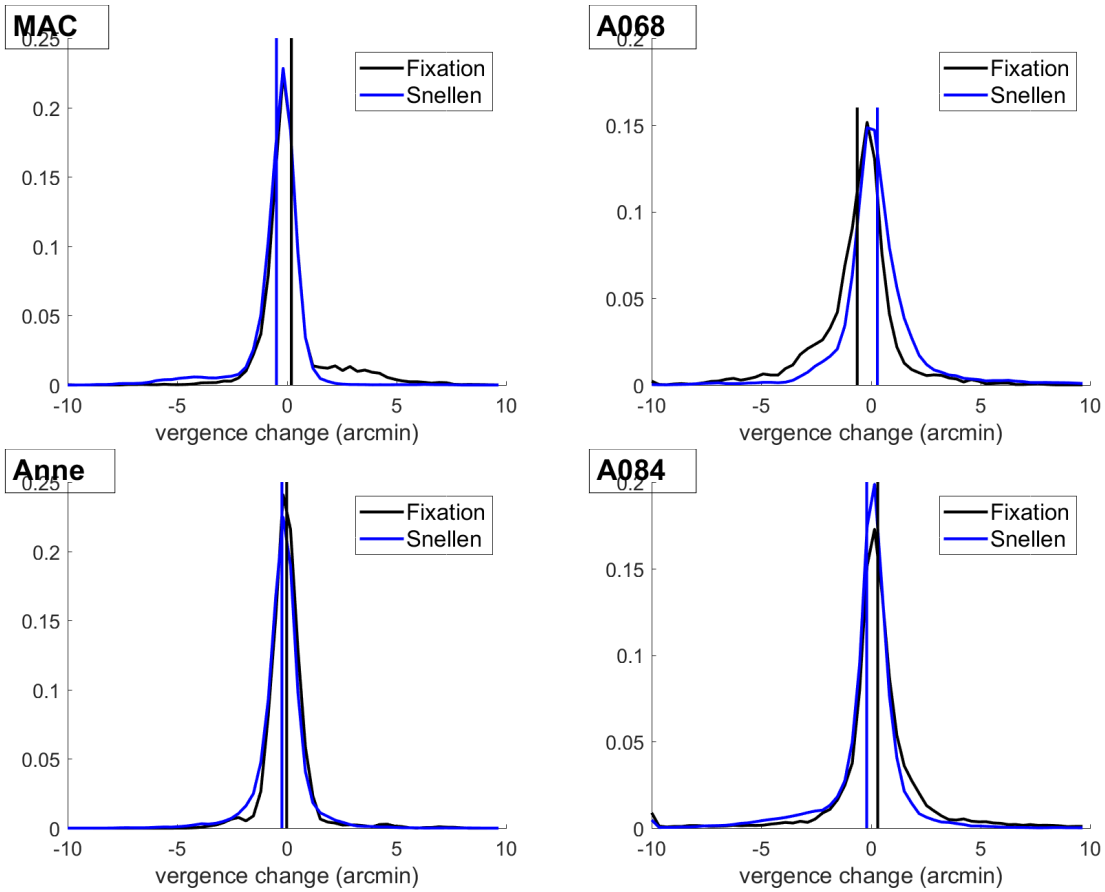


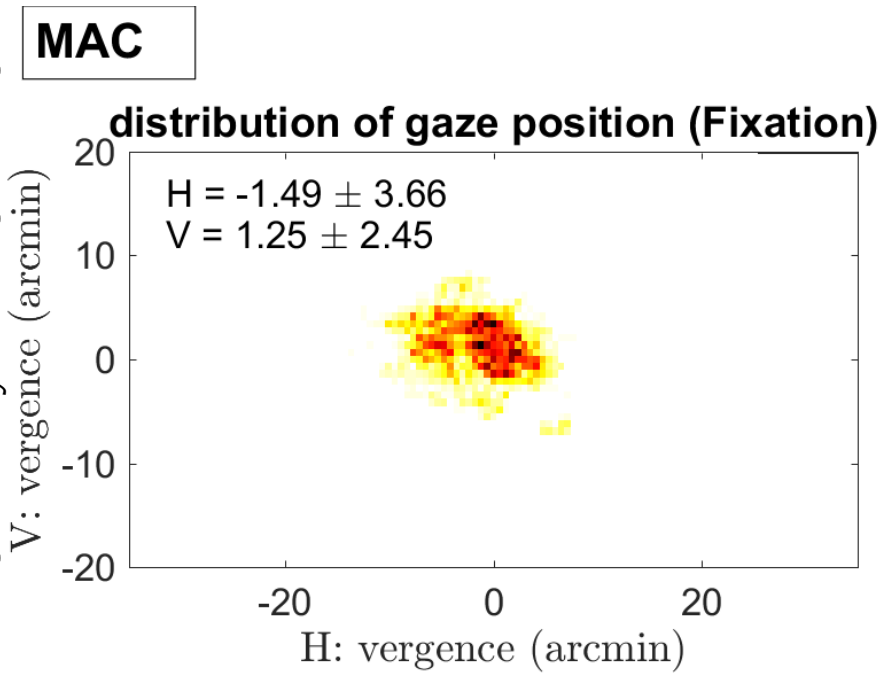
Microsaccades tend to uncross the eyes while drift on average does not change vergence.

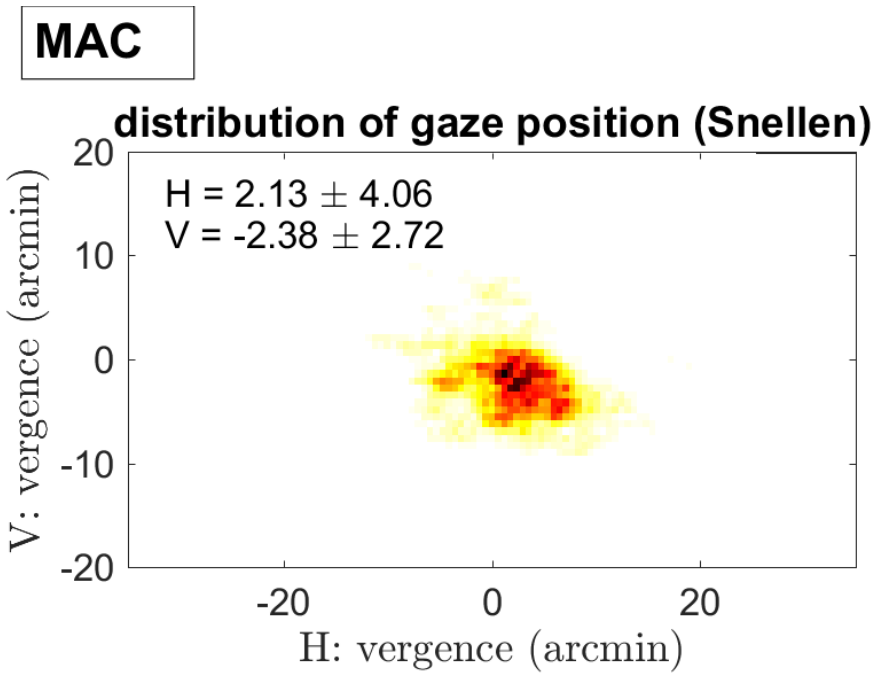
Drifts do not change vertical vergence



Positional offset of gaze

left high$\leftarrow V_y \rightarrow$ right high





crossed$\leftarrow V_x \rightarrow$ uncrossed

Positional offset of gaze

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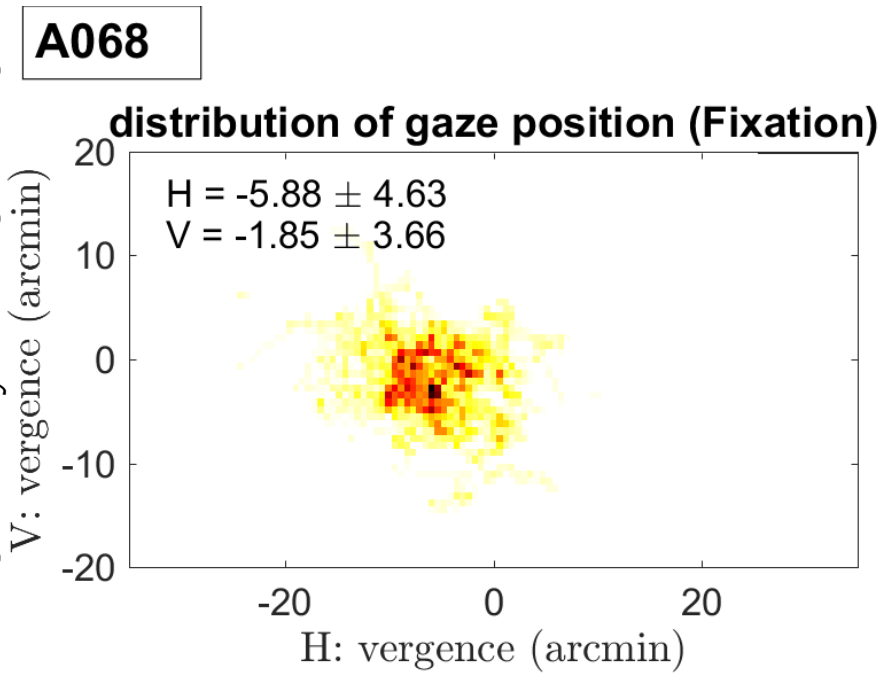

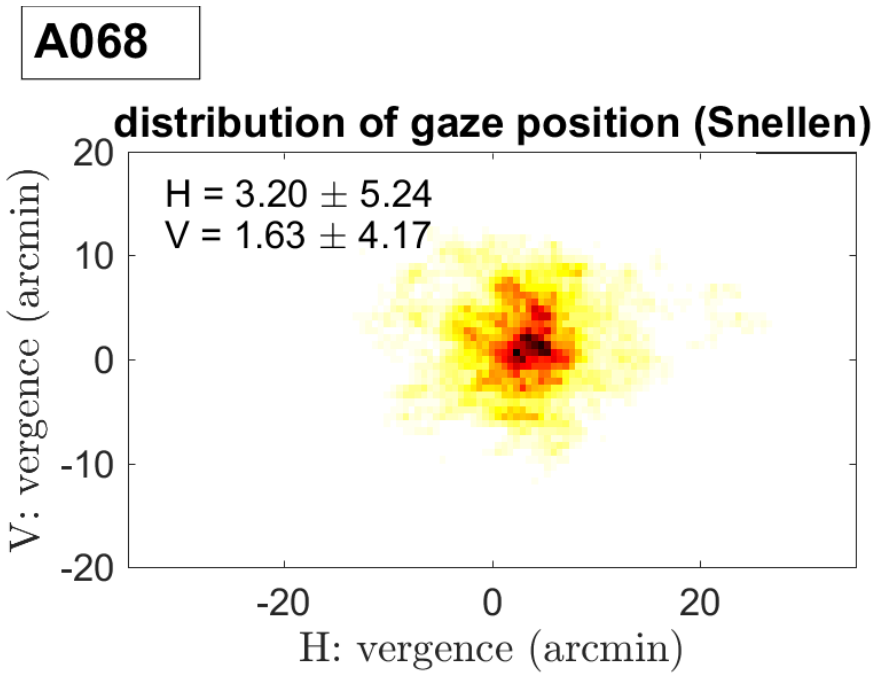

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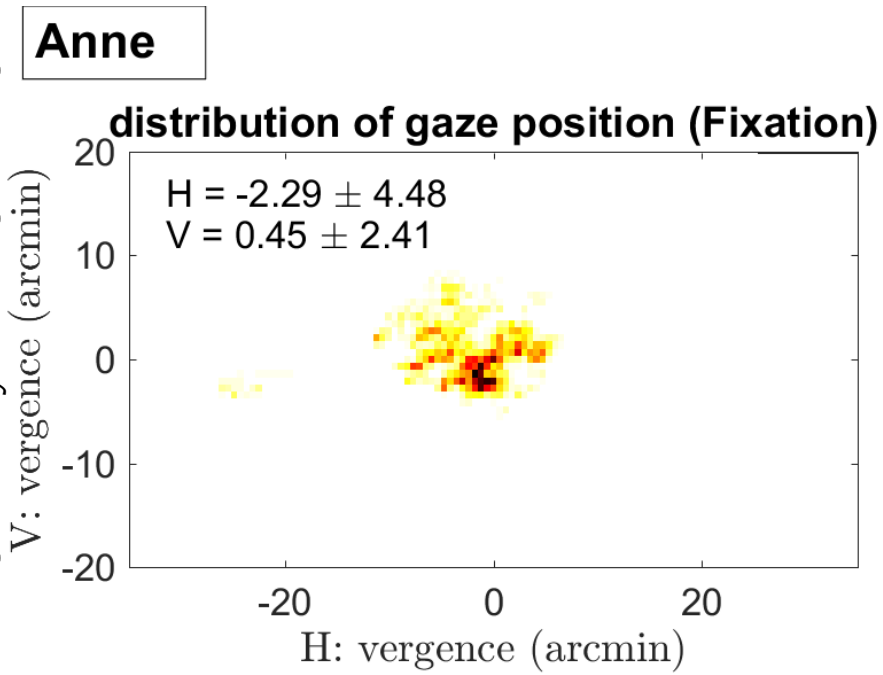

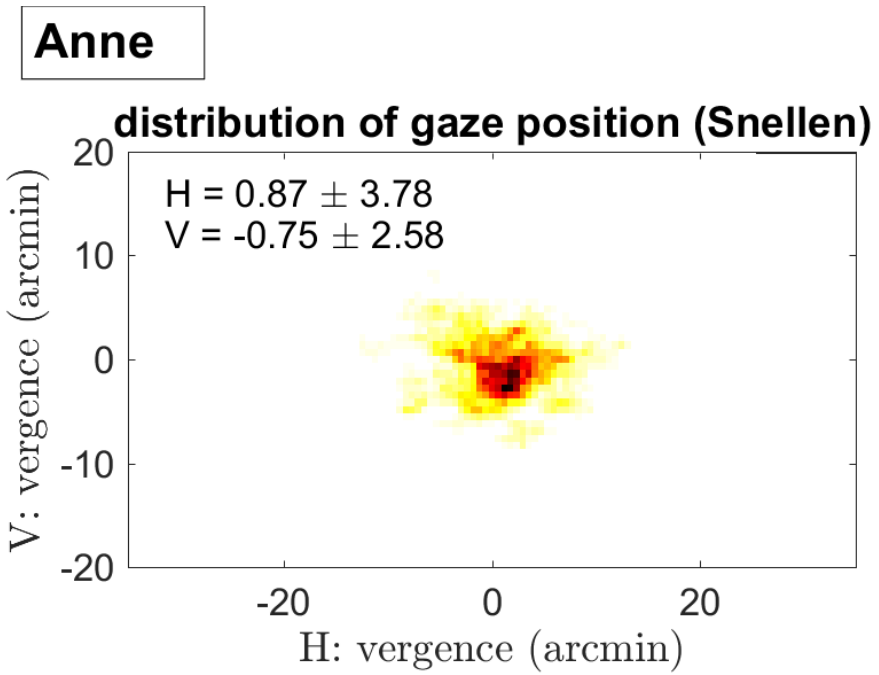

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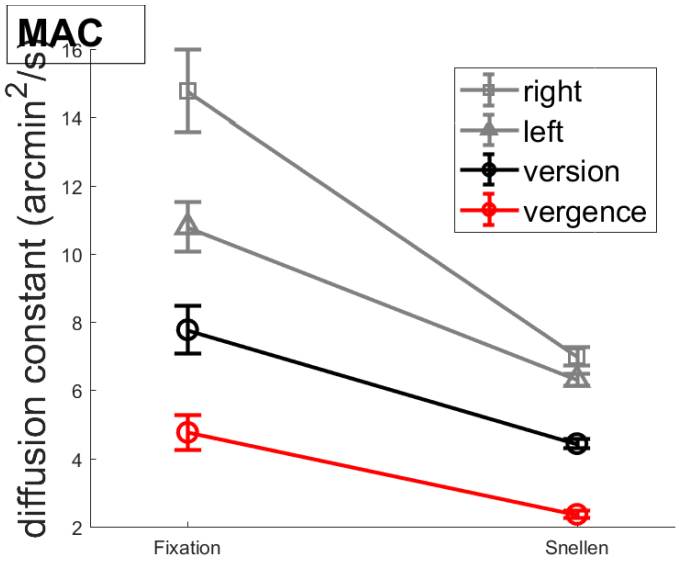
Positional offset diffuses less in Snellen



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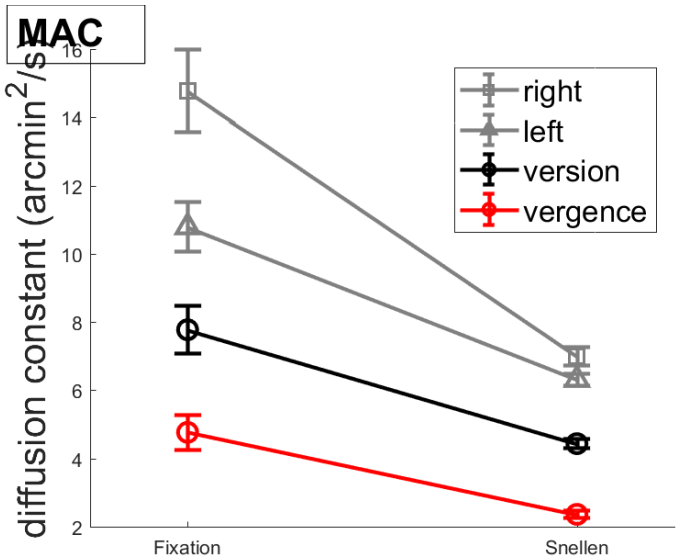

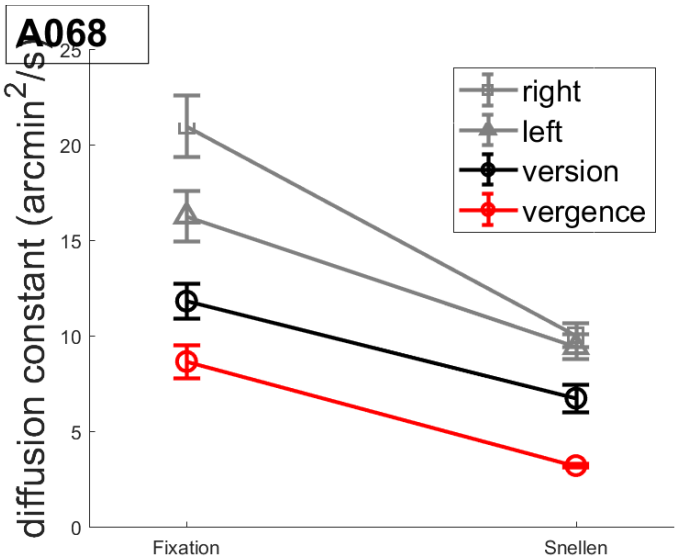

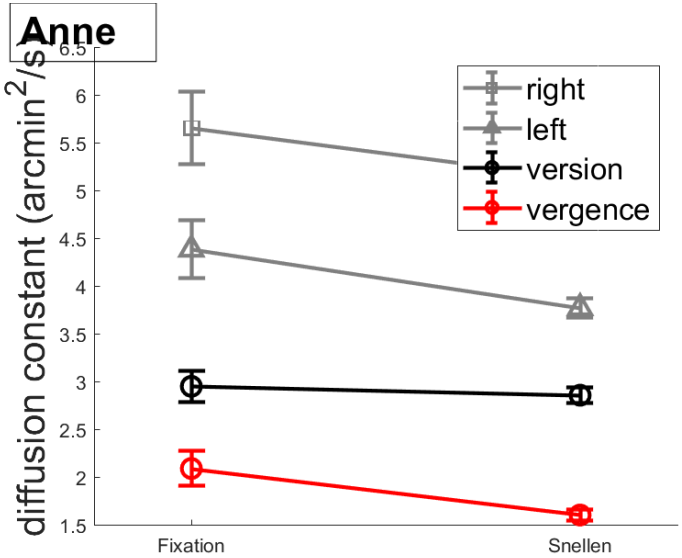

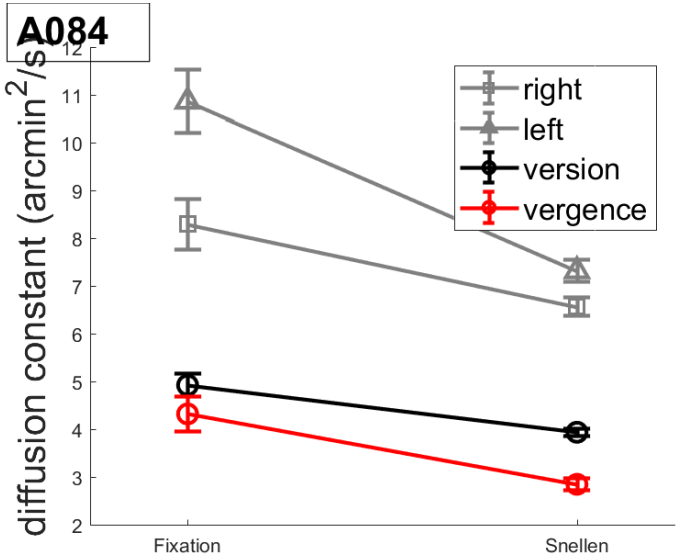

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2. How does binocular coordination change during a high acuity task?
   - Microsaccades seem to constantly uncross gaze. Why?
   - Though drifts in the eyes do not exhibit synchronous speeds or direction in these conditions, the decrease in the diffusion rate during Snellen results in slower changes in retinal disparity.