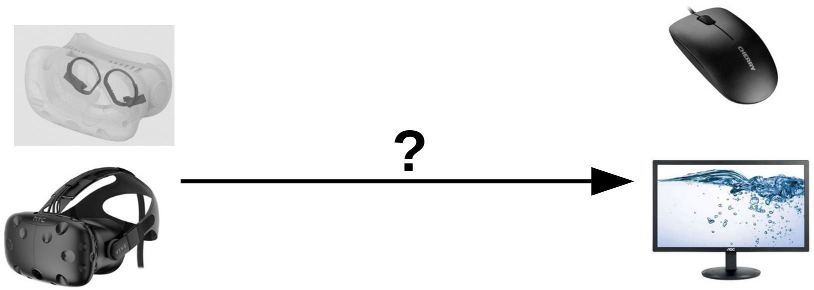
Mouse movements on-screen are an alternative to gaze in VR

Erwan David, Melissa Võ
Scene grammar lab, Frankfurt

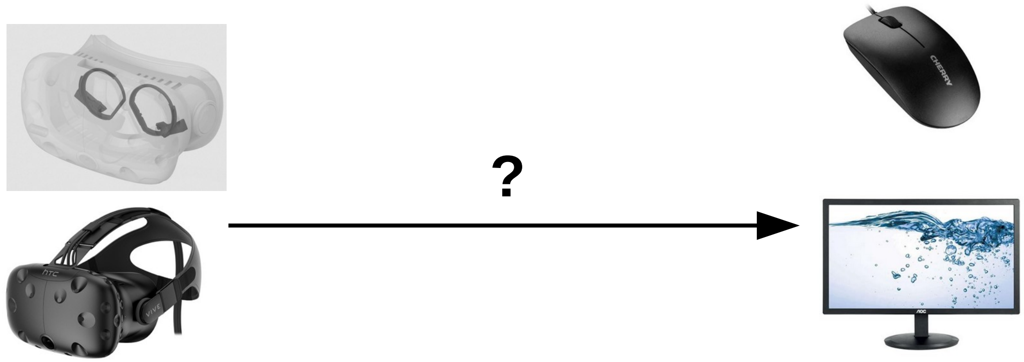
Problematic

- Can we use **mouse movement** controlling a **camera** in a 3D virtual environment on-screen as a **proxy for gaze in VR**?



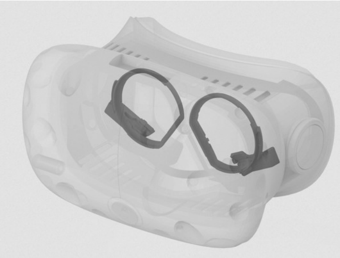
- Can we push it further? To unsupervised online experiments, for mass testing?

Why would that even work ?



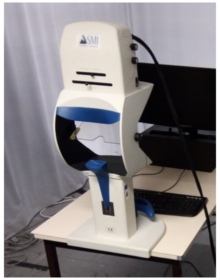
E. David - david@psych.uni-frankfurt.de

Gaze tracking



Virtual reality headset

Gaze tracking

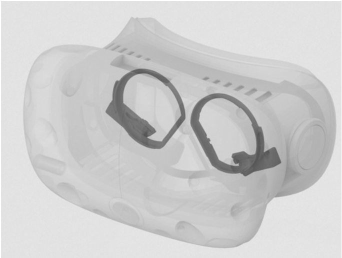


Computer screen

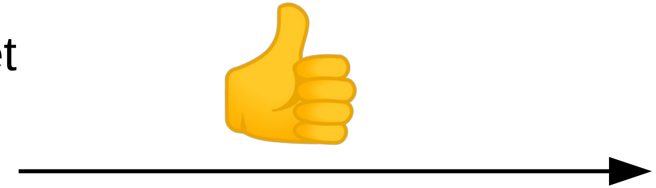
- On-screen to VR research
  - Demonstrated that behaviour is in general not different
    - In terms of fixational and saccadic biases
    - Search behaviour
    - Which parts of a scene are attended the most (saliency)

David, Beitner & Võ (MDPI-BS20, JoV21), David et al. (JoV22)

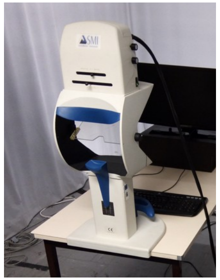
Gaze tracking



Virtual reality headset

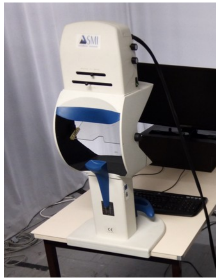


Gaze tracking



Computer screen

Gaze tracking



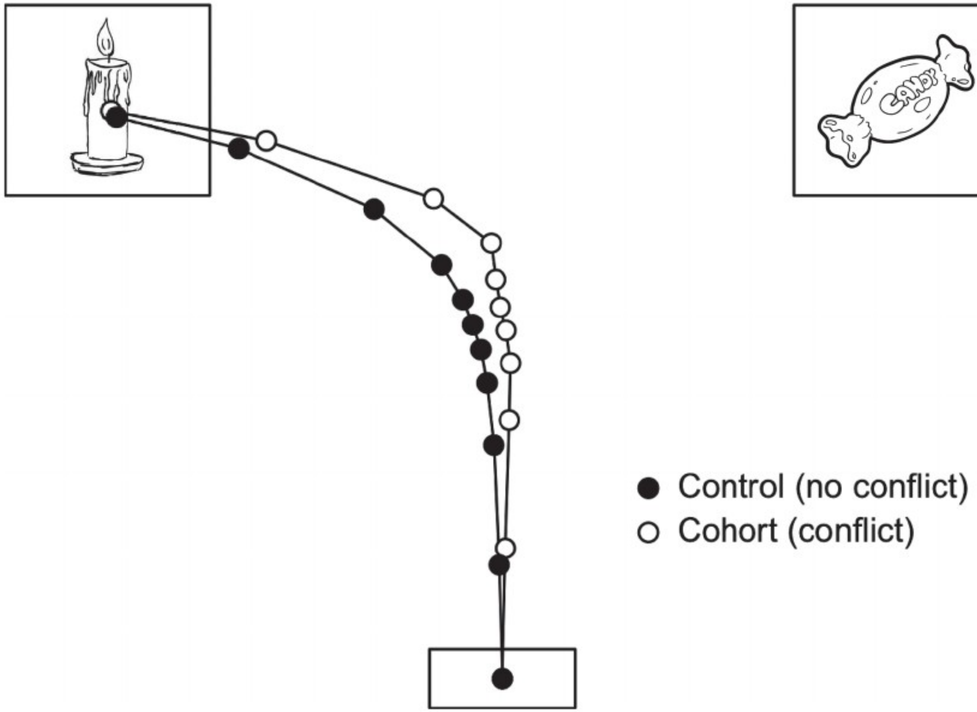
Mouse-as-a-proxy

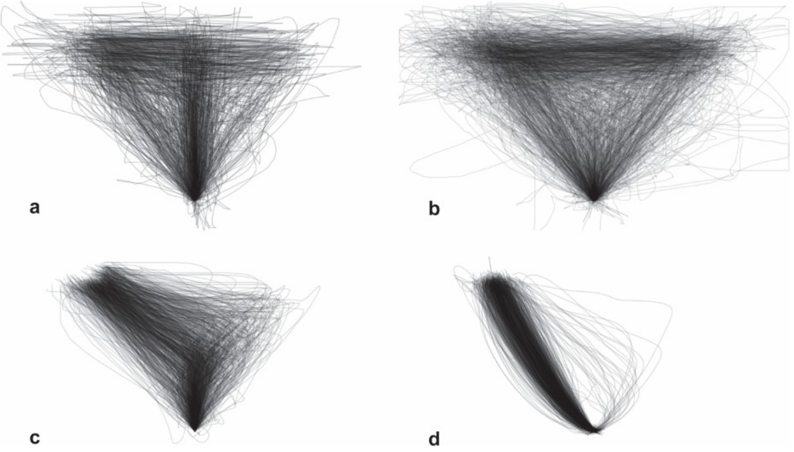
Computer screen

Computer screen

E. David - david@psych.uni-frankfurt.de

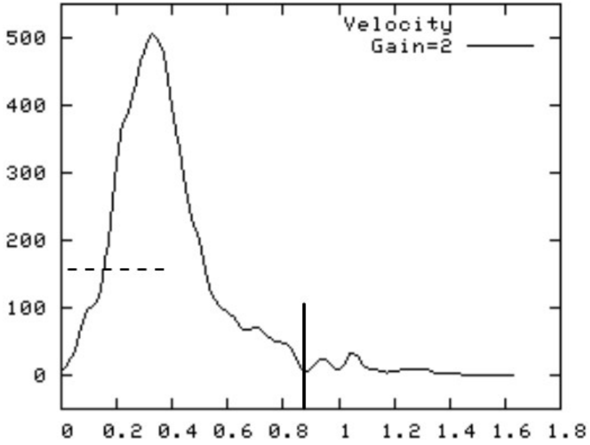
- Mouse tracking in cognitive psychology

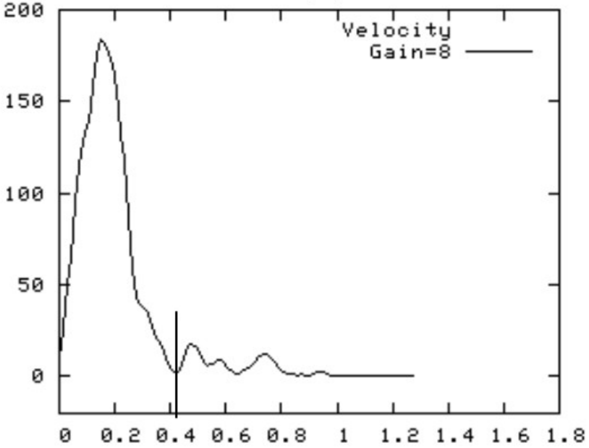




Wulf, Haslbeck, & al. (2019); see also Kieslich, Henninger, & al. (2019)

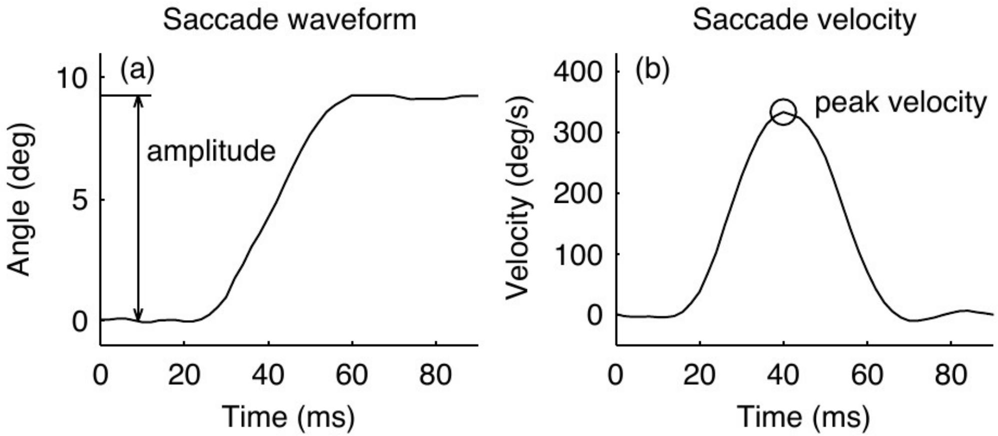
- Velocity profile of mouse movement





Mouse velocity profiles
(Bohan, Thompson, & Samuelson, 2003)

Dai, Selesnick & al. (2016)

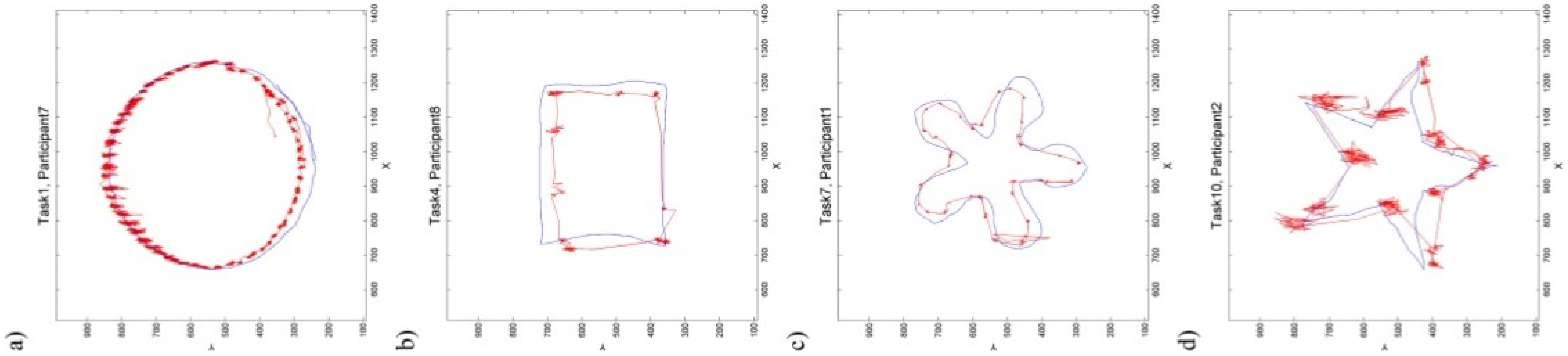


- Mouse as a proxy for gaze position

Similar saliency maps obtained from gaze data and mouse data.

SALICON (Jiang et al., CVPR15)

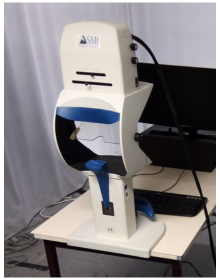
• Mouse as a proxy for gaze position



Very strong correlation between gaze and mouse position (and clicks).

Demšar & Çöltekin (PLoSOne,17), Egner et al. (JEMR18)

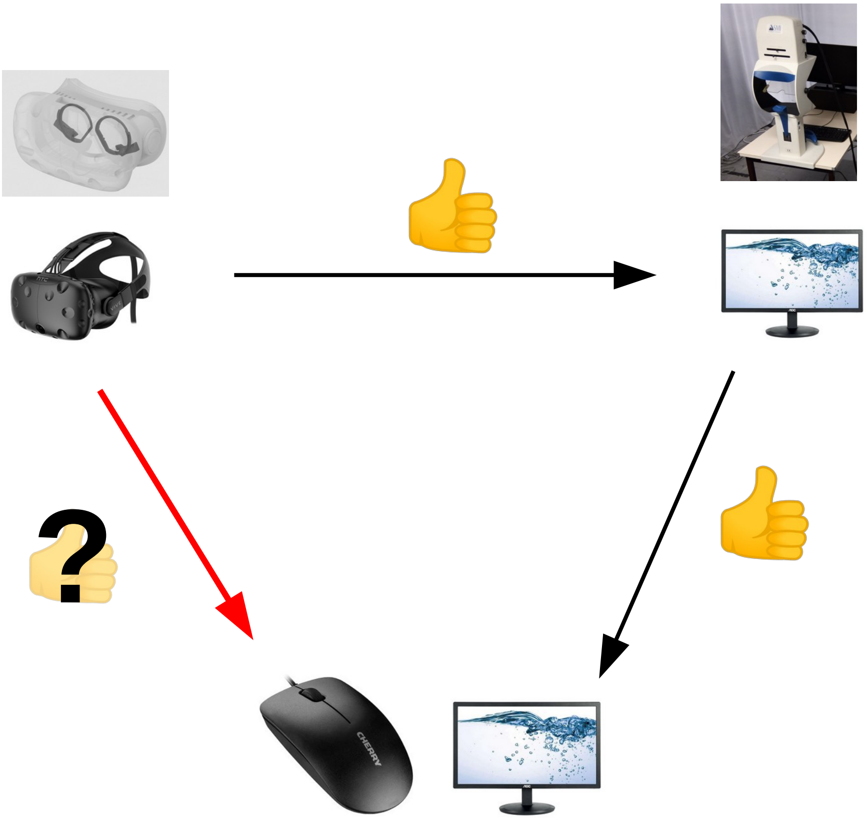
Gaze tracking



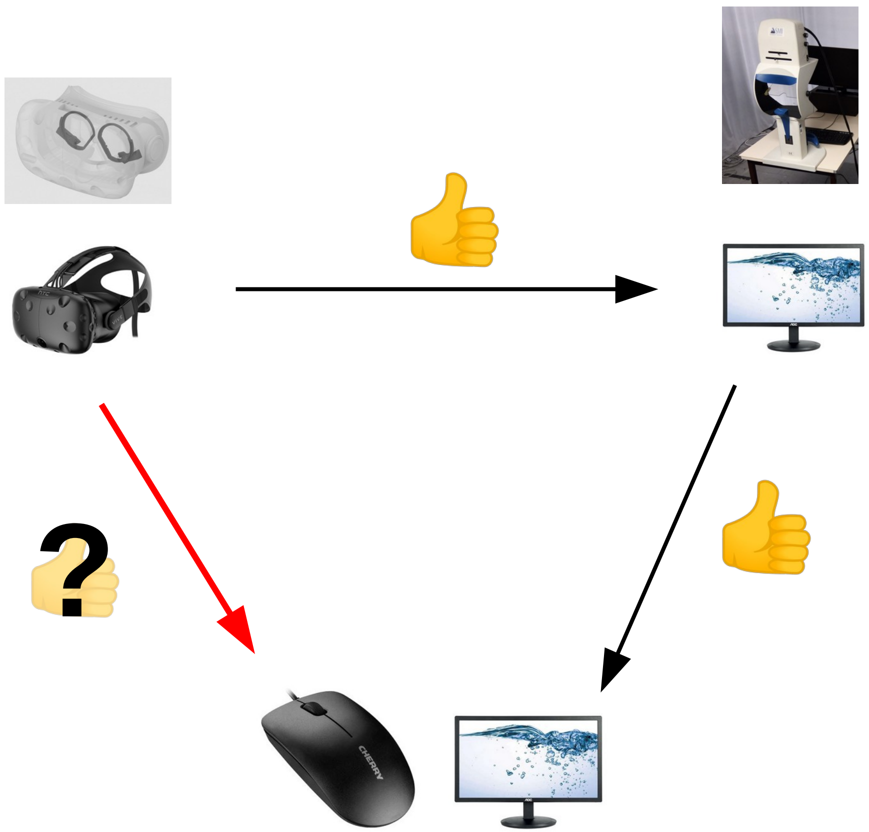
Mouse-as-a-proxy

Computer screen

Computer screen



E. David - david@psych.uni-frankfurt.de



Can this shortcut work?

With complex tasks

(object search)

And complex scenes

(indoor rooms)

- Demo
  - Trial replays

- Trial sequence

- Conditions


NO
TOUCHING

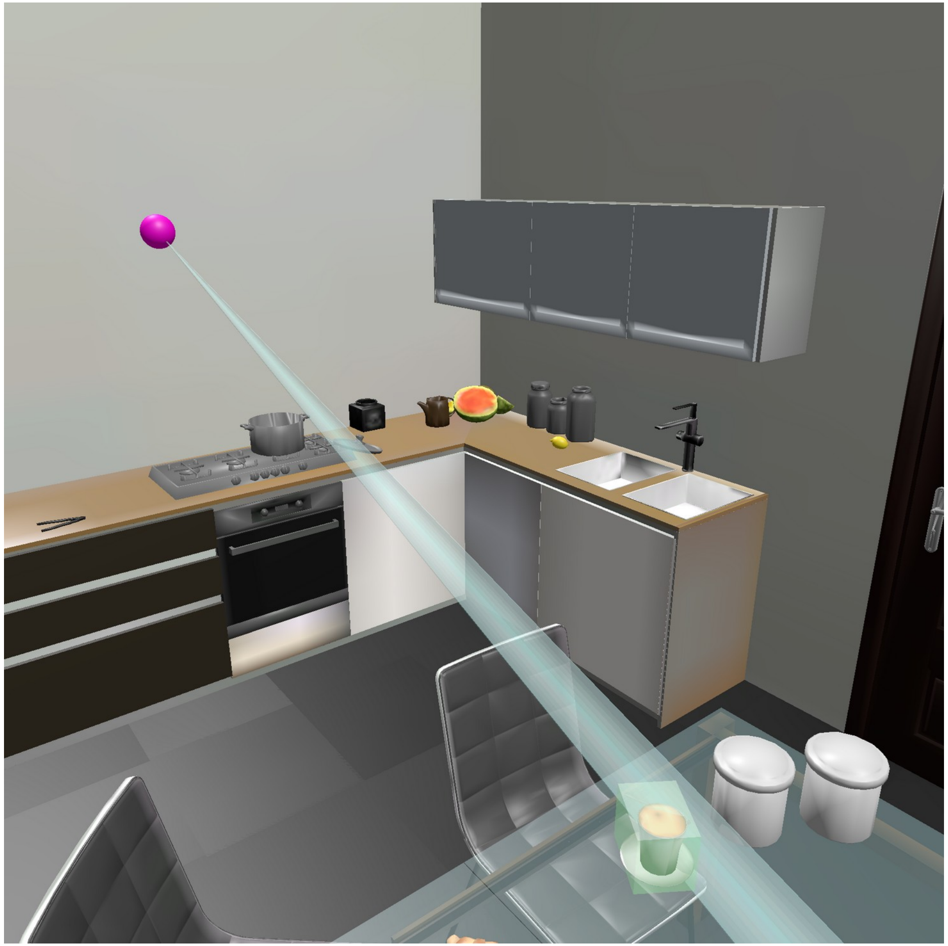

Targets: always outside
Targets: 50% outside/inside
Training
3 trials
Block 1
27 trials
Training
3 trials
Block 2
51 trials

- Recruiting

	VR	Online mouse
N	61	53
Gender	38 ♀	36 ♀
Age avg	22.6	20

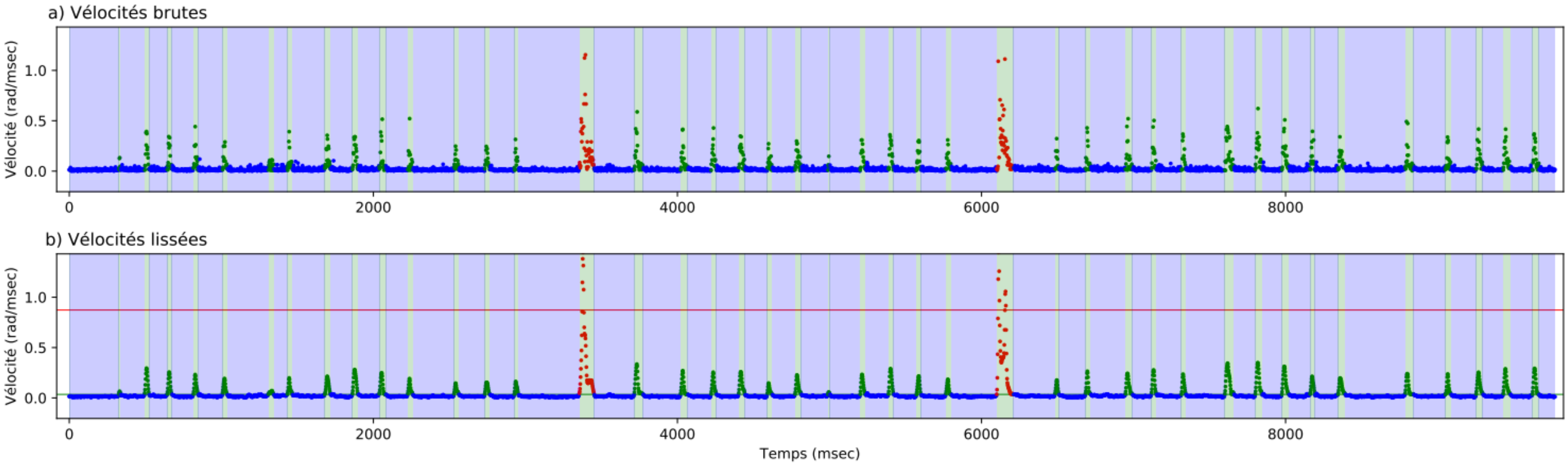
- Analysis

"Gaze" on object
Gaze cone method (4°)

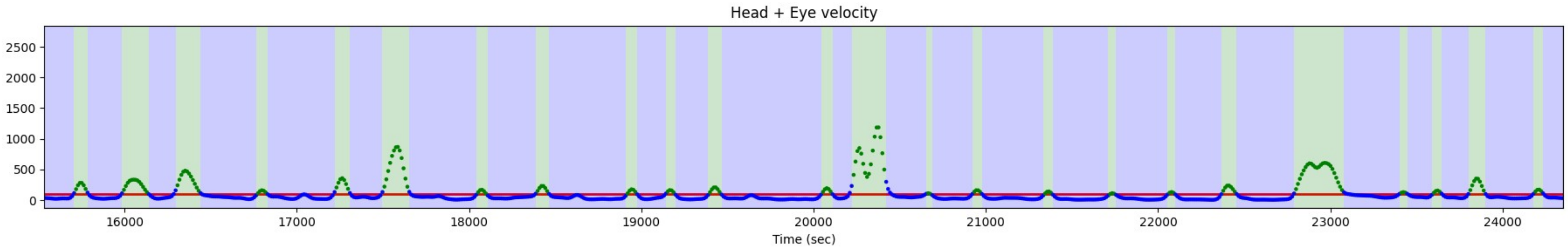


E. David - david@psych.uni-frankfurt.de

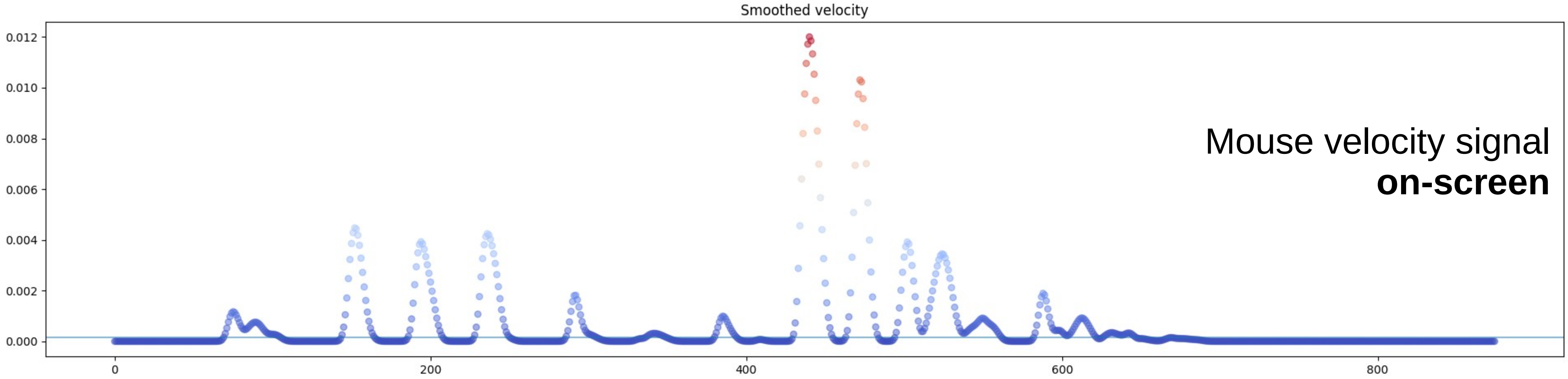
- Analysis
  - Gaze velocity signal **on-screen**



- Analysis
  - Gaze velocity signal **in VR**

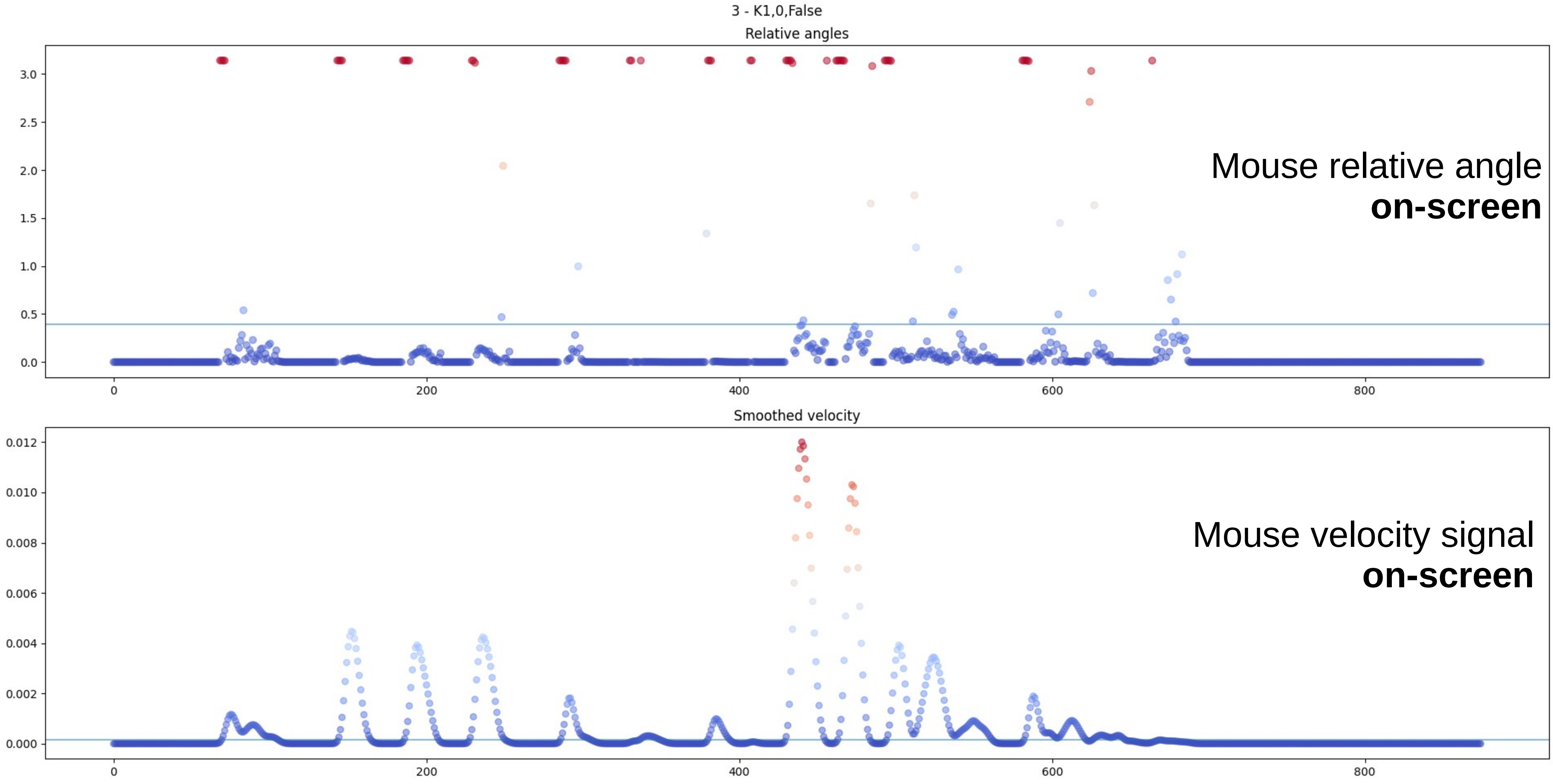


E. David - david@psych.uni-frankfurt.de



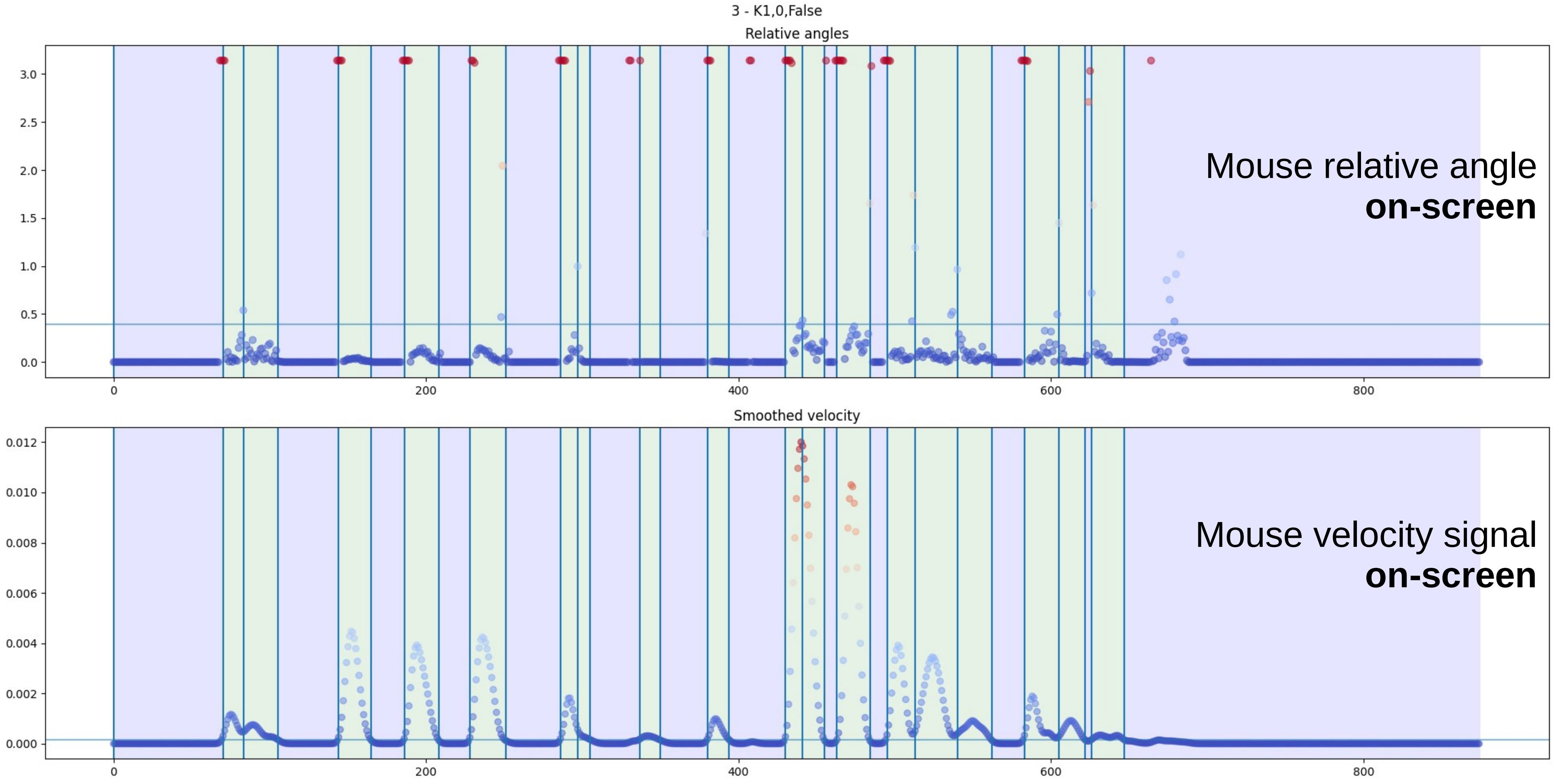
Mouse velocity signal
on-screen

E. David - david@psych.uni-frankfurt.de



Mouse relative angle
on-screen

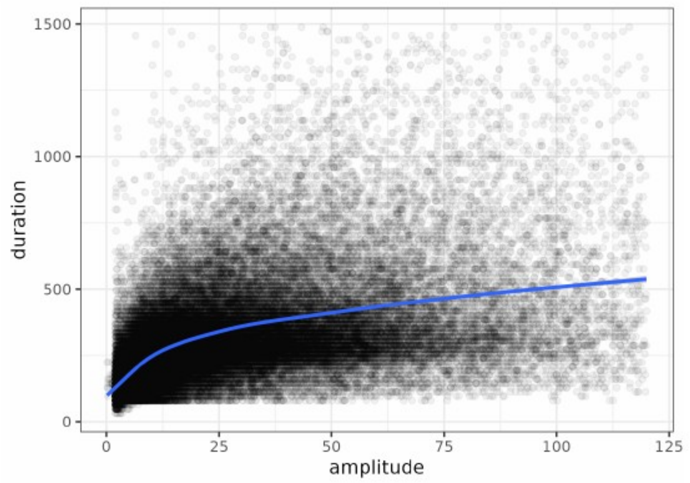
Mouse velocity signal
on-screen



Mouse relative angle
on-screen

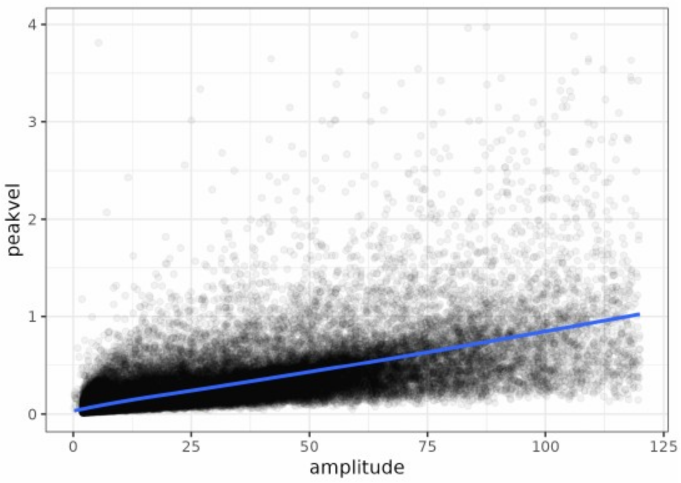
Mouse velocity signal
on-screen

- Results – main sequence



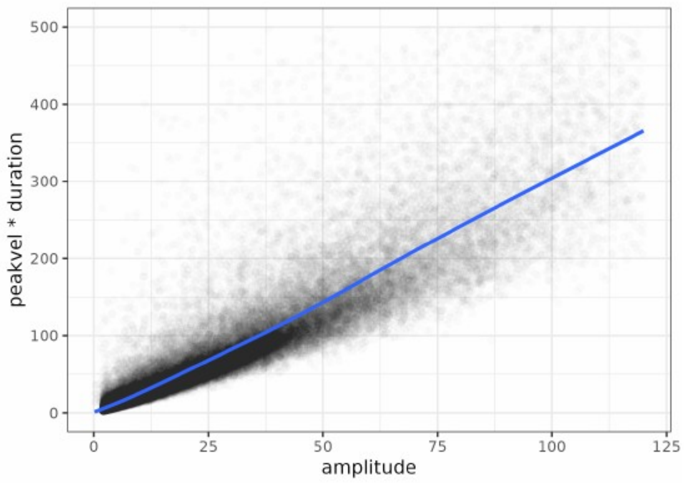
Fix. duration
x
Mov. Ampl.

(r = .51, p < .0001)



Peak velocity
x
Mov. Ampl.

(r = .8, p < .0001).



Dur x Vel
x
Mov. Ampl.

(r = .9, p < .0001)

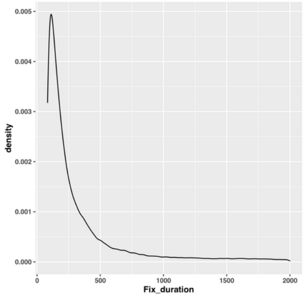
• Results

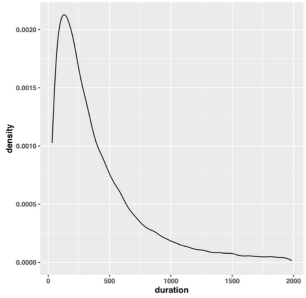
Density distributions:

Similar shapes at different scales

VR HMD | Mouse

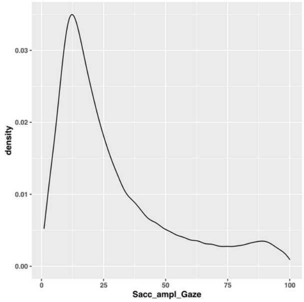
Fixation duration

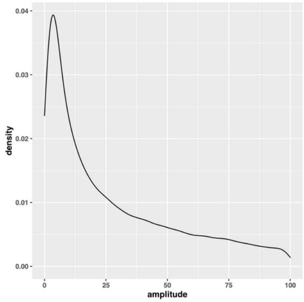




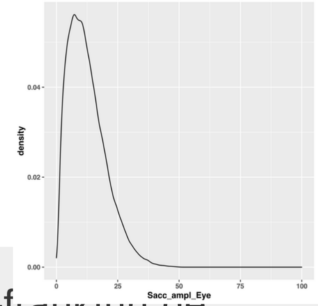
Saccade Amplitude

Gaze





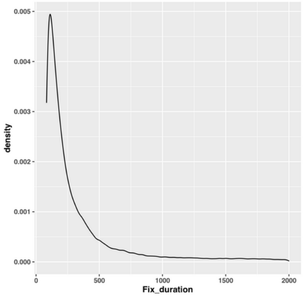
Eyes

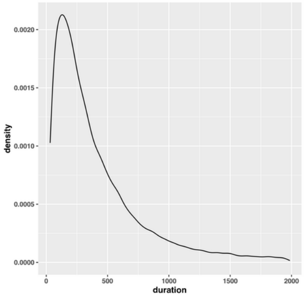


- Results

VR HMD | Mouse

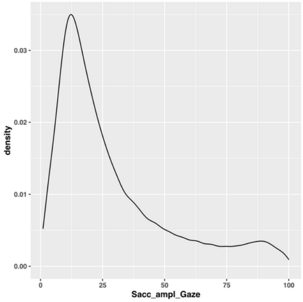
Fixation duration

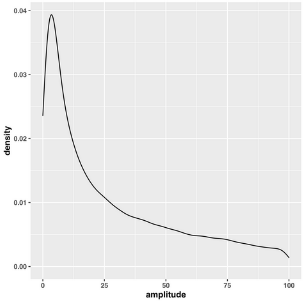




Density distributions:

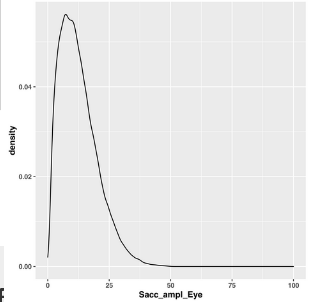
Similar shapes at different scales





		Mouse	VR		
			Gaze	Eye	Head
(pseudo-)saccade amplitude	Kurtosis	5.4	6.1	4.5	5.8
	Skewness	1.6	1.8	1.2	1.7
Log (pseudo-)fixation duration	Kurtosis	2.7	4.1		
	Skewness	-.2	1.1		

Eyes



E. David - david@psych.uni-frankfurt.de

- Where? Comparing saliency maps

- Where? Comparing saliency maps

	CC	KLD	SIM
between-same	.32 (.02)	3.37 (.18)	.32 (.01)
within-diff	.26 (.001)	5.05 (.03)	.26 (.001)
between-diff	.19 (.001)	5.66 (.02)	.2 (.001)

E. David - david@psych.uni-frankfurt.de

- Results – experimental effects

1) Linear mixed effects → *beta estimate*, *SE*

2) Compare *Betas* (δb)

3) *Beta estimate* comparison (Z-test)

$$Z = \frac{b_{VR} - b_{online}}{\sqrt{SE^2_{b_{VR}} + SE^2_{b_{online}}}}$$

Similar effect directions and amplitudes?

E. David - david@psych.uni-frankfurt.de

- Results – experimental effects

Differences between inside and outside target placement and relative to search phases

We looked at:

1) Visuo-motor behaviour

2) Search behaviour

3) Interaction with the scene

E. David - david@psych.uni-frankfurt.de

- Results – experimental effects

1) Visuo-motor behaviour

Similar: Fixation duration, saccade amplitudes

Deviations: Saccade relative angles

E. David - david@psych.uni-frankfurt.de

- Results – experimental effects

2) Search behaviour

Similar: Search phase duration

Deviations: Success & Target refixation rate

E. David - david@psych.uni-frankfurt.de

- Results – experimental effects

3) Interaction with the scene

<u>Similar</u>: Time to first interaction

<u>Deviations</u>: Item count

- Take home

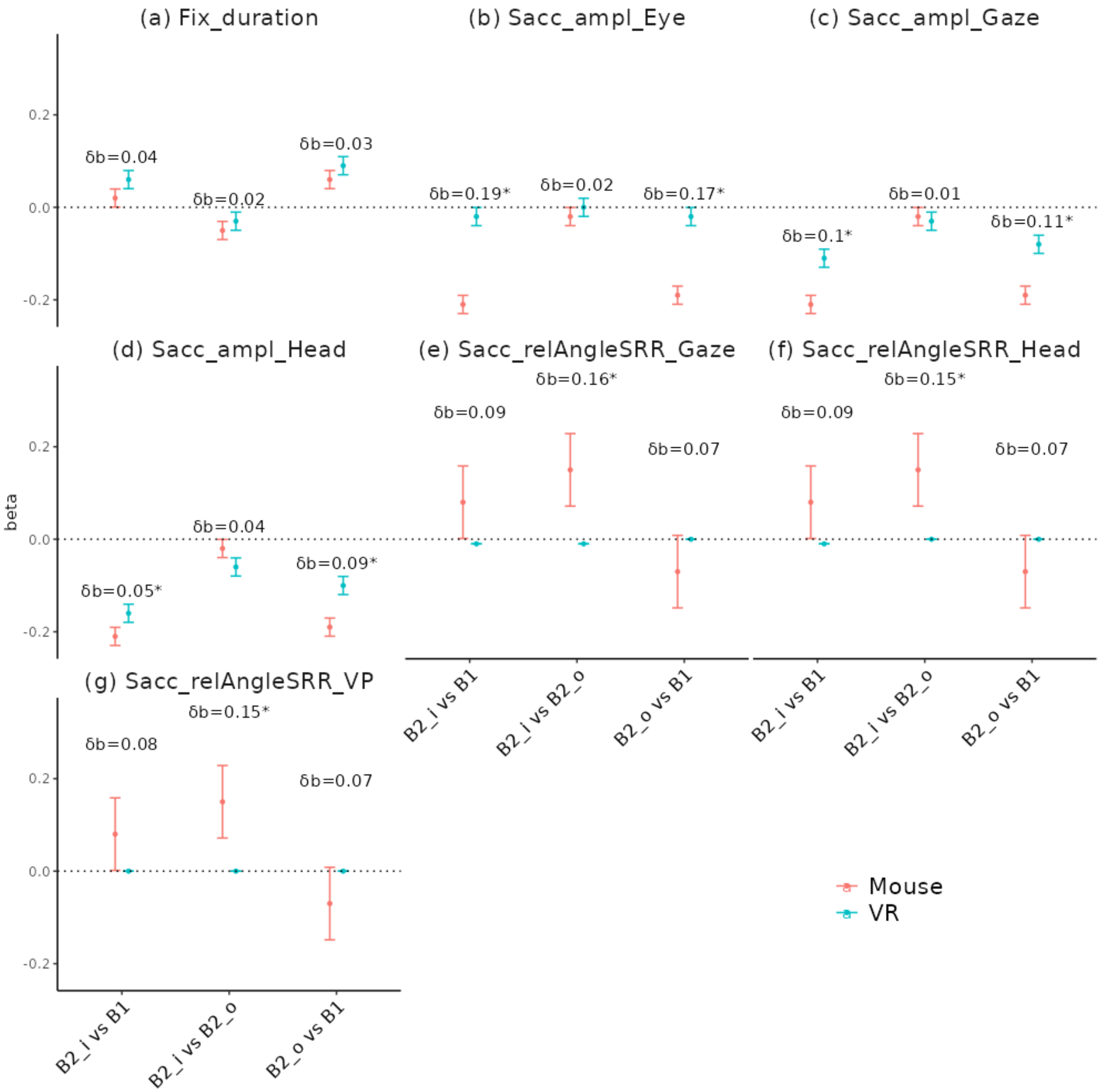
  - Profiles of **how** we look
    - ✔ Density distributions: same shapes at different scales
    - ✔ Replicate a main sequence

  - **Where** we look
    - ✔ Saliency maps are very similar
    - ✔ People look at the same locations

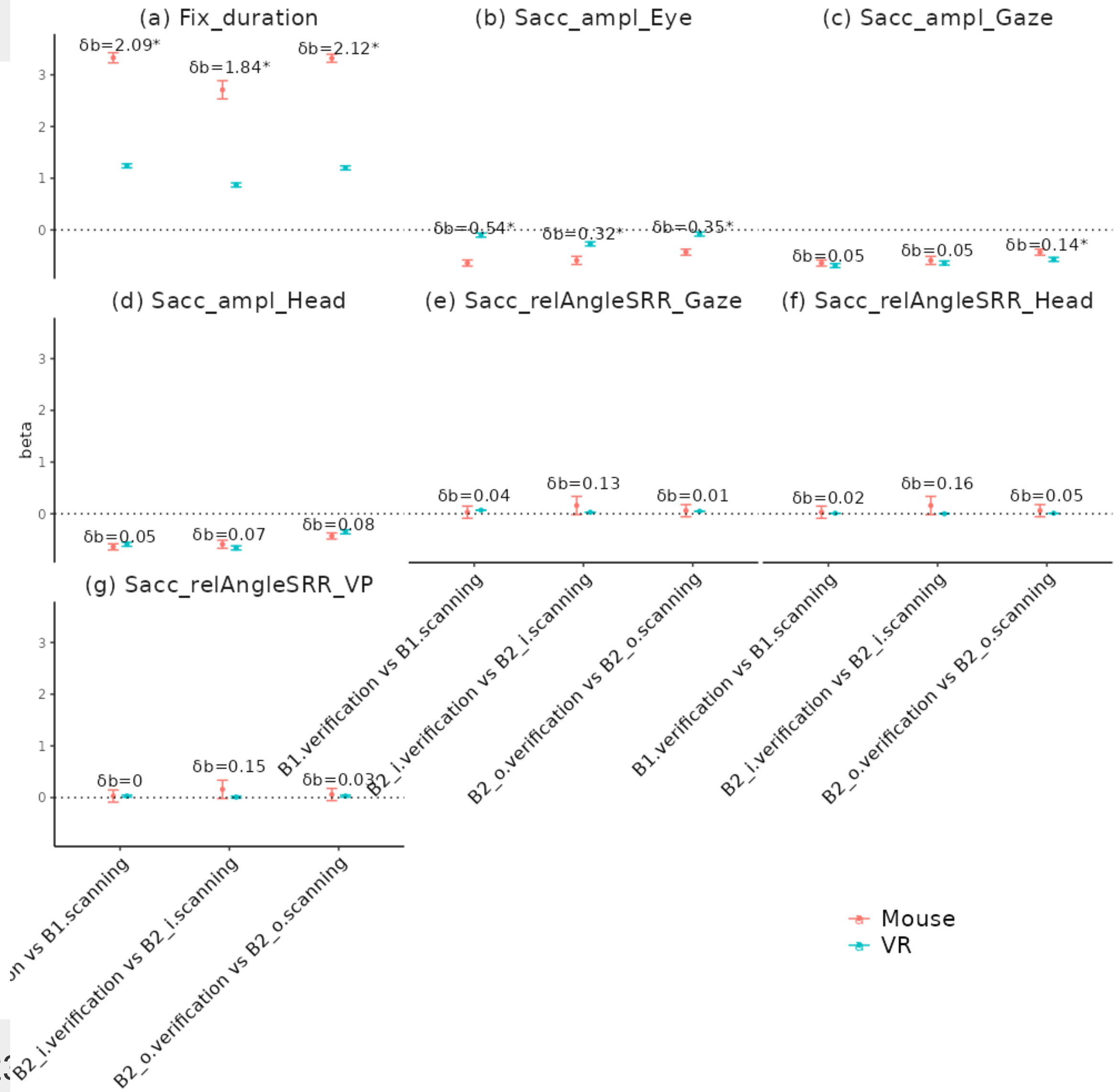
  - Experimental **effects**
    - ✔ *Visuo-motor*: closer to head and gaze data than eye’s
    - ✔ *Search*: Similar search phases, lower success rate
    - ✔ *Interacting*: more difficult in the online protocol

Thank you for your attention

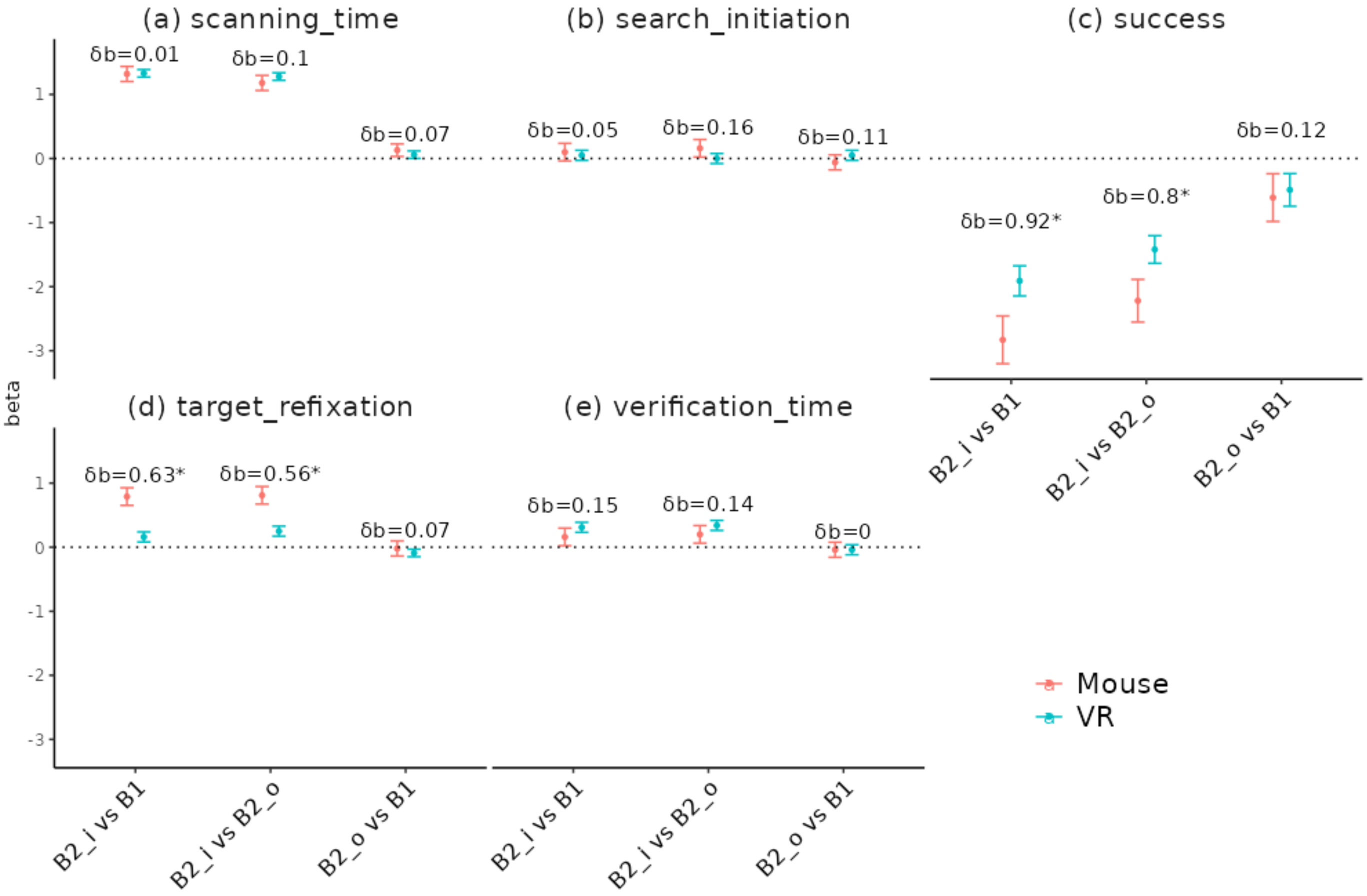
Beta-estimates – Visuo-motor



Beta-estimates – Visuo-motor



Beta-estimates – Search



Beta-estimates – Interacting