

Eyetracking

MagdaLena Matyjek



Basic research
methods

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Acknowledgement: Some of these slides were based on or inspired by slides for the previous editions of the same class by dr. Garret O'Connell and dr. Luke Tudge.

Introduction to eye tracking

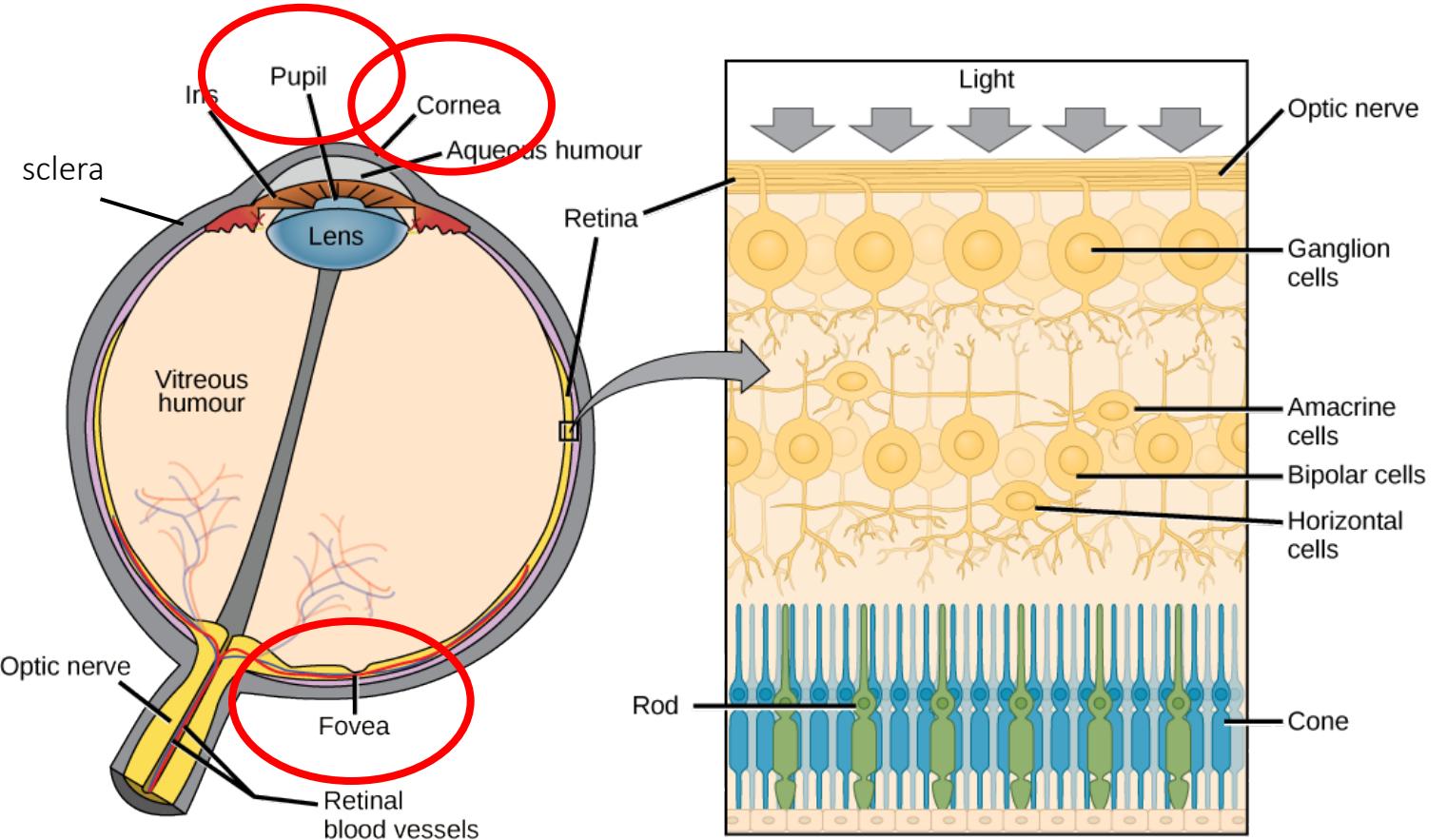
Anatomy, history, technology, use, types and set-up

The Eye

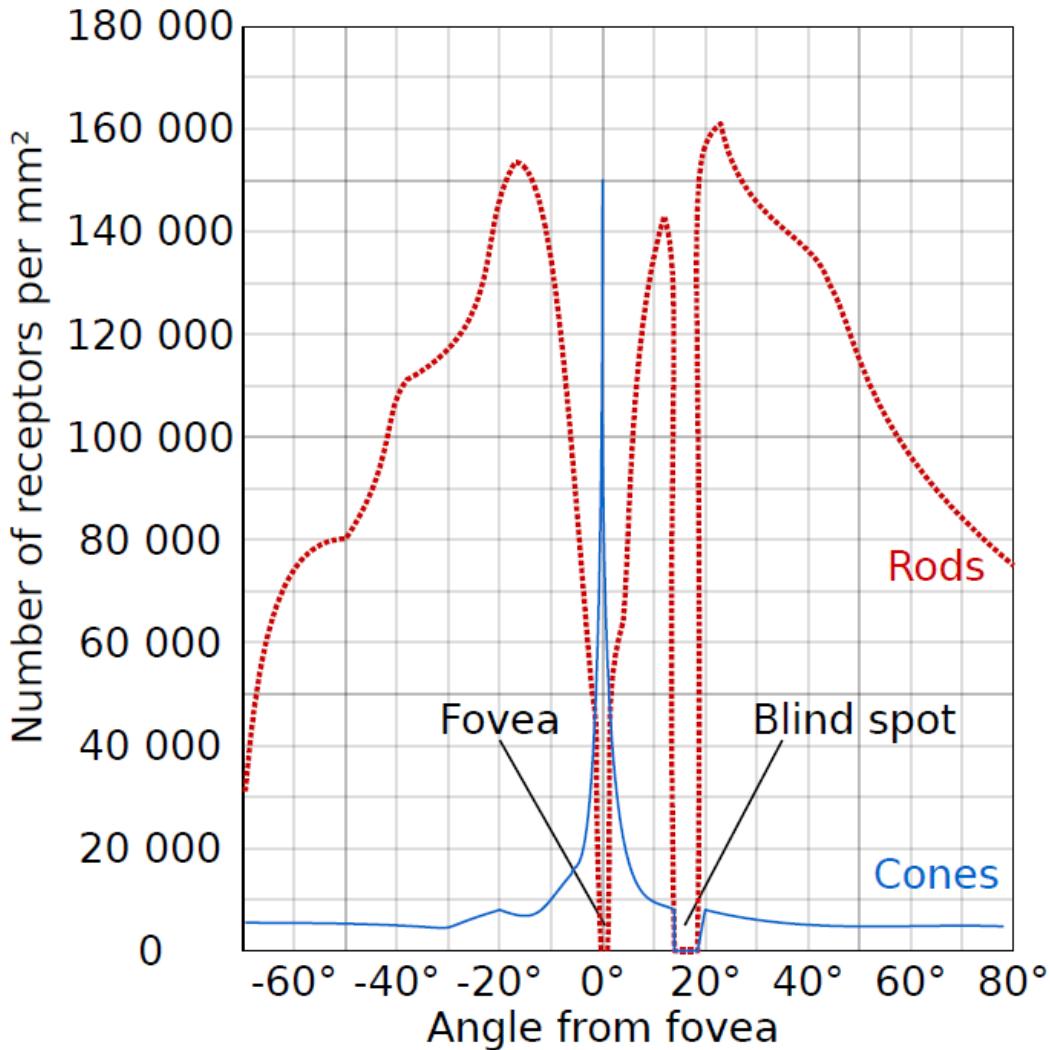


- Why is the eye interesting for the Mind & Brain researchers?
 - Relationship between mental processes and the eyes' movements
 - Thoughts, attention, feelings, planning, etc.
 - Not only for vision researchers

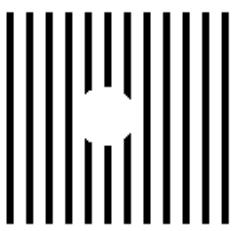
Anatomy



Cones & rods



- **Cones:**
 - Less sensitive to light
 - Of 3 types:
 - S – blue
 - M – green
 - L – red
 - Faster than rods
 - Sharp vision
- **Rods**
 - More sensitive to low intensity of light (night vision) and movement
 - Specific for one colour (blue-green)
 - Slower than cones



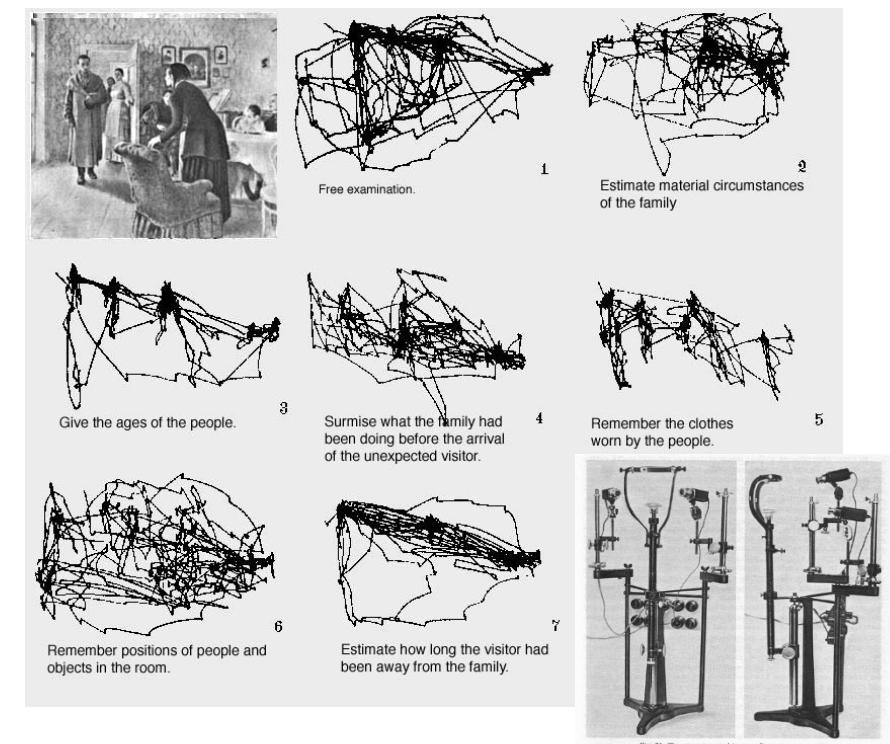
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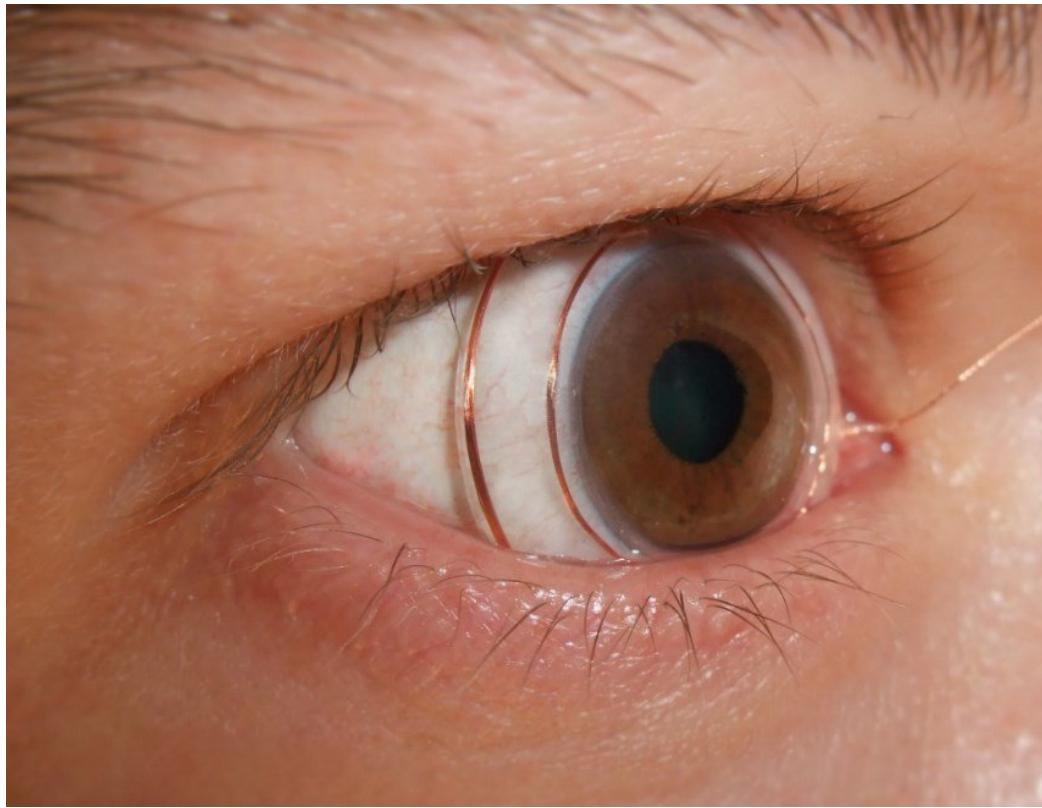
Eye tracking: history



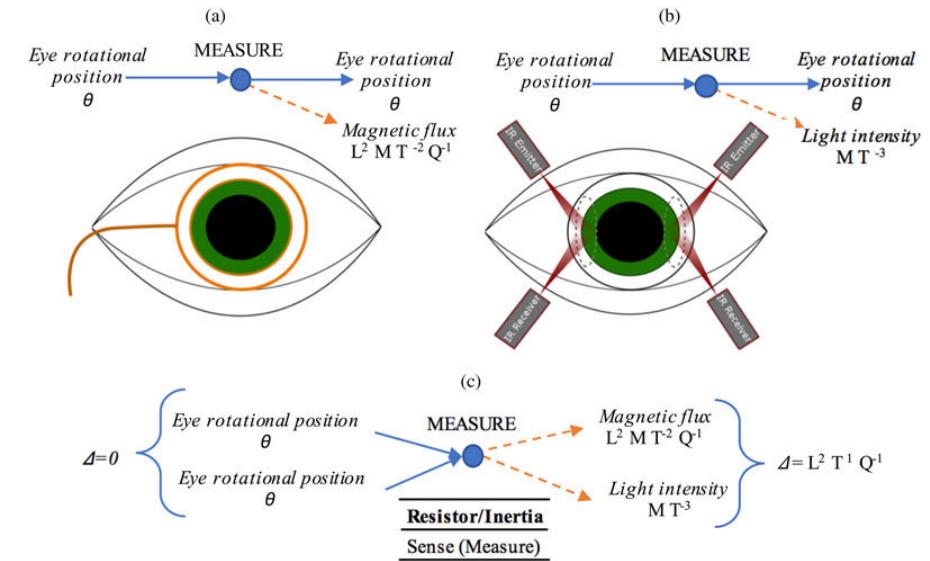
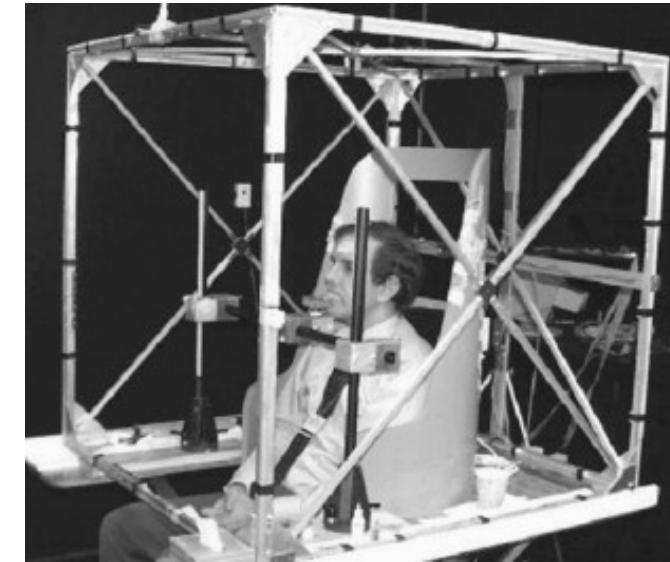
- **Javal, 1879:** reading („naked eye method“)
- **Huey, 1908:** first device
- **Yarbus, 50s & 60s:** saccades and fixations depend on the task and interests
- **Hunziker, 1970:** problem solving – tracking eyes through glass
- 70s & 80s: rapid progress
- 90s: marketing

<https://medium.com/@eyesee/eye-tracking-through-history-b2e5c7029443>

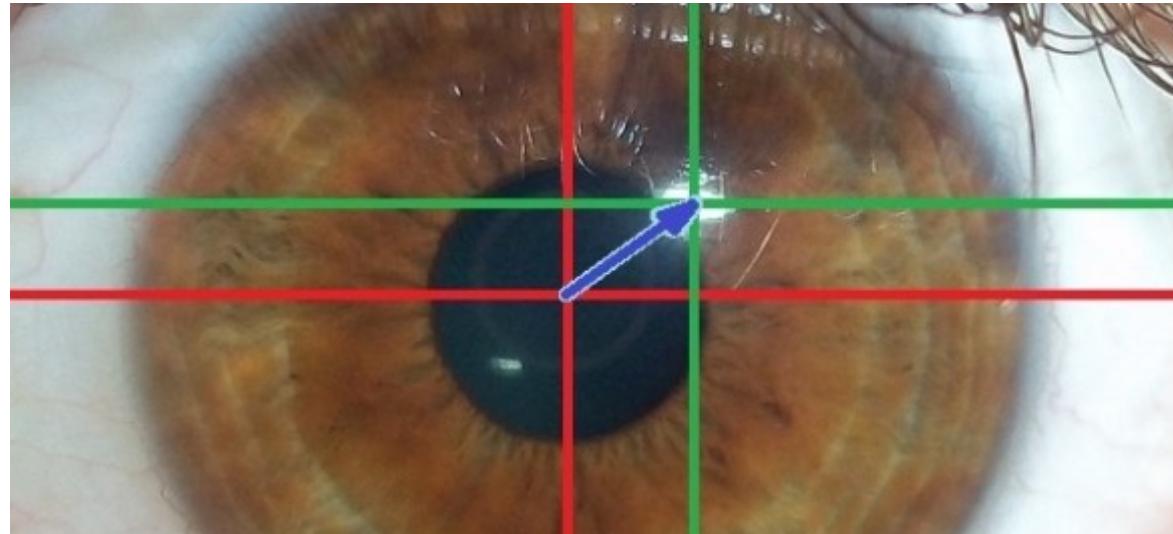




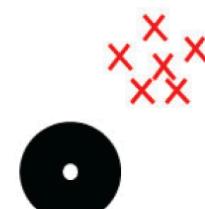
Invasive eye tracking: scleral search coil



Optical tracking



- Near-infrared technology & high-resolution camera
- Pupil
- Corneal reflection
- Pupil Centre Corneal Reflection (PCCR)
- Sampling rate: 30-2000Hz
- Price range: 100 – 50.000 USD
- Accuracy vs. Precision (calibration)



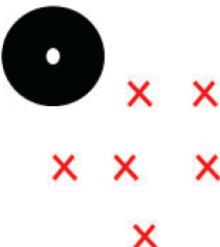
Good precision,
poor accuracy



Good accuracy,
poor precision



Good accuracy,
good precision



Poor accuracy,
poor precision

Set-up

Fixed head

Best precision, bulky



Titz, Scholz, & Sedlmeier, 2018

Head mounted

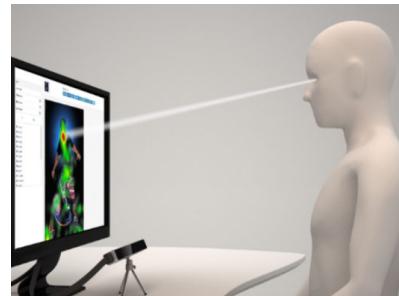
Open environment, bulky



sr-research.com

Remote

Ok precision, not bulky



theeyetribe.com

Glasses

Poor precision, open environment



tobiipro.com

Eye tracking - applications

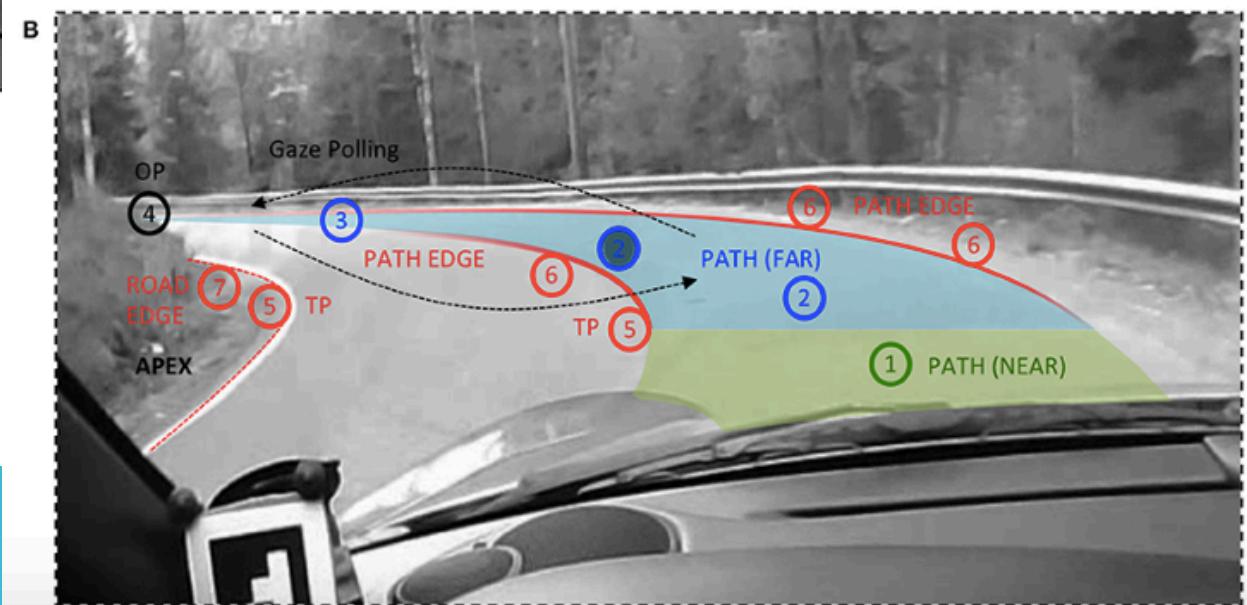
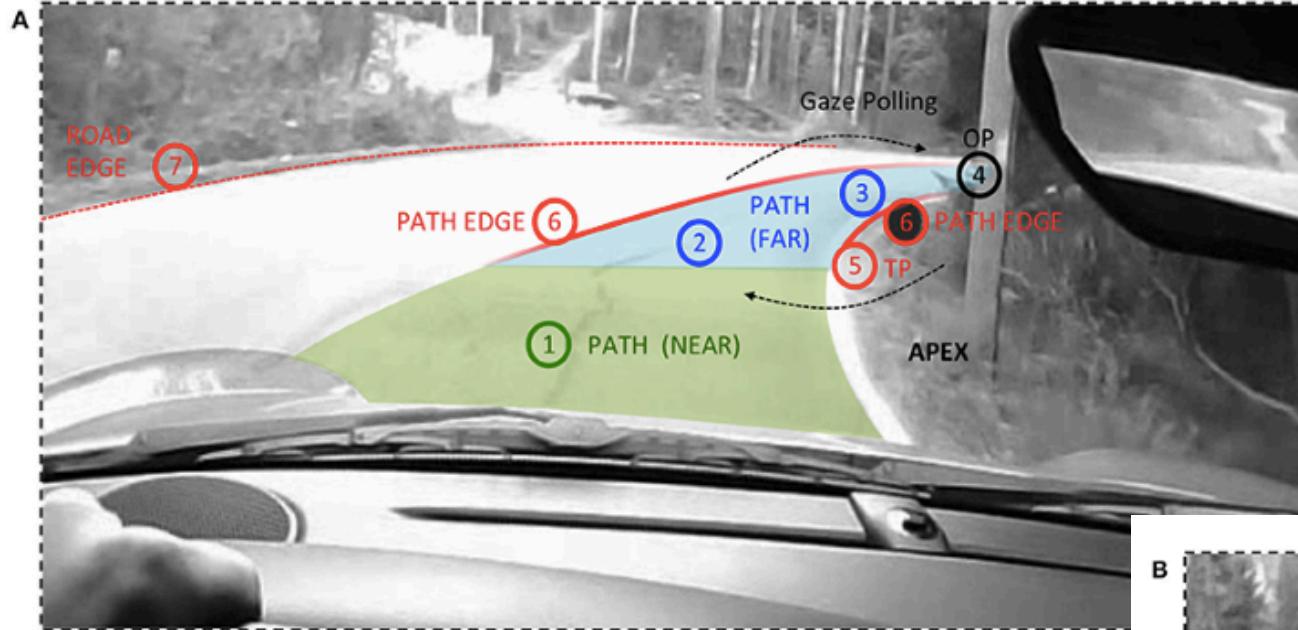
What can we measure?

Eye activity:

- where we look
- what we look at
- how much time we spend looking at it
- how our pupils respond
- when we blink

Use outside of research:

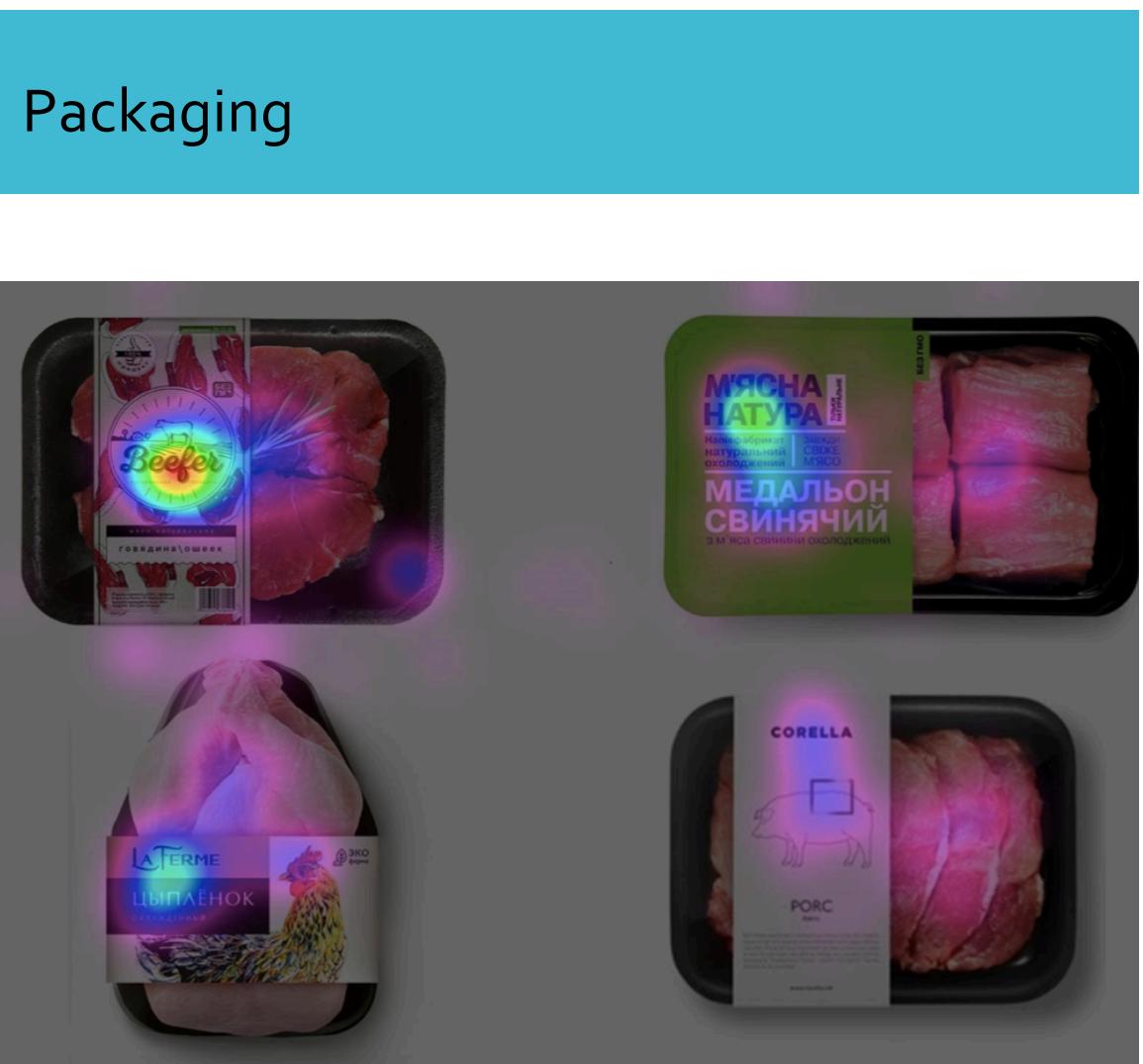
- as a **means of communication** for disabled people who can use only their eyes for input;
- in **ophthalmology**, for better understanding of eye movements to prevent, diagnose and treat abnormalities;
- **gaming**, as a controller or a way to increase immersive experience;
- for testing **usability** of websites, software, computer games, mobile devices, etc.
- **marketing**



Expertise

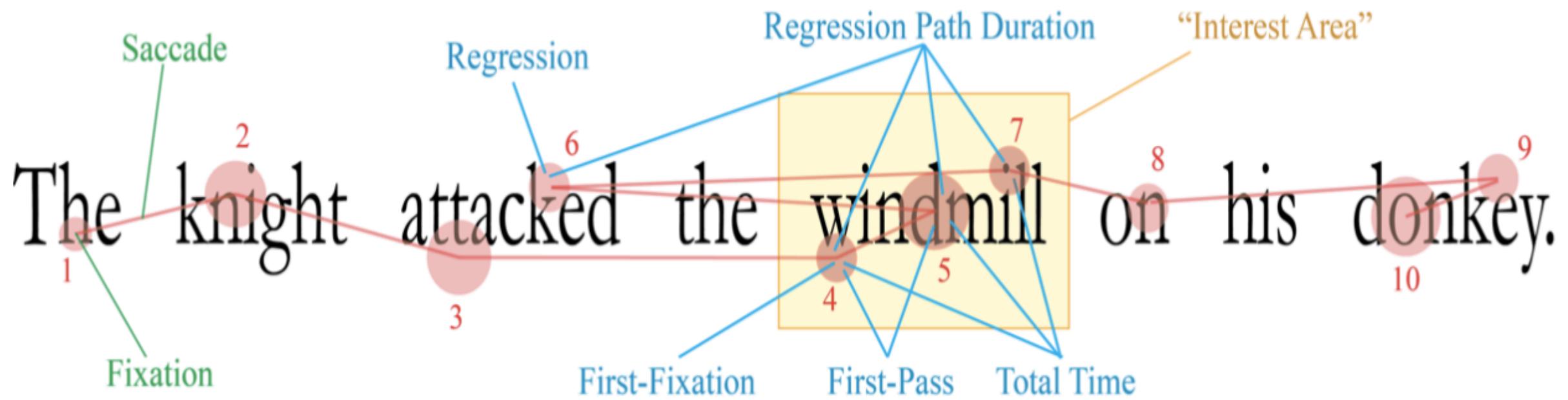


Marketing



Packaging

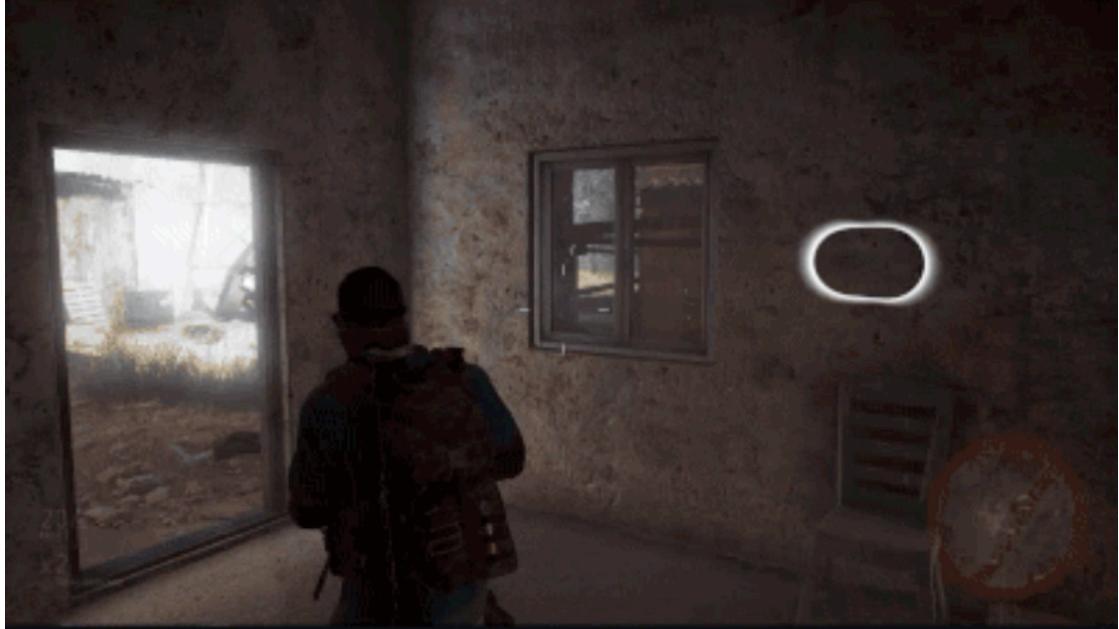
<http://consulting.md/>



Reading comprehension

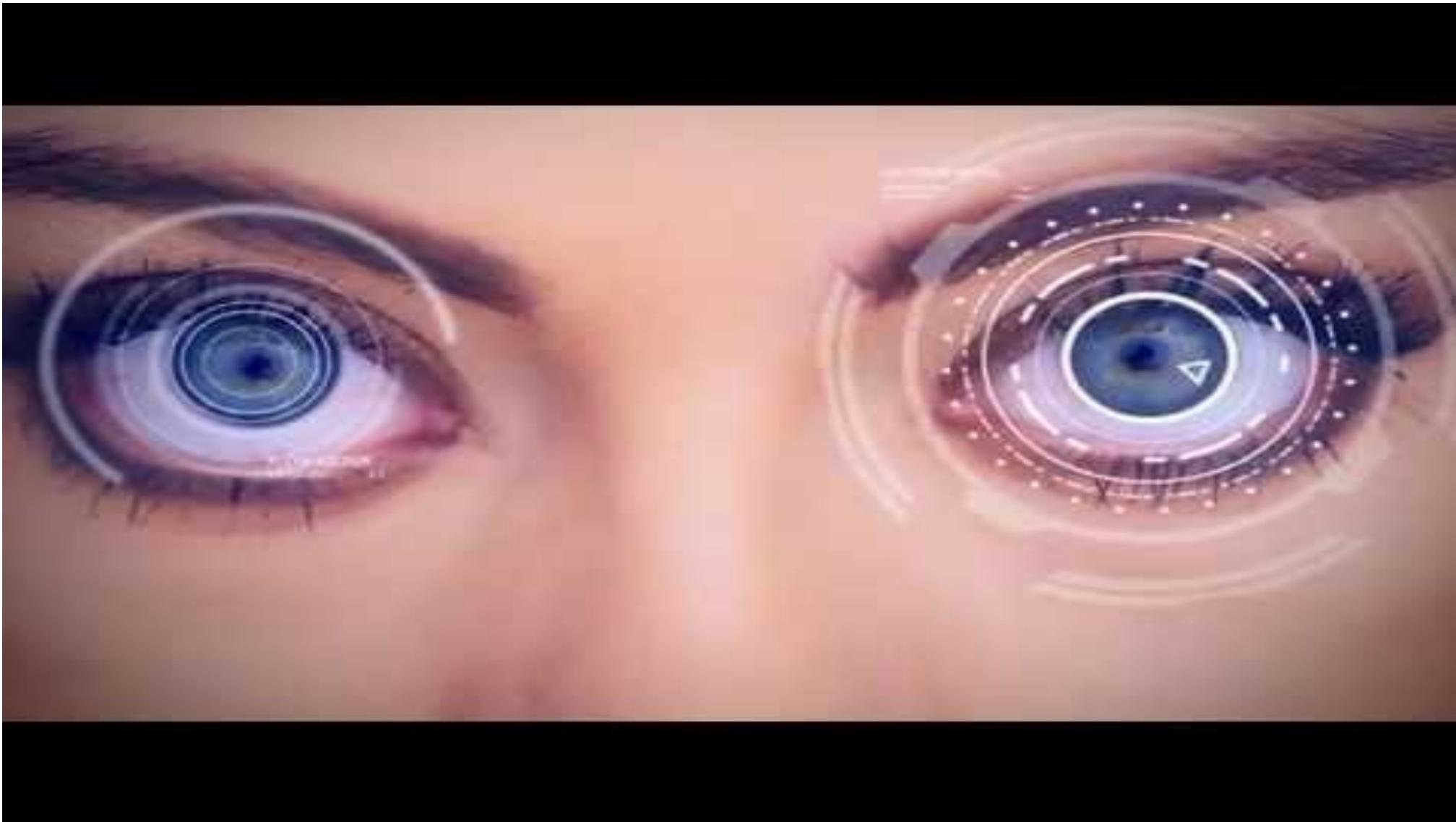


Look at a horde of zombies, they will become aware of your presence and come towards you.



Look to a light source – the environment will dim or brighten up simulating your eyes' adaptation to different lighting scenarios

Gaming



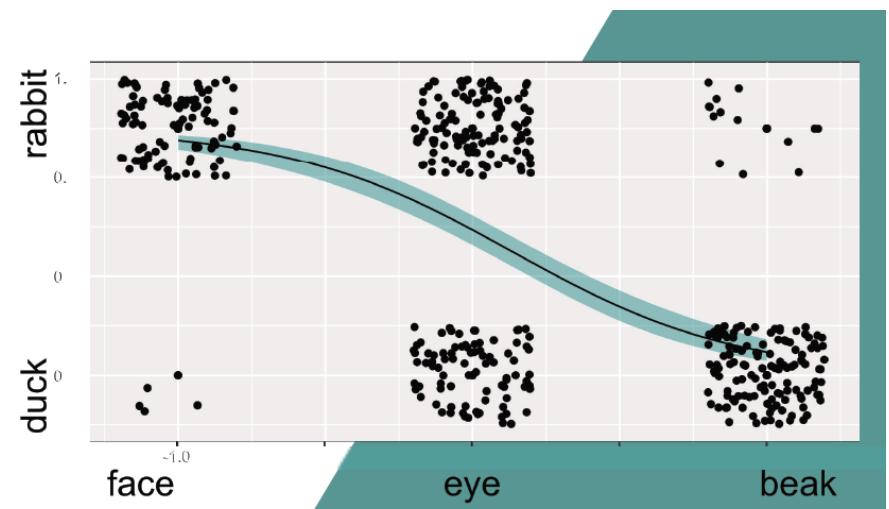
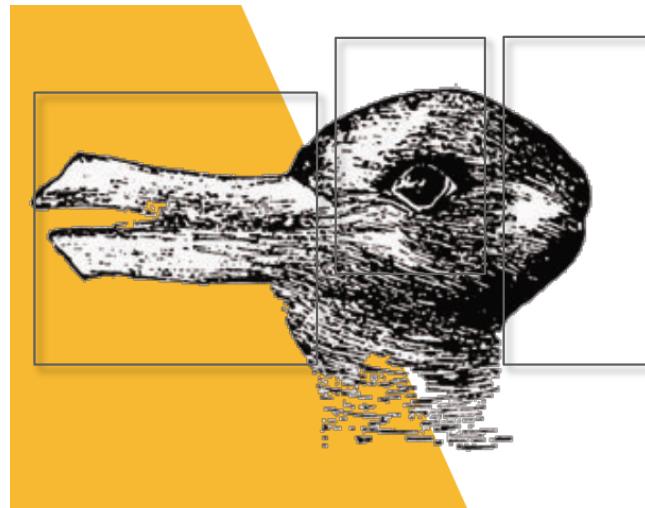
- Eye tracking glasses
- Gaming
- Marketing
- Heat-maps
- Real-life, natural recording
- Means of communication

Research

What kind of data can we collect with eyetracking technology?

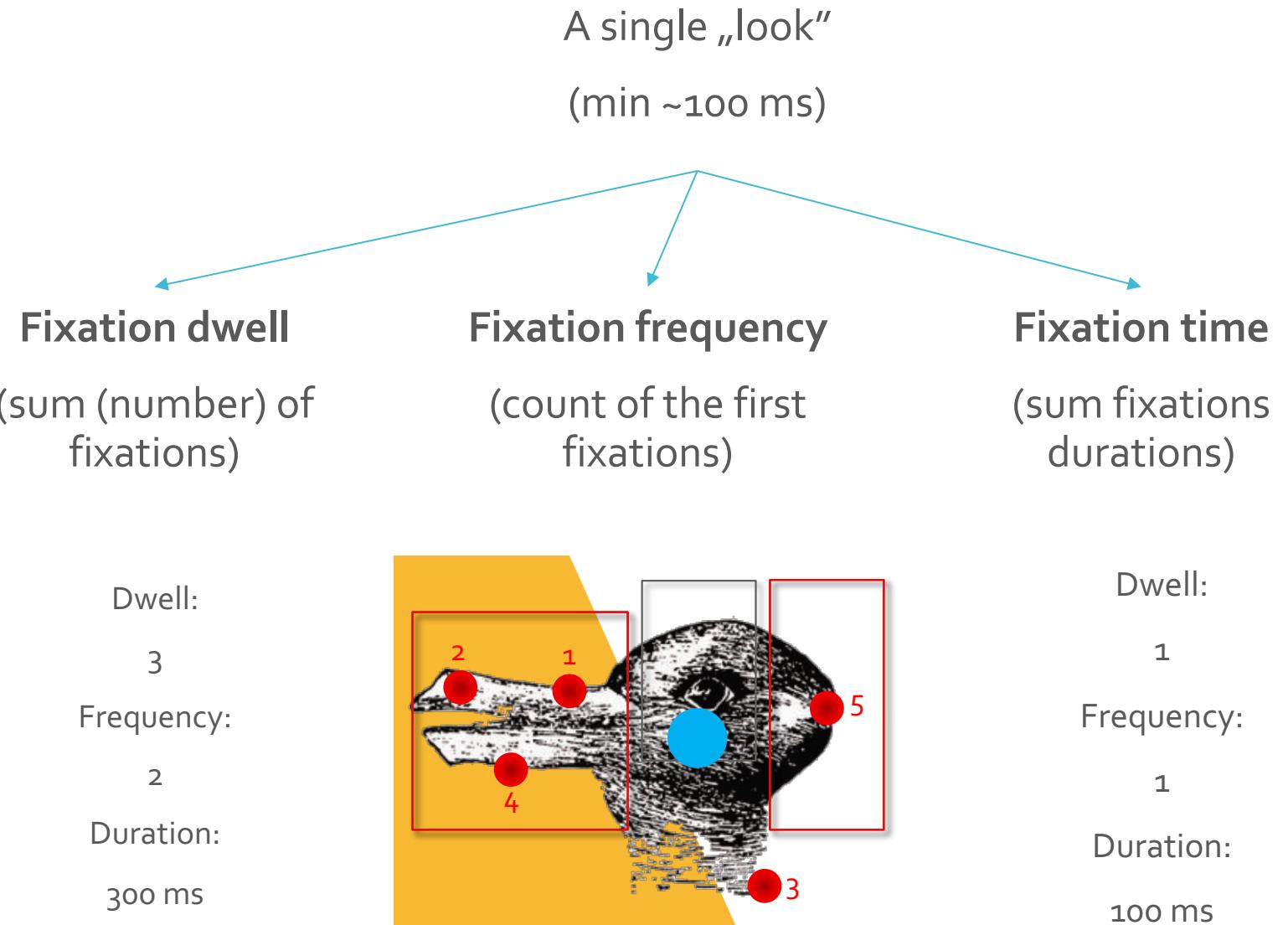
AOI

- Stimulus location defined by area-of-interest (AOI)
- Choosing the right size is important!
- Consideration: sample rate



Matyjek et al., 2016, unpublished

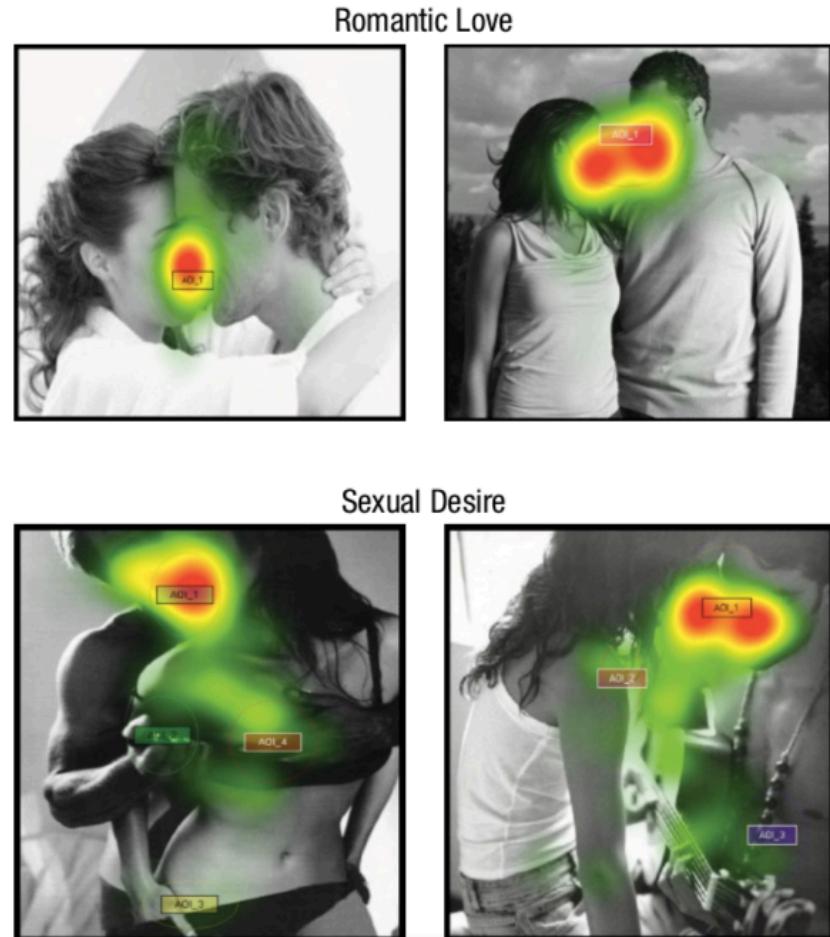
Fixations



Heat maps

An AOI-free way of visualising fixation dwell

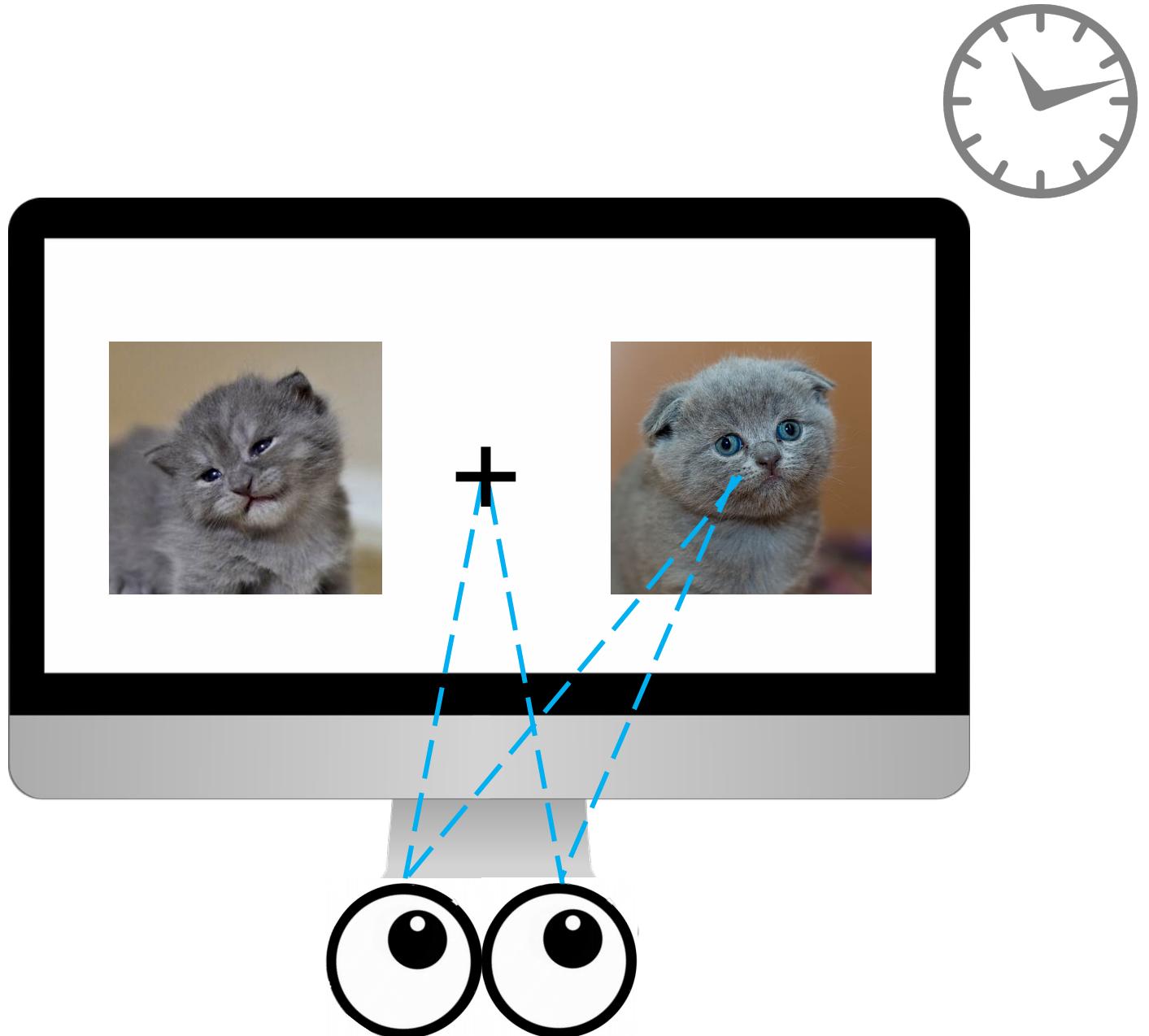
- fixation density sometimes weighted by duration
- averaged over participants



Bolmont, Cacioppo, & Cacioppo, 2014, Psych Science

Latency

Time until the first fixation



Saccades

Movements between fixations

Include:

- Start and stop position
- Latency
- Duration
- Speed
- Pattern / trajectory

DANS, KÖN OCH JAGPROJEKT

På jakt efter ungdomars kroppsspråk och den "synkretiska dansen", en sammansmältning av olika kulturers dans har jag i mitt fältarbete under hösten fört mig på olika arenor inom skolans värld. Nordiska, afrikanska, syd- och östeuropeiska ungdomar gör sina röster hörda genom sång, musik, skrik, skratt och gestaltade känslor och uttryck med hjälp av kroppsspråk och dans.

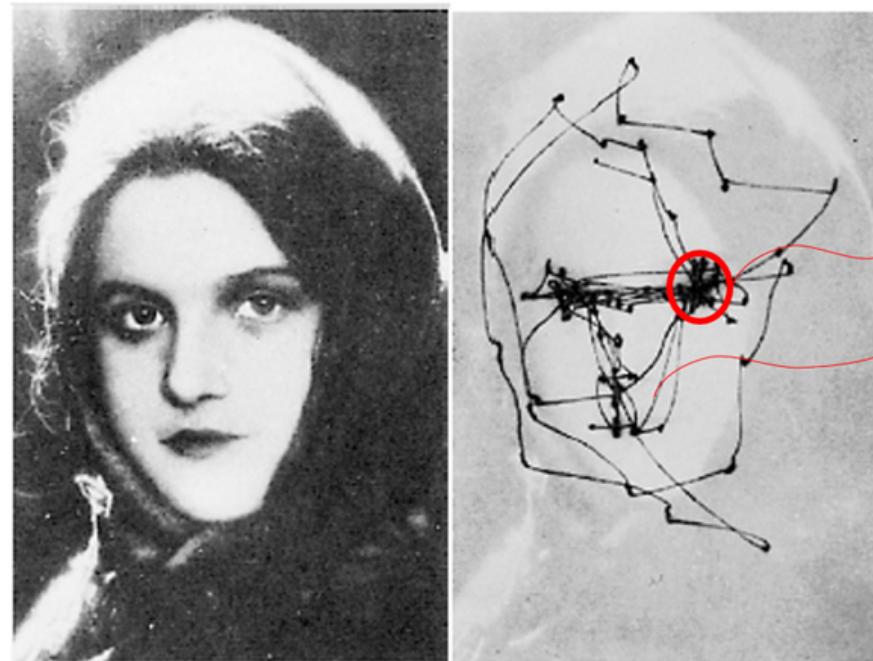
Den individuella estetiken framträder i kläder, frisyrer och symboliska tecken som förstärker ungdomarnas "jagprojekt" där också den egna stilens i kroppsrörelserna spelar en betydande roll i identitetsprövningen. Uppehållsrummet fungerar som offentlig arena där ungdomarna spelar upp sina performance liknande kroppsspråk.

Microsaccades

small, Involuntary, jerk-like movements within a fixation

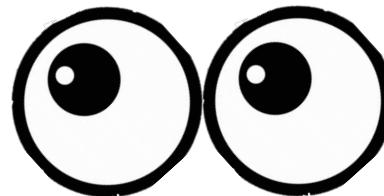
Unclear function:

- Enhancing spatial vision (correcting drifts)?
- Prevent retinal image from fading? - memory
- Conscious perception?
- Modulating neural responses (moving a stationary stimulus in and out of a neuron's receptive field)



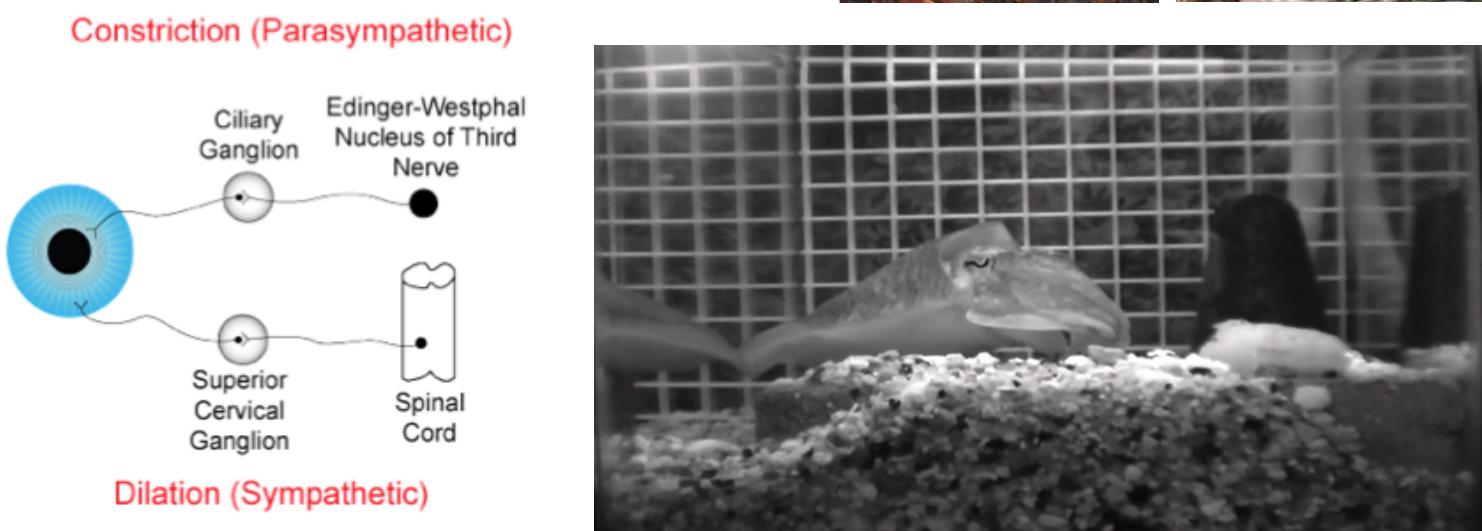
Smooth pursuit

The path of eye gaze
following a moving
stimulus



Pupillometry

diameter of the pupil,
pupillary light reflex (PLR)
– in humans ~700 ms



Pupillometry - meaning

- **Medicine**
 - Critical care: pupil size, light reflex, equality of two pupils
- **Psychology – research**
 - Arousal (sexual, emotional) - pupil dilation response (PDR)
 - Cognitive load, PDR
 - Memory load, PDR
 - Long-term memory (encoding, retrieval), PDR
 - Surprise, motivation, emotion, exploration, etc.

But what about **constrictions**?

- Pupillary light reflex (PLR)
- Other low-level equiluminant changes in stimuli (colour, motion) – reorienting pupil constrictions: selective attention?
- Tonic constriction when executing a well-learned task

Data analysis

Exemplary data

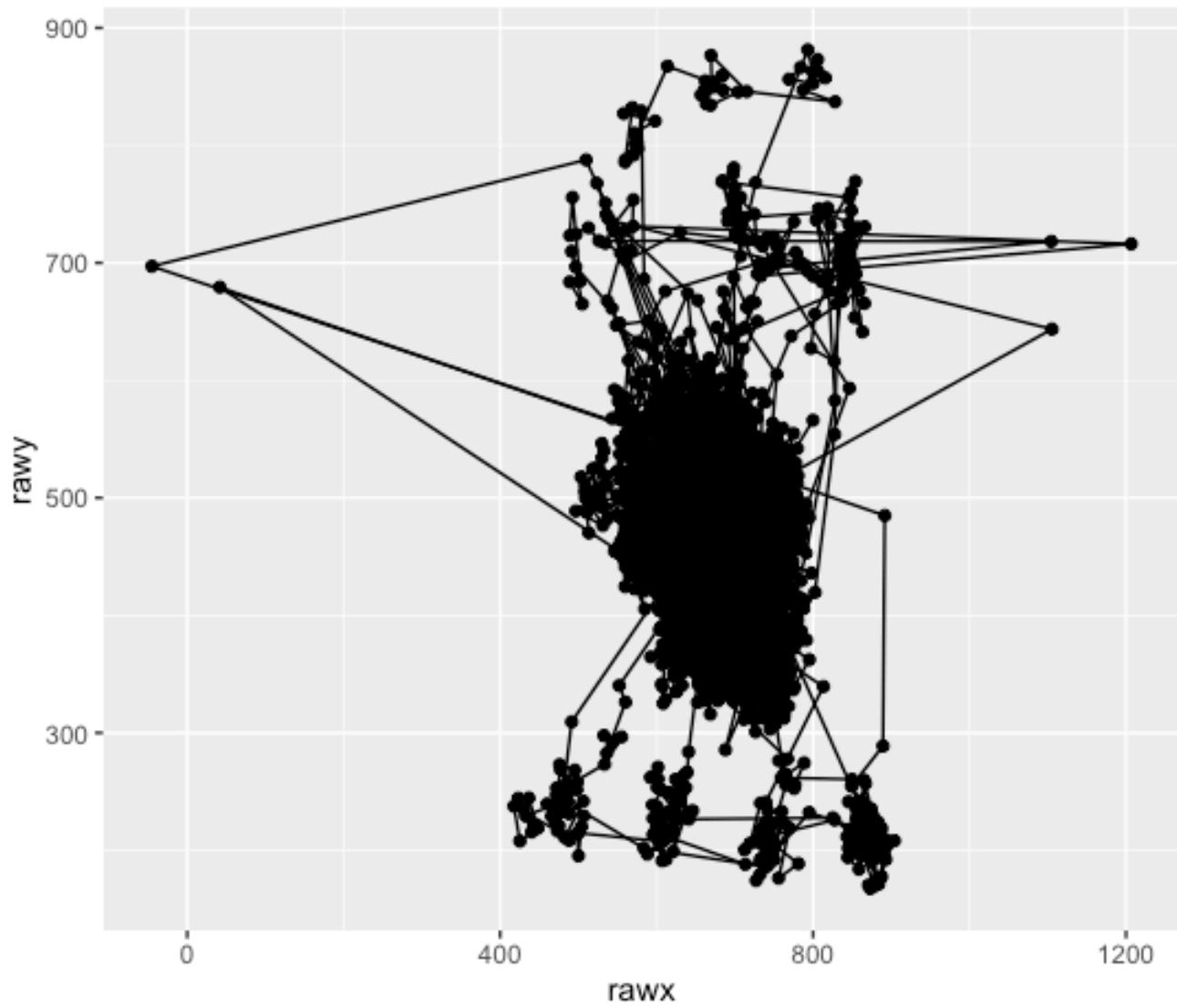
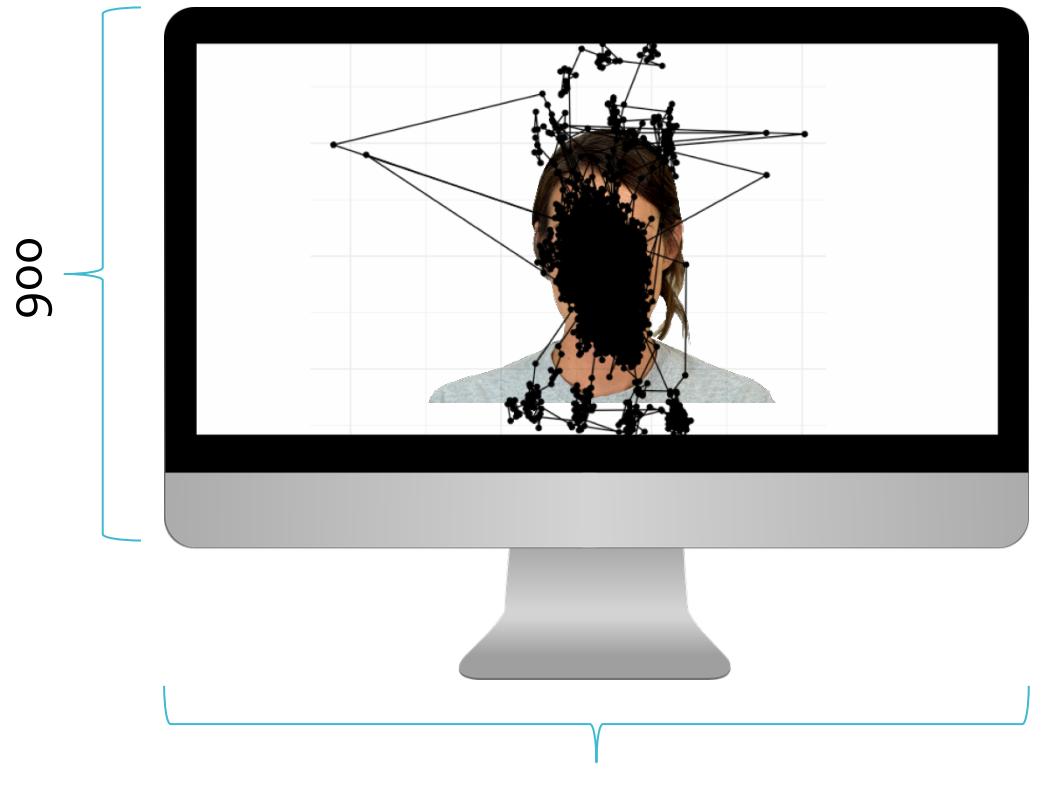
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1	MSG	2019-12-10 13:13:59.933	NA	NA	NA
2	2019-12-10 13:13:59.931	800784123	530.0952	565.9204	19.73470
3	2019-12-10 13:13:59.948	800784140	537.7161	564.1823	19.86985
4	2019-12-10 13:13:59.964	800784156	561.0669	529.8452	19.73450
5	2019-12-10 13:13:59.981	800784173	562.8224	553.5091	20.18605
	:59.997	800784189	557.0399	522.8593	19.33275
	:00.014	800784206	561.5466	575.9089	19.84775
	:00.031	800784223			90
	:00.047	800784239			25
10	2019-12-10 13:14:00.064	800784256			15
11	2019-12-10 13:14:00.081				65
12	2019-12-10 13:14:00.108		532.6516	649.2690	20.04245
13	2019-12-10 13:14:00.135		531.5295	667.4310	20.11490
14	2019-12-10 13:14:00.162	800784273	536.2996	635.7606	20.03630
15	2019-12-10 13:14:00.180	800784272	532.0245	664.2655	19.78350
16	2019-12-10 13:14:00.197	800784289	545.0134	677.5048	20.01395
17	2019-12-10 13:14:00.214	800784296	540.5254	671.4240	19.97145

Showing 1 to 19 of 30,587 entries, 5 total columns

When?
timestamp(s)

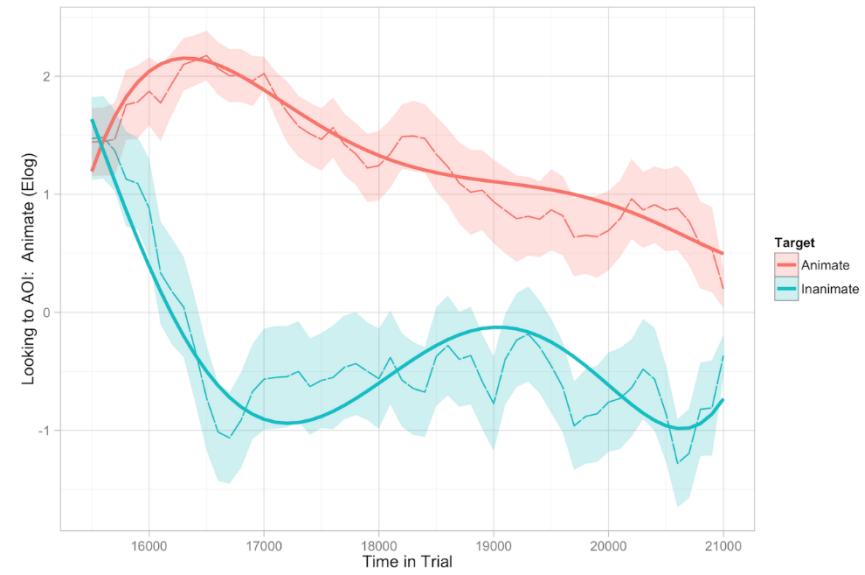
Where?
coordinates

Pupil size



Preprocessing

- Remove or interpolate eye-blanks, bad quality data
- Filtering
- Smoothing data
- Average left and right eye position and pupil diameter
- Event detection e.g. fixations, saccades



<http://www.eyetracking-r.com/>

Questions / comments?

@ magdalena.matyjek@hu-berlin.de

 LMatyjek