



# Eyetracking

MagdaLena Matyjek

Basic research  
methods

9/01/2020

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

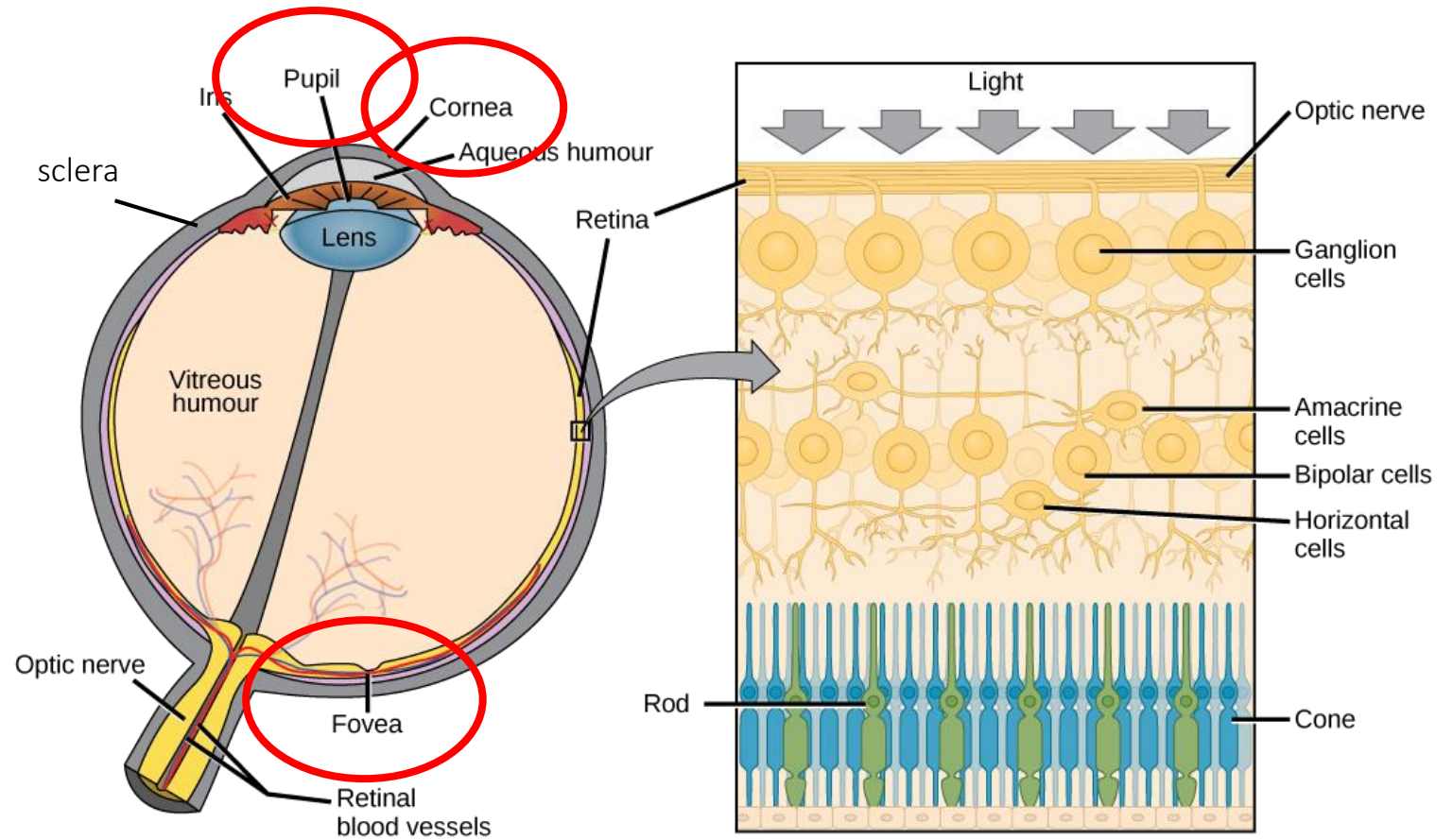
Anatomy, history, technology, use, types and set-up

# The Eye

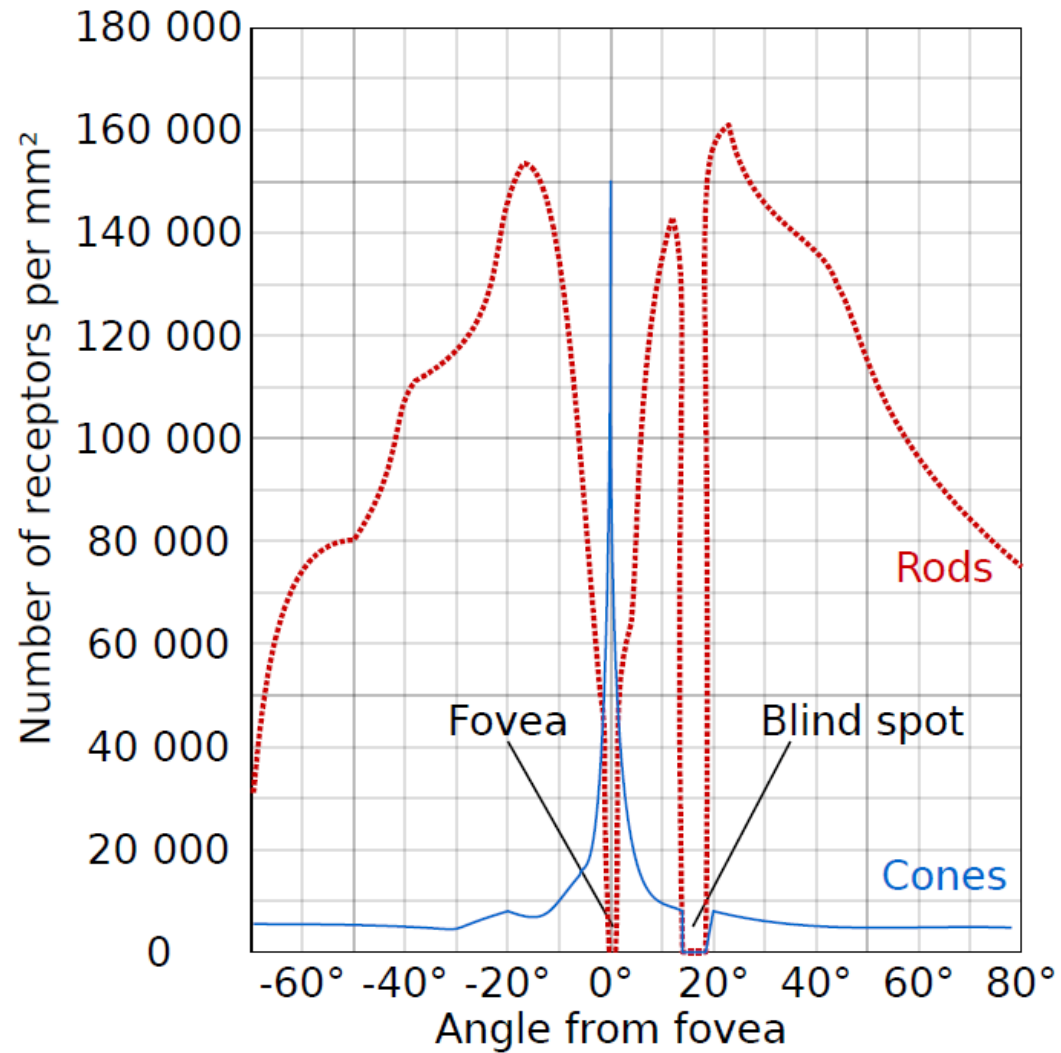


- Why is the eye interesting for the Mind & Brain researchers?
  - Relationship between mental processes and the eyes' movements
  - Thoughts, attention, feelings, planning, etc.
  - Not only for vision researchers

# Anatomy



# Cones & rods



- **Cones:**

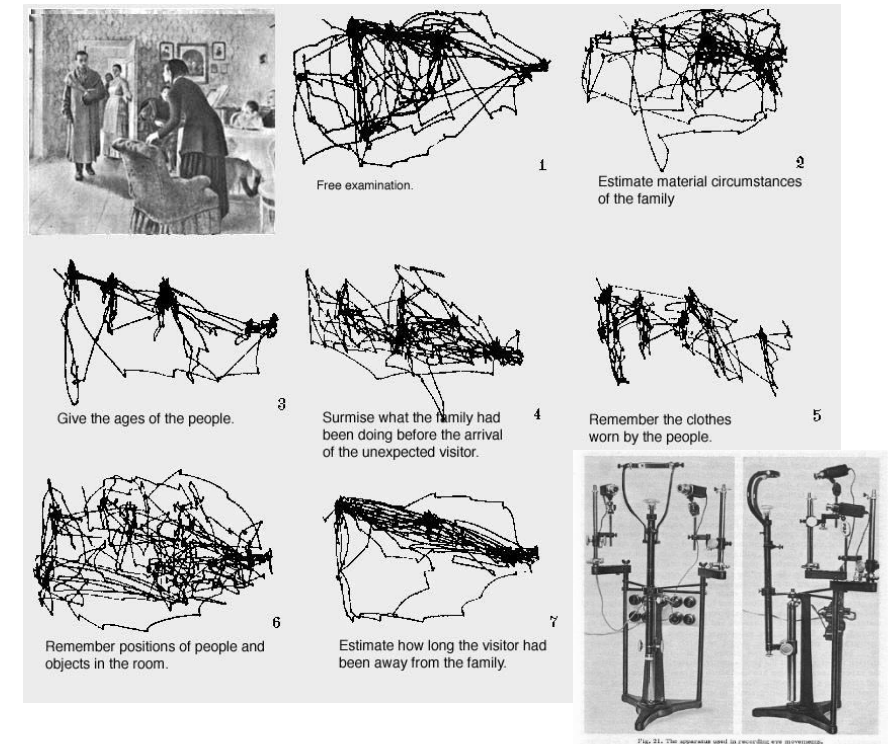
- Less sensitive to light
- Of 3 types:
  - S – blue
  - M – green
  - L – red
- Faster than rods
- Sharp vision

- **Rods**

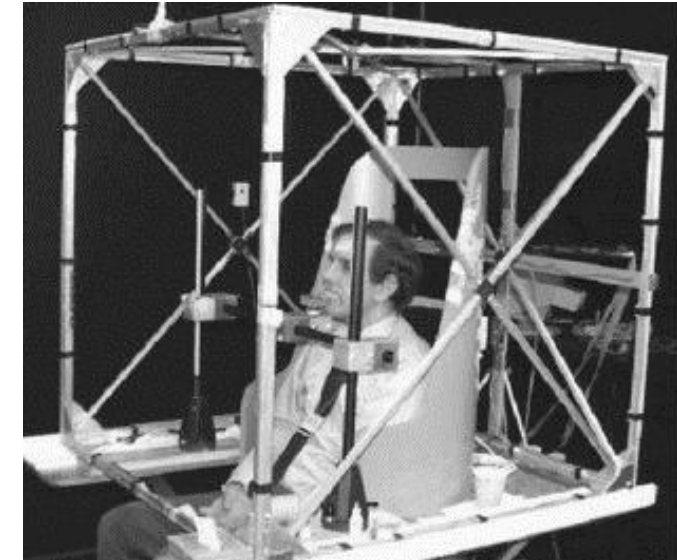
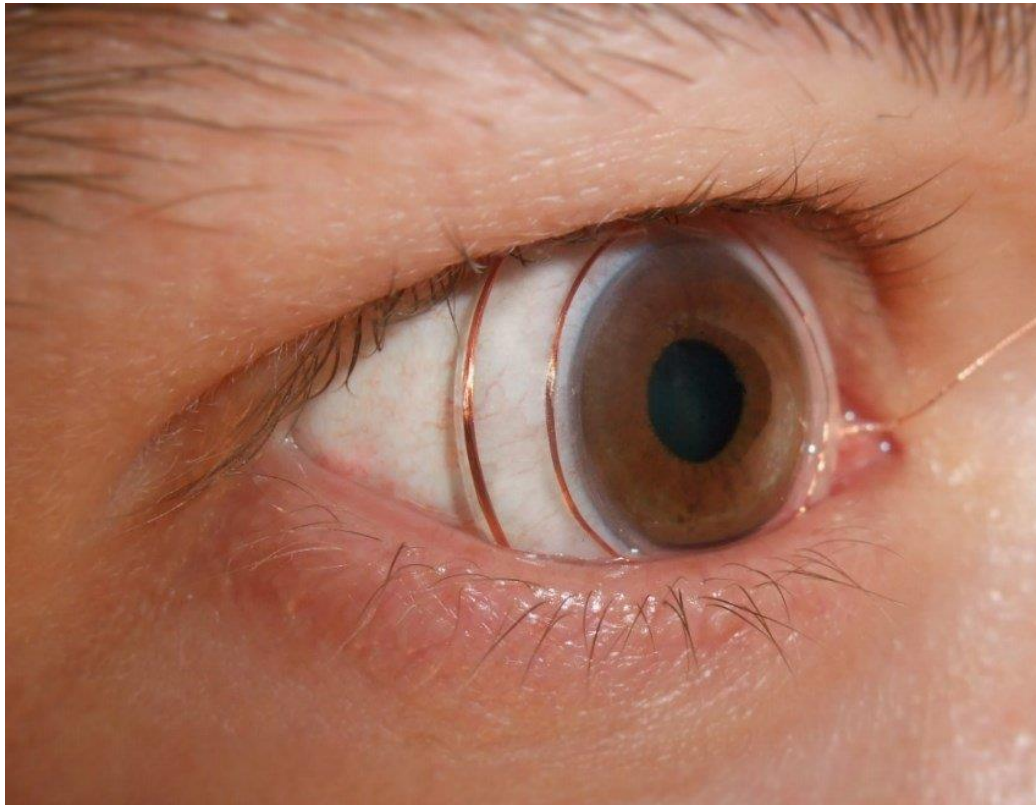
- More sensitive to low intensity of light (night vision) and movement
- Specific for one colour (blue-green)
- Slower than cones

# Eye tracking: history

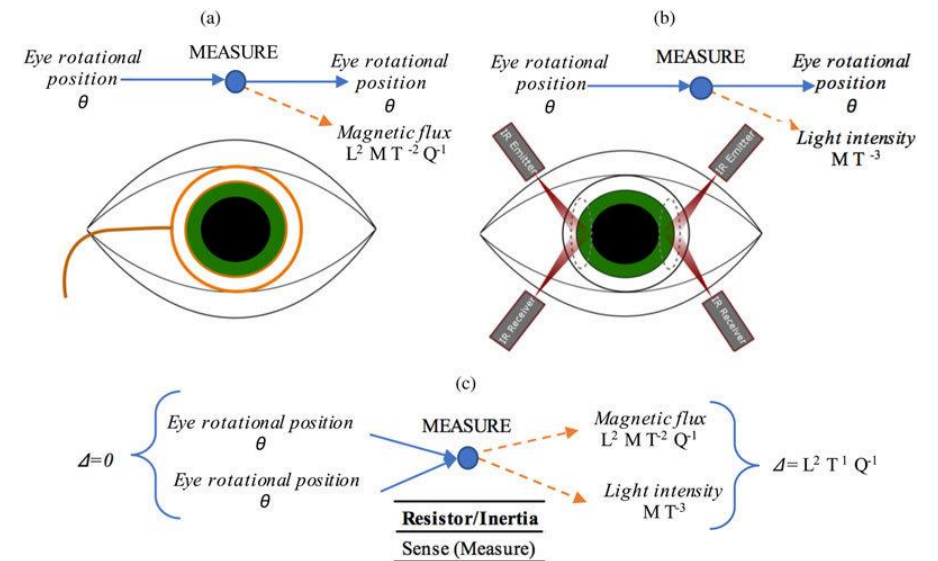
- **Javal**, 1879: reading („naked eye method“)
- **Huey**, 1908: first device
- **Yarbus**, 50s & 60s: saccades and fixations depend on the task and interests
- **Hunziker**, 1970: problem solving – tracking eyes through glass
- 70s & 80s: rapid progress
- 90s: marketing



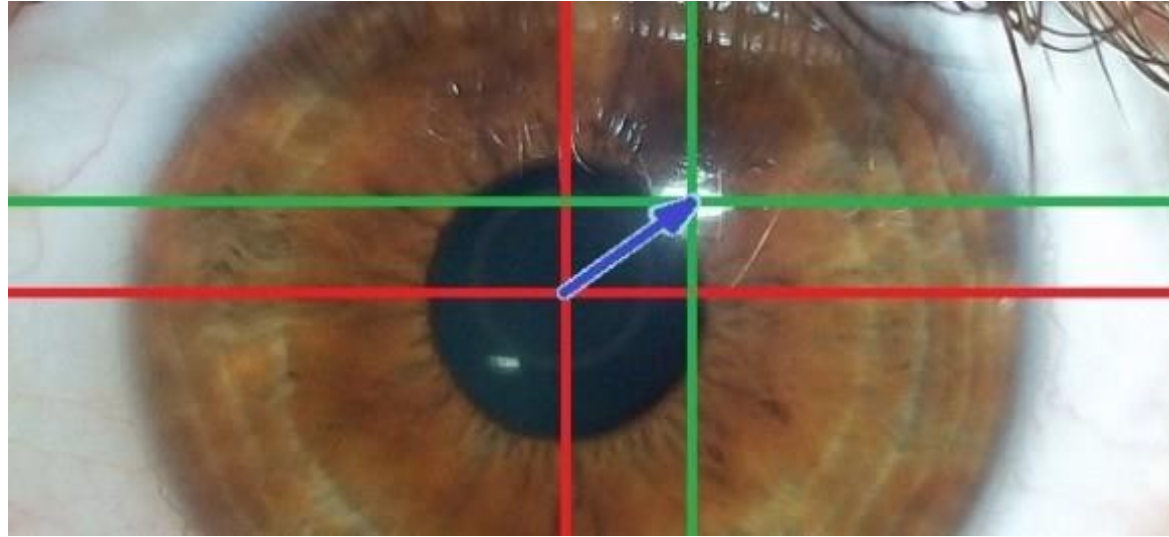




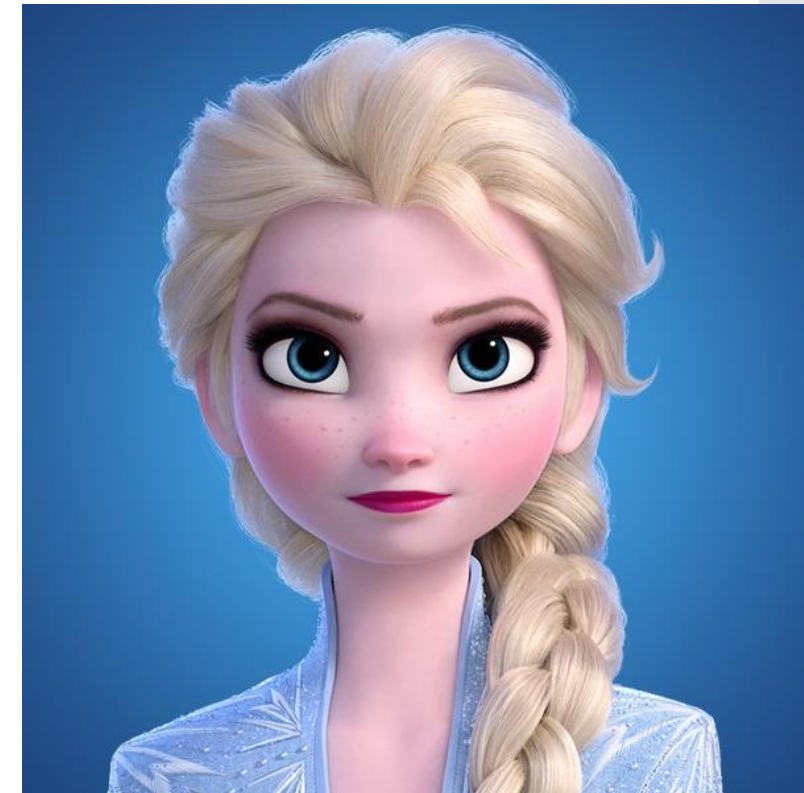
Invasive eye tracking:  
scleral search coil



# Optical tracking



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





# Set-up

## Fixed head

Best precision, bulky



Titz, Scholz, &  
Sedlmeier, 2018

## Head mounted

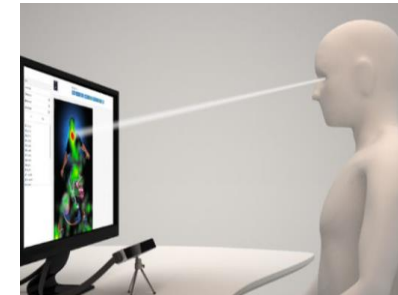
Open environment, bulky



[sr-research.com](http://sr-research.com)

## Remote

Ok precision, not bulky



[theyeyetribe.com](http://theyeyetribe.com)

## Glasses

Poor precision, open environment



[tobiipro.com](http://tobiipro.com)

# Eye tracking - applications

## What can we measure?

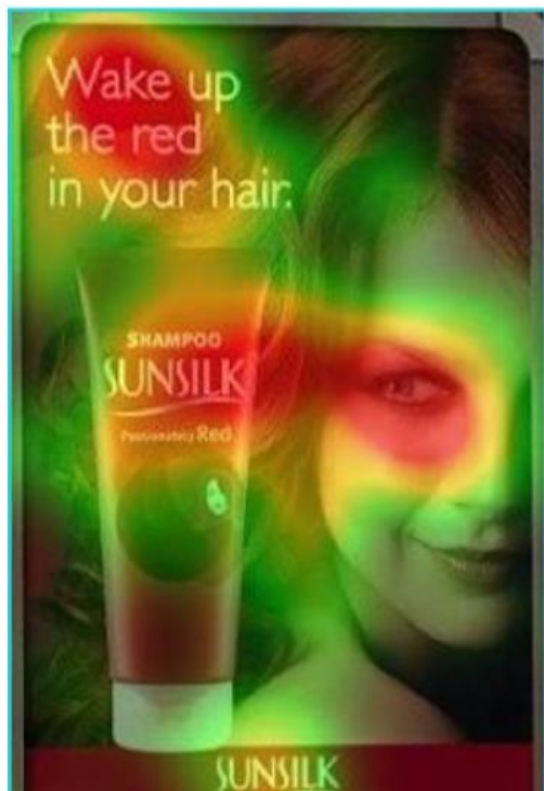
### Eye activity:

- 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**





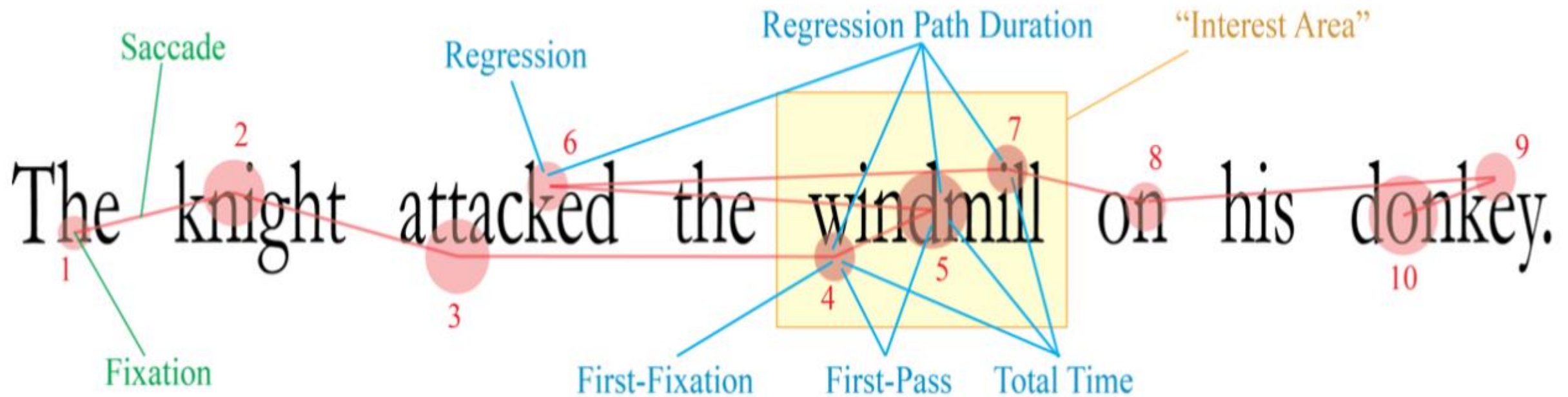
Marketing

Packaging



<http://consulting.md/>





Reading comprehension



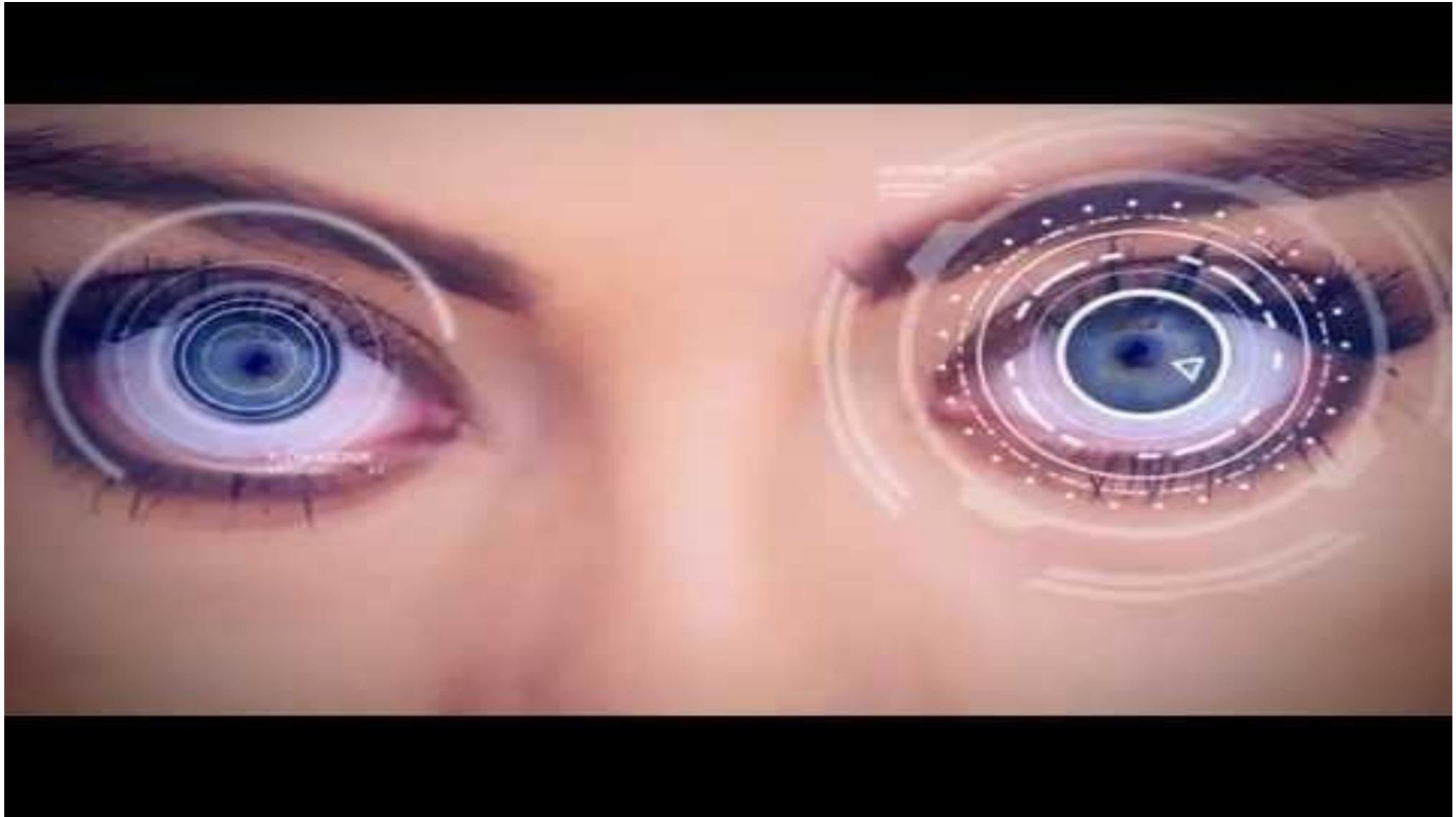


Look at a horde of zombies, they will become aware of your presence and come towards you.



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



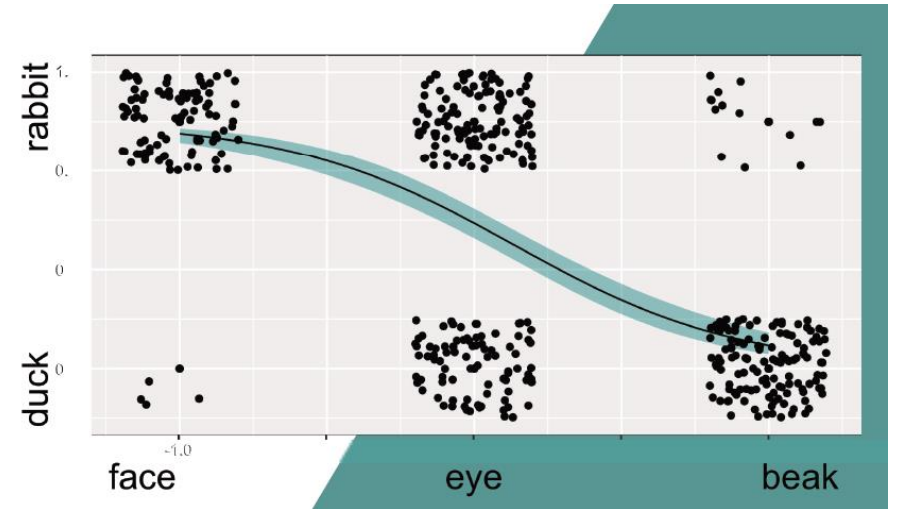
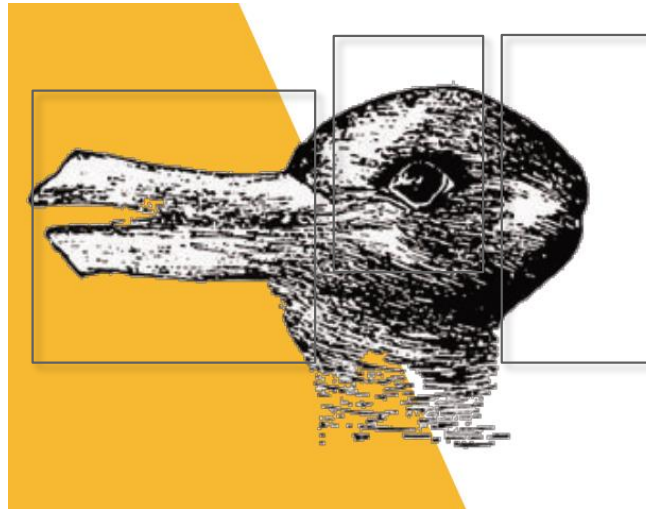
# Research

What kind of data can we collect with eyetracking technology?



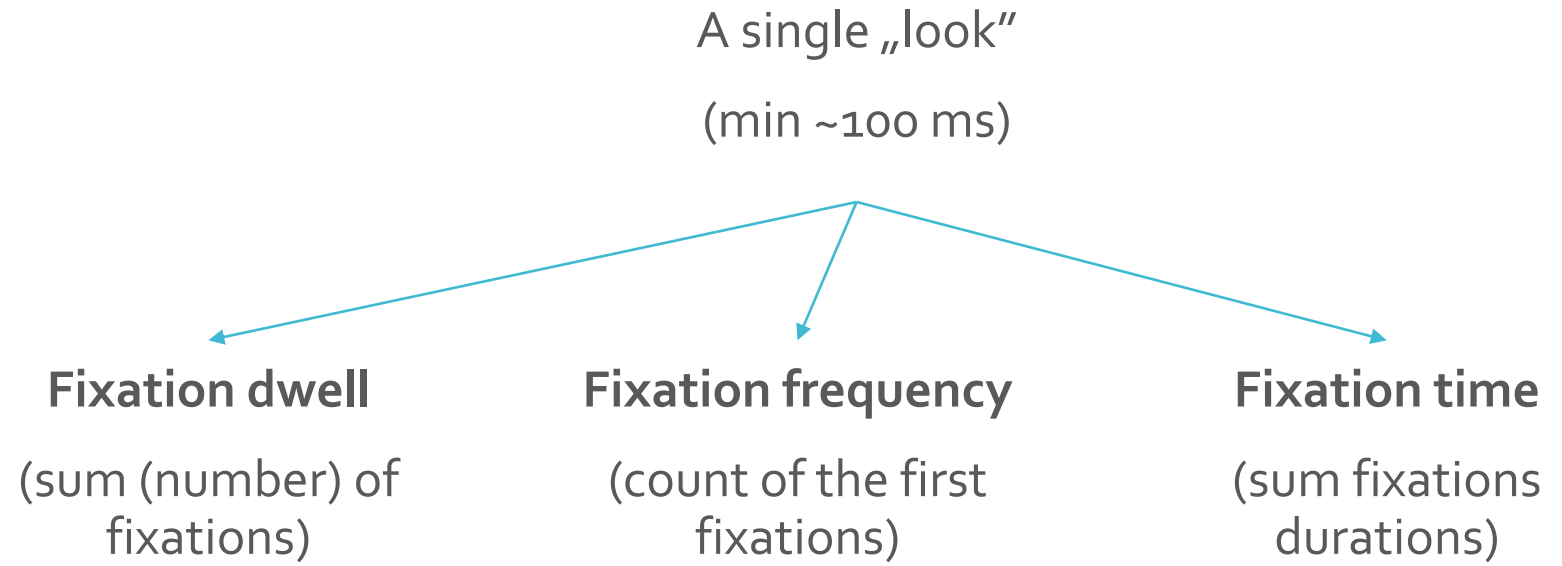
# AOI

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

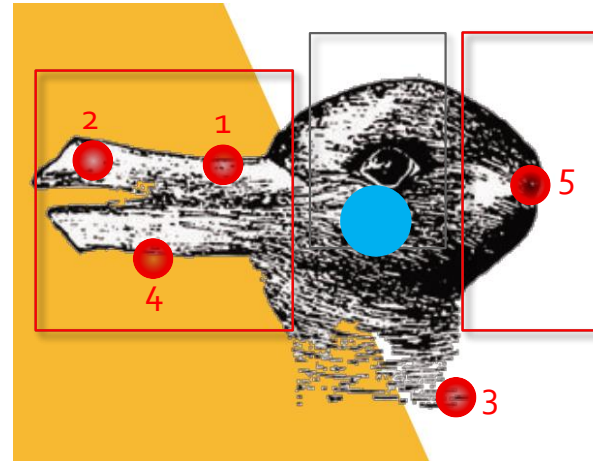


Matyjek et al., 2016, unpublished

# Fixations



Dwell:  
3  
Frequency:  
2  
Duration:  
300 ms



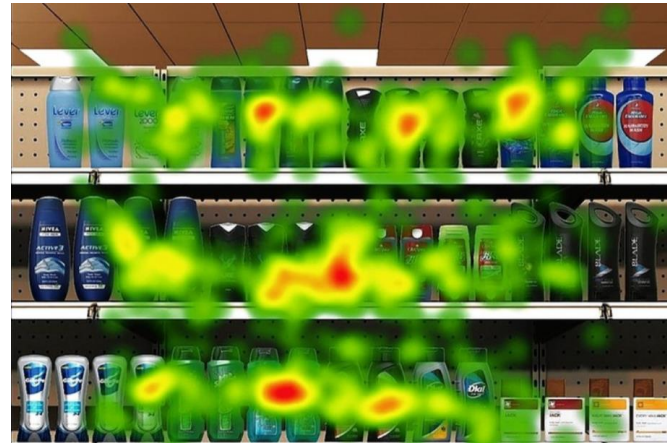
Dwell:  
1  
Frequency:  
1  
Duration:  
100 ms



# Heat maps

An AOI-free way of visualising fixation dwell

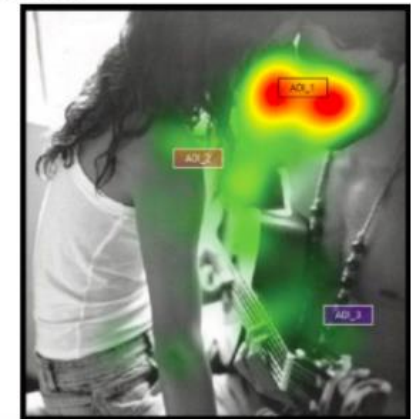
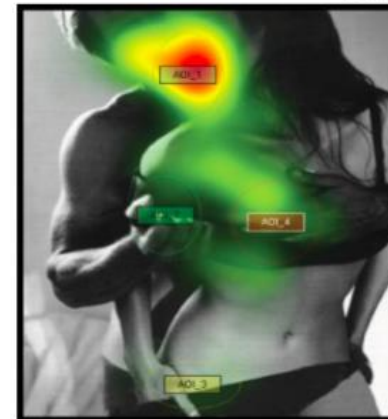
- fixation density
- sometimes weighted by duration
- averaged over participants



Romantic Love



Sexual Desire



Bolmont, Cacioppo, & Cacioppo, 2014, Psych Science

# Love Is in the Gaze: An Eye-Tracking Study of Love and Sexual Desire



**Mylene Bolmont<sup>1</sup>, John T. Cacioppo<sup>2,3,4</sup>, and  
Stephanie Cacioppo<sup>3,4</sup>**

<sup>1</sup>Department of Psychology, University of Geneva; <sup>2</sup>Department of Psychology, University of Chicago; <sup>3</sup>High-Performance Electrical NeuroImaging (HPEN) Laboratory, Center for Cognitive and Social Neuroscience, University of Chicago; and

<sup>4</sup>Department of Psychiatry and Behavioral Neuroscience, University of Chicago

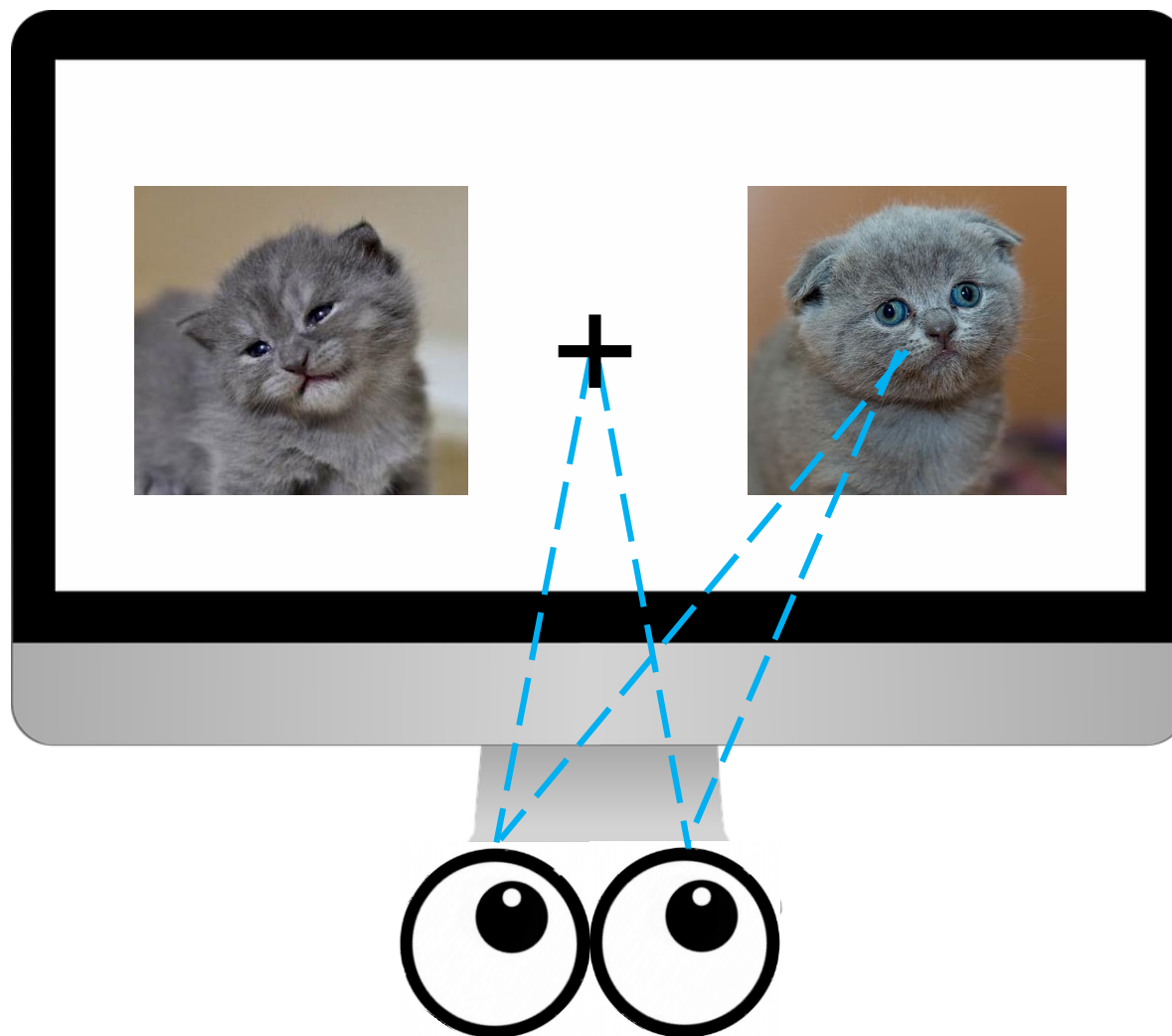
Psychological Science  
2014, Vol. 25(9) 1748–1756  
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DOI: 10.1177/0956797614539706  
[pss.sagepub.com](http://pss.sagepub.com)



# Student presentation

# 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 rört mig på olika arenor inom skolans värld. Nordiska, afrikanska, syd- och östeuropeiska ungdomar gör sina röster hörda genom sång, musik, skrik, skratt och gestaltar känslor och uttryck med hjälp av kroppsspråk och dans.

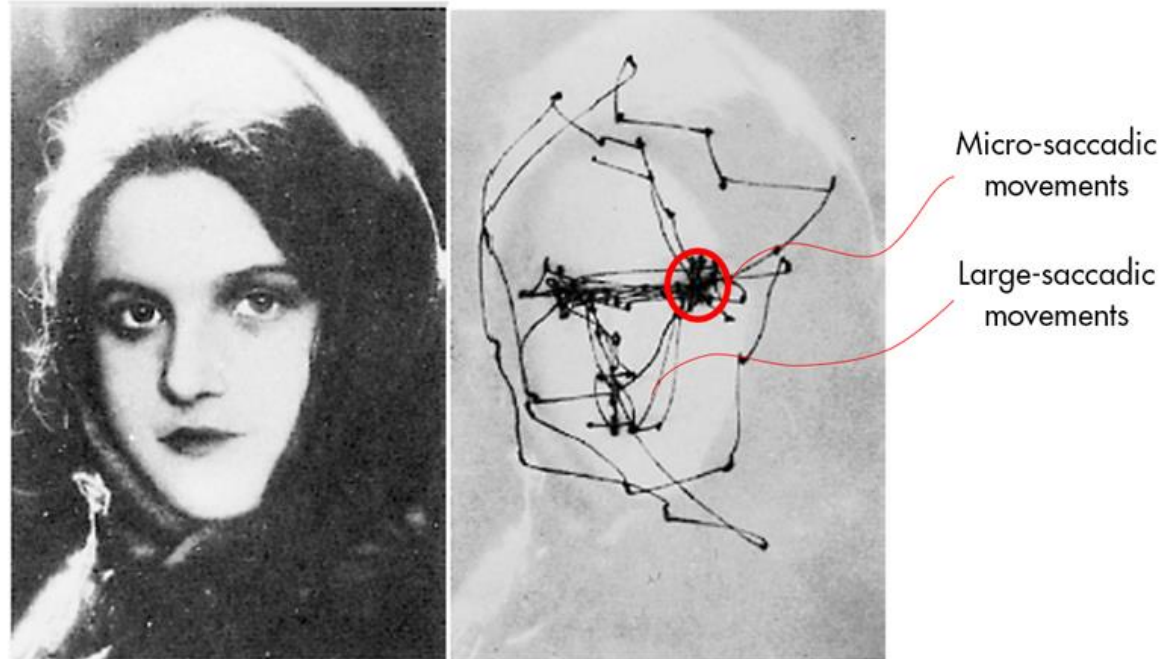
Den individuella estetiken framträder i kläder, frisyrer och symboliska tecken som förstärker ungdomarnas "jagprojekt" där också den egna stilen i kroppsrörelserna spelar en betydande roll i identitetsprövningen. Upphållsrummet fungerar som offentlig arena där ungdomarna spelar upp sina performance-liknande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

# Microsaccades

small, Involuntary, jerk-like movements within a fixation

Unclear function:

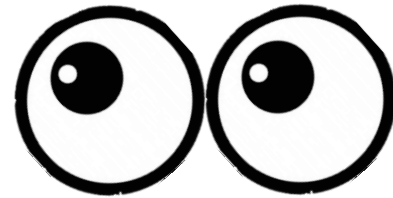
- Enhancing spatial vision (correcting drifts)?
- Prevent retinal image from fading? - memory
- Conscious perception?
- Modulating neural responses (moving a stationary stimulus in and out of a neuron's receptive field)





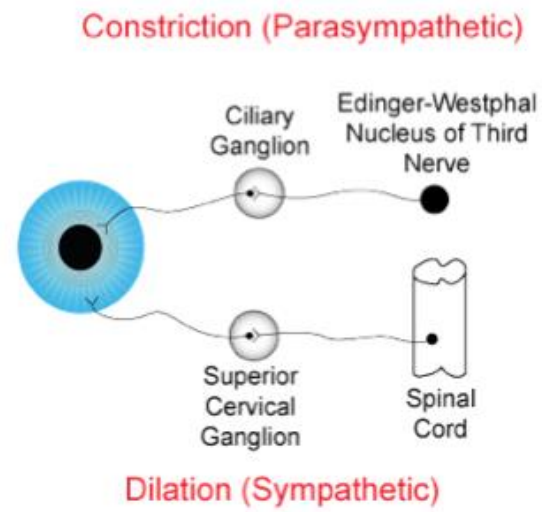
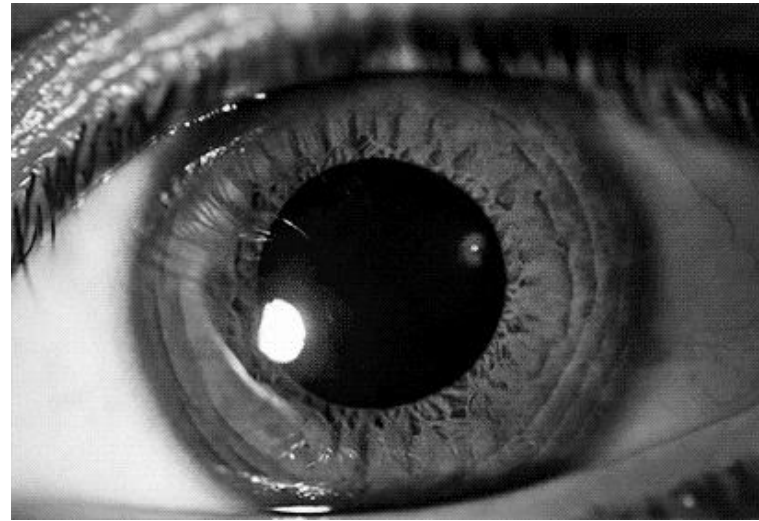
# Smooth pursuit

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

## Pupil constrictions to photographs of the sun

**Paola Binda**

Department of Psychology, University of Washington,  
Seattle, WA, USA  
Department of Physiological Sciences, Università di Pisa,  
Pisa, Italy



**Maria Pereverzeva**

Department of Psychology, University of Washington,  
Seattle, WA, USA



**Scott O. Murray**

Department of Psychology, University of Washington,  
Seattle, WA, USA



# Student presentation



# Data analysis



# Exemplary data

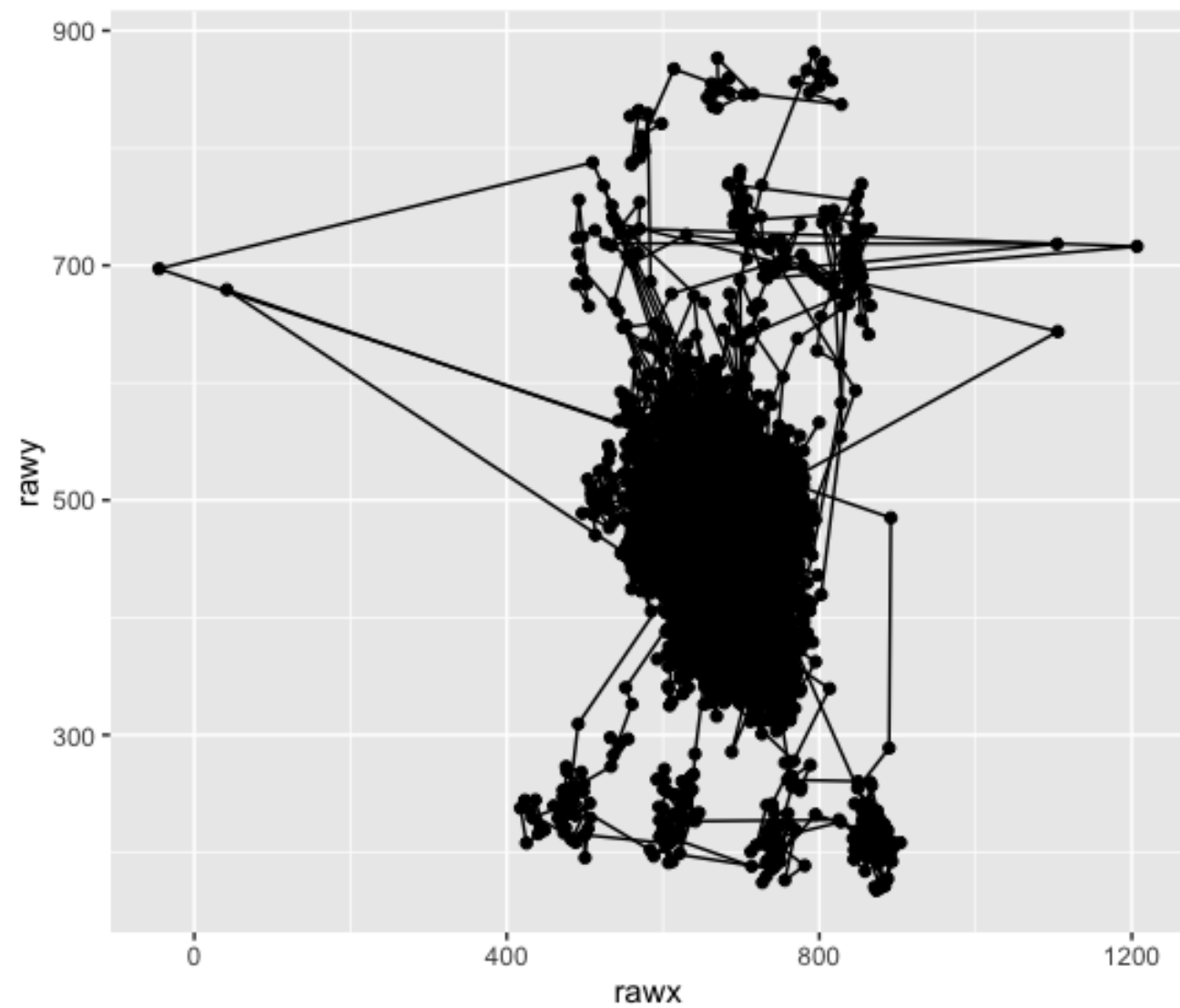
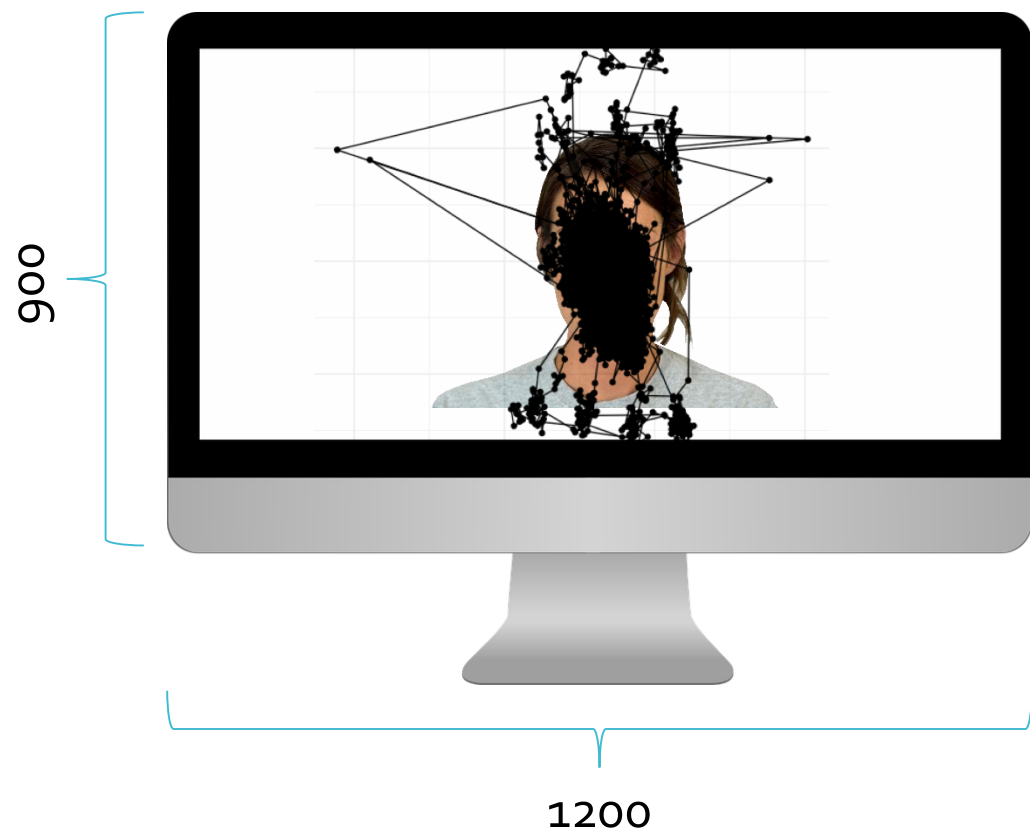
	timestamp	time	rawx	rawy	psize
1	MSG	2019-12-10 13:13:59.933	NA	NA	NA
2	2019-12-10 13:13:59.931	800784123	530.0952	565.9204	19.73470
3	2019-12-10 13:13:59.948	800784140	537.7161	564.1823	19.86985
4	2019-12-10 13:13:59.964	800784156	561.0669	529.8452	19.73450
5	2019-12-10 13:13:59.981	800784173	562.8224	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	800784273			65
12	2019-12-10 13:14:00.098	800784290	532.6516	649.2690	20.04245
13	2019-12-10 13:14:00.115	800784307	531.5295	667.4310	20.11490
14	2019-12-10 13:14:00.132	800784324	536.2996	635.7606	20.03630
15	2019-12-10 13:14:00.180	800784372	532.0245	664.2655	19.78350
16	2019-12-10 13:14:00.197	800784389	545.0134	677.5048	20.01395
17	2019-12-10 13:14:00.214	800784406	540.5254	671.4240	19.97145

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

When?  
timestamp(s)

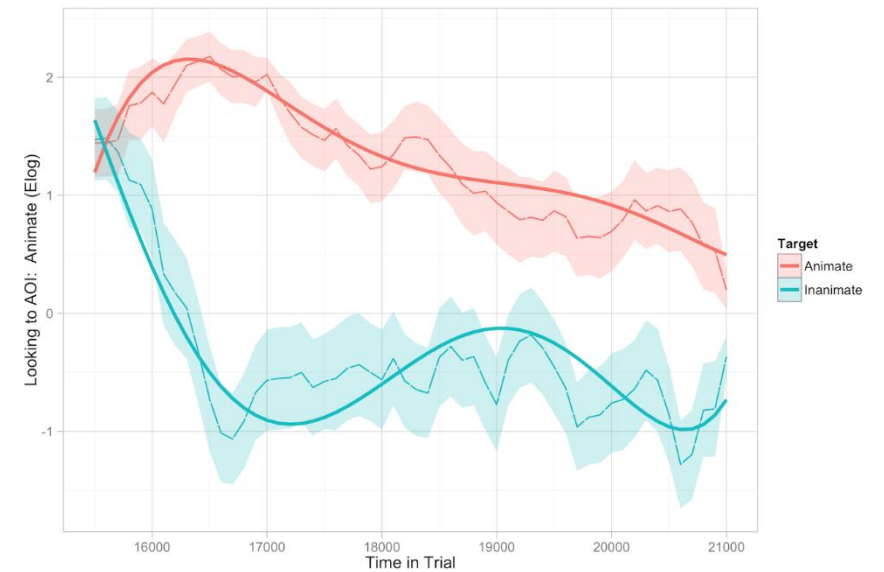
Where?  
coordinates

Pupil size



# Preprocessing

- Remove or interpolate eye-blinks, 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?

Tomorrow:

- hands-on data collection with pupillometry – emotional and neutral pictures
- 2 volunteers for eye tracking calibration needed!
- recording pupil sizes from those interested
- wear contact lenses instead of glasses if possible
- don't wear eyeliner, if possible (mascara is ok)