

# B-NP2 Übung: Eye tracking

Patrik Polgári

# 0. Preparation

# Preparation

- GitHub link on ILIAS

The screenshot shows a GitHub repository page for the user 'patrikpolgari' with the repository name 'teaching\_eye\_movements\_and\_target\_selection'. The repository is public and has 61 commits. The commit history includes several uploads of data and code files for tasks B, D, F, and E. The repository has 1 branch and 0 tags. The 'About' section indicates no description, website, or topics provided. It shows 1 watching and 0 forks. The 'Releases' section shows no releases published. The 'Languages' section shows Jupyter Notebook at 98.1% and Python at 1.9%. The 'Suggested workflows' section is based on the user's tech stack.

**Code** | **Issues** | **Pull requests** | **Actions** | **Projects** | **Wiki** | **Security** | **Insights** | **Settings**

**teaching\_eye\_movements\_and\_target\_selection** Public

**Code** | **Pin** | **Unwatch** 1 | **Fork** 0 | **Star** 0

**main** | **1 Branch** | **0 Tags**

**About**

No description, website, or topics provided.

Readme | Activity | 0 stars | 1 watching | 0 forks

**Commits**

Author	File	Message	Time	Commits
patrikpolgari	Update README.md	Upload data for tasks B, D and F	last week	5dc6643 · now 61 Commits
patrikpolgari	data_task_B	upload data_task_C	last week	
patrikpolgari	data_task_C	Upload data for tasks B, D and F	last week	
patrikpolgari	data_task_F	Upload data for tasks B, D and F	last week	
patrikpolgari	images_task_D	Upload data for tasks B, D and F	last week	
patrikpolgari	images_task_E	Add files via upload	1 hour ago	
patrikpolgari	images_task_F	reupload images_task_F	5 days ago	
patrikpolgari	ITTISalencyLib.py	upload Worksheet, B, F, G, H, ITTILasencyLib	5 days ago	
patrikpolgari	README.md	Update README.md	now	
patrikpolgari	Task_A.ipynb	Add files via upload	1 hour ago	
patrikpolgari	Task_B.ipynb	re-upload task B	22 minutes ago	
patrikpolgari	Task_C.ipynb	Add files via upload	1 hour ago	
patrikpolgari	Task_D.ipynb	Add files via upload	1 hour ago	
patrikpolgari	Task_E.ipynb	Add files via upload	1 hour ago	
patrikpolgari	Task_F.ipynb	Add files via upload	1 hour ago	

**Releases**

No releases published

[Create a new release](#)

**Packages**

No packages published

[Publish your first package](#)

**Languages**

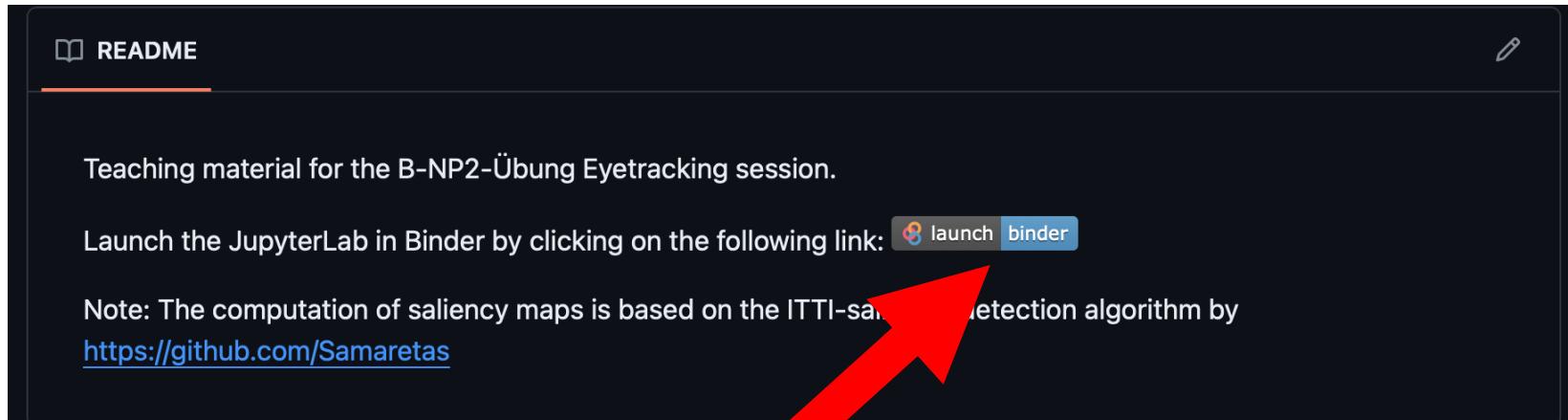
Jupyter Notebook 98.1% | Python 1.9%

**Suggested workflows**

Based on your tech stack

# Preparation

- GitHub link on ILIAS
- Scroll down to README



- Open Binder link

# Preparation

This will take some time... (might be quicker in Google Chrome)



Starting repository:

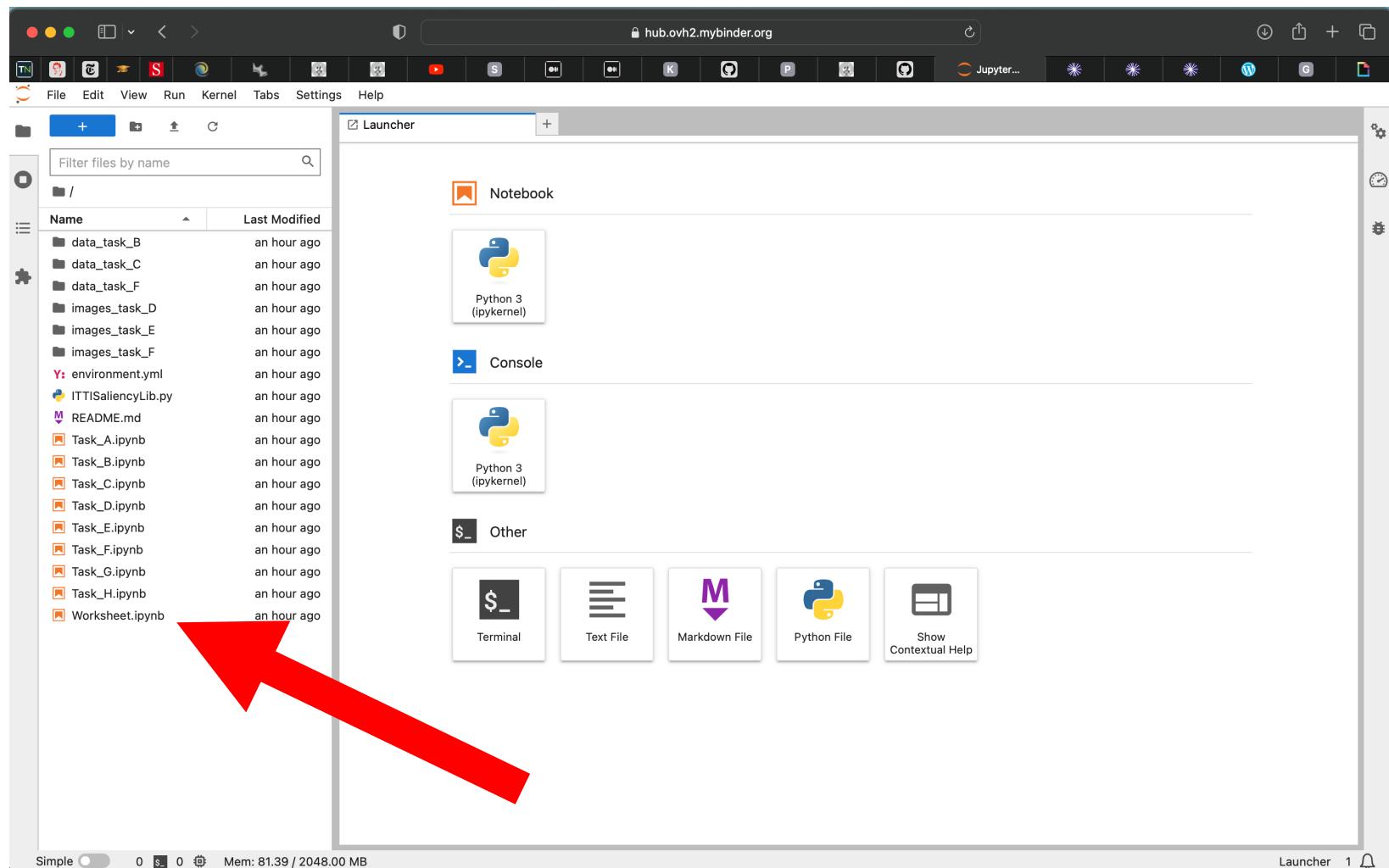
patrikpolgari/teaching\_eye\_movements\_and\_target\_selection/HEAD

New to Binder? Check out the [Binder Documentation](#) for more information

Build logs

[view raw](#) [show](#)

# Preparation



# Preparation

Sketchfab

File Edit View Run Kernel Tabs Settings Help

Run Selected Cell

Run Selected Cell and Insert Below

Run Selected Cell and Do Not Advance

Run Selected Text or Current Line in Console

Run All Above Selected Cell

Run Selected Cell and All Below

Render All Markdown Cells

Run All Cells

Restart Kernel and Run All Cells...

Task\_B.i... 1 minute ago

Task\_C.i... 3 days ago

Task\_D.i... yesterday

Task\_E.i... yesterday

Task\_F.i... yesterday

Task\_G.i... yesterday

Task\_H.i... yesterday

Workshe... 7 minutes ago

Y: environ... 2 days ago

Y: environ... yesterday

Y: environ... 2 days ago

Y: environ... 2 days ago

ITTISalie... 4 days ago

sk\_B.ipynb Task\_A.ipynb Notebook Python 3 (ipykernel)

## -processing of eye movement data and the detection of saccades

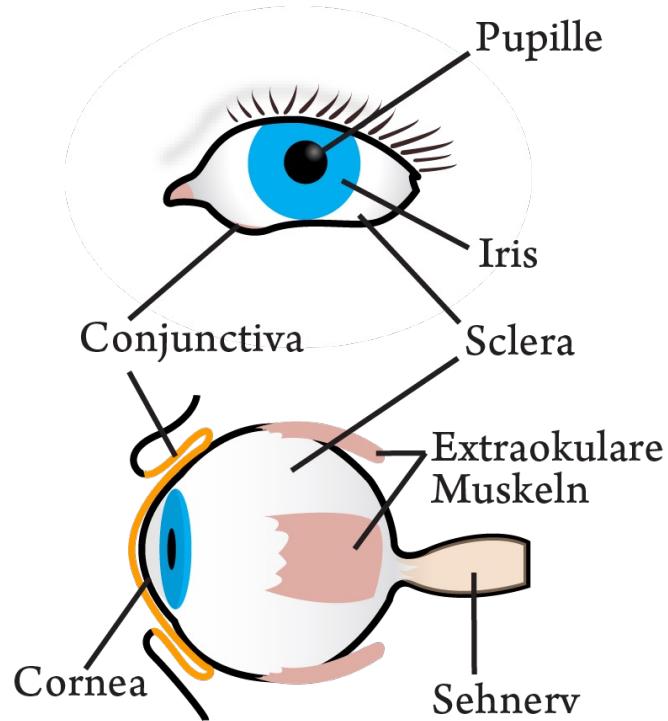
The eye movement signal from the eyetracker is usually very noisy, especially at high frequencies. In the graph below you can see the speed profile of the start of a smooth pursuit eye movement, which is interrupted by a saccade from approx. 0.2 to approx. 0.25 s. The black horizontal line indicates the target velocity of the eye movement (around 10 deg/s). Obviously, the noise exceeds the actual eye-tracking speed many times over. This is why high frequencies are often filtered out of the signal.

Would you like to receive official Jupyter news?  
Please read the privacy policy.

Open privacy policy Yes No

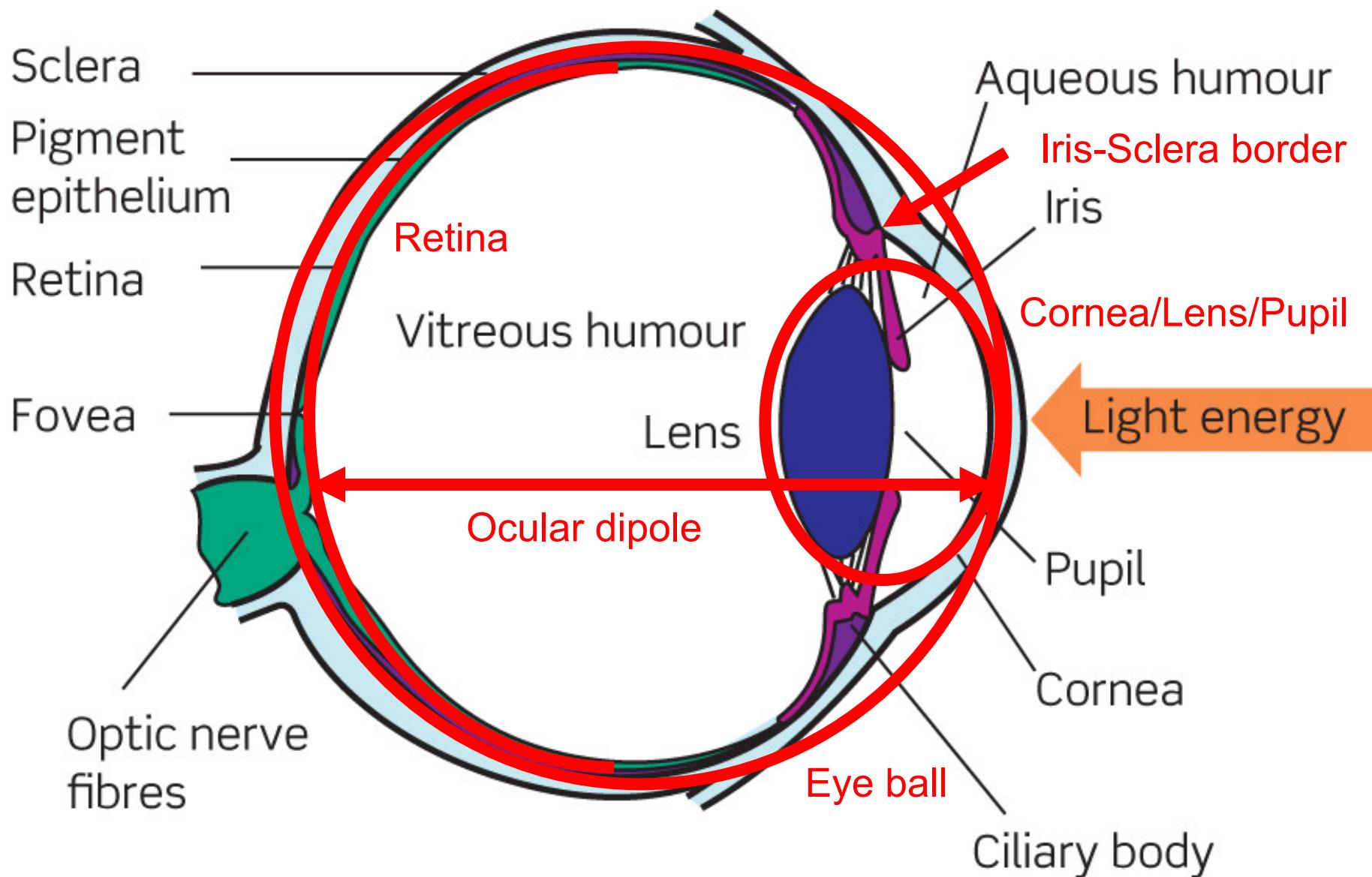
Log: Task\_B.ipynb + Add Checkpoint Clear Log Log Level: Warning

Simple 0 S 6 Python 3 (ipykernel) | Idle Mode: Command Ln 1, Col 1 Task\_B.ipynb 1

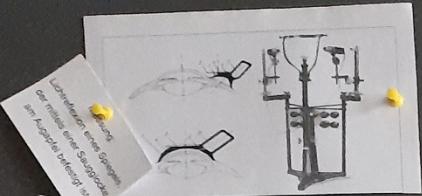


# 1. How are eye movements actually measured?

# Which signals can be quantified to measure eye movements?



Name	Messung	Signal	Vor- & Nachteile
Eyetracker von Yarbus	Lichtreflexion eines Spiegels, der mittels einer Saugglocke am Augapfel befestigt ist.	Position des Augapfels	Vorteil: Hohe räumliche und zeitliche Auflösung Nachteil: Extrem invasiv, Datenaufzeichnung schwierig
Scleral search coil	Elektro-magnetisch induzierte Spannung in einem Leiter, der sich in einer Kontaktlinse befindet.	Position des Augapfels	Vorteil: Hohe räumliche und zeitliche Auflösung Nachteil: Sehr invasiv
Electro-oculogramm	Elektrische Spannung in Elektroden, die auf Schläfen, Stirn und Wange aufgebracht sind.	Relative Position von Netzhaut und Linse	Vorteil: Hohe zeitliche Auflösung, auch bei geschlossenen Augen messbar Nachteil: Viele Störsignale
Dual-purkinje tracker	Stellung von Elektromotoren, die die 1. und 4. Purkinje Reflexion auf 2 Sensoren stabilisieren.	Relative Position von Cornea und Linse	Vorteil: Hohe räumliche und zeitliche Auflösung Nachteil: Umständliche Handhabung
Limbus eye tracker	Elektrische Spannung in photosensitiver Diode, die auf das Auge gerichtet ist.	Position der Grenzen von Iris und Sklera	Vorteil: Hohe zeitliche Auflösung Nachteil: Viele Störsignale
Scanning laser ophthalmoscope	Hochauflösendes Bild der Netzhaut, das Blutgefäße und einzelne Rezeptoren zeigt	Position der Photorezeptoren	Vorteil: Extrem hohe räumliche Auflösung Nachteil: Niedrige zeitliche Auflösung, teuer und aufwändig
Video-basierter eye tracker	Infrarotbild des Auges mit Pupille und Reflexion auf der Cornea	Relative Position der Pupille und der 1. Purkinje Reflexion	Vorteil: Hohe räumliche und zeitliche Auflösung, leichte Handhabung
Web cam eye tracking	Bild des Kopfes mit Augen und Pupillen	Relative Position des Kopfes und der Pupille	Vorteil: Leichte Handhabung Nachteil: Niedrige räumliche und zeitliche Auflösung



Vorteil: Hohe räumliche und zeitliche Auflösung  
Nachteil: Umständliche Handhabung

Eyetracker von Yarbus

Signal:  
Position des Augapfels



Vorteil: Hohe räumliche und zeitliche Auflösung  
Nachteil: Sehr invasiv

Scleral search coil

Messung:  
Elektro-magnetisch induzierte Spannung in einem Leiter, der sich in einer Kontaktlinse befindet.

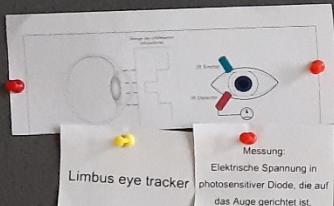
Signal:  
Position des Augapfels



Signal:  
Relative Position von Cornea und Linse

al-purkinje tracker

Bildung von Elektromeren, die die 1. und 4. Purkinje Reflexion auf 2. Sessoren erzeugen.



Messung:  
Elektrische Spannung in photosensitiver Diode, die auf das Auge gerichtet ist.

Signal:  
Position der Grenzen von Iris und Sklera



Vorteil: Hohe zeitliche Auflösung, auch bei geschlossenen Augen messbar  
Nachteil: Viele Störsignale

Electro-oculogramm

Signal:  
Relative Position von Netzhaut und Linse

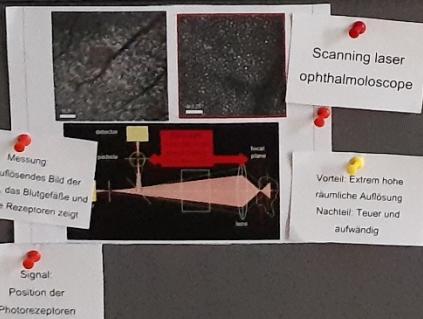
Messung:  
Elektrische Spannung in Elektroden, die auf Schläfen, Stirn und Wange aufgebracht sind.



Vorteil: Hohe räumliche und zeitliche Auflösung, leichte Handhabung

Video-basierter eye tracker

Messung:  
Kinnlotos des Auges mit Pupille und Reflexion auf der Cornea



Scanning laser ophthalmoscope

Messung:  
Hochauflösendes Bild der Netzhaut, das Blutgefäße und einzelne Rezeptoren zeigt

Vorteil: Extrem hohe räumliche Auflösung  
Nachteil: Teuer und aufwändig

Signal:  
Position der Photorezeptoren

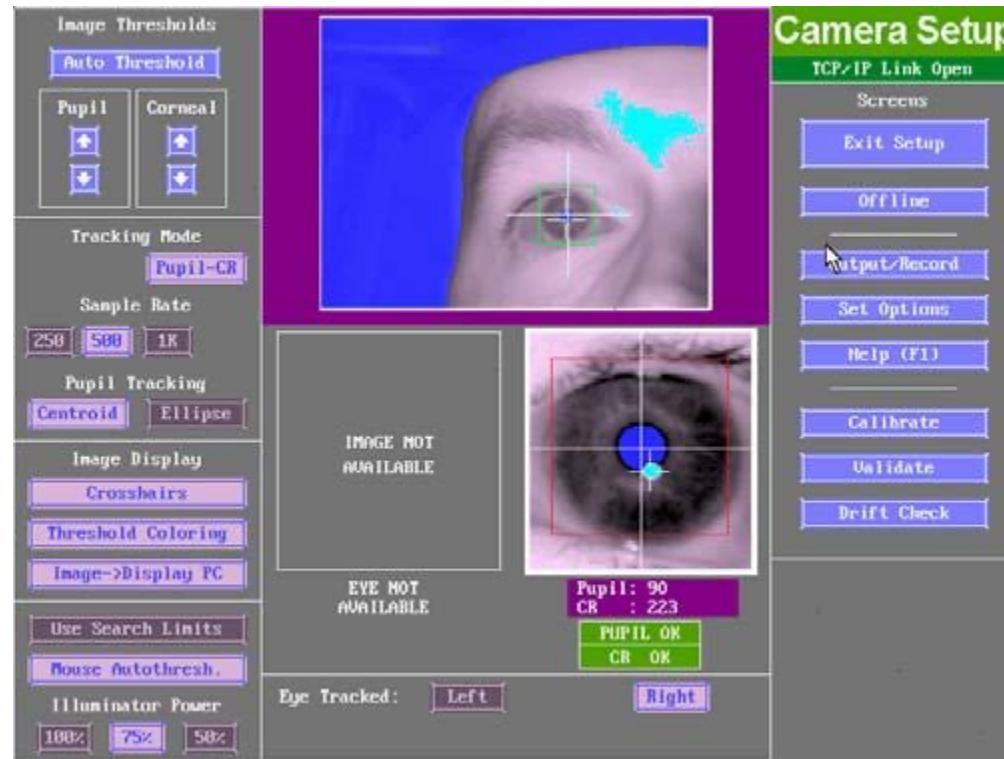


Vorteil: Leichte Handhabung  
Nachteil: Niedrige räumliche und zeitliche Auflösung

Web cam eye tracking

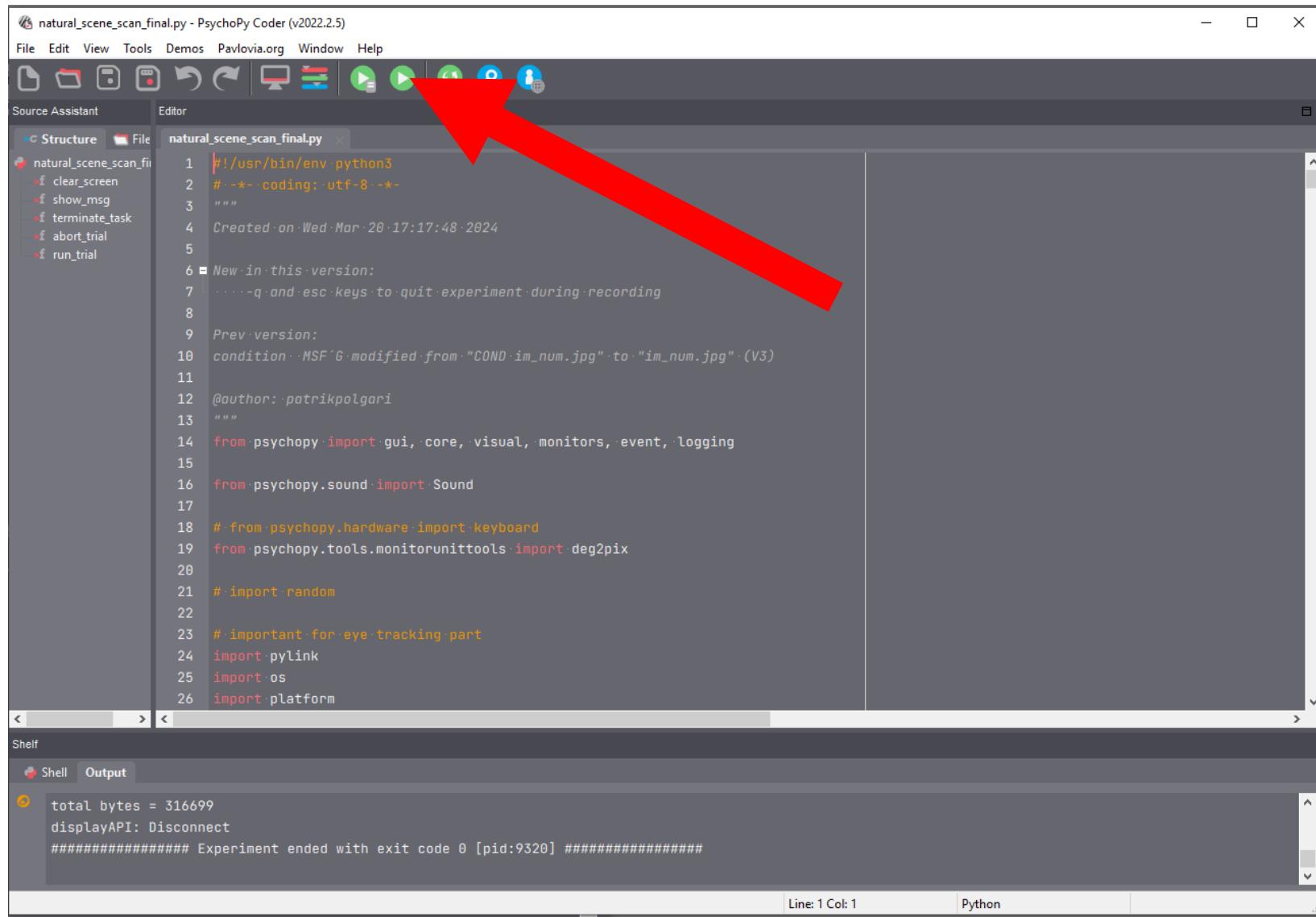
Signal:  
Relative Position des Kopfes und der Pupille

Messung:  
Bild des Kopfes mit Augen und Pupillen

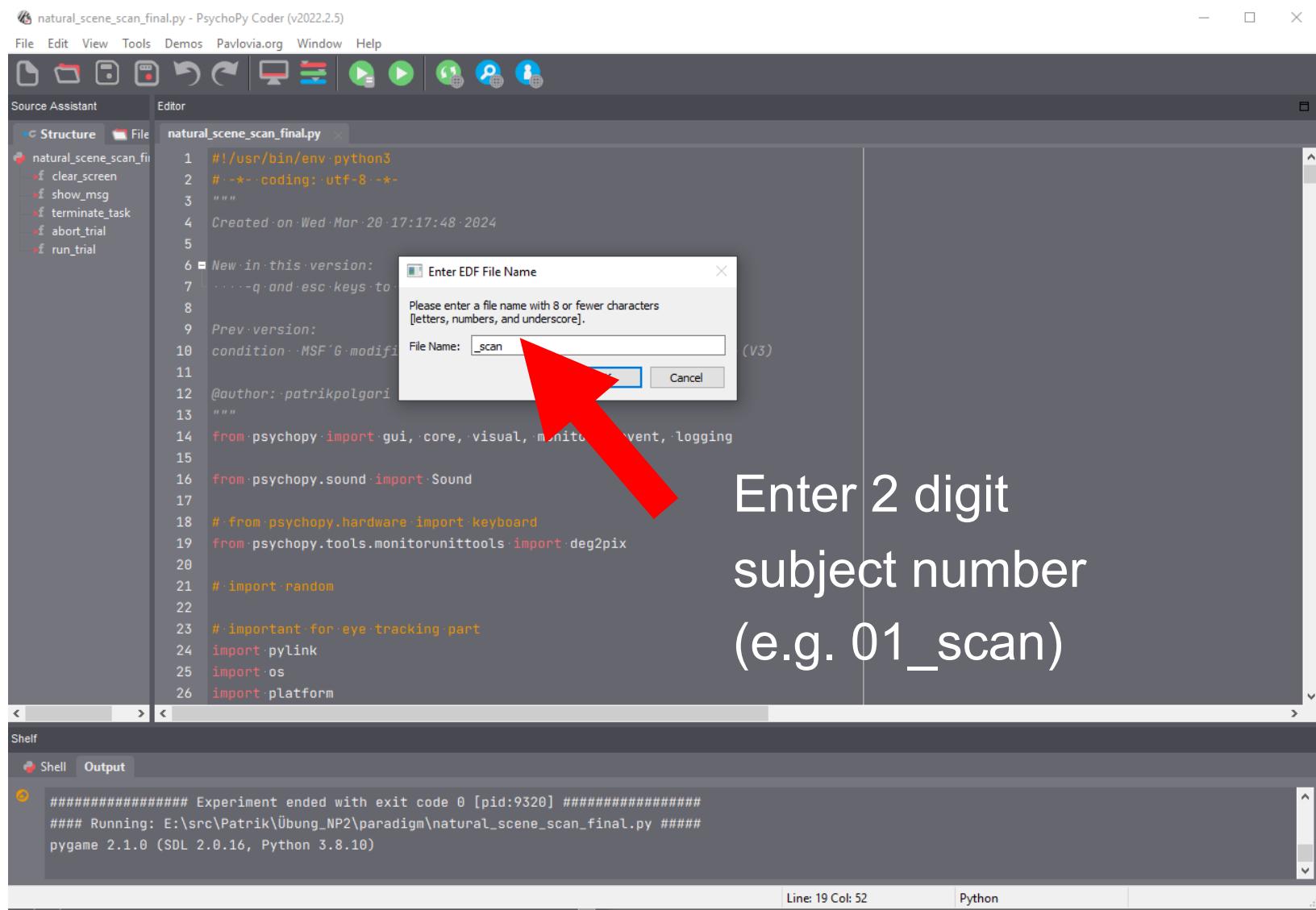


## 2. How is our eye tracker operated?

# Starting experiment

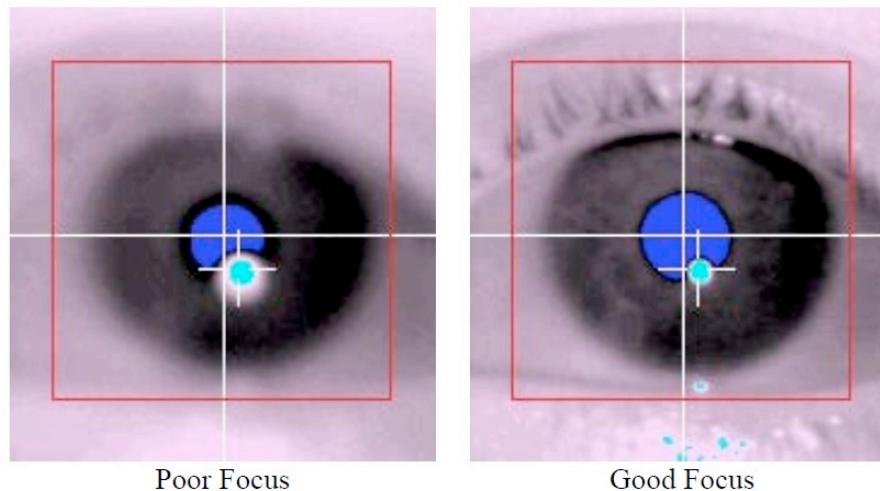


# Starting experiment



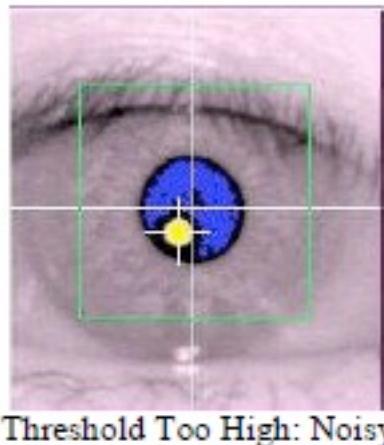
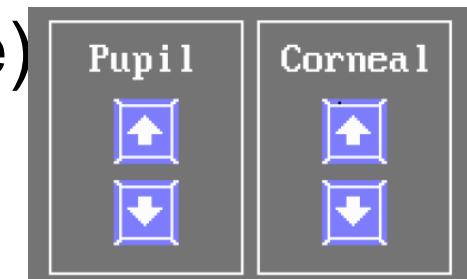
# Setting up the Eyetracker

## 1. Focusing (turning the lens, as with a camera)

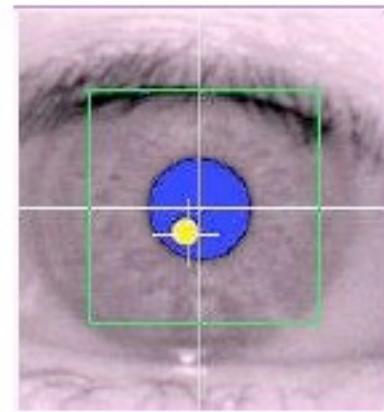


# Setting up the Eyetracker

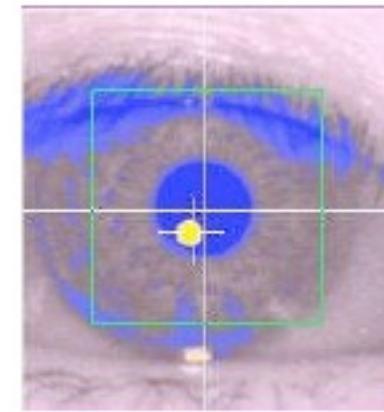
1. Focusing (turning the lens, as with a camera)
2. Setting the limit value ('Autothreshold' / A on keyboard / manually using the mouse)



Threshold Too High: Noisy



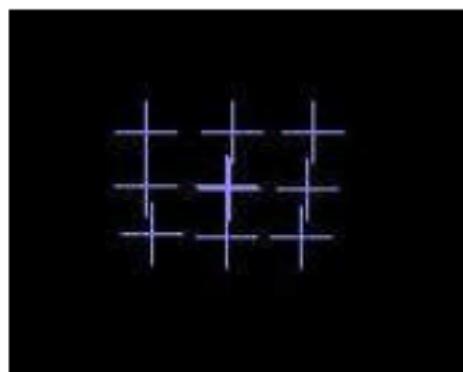
Good Pupil Threshold



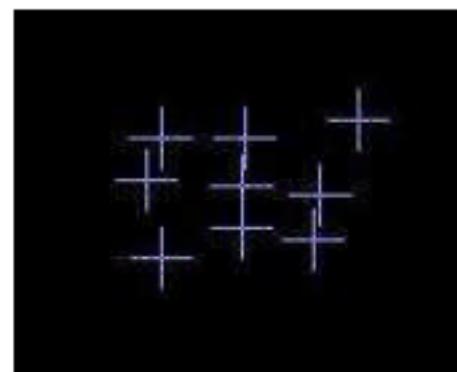
Threshold too Low: Shadows

# Setting up the Eyetracker

1. Focusing (turning the lens, as with a camera)
2. Setting the limit value ('Autothreshold' / A on keyboard / manually using the mouse)
3. Calibrate (C on keyboard or mouse)



Good Calibration



Poor Calibration

# Setting up the Eyetracker

1. Focusing (turning the lens, as with a camera)
2. Setting the limit value ('Autothreshold' / A on keyboard / manually using the mouse)
3. Calibrate (C on keyboard or mouse)
4. Validate (V on keyboard or mouse)

# Why calibrate and validate?

- General calibration

- Every measuring device must be calibrated.
- Measured values should conform to a specific unit.
- Measurement deviation is determined.

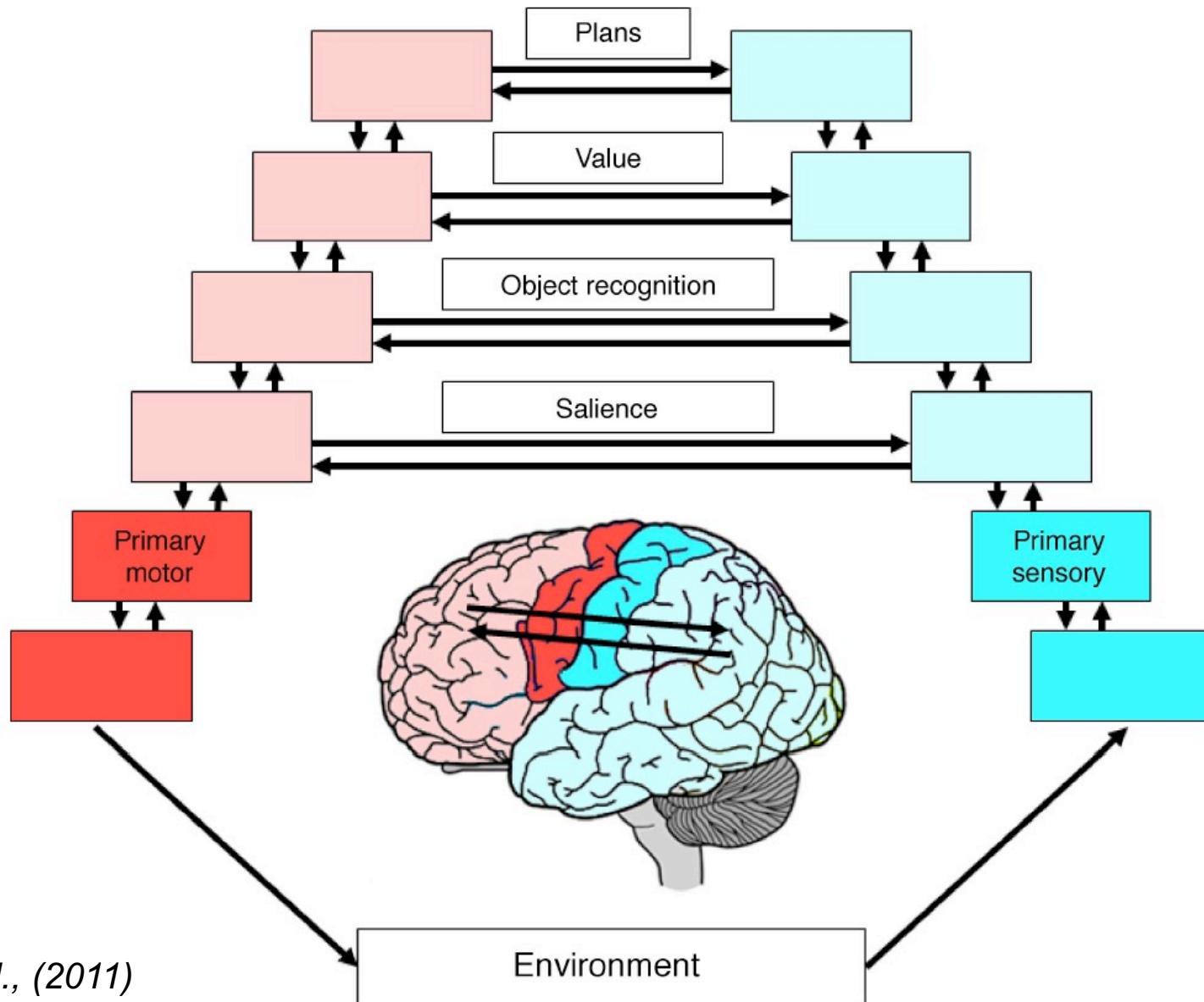
- Eye tracker calibration

- Device learns the relationship between gaze position on the screen and the position of the pupil and corneal reflection in the camera image.
- In order to know the gaze position, the participant must fixate 9 points on the screen in succession (**Calibration**).
- The procedure is repeated once to determine the deviation (**Validation**).

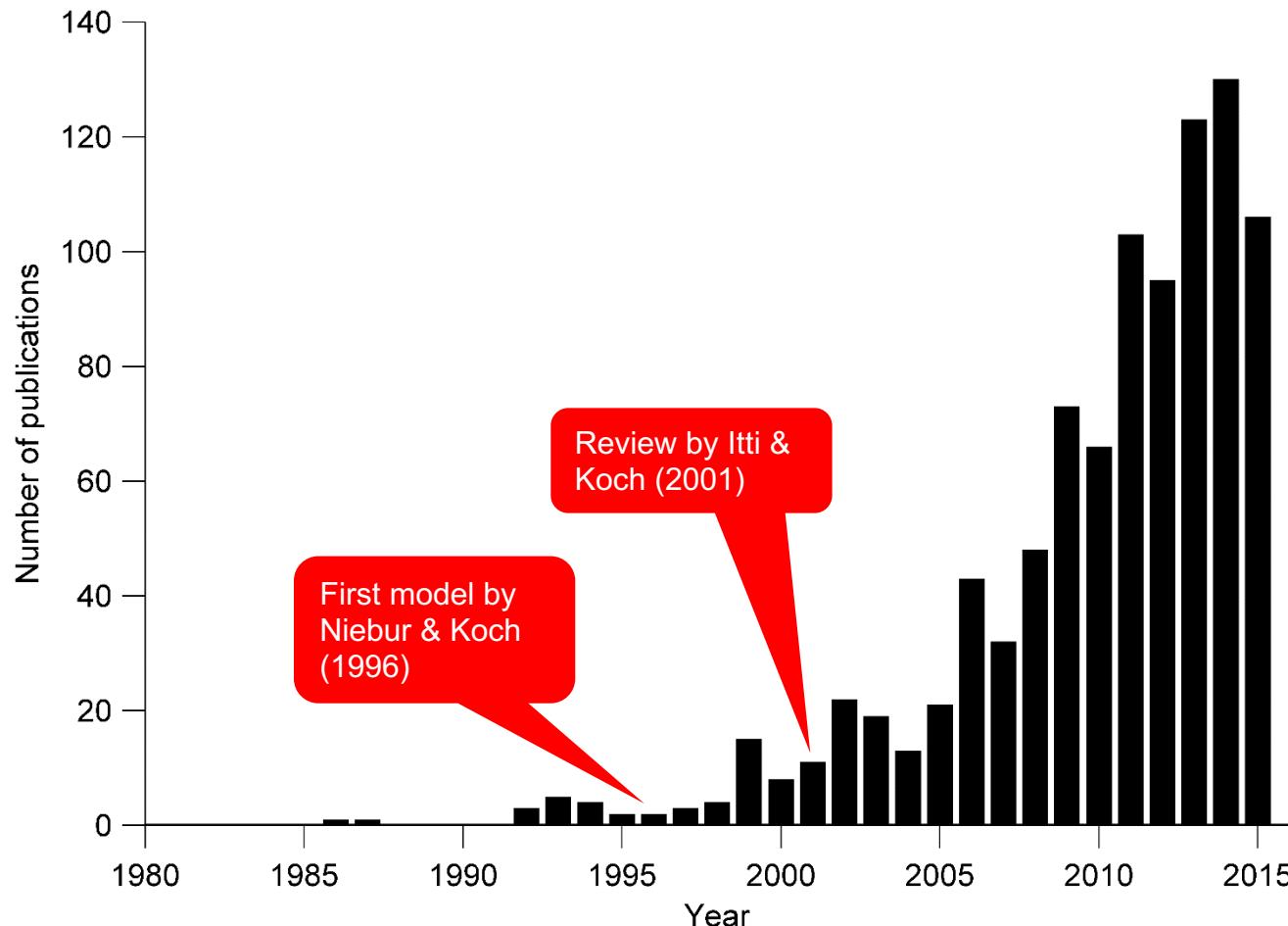
From basic research in neuroscience to application in ergonomics

### 3. Salience models

# What attracts our gaze?

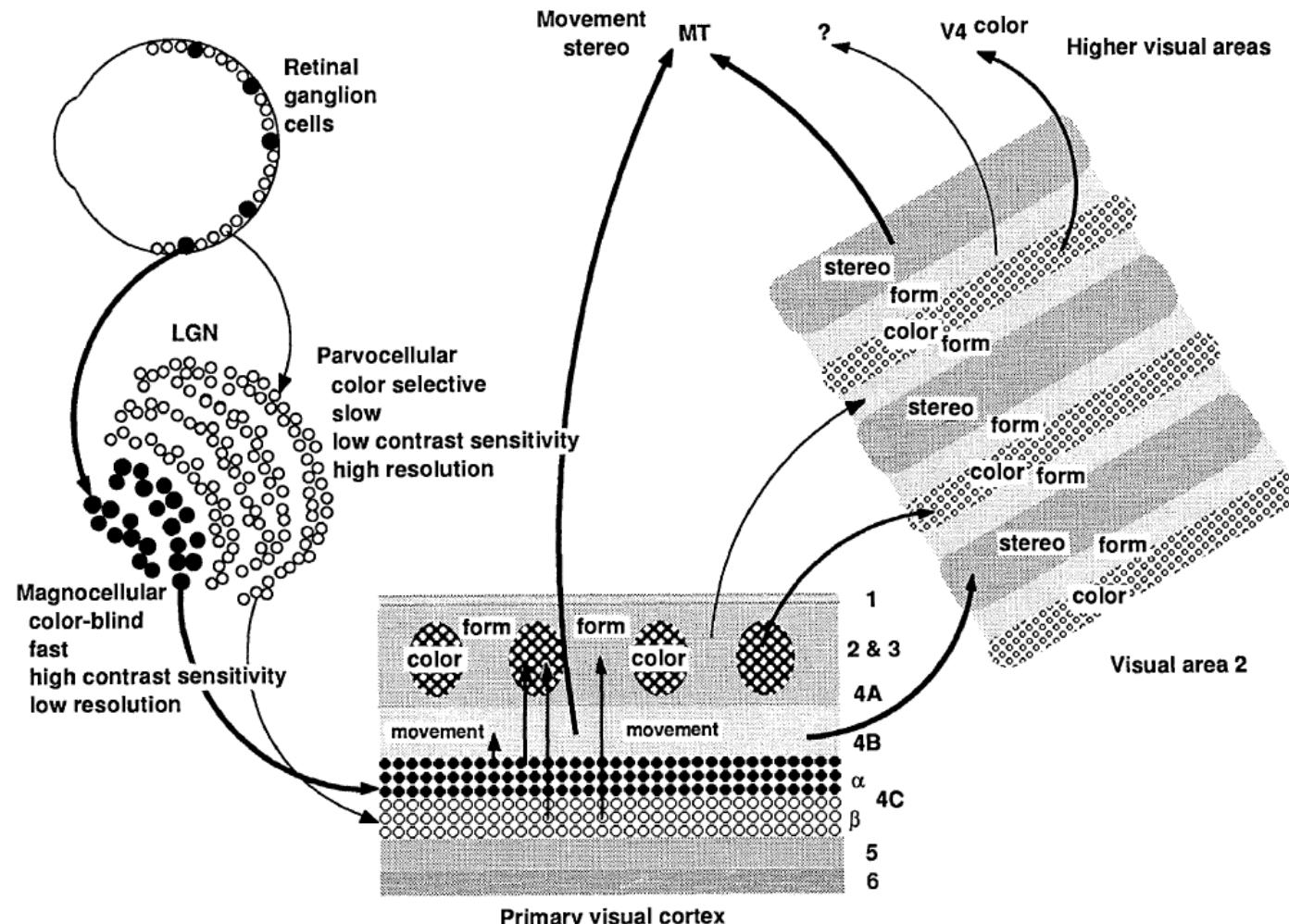


# Historical development of salience models



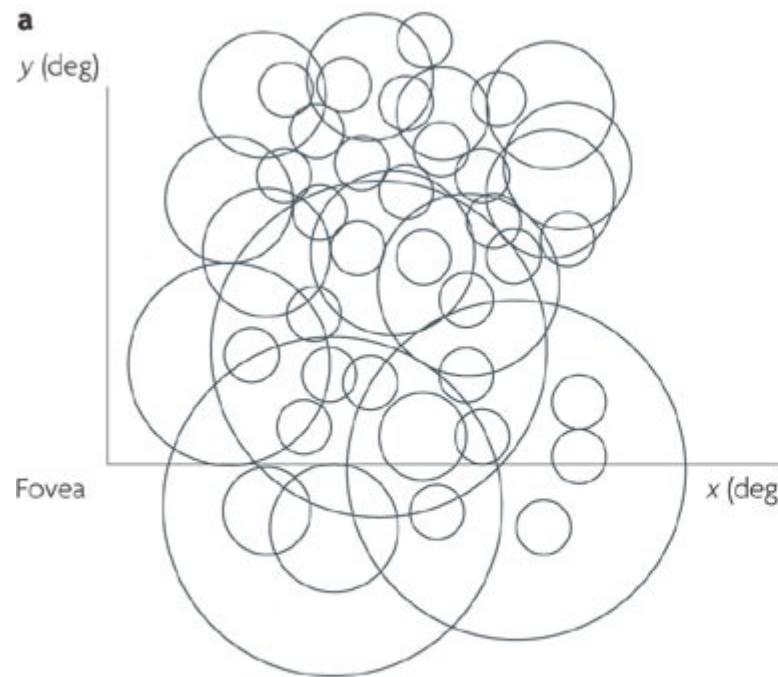
# 1) Processing in the visual cortex

## a. Separation of visual properties / features



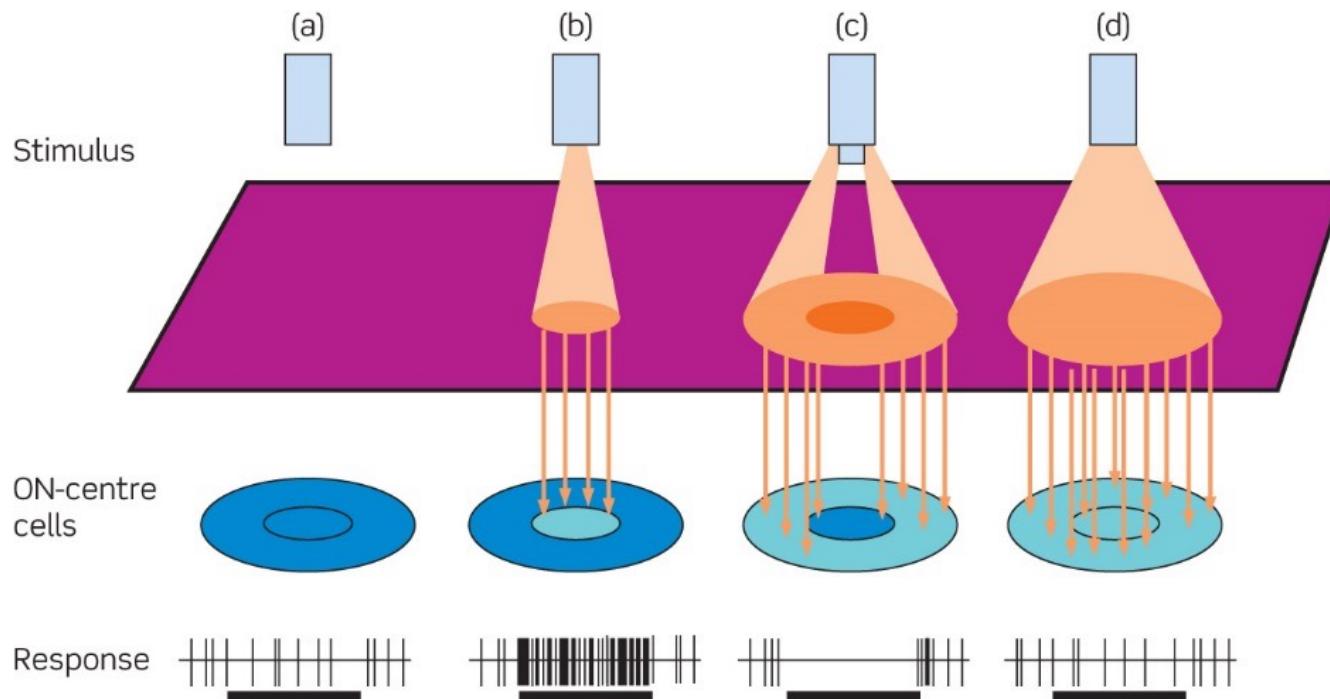
# 1) Processing in the visual cortex

- a. Separation of visual properties / features
- b. Multiple spatial scales



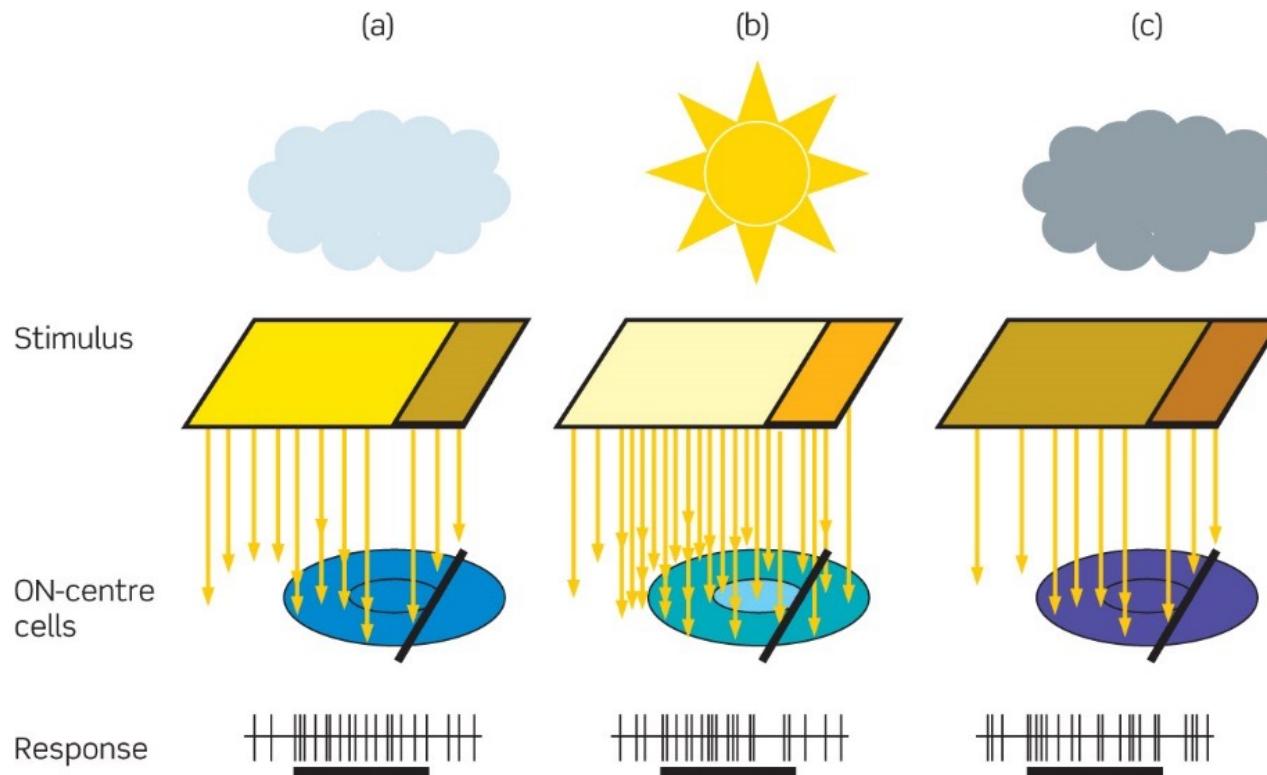
# 1) Processing in the visual cortex

- a. Separation of visual properties / features
- b. Multiple spatial scales
- c. Center-Surround contrast

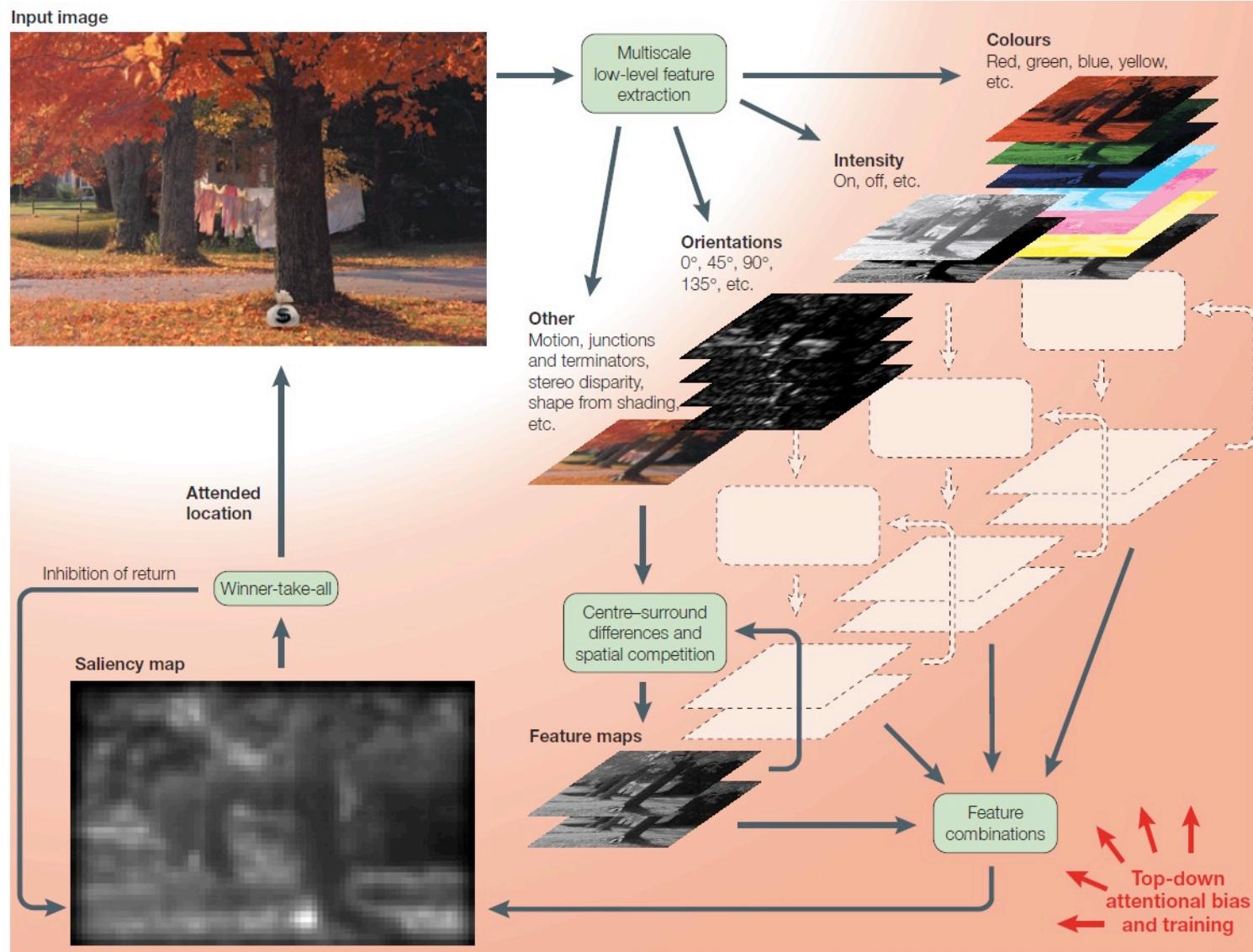


# 1) Processing in the visual cortex

- a. Separation of visual properties / features
- b. Multiple spatial scales
- c. Center-Surround contrast

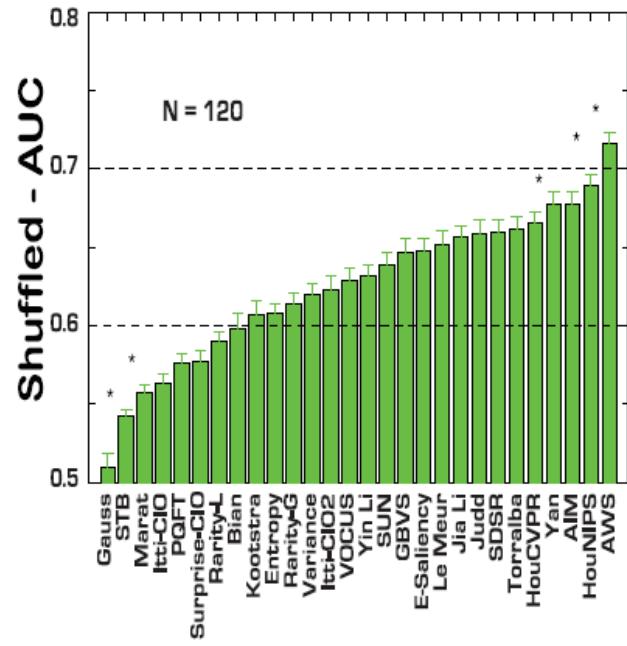


## 2) Salience model by Itti & Koch

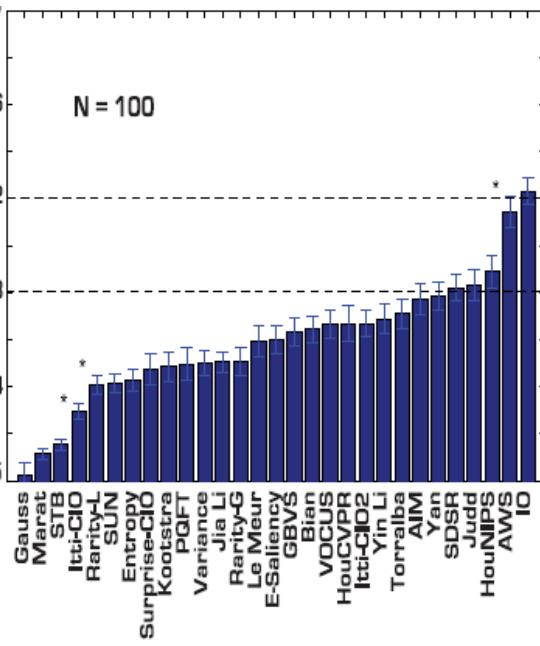


### 3) Comparison with eye movements

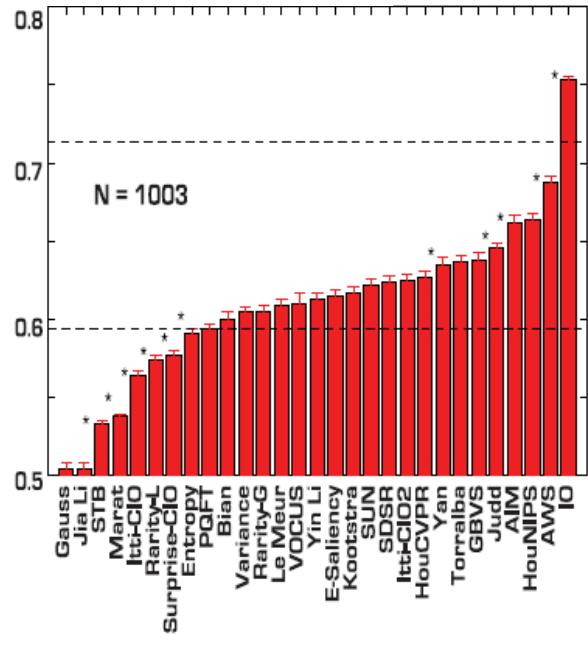
Bruce & Tsotsos



Kootstra & Schomacker



Judd et al.

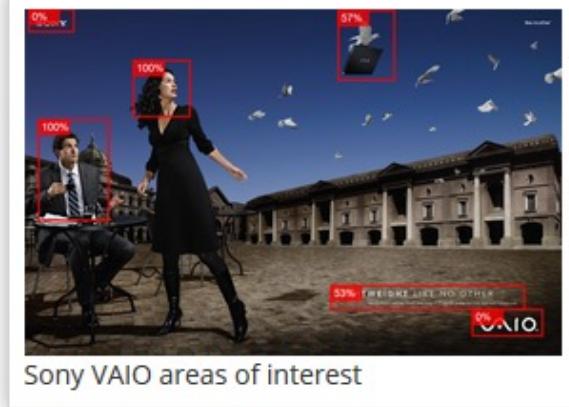


## 4) Application in ergonomics

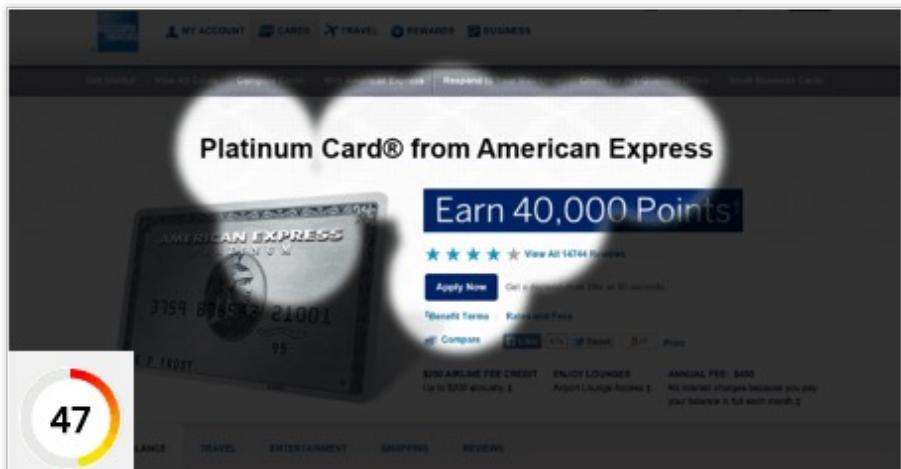
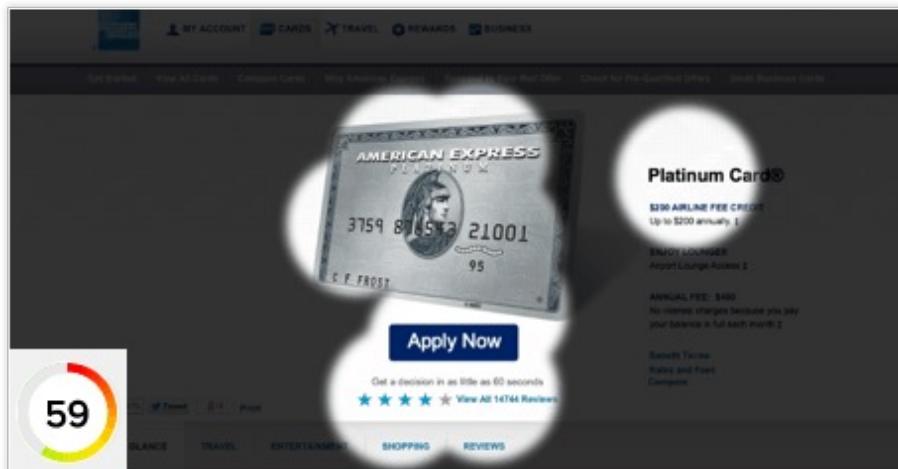
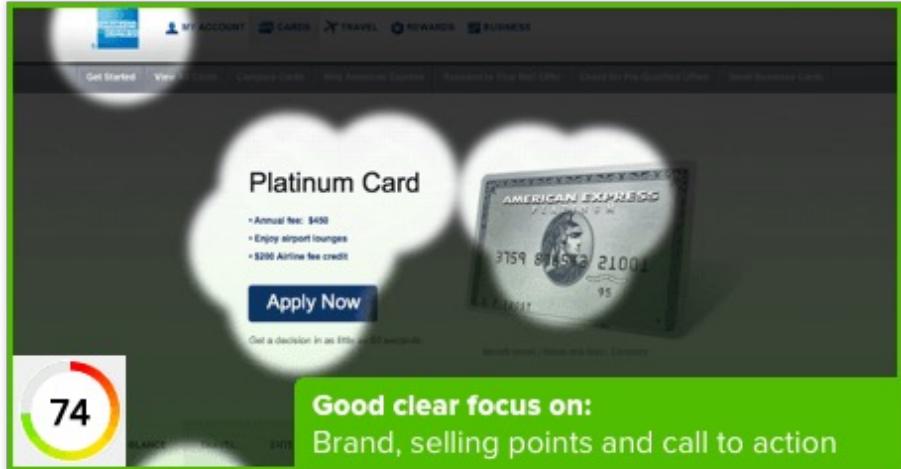
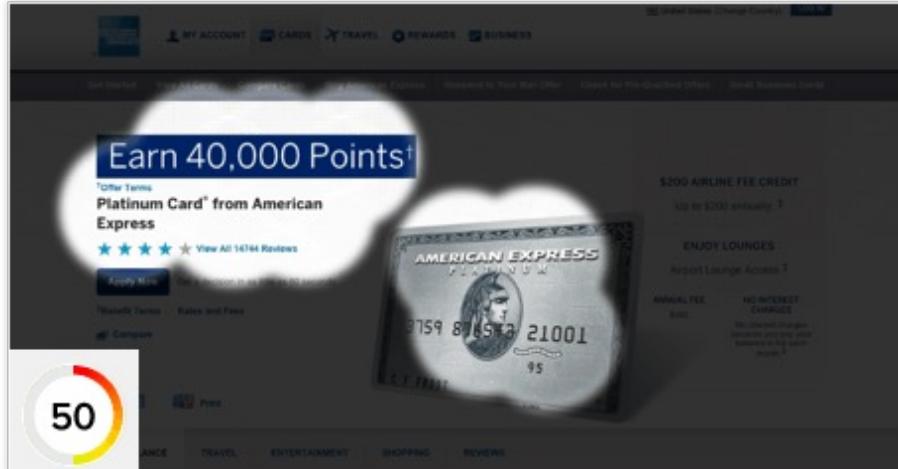
### Usability Design:

- What is paid attention to / noticed by users?
- What distracts users from their task?
- Where should important elements be positioned?

## 4) Application in ergonomics



# 4) Application in ergonomics



## 4) Application in ergonomics

An incomplete list of companies:

- [www.eyequant.com](http://www.eyequant.com)
- [www.feng-gui.com](http://www.feng-gui.com)
- <https://vas.3m.com/>
- <https://attentioninsight.com/>
- <https://www.visualeyes.design/>
- <https://www.expoze.io/about>