



# Mind reading for £40!

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Chaires de recherche  
du Canada

Canada Research  
Chairs

Canada



# Outline of this talk

- Some « data collection »
- Eye tracking methodology
  - Principles
  - Practical aspects
- DIY eye trackers
  - Our very own!
- Data manipulation/visualisation/analysis
  - Current approaches
  - Limits/challenges
- Illustration through experimental findings
  - Your « data »!



# A brief experiment

Where we play with your pupils

# Instructions

- I will now show you six simple arithmetic problems
  - Essentially, I need you to add two 3-digit numbers
  - Each problem is shown for 10 seconds
  - I need you to solve the problems outloud
    - Ignore neighbours. They'll probably get them wrong.
- Ready?

+

267

+122

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=

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+

$$\begin{array}{r} 549 \\ +793 \\ \hline \end{array}$$

$$= \underline{\quad}$$



+

528

+211

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=

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+

497

+856

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=

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+

354

+625

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=

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+

721

+489

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=

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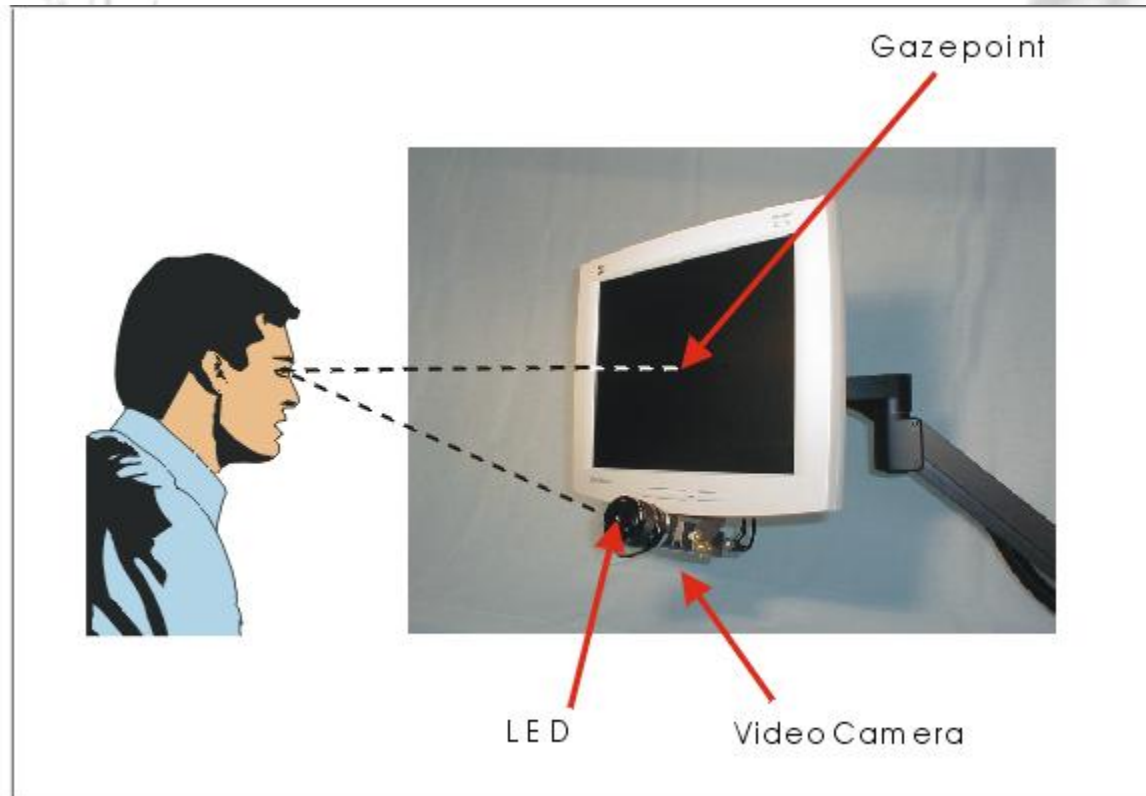
**Thank you!**

We will return to this experiment at  
the end...

A close-up, grayscale image of a human eye, focusing on the iris and eyelashes. The eye is looking slightly to the right. The text "Eye tracking methodology" is overlaid in the center of the image.

# Eye tracking methodology

# Basic idea

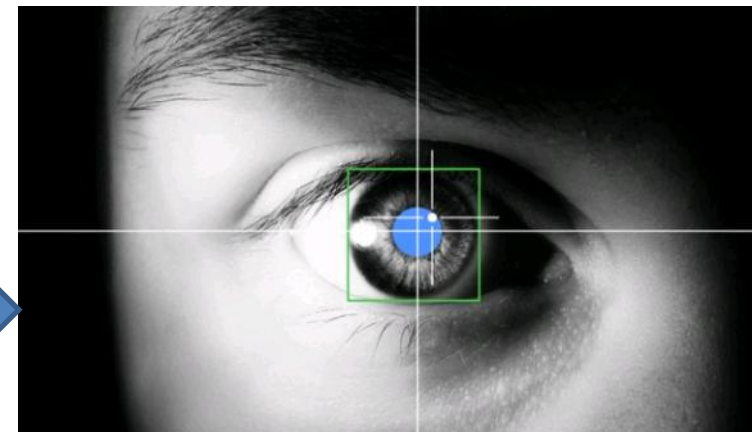
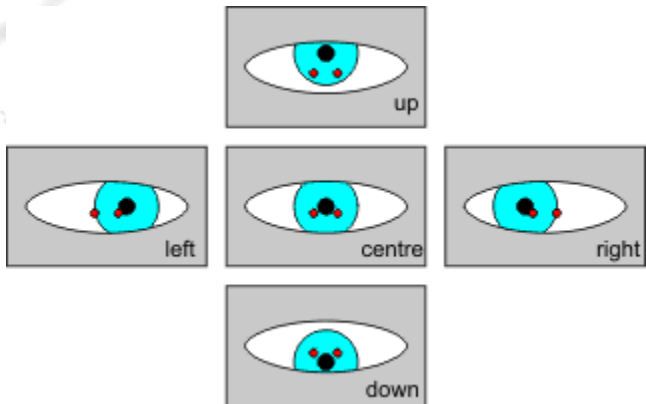
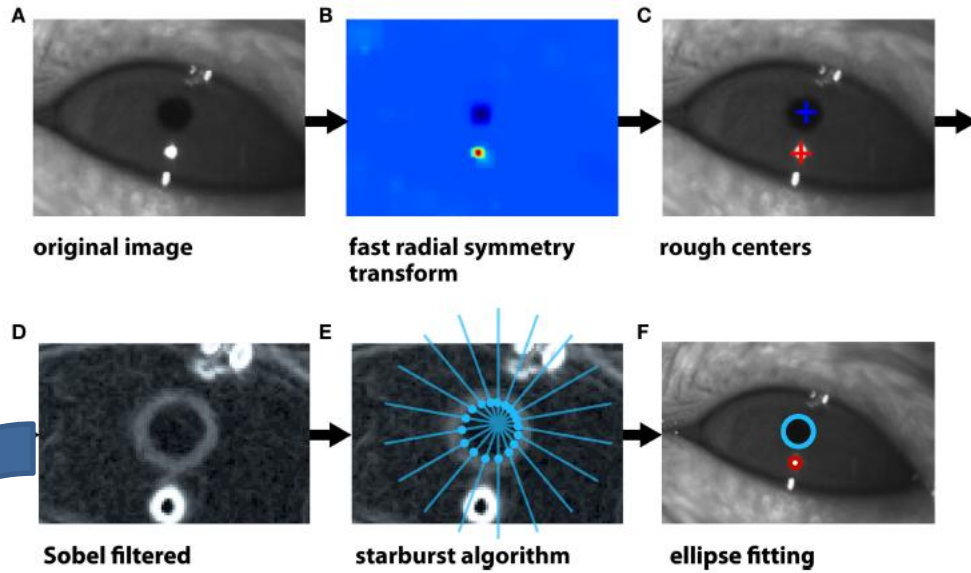


# Terminology

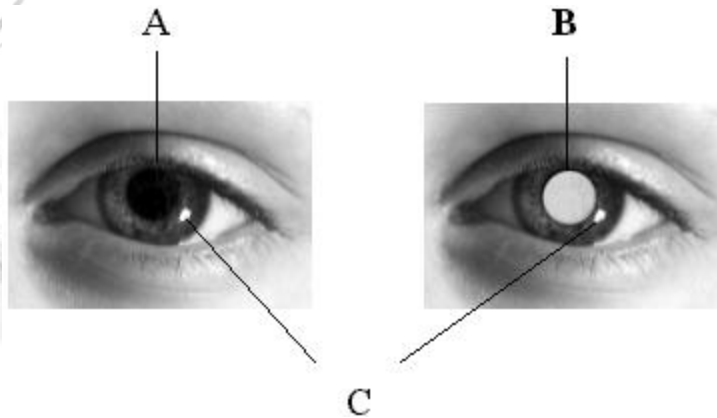
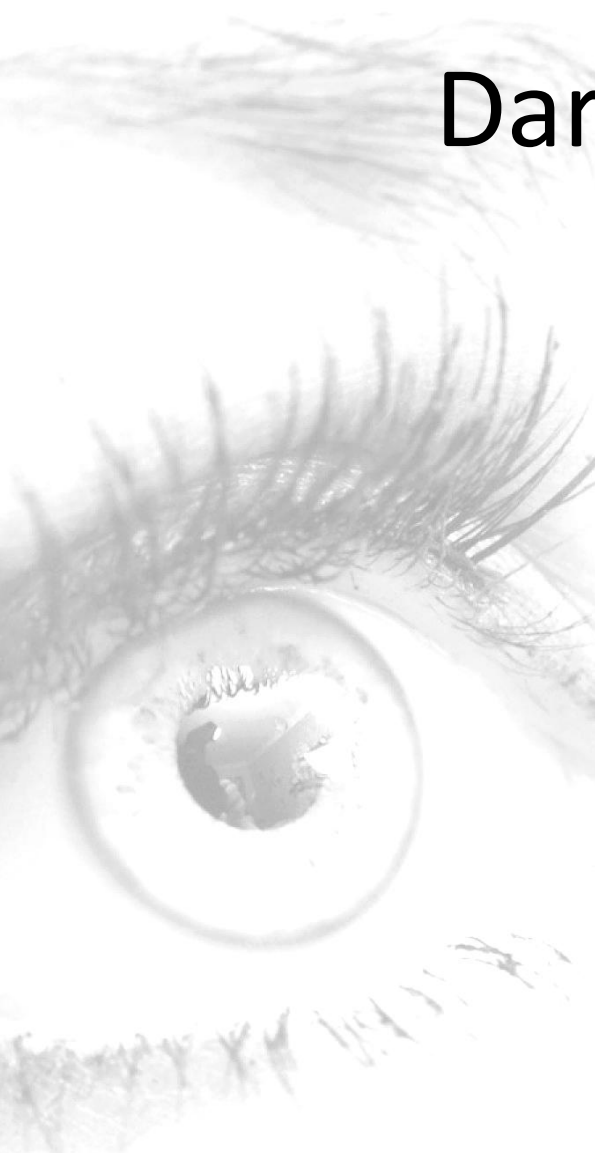


- Gaze point: where a participant looks
- Corneal reflection: visible reflection of a light signal on the cornea
- Dark pupil: the opening in the center of the iris when it appears dark
- White pupil: the opening in the center of the iris when it appears bright

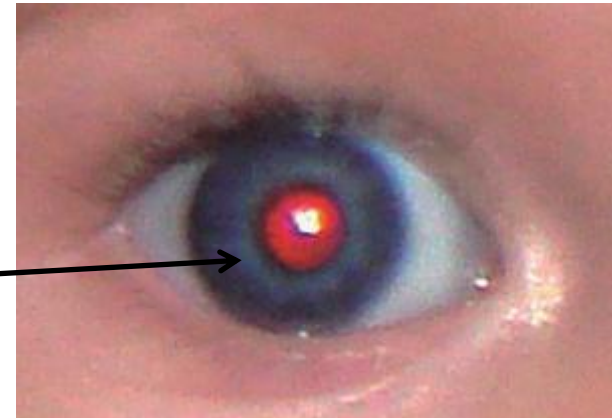
# In images



# Dark eyes? Very dark?



Same principle  
as in those sad  
party pictures

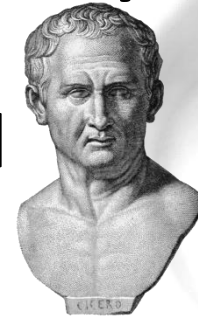


# Pupil diameter

- Primary function of the pupil is to modulate amount of light reaching retina
  - Pupillary light-reflex
    - Dilate in dark
    - Constrict in brightness
- Accidental « function » of the pupil is to index mental load / attention / arousal
  - Locus Coeruleus (brainstem structure) involved in arousal, stress, attention, emotions
  - Main brain site for production of norepinephrine
  - Iris dilator muscle happens to respond to norepinephrine
    - Eyes as windows to the Locus Coeruleus then!

# History of pupillometry

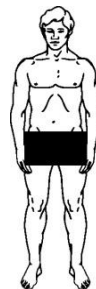
- The eyes are the window to the soul (Cicero, -45)



- Atropine (*Atropa belladonna*)



- Hess & Polt (1960)



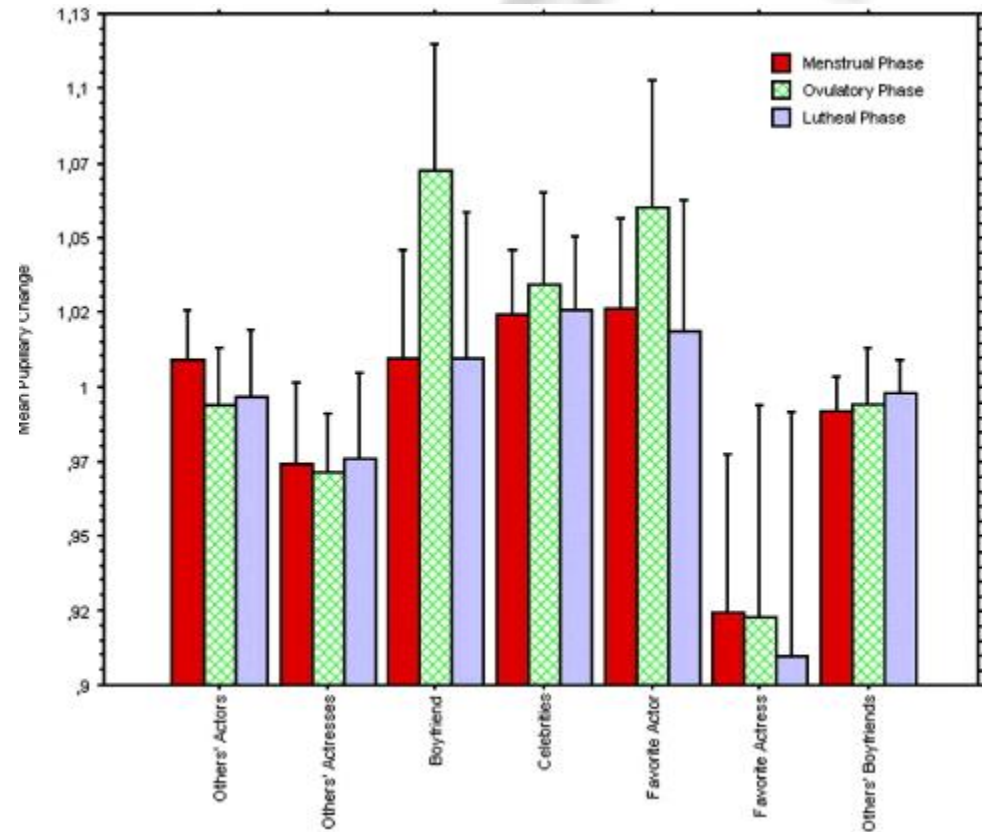
- Fitzgerald (1968)





# Let's (not) talk about sex, baby

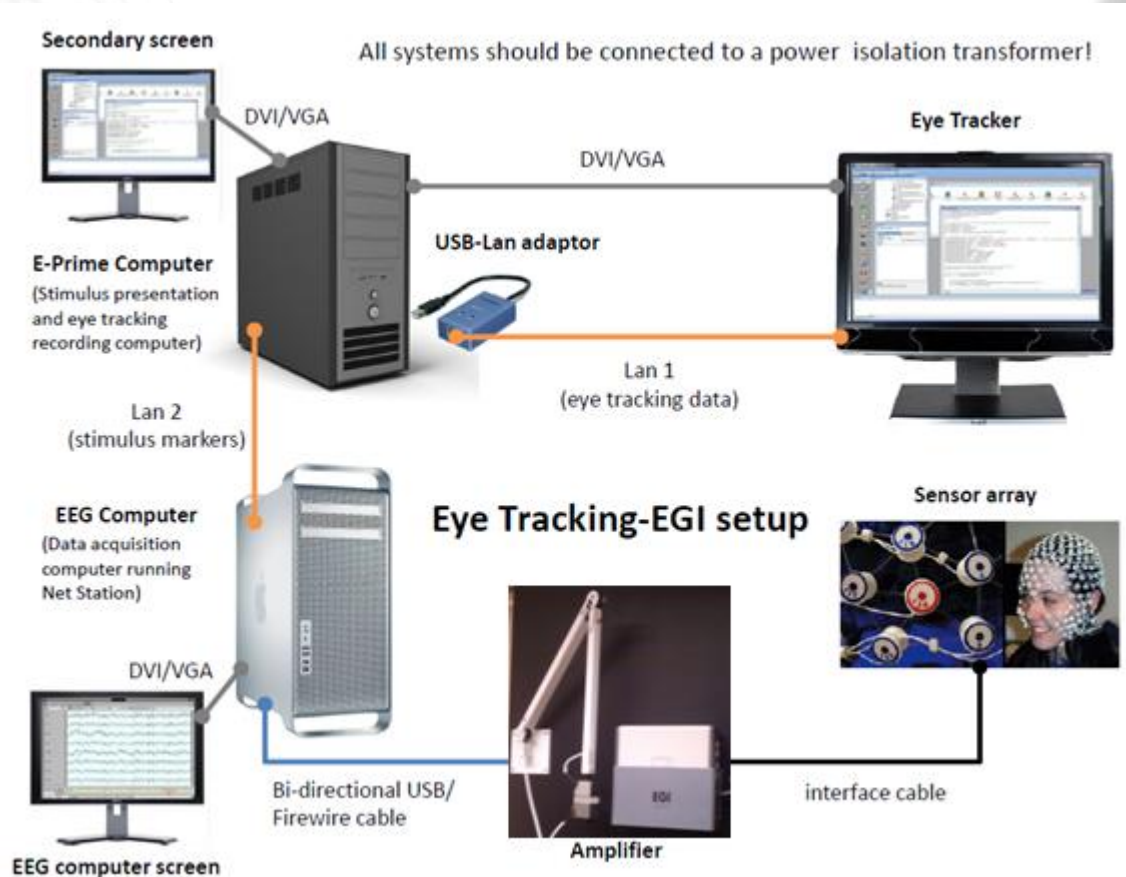
- Women looked at pictures of:
  - Their boyfriend <3
  - Others' boyfriends
  - Favourite actor <3<3<3
  - Others' favourite actor
  - ...
- At three different times of their hormonal cycle



# Data collection



# Setup? Depends



# Regardless of setup

- Data collection requires
  - Calibration
  - Stimuli
  - Events
- In a context where other measures are also carried out (e.g., EEG), need to synch event markers

# Active or passive tracking?

- Passive
  - Data is collected (with or without event markers) without effect on experimental unfolding
- Active
  - Experimental unfolding is function of eye gaze
    - For example, trials begin when a fixation point is looked at



# DIY eye tracking

For those who can't fork out upwards  
of £30K to get on the eye tracking  
ladder

# Option 1. ~£50

- Hardware:

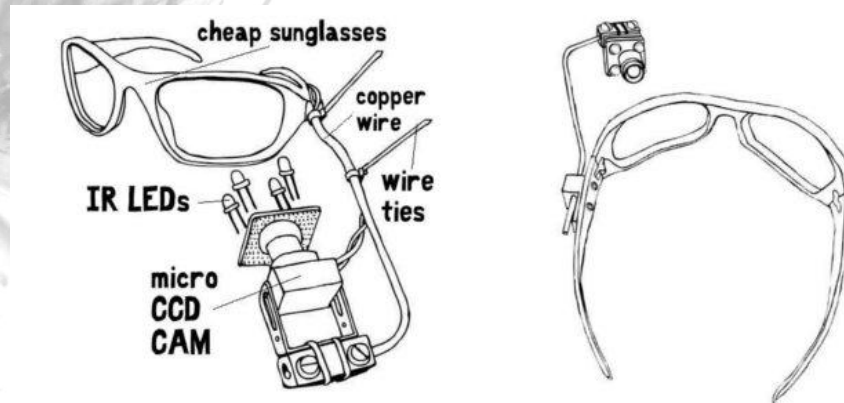
<http://rmantiuk.strony.wi.ps.pl/projects/diy/data/How to build DIY.pdf>



- Software (free to use for non-commercial purposes): <http://www.gazegroup.org/downloads/23-gazetracker>

# Option 2. ~£90

- Hardware: <http://ffff.at/eyewriter/The-EyeWriter.pdf>



- Software (free to use for non-commercial purposes):

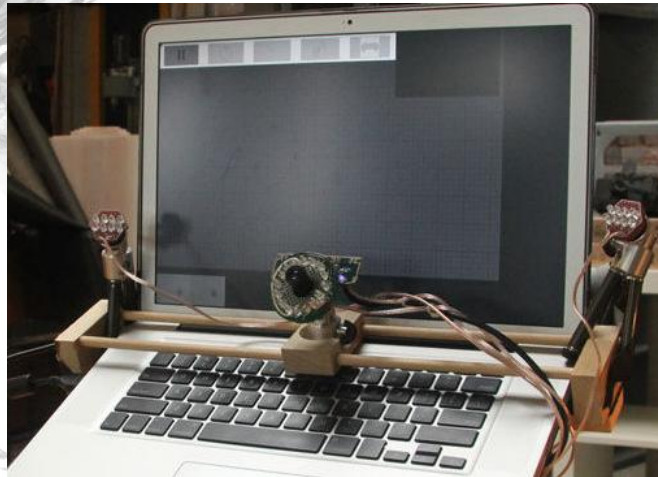
<https://github.com/eyewriter/eyewriter/tree/master/eyeWriterTracker>



# Option 3. ~£125

- Hardware:

<http://www.instructables.com/id/The-EyeWriter-20/?ALLSTEPS>



- Software (free to use for non-commercial purposes):

<http://github.com/eyewriter/eyewriter/tree/remoteEyetracker>



# Building an eye tracker

Based on Kowalik (2010)

<http://www.mkowalik.pl/et/How%20to%20build%20low%20cost%20eyetracking%20glasses.pdf>

# Parts needed

## Head mounting

Cycling glasses with  
removable lenses



£10.99

5mm aluminum wire



£8.07

Heat shrink tubing



£2.39

Cable ties



£1.99

## IR illumination

¼ W 22R resistor



£0.36

950nm IR LEDs



£4.32

Unexposed developed  
negative film



£0.00

## Video capture

Microsoft LifeCam VX-1000



£12.58

Total: £40.70

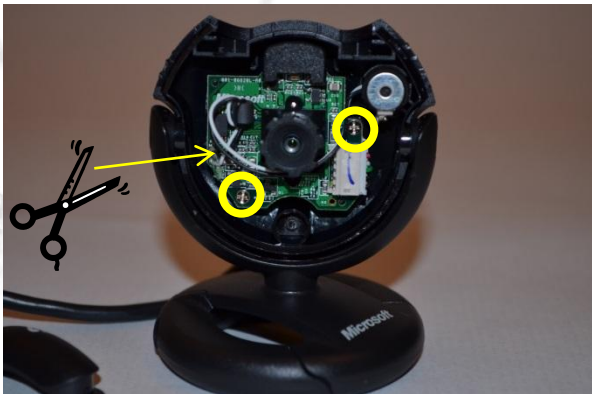
# Acquiring the video acquisition board



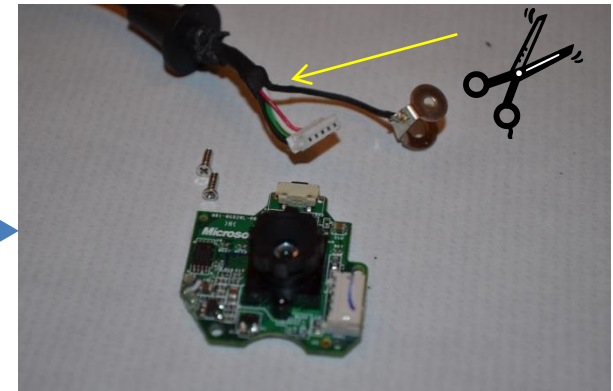
Turn over



Unscrew then  
remove casing

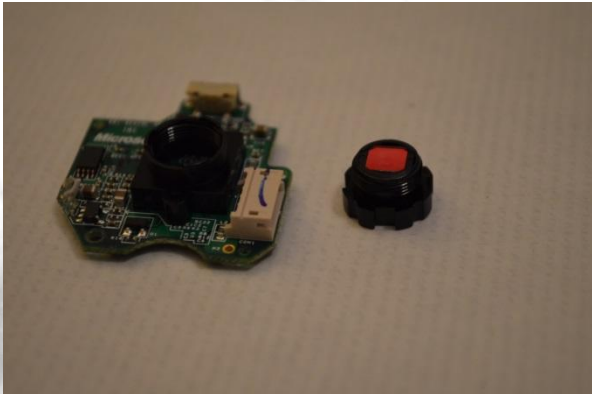


Unscrew circuit board and  
cut microphone wire

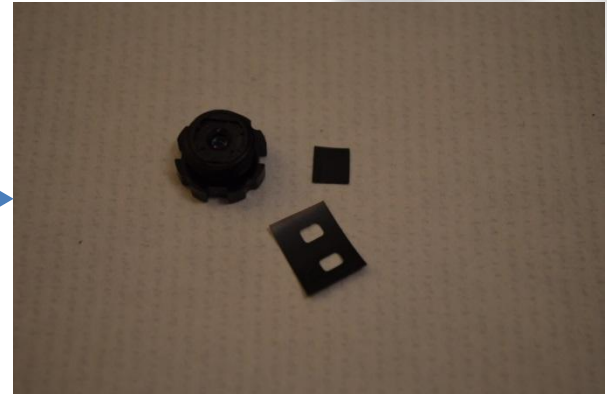


Unplug board, cut extra wire

# Turn the camera into IR camera



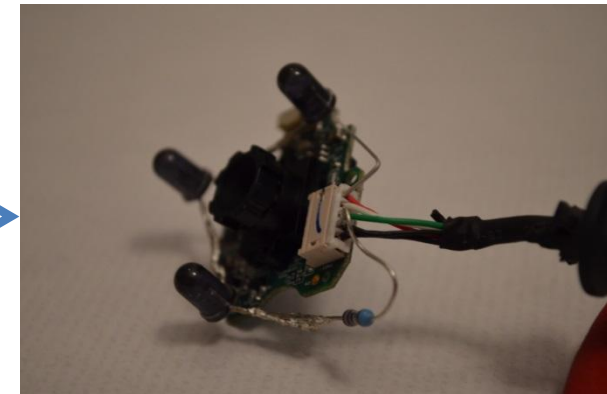
Unscrew camera lens and remove natural light filter



Cut new IR filter from negative film, insert in mount, and screw back lens



Create IR LED array with resistor



When installed (later), LEDs will be powered by USB

# If all goes well on the IR front...

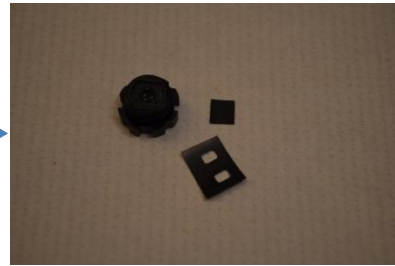
Original camera



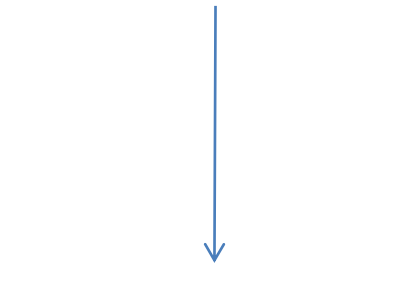
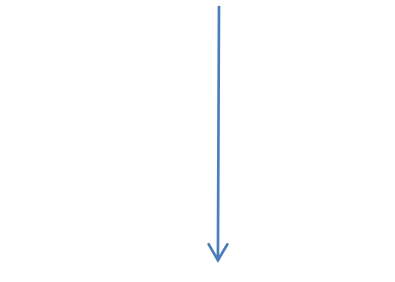
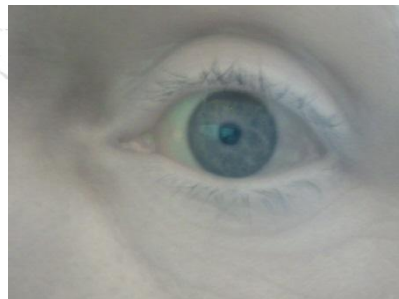
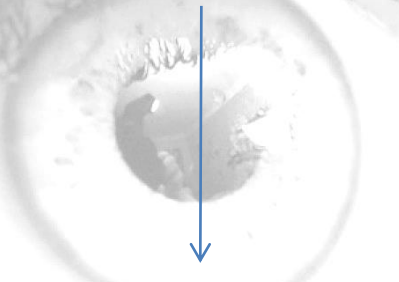
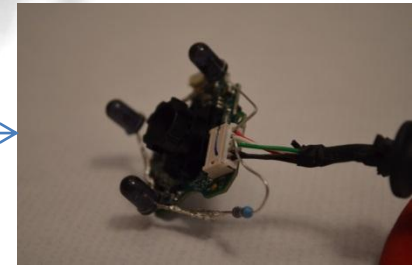
Natural light  
filter removed



IR filter added



IR illuminators  
added



# Head mount the eye tracker (1)



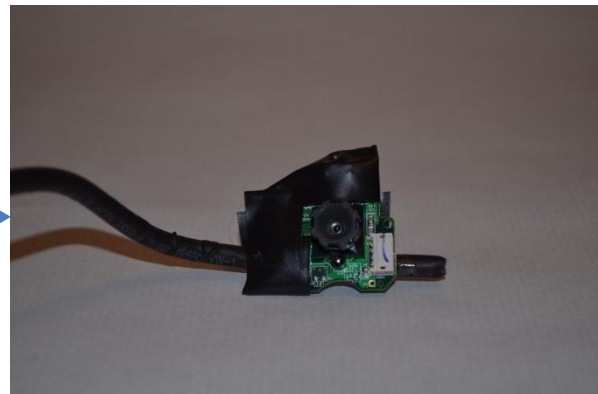
Cut and shape segment of aluminum wire to attach camera to glasses



Cover with tubing and heat shrink (provides electrical insulation + good looks)

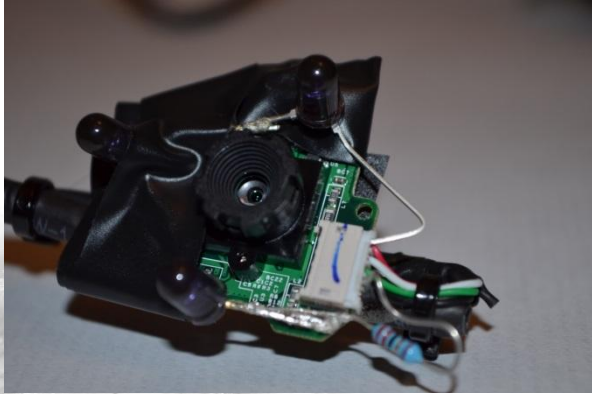


Screw and/or glue (non conductive/corrosive) camera to arm



Optional: cover circuit board with electrical tape

# Head mount the eye tracker (2)



Plug and attach USB cable.  
Install LED array, using red  
and black USB cable sockets



Reshape array then  
(optional) cover with  
electrical tape



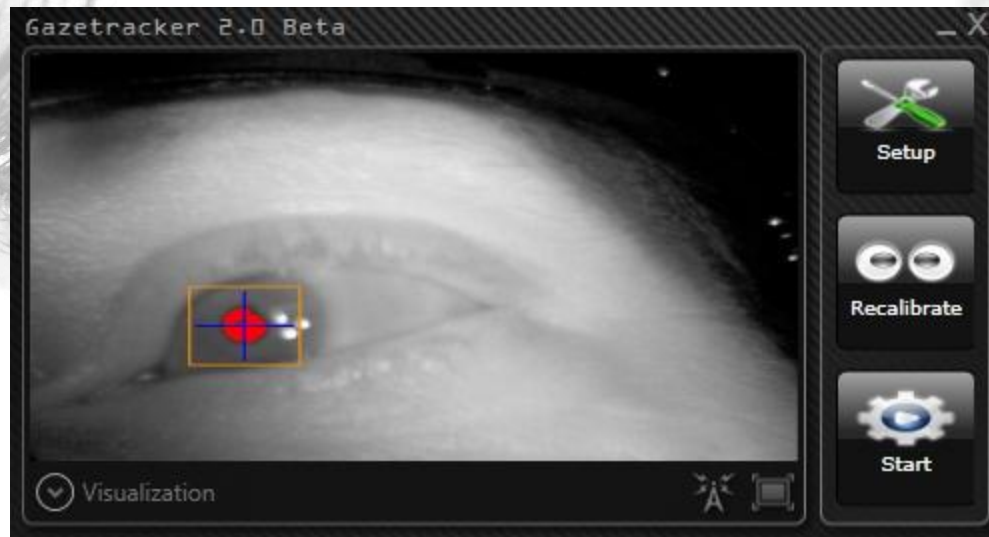
Attach arm to frames using  
cable ties. Fasten cable to  
arm as well (mind the ear)



Your very own eye tracker is  
ready. Enjoy!



# Demo



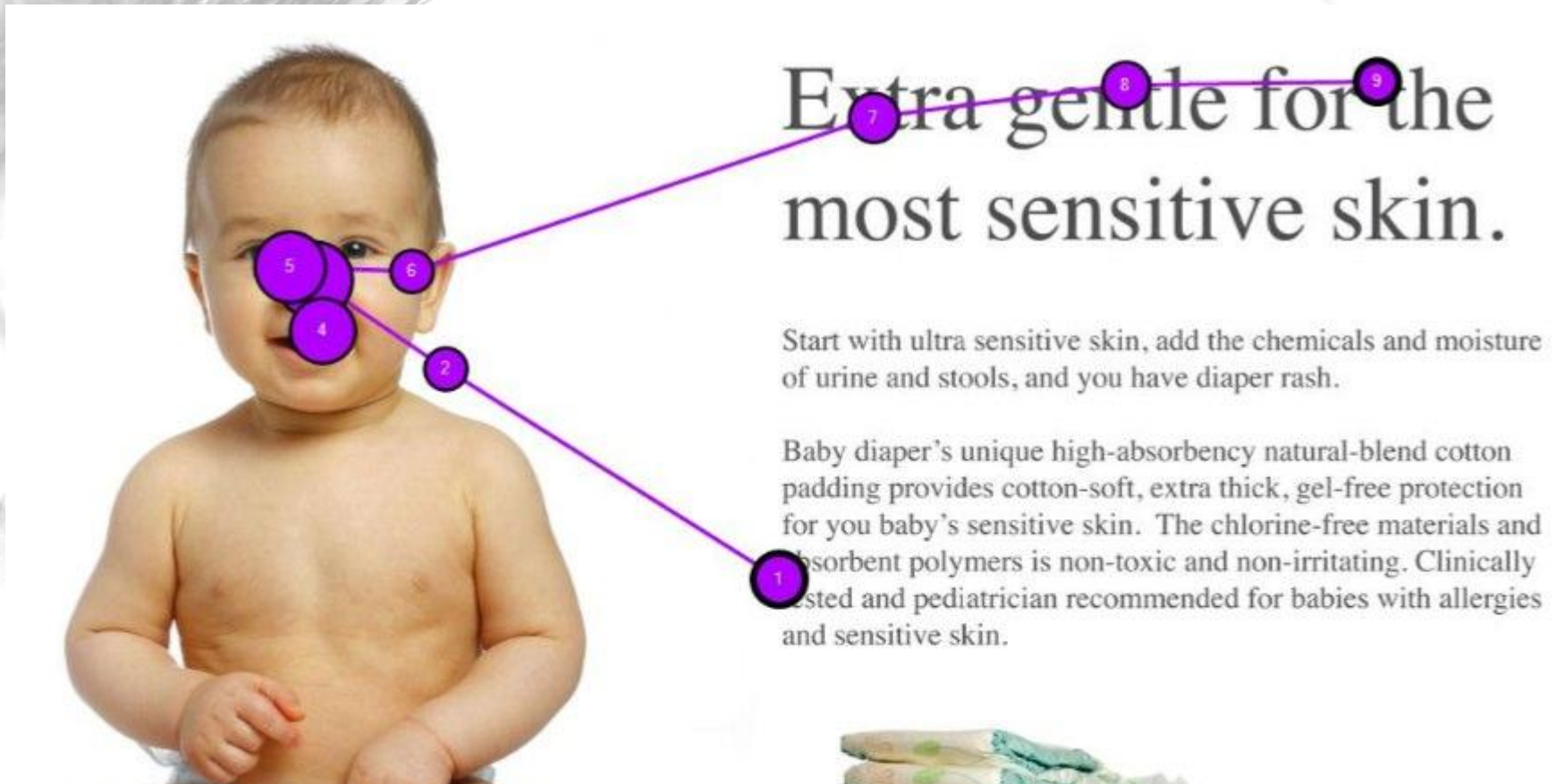
B	C	D	E	F	G	H	
ession	ID	TETTime	RTTime	CursorX	CursorY	TimestampS	Times
1	32	13593586247	40822	416	281	1359358624	
1	33	13593586247	40839	414	284	1359358624	
1	34	13593586247	40855	416	282	1359358624	
1	35	13593586247	40872	416	282	1359358624	
1	36	13593586247	40889	416	282	1359358624	
1	37	13593586247	40906	416	282	1359358624	
1	38	13593586247	40923	416	282	1359358624	
1	39	13593586247	40940	416	282	1359358624	
1	40	13593586247	40957	416	282	1359358624	
1	41	13593586248	40972	413	281	1359358624	
1	42	13593586248	40989	414	281	1359358624	
1	43	13593586249	41005	415	280	1	
1	44	13593586249	41022	416	282	1	
1	45	13593586249	41039	395	272	1	
1	46	13593586249	41055	386	256	1	
1	47	13593586249	41072	387	257	1	
1	48	13593586249	41089	385	258	1	
1	49	13593586250	41105	383	259	1	
1	50	13593586250	41122	381	257	1	
1	51	13593586250	41139	385	256	1	

Manipulation / visualisation /  
 analysis



# (Sequence of ) Fixations

- Fixation: the gaze point remains in a specific area (e.g., radius in pixels) for a minimal duration



Extra gentle for the most sensitive skin.

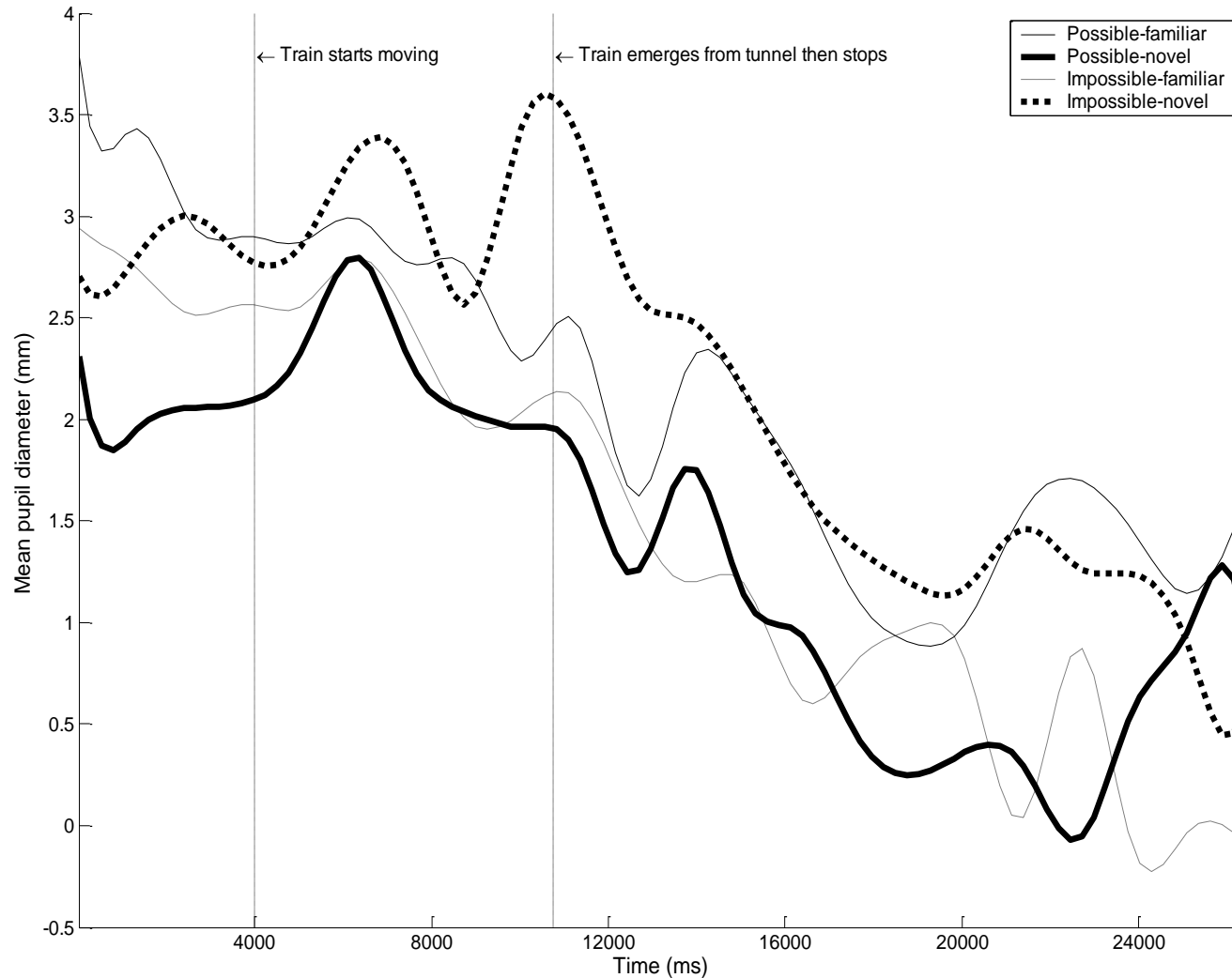
Start with ultra sensitive skin, add the chemicals and moisture of urine and stools, and you have diaper rash.

Baby diaper's unique high-absorbency natural-blend cotton padding provides cotton-soft, extra thick, gel-free protection for you baby's sensitive skin. The chlorine-free materials and absorbent polymers is non-toxic and non-irritating. Clinically tested and pediatrician recommended for babies with allergies and sensitive skin.

# Heat maps



# Pupillometry





Let's look at « your » data

I am absolutely confident it would  
look like this

# Task

Easy 1

$$\begin{array}{r} 267 \\ +122 \\ \hline = \underline{\quad\quad} \end{array}$$

Easy 2

$$\begin{array}{r} 528 \\ +211 \\ \hline = \underline{\quad\quad} \end{array}$$

Easy 3

$$\begin{array}{r} 354 \\ +625 \\ \hline = \underline{\quad\quad} \end{array}$$

Hard 1

$$\begin{array}{r} 549 \\ +793 \\ \hline = \underline{\quad\quad} \end{array}$$

Hard 2

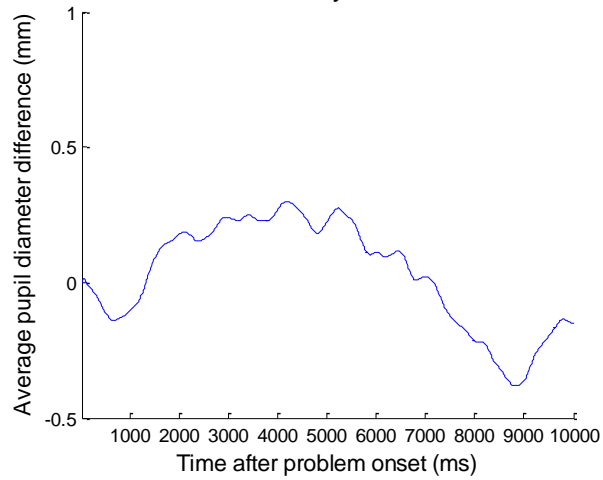
$$\begin{array}{r} 497 \\ +856 \\ \hline = \underline{\quad\quad} \end{array}$$

Hard 3

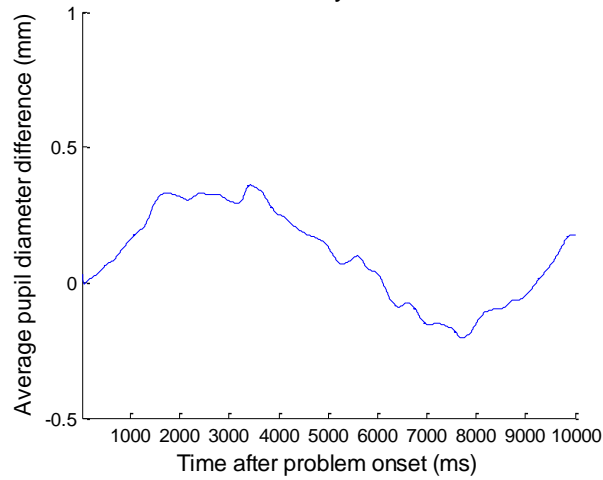
$$\begin{array}{r} 721 \\ +489 \\ \hline = \underline{\quad\quad} \end{array}$$

# Trial data

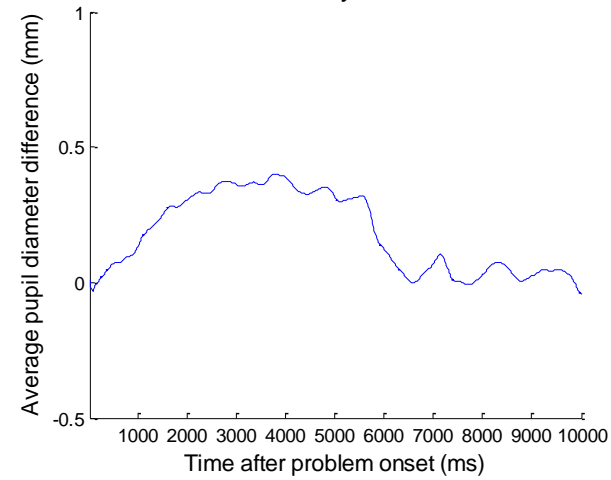
Easy 1



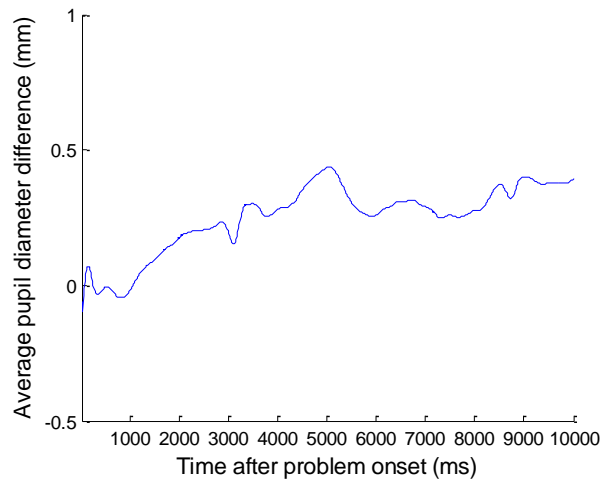
Easy 2



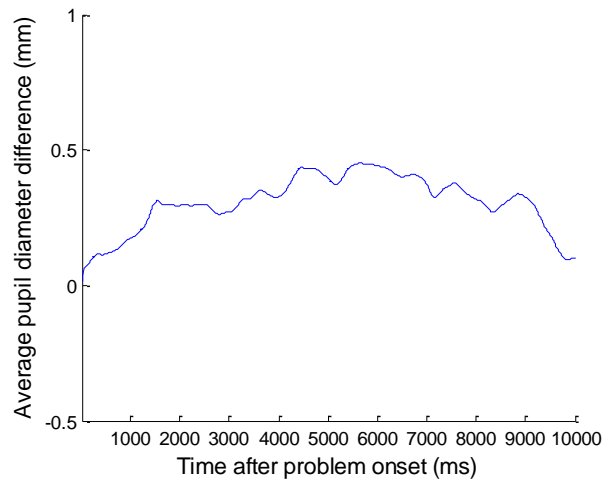
Easy 3



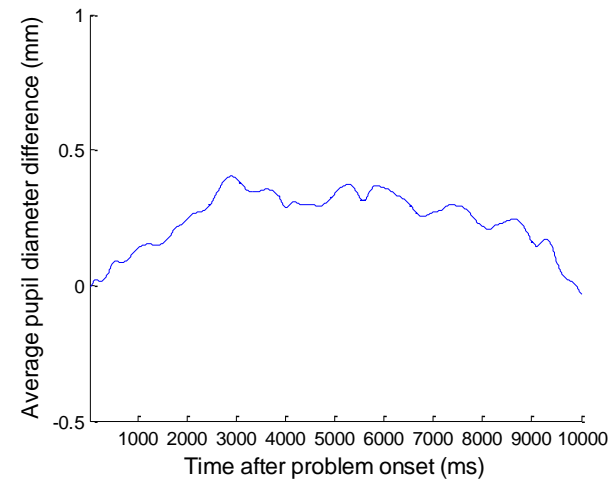
Hard 1



Hard 2

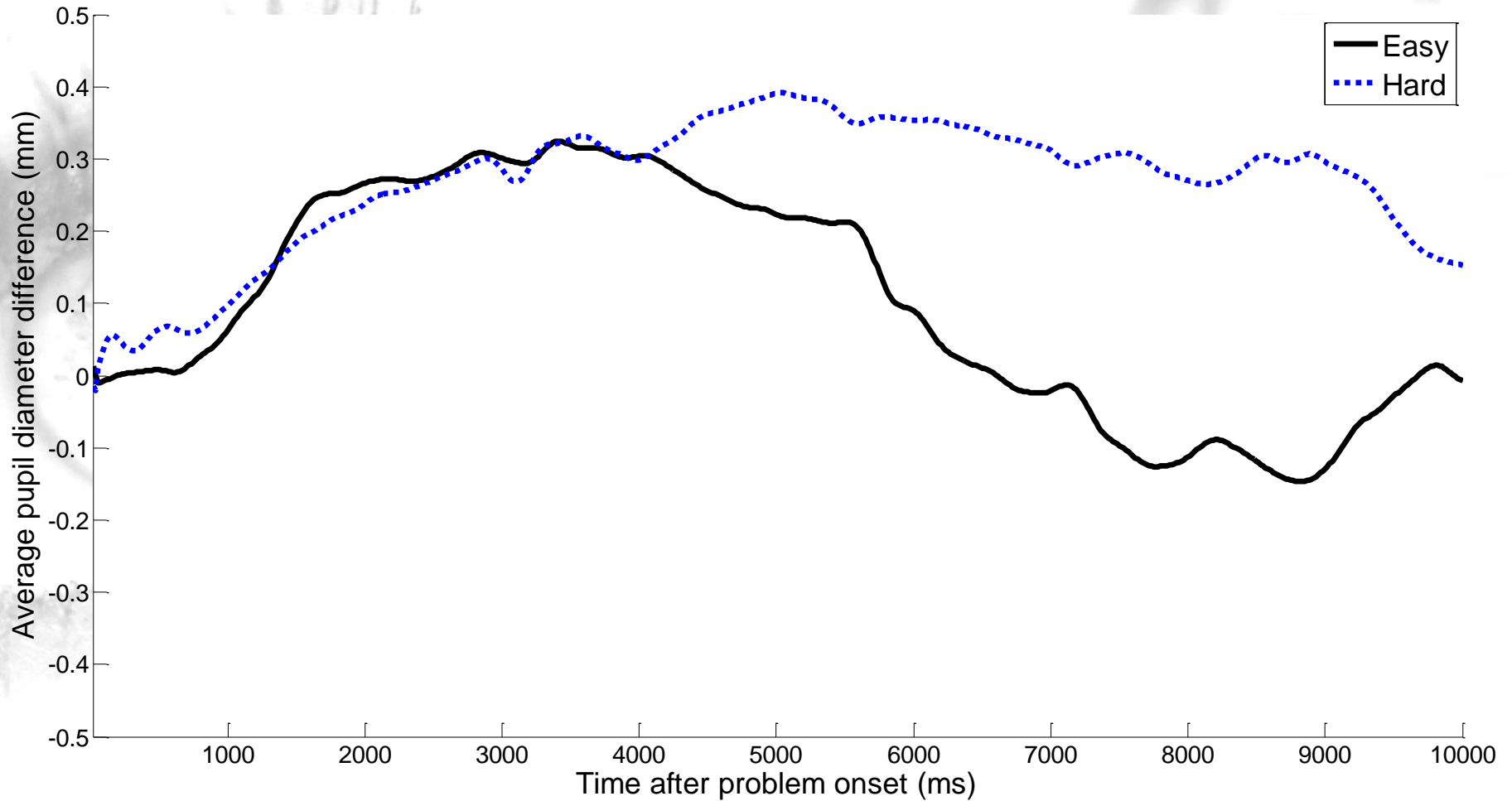


Hard 3





# Mean per problem type



# Further reading

- **General overview of task-evoked pupillometry**
  - Laeng, B., Sirois, S., & Gredebäck, G. (2012). Pupillometry: a window to the preconscious? *Perspectives on Psychological Science*, 7(1), 18-27.
- **Functional data analysis of pupil diameter**
  - Jackson, I., & Sirois, S. (2009). Infant cognition: going full factorial with pupil dilation. *Developmental Science*, 12(4), 670-679.
- **Measurement errors (and fixes thereof) of pupil diameter estimation in eye trackers**
  - Brisson, J., Mainville, M., Mailloux, D., Beaulieu, C., Serres, J., & Sirois, S. (2013). Pupil diameter measurement errors as a function of gaze direction in corneal reflection eyetrackers. *Behavior Research Methods*, 1-10. doi: 10.3758/s13428-013-0327-0



**Thank you!**