

# Smart Eyewear and Beyond

From Cognition-Aware Interactions Towards Augmenting Human Senses

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Keio Media Design  
Keio University, Tokyo, Japan  
<http://kaikunze.de/>

# My Background

Professor

Graduate School of Media Design, Keio University

Research Assistant Professor

Osaka Prefecture University

Visiting Researcher at MIT Media Lab

MIT, Cambridge, USA

phD in Ubiquitous/Wearable Computing (2011)

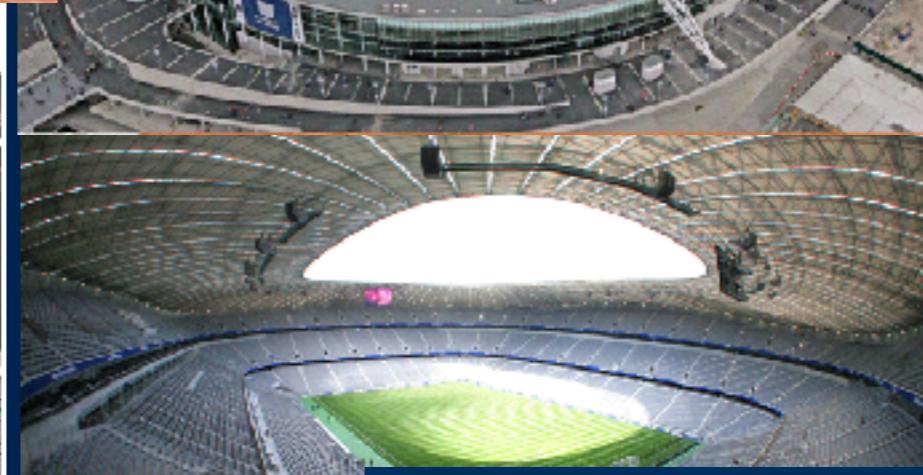
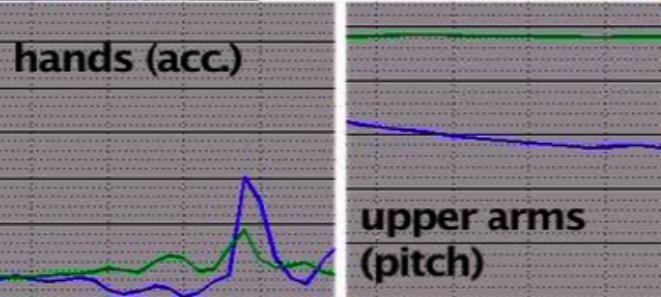
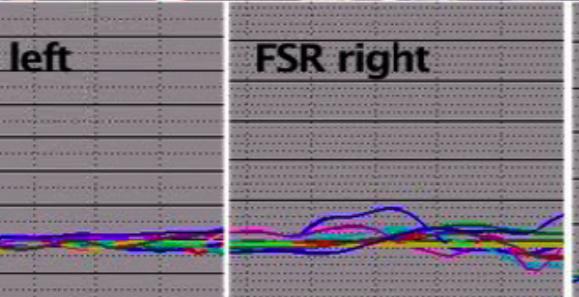
University Passau, Germany

Collaborations with PARC, SUN, Deutsche Börse ...

Palo Alto, Grenoble, Frankfurt, Innsbruck



**ZEISS**



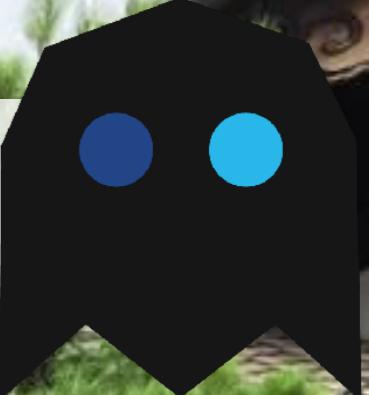


甲斐

*Kai*

<http://geist.pro>

# Geist Team and Friends



<http://geist.pro/>  
[kai@kmd.keio.ac.jp](mailto:kai@kmd.keio.ac.jp)  
twitter: @k\_garten  
facebook: kai.kunze

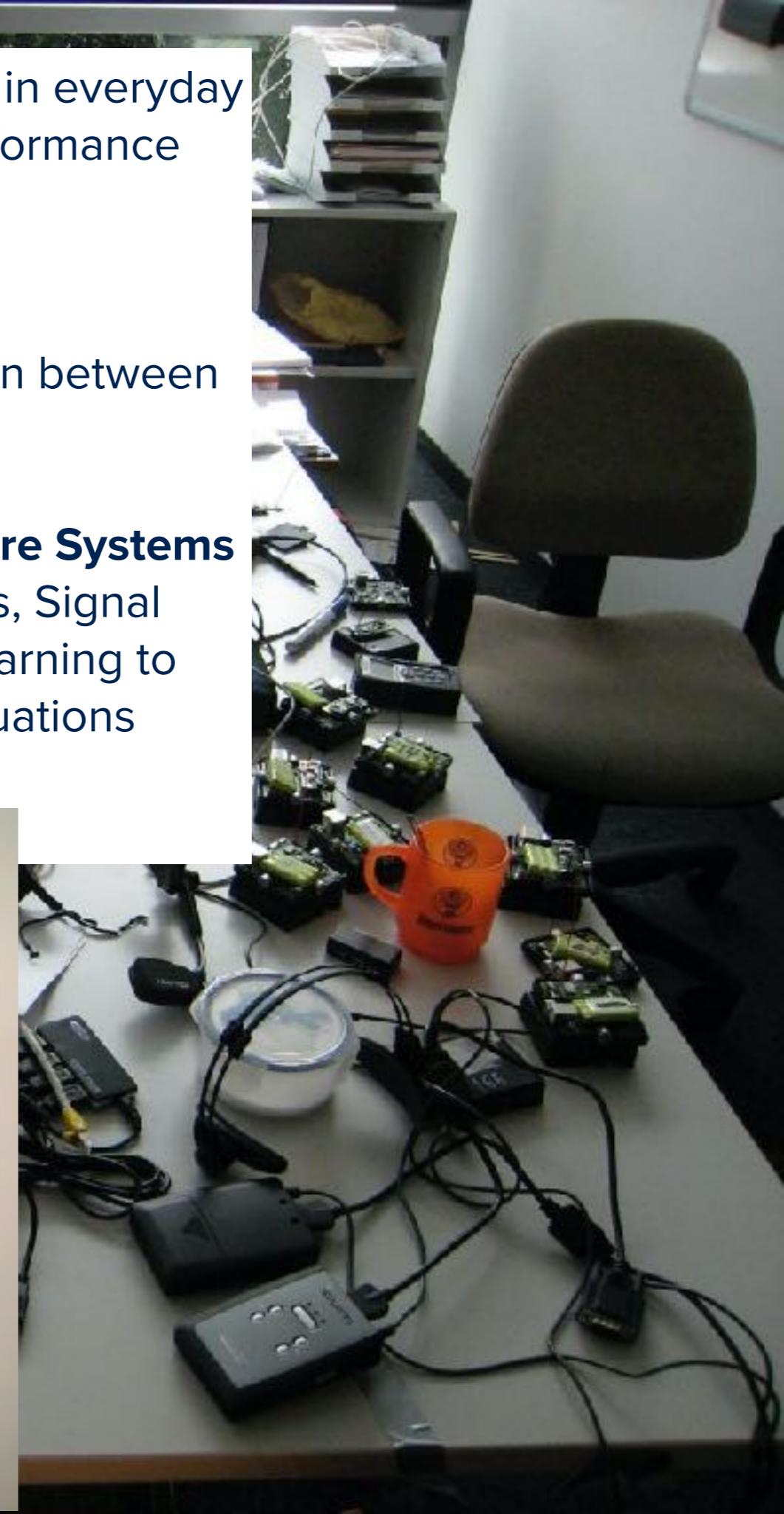
# Physical



With the computers surrounding us in everyday life, worn on our bodies, the performance bottle neck is  
**Human Attention.**

Key challenge: intuitive cooperation between humans and computers

**Activity Recognition, Context-Aware Systems**  
Using a Combination of Sensors, Signal Processing, Applied Machine Learning to Support Users in Everyday Situations



# Wearable Computing around 2005

Maintenance Scenario Collaboration with Zeiss, Oberkochen.



Kunze, Kai, et al. "Does context matter?-a quantitative evaluation in a real world maintenance scenario." *International Conference on Pervasive Computing*. Nara, Japan, 2009.

# Wearable Computing – Activity Recognition becomes Mainstream



Kunze Kai. Compensating for On-Body Placement Effects in Activity Recognition, 2011.  
Eyewear and Beyond - Kai Kunze

# Cognitive

# Tracking Cognitive Tasks— Reading Habits



Where to start?

Ubiquitous learning activity: reading



# *How much are you reading?*

Kai Kunze et al. Quantifying Reading Habits — Counting How Many Words You Read. UbiComp 2015.

# *What are you reading?*

Kai Kunze et al. I know what you are reading – Recognition of document types using mobile eye tracking, ISWC 2013, Zurich.



# *How much do you understand?*

K. Kunze, H. Kawaichi, K. Yoshimura, K. Kise. Towards inferring language expertise using eye tracking. WIP ACM SIGCHI Conference on Human Factors in Computing Systems, Paris, France 2013.

Kazuyo Yoshimura, Kai Kunze and Koichi Kise. The Eye as the Window of the Language Ability: Estimation of English Skills by Analyzing Eye Movement While Reading Documents, ICDAR, 2015/

- Kai Kunze

# Cognitive Activity Tracking in Everyday Life



# Cognitive

J!NS MEME: From Research to Product

# Overview of J!NS MEME



GOOD DESIGN  
AWARD 2015



## J!NS MEME

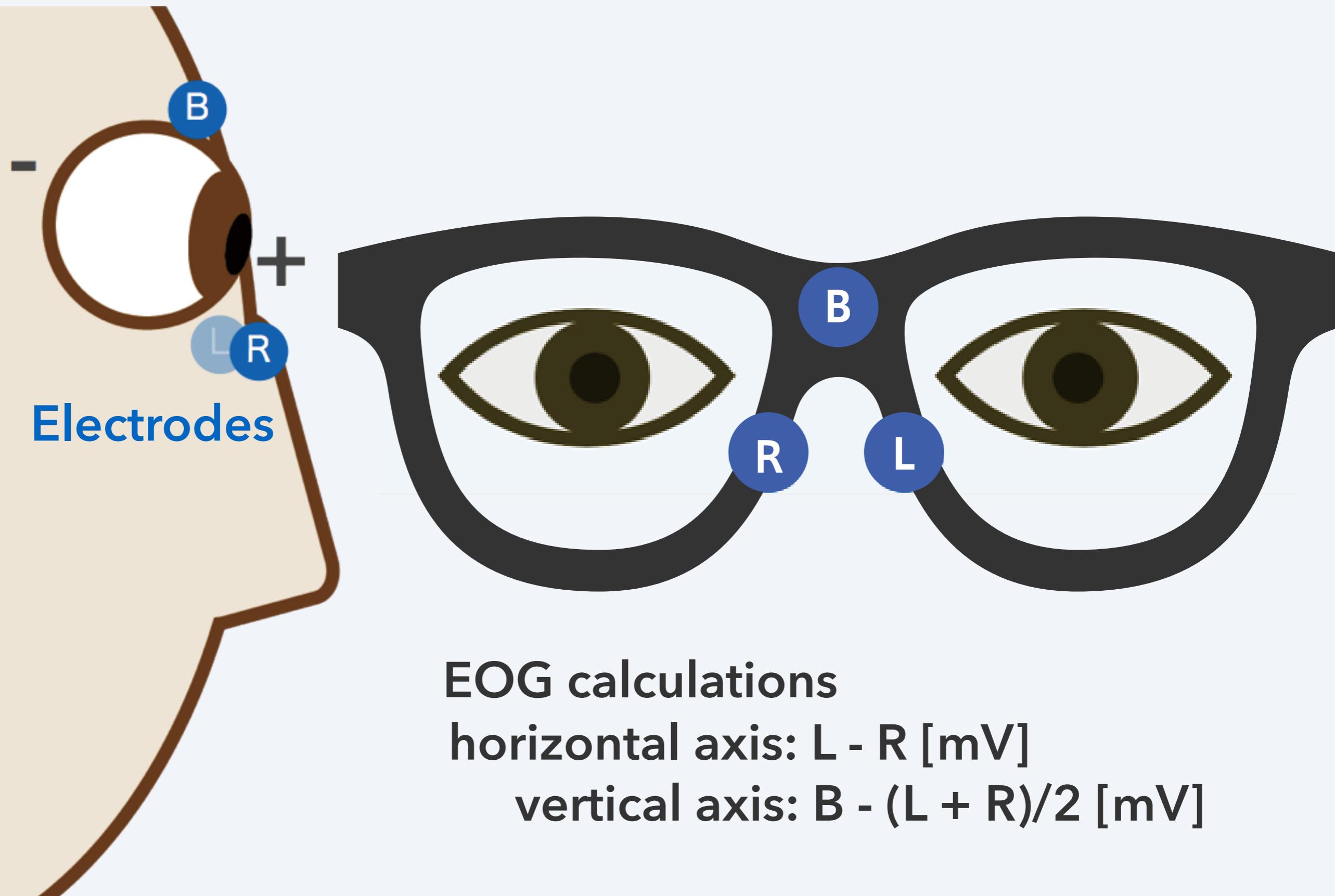
Eyewear and Beyond - Kai Kunze

- 3-axis accelerometer
- 3-axis gyroscope
- 2-axis EOG



JINS MEME, smart EOG glasses, can be easily confused with [normal glasses](#).

# Overview of J!NS MEME



# Demo

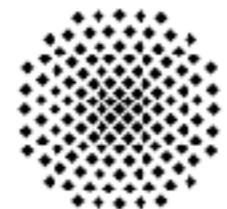
J!NS MEME: From Research to Product

# Meme Academic Collaborations

Used by over 30 research institutes (just the most prominent ones are highlighted with whom we publish)



**mit  
media  
lab**



**Universität  
Stuttgart**



**MAX-PLANCK-GESELLSCHAFT**



**TECHNISCHE UNIVERSITÄT  
KAIERSLAUTERN**



**UNIVERSITÄT  
SIEGEN**



**University of  
South Australia**

**KAIST**



**Royal College of Art**  
Postgraduate Art and Design



# Project with J!NS for MEME 2.0

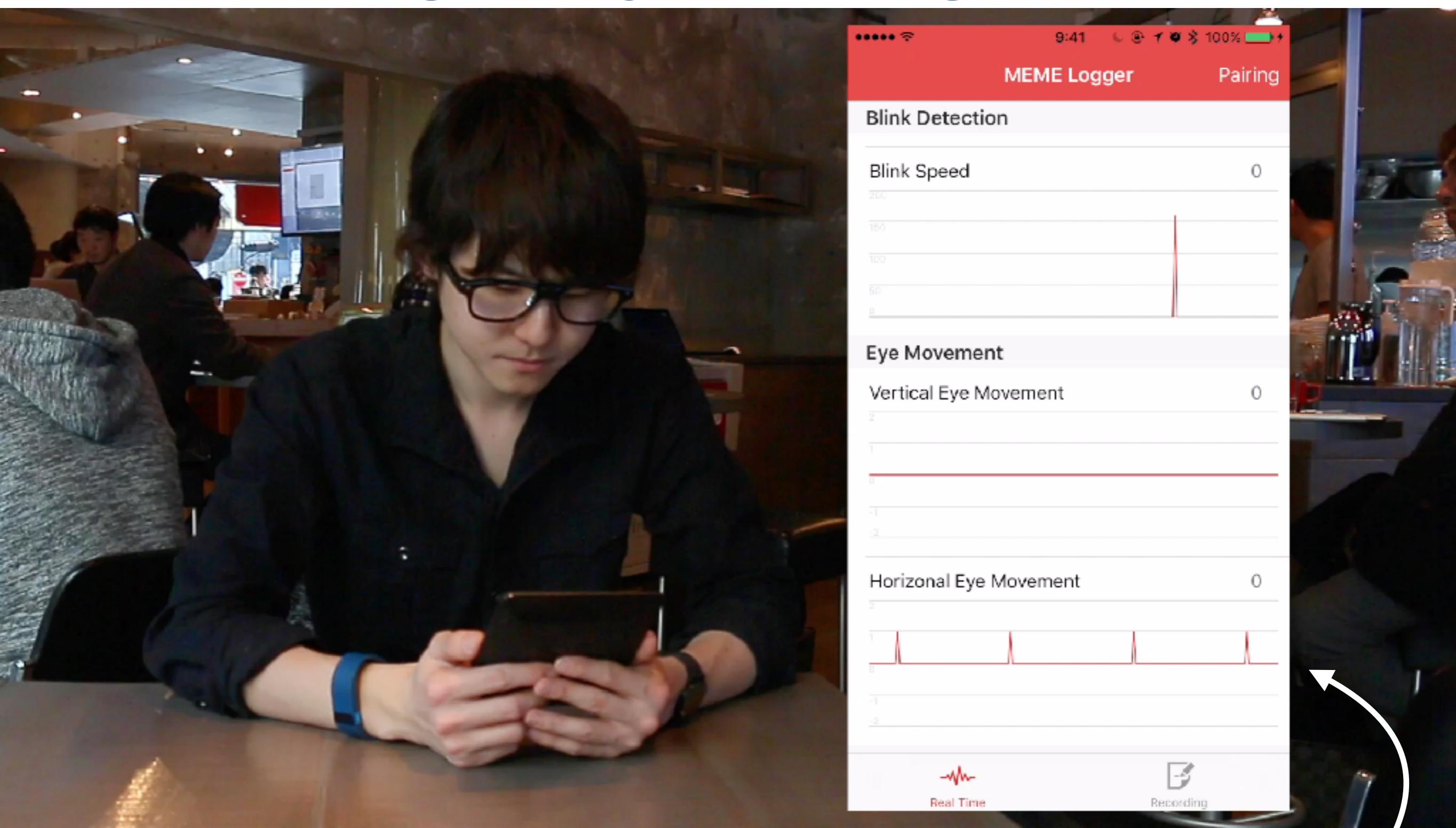
The longest, continuous, external  
research and development member of the team (over 3 years now)

J!NS



Ozan Cakmakci, Thad Starner

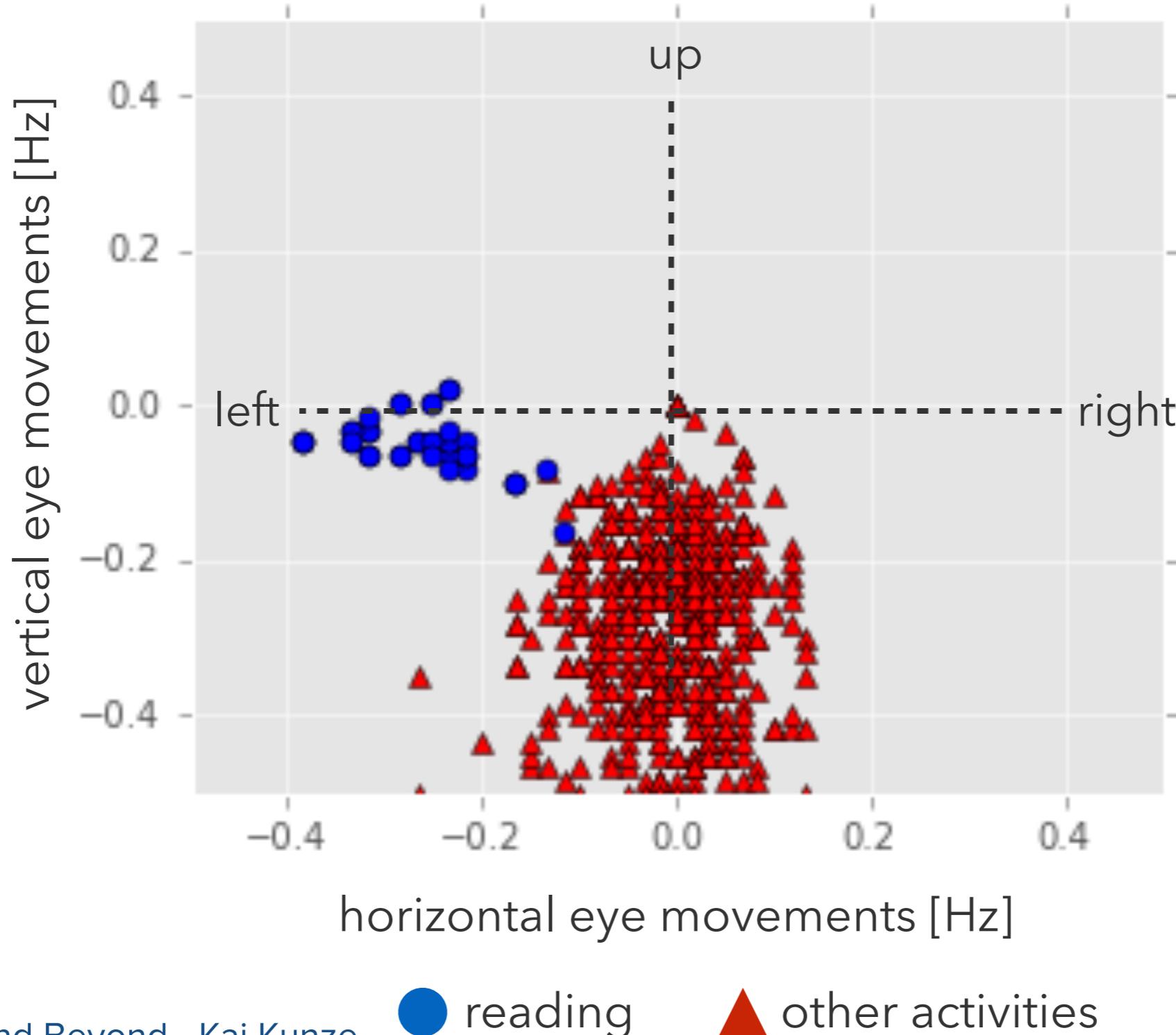
# Detecting daily reading activities



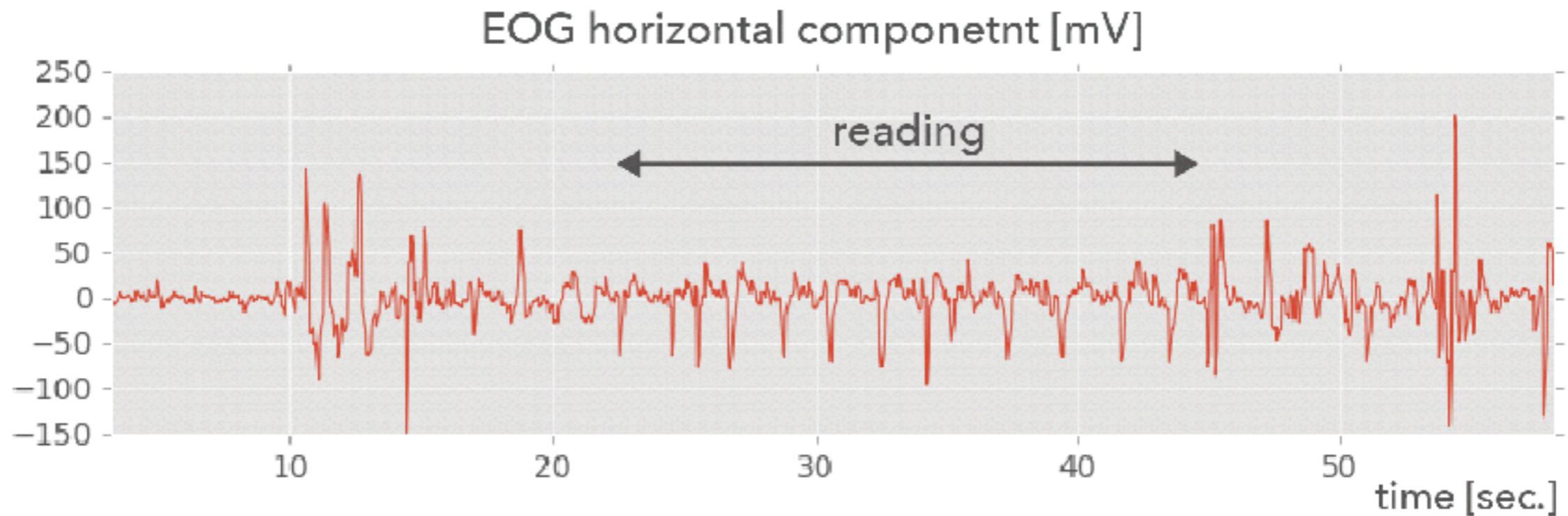
frequent “right to left” eye movements associated with line breaks

# Reading detection approach

Frequencies of eye movements during a day

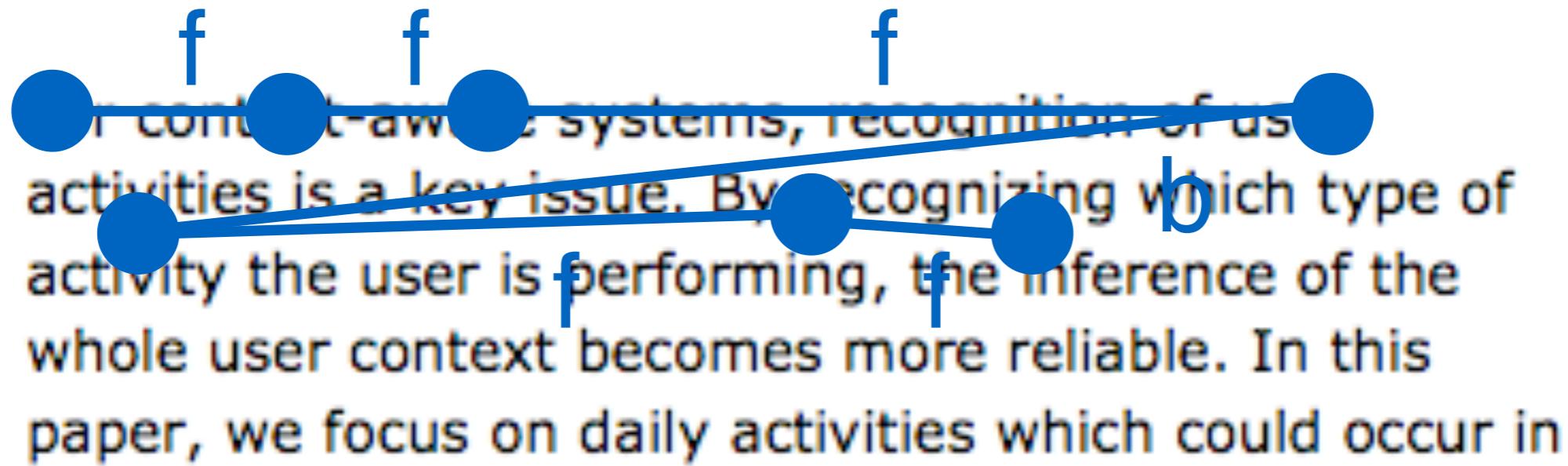
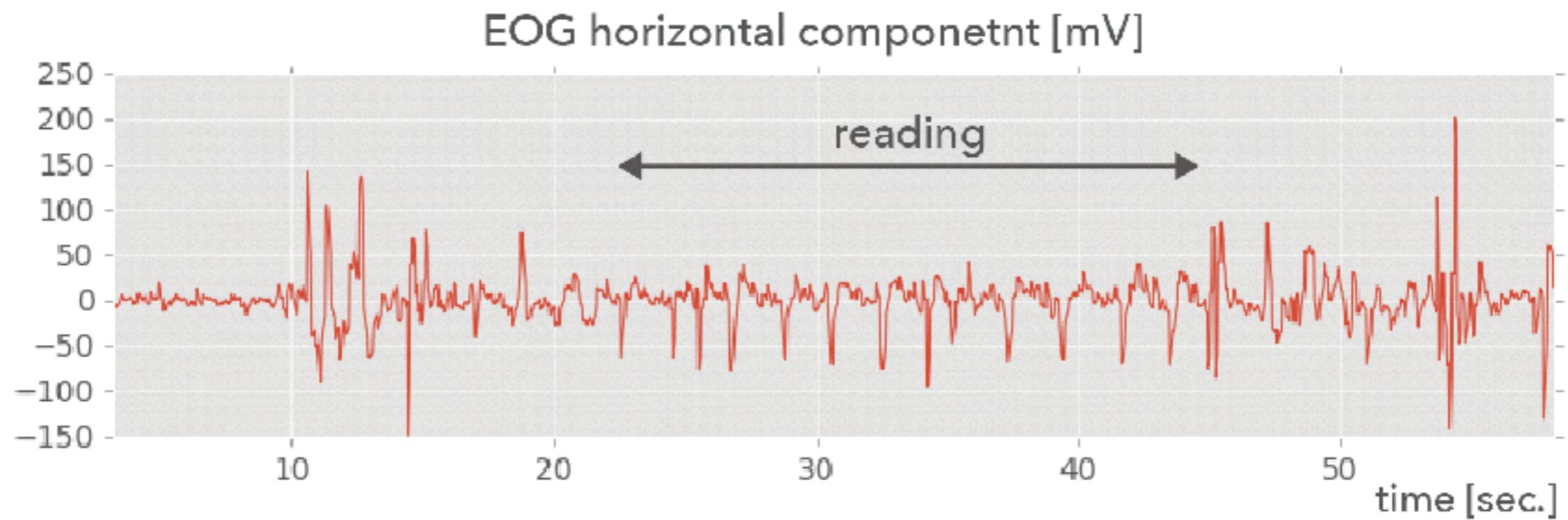


# Word count estimation approach

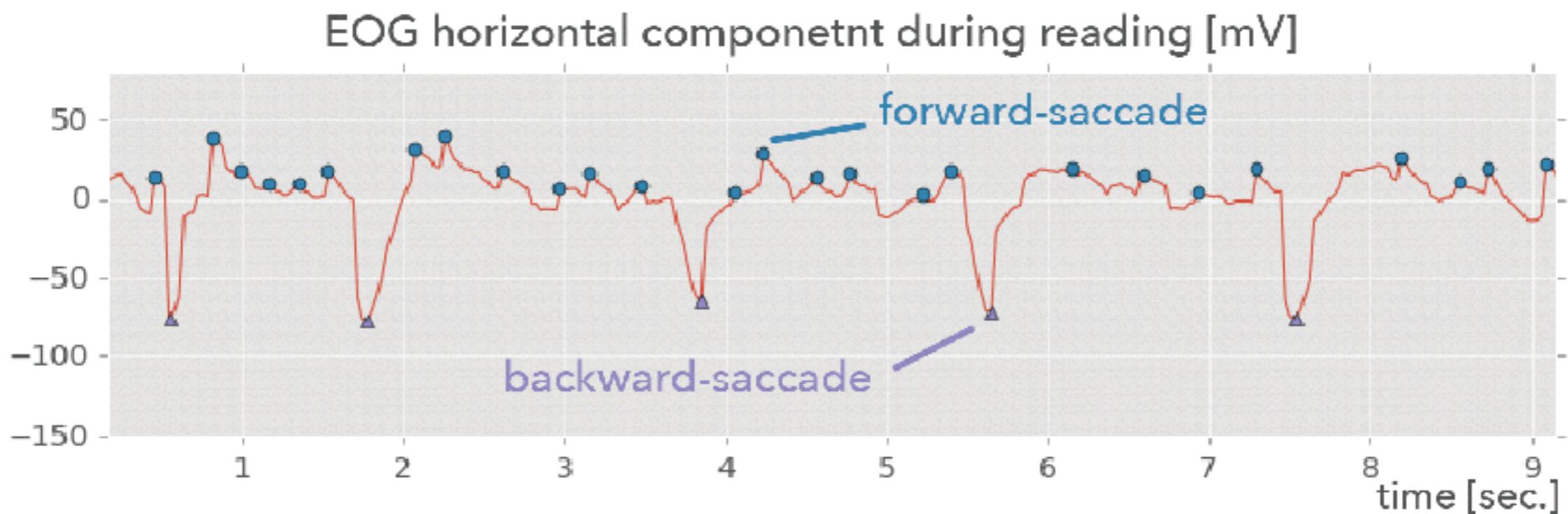
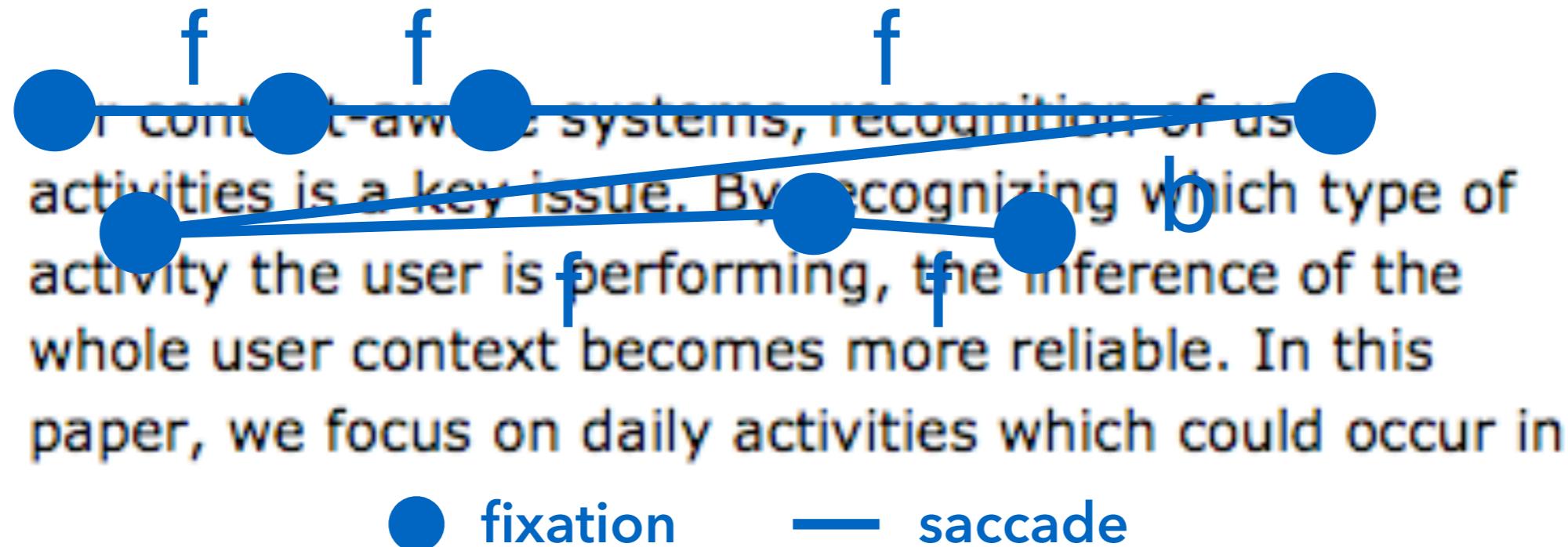


Quantifying Reading Habits – Counting How Many Words You Read. UbiComp 2015.

# Word count estimation approach

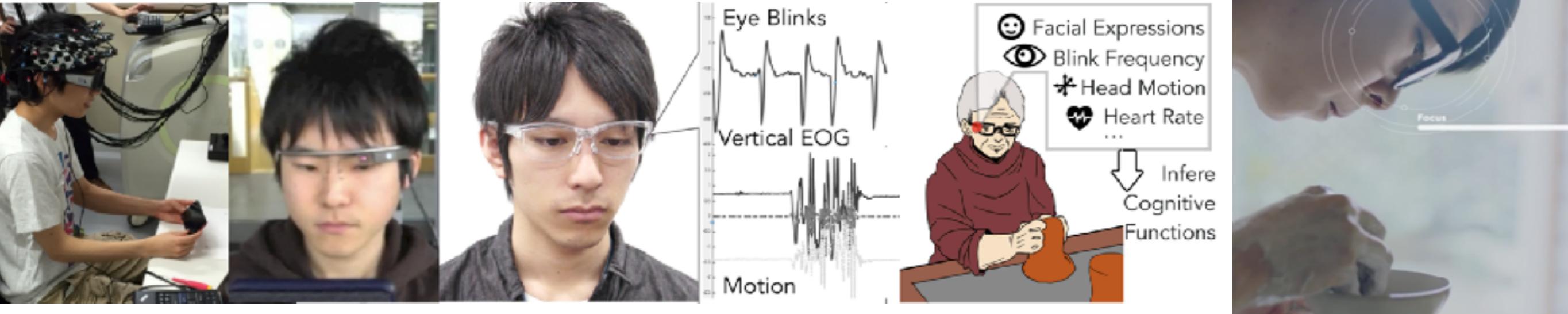


# Word count estimation approach

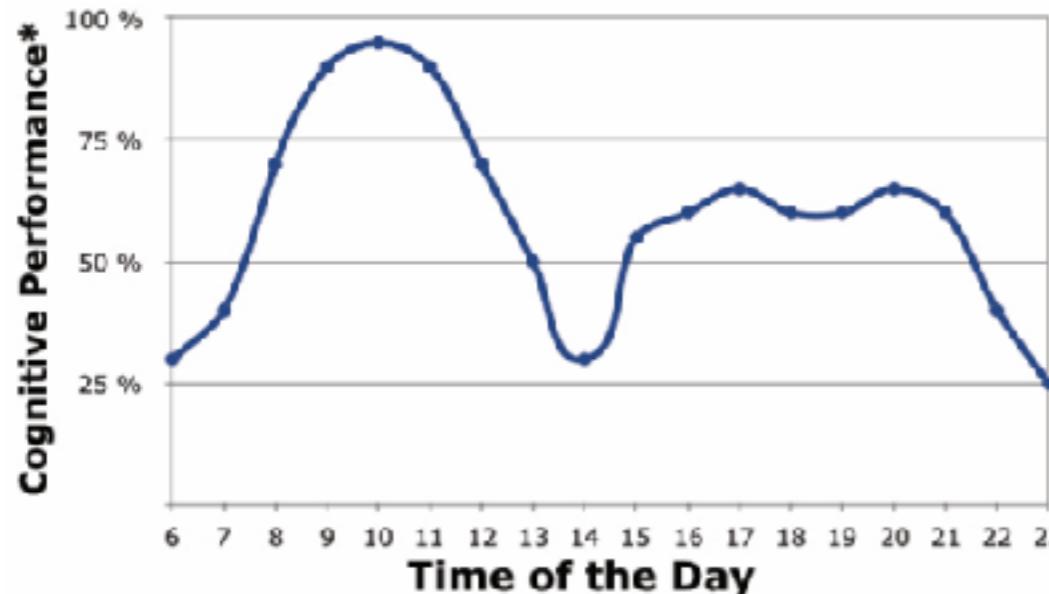


# Long Term Tracking

# JST Sakigake: Open Eyewear



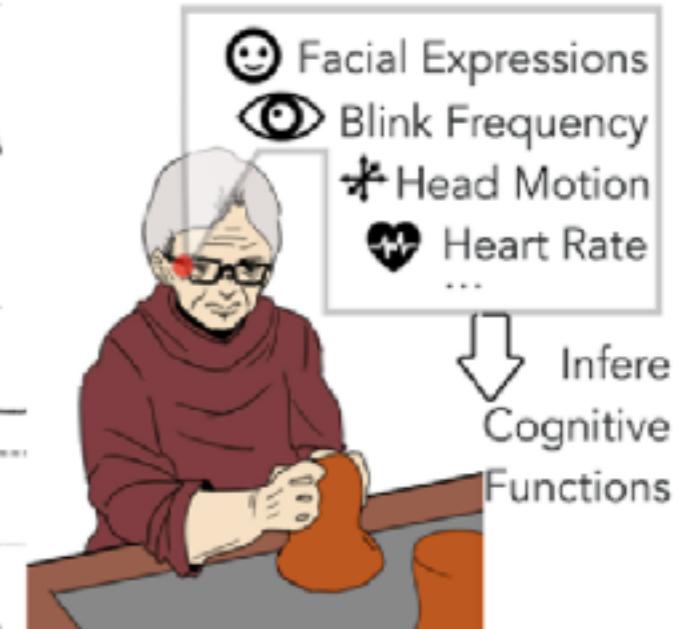
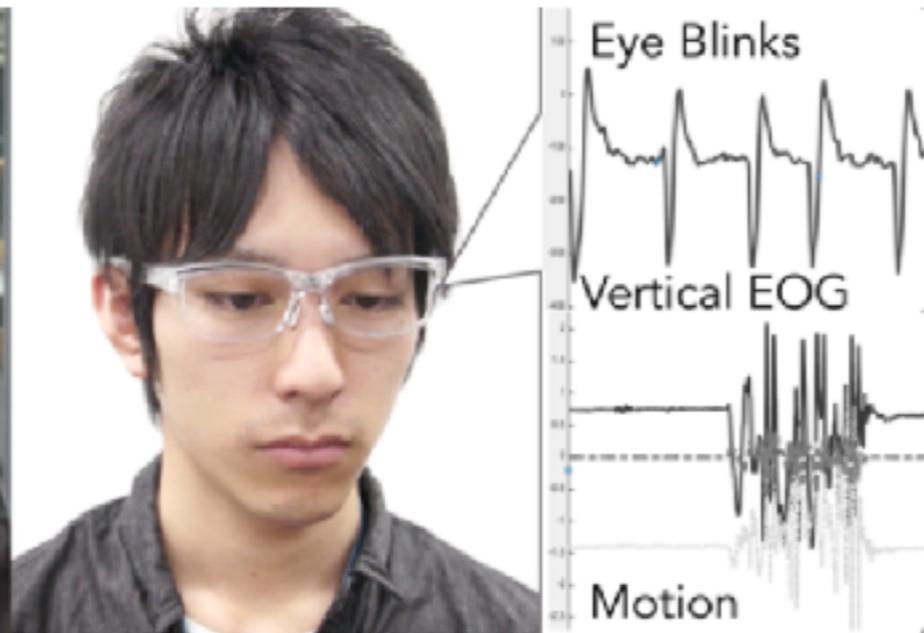
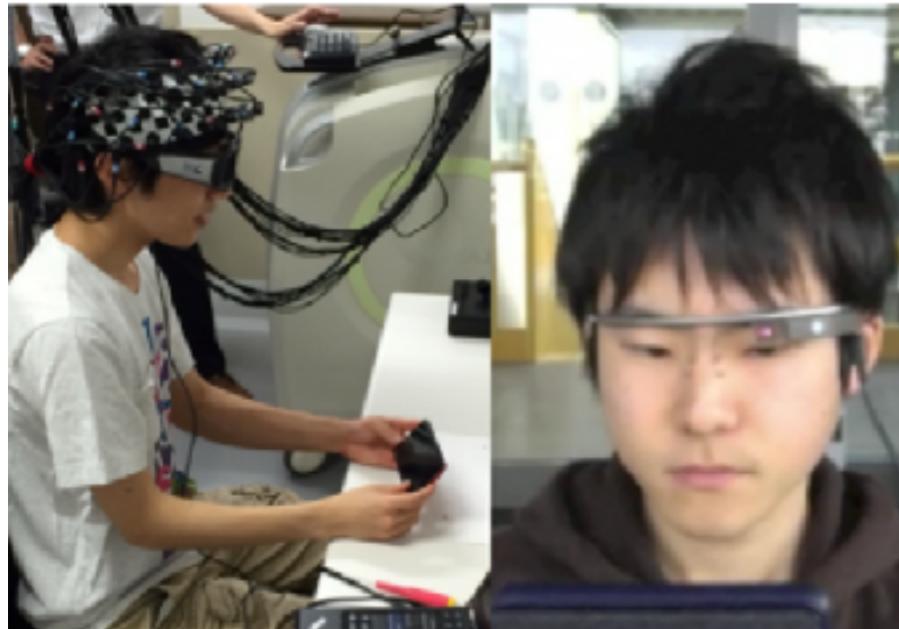
# Artificial Intelligence versus Human Intelligence



\*assessed over the digit symbol substitution task

Goel et al, 2013 [1]

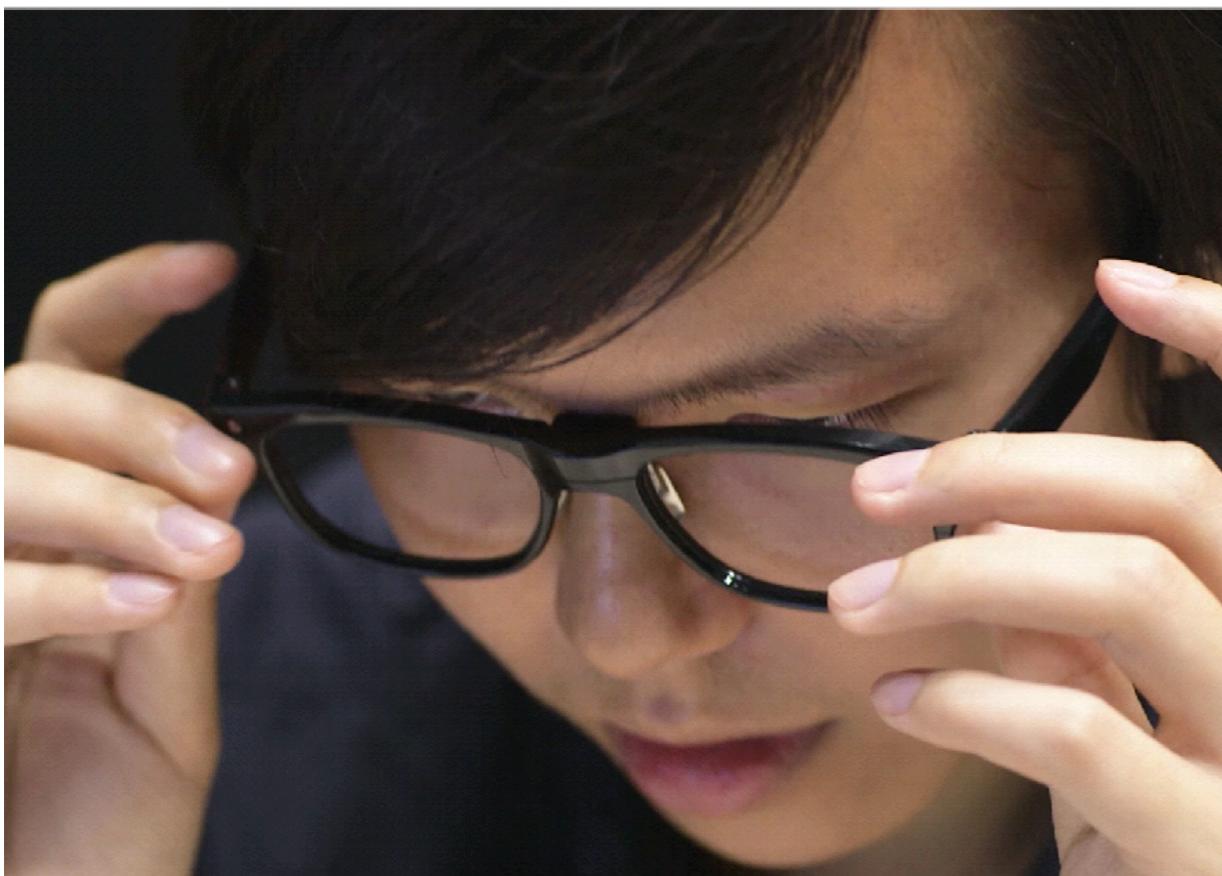
Humans have performance fluctuations  
Can we model those fluctuations?  
Can we use them for implicit interactions?



Smart Eyewear as a sensing and interaction platform

Assessing fatigue / cognitive load and making interactions easier

# Long Term Alertness Study



16 participants, 2 weeks

At least 10 hours a day: Electrooculography  
+ Motion Sensors

“Groundtruth” every 2 hours:

Standard Cognitive Tests on the Smart Phone

Karolinska Sleepiness Scale

Psychomotor vigilance task (PVT)

Stroop Test

Log Caffeine intake and Naps

Sessions in the lab with fNIRS

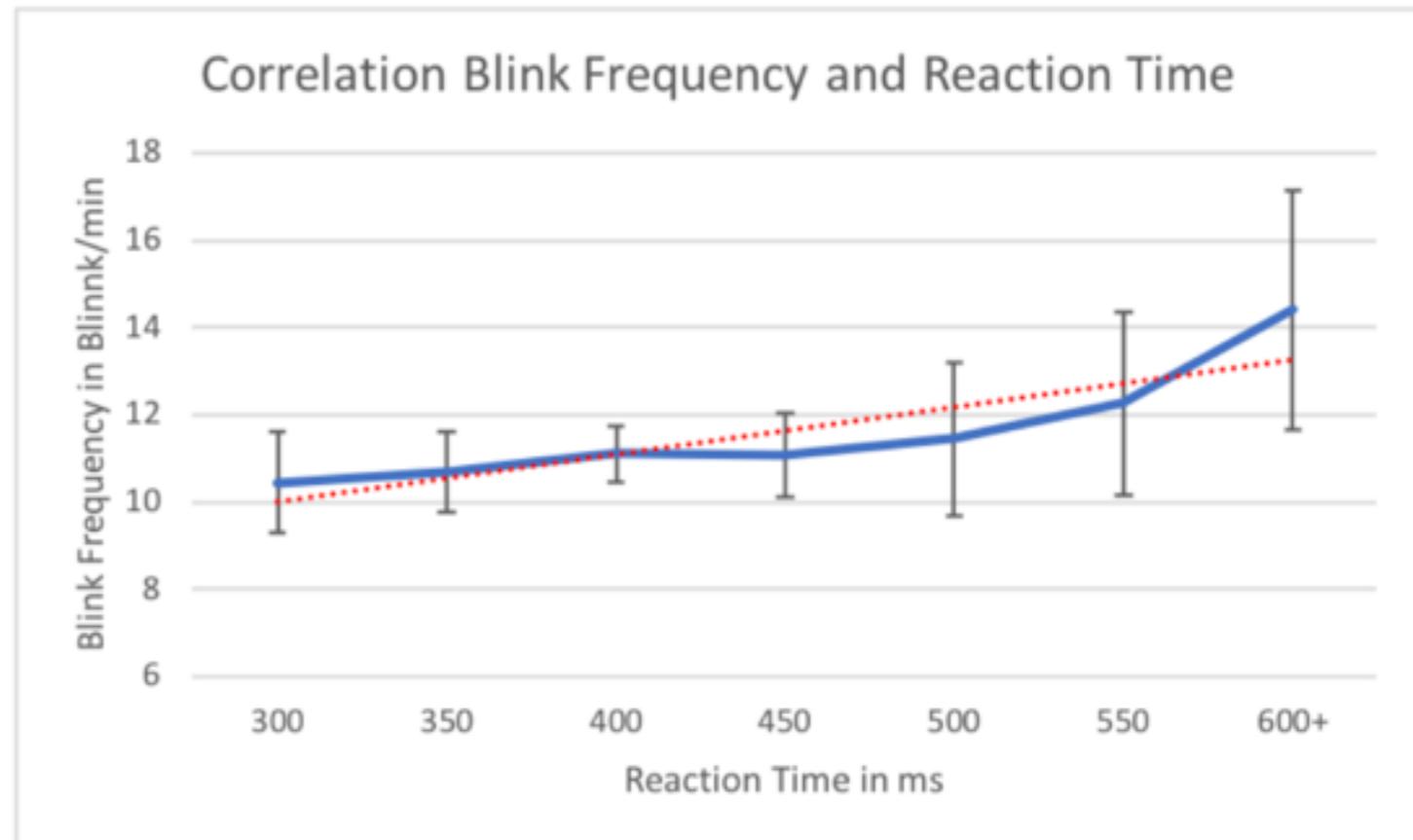
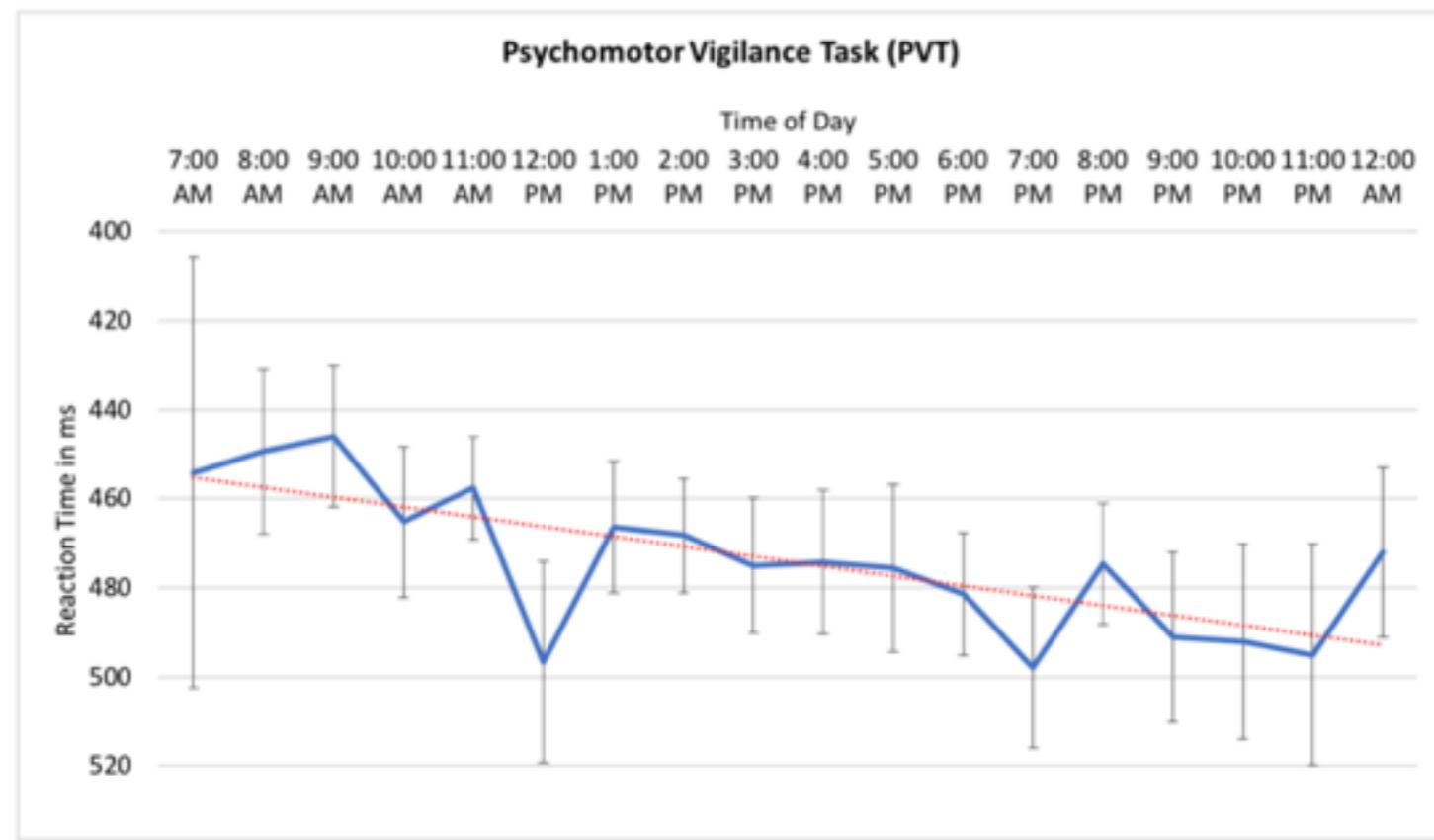
Tag, Benjamin, et al. "Continuous Alertness Assessments: Using EOG Glasses to Unobtrusively Monitor Fatigue Levels In-The-Wild." *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, 2019.

BF affected RT

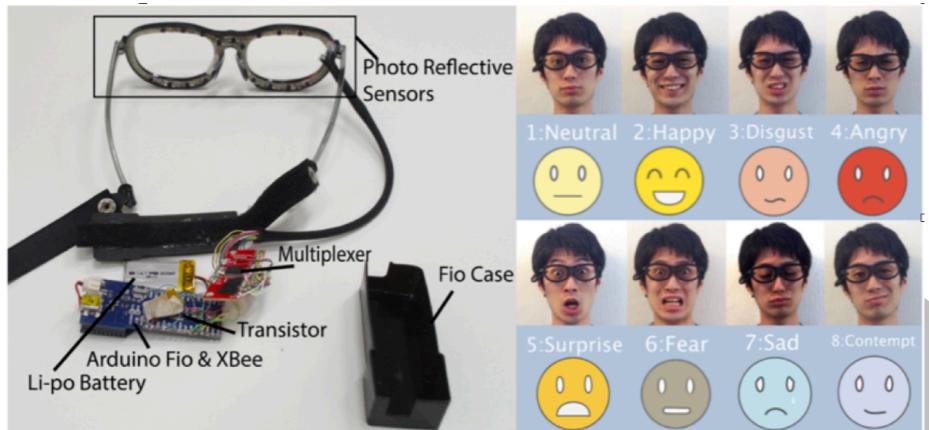
$$(x^2(1) = 4.32, p = 0.001)$$

increasing the RT by  
about 1.64 milliseconds  
 $\pm 0.38$  (standard error)  
per unit of blink added

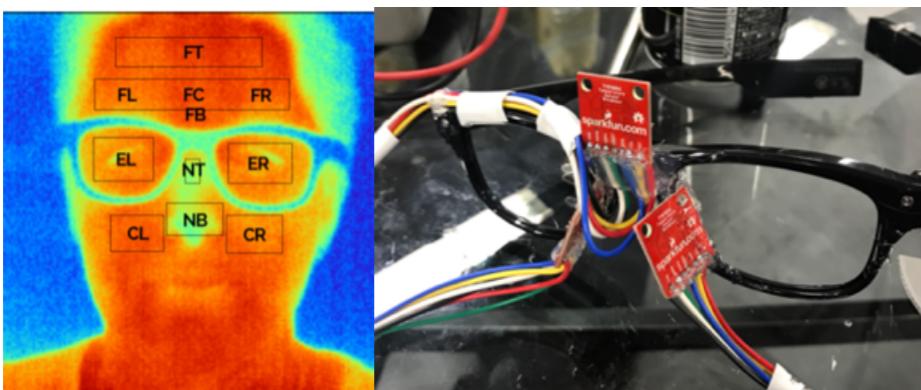
i.e., an increase of 1  
blink/hour.



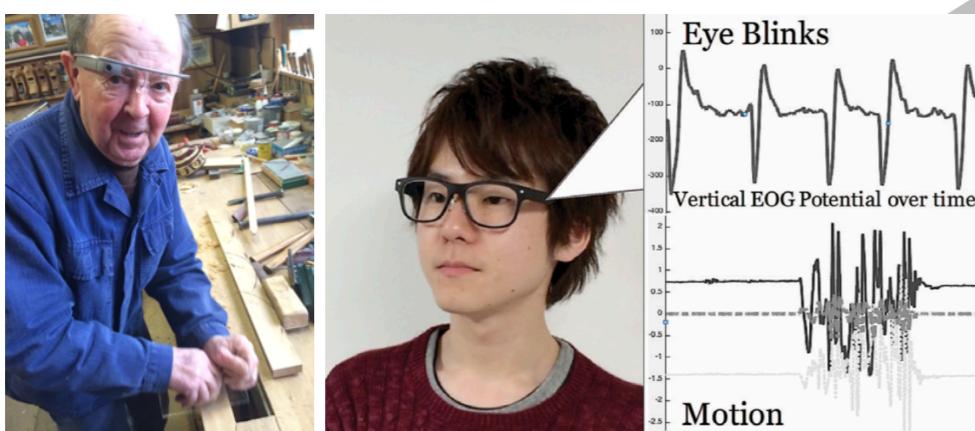
# Combining Sensing Modalities



[Evaluation of Facial Expression Recognition by A Smart Eyewear for Facial Direction Changes, Repeatability and Positional Drift.](#) Masai, Katsutoshi and Kunze, Kai et al., ACM Transactions on Interactive Intelligent Systems. 2017.



[Facial thermography for attention tracking on smart eyewear: An initial study.](#) Tag, Benjamin and Kunze, Kai et al.. CHI Adjunct. 2017



[Making Regular Eyeglasses Smart.](#) Amft, Oliver and Wahl, Florian and Ishimaru, Shoya and Kunze, Kai. Pervasive Computing, IEEE. 2015.  
[Sensor Placement Variations in Wearable Activity Recognition.](#) Kunze, Kai and Lukowicz, Paul. Pervasive Computing, IEEE. 2014.



Towards an  
“Arduino” platform  
for smart eyewear

-  facial expressions
-  eye movements
-  head motion
-  face temperature
-  muscle movement
-  electroencephalogram ....

Standalone



Sensor recordings  
Simple inference

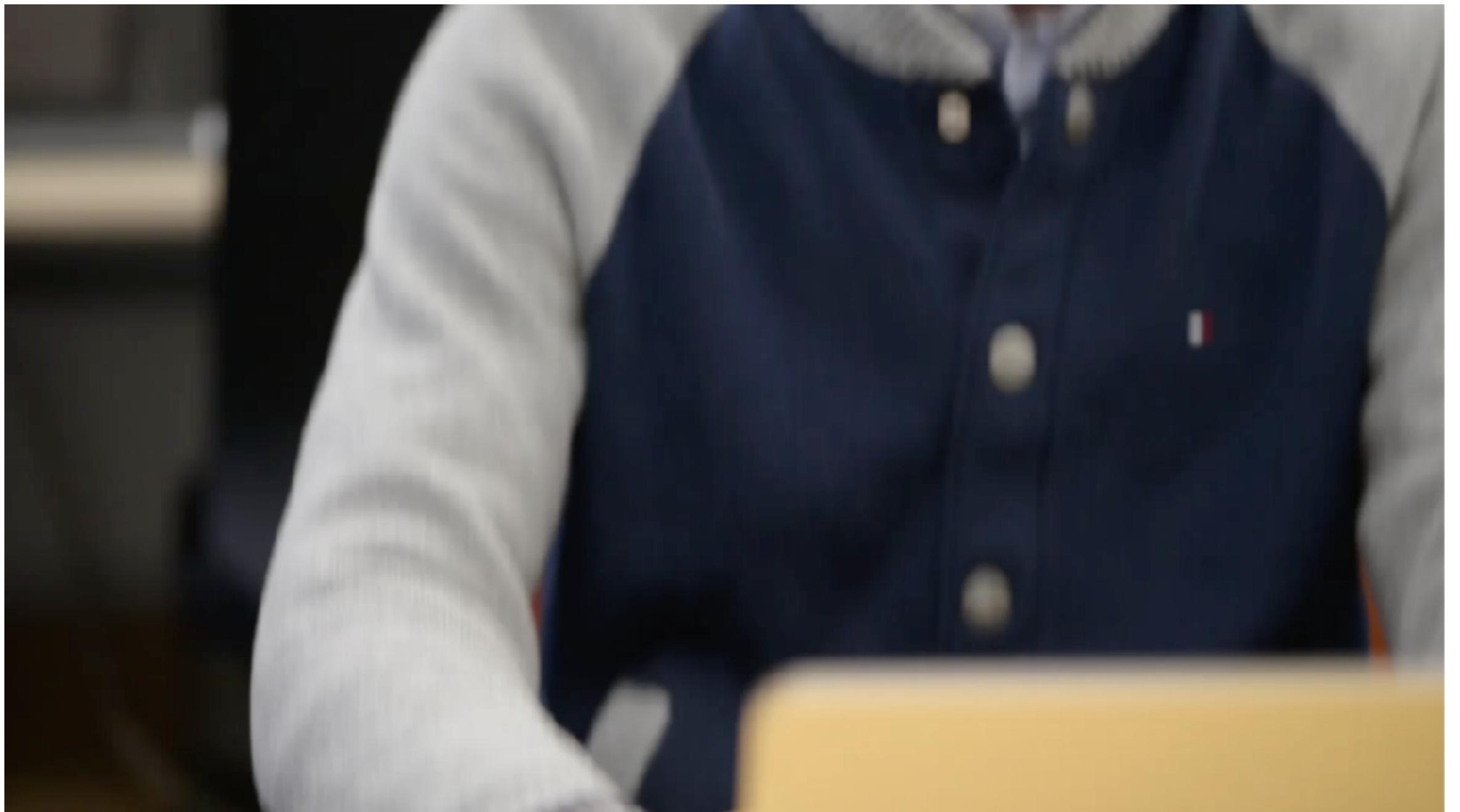
Eyewear with  
Smartphone



Interactions  
Complex inference

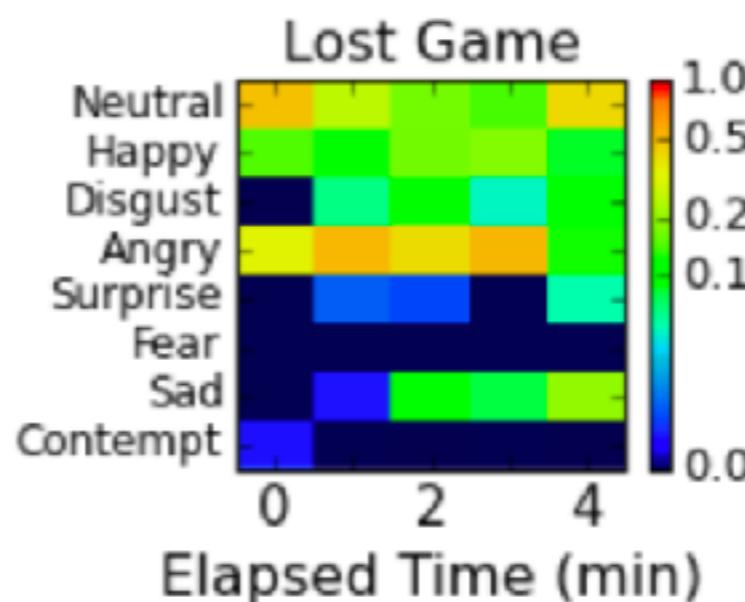
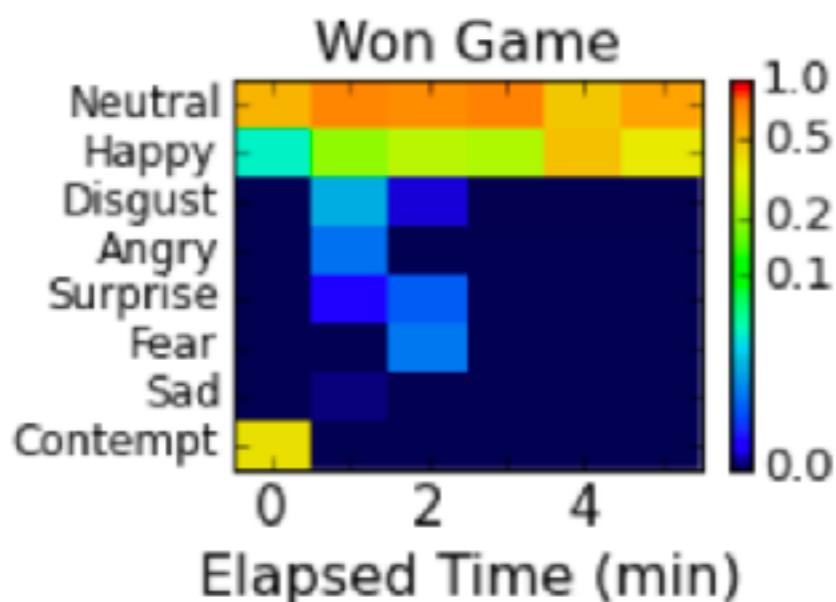
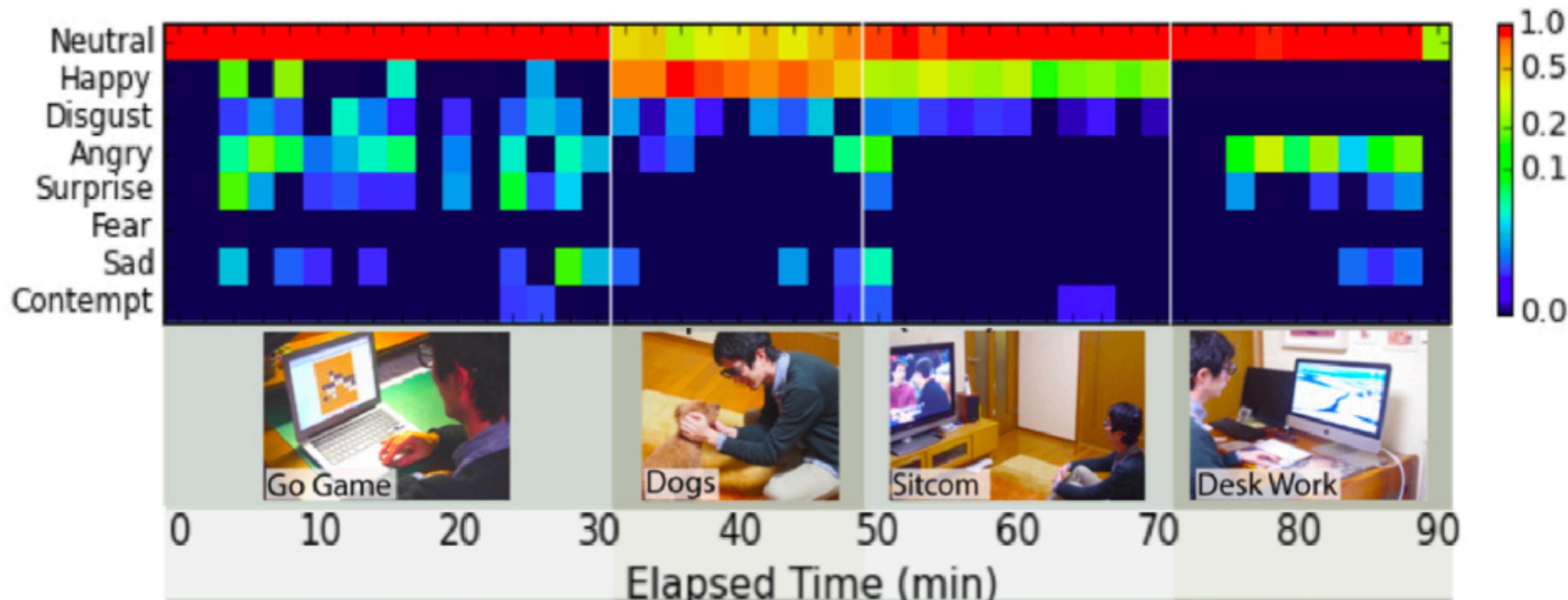


Evaluation on feasibility and  
accuracy compared with  
medical/lab measurements



Katsutoshi Masai, Yuta Sugiura, Masa Ogata, Kai Kunze, Masahiko Inami, Maki Sugimoto: Facial Expression Recognition in Daily Life by Embedded Photo Reflective Sensors on Smart Eyewear. IUI 2016:

# Facial Expressions Change Depending on Activities



# Facial Thermography for Cognitive Load

Depending on cognitive load facial temperature gradients change by 0.5 - 0.3 degrees.

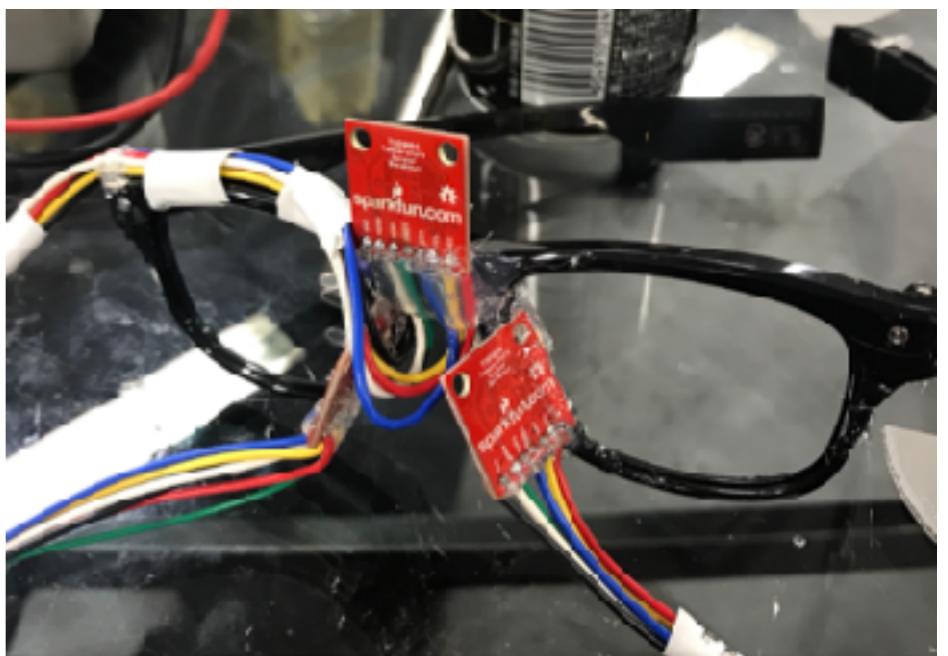
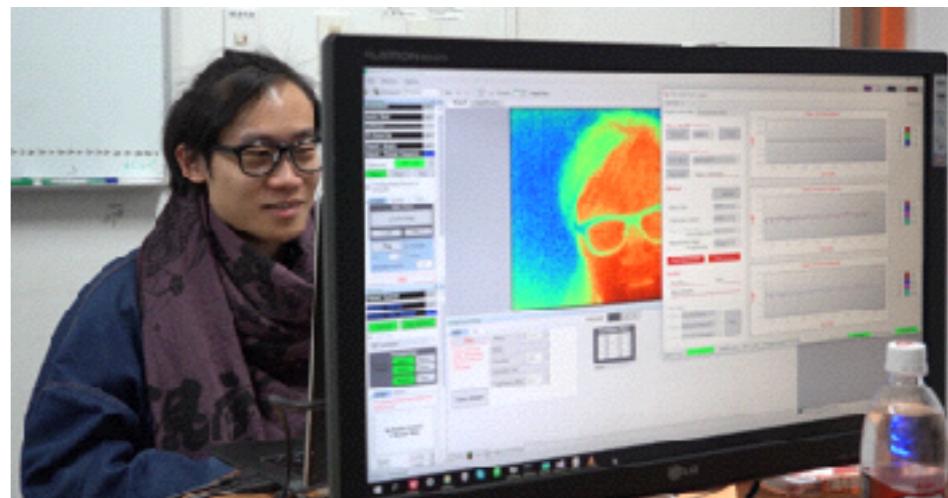
Cognitive Load increase



Cognitive Load decrease

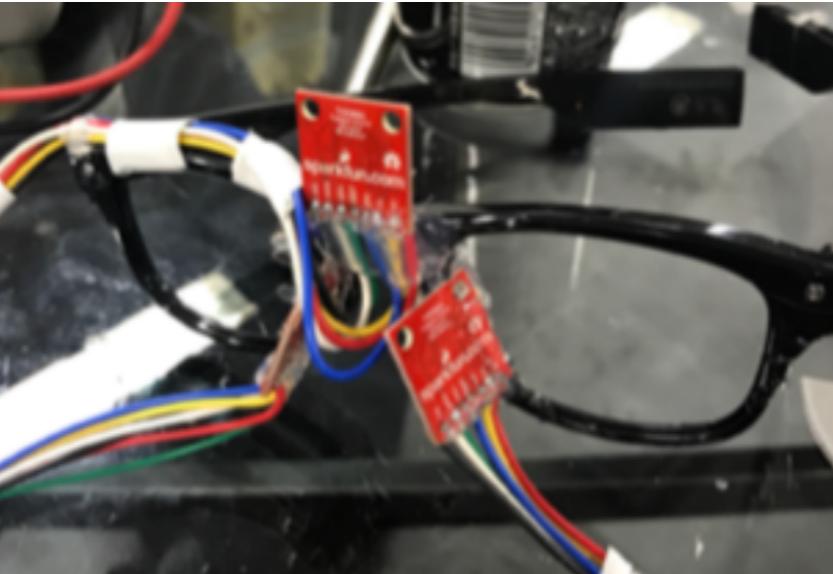
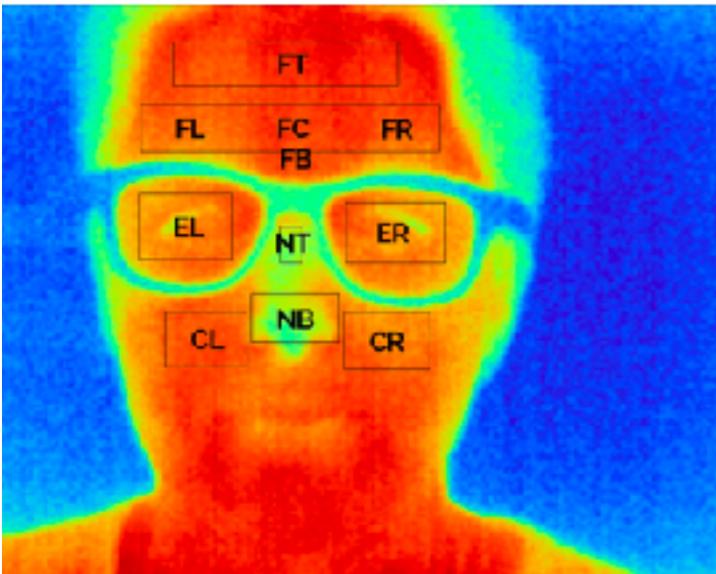


Facial Temperature Sensing on Smart Eyewear for Affective Computing  
Accepted at UbiComp Work in Progress  
Eyewear and Beyond - Kai Kunze

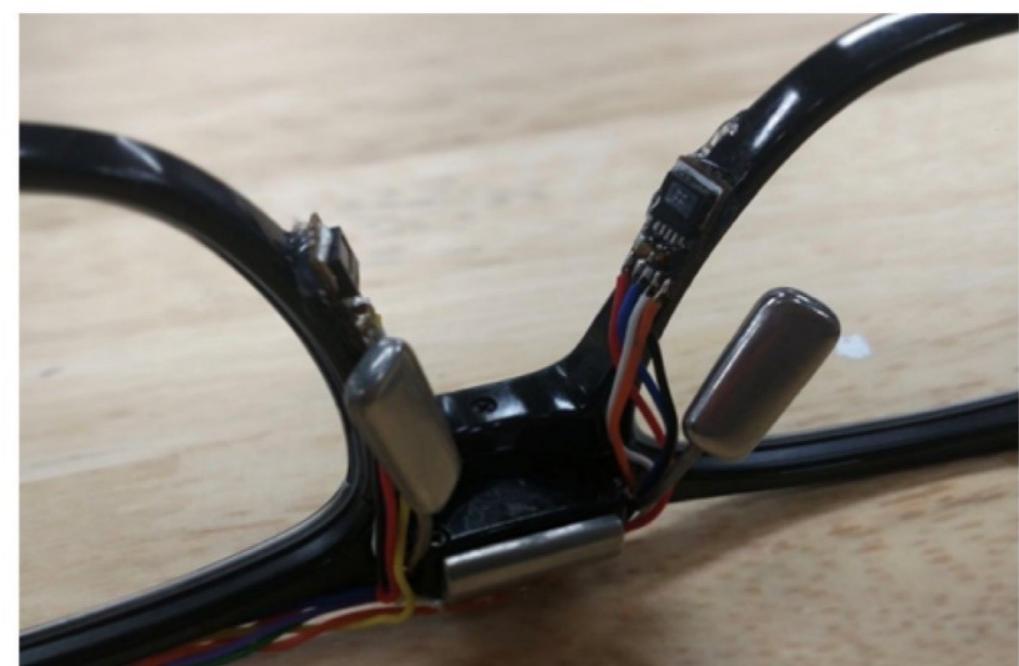


# Working on Cognitive Load / Stress

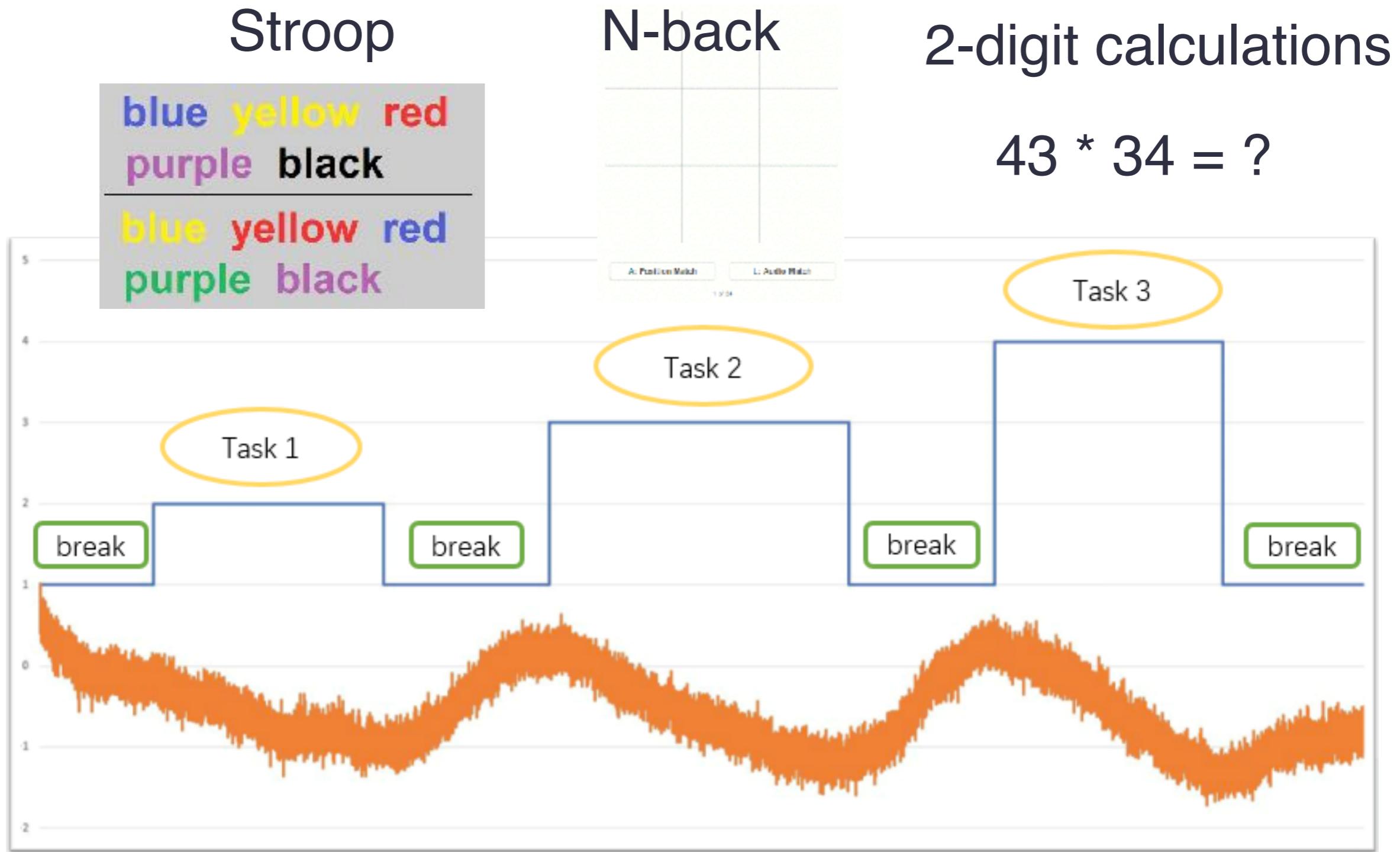
## Contactless Thermal Sensing Prototype



Zhengren, F., Chernyshov, G., Zheng, D., & Kunze, K. (2019, September). Cognitive load assessment from facial temperature using smart eyewear. In *Proceedings of the 2019 ACM UbiComp* (pp. 657-660). ACM.



# Thermal difference between nose and forehead



Zhengren, F., Chernyshov, G., Zheng, D., & Kunze, K. (2019, September). Cognitive load assessment from facial temperature using smart eyewear. In *Proceedings of the 2019 ACM UbiComp* (pp. 657-660). ACM.

# What's next?



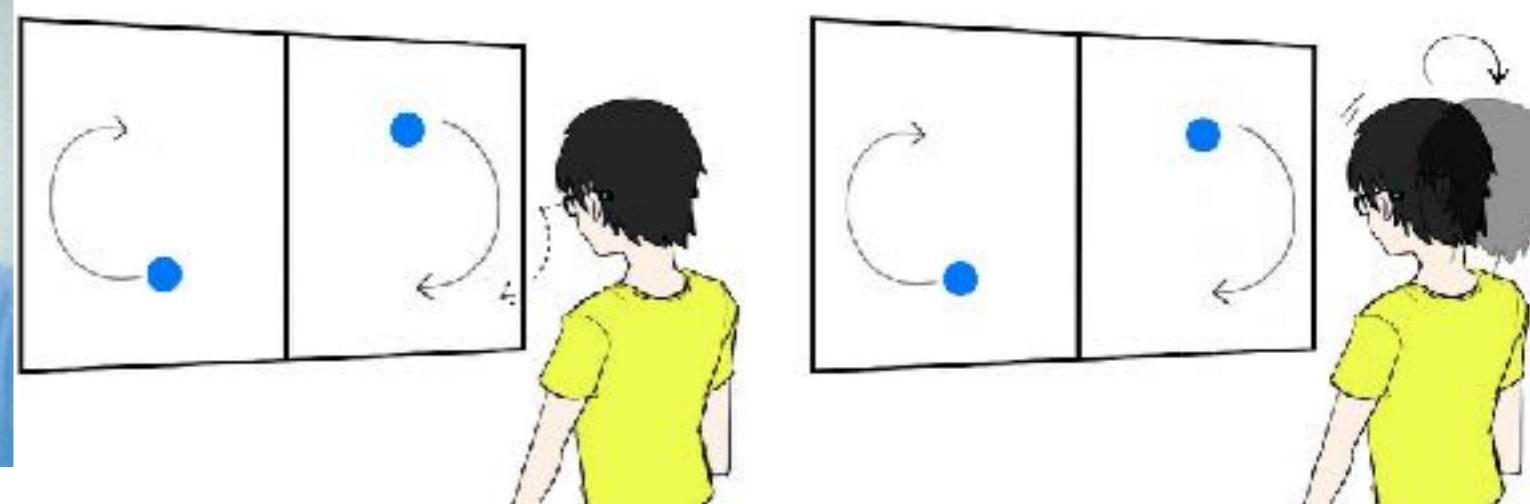
Can we track attention, concentration with affordable sensors over the whole day?

What are healthy habits?

How can we design interactions to improve given functions?

# Interaction

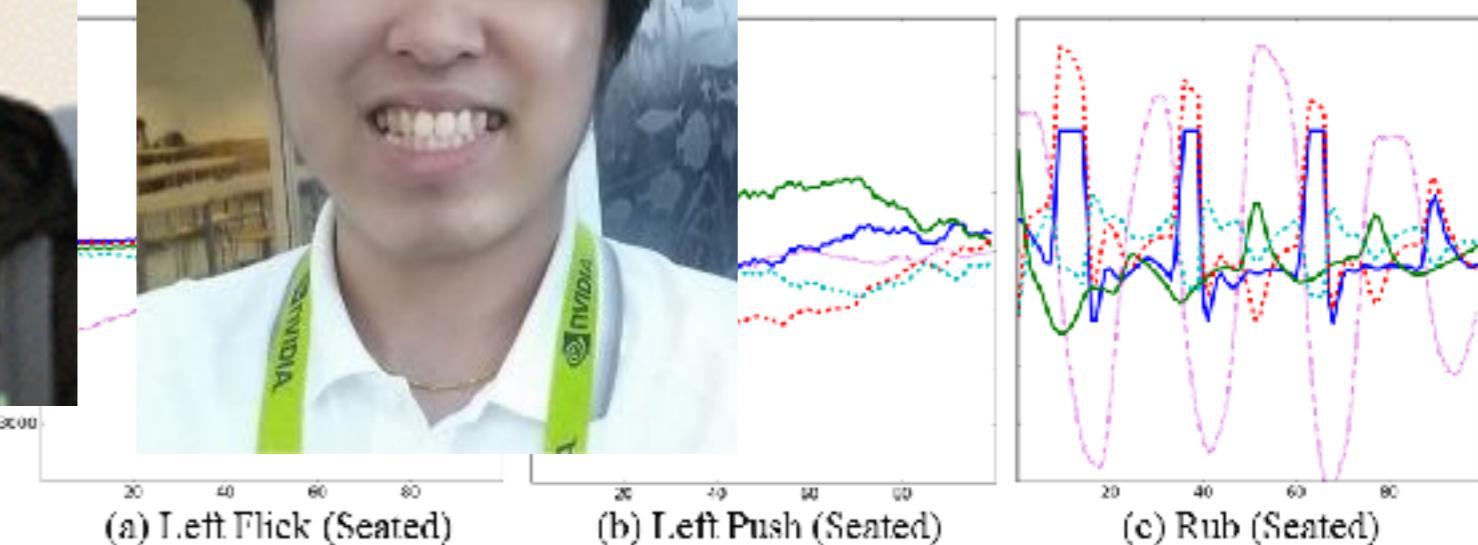
# Subtle Interactions with Smart Eyewear



Collaboration with Woontack Woo, Thad Starner, Aaron Quigley



Eyewear and Beyond - Kai Kunze



# Smooth Pursuit On MEME

*Physical Orbits*

**Smooth Pursuit Interactions with real-world environment**

Murtaza Dhuliawala, Juyoung Lee, Junichi Shimizu, Andreas Bulling, Kai Kunze, Thad Starner, and Woontack Woo. 2016. Smooth eye movement interaction using EOG glasses. In Proceedings of the 18th ACM International Conference on Multimodal Interaction (ICMI '16). ACM, New York, NY, USA, 307-311. DOI: <https://doi.org/10.1145/2993148.2993181>



## Itchy Nose

Discreet Gesture Interaction using EOG Sensors in Smart Eyewear

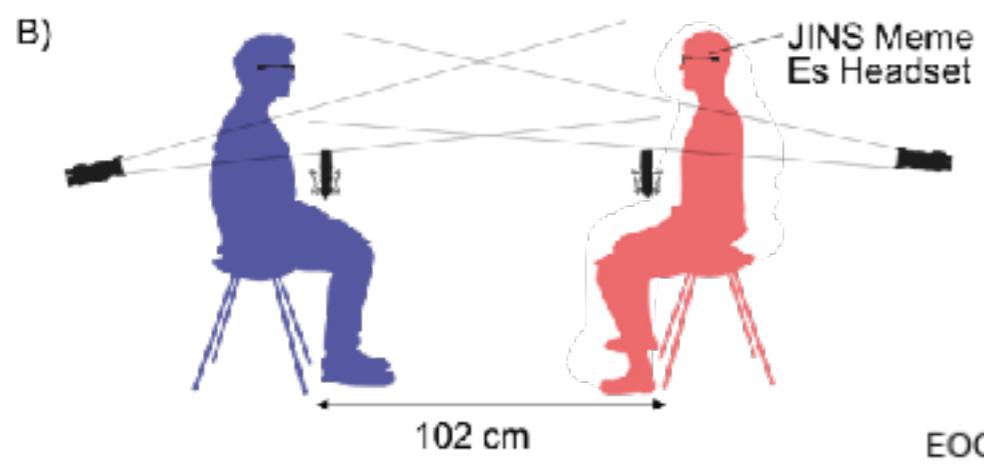
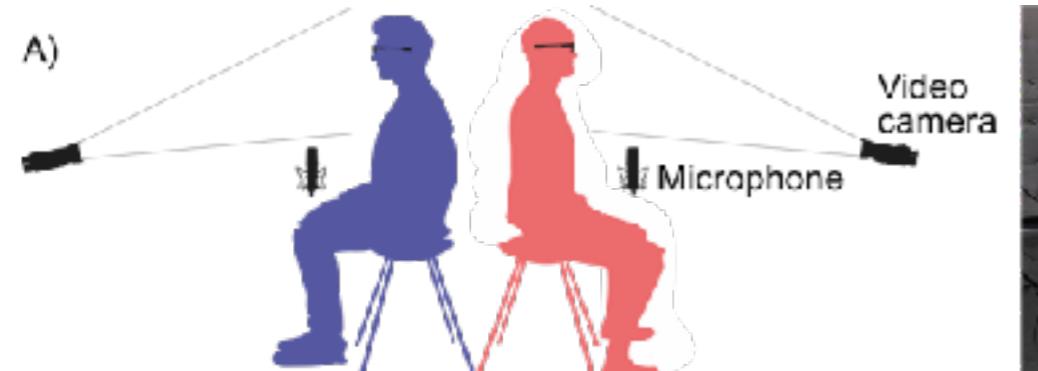
Juyoung Lee<sup>1</sup>, Hui-Shyong Yeo<sup>2</sup>, Murtaza Dhuliawala<sup>3</sup>, Jедидия Акано<sup>3</sup>, Junichi Shimizu<sup>4</sup>, Thad Starner<sup>3</sup>, Aaron Quigley<sup>2</sup>, Woontack Woo<sup>1</sup>, Kai Kunze<sup>4</sup>

<sup>1</sup>KAIST, <sup>2</sup>University of St. Andrews, <sup>3</sup>Georgia Institute of Technology, <sup>4</sup>Keio University

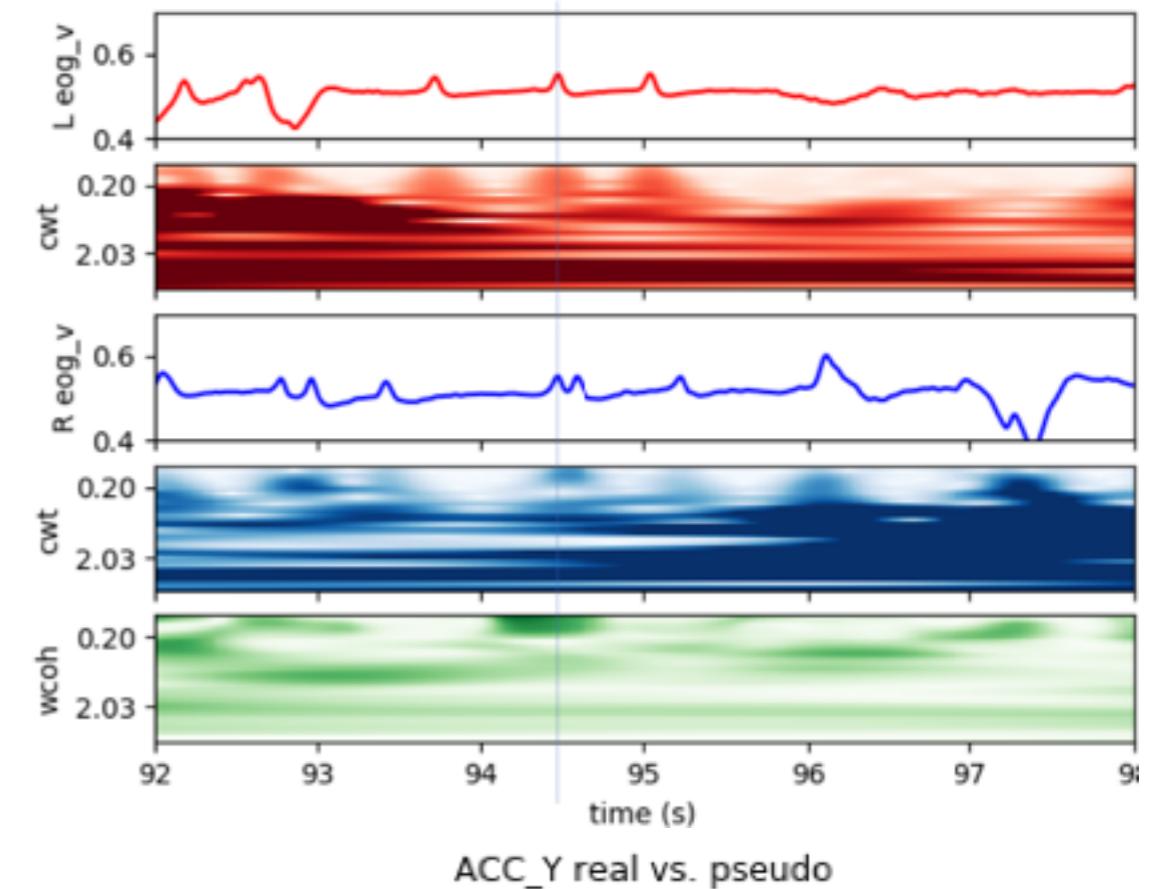
"Royalty Free Music from Bensound"

# Social Interactions

# UbiComp/ISWC: Blink as You Sync: Uncovering Eye and Nod Synchrony in Conversation using Wearable Sensing



EOG\_V real vs. pseudo

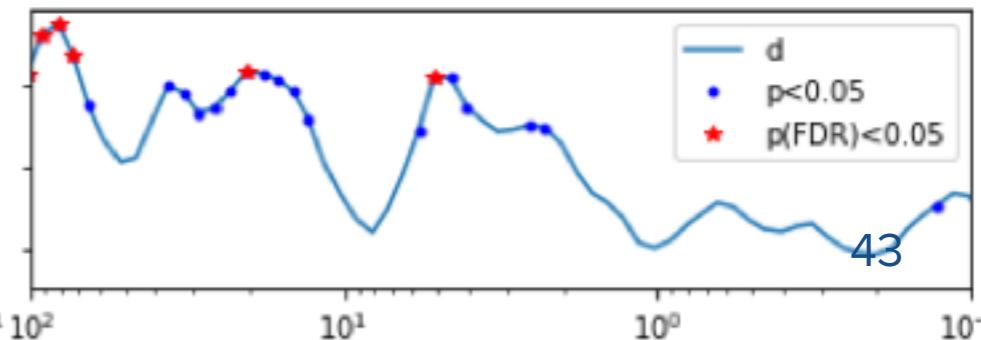
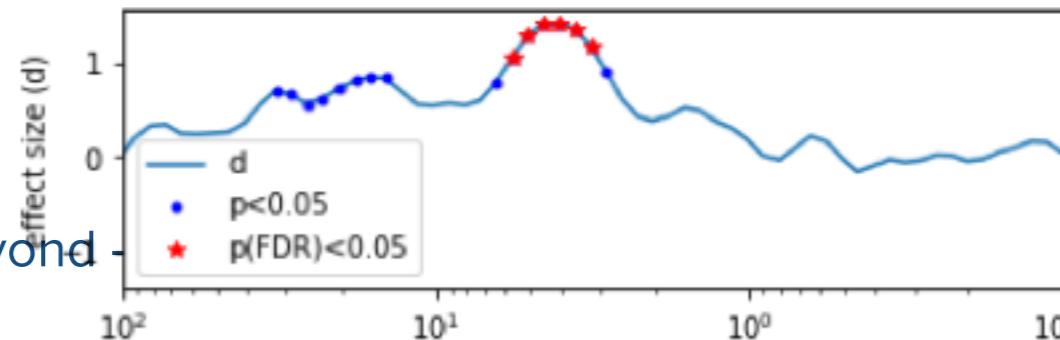
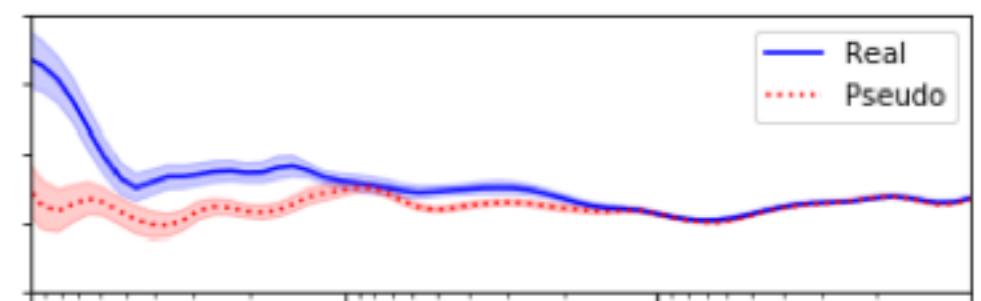
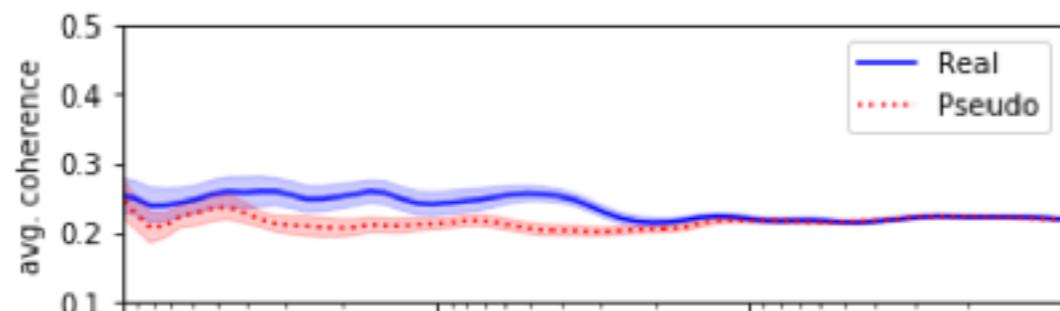


ACC\_Y real vs. pseudo

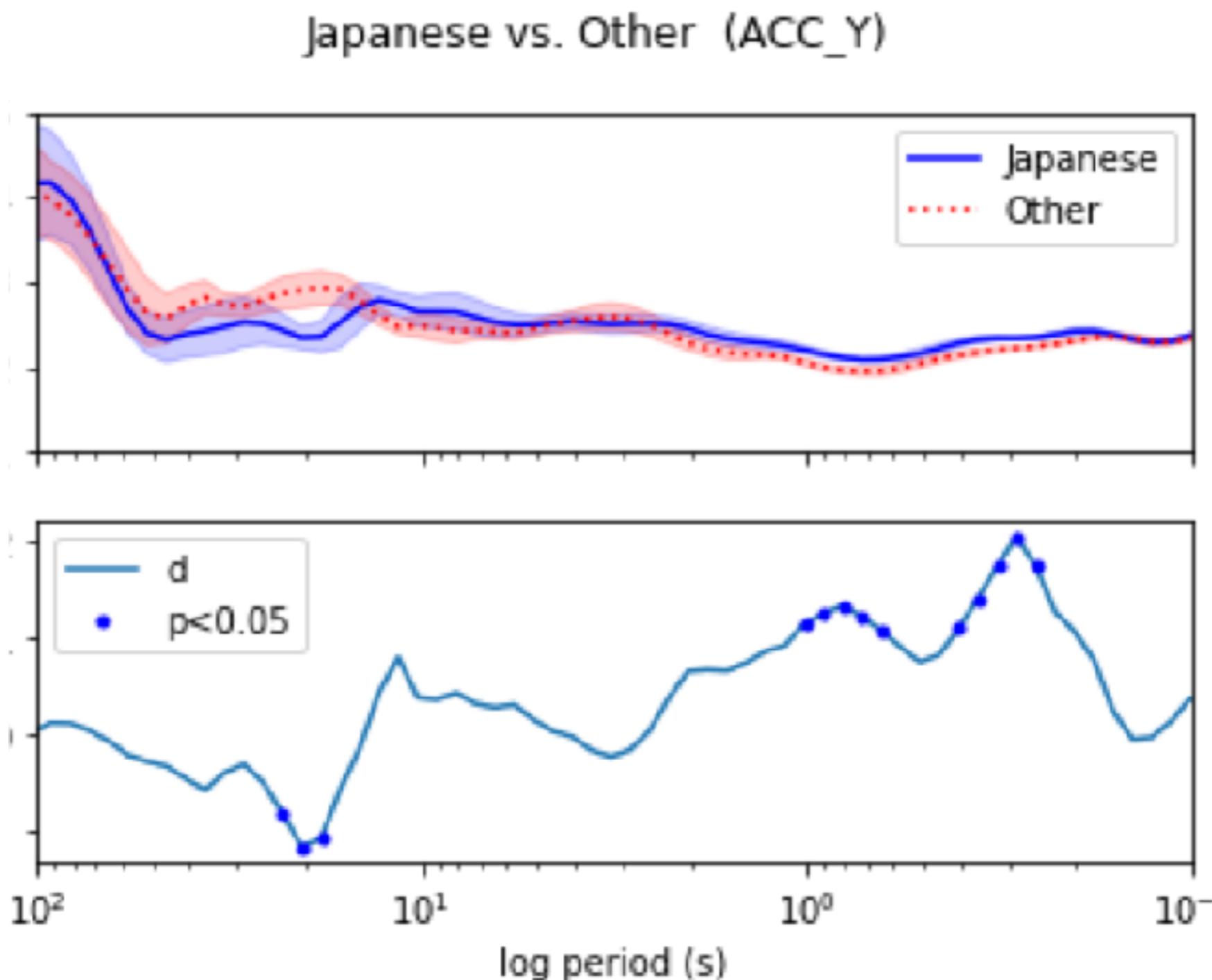
Gupta, Aman, et al. "Blink as you sync: uncovering eye and nod synchrony in conversation using wearable sensing." *Proceedings of the 23rd International Symposium on Wearable Computers*. ACM, 2019.

APA

Eyewear and Beyond

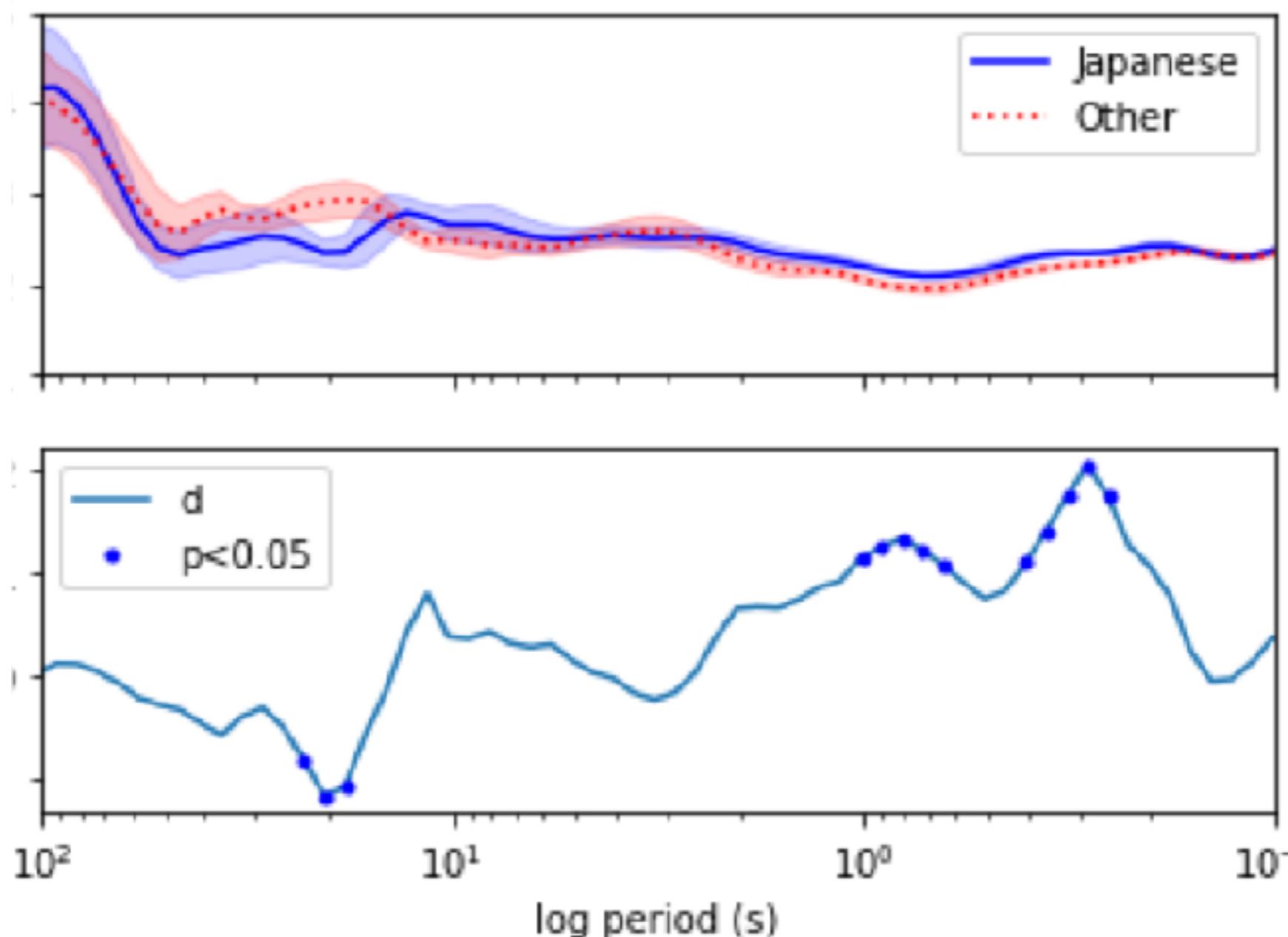


# Not published: Different Nodding Behavior for Japanese Speakers



# Different Nodding Behavior for Japanese Speakers

Japanese vs. Other (ACC\_Y)



# EYEWEAR COMPUTING IN THE WILD

LARGE SCALE DATASET RECORDING

10th Sept. 13:00 - 17:

We recorded over 75 UbiComp participants

in over 16 sessions



# **Augmented**

An Outlook on Future Work

# Towards Augmenting Human Senses

Example: Digital Camera Systems

higher framerate than the human eye

Perception of a broad spectrum – beyond the visible light etc.



picture by Patrick Breen CC BY-NC-ND 2.0

Can we utilise the recognition of cognitive states etc. to create new and amplified senses based on digital technologies that are intuitive to use?

# Simple Example —Squint to Zoom



Implementation on  
MEME, Desktop with  
eye tracker and  
HoloLens

Squint to Zoom: Augmenting our Sense of Vision with Zoom Caps. CHI Amplify Workshop 2017

# Augmenting our Senses

Special interest: Somatosensory System

How to use

pressure, temperature, texture, pain and body position

to integrate technology more with our senses.

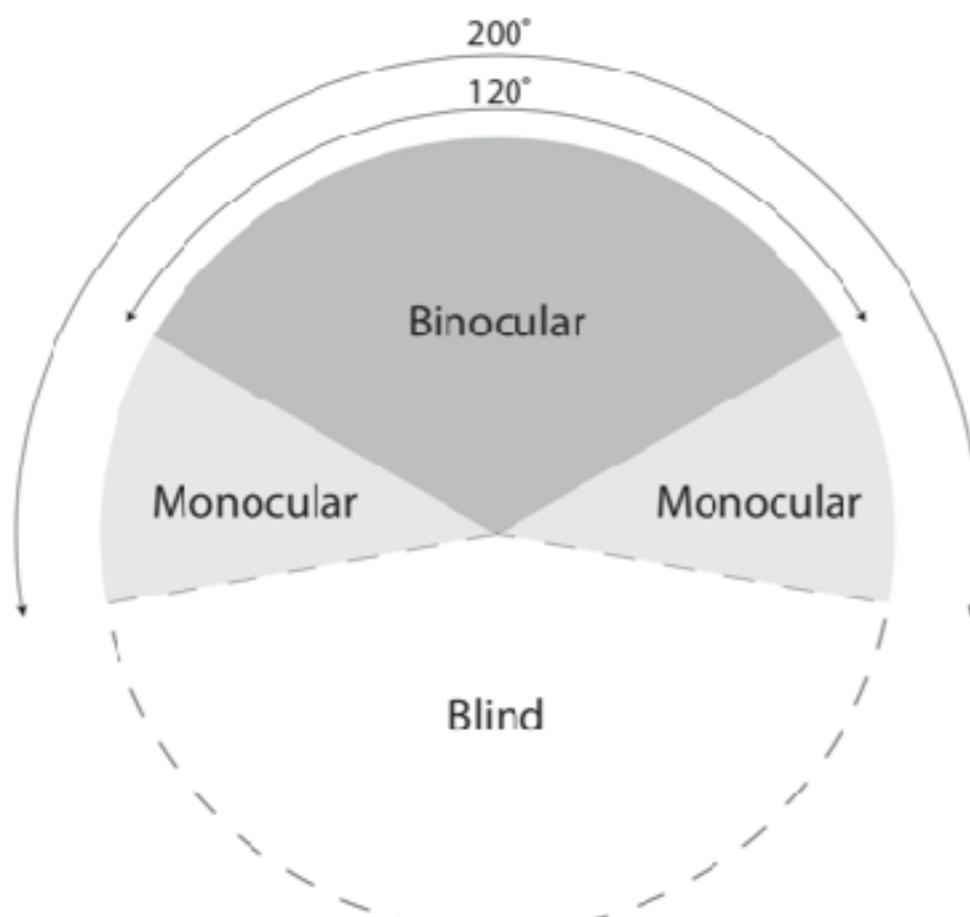
# Integrating tech better with our senses

Skill /Experience Transfer and Learning

Empathy / Agency / Ownership

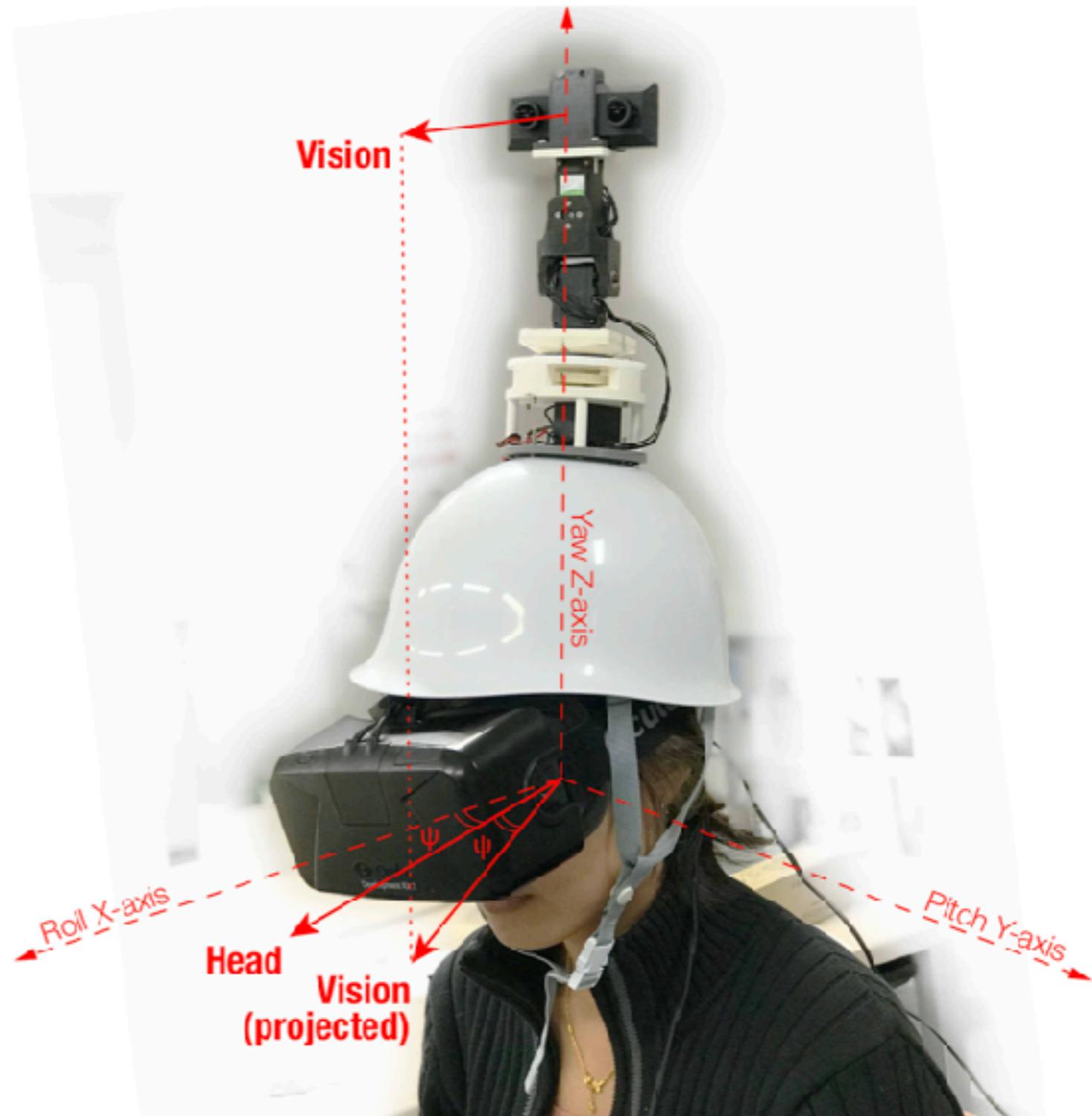
Editing our Body Schema

# How to edit our body schema?



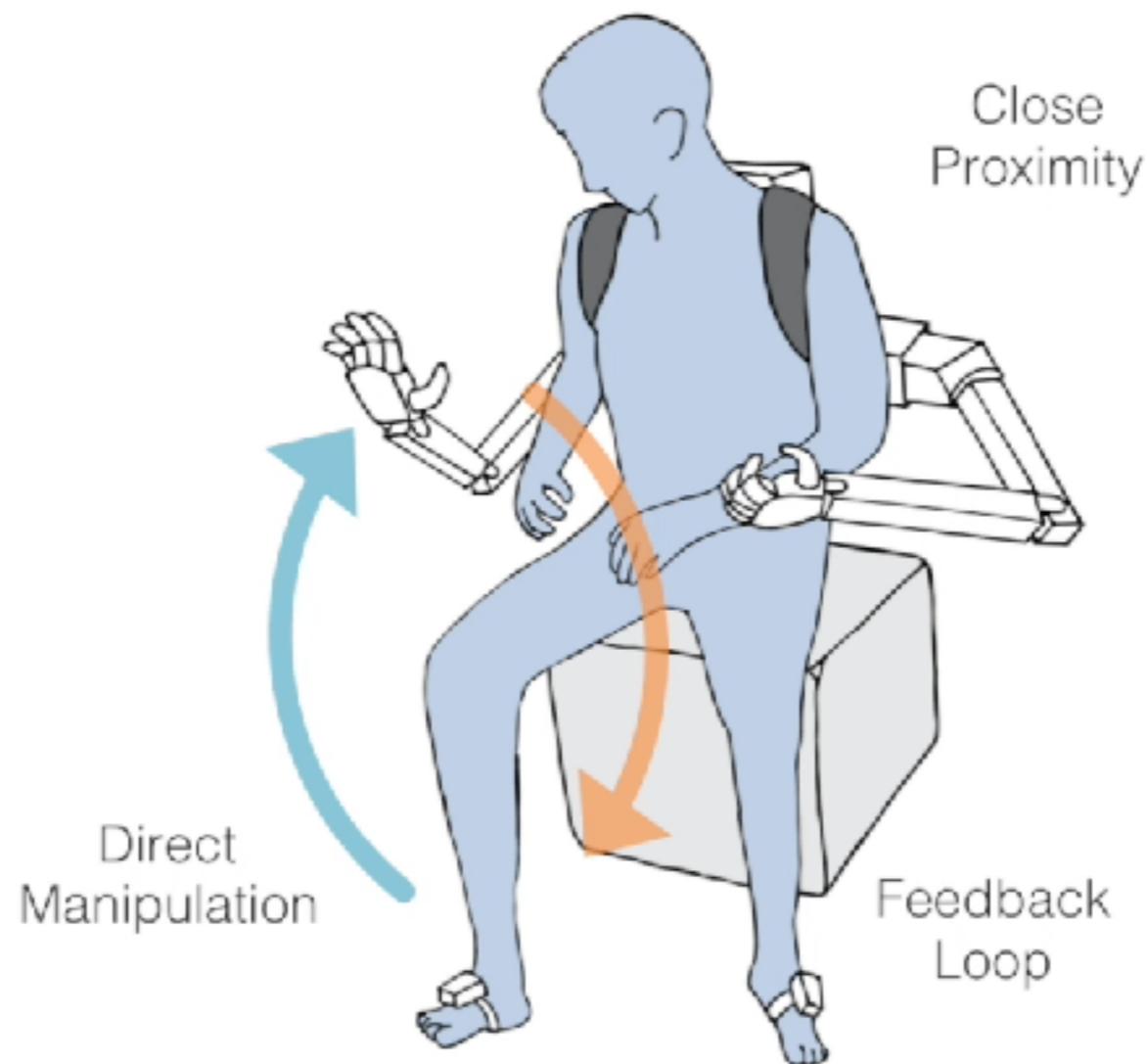
Unconstrained Neck: Omnidirectional Observation  
from an Extra Robotic Neck, Lichao Shen, Yamen  
Saraji, Kai Kunze, Kouta Minamizawa (Keio University)

Augmented Human 2018



# How to edit our body schema?

MHD Yamen Saraiji, Tomoya Sasaki, Kai Kunze, Kouta Minamizawa, and Masahiko Inami.  
2018. MetaArms: Body Remapping Using Feet-Controlled Artificial Arms. In Proceedings of  
the 31st Annual ACM Symposium on User Interface Software and Technology (UIST '18). ACM,  
New York, NY, USA, 65-74. DOI: <https://doi.org/10.1145/3242587.3242665>

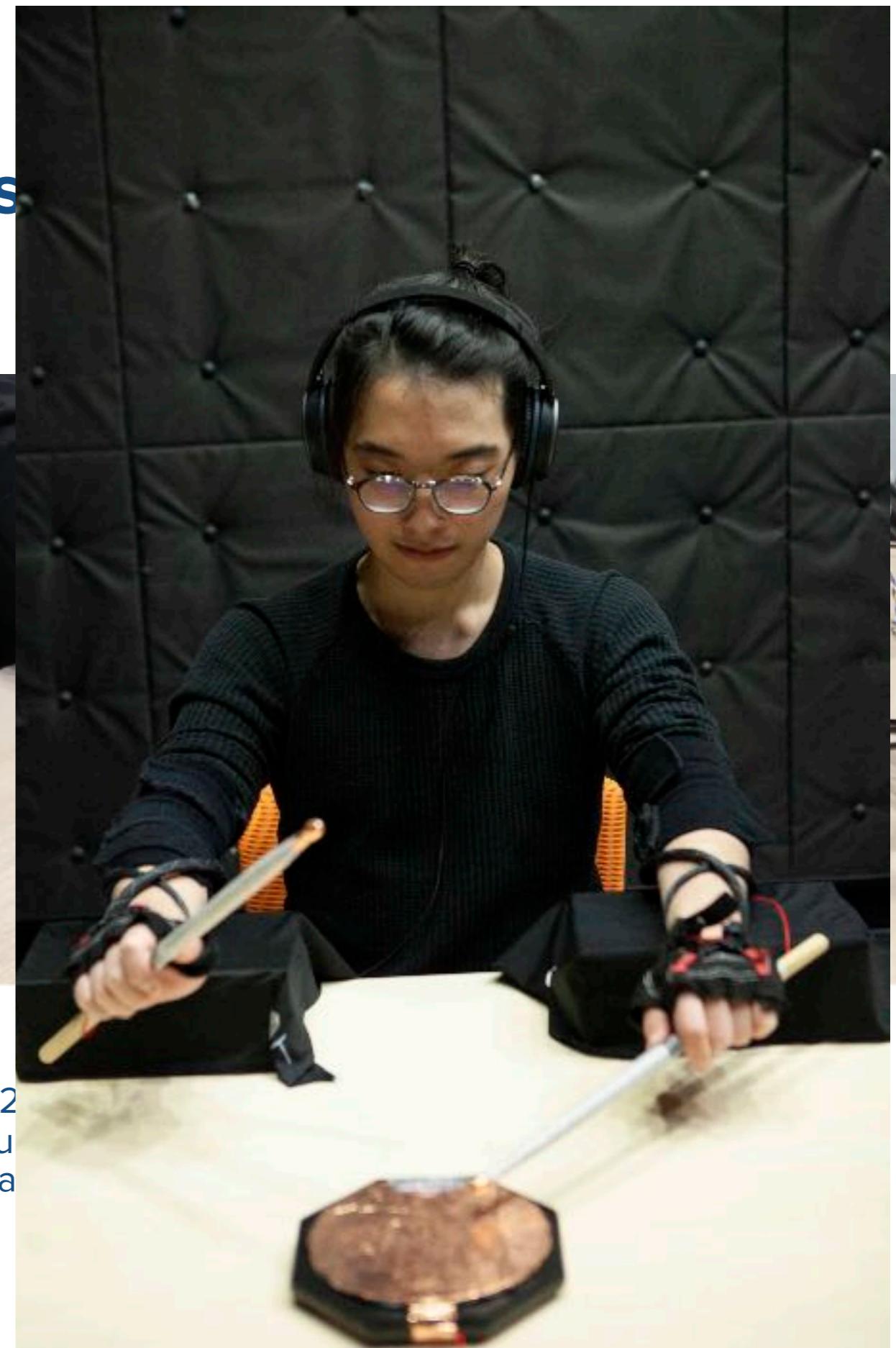
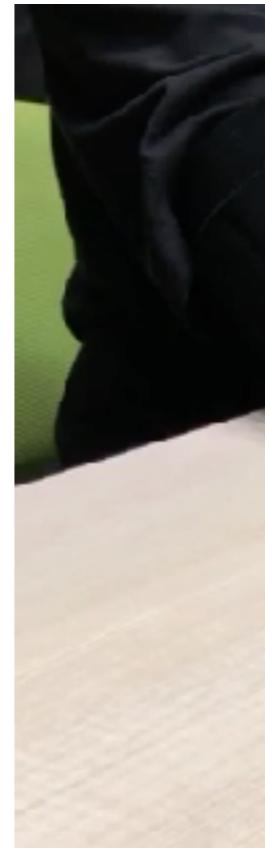
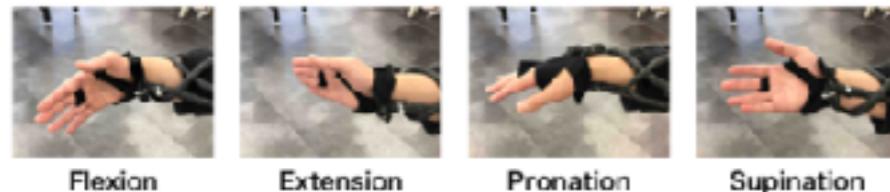
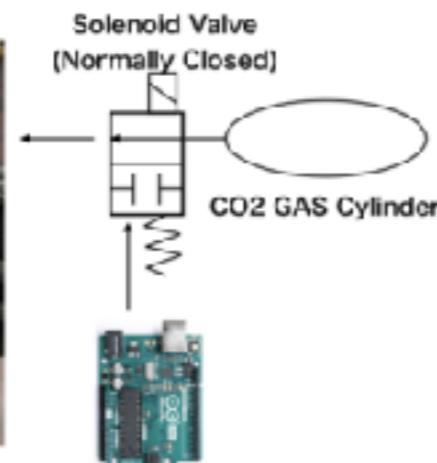


# Haptic Muscle Wire



Chernyshov, George, et al. "Shape memory alloy wire actuators for soft, wearable haptic devices." *Proceedings of the 2018 ACM International Symposium on Wearable Computers*. ACM, 2018.

# Can we program ourselves? Collaboration with Kurita Sens (Chicago University)

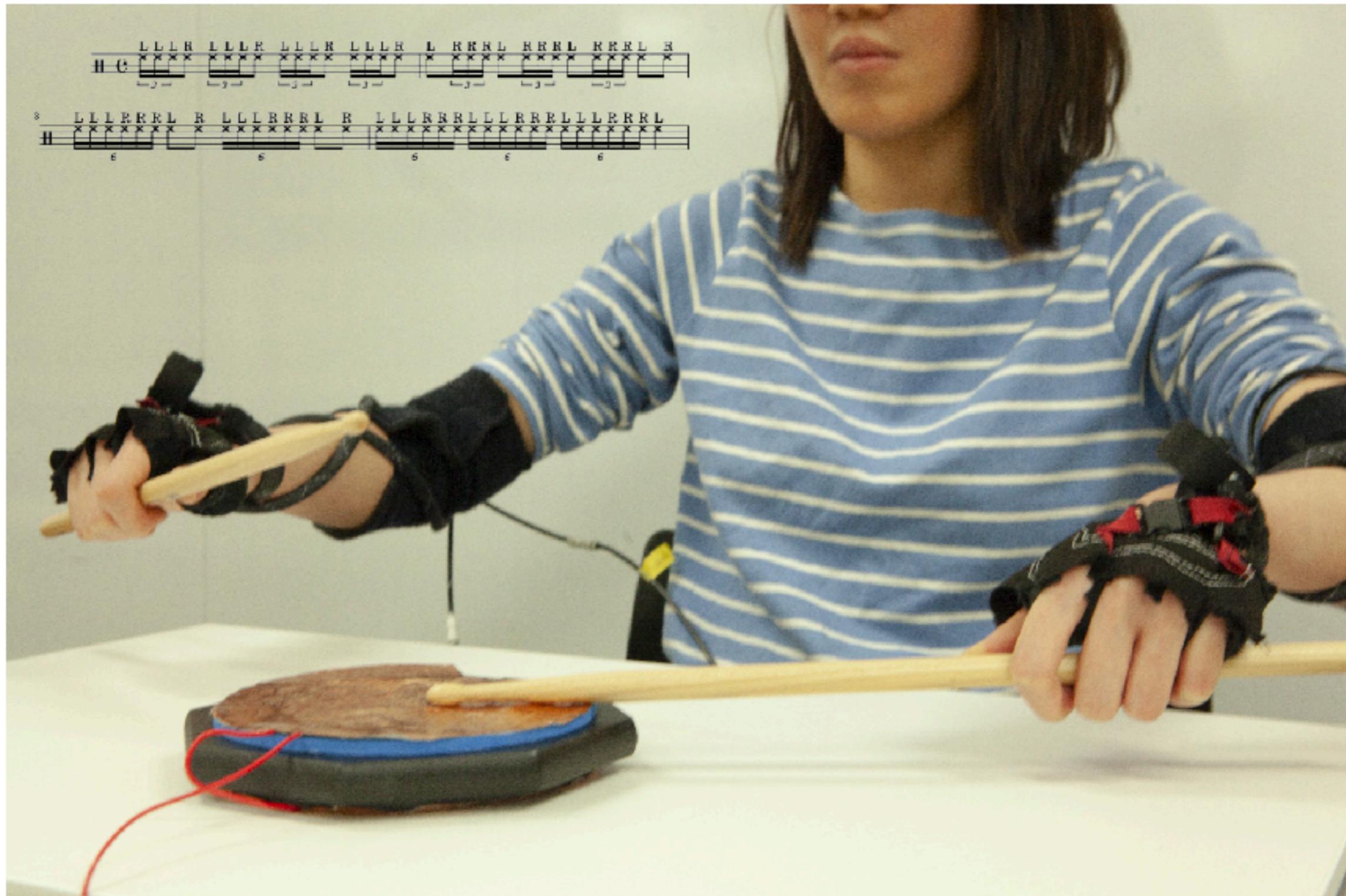


Takashi Goto, Swagata Das, Yuichi Kurita, and Kai Kunze. 2018.  
Guidance: an Intuitive Device based on Pneumatic Gel Muscles.  
31st Annual ACM Symposium on User Interface Software and Technology Adjunct Proceedings (UIST '18 Adjunct).

# artificial muscles



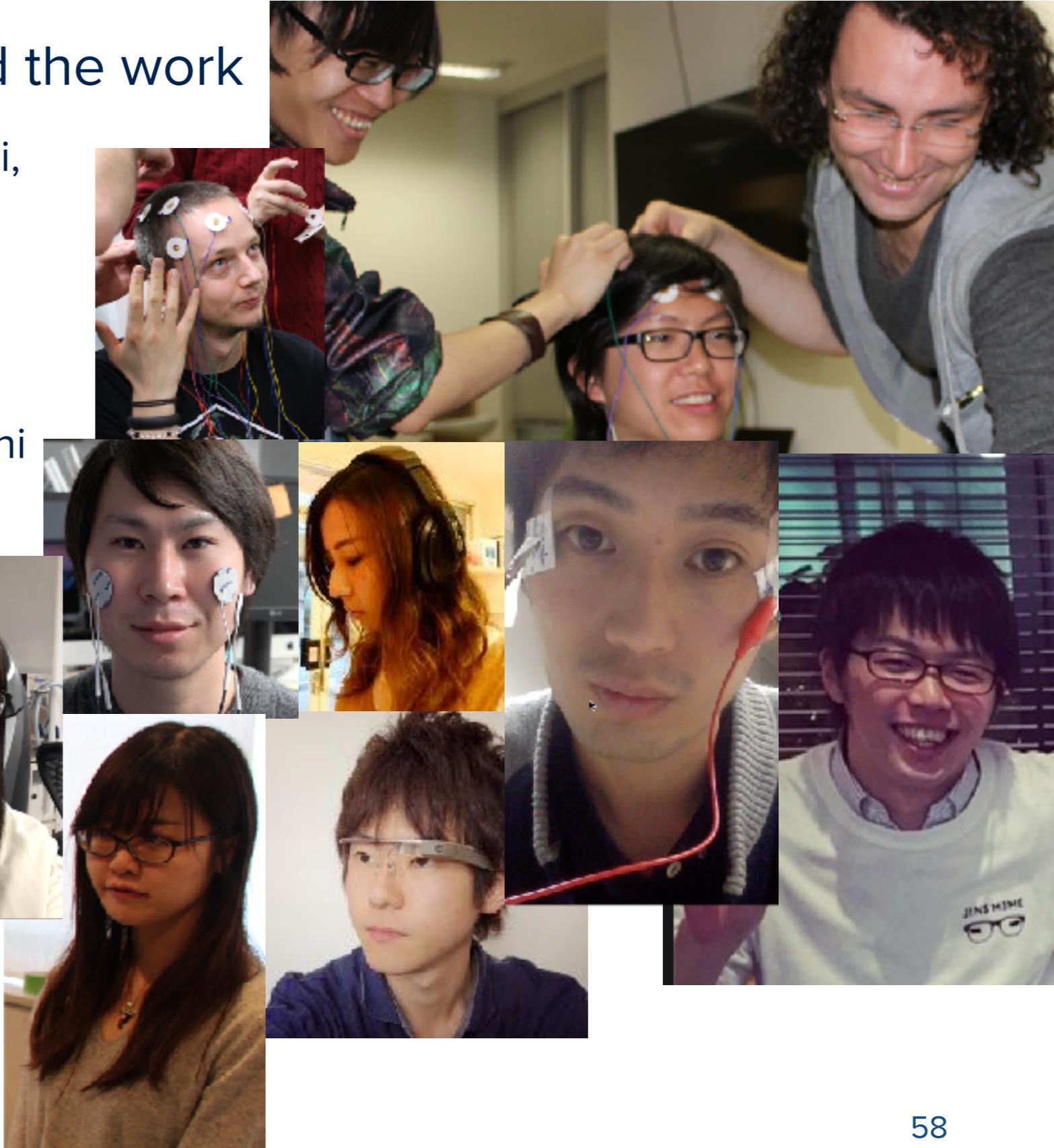
# Improves Skill Acquisition in Drumming



# Special Thanks to ...

to the people who actually did the work

George Chernyshov      Masai Katsutoshi,  
Pai Yun Suen,                Takashi Goto,  
Lai Yen-Chin,                Kouta  
Yuan Ling Feng,             Minamizawa,  
Junichi Shimizu,            Masashi Nakatani  
Takuro Nakao,  
Haruna Fushimi,  
Cedric Carême,  
Benjamin Tag,  
Vilhelmina Sokol  
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# Questions, Remarks, Violent Dissent?

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