

# **W!NCE: Unobtrusive Sensing of Upper Facial Action Units with EOG-based Eyewear**



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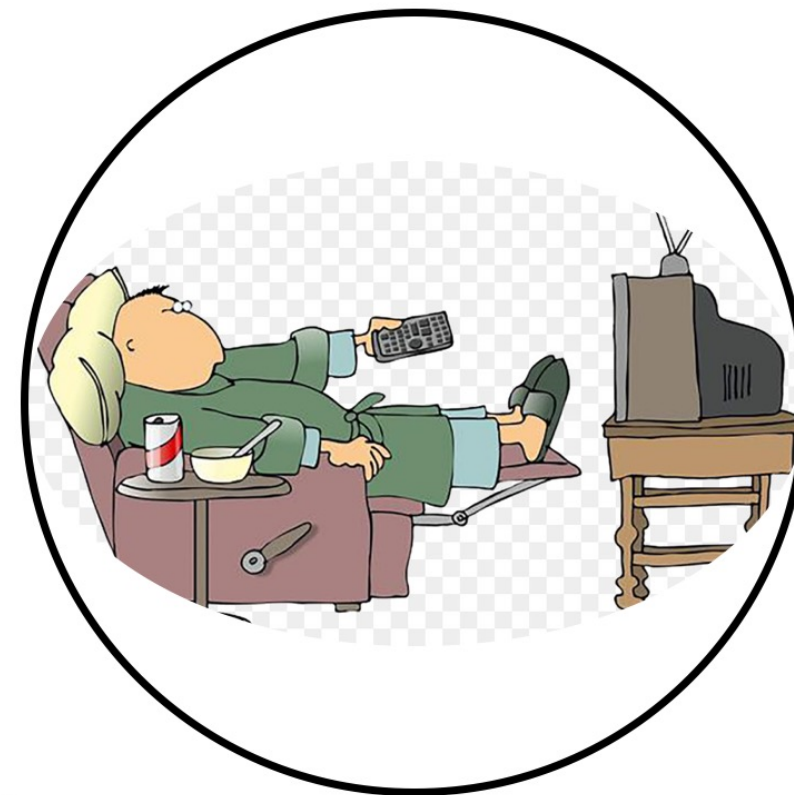
UMassAmherst

# Why Measure Facial Expressions?

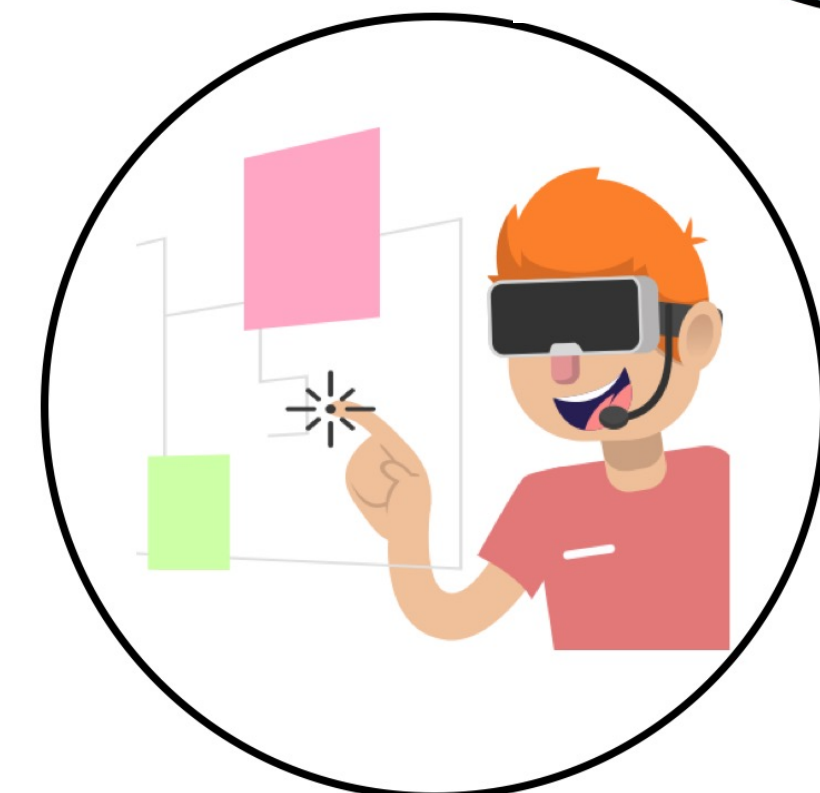
## Pain Monitoring



## Entertainment

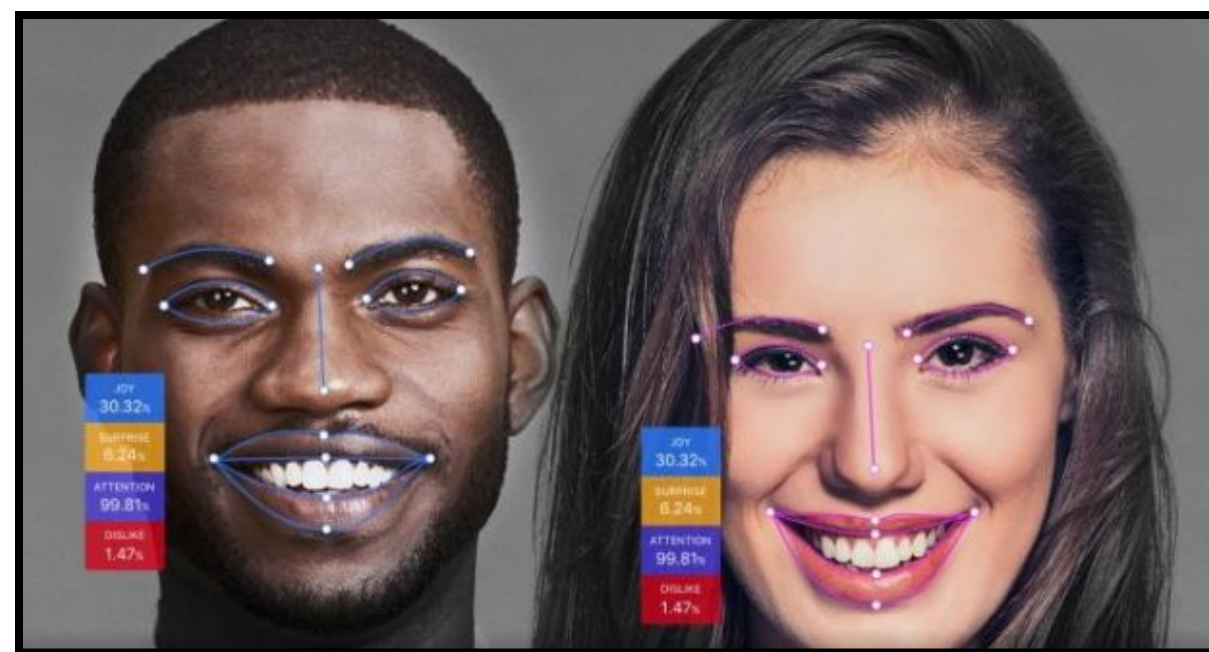
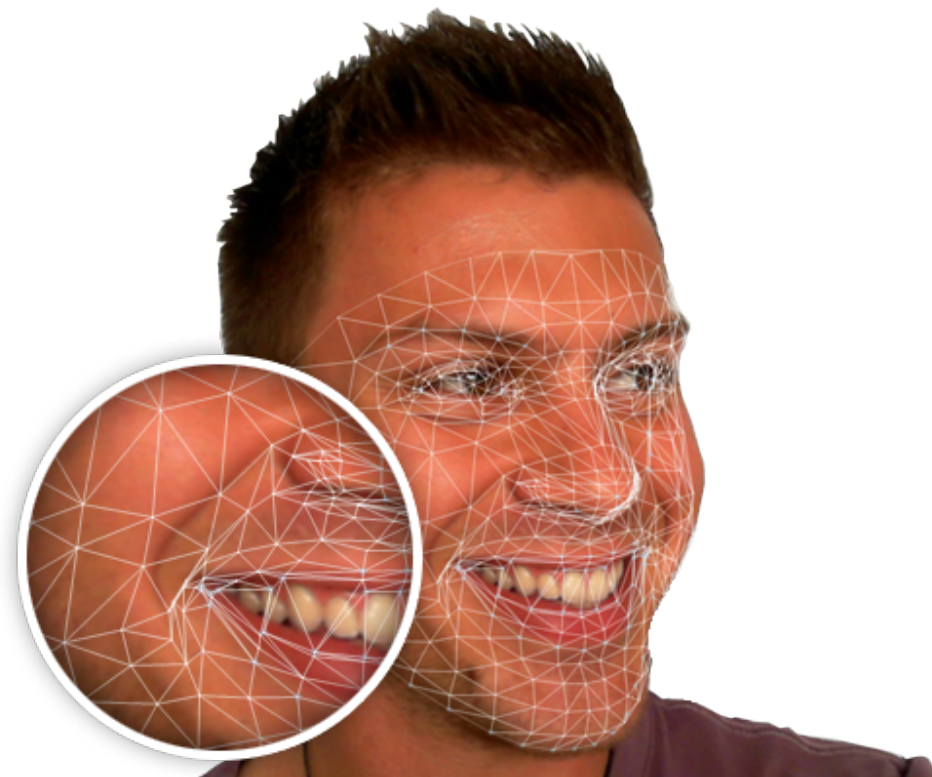


## AR/VR Systems

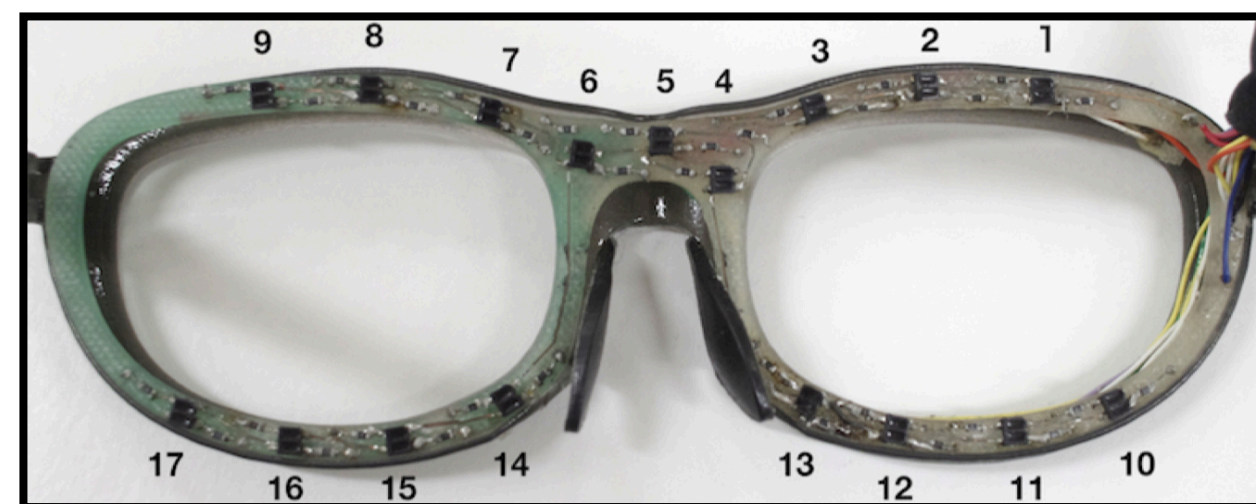
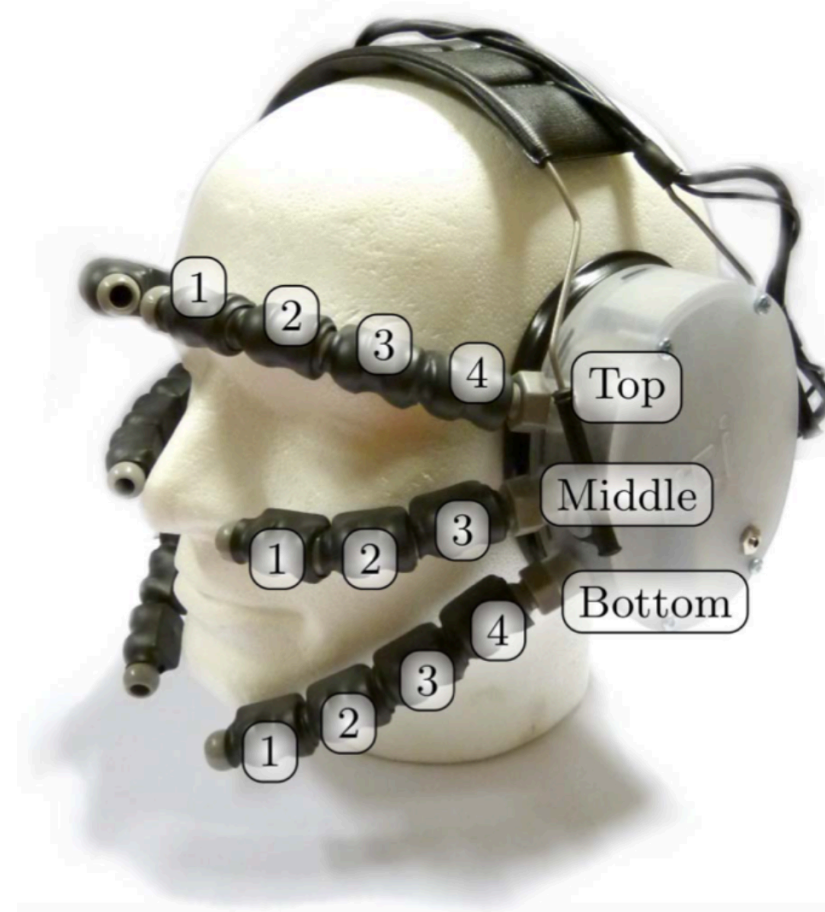


# How Can We Measure Facial Expressions?

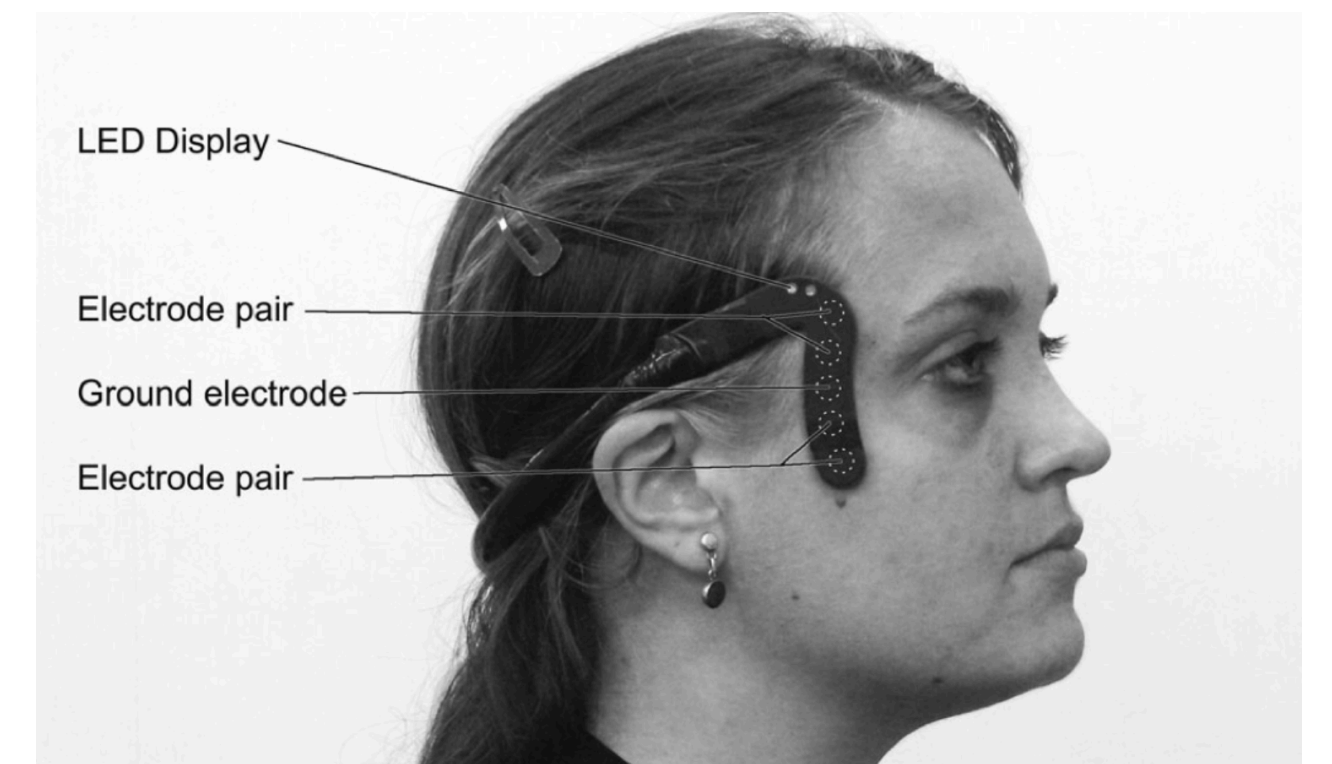
## Vision-based Systems



## Proximity Sensors



## Electromyography (EMG)



# Ideal Facial Expressions Monitoring System Should Be ...

Wearable **W!NCE**

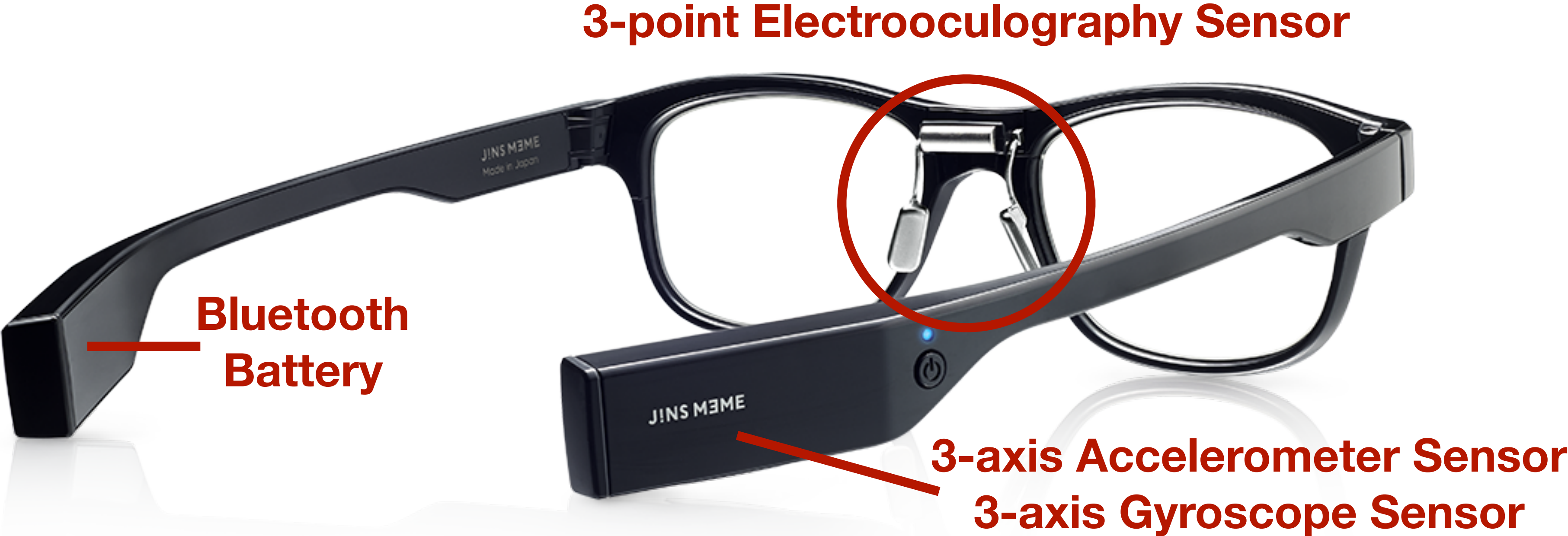
Unobtrusive

Robust

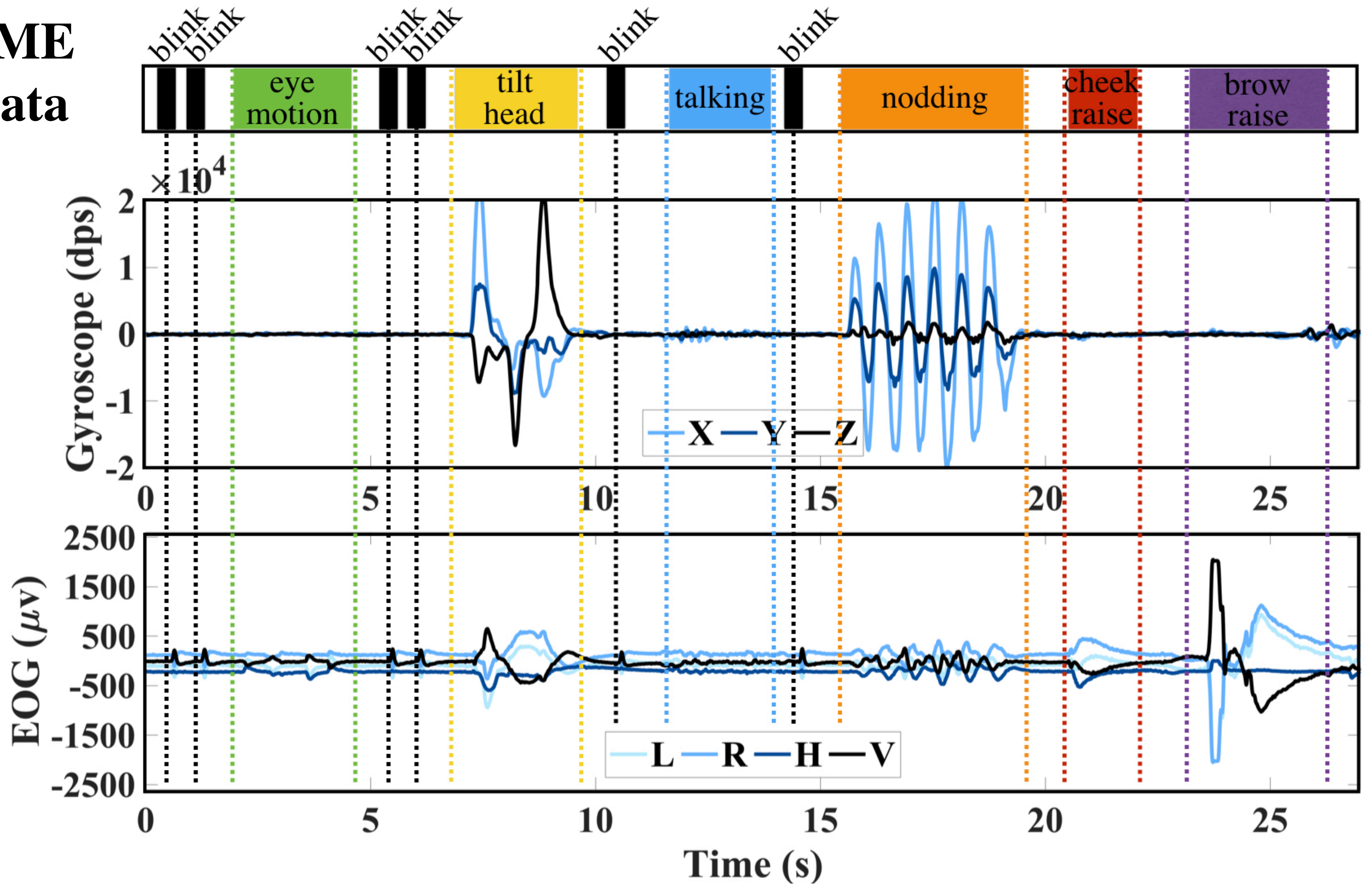
Privacy-sensitive



# J!NS MEME Platform

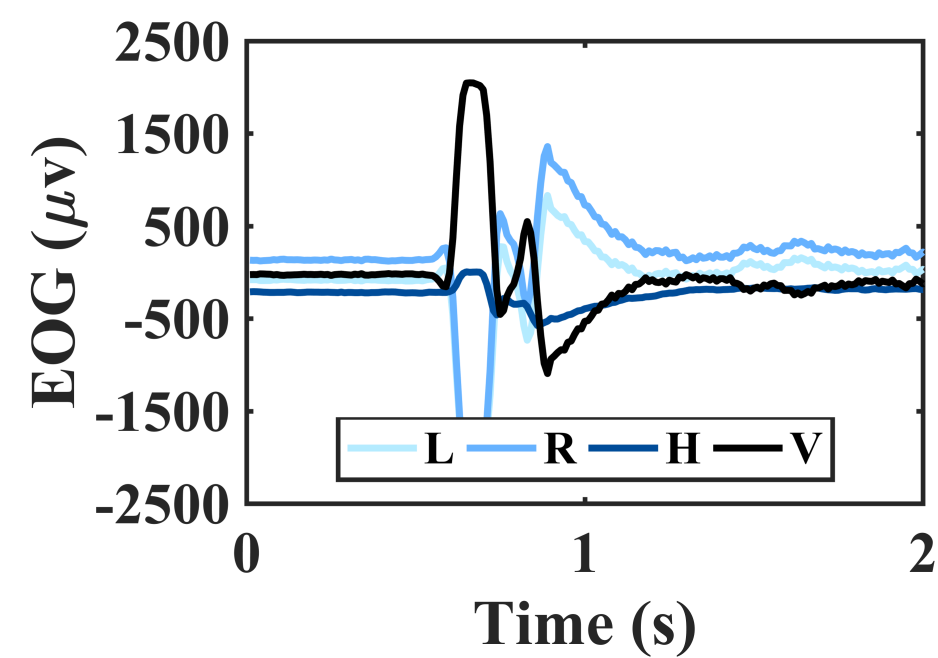


# J!NS MEME Sample Data

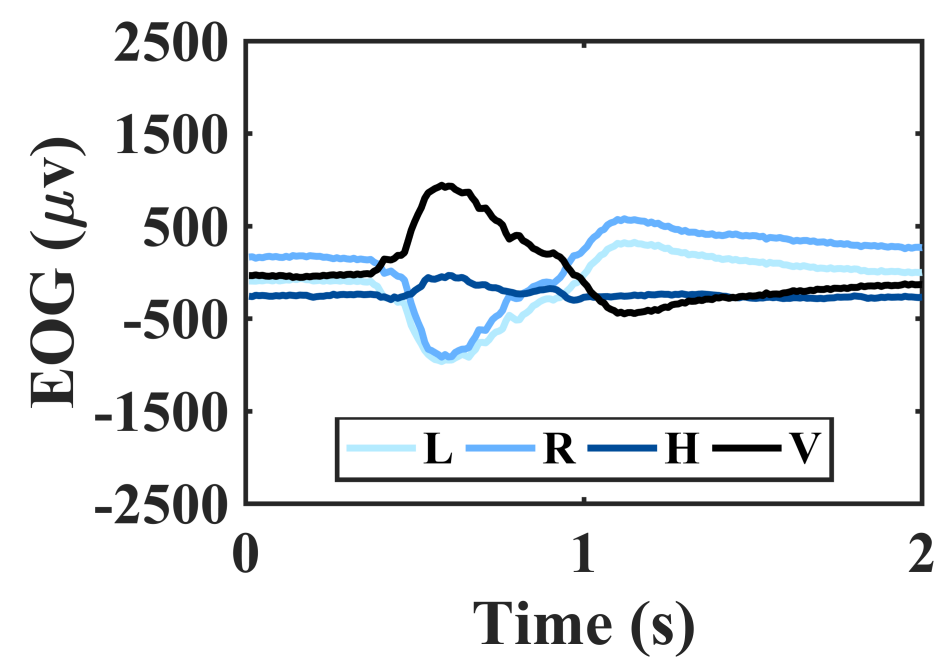
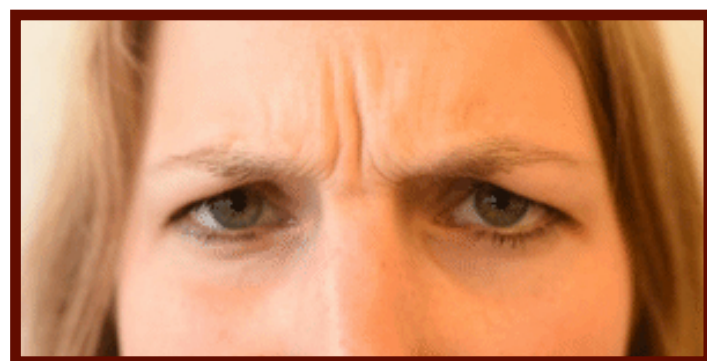


# W!NCE's Scope

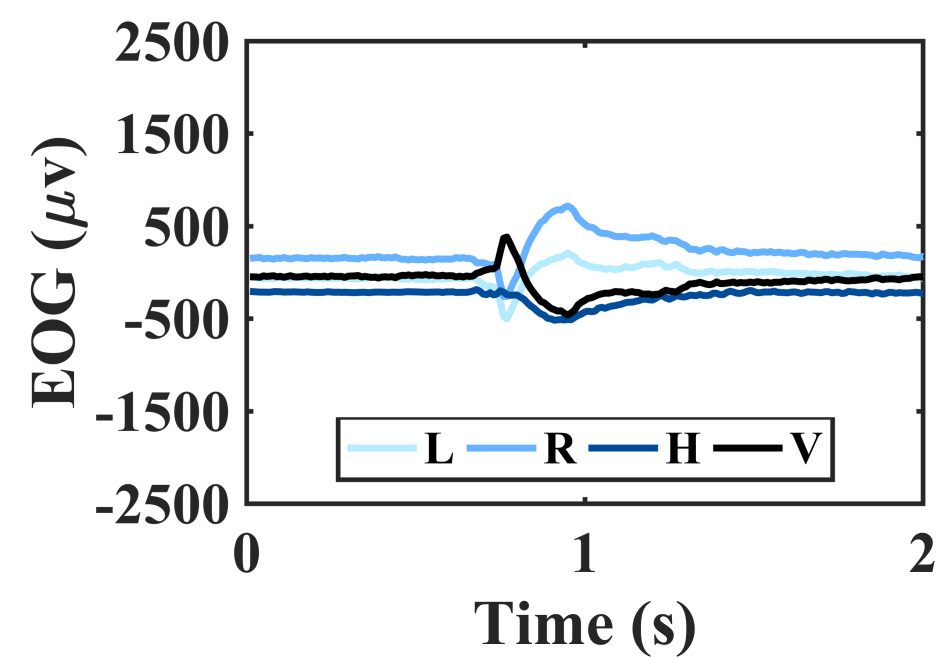
**Brow raiser (AU01)**



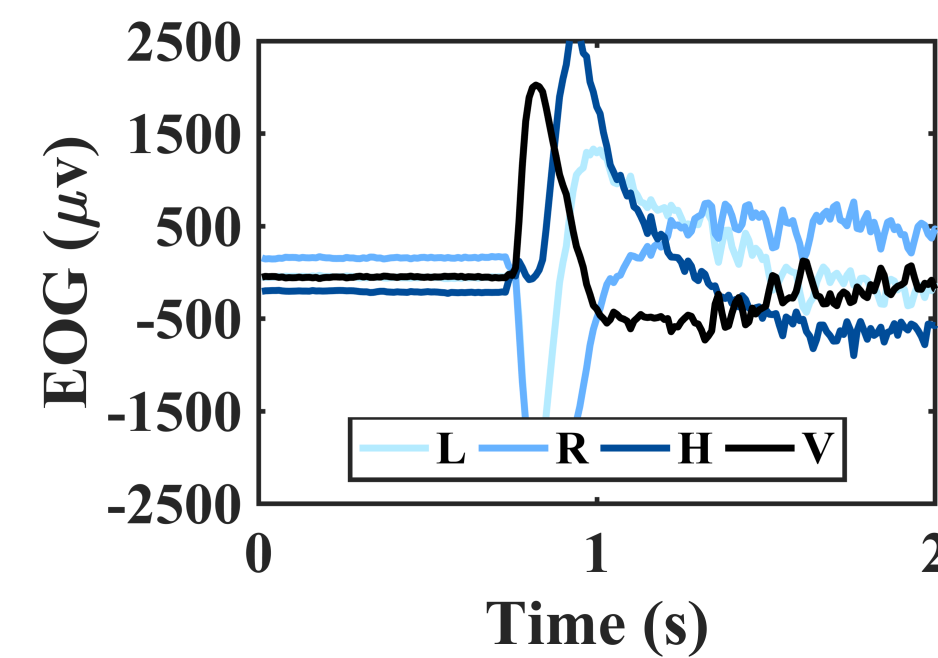
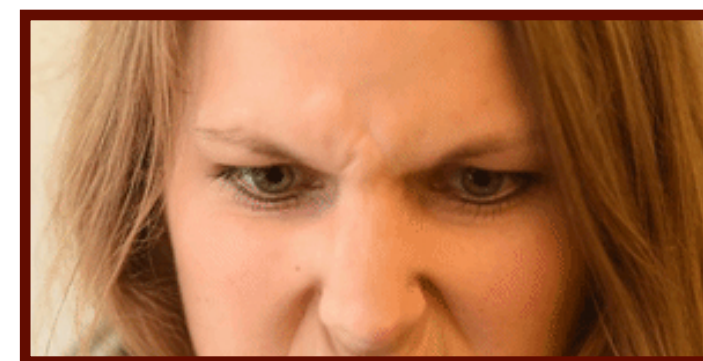
**Brow lower (AU04)**



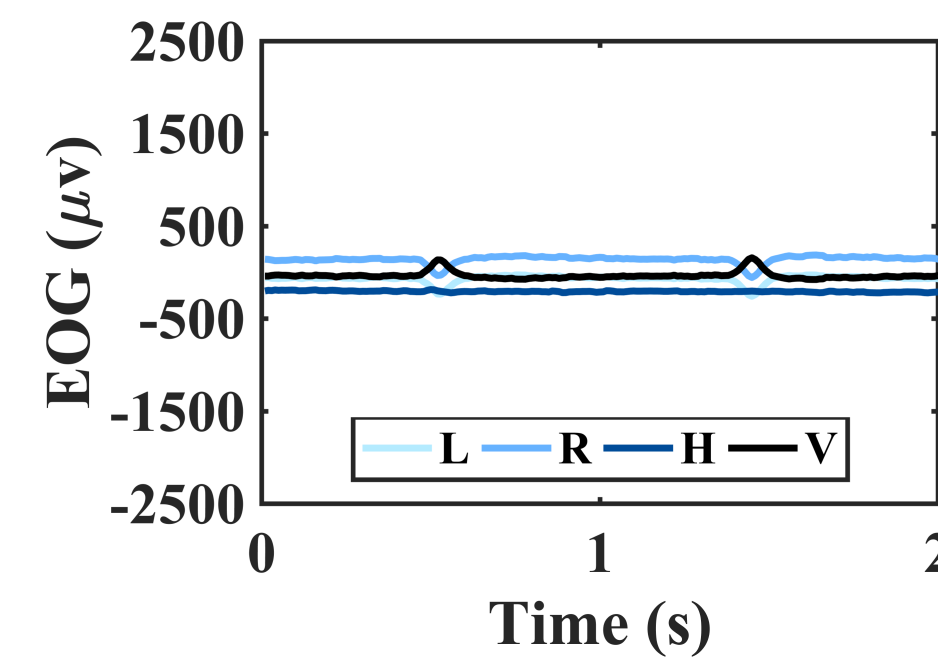
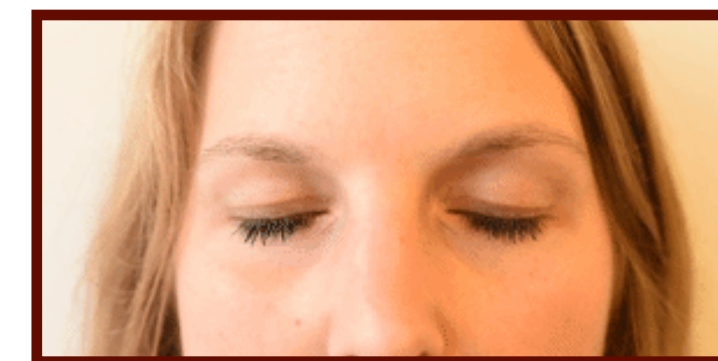
**Cheek raiser (AU06)**



**Nose wrinkles (AU09)**



**Blink (AU45)**

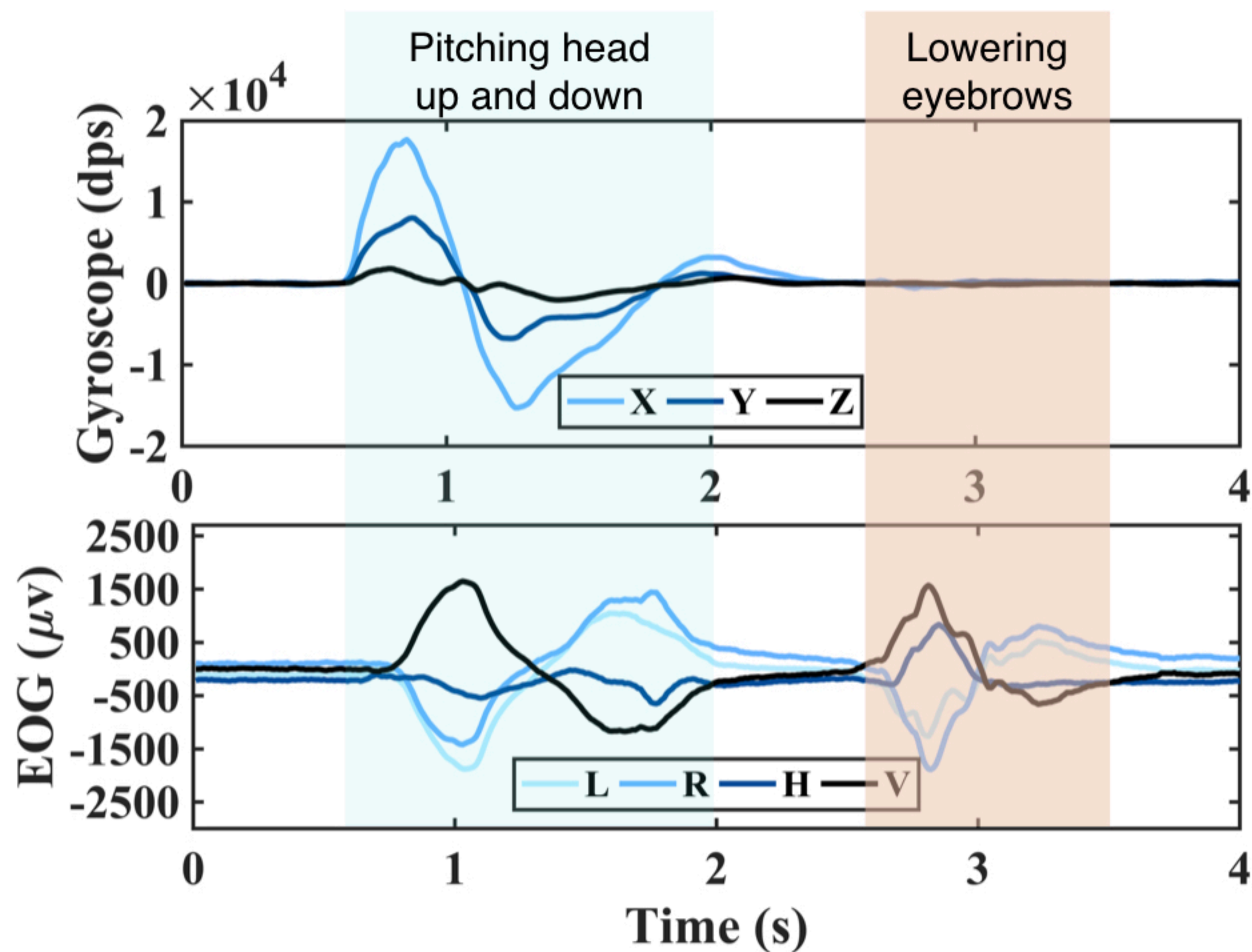


# What are the Challenges in Motion Artifact Removal?

Facial gestures are not periodic signals.

Motion artifact and facial action units have similar frequency content.

The signal strength of motion artifact is comparable with facial action units.





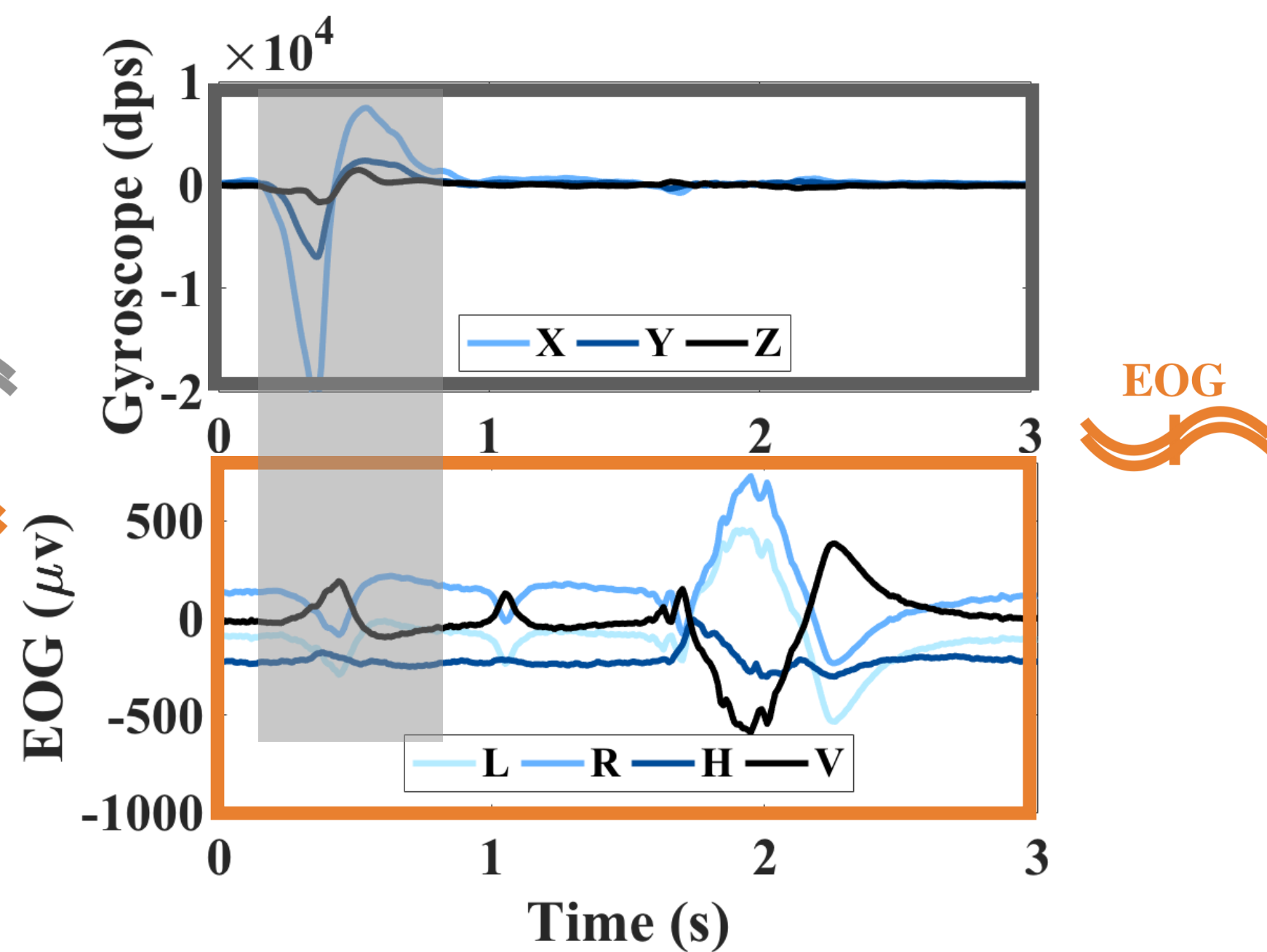
# W!NCE's Computational Pipeline

Data Collection and Preprocessing

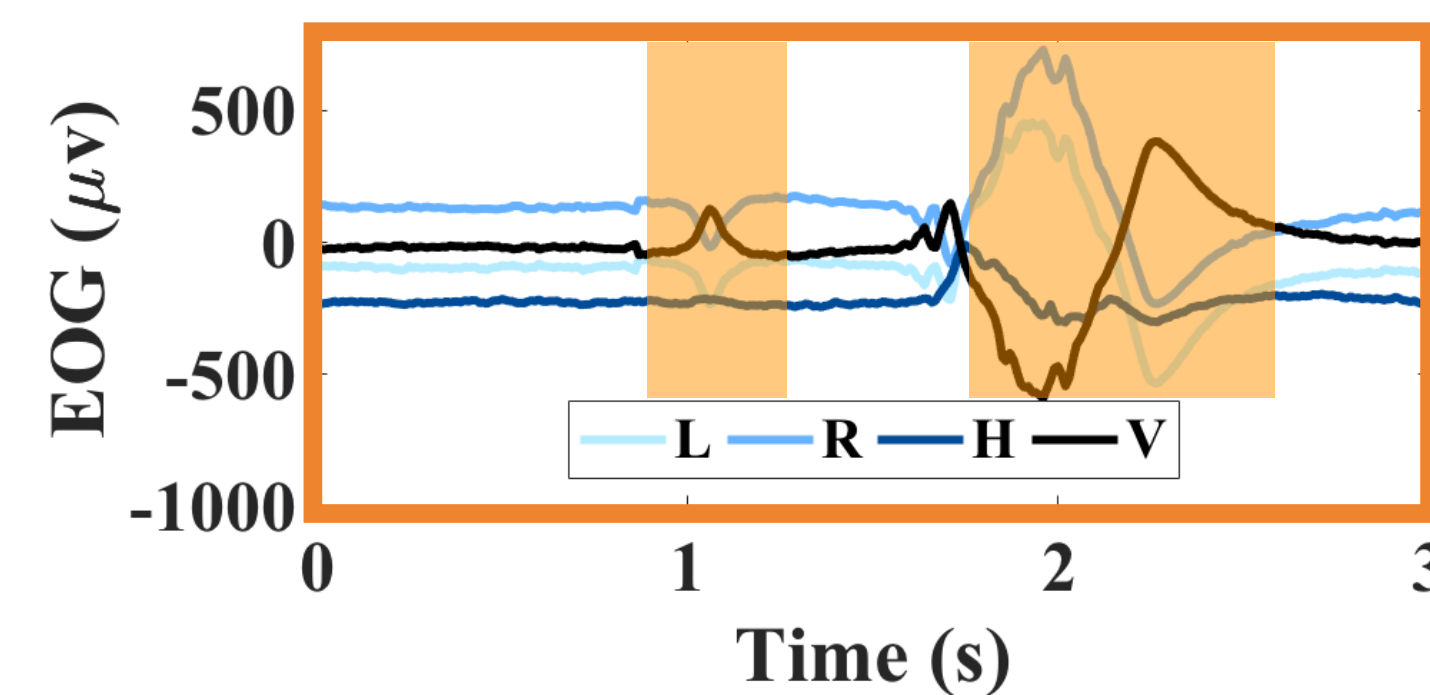


IMU  
EOG

Motion Artifact Removal

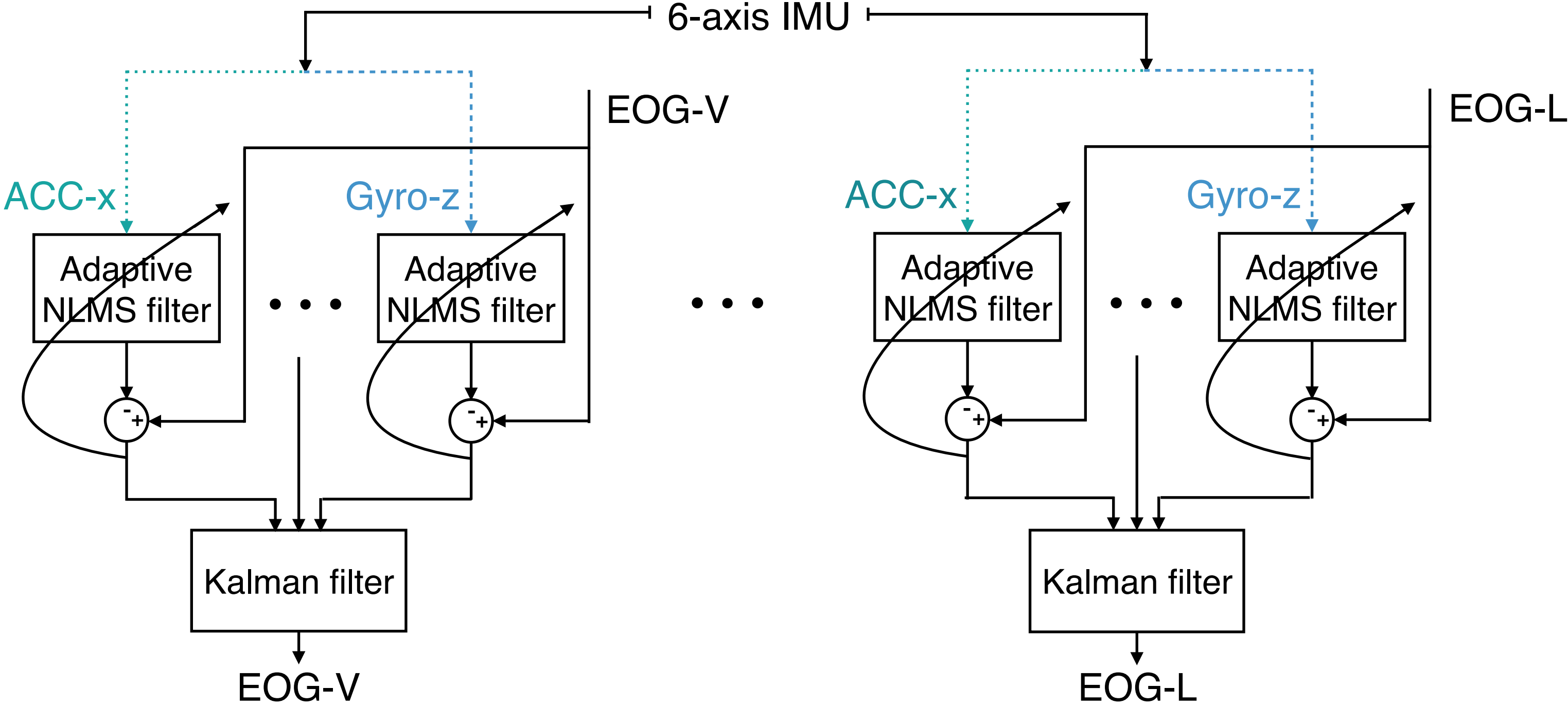


Upper Facial Action Units and Blinks Detection

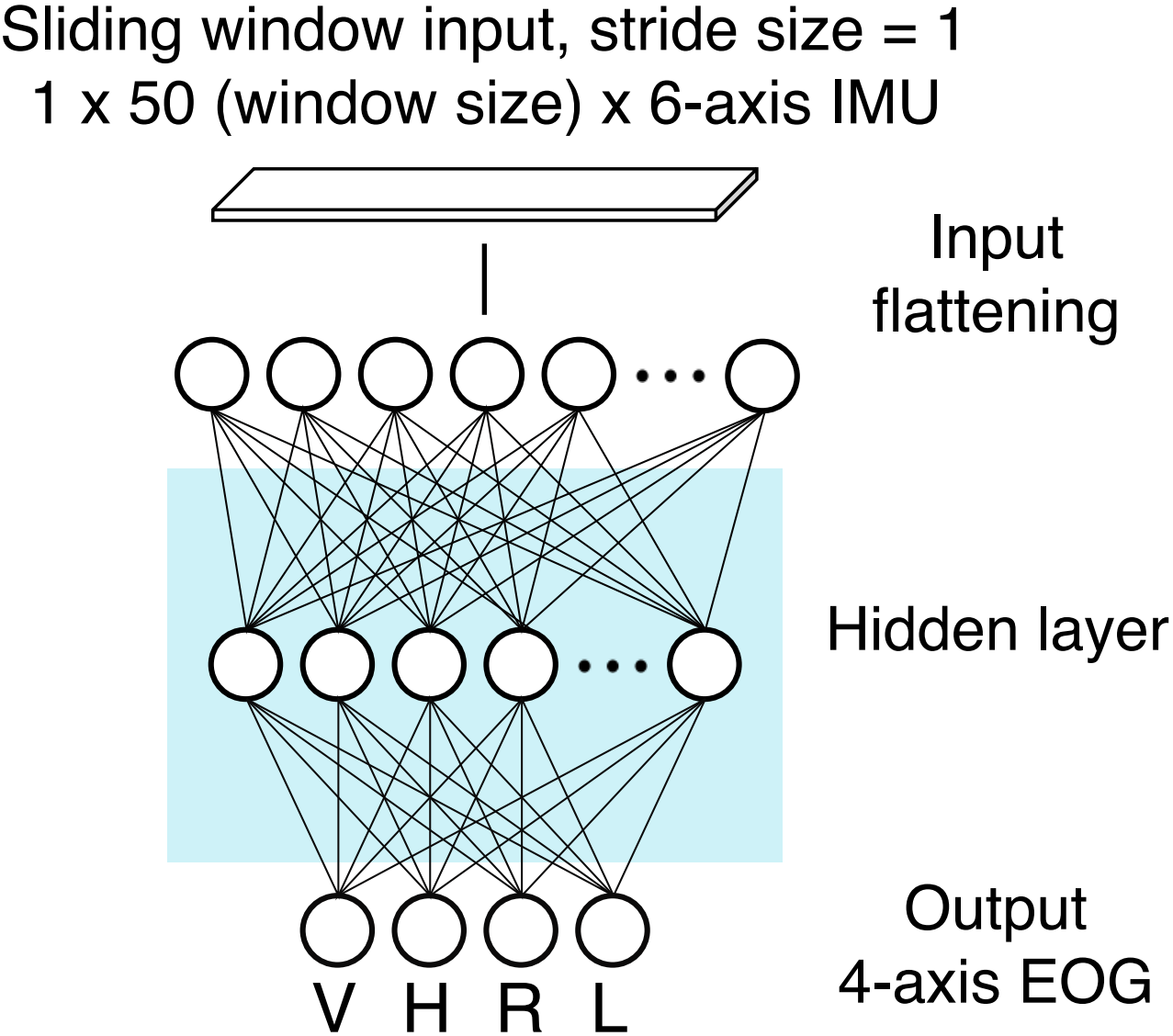


# Stage 1 - Motion Artifact Removal

## Multi-stage Adaptive NLMS Filter

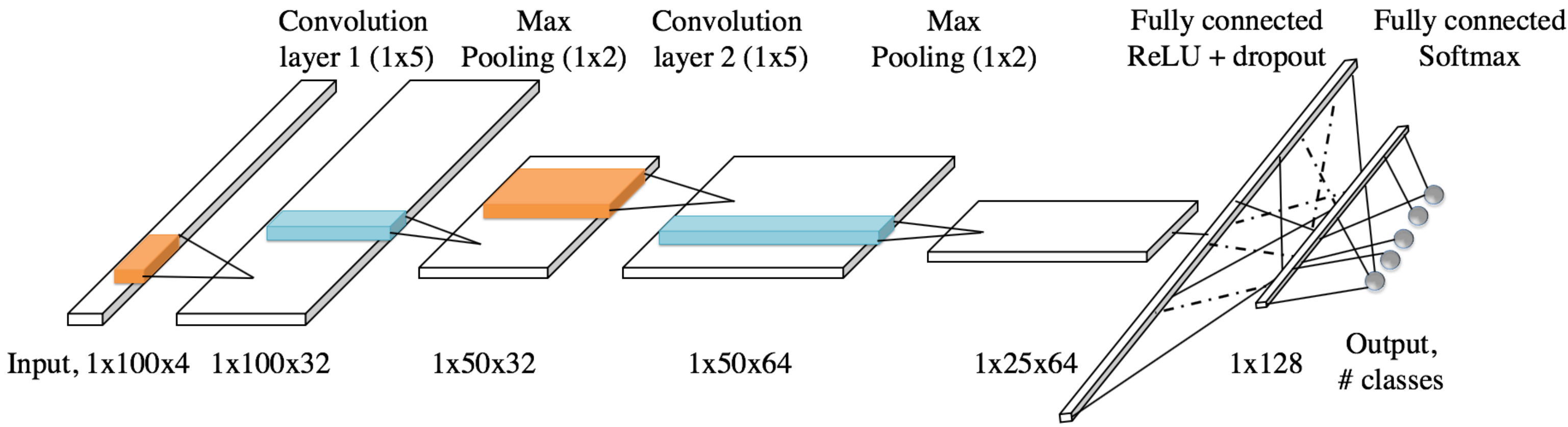


## Neural Network-based Filter



# Stage 2 - Facial Action Units Detection

## CNN Architecture



## CNN Model Specifications

<b>Input size</b>	height = 1 (time series data) width = window size dimension = 4-axis EOG
<b>Output size</b>	number of classes = 5
<b>Convolution filter 1 size</b>	1 x 5 x 32
<b>Convolution filter 2 size</b>	1 x 5 x 64
<b>Fully connected layer</b>	128
<b>Learning rate</b>	0.0001
<b>Dropout probability</b>	0.5

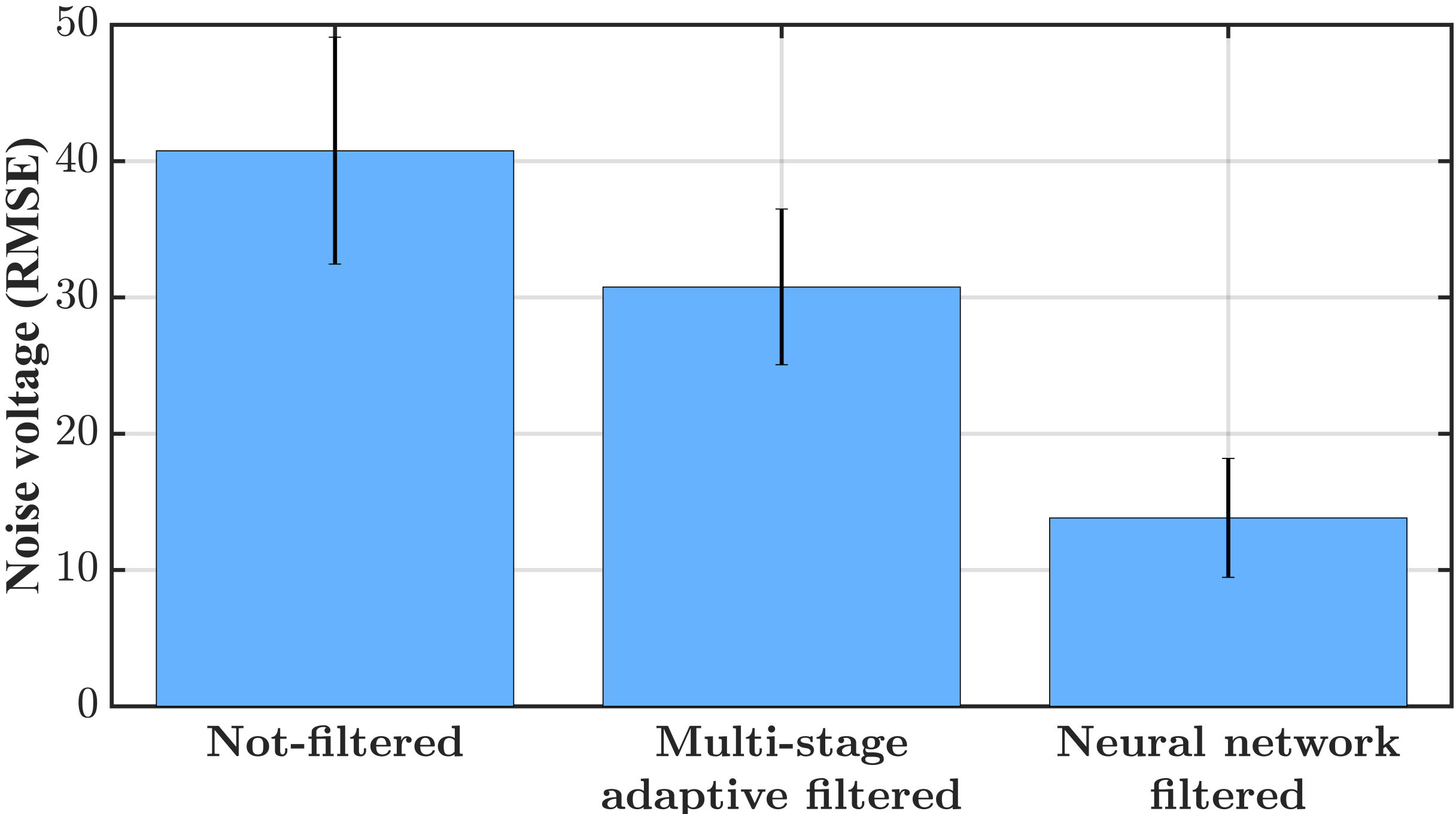
# Evaluation

- ◆ Motion Artifact Removal Stage Evaluation
- ◆ Overall Performance of W!NCE for Facial Action Detection
- ◆ Case Study: Pain Monitoring
- ◆ W!NCE Benchmarks (please refer to the paper)

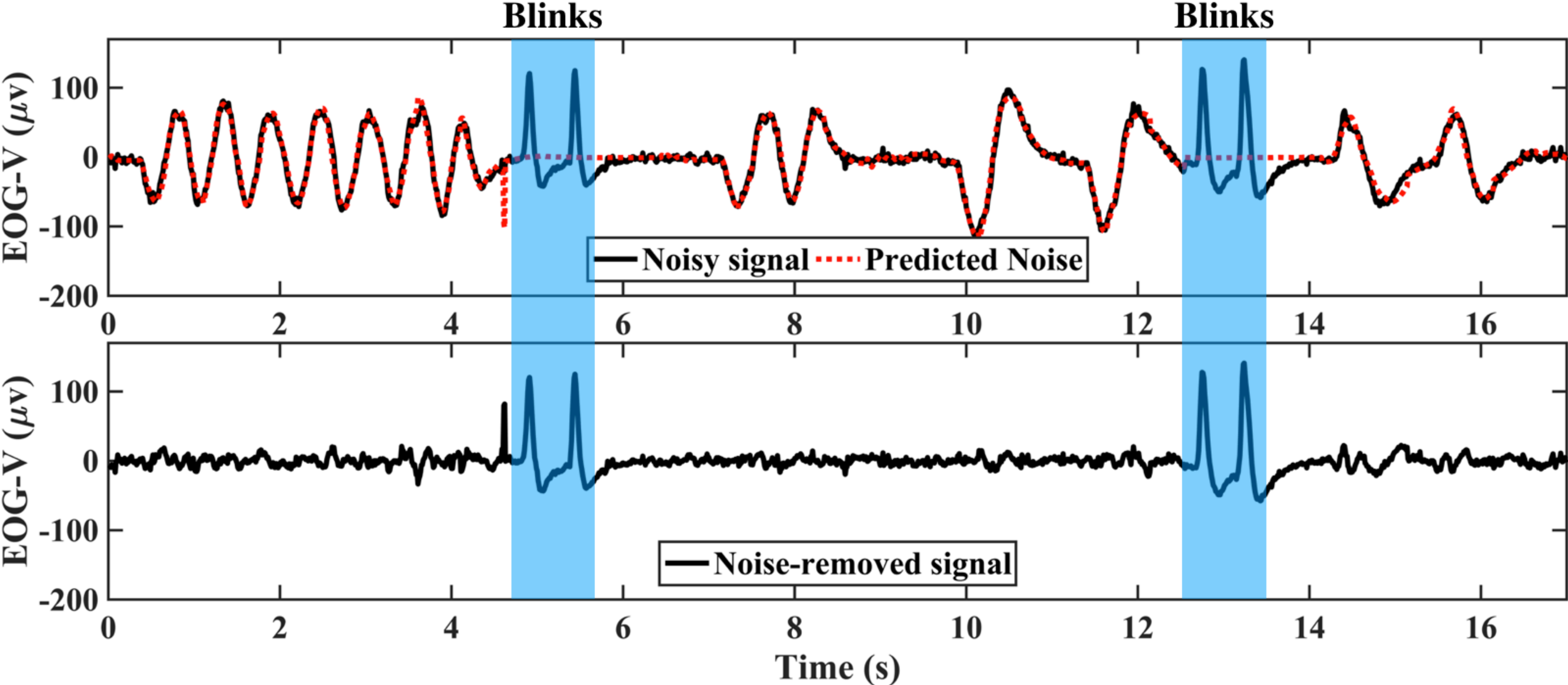
# Comparison of Motion Artifact Removal Methods

Dataset:

- 5 participants
- 3 different head movements — pitch, roll, yaw, and walking on a treadmill (~ 50 min data for each user)



# Example of Motion Artifact Removal with Neural Network-based Filter



# Evaluation of Facial Action Units Detection

## Dataset:

- 17 participants
- 20 times of each action unit (5 classes)
- Stationary
- Walking
- Head-movement  
(over 1700 upper face action units and 8300 blinks)



# Evaluation of Facial Action Units Detection

<b>Facial action</b>	<b>Setting</b>	<b>Precision</b>	<b>Recall</b>	<b>F1 Score</b>
<b>FACS</b>	<b>Stationary</b>	$0.88 \pm 0.06$	$0.88 \pm 0.07$	$0.88 \pm 0.06$
	<b>Walking</b>	$0.84 \pm 0.08$	$0.83 \pm 0.08$	$0.83 \pm 0.08$
	<b>Head-movement</b>	$0.82 \pm 0.07$	$0.80 \pm 0.06$	$0.81 \pm 0.07$
<b>Blinks</b>	<b>Stationary</b>	$0.96 \pm 0.09$	$0.94 \pm 0.08$	$0.95 \pm 0.08$
	<b>Walking</b>	$0.90 \pm 0.11$	$0.91 \pm 0.1$	$0.90 \pm 0.1$
	<b>Head-movement</b>	$0.91 \pm 0.09$	$0.89 \pm 0.08$	$0.90 \pm 0.09$



# Case Study: Pain Monitoring

AU4 - Brow Lower

AU43 - Eye Closure

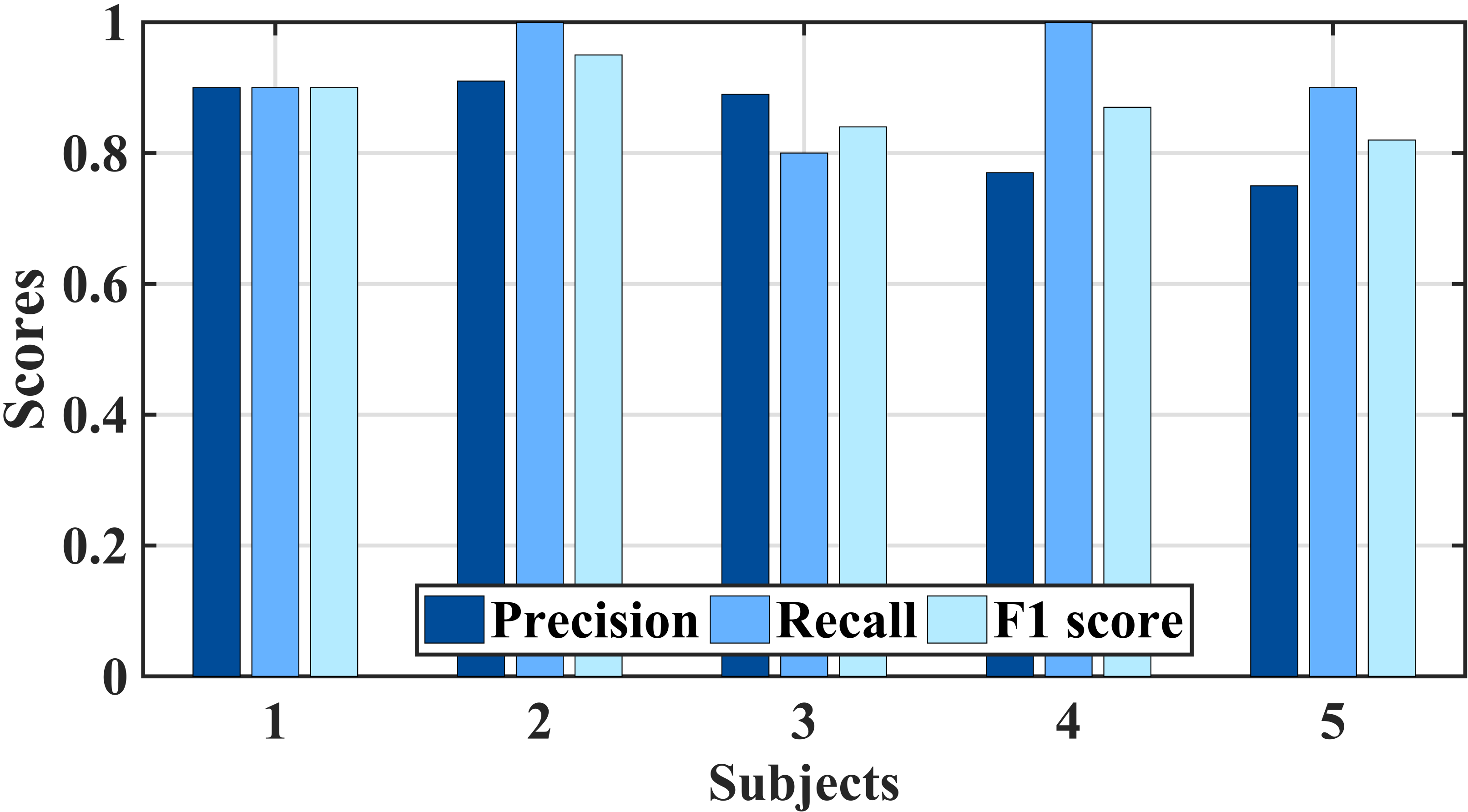
AU9 - Nose Wrinkler

AU6 - Cheek Raiser



$$\text{Pain} = \text{AU4} + (\text{AU6}||\text{AU7}) + (\text{AU9}||\text{AU10}) + \text{AU43}$$

# Case Study: Pain Monitoring



# Conclusions

- ◆ W!NCE can detect facial action units in real-time and under natural settings with an easy to wear commercial eyeglass.
- ◆ W!NCE is robust to motion artifact. It can effectively remove substantial fraction of artifacts due to head and body movement from a multi-channel EOG signal by leveraging IMU signal.
- ◆ W!NCE presents a new way to use wearables for important applications like pain and emotion sensing without requiring intrusive cameras.

Thanks & Questions?