2022UBICOMP

On the Impact of Lateralization in Physiological Signals from Wearable Sensors

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Lateralization Impact

Justification & Approach

EDA

Lateralization of physiological signals [20, 22]

BVP

L R

Wrist device position

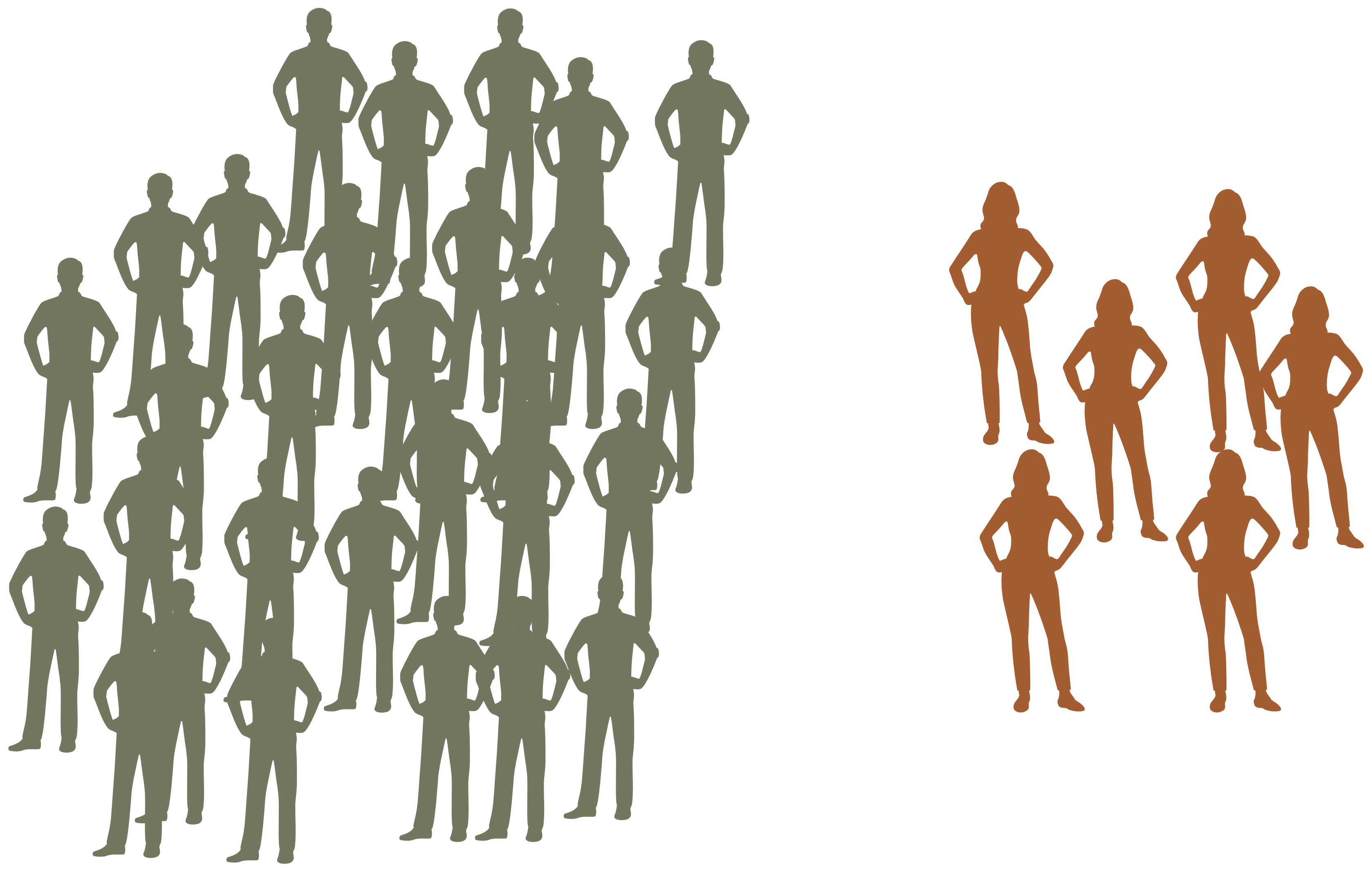
Impact real world?

- Left vs Right analysis
- Impact on ML model
  - Train and test on different sides
  - "Worst case" scenario

Data

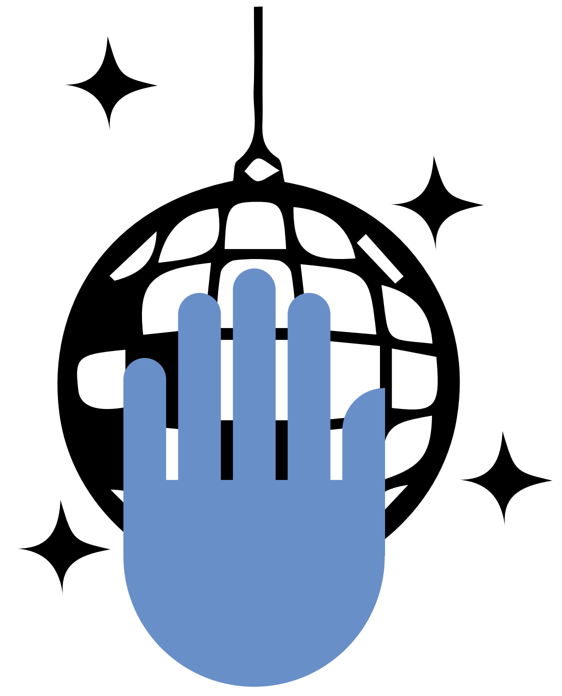
USILaughs[6]

Setup

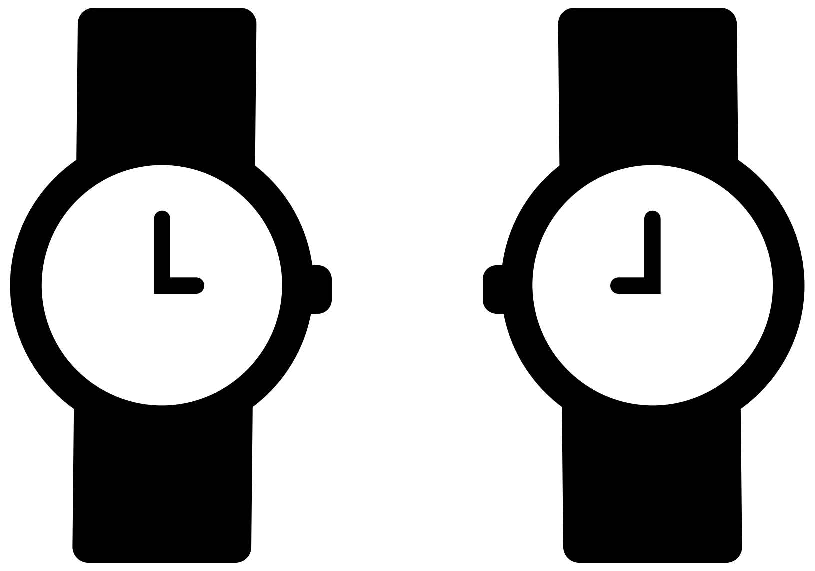


34 people

82% ♂ 18% ♀



Limited User Movements



L R

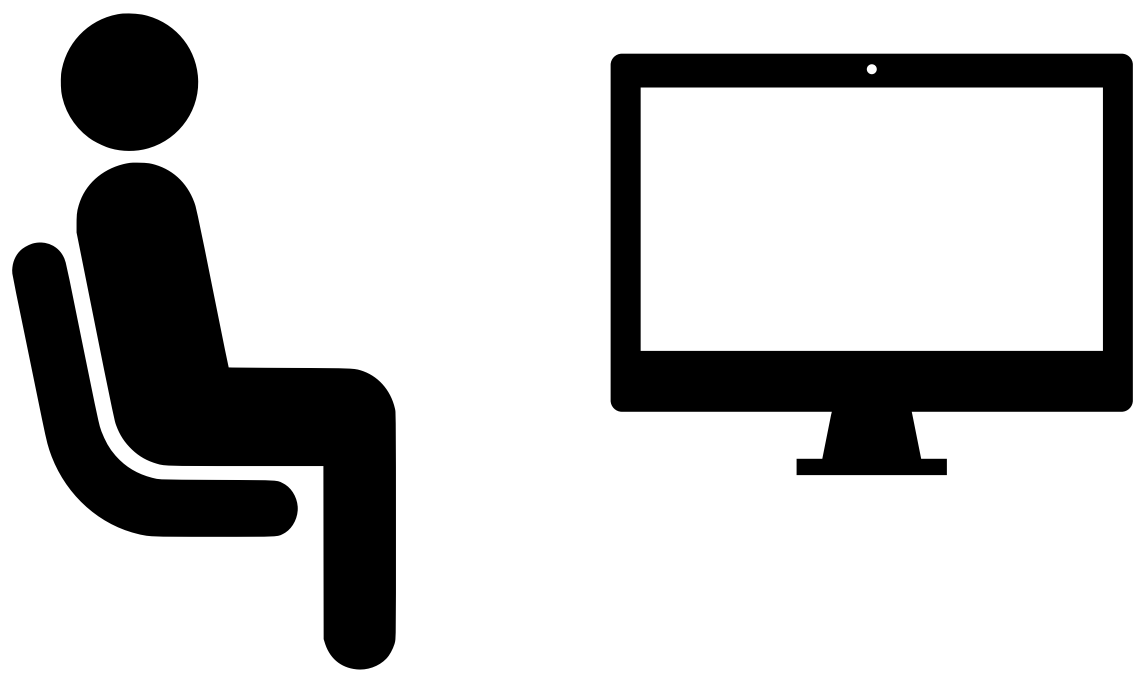
On both hands!

Empatica E4©

- ElectroDermal Activity (EDA)
- Blood Volume Pulse (BVP)
- Skin Temperature (ST)
- Accelerometer (ACC)

USILaughs[6]

Data Collection



Show Videos

↓

😂 Record Laughs 😂

Relax	Videos	Clapping Hands	Fake Laugh	Cognitive Load

Multiple Events

USILaughs[6]

Data Cleaning & Preparation [1]

MIN-MAX NORM USER-WISE

EDA

- 4Hz
- 1st Butterworth low-pass (0.4 Hz)
- Phasic Component[3, 9]
- Norm mixed EDA

BVP

- 64Hz
- 1st Butterworth low-pass (5 Hz)

[26]

- 4Hz
- *Not used by* [6]

ACC

- 32Hz
- Avg 3-axis

Feature extraction

Quantification of Lateralization

In the literature

Lateralization of physiological signals

What to expect

EDA

- **Can differ!** [10, 20, 22, 29]

Phasic

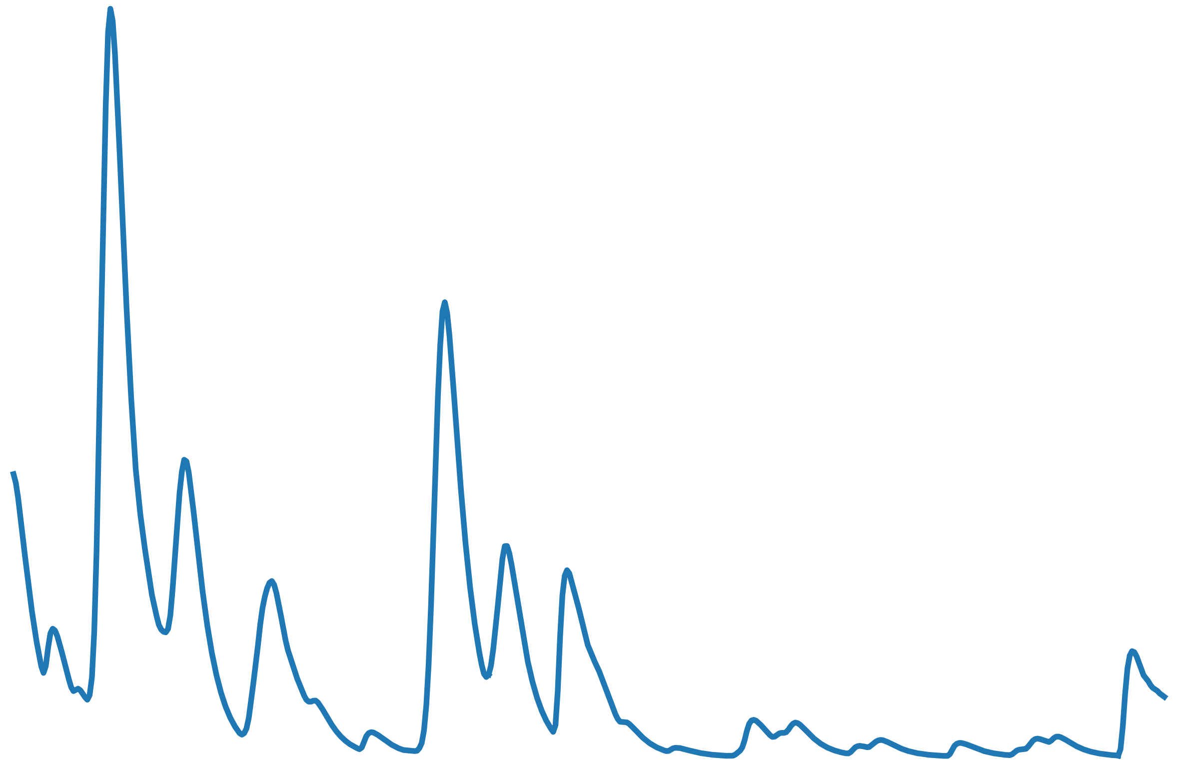
BVP

- Should **not differ** [5,6,7] [11, 23]

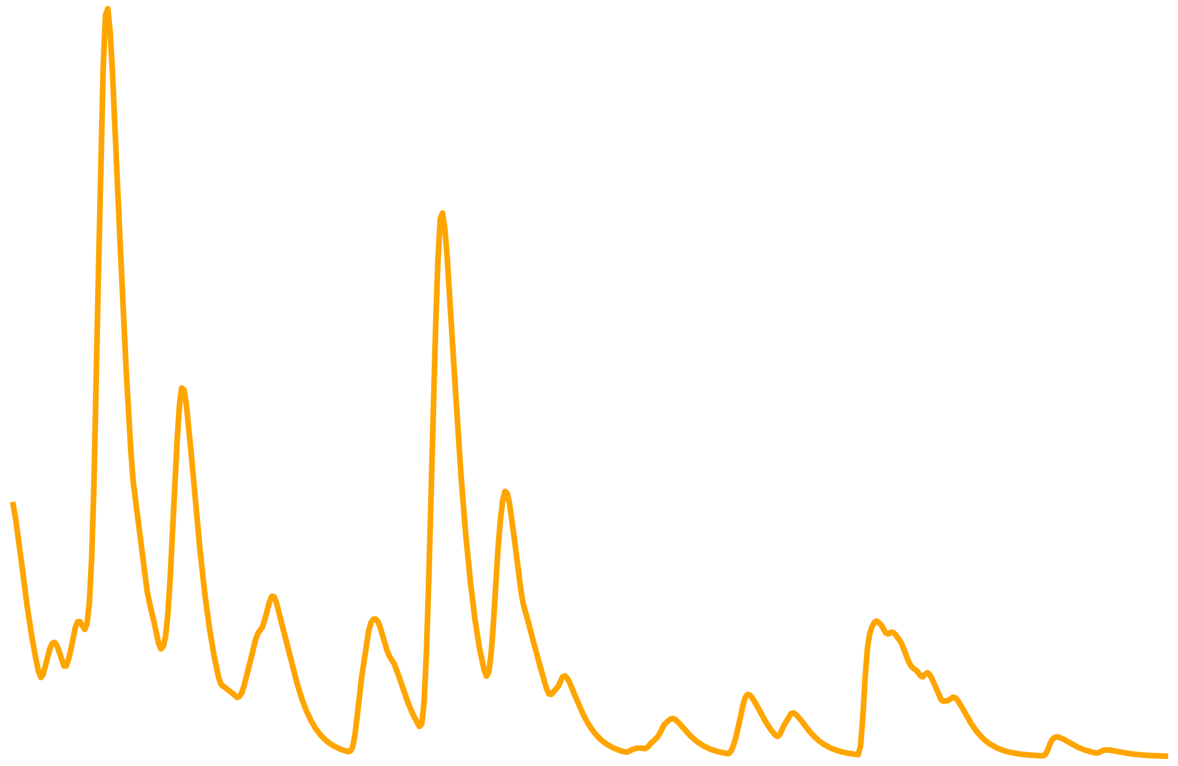
Correlation

Analysis of raw signals

Correlation raw signal



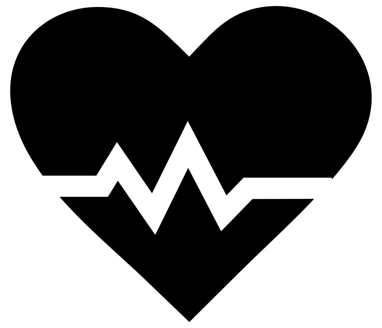
LEFT



RIGHT

Pearson's ρ   Spearman's ρ   Kendall's τ [17]

EDA



BVP

Per-event

Clapping Hands

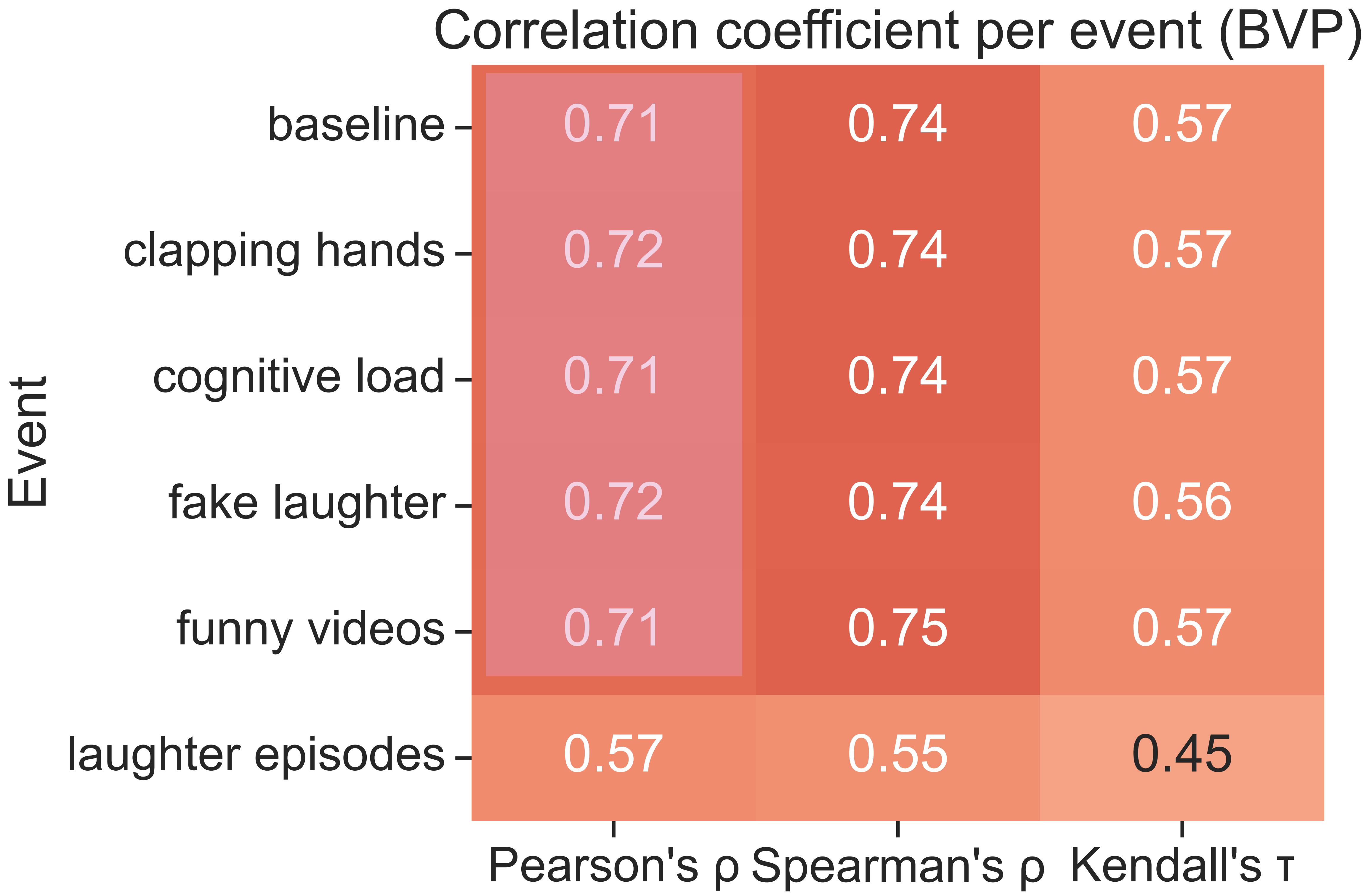
Fake Laugh

Cognitive Load

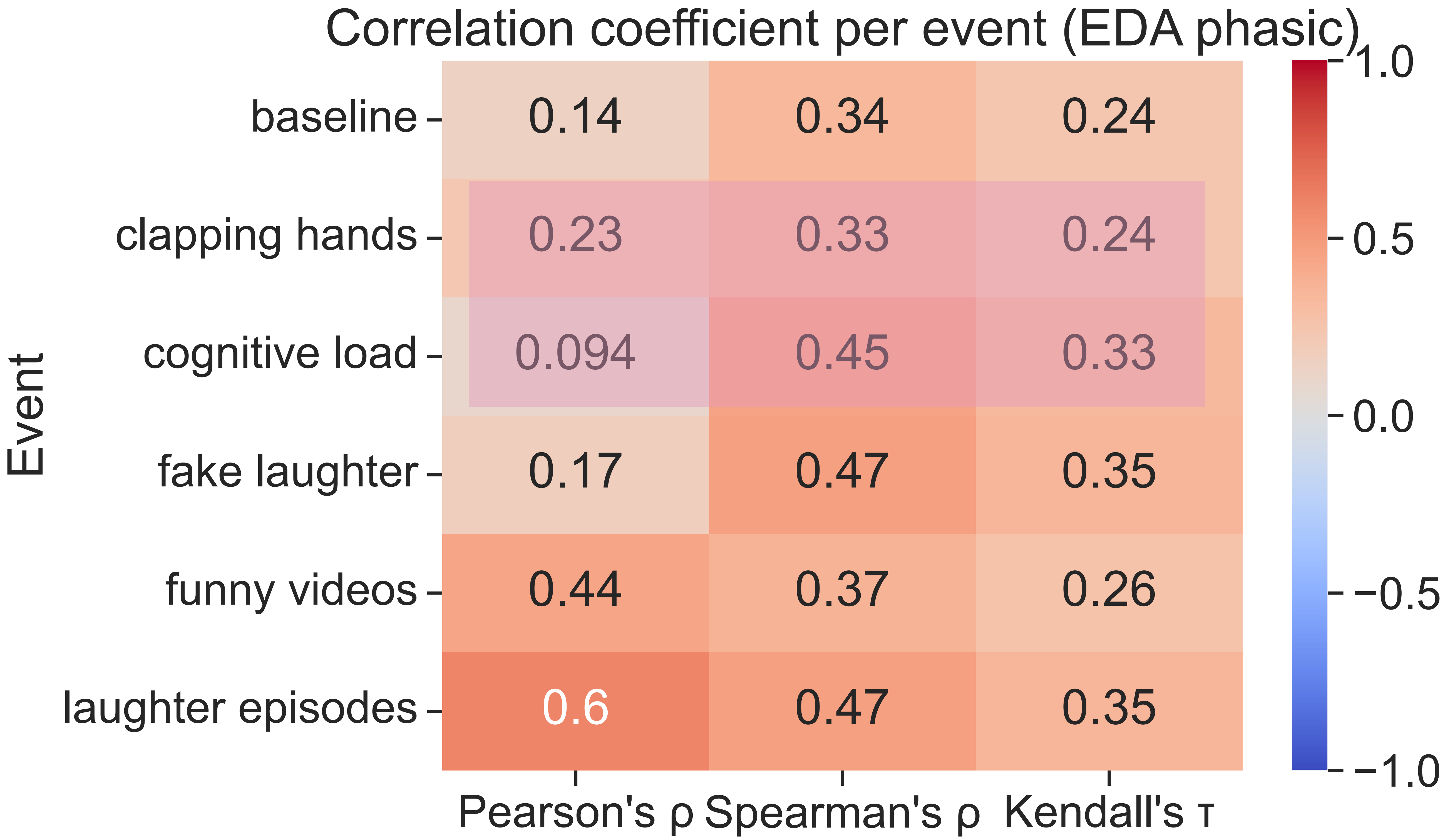
Correlation

Event Correlation Results

Consistency!

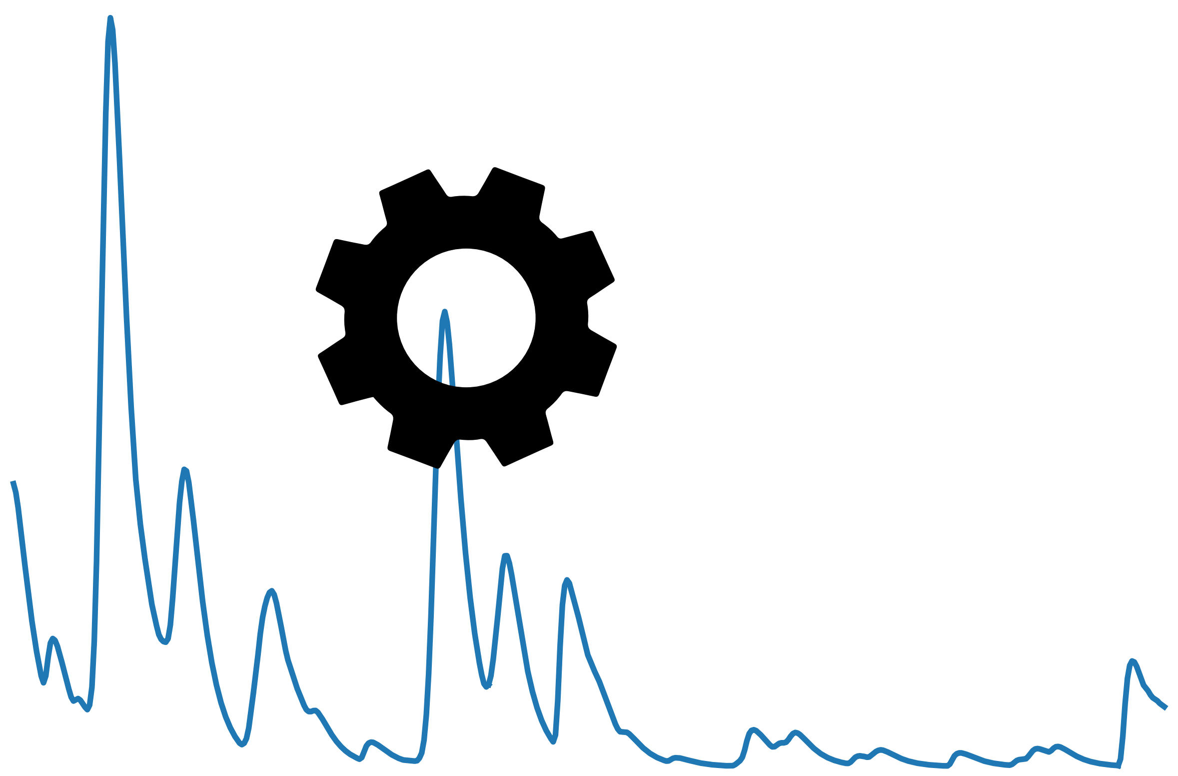


Variations



Effect size

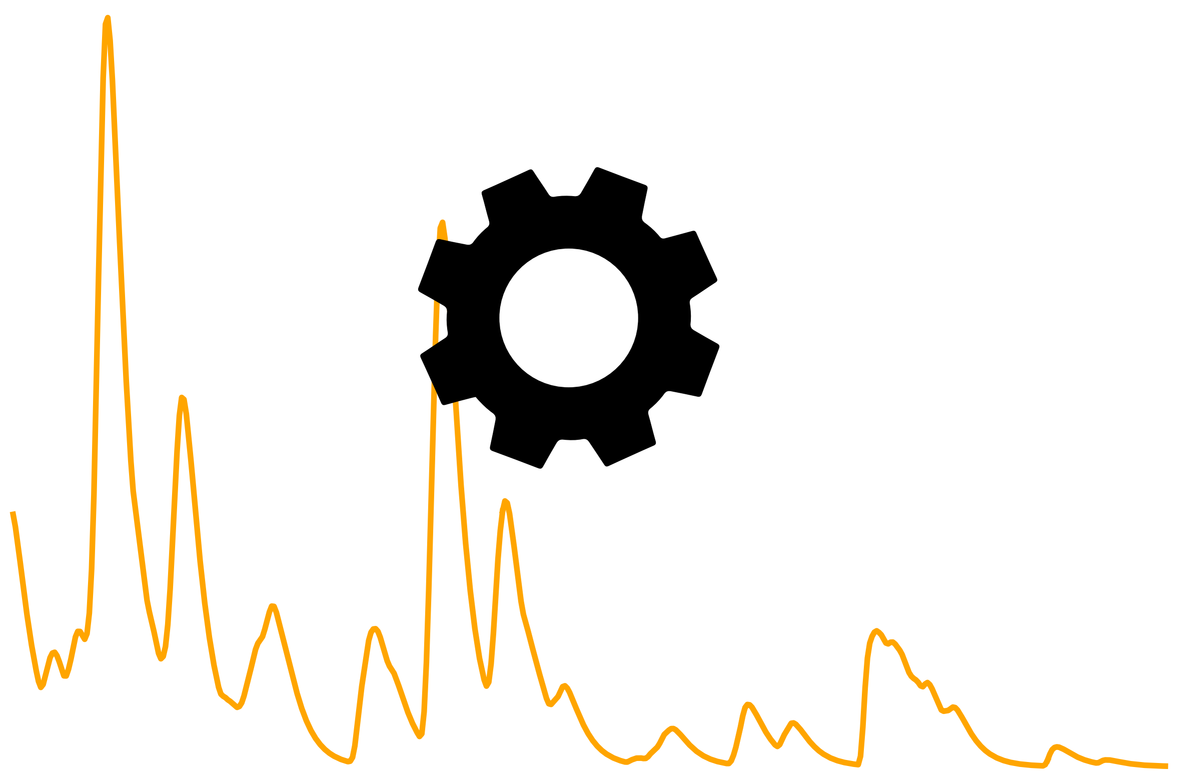
Analysis of raw signals



LEFT features

Effect size of features

Cliff's δ [16]



RIGHT features

EDA

BVP

Per-event

Clapping Hands

Fake Laugh

Cognitive Load

Effect size

Cliff's δ Results

Cliff Delta values (BVP)

Event	min	max	mean	std	slope	hr mean	auc
baseline	0.098	-0.044	0.043	-0.187	-0.022	-0.169	0.013
clapping hands	0.122	-0.045	0.089	-0.256	-0.023	-0.109	0.089
cognitive load	0.106	0.065	0.089	-0.137	0.008	-0.254	0.089
fake laughter	-0.019	-0.028	-0.006	-0.141	-0.079	-0.143	-0.006
funny videos	0.04	-0.045	0.016	-0.137	0.063	-0.137	-0.026
laughter episodes	0.151	0.063	0.127	-0.154	0.043	0.059	0.004

Cliff Delta values (EDA phasic)

Event	min	max	mean	std	slope	number of peaks
baseline	-0.074	0.014	-0.017	-0.007	0.009	-0.124
clapping hands	-0.125	-0.127	-0.104	-0.139	0.16	0.005
cognitive load	0.025	0.055	0.062	0.037	0.025	-0.136
fake laughter	-0.012	-0.053	-0.049	-0.051	-0.166	-0.055
funny videos	-0.058	-0.065	-0.068	-0.061	0.003	-0.034
laughter episodes	-0.004	0.003	0.001	-0.0	-0.094	-0.025

Feature

ML Task

Idea

Real-world applications

BVP

EDA

Differences & Lateralization

😂 Laughter Recognition

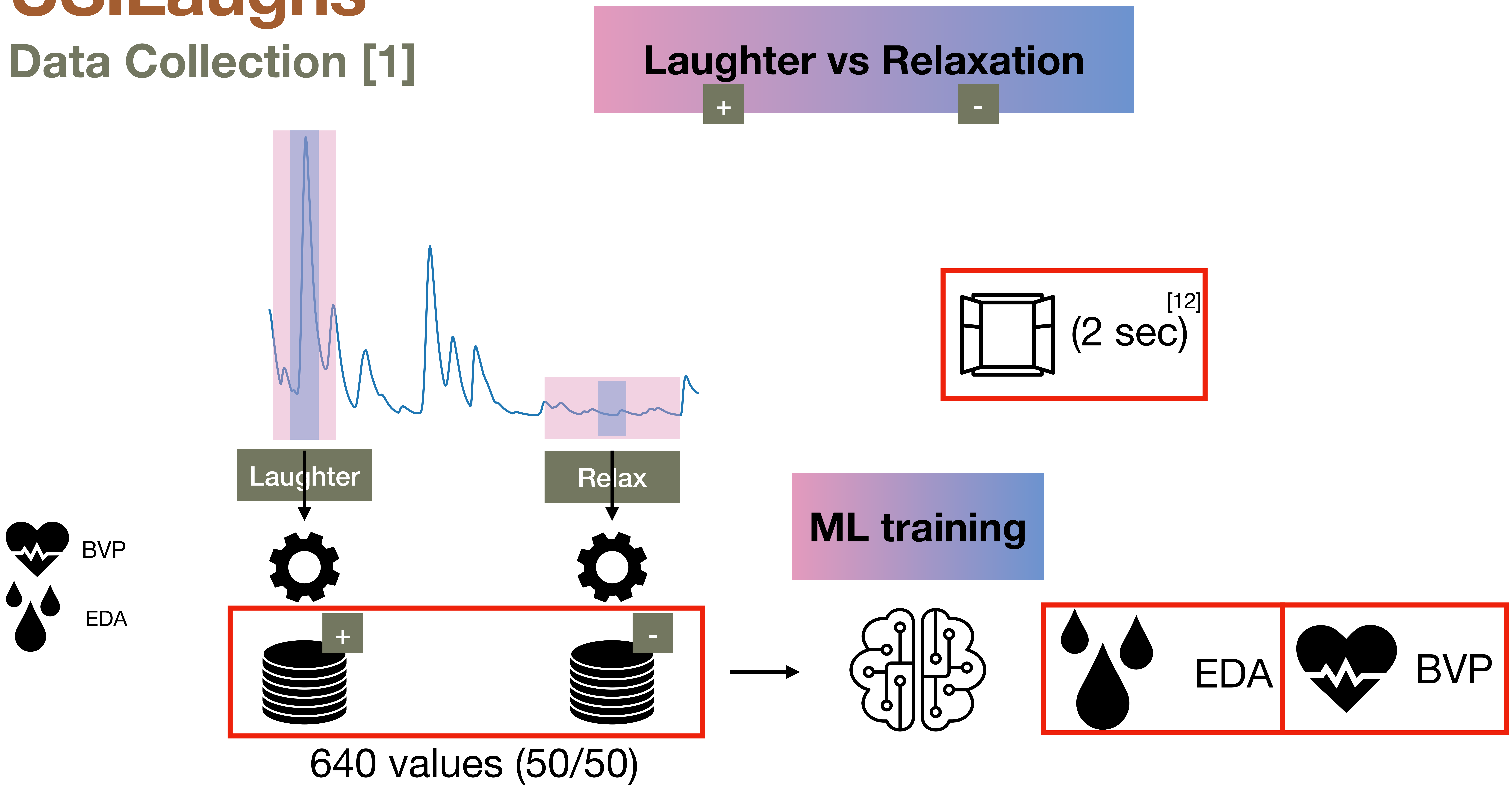
Apply real-world ML tasks

Train-test opposite sides

Worst case

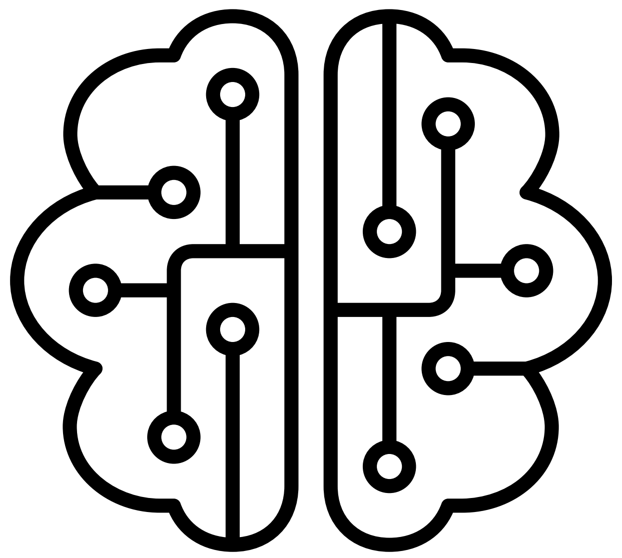
USILaughs

Data Collection [1]



ML Models

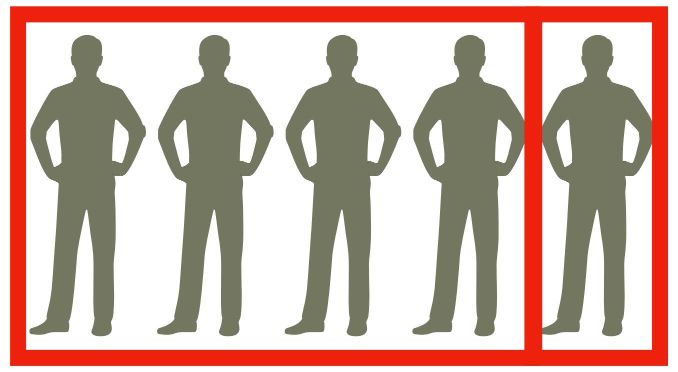
Classical Machine Learning



- KNN
- SVM
- Gaussian Process
- Gaussian Naïve Bayes
- QDA
- Decision Tree
  - Random Forest
  - XGBoost

Accuracy

Leave-One-Subject-Out Cross Validation

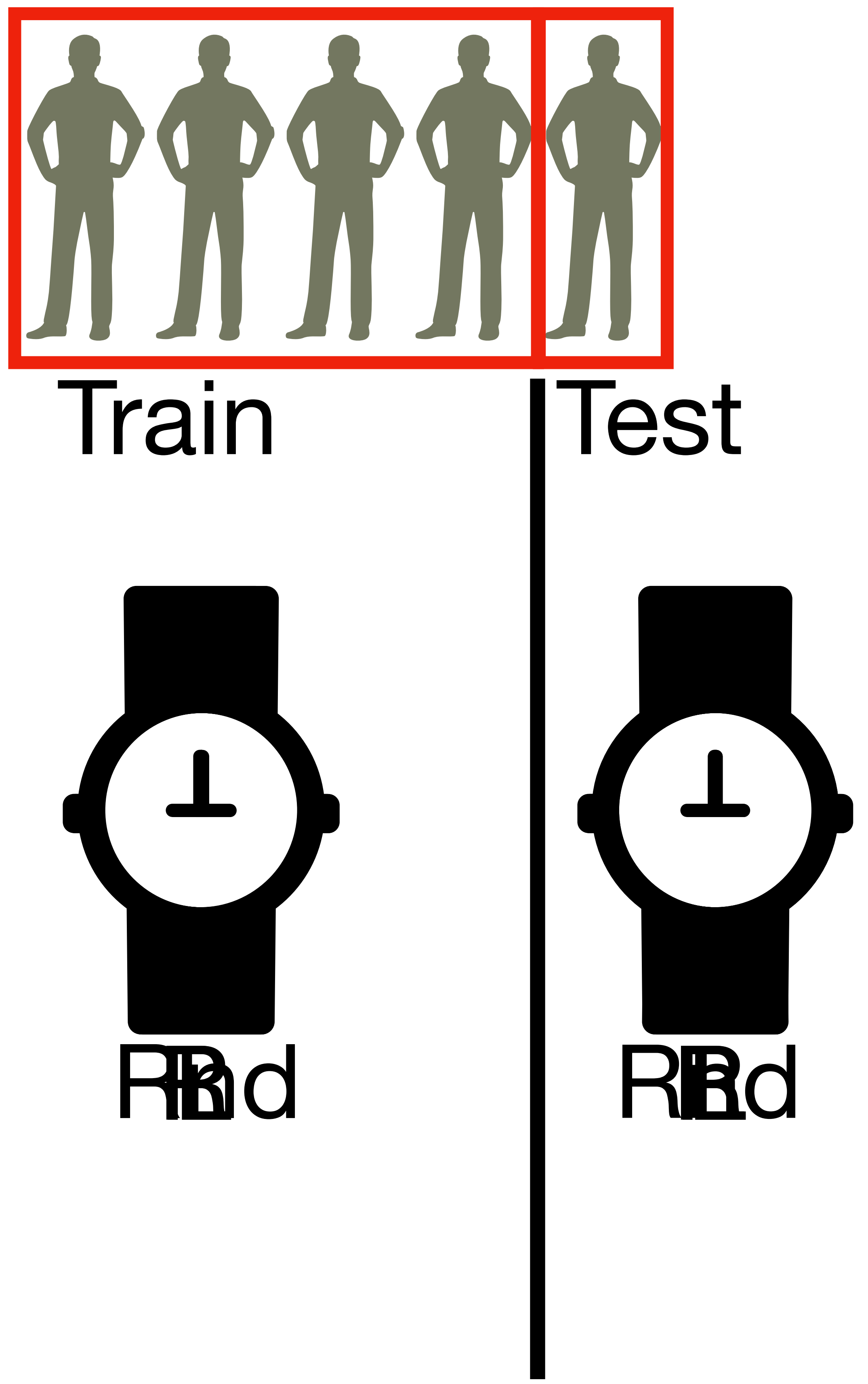


Train Test

Training and testing

Paradigms implemented

Train/test different sides!



Worst case scenario

Results

Laughter Recognition ML

Side/Sensor	EDA	PPG
Train**Left,** Test**Left**	59.0 ± 0.6	57.1 ± 0.6
Train**Right,** Test**Right**	54.4 ± 0.7	54.7 ± 0.7
Train**Random,** Test**Random**	49.2 ± 0.7	56.5 ± 0.6
Train**Left,** Test**Right**	54.8 ± 0.6	53.0 ± 0.5
Train**Right,** Test**Left**	58.7 ± 0.6	54.7 ± 0.5
Random Baseline	*50.9 ± 2.2*	

Conclusions

- We confirmed EDA lateralization
- We found small differences in BVP
- Worst case scenario ML
  - Reduction in performance for EDA-trained models
- Training and testing on different sides <u>**might** decrease performance</u>

Thank you!

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