

EPFL

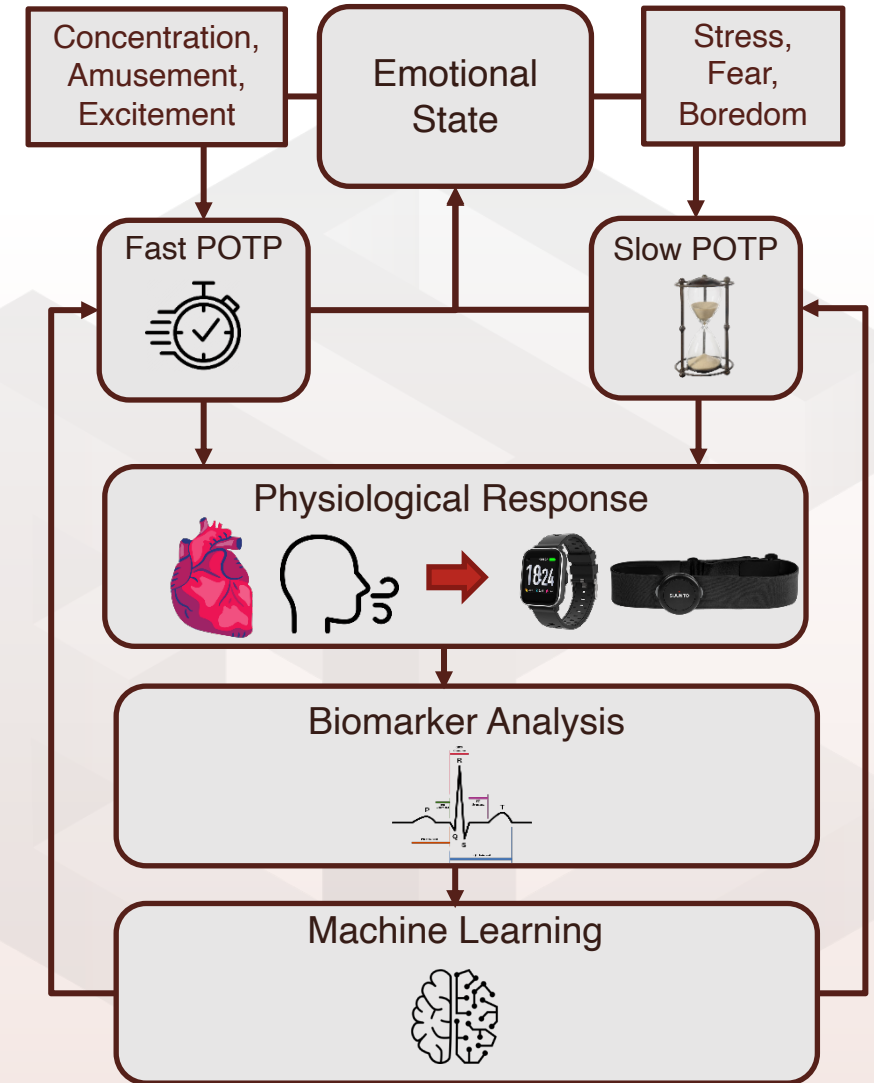


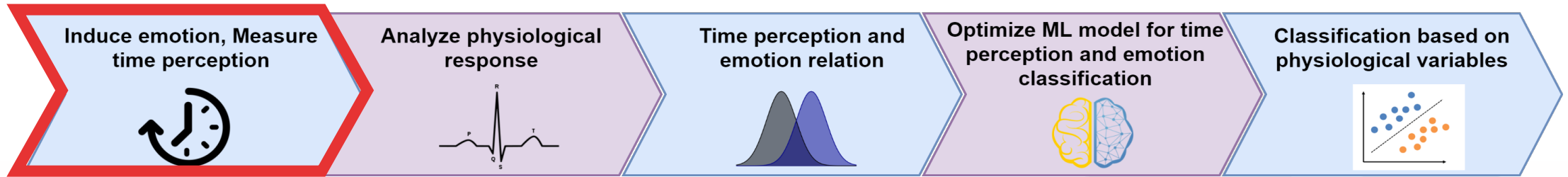
Wearable and Continuous Prediction of Passage of Time Perception for Monitoring Mental Health

Lara Orlandic, Adriana Arza Valdes, David Atienza
Embedded Systems Laboratory, EPFL

- Passage of time perception (POTP) linked to emotions
 - Easily quantifiable, unambiguous metric
- Emotions linked to homeostatic state
 - Changes in physiological signals
 - Measured continuously and noninvasively
 - Analyze biomarkers

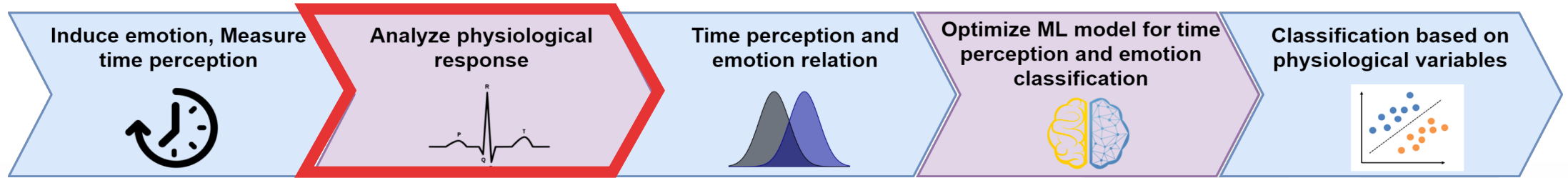
Goal: Develop ML models for predicting POTP based on biomarkers for real-time mental health monitoring



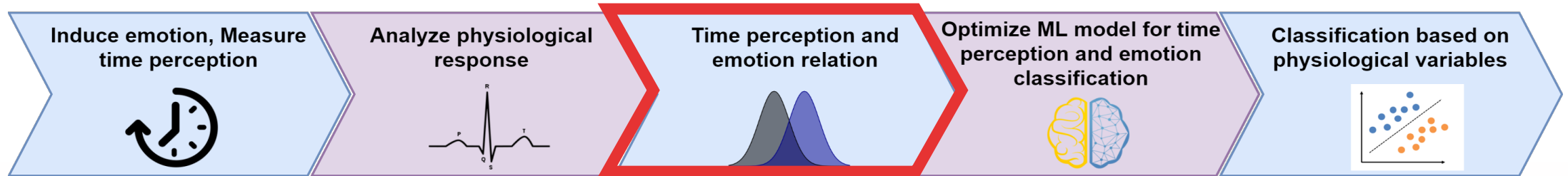


- Experiment: emotional short films and cognitive tasks
 - Measured ECG, SKT, EDA, RSP, PPG
 - Two wearable sensors

Segment	Duration	Class
Relaxation audio	3 min	Rest
Neutral clip	2 min	Neutral
Rest	2 min	Neutral
Fear clip	2 min	Emotional
Math task	3 min	Cognitive
Rest	1.5 min	Rest
Stroop test	1.5 min	Cognitive
Sadness clip	1.5 min	Emotional
Rest	3 min	Rest



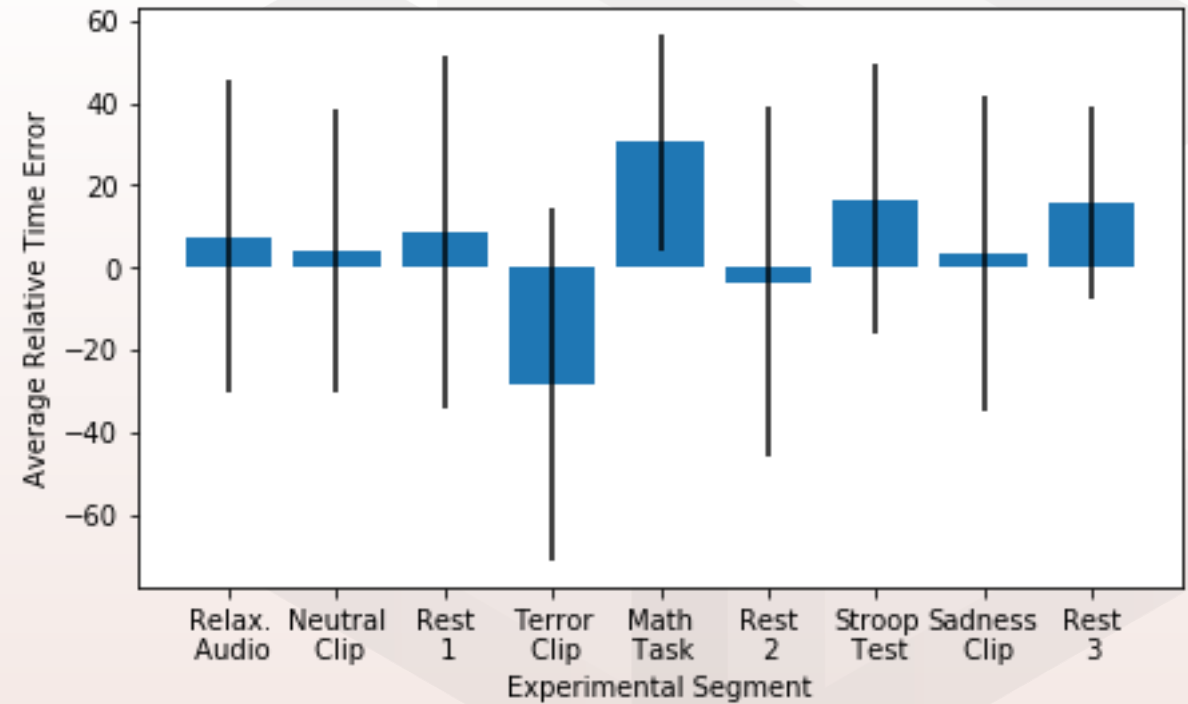
- Segmented signals into 45s windows
- Extracted 80 biomarkers
- Time and frequency domain features

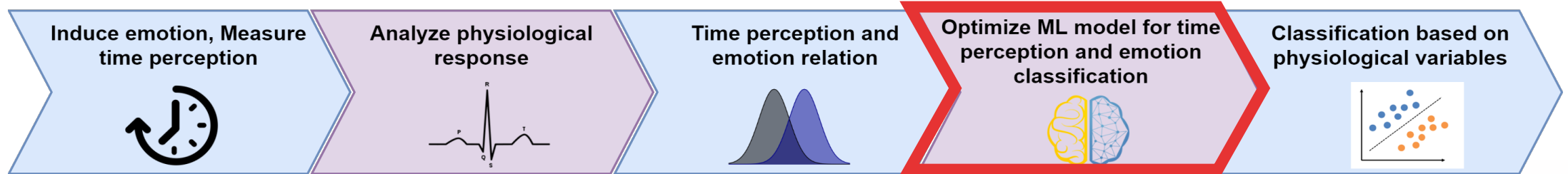


- Analyzed average t_{rel} in each segment
 - Computed relative time error:

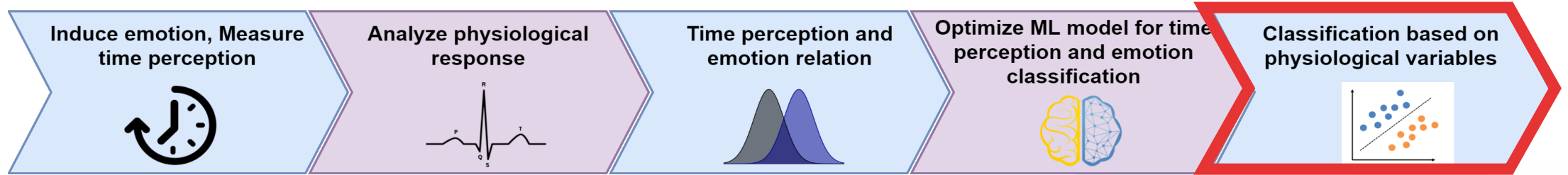
$$t_{rel} = \frac{t_{correct} - t_{perceived}}{t_{correct}}$$

- Grouped segments with same POTP direction
- Performed statistical significance tests

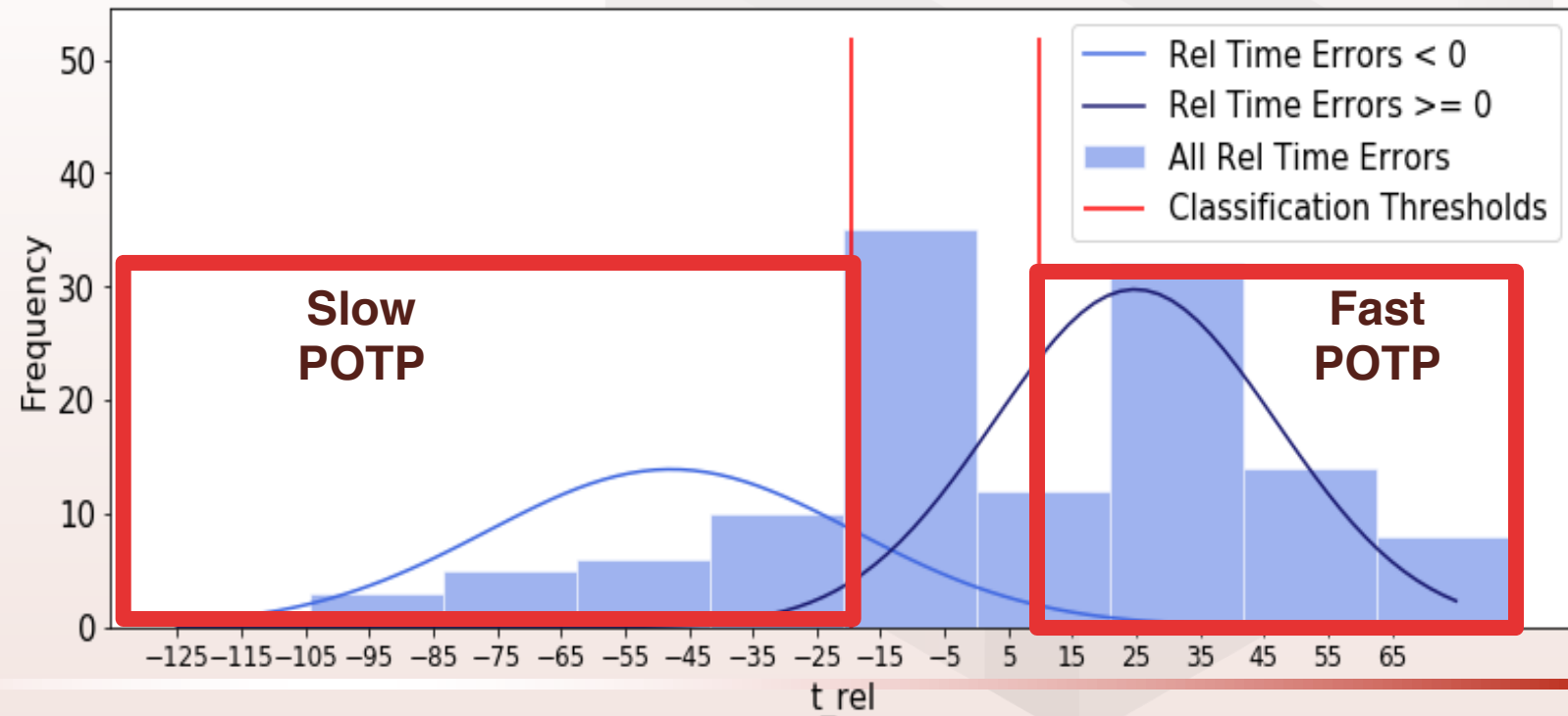




- Compared 8 ML algorithms using Leave-n-Subjects-Out Cross-Validation
- Feature elimination
- Hyperparameter tuning

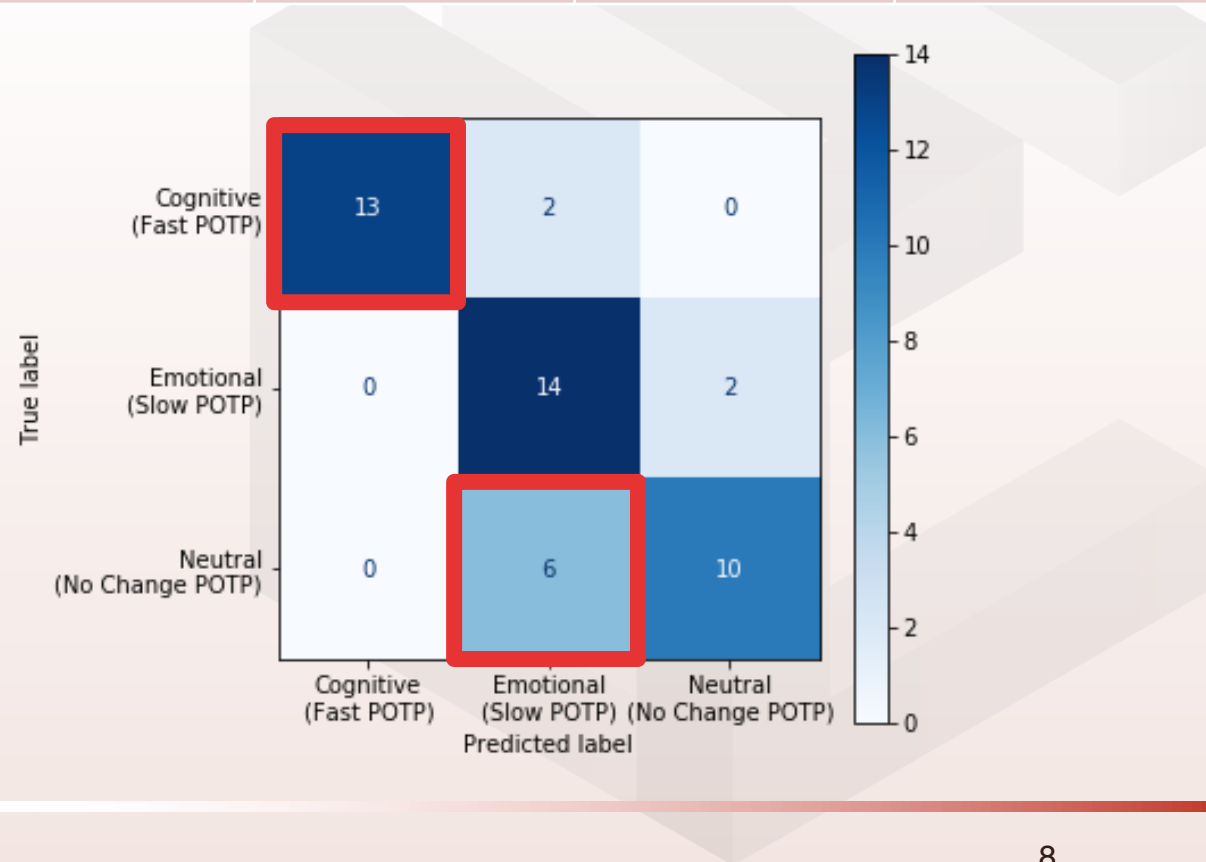


- Performed two classification tasks:
 - Experimental segment classification
 - Slow vs Fast POTP across all segments



- Statistical significance of t_{rel}
- Experimental state classification
 - **Average F-1 score: 79%**
 - F-1 score for Fast POTP: 93%
 - Most important features:
 - Skin conductance gradient (SCL_gradient)
 - Skin temperature total power (SKT_TOTAL_POWER)

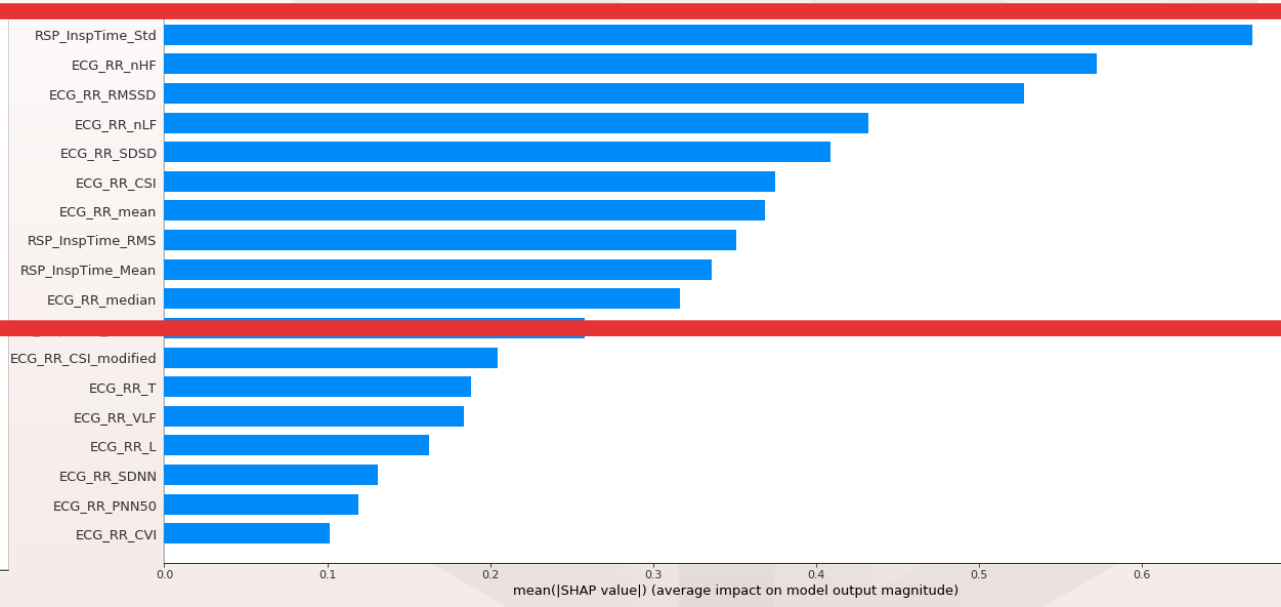
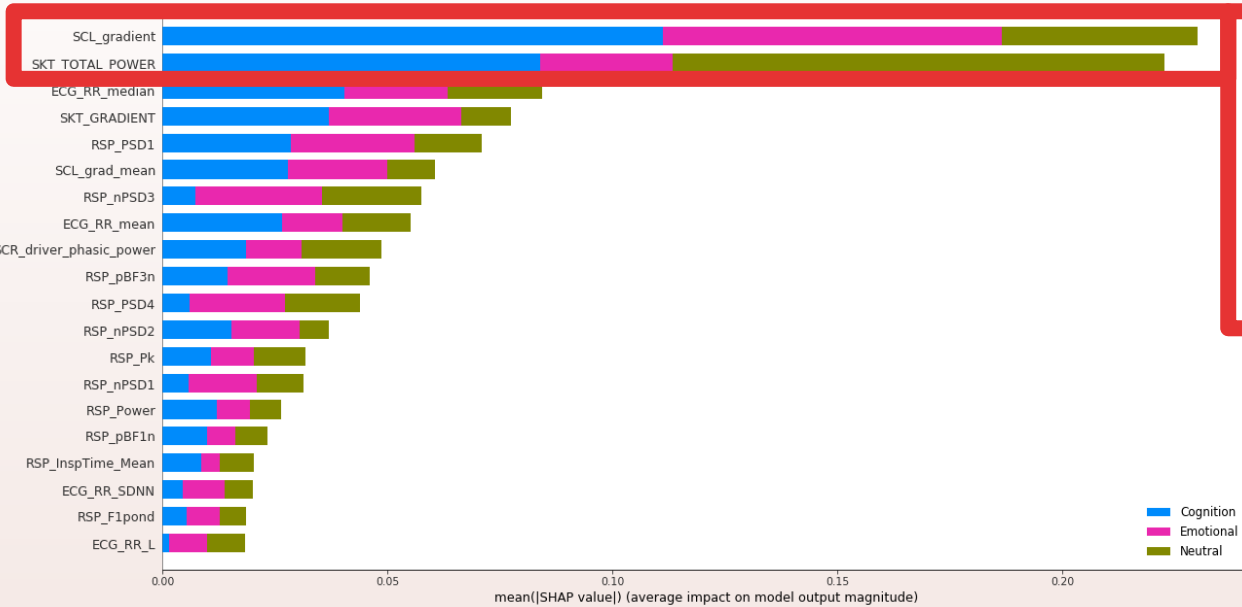
Exp. state	Avg. t_{rel}	P-value	POTP
Emotional	-16.1%	0.0456	Slow
Neutral	6.94%	0.942	No change
Cognitive	23.6%	2×10^{-5}	Fast



- **F-1 score: 77.1%**
- Most important biomarkers from ECG and RSP signals

Experimental State Classifier

Time Label Classifier



- POTP is related to emotions
- ML algorithms can predict POTP based on subjects' biomarkers

Continuous POTP monitoring can be achieved using wearable devices

- Future work
 - Test a larger, more diverse set of subjects
 - Use longer experimental tasks