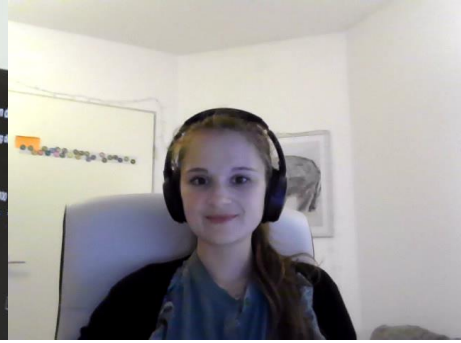
NEUROERGONOMICS
CONFERENCE 2021



Decoding Neurophysiological Correlates of Cognitive and Affective States

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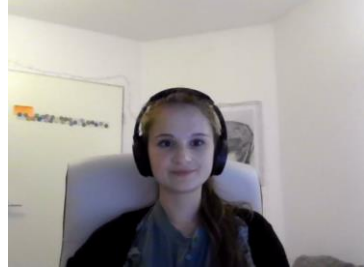
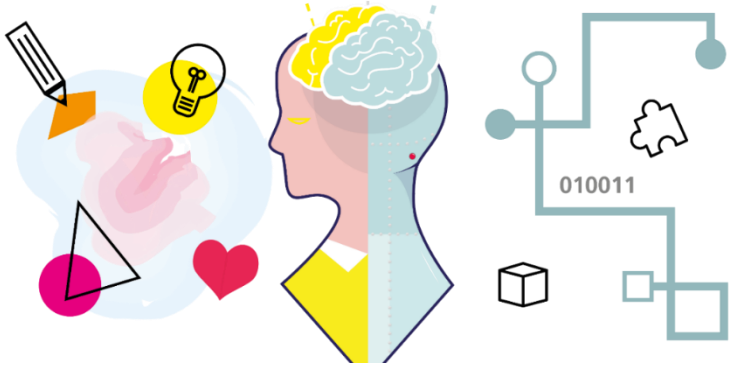
Background



- **Robust decoding** of activation patterns associated with affective and cognitive states is crucial for neuroergonomics applications [1,2]
- In naturalistic environments, **mental states** do not occur isolated but rather **interact with each other**
- Electroencephalographic (**EEG**) recordings capture **activation patterns** associated with the current **emotional states** and level of **working memory load**
- **Training decoding model** requires labels that represent the assumed **true current state**, that is the **ground truth (GT)**

Emotion



Cognition

[1] Appriou et al. (2020). Modern Machine-Learning Algorithms: For Classifying Cognitive and Affective States From Electroencephalography Signals. IEEE Syst. Man Cybern. Mag. 6, 29–38. doi: 10.1109/MSMC.2020.2968638
[2] Vukelić, et al. (2020). Oscillatory EEG Signatures of Affective Processes during Interaction with Adaptive Computer Systems. Brain Sci 11. doi: 10.3390/brainsci11010035

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Aim of the Research

1 Investigate the **decoding** performance of **simultaneously induced cognitive and emotional states**

2 Investigate how the **choice of the ground truth (GT)** affect the decoding performance

- **Reference ratings** from the IADS as GT
- **Individual subjective** ratings as GT

EEG data from five participants (2 female, 1 diverse; $M = 23 \pm 1.02$ years)

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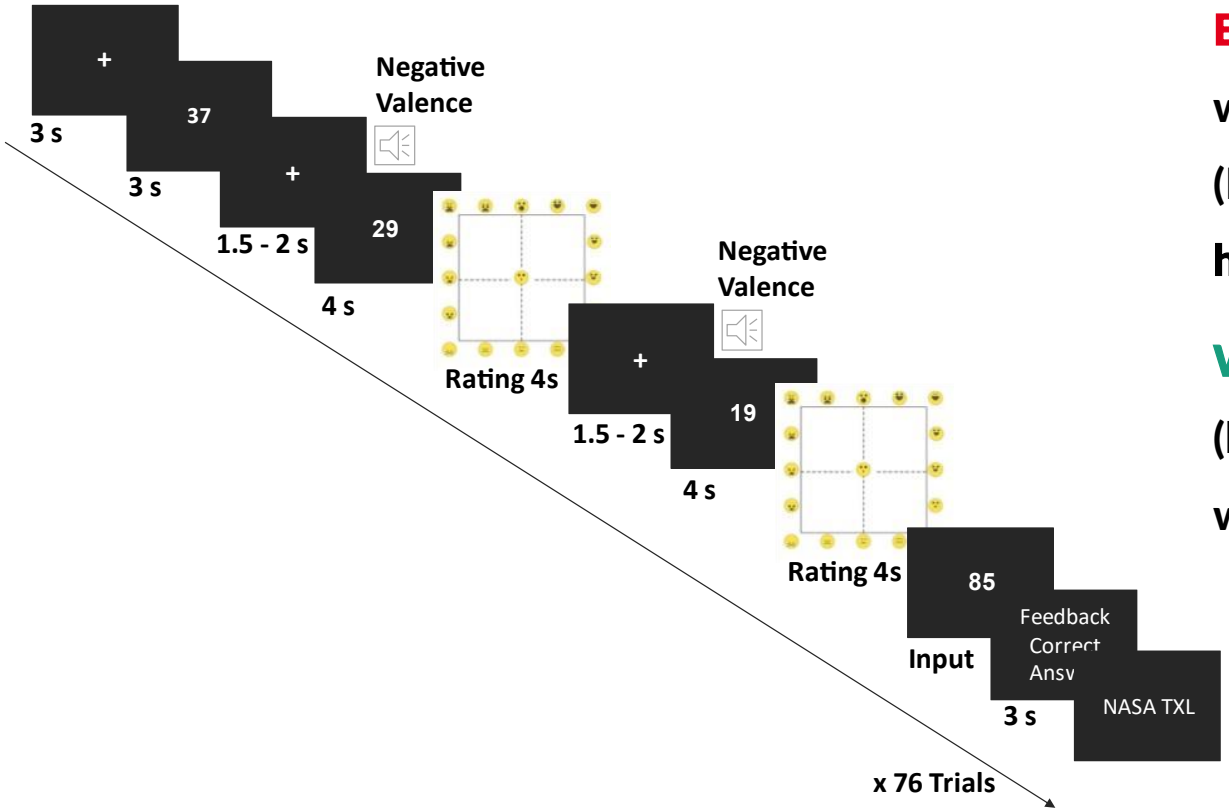
Experimental Procedure



Emotional states: Simultaneously induced during the task with sounds of the International Affective Digitized Sounds (IADS) database with **low** (negative), **average** (neutral), and **high** (positive) **valence** [9]

Workload levels: Elementary calculation with either **1-digit** (low working memory load, LWML) or **2-digit numbers** (high working memory load, HWML)

[3] Bradley, M. M., and Lang, P. J. (2007). The International Affective Digitized Sounds (IADS-2): Affective ratings of sounds and instruction manual. University of Florida, Gainesville, FL, Tech. Rep. B-3.

EEG Processing Pipeline

De-trending
Zero-padding
Re-referencing

→

Filtering
Notch (IIR)
Bandpass (FIR)

→

Epoching
4 sec after stimulus onset

→

Artefact removal
Amplitude rejection
ICA

→

Downsampling
250 Hz

↓

Baseline Correction
200 ms before stimulus onset

→

Feature Extraction
Filter Bank Common Spatial Pattern (FBCSP)

→

PCA
4 components

→

LDA
Reference ratings from the IADS

→

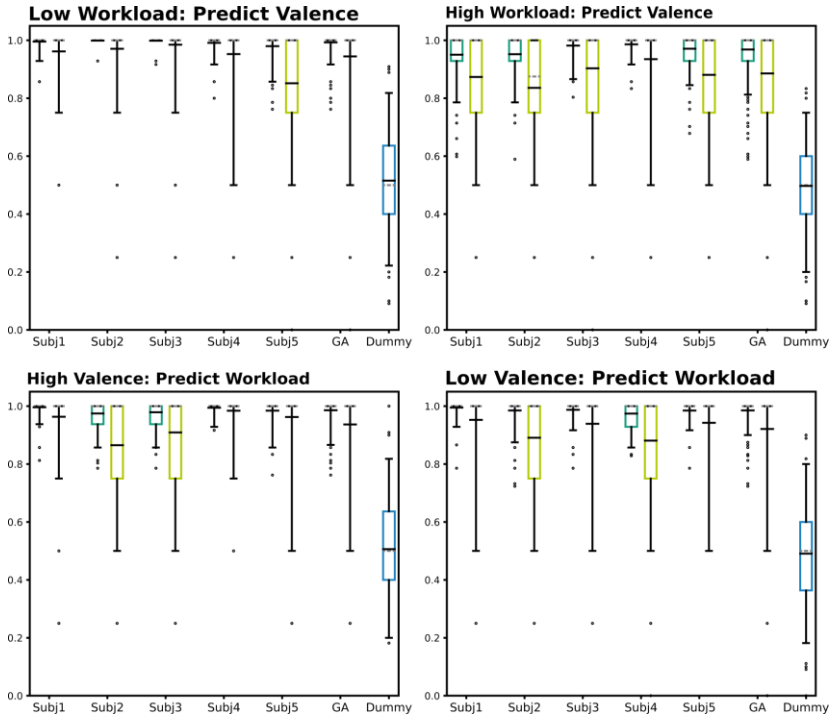
Stats (AUC)
Dummy classifier & Theoretical chance level

LDA
Individual subjective ratings

→

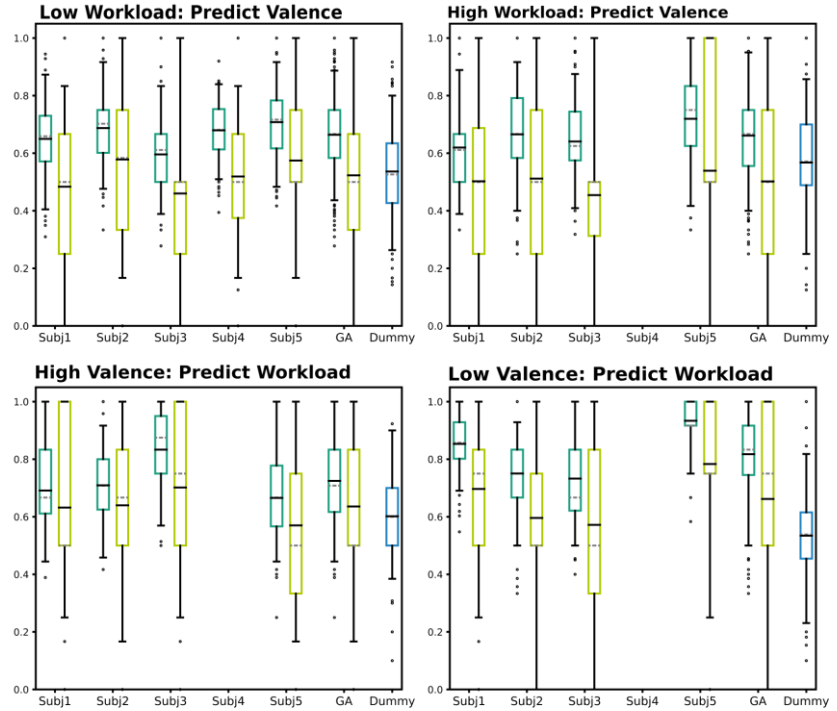
Average Decoding Performance

Reference ratings from the IADS



Drop in Accuracy

Individual subjective ratings



- **High decoding performance** of interacting mental states for **reference ratings as labels** with **averaged balanced accuracies between 88.6 % and 94.4 %**

- **Chance-level decoding performance** for **subjective labels** with **averaged balanced accuracies between 50.2 % and 66.2 %**

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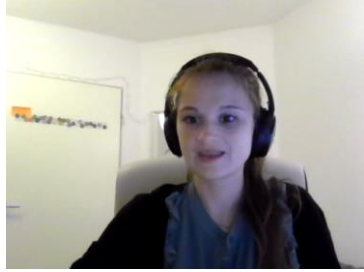
Take Home Message

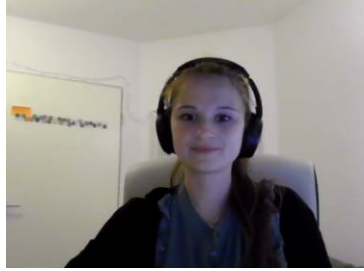


1 We could decode simultaneously experienced cognitive and emotional states with **high classification accuracy when using the reference ratings** as a ground truth **but not when using the individual subjective ratings.**

2 Decrease in decoding performance for the **subjective labels** might be explained by **modulating effects** (e.g., social desirability or limited ability to reliably estimate past experiences)

3 Further research is needed to a) investigate **reasons for observed discrepancy** and b) obtain **suitable GT and calibration tasks for Brain-Computer Interface** training models

Questions?



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Reference

[1] Appriou et al. (2020). Modern Machine-Learning Algorithms: For Classifying Cognitive and Affective States From Electroencephalography Signals. IEEE Syst. Man Cybern. Mag. 6, 29–38. doi: 10.1109/MSMC.2020.2968638

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Funding

This work was supported by grants from the Baden-Wuerttemberg Ministry for Economic Affairs, Labour and Housing (Project »KI-Fortschrittszentrum Lernende Systeme und Kognitive Robotik«).