



Exploring ECG and Eye-Tracking Biomarkers for Emotion Recognition: A Pilot Study



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1 INTRODUCTION & BACKGROUND

Emotions influence perception, decision-making, learning, and mental health. Common emotion recognition methods—such as facial expression or speech analysis—are often biased, easy to manipulate, and limited in real-world applications. These methods particularly struggle in contexts where users express emotions in atypical ways, such as in older adults, individuals with disabilities, neurodivergent users, or assistive systems where facial or verbal cues may be weak or absent. Physiological signals such as heart rate variability (HRV) and pupil dilation offer objective, involuntary, and privacy-respecting alternatives. This pilot study explores ECG and eye-tracking as dimensional emotion markers, with the goal of mapping them to the Circumplex Model of Affect along the axes of valence and arousal.

RESEARCH QUESTION

Can ECG-based, and eye-tracking measures reliably reflect participants' emotional responses, particularly along the dimensions of valence and arousal?

METHOD & PLANNED ANALYSES

The pilot study was conducted in a controlled laboratory setting with 14 participants. Each participant was exposed to 100 emotionally categorized images from the International Affective Picture System (IAPS). The experimental procedure was implemented using PsychoPy. ECG was recorded via wearable sensors to assess HRV parameters (e.g., RMSSD, LF/HF ratio), while eye-tracking data were used to capture pupil dilation as an indicator of physiological arousal. After each image, participants rated their emotional state on two 7-point Likert scales for valence and arousal. All data streams—including biosignals and stimulus presentation—were synchronized using Lab Streaming Layer (LSL). The setup ensures precise temporal alignment of physiological responses with stimulus timing.

PLANNED ANALYSES

The collected data will be preprocessed and cleaned (e.g., artifact correction, signal segmentation). Key features will be extracted from ECG and eye-tracking data per trial. These physiological indicators will then be correlated with self-reported valence and arousal ratings. The goal is to explore how features in ECG and pupil size reflect dimensional emotional states. Due to the limited sample size, no machine learning classification will be performed in this phase. Instead, the analysis will focus on identifying signal patterns and building hypotheses for future modeling.



Figure 2: Experimental Setup



2 THEOR. FRAMEWORK

This study uses the Circumplex Model of Emotion (Russell, 1980), which conceptualizes affective experience along two continuous axes: valence (pleasant vs. unpleasant) and arousal (calm vs. activated).

This dimensional model provides a robust alternative to categorical emotion labels and allows for culture-independent, physiologically grounded measurement of affective states.

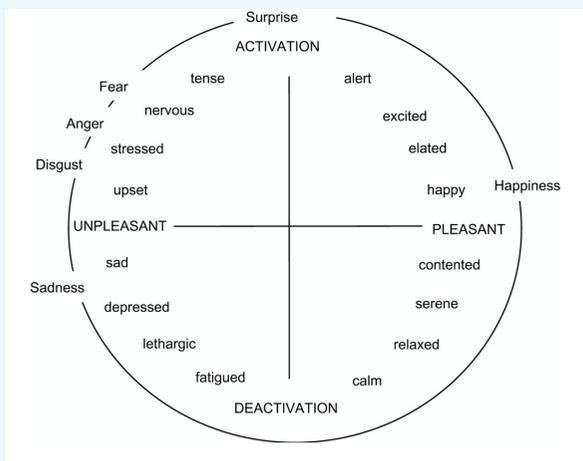


Figure 1: Circumplex of emotion (Russel, 1980)

OUTLOOK AND NEXT STEPS

In the next phase of the project, the sample size will be expanded to improve statistical power and allow for more generalizable results. Additionally, the team is currently designing immersive virtual reality (VR) environments to induce emotional states in more ecologically valid and interactive settings. These VR scenarios will be tailored to elicit specific valence-arousal combinations and allow for richer multimodal measurement. In addition, a diary study is planned. The long-term vision is to develop an open-source, adaptive system for dimensional emotion recognition based on physiological signals, with applications in healthcare, education, and assistive technologies.

CONTACT AND ACKNOWLEDGMENTS

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