A Physiological Signal Database to Study the Influence of Music-Induced Emotions in the Autonomic Nervous System

Alexia Suárez-Pérez[1], Pedro Álvarez[2], Raquel Bailón[1]

[1] Biomedical Signal Interpretation and Computational Simulation (BSICoS),
Biomedical Research Networking Center in Bioengineering, Biomaterials and Nanomedicine (CIBER-BBN)
[2] Distributed Computing (DisCo)
Aragón Institute of Engineering Research (I3A)
University of Zaragoza, Mariano Esquillor s/n, 50018, Zaragoza, Spain.
Tel. +34-976762707, e-mail: *asuarez@unizar.es*

Abstract

A synchronized multimodal physiological framework is proposed for studying music-induced emotions. The objective is to design an experimental protocol for affective computing and emotion recognition research. Electrocardiogram (ECG), electrodermal activity (EDA), respiration, and photoplethysmography (PPG) from 50 participants are recorded with Pick-A-Mood (PAM) annotations. Results reveal autonomic differences across emotional states.

Introduction

Music is a powerful stimulus for felling emotions in humans. In recent years, physiological signal analysis has become increasingly relevant for emotion recognition in affective computing. Signals such as ECG, EDA, respiration, and PPG provide valuable information related to emotional states.

This work presents the design and creation of a multimodal physiological database for the study of emotions induced by music. Physiological signals were acquired from multiple wearable and biomedical devices while participants listened to musical fragments selected to evoke a diverse range of emotional responses. These emotions were characterized according to Russell's circumplex model of affect, which represents emotions within a two-dimensional space defined by valence (pleasantness) and arousal (activation), allowing the selection of stimuli from the four resulting quadrants [4]. Subjective emotional annotations were additionally collected using the PAM model [2].

Materials and Methods

Participants

Prior to participation, all subjects provided informed consent and completed a pre-experimental questionnaire including demographic information, musical expertise, presence of cardiovascular, neurological, or psychological conditions, and preferred musical genres.

A total of 50 participants (25 women and 25 men) were included in the study. Individuals with high musical expertise or reported cardiovascular, neurological, or psychological conditions were excluded to reduce potential confounding factors.

Before the experiment, participants reported their current emotional state by selecting the pictogram in the PAM model that best represented their feelings.

Acquisition Devices

Several physiological devices were used during the experiment.

The Medicom MTD ENCEPHALAN-EEGR-19/26 recorded ECG, EDA, PPG (index finger and right earlobe), temperature (ring finger), and respiration signals at 250 Hz. A Polar Verity Sense was placed on the left biceps to record PPG at 55 Hz. An Empatica E4 (EmbracePlus) was worn on the left wrist, recording PPG and accelerometer signals at 64 Hz. Finally, a MAXREFDES103 Health Sensor Band was placed on the right wrist to record PPG at 256 Hz.

Once all devices were properly positioned and correct signal acquisition was verified, headphones were placed on the participant and the experiment was initiated.

Experimental Protocol

The experimental session lasted 25 min and 30 s and consisted of three phases. First, a baseline stage was conducted using whale music to induce a neutral emotional state [3]. Baseline segments of 2 min were presented at the beginning and end of the experiment, together with additional 30-second segments before each song.

Next, participants listened to eight musical fragments (2 min each), with two songs selected from each quadrant of the valence-arousal model [4], the same songs that were used in another experiment [1]. To minimize order effects, ten randomized playlists were created and participants were randomly assigned to one of them.

Finally, after each song, participants reported their perceived emotional state using the PAM model, allowing the perceived emotion felt by each musical fragment to be recorded.

Signals Preprocessing

All signals were resampled to 500 Hz to facilitate synchronization between devices. For this purpose, the heart rate (HR) signal derived from the PPG recorded on the index finger using the Medicom MTD ENCEPHALAN-EEGR-19/26 was used as the reference, while HR signals derived from the PPG recordings of the remaining devices were aligned accordingly.

Additionally, accelerometer (ACC) signals from the Empatica E4 were used to precisely segment the experiment into its different phases, particularly to delimit the 15-second perceived emotion annotation periods, during which a clear increase in movement was observed as participants circled their responses on the PAM pictogram.

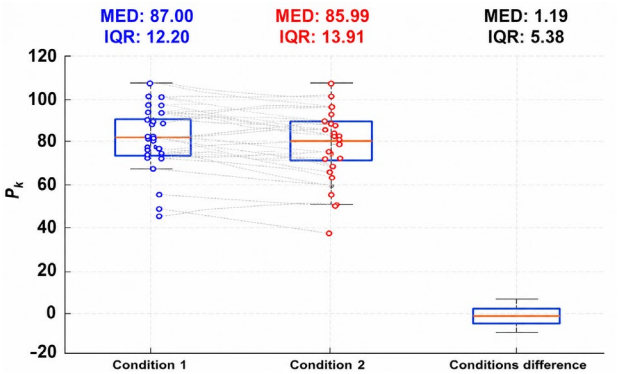

Fig. 1 Boxplot representation of the peakness (P_k) metric between two different conditions. Condition 1: positive valence, high arousal, Condition 2: positive valence, low arousal.

Preliminary Results

Preliminary ECG and respiration results in female participants identified physiological metrics associated with autonomic nervous system (ANS) changes in response to induced emotional states. Significant differences were found across several metrics for both perceived and induced emotions, highlighting their potential for emotion recognition and affective state monitoring. Some markers may be particularly relevant for well-being applications, such as detecting intense negative emotional states like stress or anxiety. Figure 1 illustrates one of these differences through the peakness (P_k) metric, which reflects respiratory stability, comparing two positive-valence conditions with different arousal levels.

Conclusion

This work introduces a synchronized multimodal dataset for studying music-induced emotions using physiological signals and PAM annotations, showing preliminary ECG and respiration results with discriminative patterns between emotional states and supporting future affective computing research in feature extraction, classification, and multimodal emotion recognition.

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