Heart Rate Variability (HRV) during anger emotion stimulation: features for affective

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Abstract. Recent studies have revealed the relationship between human Emotion and health. Researchers are trying to find the best features to distinguish human Emotion through its psychophysiology signals in the Affective Computing study. Humans have six basic emotions, such as Anger, Sadness, Happy, Surprise, Fear, and Disgust. Emotions affect human ANS (Autonomous Nervous System). The heart is one of the human inner organs affected by the ANS (working under ANS). Heart rate is one of the Psychophysiological signals that changed depends on human Emotion. This study tried to analyze the difference between human heart rate during Anger and Normal Emotion Stimulation. Video Stimuli were used to Evoke Emotion. 15 Participant's heartbeats were recorded using an ECG sensor from E-Health Sensor Platform v2.0. We used HRV (Heart Rate Variability) MeanRR feature as a comparison. Some studies said that experiencing long-term Anger Emotions can cause serious illness to the human body. There are some differences in the MeanRR feature between ANGER State and NORMAL State. The findings of this investigation complement those of earlier studies about HRV. This research supports the idea that HRV can be used as a feature to detect human affect state.

1. Introduction
Mental health is an essential component of patients with a chronic disease. Many researchers said that Mental or Human Affect has a strong relationship with human health [5][7]. Positive and Negative Emotion can have a different effect on human health [5]. Some researchers said that negative Emotion could trigger chronic disease. Monitoring human affect is very important to keep humans from triggering the chronic disease on their bodies or even protecting humans with a chronic disease not getting worse because of their mental. A system that can detect or monitor human affect state can play an important role in addressing negative Emotion's effect on human health.

In Computer Science, there is a field of study named Affective Computing. Affective Computing is a field of study focusing on recognizing, interpreting, and simulating human affects [1]. It can help the scientist to recognize the human affect state. Some studied have been done to detect human affect based on their face, voice, and even gesture [8]. But the limitation of using Face Recognition is that it can be deceiving, it means that even some people are experiencing sad Emotions, they can look happy on the face [8]. To solve this limitation, we should use features that cannot be influenced by human will. According to the study held by Christian Peter in 2012, physiological sensing (internal part) can
be used to recognize human affect [10]. In this study, we will use the human heart rate as a feature to recognize human affect as has been used in our previous research [3]. Human heart rate works under the Autonomous Nervous System (ANS). The ANS acts unconsciously, and it controls systems like the human heart rate, respiratory rate, and sexual arousal. RR Interval is features from heart rate that occur. Data for this study were collected using an ECG sensor.

Twenty-one participants were recruited for this study and had been signing the informed consent. Our previous study in 2018 shows that HRVi (HRV Triangular) can be used as features to distinguish sad Emotion and normal emotion [2]. To build an emotional environment, we used Video Stimuli to evoke the participant's affect or Emotion. This video was studied before in 2015, and the result said that it is suitable for evoking human Emotion, especially for Indonesian people [11]. Some other videos, like LIRIS ACCEDE, studied by baveye et al. [9], had been using to provoke European people's emotions. Video is an excellent method to evoke Emotion [6][8]. ECG sensor used in this research has been previously investigated and published [4]. To analyze HRV, we were using the KubiosHRV application to obtain MeanRR features.

2. Methodology

Our proposed method is shown in figure 1. Our previous research has used this method to distinguish Normal Emotion and Sad Emotion [2].

2.1 Hardware And Software Preparation

E-Health Sensor Platform v2.0 (figure 2) was used to read psychophysiological Signals from the human body. It is a product from Libellium Cooking Hack. It has nine sensors embedded on a single board, such as ECG, EMG, Galvanic Skin Resistance, SPO2, Respiratory, Blood Pressure, Glucose, Temperature Sensor, and Body Position Sensor.

Figure 1. Propose method

Figure 2. E-Health Sensor Platform V2.0
This platform was connected to Arduino Uno to read and send the ECG sensor data to the CPU. Serial Communication was used to send data from Arduino Uno to the CPU, and we were using Coolterm application to read the data from Arduino Uno. Figure 3 shows the results obtained by Coolterm Application from Serial Communication Port.

![Figure 3. Data Recording using Coolterm application](image)

Arduino Uno was used to capturing data from E-Health Sensor Platform V2.0. We were using 50 Hz data sampling to get the best result on the ECG graphic. KSTPlot was used to display data from the ECG sensor. The experiments were run using custom software written in with C++ programming language.

2.2 Participants Checkup
A random sample of participants with age between 16 and 35 years was included in this study. They were recruited from university students. Criteria for selecting the subjects were as follows:

a. Have no mental disorder
b. Have no Heart Problem

Of the initial cohort of 21 participants, nine were female and 12 male. To identify the participant's agreement, they were asked to read the informed consent and signing the consent form.

2.3 Stimulation Process – Signal Recording
This process was done seven days after participants signing the consent form. 4 participants were recorded each day. This process takes six working days. The Stimulation process is divided into 3 sessions: Baseline Stage, Stimuli Stage, and Relax Stage (fig.4).

![Figure 4. Stimulation Process stages](image)

Baseline Stage is where participants did nothing for 1 minute and data recording was started. Stimuli Stage the participants showed a stimuli video, and the Relax Stage participants stop watching the video but data recording continues for 1 minute (fig.4).
Before data collection or data recording, the participants received an explanation of the study. The first step in this process was to settle the ECG probe to the participants' chest (fig.5). After the ECG was set, we tried to read the data and put it on display. If the data show no error or noise, then we could continue to the Baseline Stage. Once the participants said they were ready to continue, we started recording ECG data using the Coolterm application for 1 minute. After recording the Baseline Stage, the participants were then shown video stimuli to revoke their Emotion (fig.6). Once the video stimuli were finished, we continue to the Relax stage for 1 minute. Finally, participants were asked to fill the questionnaire about their feeling. Data was stored in a CSV file, so it can be displayed using KSTPlot.

2.4 HRV Process
All analyses were carried out using the KubiosHRV application (fig.7). This application was made based on Matlab software. Data that has been stored on a CSV file then processed on KubiosHRV, and it automatically detects the R peak and calculates all the HRV features.
As shown in figure 7, we can see the R peak detection graphic and the RR Interval graphic. It also presented the value of Time Domain HRV such as MeanRR. Each of three-stage of the stimulation process was analyzed to obtain the value of MeanRR features.

3. Result And Discussion
Of 51 participants who were sent invitations, 31 returned the reply, of whom 21 agreed to continue the study. There were only 15 participants who said that they feel the anger emotion while watching the video stimuli. Participants who did not feel anger were asked to suggest other reasons for their feelings about the video stimuli.

Table 1 illustrates the result of MeanRR while on Baseline, Stimuli, and Relax Stage of each participant.

| Participant | MeanRR (Ms) | Baseline | Stimuli | Relax |
|-------------|-------------|----------|---------|-------|
| A           | 772.70      | 840.12   | 781.00  |
| B           | 739.94      | 799.58   | 721.09  |
| C           | 916.33      | 876.34   | 878.46  |
| D           | 663.35      | 673.84   | 669.61  |
| E           | 992.22      | 917.62   | 872.68  |
| F           | 702.24      | 767.87   | 717.03  |
| G           | 658.24      | 664.23   | 668.87  |
| H           | 912.86      | 875.73   | 762.79  |
| I           | 789.29      | 673.90   | 709.94  |
| J           | 689.54      | 711.37   | 695.03  |
| K           | 659.35      | 612.21   | 642.39  |
| L           | 740.43      | 758.45   | 605.81  |
| M           | 699.26      | 707.43   | 672.70  |
| N           | 785.45      | 828.55   | 770.09  |
| O           | 609.59      | 667.25   | 634.78  |

Descriptive Stat

| Stat            | Mean | Median | Skewness | Minimum | Maximum |
|-----------------|------|--------|----------|---------|---------|
| MeanRR Baseline | 755.39 | 758.30 | 720.15 | 609.59 | 992.22 |
| MeanRR Stimuli  | 758.30 | 758.45 | 709.94 | 612.21 | 917.62 |
| MeanRR Relax    | 720.15 | 709.94 | 0.78    | 605.81 | 878.46 |

The mean MeanRR value for Baseline was 755.39, for Stimuli was 758.30, and Relax stage was 720.15. There was a difference between the three Stages of MeanRR. Figure 8 shows that there were 10 participants shows increasing in MeanRR while watching the video stimuli. On the opposite, there were 5 participants shows decreasing. This is a surprising result, and there is a significant change in MeanRR value while watching video stimuli (whether it Increase or decrease). Another reported result of this chart was 2 participants (E and H), showing the decreased value from Baseline to relax Stage.

According to these data, we can infer a difference in MeanRR on those three stages. A possible explanation for this might be that the human heart beats faster when in an angry state. These findings may be somewhat limited by the ECG sensor that used only three-wire.
4. Conclusion
The purpose of the current study was to determine the differences of MeanRR between normal state and anger state. From the data that has been compared in the result section, we can say that there is a difference between the Normal State and Anger State of human affect or Emotion. The results of this study indicate that we can use MeanRR features to distinguished human affect states. This investigation's findings complement those of earlier studies about using a psychophysiological signal to detect human affect. The study should be repeated using other features of HRV, such as in the Frequency Domain. Our previous research [2] concluded that HRVi could distinguish between Normal and Sad Emotion. The evidence from these two studies suggests that HRV can be used as a feature to detect the Human Affect state or Emotion State.

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