Analysis on Human Heart Signal during Sad Video Stimuli using Heart Rate Variability Triangular Index (HRVi)

Lantana Dioren Rumpa
Department of Electrical Engineering
Universitas Kristen Indonesia Toraja
Makale, Indonesia
dionrumpa@ukitoraja.ac.id

Adhi Dharma Wibawa
Department of Computer Engineering
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia
adhiosa@ee.its.ac.id

Muhammad Attamimi
Department of Electrical Engineering
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia
attamimi@ee.its.ac.id

Petrus Sampelawang
Department of Mechanical Engineering
Universitas Kristen Indonesia Toraja
Makale, Indonesia
sampelawangp@ukitoraja.ac.id

Mauridhi Hery Purnomo
Department of Computer Engineering
Institut Teknologi Sepuluh Nopember
Surabaya, Indonesia
hery@ee.its.ac.id

Srivan Palelleng
Department of Information Engineering
Universitas Kristen Indonesia Toraja
Makale, Indonesia
srivan_palelleng@ukitoraja.ac.id

***Abstract*— Researchers have discovered so far, that there is a closed relationship between psychological conditions and the physiological condition. Many researchers found that emotions affect a person's health, especially negative emotions. In this paper, we evaluated the correlation between the human's emotions and the heart signals. Heart signals were recorded using ECG sensors. Then, by using Kubios HRV we collected the HRV value both in time and frequency domain. This paper focused on data which was extracted using the RR Interval feature. The 29 healthy subjects were induced using video stimuli after they agreed through the consent form. The RR Interval feature that has been extracted was then analyzed using KUBIOS to obtain the value of HRVi (Heart Rate Variability Triangular Index) in time domains. The results show that the average HRVi value after being induced by video stimuli is 14.87. There is a significant difference between HRVi value before and after the stimulation process. Immediate increase of HRVi can lead to a fatal heart attack. The result showed us that in seven minute, HRVi value can immediately increase after experiencing Sad Emotion induced by Sad Video Stimuli.**

Keyword : Sad Emotion, Heart Rate Variability, ECG, Kubios HRV, HRV Triangular Index, HRVi

I. INTRODUCTION

The relationship between emotion and human health has led some researchers to focus on searching for the impact of emotional states on health, especially negative emotions. Some researchers found that negative emotions can lead to chronic diseases. Even research conducted by [1] said that humans who often feel negative emotions are more likely to be short-lived [2].

Presmann and his colleagues found that the human immune system is strongly influenced by psychological conditions (emotions). Humans are susceptible to disease if the immune system less-vigorous [2]. Basically, human have six emotions according to Paul Ekman [3][4] such as: Happy, Sad, Angry, Surprise, Fear and Disgust. When humans feel an emotional state, there will be alteration in the human body, especially enzymes, muscles and glands. This situation will affect the human nervous system, especially ANS (Autonomous Nervous System) [5]. Heart is one part of the human body that is affected by ANS. Heartbeat is not under human consciousness.

According to [5], if humans are experiencing emotions, the heartbeat will definitely be affected. The ANS plays an important role not only in physiological situations, but also in various pathological settings such as diabetic neuropathy, Myocardial Infarction (MI) and Congestive Heart Failure (CHF). Autonomic interference associating increased Heartrate has been been strongly affect in the sudden cardiac death [6]. Our previous work about correlation between Breathing and Stimuli using SPO2 Sensor said that Sad Video increased Heart Pulse [7],[8]. Automatically it can affect the Blood Pressure.

In this paper, to evoke sad emotions, each subject were induced by video stimuli. We use video stimuli from our previous work [9]. While subjects watching the video, an ECG sensor is mounted on their body (chest part). During the induction process, heart activity will be recorded using an ECG sensor from E-Health Sensor Platform v2.0. In order to record the data from E-Health Sensor Platform v2.0, it has to be connected with Arduino Uno. To estabilish a connection between Arduino Uno and PC, we used a serial cable or USB cable. A third party Software is needed to read the data stream from Arduino to PC. In this study, we used *CoolTerm* that contruct by Roger Meier [10]. The data that has been captured by this tool was recorded to build a dataset.

Psychophysiology Signal Dataset is a set of signals from our subjects that was recorded using ECG Sensor. After the process was completed, subjects were asked to fill out questionnaires that aimed to assess themselves about the emotions they felt during the induction process.

Heart rate signal is stored on the hard drive then the RR interval feature is extracted. Then, we explore and analyze HRVi using the Kubios HRV software.

Our hypothesis says that there are significance relation between HRVi and Emotion after Video Induction. We were also compared HRVi values between induced by video and people with chronic heart disease. We also argue that there are similarities in the HRVi values of people who are experiencing sad emotions and people who have heart disease.

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In 2016 Abreau said that HRV Geometric Index (including HRVi) has a strong correlation with type 1 diabetes melitus [11] and Lutfi said that HRVi associated with Asthma [12].

II. METHOD

Our experimental procedure is shown in Fig. 1.

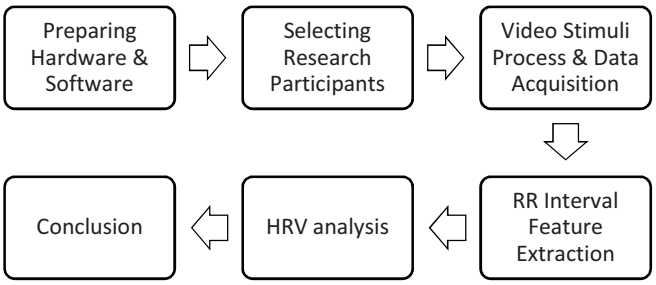

Fig 1. Proposed Method

A. Preparing Hardware and Software

E-Health Sensor Platform v2.0 was used to connect ECG Sensor and Arduino Uno. Three ECG Probe was connected to this Platform to gain Heart Signal. E-Health Sensor Platform v2.0 is a platform created by libellium and a multifunctional platform for detecting human biological signals. ECG is one of the sensors that integrated into this platform. Besides ECG, sensors such as Air Flow, ECG, Blood Pressure, GSR are also integrated into this platform (see Fig. 2).

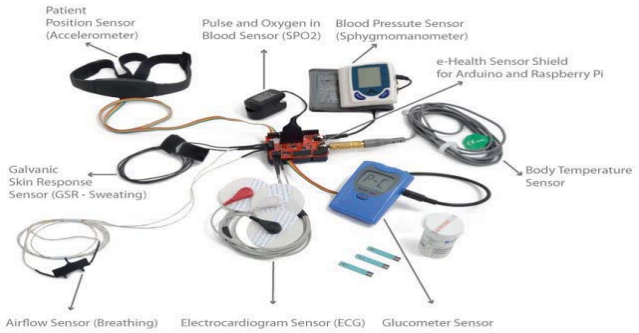

Fig 2. E-Health Sensor Platform v2.0

B. Selecting Subjects

In this study, we used random selection method to obtain 41 subjects. The subjects aged between 17-25 years. Subjects are healthy and do not have chronic diseases. There were 12 males and 17 females for the subjects, which were informed about this research method, the purpose of this research and the process of evoking the emotion with video and also they were informed about the data retrieval process.

C. Video Stimuli Process and Data Acquisition

At this stage, we performed emotional stimulation and data collection. The process of emotional stimuli used the videos that we have previously studied. Subjects who have agreed to this process will receive a schedule and briefing. We conducted the data collection with three to five subjects per day for five days in a week. The data of one-hour length was collected for each subject.

The process began with a briefing about the data collection process. The subject 's body was equipped with an ECG electrode by our assistants. ECG electrodes were then connected to the platform and then the cardiac output was tested. If the output signal was as expected, then the subjects was sit down and the data collection process began. The data collection process was divided into three sessions: Baseline Session, Stimuli Session, and Recovery Session (see Fig. 3).

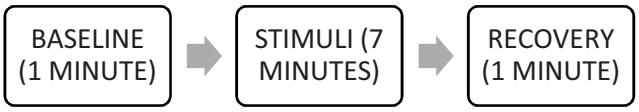

Fig 3. Data Collection Process (three sessions)

The First Session was Baseline Session, where subjects were requested to sit down and listened to a song/music from the headset. Relaxation was needed by the subjects. This was also aimed to record Heartbeat before stimulation. In this session, the data as well as acquisition process was started to be recorded. We were using Coolterm to record the data from the ECG Sensor to the PC via serial port.

The stimuli session was the stage where subjects began to watch stimuli videos. This session lasted seven minutes or equals to video stimuli's duration. In this session, the data recording process continued until the stimuli process had been completed.

Recovery session was a stage where video stimuli had been completed. Data recording process still continued for one minute. The purpose of this stage is to verify subjects' heart responses after watching stimuli videos. After the recovery session, subjects was asked to fill in the post-questionnaire in order to detect their real emotion by self-assessment method.

D. Feature Extraction

The output of the ECG sensor is the PQRST signal. This signal is produced by electrical waves found on the surface of human skin. Electric current in the heart spreads and moves to the surface of the skin. This provides a potential difference in the surface of the skin, so it can be detected using ECG electrodes. The PQRST signal form is shown in Figure 4.

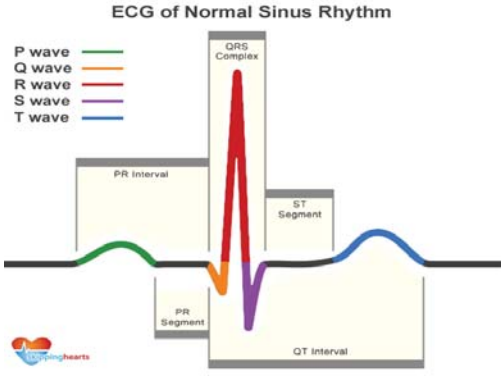

Fig. 4. ECG Signal (PQRST)

Every single beat in a heart cycle has three main waves:

1) *P Wave. This wave is affected by the atrial muscle.*
2) *QRS Wave. Contraction of thick ventricular muscles.*
3) *T Wave. Ventricular muscle is repose and electricity becomes normal.*

RR Interval is the interval from the peak of one QRS complex to the peak of the next as shown on an electrocardiogram. It is used to assess the ventricular rate. In this paper we tried to Extract RR Interval from ECG signal. Kubios HRV is a tool that we used to extract RR Interval from our dataset of human psychophysiology signal (Figure 5).

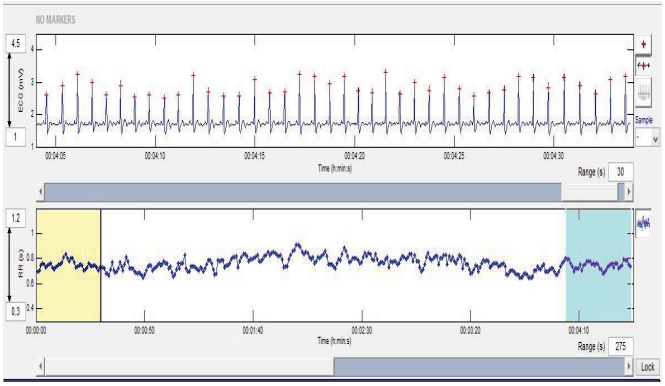

Fig. 5. Features Extraction with Kubios HRV

Kubios HRV is also made a result of HRV value both in Time-Domain and Frequency-Domain. Time-Domain HRV result covers Mean RR, STDRR (Standard Deviation), STD HR, RMSSD, NN50, pNN50, HRV Triangular Index, and TINN. The Frequency-Domain result attributes covers such as VLF (Very Low Frequency), HF (High Frequency), LF (Low Frequency), and LF/HF (Ratio between LF and HF).

Time-Domain Results

Variable	Value	Units
Mean RR*	761.64	ms
STD RR (SDNN)	74.824	ms
Mean HR*	79.345	1/min
STD HR	6.1198	1/min
RMSSD	81.188	ms
NN50	33	
pNN50	9.2179	%
HRV triangular index	13.296	
TINN	370	ms

* Calculated from the non-detrended selected RR series.

Frequency-Domain Results

Variable	VLF	LF	HF	LF/HF
FFT Results				
Peak (Hz)	0.0039063	0.046875	0.26172	
Power (ms2)	2925.8	2717.2	3056.0	0.88913
Power (%)	33.593	31.198	35.089	
Power (n.u.)		46.981	52.839	
AR Results				
Peak (Hz)	0.0039063	0.042969	0.21484	
Power (ms2)	2200.5	1922.9	2378.4	0.80847
Power (%)	33.789	29.525	36.520	
Power (n.u.)		44.592	55.156	

Fig. 6. HRV Result Time-Domain and Frequency-Domain

In this paper, we tried to figure out the HRV value when human experienced Sad Emotion. We were using HRVi to compare the value of human psychophysiology signals when they felt Normal emotion (Before Stimulation) and Sad Emotion.

E. HRVi Analysis

HRVi [13] is one of the geometric indices in Time-Domain HRV. The NN (Normal to Normal) interval circuit can also be converted to a geometric patterns, such as the density distribution of NN time intervals, the distribution of pattern density differences between adjacent NN intervals. Therefore we can said that HRVi is classified as Time-Domain HRV. Some researcher used RRtri acronym refers to Triangular Index [11]. In this study, we used Kubios HRV to analyze HRVi value from RR Interval. In Fig. 6, we can see the result of HRVi from Kubios HRV software. The HRV triangular index measurement is the integral of the density distribution divided by the maximum of the density distribution.

Some researchers have studied HRVi's relationship with several chronic diseases. Because HRVi is associated with Autonumous Nervous System [14] and pulmonary function, in this study we also try to find whether HRVi's drastic changes are dangerous.

III. RESULTS

The value of HRV Triangular Index from each subject in the Psychophysiology Dataset were summarized in Table 1. In fact, we have 29 subjects, but after they fill out the questionnaire only 15 subjects experienced Sad Emotion towards Video Stimuli. Others subjects experienced another emotion, hence we did not use their dataset as an analyzed data in this study. We were focusing on analyzed Sad Emotion Psychophysiology Signal on this paper. Other Emotios will be analyzed and studied in the future work.

TABLE I. HRVI VALUE OF THE PSYCHOPHYSIOLOGY DATASET FOR EACH SUBJECT

NO	BASELINE	STIMULI	RECOVERY
Subject 1	11.50	18.82	8.22
Subject 2	22.33	30.00	16.20
Subject 3	8.00	17.48	11.33
Subject 4	7.73	13.12	7.00
Subject 5	9.67	25.44	14.00
Subject 6	6.50	9.50	6.54
Subject 7	14.33	10.78	10.30
Subject 8	10.50	17.95	6.55
Subject 9	10.71	15.77	7.70
Subject 10	6.62	9.59	7.91
Subject 11	6.69	9.04	5.35
Subject 12	4.88	13.24	6.73
Subject 13	8.80	8.24	7.25
Subject 14	8.10	11.47	9.33
Subject 15	6.53	12.60	12.00
Descriptive Statistic			
Mean	**9.53**	**14.87**	**9.09**
Standard Error	**1.11**	**1.61**	**0.80**
Median	**8.10**	**13.12**	**7.91**
Standard Deviation	**4.29**	**6.25**	**3.09**
Sample Variance	**18.40**	**39.08**	**9.57**
Kurtosis	**5.39**	**1.30**	**0.52**
Skewness	**2.09**	**1.29**	**1.10**
Range	**17.45**	**21.76**	**10.85**
Minimum	**4.88**	**8.24**	**5.35**
Maximum	**22.33**	**30.00**	**16.20**

Sum	**142.89**	**223.04**	**136.41**
Count	**15.00**	**15.00**	**15.00**

From 15 subjects, we found that the HRVi of 13 subjects was increased while watching sad video whereas the other two subjects was decreased. Before stimulation, the average HRVi value was 9.53, it refers to normal heartrate (without stimulation) HRVi.

During stimulation process, HRVi was increased to 14.87. After stimulation, the HRVi value decreased back to normal at 9.09. Baseline Session has a HRVi range between 4.88 to 22.33. Stimuli Session range between 8.24 to 30.00. Recovery Session ranged between 5.35 to 16.20.

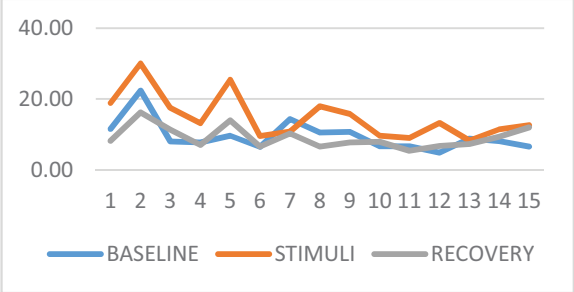

Fig. 7. Three Sessions Comparison Chart

Figure 7 shows us that Stimuli Session has a biggest Value than Baseline and Recovery Session. Other result show us that Recovery Session has smallest Value. We assume that in one minute after watching Video Stimuli most of subjects return to the initial state (Normal State).

TABLE II. REGRESSION STATISTICS

Regression Statistics	
Multiple R	0.689277115
R Square	0.475102942
Adjusted R Square	0.434726245
Standard Error	4.700328766
Observations	15
ANOVA Significance F	0.004474435

Pearson Correlation value (0.6899277115) on table II shows us that there is a strong positive relation between HRVi and Emotion. And Significance F Value ($0.004474435 < 0.01$) give us information that Emotion (Stimulated by Video) has a significant effect on HRVi.

IV. CONCLUSION AND DISCUSSION

After we observed the result we can say that there is a difference HRVi value before and after stimulation. We also conclude that Sad Video Stimuli has an effect on HRVi. It also can increase HRVi during Stimulation Process. We also believe that Video Stimuli affect Heartrate in an instant way.

Value Escalation in Stimuli Session has given us a view that people who experienced Sad Emotion could increase their HRVi. All of this experiment was held in short-term data acquisition. Sad Stimuli can increase HRVi in short time (seven minutes). We assume that if we are experienced Sad Emotion, it is equal to give a heavy task to our heart. But this is only our opinion, it needs more studied to reveal this.

Result from Table 1 shows us that Video Stimuli has a same effect on 13 subject. It create an increased pattern from HRVi value. We need more subject to study the pattern of Psychophysiology Signal especially Sad Emotion Signal.

Some researcher said that suddenly increase in HRVi can lead to Nervous System disbalance [6] and further may trigger disbalanced in breathing. Disbalanced in Nervous system can affect many things in human body. Asthma maybe triggered by this HRVi increased.

Future work of this study is to reveal other Emotion associated with Heartrate. We also believe whether Video Stimuli can be used for Heart Therapy because it can drastically change HRVi in a minute. This certainly requires deeper research.

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