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PHYSIOLOGICAL PATTERN OF HUMAN STATE EMOTION BASED ON ECG AND PULSE SENSOR

[1]ADHI DHARMA WIBAWA, [2]MAURIDHI H PURNOMO, [3]AKHMAD MARZUKI, [4]LANTANA D RUMPA

[1]PhD., Department of Multimedia and Network Engineering, Institut Teknologi Sepuluh Nopember, Indonesia
[2]Prof., Department of Multimedia and Network Engineering, Institut Teknologi Sepuluh Nopember, Indonesia
[3,4]Master., Department of Electrical Engineering, Institut Teknologi Sepuluh Nopember, Indonesia

E-mail: [1]adhiosa@te.its.ac.id

ABSTRACT

It has been known widely that emotion effects the human being physically and phsycologically, whether it is a positive or the negative emotion. With the develpoment of e-Health sensors technology nowadays, those human emotions can be described physiologically so that some negative impacts of negative emotions then can be avoided through monitoring. This study presents the physiological data of 6 human state emotions (happy, fear, sad, angry, surprise, disgust) in term of timing of onset, offset and the behaviour of physiological data due to emotion stimulation. The result of this study will be used as the basic information in term of physiological pattern in developing the early warning sistem for patient with chronical diseases. Two e-Health vital sign sensors were used to record the physiological data during video stimulation, ECG and pulse sensors. Six different videos for 6 different emotions stimulation were used to trigger the participant's emotion. 30 healthy participants were involved in this experiment. Some features from both sensors such as mean of R-R interval during baseline and stimulation, onset and offset timing were presented. Sad emotion showed the highest mean of heart rate activity during stimulation compared to other emotion, while happy emotion can lower human heart beat during stimulation.

Keywords: *Basic human emotion, Physiological pattern of human emotion, e-Health sensor, Pulse and ECG sensor, vital sign sensors*

1. INTRODUCTION

Human emotion has been studied by many researchers in the past. Some studies have shown that emotion has a significant influence in human's health [14], whether it is a negative or positive emotion. Happy emotion has been studied by [3][9] that shows its potential in increasing human physical performance. Other report said that positive emotion like happines can also increase the brain's performance especially in memorizing information and math [6]. Ostir and Kawamoto [12][7] even showed in their researches that positive emotion can prolong human life. Moreover, contrary it has been reported by [5] that negative emotion could decrease the immune system, and increase the level of blood pressure [3]. Furthermore, negative emotion could also make some acute deseases becoming worse such as blood pressure, asthma [1], diabetes mellitus or cardiovascular disease [14]. Recently, patient's treatment and monitoring have been done very well by practitioners mainly in term of their physical condition. However, less attention is given by the hospital system or practitioners to monitor the patient emotion in which from literatures we can see that emotion has a great effect on human's health. Since the technology of vital sign sensors has been developed in a more mature stage, the way doctors treating patients also changes especially in term of patient monitoring system [16]. This study presents physiological pattern of 30 healthy subjects when they express their basic emotions [13] due to a video stimulation by using ECG and Pulse vital sign sensor. This pattern would be useful as the basic information of smart system development for e-Health monitoring system for elderly people who live alone in their housing. This

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system will be able to identify the dangerous pattern of physiological respond from elderly people so that some warning then can also be developed. Some studies have showed that emotion has a potential in biasing someone in making a decision, this could be a critical issue when relating to a specific profession in the society [2]. We hypothesized that each emotion has a unique physiological pattern when they are being expressed and must be subject specific. More over, during video stimulation, the heart beat activity is higher, compared to the baseline condition when the subjects were in relax condition. We hope that the result of this study can be used as reference for developing early detection system for patient's emotion monitoring system so that some negative impacts due to negative emotion expression can be avoided especially for patients or older people with acute diseases like Cardiovascular, High Blood Pressure or Diabetes Mellitus. Other important information regarding the behaviour of each emotion in relation with the video stimulation would also be discussed in this paper such as which emotion is more potential in triggering Cardiovascular problem.

2. METHOD

This study involved 30 healthy subjects with age ranges from 17 to 25 years old. The gender composition was 13 male and 17 female. Each subject signed an inform concent before involving in experiment. All necessary information including the side effect of watching video stimuli have been explained to all subjects. Subject may leave all experiment when they feel uncomfort during measurement. The list of video stimulation and its duration was shown in table 1.

Table 1. Video stimuli duration

No	Type of video stimulation	Duration (minutes)
1	Happy	08:46
2	Fear	02:41
3	Sad	07:01
4	Angry	01:57
5	Surprise	00:21
6	Disgust	02:29

Six basic human emotion [13] were trigerred by using 6 video stimuli that have been validated by [15], they were: happy, fear, sad, angry, surprise and disgust. Questionare must be filled by each participant to confirm their emotion respond after stimulation to validate the level of their emotion. The order of stimulation was shown in figure 1. During emotion stimulation, there was a break of 30 minutes to one hour in between two video stimulation. The flow process of experiment was described in figure 1. Pulse and ECG sensor from E-Health Platform v2.0 Sensor (by Coocking Hack Libelium) were implemented to record the physiological data at the same time.

The first recording was done at about one minute before the video was played. It was continued during the video playing, until about one minute after the video ended. In this experiment a break was given for about 30 minutes in between two triggers (two video stimulations) so that normal/relax condition then can be achieved from the influence of previous stimulation.

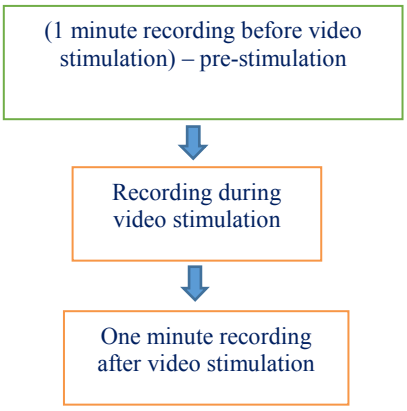

Figure 1. The flow process of Pulse and ECG sensor recording

2.1 Experimental set up

2.1.1.Pulse sensor

Pulse data was recorded via subject's finger tip. Human heartbeat/pulse depends on some parameters, in order to improve the accuracy in recognizing emotion pattern physiologically, a data normalization is needed. Normalization is normally used to minimize the effects of differences signals in term of age, gender, ethnicity and changes in hormone cycle of participants [4].

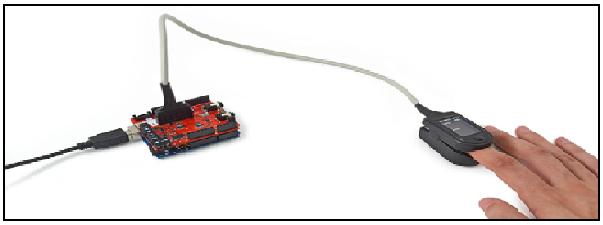

Figure 1. Pulse sensor at finger tip (www.coocking-hacks.com)

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In this experiment, pulse sensor from E-Health Platform v2.0 Sensor (Coocking Hack Libellium) was used to record the physiological data of each emotional state. This sensor is a non-invasive, practical to monitor the pulse and Oxygen levels in the human body. This sensor is connected to a sensor module in e-health system then connected to Arduino. From Arduino the data then transmitted to a CPU using serial data reader CoolTerm for analysis (available freely online). The sampling frequency for reading the data was 46 Hz. The sensor was fitted to the index finger or thumb of volunteer (figure 1). The data in PC was saved in txt format. The experiment was done in a comfortable room with air conditioner, separated from any human disturbances such as noise or other things that can distract volunteer's attention.

2.1.2. ECG sensor

The ECG sensors that were used in this experiment was from cooking-hacks. The recording process of cardiovascular data was done parallelly with pulse sensor. The placement of sensors was based on the cooking-hacks manual (see figure 2). Some tools and devices that were used during cardiovascular data recording are:

1. CoolTerm application, this free software was used to read the serial communication data between Arduino and PC (can be download in: http://freeware.the-meiers.org).
2. KST Plot application, is also free application that was used to show in realtime the graph from ECG sensor through a serial data communication (from Arduino to PC). Stopwatch was used to measure the time of pre-recording, recording and post-recording.

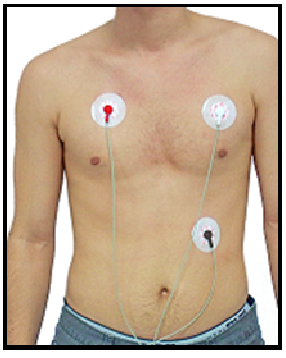

Figure 2. ECG sensor placement

Each subject was prepared by sitting comfortably and in relax condition, with all sensors were already attached. When he/she was ready, then the pre-recording was started for 1 minute as the baseline.

2.2 Determining the Baseline

Characteristic data from Pulse and ECG sensors are subjec specific, meaning that the recorded data from one person may vary significantly compared to others, that is why in this experiment the range between baseline and peak would be used as the data of emotion expression range. Due to this condition, subjective baseline is important in determining the level of data. In this study, baseline was defined as the level of data when the condition of participant's emotion is in relax or comfort condition. However, normalization is need for each single recorded data. For Pulse sensor, baseline was used to normalize the recorded data [10]. The normalization was done based on equation (1):

$$\overline{p} = \frac{p - p_{\min}}{p_{\max} - p_{\min}} \quad \text{.....(1)}$$

while, $\overline{p}$ = normalized pulse value for analisis

p = recorded pulse value

p_{min} = minimum pulse value during baseline

p_{max} = maxium pulse value during baseline

$p_{max} - p_{min}$ = range pulse of baseline

According to equation (1), we can have the mean of baseline from all participants in their relax condition. This average baseline will be compared to the baseline obtained from literatures as our validation process before continuing to the next steps. All of pulse parameters for our analysis were derrived from this mean of baseline, such as time of arousal (time that was calculated from the video start till the data was higher than the baseline) or called onset position, offset position (the condition when the data was lower than the baseline), peak of the data (peak of the emotion response) and number of amplitudes.

For ECG sensor, Heart Rate Value (HRV) and its properties were used as parameters of ECG sensor such as R-R interval value (time distance between two peaks of ECG data), mean of R-R interval (in a specific time frame) for example, time frame during pre-stimulation or time frame during stimulation.

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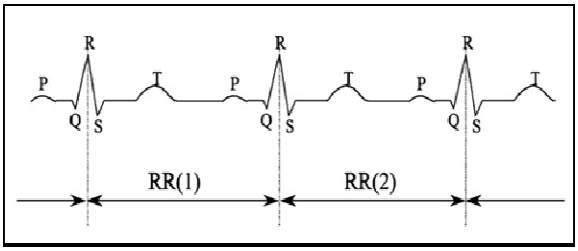

Figure 3. value of RR Interval [18]

In addition, in ECG data, onset is important not only in determining the status of emotion but also describing the behaviour of subject's emotion, beside contains information of video stimulation effectiveness. While offset determined the recovery status and the duration for recovery. However, one should remember that offset does not always show up in our last time frame of recording after the video was stopped (about one minute duration) because offset describes someone's recovery process, and in some condition, when the emotion was not recovered well, offset just didn't present. In ECG data, the lower the value of R-R interval meaning that the number of heart beat is more, and certainly the tense of the blood vessel also increases. An onset was defined when the data (mean of R-R interval) was lower than the baseline value. Peak data will be defined as the lowest R-R interval value.

3. RESULT

The result of this experiment in term of Pulse and ECG data were subjectively related to the video stimulation that we used during experiment, including the position of onset and offset, time of arousal, time of recovery, amplitude etc. However the physiological pattern that was obtained from this experiment may result a new insight and gained new knowledge in studying human emotion in physiological pattern. Regarding the pulse sensors, from 30 volunteers, the physiological pattern of six emotions were described in figures below. Figure 1 showed how is the behaviour of each emotion in responding the video stimulation during experiment, for example, surprise emotion had the shortest periode in term of time respond and this agrees with the nature of surprise video stimulation (see figure 3 too). Disgust showed the longest time respond. However, this result again is subjective to the video stimulation that we used. Figure 2 showed the mean of maximum amplitude of each emotion during stimulation. Happy seems to have the highest amplitude in terms of Pulse sensor, followed by disgust and then sad.

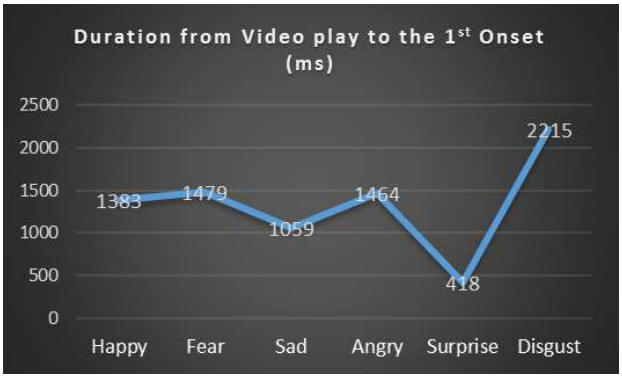

Figure 1. Mean of duration of emotion arousal from video play to the 1st Onset in milisecond (ms) – Pulse sensor

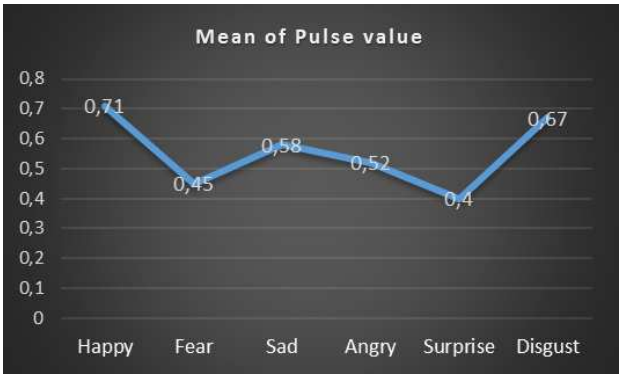

Figure 2. Mean of Pulse value from all 6 emotions – Pulse sensor

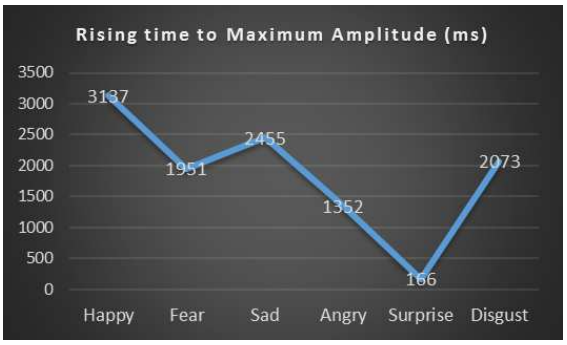

Figure 3. Duration of rising time from the 1st onset to the maximum peak of each emotion in ms – Pulse sensor

For ECG sensor, the mean of R-R interval during baseline from 12 participants as example was showed in figure 4. For ECG sensor data, the value of R-R interval represents the data of beat per minute (BPM). The smaller the value of R-R interval, the more beat per minute data they have. For example, R-R interval with value 600 is more

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activity in term of heart beat compared to R-R interval of 700.

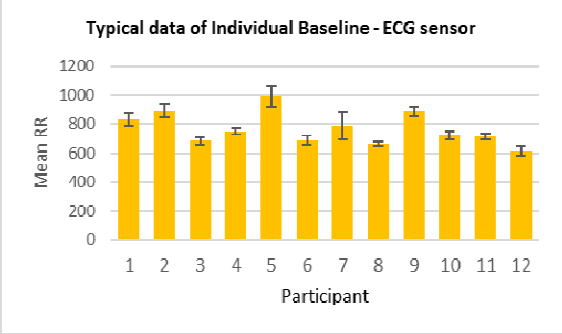

Figure 4. Typical data of mean R-R interval from each participant data during baseline (before video stimuli)

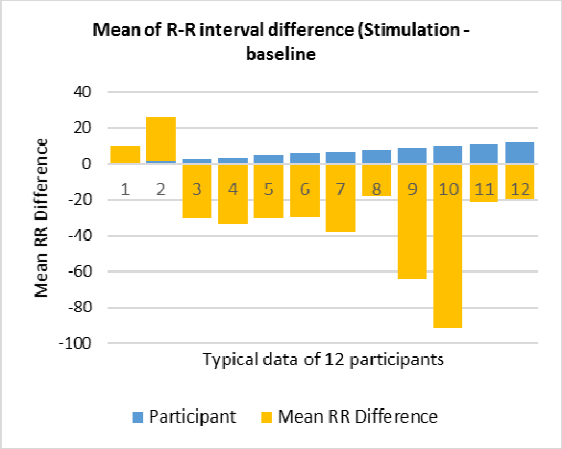

Figure 5. Typical data of Mean of R-R interval difference per participant (R-R interval during video stimulation – R-R interval during baseline)

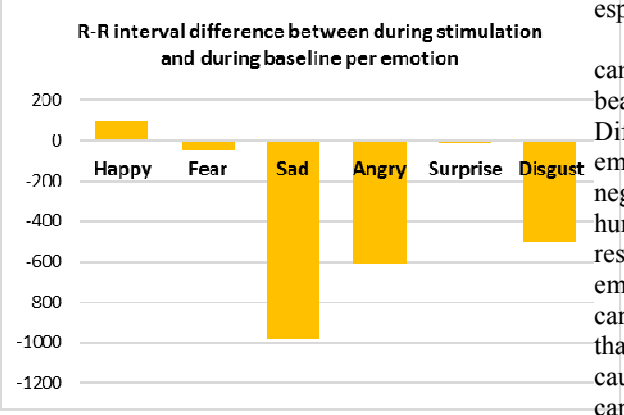

Figure 6. Mean R-R interval difference between during video off/baseline and during stimulation per emotion

4. DISCUSSION AND CONCLUSION

The results showed that Pulse sensor can show important data in term of timing (see figure 1-3), while ECG sensors showed more in the behaviour of heart activity (see figure 4-6). When considering the Pulse sensor (see figure 1), video stimulation of surprise triggered the emotion to rise up faster than any other emotions, this result agrees well with the nature of surprised stimulation. However, surprise stimulation showed also as the shortest emotional respond that reaches to the maximum amplitude during stimulation, compared to other emotions (see figure 3). More over, surprise showed as the lowest emotional respond in terms of heart beat amplitude (see figure 2), from this fact we opinioned that this surprise video stimulation was not dangerous to the cardiovascular activity. Figure 2 showed that happy, disgust and sad are the 3 emotions that have the highest amplitude. This means that they have more potential in trigering the cardiovascular problem. When considering figure 3, happy seems to have the longest respond to rise up, followed by sad. We think that this is because trigering happy and sad emotion at some point need time. The subjects need to think the facts that they saw from the video, and they need to correlate that video with their life experiences or memories. That is why, happy and sad showed the longest time to respond from the participants. When relating this result with the facts in our daily life, we can temporarily conclude that surprise news followed by sad news (surprise sad news) can have bigger potential in triggering cardiovascular problem, especially for elderly people.

Furthermore, when considering ECG data, we can see that sad emotion triggered the highest heart beat, followed by angry and disgust (see figure 6). Difference condition was recorded during happy emotion. This means that, as we all know that negative emotion has a significance impact on human's health and immune system [5], from this result we should be aware of the impact of sad emotion, especially to the older people with cardiovascular or diabetic disease. We speculate that this could be the cause of heart attack that causing many death in older people with cardiovascular disease in the world wide. Contrary condition happened during happy stimulation, we recorded that during happy stimulation the heart beat in general was lower, this indicating the relax condition of participants during happy stimulation.

When we look at figure 4, we can see that the baseline condition of every person is different and

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very subject specific. Type of person, educational background and other social aspects are also part of subject specific condition even though further study need to be performed to prove it scientifically. From figure 5, we see that during stimulation, in general the activity of heart beat was increasing, this was showed by the fact that the mean of R-R interval during stimulation was smaller compared to R-R interval during baseline (before stimulation). That is why the result in general was negative (see figure 5). However the increase was also difference among participants. For example, subject number 10 (figure 5) seemed to have more emotional responds, compared to others. This study can also be used to described a typical information of someone's emotion or group of people's emotion. From all of those results we can conclude that Pulse and ECG sensor can be used to describe human emotion respond physiologically in two ways, the timing and the behaviour of the 6 basic emotions. Sad emotion has the highest heart activity during stimulation (especially based on ECG data), this means that sad has a higher potential in triggering some problems like heart attack or high blood pressure especially for people with cardiovascular disease or older people. Happy seems to be useful in relaxing people' emotion. However, further study need to be performed to evaluate and measure in detail the impacts of all of these emotions to the human health, and if necessary the result should be validated by the subject's psychological data.

These two important data (Pulse and ECG) have completed each other and agreed with the previous study [11] so that some understanding and new knowledge regarding the physiological data of human emotion during stimulation can be obtained. Even though these data are subjective to the participants background and the type of video stimulation that were used, however the pattern of all physiological information remains important especially for developing an early warning system for e-Health monitoring system for elderly people because their behaviour remains objective. This result, however, was too broad, since we included 6 basic emotions in the experiment. In the near future, we will focus on only 3 important emotions such as sad, happy and angry, so that better observation and analysis can be done to gain better knowledge in understanding human emotion physiologically.

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