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A Review of ECG signals for Human Emotion Detection

[1]Deepak Kumar
M.Tech Scholar, Department of Digital Communication,
Arya College of Engineering & IT, Jaipur, Rajasthan

[2]Prof. Hemant Kumar Gupta
Professor, Department of Electronics & Communication,
Arya College of Engineering & IT, Jaipur, Rajasthan

[3]Prof. Rahul Shrivastava
Professor, Department of Electronics & Communication,
Arya College of Engineering & IT, Jaipur, Rajasthan

Abstract: This article evaluates the present development by means of literature review in determining the association between emotions, mainly worry, and the various physiological signals with special attention on the exclusive patterns of the electrocardiogram or ECG waveform. An initial investigation was carried out to evaluate which aspects in the ECG waveform can be most suitably related with worry, except from those. Hence, it has been observed that emotion identification utilizing particular aspects of ECG is investigated to a lesser degree compared to other physiological reactions like speech signals, skin conductance and temperature, facial expression, heart rate and blood pressure. With the initial investigation, it was further discovered that the T waves levels out consequently and there is some likelihood of P waves.

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I. INTRODUCTION

Customarily, electrocardiogram or ECG has been utilized to detect cardiovascular illnesses and cardiac anomalies medically (Israel *et al.*, 2005). ECG gives much data concerning the cardiac roles via its patterns. Contrary to before, the utilization of ECG has evolved to be more widespread to count fields such as dishonesty sensing, stress and feeling metrics and person recognition these days. This started with William James hypothesizing in 1894 that the sensory signals from our brains ended up in exclusive physiological reactions that are brought about by the incitement and which subsequently generate the related emotions (Rainville *et al.*, 2006). This ignited some attention in studying if an exclusive mixture of physiological reactions might mirror a particular emotion, which implies that if an emotion may be identified just by viewing the bodily reaction and implies even the likelihood of measuring emotions though the use of such physiological signals. Emotion identification, particularly employing biological signals, turned out to be popular recently as a growing number of methods were conceived for quantification of bodily reaction. Reactions that are gauged with facility, like skin temperature, blood pressure, and heart rate, were general domains to be studied. Afterwards, more attention was aroused in investigating the exclusivity of the ECG waveform as one of the biological signals to provide us intuitions into people's feelings.

In this research, we endeavour to evaluate the actual development, by means of literature in determining the association between emotions, mainly worry, and the various bodily signals with specific attention on the exclusive patterns of the ECG waveform. An initial investigation was carried out to evaluate which aspects in the ECG waveform can be more suitably related with worry, except from those.

II. EMOTION

As per the American Psychological Association or APA dictionary (2006), emotion is described to be a complicated response pattern, implicating practical, behavioral, and bodily components, through which the person tries to handle an individually important subject or occasion. There are disputes concerning whether emotions originate from the bodily reactions (James-Lange Theory) or bodily reactions are evoked at the same time as feelings by the emotion-eliciting stimulus (Cannon-Bard Theory) (Myes, 2001). Still, this would not be critical at this stage as in this investigation, we are just confirming if there is a particular ECG stamp to worry, whether it is an origin or an impact.

III. ORIGIN AND MECHANISM OF ECG

ECG is a technique which gauges the electrical potential and notes the cardiac electrical activity with time. Such bioelectric potentials occur because of the electrochemical activity of nervous cells, which are cells that can conduct motion potential. The muscle fibres (additionally called myocytes) of the heart are built of these cells. Furthermore, the heart contains a cluster of particular cells, which may impulsively create urge, at the Sino-Atrial or SA node. This node, also the pacemaker in a cardiac phase, will shoot at the myocytes at the atria, then extend the urge to the Atrio-Ventricular or AV node. This AV node will now send the urge to the ventricles through Bundle of His and Purkinje fibres and result in the ensuing tightening of the heart muscles. This ends up in a heartbeat.

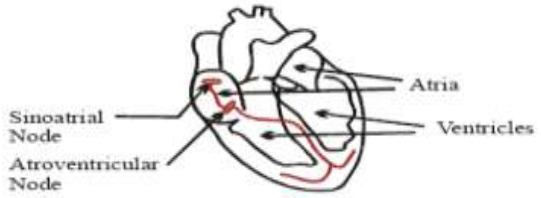

Figure 1: The heart and its pacemaker. SA node is the primary pacemaker. The red line shows the path which the electric impulse takes.

The orientation of the extension of electricity begins at the atria and ends at the ventricular peak (Bowbrick and Borg, 2006). To analyze the patterns, one has to gauge the potential. It is normally considered to be a net comparable current dipole situated at the electrical core of the heart, which resides inside the heart (Hynes). Afterwards, this may be easily determined by providing to this electric current a vector. Every heartbeat comprises of P, R, and T composites.

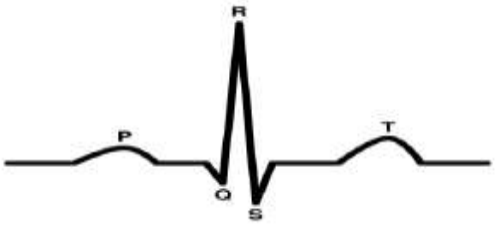

Fig. 2 shows a normal waveform.

Every composite or portion matches to dissimilar stages of the cardiac sequence. The P-wave is found while the atrial is depolarizing, the QRS-wave is the moment the ventricles are depolarized, whereas the T wave is because the ventricular repolarises.

IV. LITERATURE SURVEY

Up till now, emotion identification utilizing bodily reactions is a comparatively novel domain, which has yet to be investigated. The most frequent bodily reactions that are employed to identify feelings are the expressions of the face and speech signals (Haag *et al.*, 2004). Alternative usual ones are skin temperature, skin conductance, blood pressure, heart rate, and respiratory rate (Bauer, 1998). Of these, some are also employed in polygraphs really frequently. ECG, if being utilized in feelings identification trials, is typically for the RR gap to compute the heart rate and additionally the Heart Rate Variability or HRV. The characteristics of ECG waveform are currently studied, though they were mostly for clinical functions. Numerous investigations on ECG waveform were to determine if any characteristics could indicate a person's vulnerability to cardiac illnesses or anxiety disorder or spontaneous death. Previous studies have been carried out on the way the QT dispersion, which is the utmost interlead disparity in QT gap 12-lead ECG, relates positively with the people having anxiety warning signs (Uyarel *et al.*, 2006). The State-Trait Anxiety Inventory level was utilized to gauge the degree of anxiety in the person's nature, in other words, the propensity of the person to feel worried, or at that moment in time. That is, it is to determine if the QT distribution may be a state or a character signature (Uyarel *et al.*, 2006). In fact, the greater the value, the greater the QT gap is, even for the people who do not have cardiovascular anomalies (Piccirillo *et al.*, 1999). This means a greater danger of having abrupt or extended anxiety. Comparable researches on P wave distribution and optimum P time-span have been conducted by Uyarel *et al.* (2005). These two aspects were observed to be consequently associated with anxiety. Whereas these investigations have proven association between anxiety and these researched aspects, no action was taken on the people under observation to incite this feeling. For different trials which implicated emotion stimulus, the characteristics of ECG are as yet not studied deeply, apart for utilizing its RR gaps and HRV. ECG may further be utilized to recognize people (Israel *et al.*, 2005).

V. EXPERIMENT

A. *Subject And Equipment*

Two persons in good health, having no medical records of coronary illnesses or anomalies, and who do not follow any treatment before the trial, took part in the trial for the viability investigation. They are ladies aged 22 and 23.

B. *Procedure*

Before the experiment, the ladies were asked to fill a medical screening questionnaire to guarantee that they are sufficiently healthy for the experiment. Advance alert that the trial involved shocking portions was provided to the ladies. They would subsequently be connected on the Neuroscan equipment. Standard Lead II ECG setup was employed. A couple of electrodes were positioned on the two collar bones and the ground electrode was tied to their waists. The ladies were then informed that an ECG reference gauge of ten minutes would be noted initially and then they would be exposed to a five-minute video which can be outrageous. Though, prior to the conclusion of the tenth minute, at the seventh minute, the tester would stun the ladies by yelling really stridently behind them. They additionally would not be exposed to absolutely any movie. Immediately after the stunning, five more minutes of recording will be taken. Lastly, the ladies will be verbally requested to provide some opinion concerning the trial.

C. *Analysis*

The outcomes were only being found and studied by ocular contrasting between the reference ECG and the ECG during the anxiety moment. This is only to collect some of the clear characteristics that can actually be correlated with anxiety.

VI. RESULTS AND DISCUSSION

Immediately after stunning, the two ladies had a rise in their heart rates. A rise in HR means a reduction in the duration of a sequence. A minute after the stunning, the HR begins to lower to the dormant HR.

A. *Subject 1*

The ECG waves look more disorderly compared to the dormant ECG waves. In the collected waves, there are those that looked like P waves though they, simultaneously, seem to be similar to moving items. Thus, it is not finalized if numerous P waves are observed because of the quantity of items. The average amplitude of the P wave prior to stunning is -278μV whereas after stunning, the P wave possesses a mean of -287.81μV. There appears to be more variance in the P am-278μV plitude. In fact, lady 1, when stunned, has greater negative QRS amplitude. When mapped, the ECG waveform models, typically, QRS amplitude has greater negativity.

ECG Wave	Before Stunning Amplitude	After Stunning Amplitude
P Wave	-278μV	-287.81μV
QRS Wave	-1478.74μV	-1520.75μV
T Wave	-49.21μV	-62.30μV

A mean of -1520.75μV is acquired from six haphazard models picked from the minute right after the stunning while the mean of the QRS amplitude of her dormant ECG reference is just -1478.74μV. It is further observed that there is more variance in the QRS waves' amplitude immediately after the stunning compared to before stunning. Ten haphazard samples were obtained to calculate the amplitude of the P wave. There is additionally a rise in the T waves amplitude immediately after stunning. Prior to the stunning, it is -49.21μV, but immediately afterwards it becomes -62.30μV. Sometime later, the T waves appeared to be leveled out and then it returned to the usual. The PR gap prior to and after stunning is 0.151s and 0.146s respectively. This might be because of the tightening of the entire sequence. The QRS gap stayed almost unchanged. Fascinatingly, the QT gap augmented even if the sequence duration has decreased. It rises from 0.361s to 0.366s even though the sequence duration has witnessed a reduction from 0.769s to 0.667s. Moreover, there is an increase in variance in the PR gap and the QT gaps, though equivalent variance for the QRS gap in ECG waves collected immediately after the stunning and prior to stunning. A minimum of one minute after the stunning, the ECG waves variance went back to almost similar values as prior to stunning.

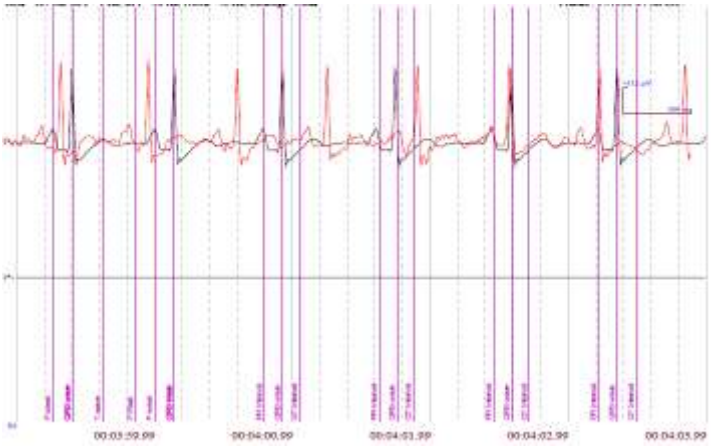

Figure 3: The superimposition of the ECG waves before and right after shock. The black graph shows the baseline ECG whereas the red graph shows the ECG right after shock

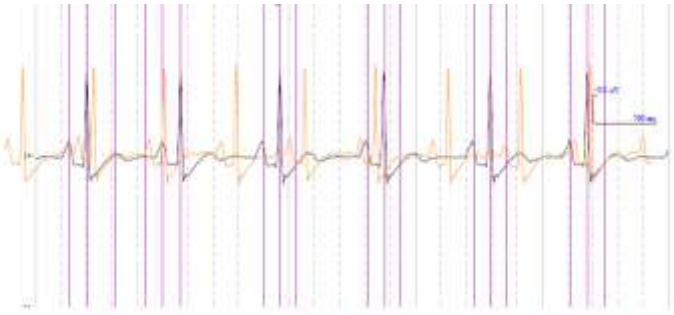

Figure 2: The smoothing out of T waves after shock which occurred seconds after fig 1.

B. *Subject 2*

At the moment of stunning, there is an occurrence of numerous P waves. Immediately after the stunning, the ECG waves did not become more disorderly as what had happened for the first lady. Furthermore, there is the fact that the T waves leveled out, which did not happen immediately after the stunning, rather seconds after that. The QRS waves amplitude, contrary to those of the initial lady, lowered from 1307.5μV to 1288.7μV. There was a decrease in the P waves from -98.61μV to -21.86μV. Though, something is remarkable about the outcomes collected from this lady in that the ECG waves look to be undulating in a sine wave. It is contrasted by overlapping. The amplitudes are equivalent for prior to and after the stunning.

Figure 3: The superimposition of the ECG waves before and right after shock for subject 2.

Twenty seconds after the stunning, the red ECG waves are studied and smaller T wave and the plunge between the T and P waves are leveled out.

Figure 4: Multiple P waves were observed at the point of shocking

ECG Wave	Before Stunning Amplitude	After Stunning Amplitude
P Wave	-98.61μV	-21.86μV
QRS Wave	1307.5μV	1288.7μV
T Wave	-	-

VII. DISCUSSION

The outcomes collected for numerous P waves were not decisive because of the occurrence of a significant quantity of factors immediately after stunning which might be because of movement. Though, it is curious that factors just happen for the first lady even though under our scrutiny, it was obvious that the second lady has greater motion at the moment of stunning while the first lady was significantly more immobile. This was improbable to be because of her electrodes being less tight since the items just happened immediately after the stunning, not during the entire ECG collection. The ECG of the two ladies diverge from the standard ECG, particularly for the second lady, even though there was no sign of any heart anomalies in the medical screening test.

There is a rise in the QT gap as well as the QT distribution, which is the divergence between the greatest and least QT gap. This is previously backed by accessible researches like Uyagel *et al.* (2005) which proved that a greater QT distribution may signal a greater stage of anxiety. Ishida observed that the QT distribution had positive association with greater concerned and/or vagal inflections. Though, there is some incorrectness implicated while interpreting the precise onset and offset periods. Concerning the P wave, there is a reduction in the duration for P wave which is because the heart rate has increased and as such, a reduction in the duration of one entire sequence. There is additionally a small rise in the P distribution. Though, this is as uncertain as the QT distribution because of the mistakes in interpreting the precise times.

VIII. LIMITATIONS

Mistakes might come from the origins below:

- Inevitable movements that the subject makes when stunned.
- Medical screening test can be unsuitable to filter people having heart anomalies as numerous of these health conditions pass unnoticed.
- Occurrences must be appropriately noted. Now, the timings for the occurrences are estimates only.
- Convention must be regularized. The yelling of the experimenter can diverge in volume.
- It is tough to pinpoint precisely the onset of a particular wave and hence, the divergence in time could be because of human mistakes.

IX. RECOMMENDATION

Recommendations to correct the corresponding mistakes stated above are:

- Apply shoulder bands to fix the electrodes to the person.
- Carry out actual medical check-up prior to permitting a person to take part in the trial.
- Create some buttons to push to signify the moment of stunning in the ECG records.
- A uniform soundtrack must be utilized or a different method of stunning the person that can be regularized must be utilized.

X. CONCLUSION

Emotion identification utilizing more particular aspects of ECG is observed to be a somewhat uninvestigated field, therefore it deserves researching. There are some appealing characteristics about the outcomes obtained in this trial. There is no tangible proof that there are numerous P waves because of the occurrence of a quantity of mistakes. Aside from the probability of numerous P waves, an option to verify is the leveling out of the T waves as well. Even if the results we collected had many constraints and mistakes, they are still moderately dependable as the other characteristic of waveforms – the QT gap, which actual researches have

investigated previously, are as they are anticipated to be. Though, the divergence in QT and P gap may be because of human mistakes in interpreting the beginning time. Additional trials with improved conventions must be performed to experiment. The investigation that will come later will be more detailed, going over more aspects that could not be identified with ocular contrasting.

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