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THE EFFECT OF EMOTIONS ON ELECTROCARDIOGRAM

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ABSTRACT

This paper reports the effect of emotions on human electrocardiogram (ECG). The overall goal was to study changes in ECG while the subject is in emotional state. The subjects were provided with some questions which can induce a particular emotional state and measured the subject's ECG with BIOPAC system. Then the ECG signal was analysed with the help of BIOPAC AcqKnowledge software. The Power Spectral Density (PSD) and Standard Deviation (SD) were calculated for the ECG signal under normal condition and during emotional state. The results obtained are encouraging. The assessment of the data suggests that ECG can be used to study emotional states of a person.

Keywords: ECG, emotions, BIOPAC, Power Spectral Density (PSD), Standard Deviation (SD)

INTRODUCTION

Many studies in the field of psychology indicate that the body functions, including: blood pressure, ECG and respiration rate are controlled by Autonomic Nervous System (ANS). This part of nervous system cannot be controlled artificially, but is influenced by the mental states of an individual. Therefore, it was presumed that the changes in mental states would be reflected to the changes in electrocardiogram. Figure 1 shows the whole process of the study of ECG w.r.t. to emotions.

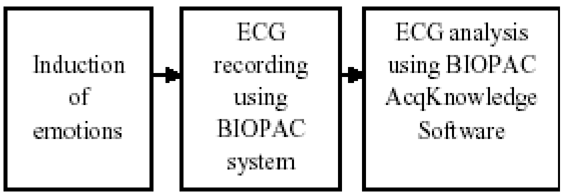

Figure 1. Emotion induction, ECG recording and ECG analysis

Emotions are related to motivation in that they lend strength or intensity to an action. There are two aspects of emotions: (1) inner emotions, such as the feelings of fear, love, anger, joy, anxiety, hope, and so on, those are entirely within a person, and (2) the outward expressions and displays of emotional behavior. Emotional behavior includes such complex behaviors as attack and such simple actions as laughing, sweating, crying, or blushing. Emotional behavior is achieved by integrated activity of autonomic and somatic efferent systems and provides an outward sign that an emotion has occurred.

The two aspects of emotion are served by different parts of the brain, and these aspects can occur independently in certain diseases and in experimental situations. Inner emotions involve the cerebral cortex and various areas of limbic system – the hypothalamus – and the brain stem. Emotional behavior, unlike inner emotions, can be studied reasonably well because it includes responses of the autonomic, endocrine, and motor systems that are easily measured.

Stimulation of limbic structures other than the hypothalamus causes a wide variety of complex emotional behaviors that receive their final coordination by the hypothalamus. For example, stimulation of one area of the limbic system caused an animal to approach the researcher as though expecting a reward, whereas stimulation of a second area caused the animal to stop the behavior it was performing, as though fearing punishment. Stimulation of third region caused the animal to arch its back, puff out its tail, hiss, snarl, bare its claws and teeth, flatten its ears, and strike. Simultaneously, its heart rate, blood pressure, respiration, salivation, and concentrations of plasma epinephrine and fatty acids all increased.

In order to observe the changes in electrocardiogram rate w.r.t. changes in cognitive states, the subjects were provided with some questions/problems which can induce a particular emotional state. During this process of questioning, their ECG was recorded using BIOPAC system.

SIGNAL ACQUISITION

Lead II ECG was recorded using electrocardiogram amplifier module (ECG 100C) in BIOPAC. ECG 100C is a single channel, high gain, differential input, biopotential amplifier designed specifically for monitoring the heart's electrical activity. It has built in derive capability for use with shielded electrode leads. It is designed to pass the ECG signal (P,Q,R,S,T) with minimal distortion.

The best choice of electrodes depends on the application, but typically the EL500 series of adhesive/disposable snap electrodes are used in conjunction with LEAD 110S pinch lead. In our study Ag – AgCl disposable lead electrodes were used.

Three electrodes are used to record Lead II ECG signal. Two active electrodes are affixed on right arm (RA) and left leg (LL). Reference electrode is applied on right leg (RL) of the subject. The electrodes are connected to the ECG amplifier (ECG 100C) using three leads.

The ECG 100C includes a high pass filter that is used to stabilize the ECG base line. When the HP switch is set to 1.0 Hz, P and T wave amplitudes will be reduced somewhat, but the QRS wave will be virtually unchanged. The HP switch is usually ON when using the ECG 100C for rate measurement only or when monitoring the ECG of an active subject. Modules are factory preset for 50 Hz or 60 Hz notch options to match the wall power line frequency of the destination country.

The following settings of the ECG 100C are used to record ECG II of the subject: Gain: 1000, Output selection: Normal, Low pass filter: 35Hz, High pass filter: 0.5 Hz

Figure 2. ECG recording using BIOPAC system

Data of each subject was recorded for 15 minutes. The subject is assumed to be at rest state for first 7 minutes. After that the subject was provided with an aptitude problem shown on multimedia projector. Since emotional state is defined as the state when emotional aspects are dominating in the mental activities. Also, surprise, confusion and embarrassment are supposed to be major factors evoking the state of emotions. Therefore, the subject was asked to solve an aptitude problem to produce this state.

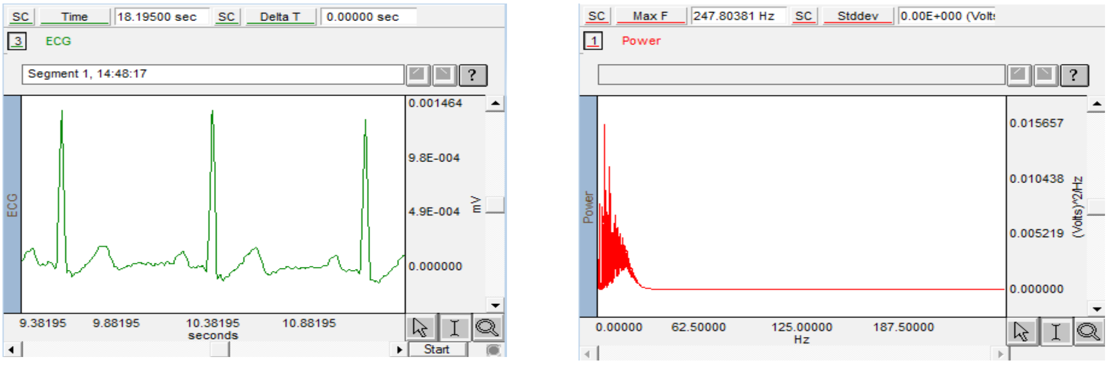

Figure 3. Recorded ECG signal and its Power Spectral Density (PSD)

SIGNAL ANALYSIS

In most of the cases, analysis is performed after the data has been collected. This involves creating, managing and saving files, as well as editing data, performing mathematical transformations and displaying data in various ways.

The laboratory experiments have been performed in which 22 subjects were involved. They were male and female student majority of post graduate students. The ECG was recorded when they were exercising the required tasks as described above. The signal analysis has been performed with help of BIOPAC AcqKnowlwdge software. The ECG recorded and its Power Spectral Density (PSD) is shown in figure 3.

RESULTS AND DISCUSSION

In this experimental work, we analyzed the relationship between emotions and the autonomic nervous system through ECG. From the Standard Deviations (SD) calculated for PSD signals, during rest state and emotional state of the subject, it has been observed that the SD increases when the subject's mental state changes from the rest state to emotional state. This result is found in case of 90.93% subjects. The results obtained are quite satisfactory.

Many factors determine the performance of this study. These factors include the measurement of ECG, the signal analysis methods that extract signal features and other environmental factors. ECG measurement is affected by high contact impedance due to sweating. To reduce this impedance jelly is used. The measurements also depend on whether the subject is sitting or lying on the bed. In this work all measurements were performed while the subject was lying on the bed.

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