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RESEARCH ARTICLE

COMPARING MUSICAL PERCEPTION BETWEEN FETALS AND NEONATALS IN QUIET ENVIRONMENT AND ALPHA MUSIC ENVIRONMENT.

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Abstract

Fetal auditory response generally occurs after the 28th week of pregnancy and in this period, a fetus reacts to the auditory stimulants which are from the outside world. Learning after birth is commonly based on the brain based learning and a lot of studies show that a neonatal can be distinguish the auditory stimulants in detail. In this study, to see and to compare thefetal's auditory response before birth and the neonatal's auditory response after birth, 20 pregnant subjects who are in the 36th week of the pregnancy and 20 neonatal subjects who wereborn healthy are chosen and in the quiet and alpha music environments, ECG outputs are obtained from the heart rhythm and motor activity of the participants. Alpha wave is a common waveform which is clearly seen in the beginning part of the relaxation and this wave has a lower frequency range. When this information and quiet environment data are based on, a rhythm decrease whose duration is approximately 8,23 seconds is obtained for the fetals in the alpha music environment. For this reason, it can be said that fetals learn the alpha music easier than neonatals and this music makes fetals much more relaxed than neonatals and as a result, more slow heart rhythms are acquired from fetals. According to the obtained results, the musical perception of the fetal is correlated with his/her mother and the accuracy of the obtained results is supported with the specific features of ECG data and statistical data.

Introduction:-

Brain based learning is the unique model which has many different theories [1]. This model is generally associated with the brain's structure and function [2]. Brain based learning contains the brain's rules for meaningful learning, respectively. Hebb who was the pioneer of this model achieved a lot of neurophysiological studies that were about brain based learning in detail [3].

Learning function occurs with some chemical and electrical variations in the brain, especially with the establishment of the synoptic links [4]. Indeed, for the learning process, most of the functions of the body such as hearing, smelling etc. are commonly used [5].

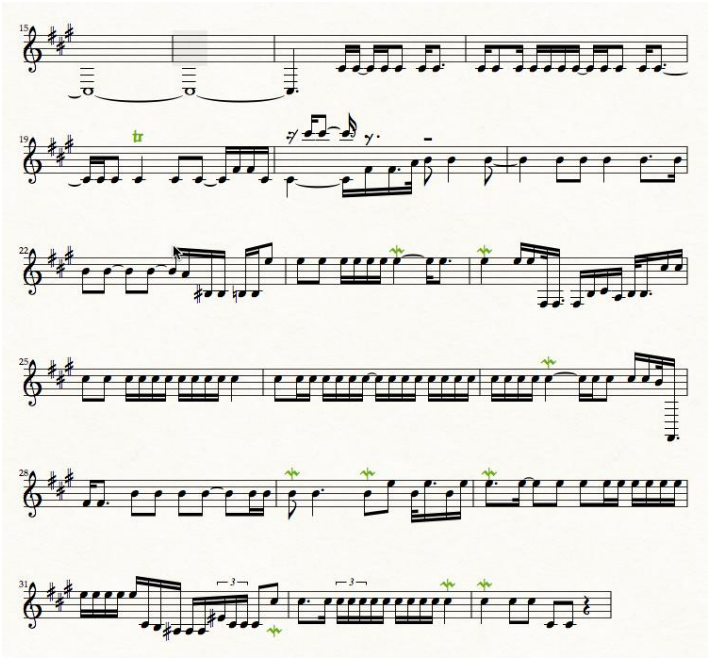
Brain waves are generally measured with a device which is called Electroencephalography (EEG) [6]. Basically, there are 4 types of brain waves; these are alpha, delta, theta and beta [7]. Nowadays, with the development of the technology, different kinds of methods are used to differentiate these waves [8]. Each wave type is linked to the state of consciousness and in this study, alpha waves are used in detail. Alpha waves are generally in the range of 7,5-12 Hz and they are commonly seen in the state of relaxation [9]. In the branch of music, these brain wave propagations are activated with some instrumental musics and these musics are used in many areas [10].

The aim of this study is to analyze the relationship between brain based learning and learning with music issues, so musical perception between fetals and neonatals are analyzed and compared. Regarding this situation, quiet environment and alpha music environment are used in this work and for these environments, fetal heart rhythm and motor activity measurements are evaluated from 20 pregnant participants' fetuses and 20 healthy neonatals. Moreover, the duration of every music is approximately 10 minutes and the total duration of ECG records is totally 20 minutes. Obtained heart rhythm data are processed in MATLAB® interface with using signal processing methods and auditory responses are interpreted for two different environments. According to the obtained results, in the alpha music environment, a rhythmic fall is obtained and this decrease takes approximately 8,23 seconds, so alpha music is perceived by fetalssuccessfully.This obtained decrease is not seen in neonatals and it can be said that in the mother's womb the fetal can distinguish the musical environment more successfully than the neonatal. Finally, in literature, there have been any works about this topic yet.

Materials and methods:-

Music Selection:-

For this work, for the first stage, 10-minute heart rhythm recordings were evaluated from the pregnant participants in the quiet environment. Second, 10-minute heart rhythm recordings were evaluated from the pregnant participants in the alpha music environment. For the second stage, neonatals who were born healthy are generally used and first, 10-minute heart rhythm recordings were obtained from neonatals in the quiet environment. Second, 10-minute heart rhythm recordings were obtained from the pregnant participants in the alpha music environment. Alpha music is consisted from instrumental repeating areas whose duration is approximately 2 minutes and the note distributions of the musics are created using Logic Pro X software by Berkan Ural and NaciyeHardalaç and these are clearly given in Figure-1.



(a)

Figure1: Note distribution of the selected music; (a) Note distribution of alpha music.

Data Collection:-

This research was held with the participation of 20 volunteer pregnant women and 20 healthy neonatals. When choosing the participants, non-smoking women who are carrying a singleton fetus with uncomplicated pregnancies are chosen as subjects. These data were collected from Fırat University Faculty of Medicine Department of Obstetrics and Gynecology with the cooperation of Associated Prof. SalihBurçinKavak. Mother participants' age, height, body weight and education age values were 38 ± 1.50 year, 171,45 ± 6,52 centimeter, 80,18 ± 7,21 kilogram, 17,5 ± 1,5 year. Neonatal participants' age, body weight values were 34 ± 1.50 (hour), 13,42 ± 4,41 kilogram.In addition, in this study, Assistant Prof. NaciyeHardalaç who is the owner of the idea has an active role in the

determination of musics, listening times and analyzing the musical results in detail. Also, M.Sc. Research Assistant Berkan URAL has an active role in the experimental of the work and in the analyzing stages.

Data Analysis:-

Data were processed in MATLAB® interface and with using Pan Tompkins Algorithm, QRS complex and rhythm analysis were performed in ECG signals. Data analysis and interpretation parts were given as a flowchart in Figure-1.

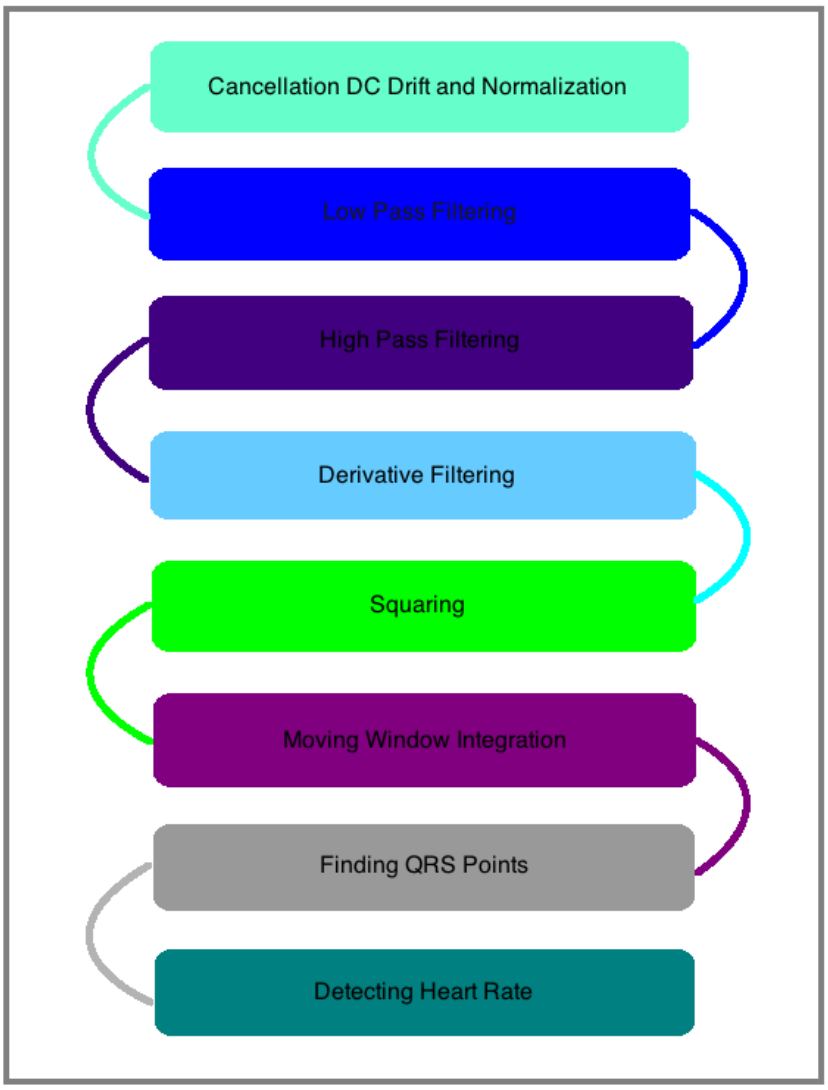


Figure2: Data analysis flowchart with Pan Tompkins Algorithm.

For each stage of the system, the output of the previous stage was the input of the subsequent stage. Every stage was described in detail below.

Each of ECG data which were used in this study had complex parts [11]. Every data's duration was approximately 20 minutes and their sample value was in the range of 0-225000. ECG outputs were mainly consisted from two main signals which were obtained from quiet environment and alpha music environment and the duration of each signal was 10 minutes, respectively.

Classically, an ECG signal was consisted from five different areas [12]. These were P, Q, R, S, T areas and each of them had an important information about the heart activity [13]. These important areas were based on to compare and analyze the ECG results in detail.

❖ **Cancellation DC Drift and Normalization:-**

After ECG data acquisition, firstly, the original signal was differentiated from environmental noises [14]. At this stage, an important type of noises was seen in the signal; this was high frequency noise. For eliminating this type of noise, signal was put forward to the DC zero level [15]. This stage was performed by subtracting original signal from the average of this signal [16].

❖ **Low Pass Filtering:-**

The second stage was the removal of high frequency noises. For this stage, a special low pass filter was chosen and was used for the signal [17]. For this work, generally, five point moving average low pass filter was used for filtering and with using this type of filter, filtering and smoothing operations were performed successfully [18].

❖ **High Pass Filtering:-**

For the thirdstage, the signal had not a perfect view yet and this hadsome low frequency based noises [19]. At this stage, to eliminate low frequency noises, a special high pass filter was designed and used for filtering.

❖ **Derivative Filtering:-**

After high pass filtering, only 50 Hz mains-borne noise remained back. At the fourth stage, the objective was designing a filter to remove this type of noise from the signal, so a special Derivative filter was designed and this was used for filtering [20]. In addition, this filter could remove some harmonics from the output signal [21].

❖ **Squaring:-**

The fifth stage led the signal to turn into the square view, so these signals could be easily processed [22]. At the end of this stage, signal was ready for the other stage.

❖ **Moving Window Integrator:-**

For the sixth stage, thirty windows were chosen and each window had to have a standard value, so this value was chosen as 1 [23]. With using these windows in detail, median and average filtering processes were performed on the signal [24]. Indeed, to analyze the signal simultaneously, a delay time was added to the signal and then the integration process was achieved [25].

❖ **Finding QRS Points:-**

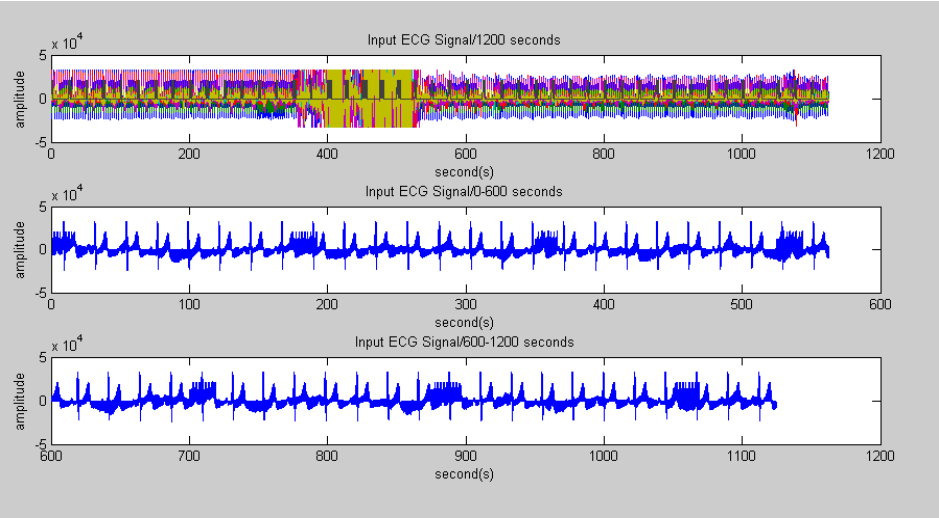
After these stages which were mentioned above, mathematical perfection was gained to the signal and for this stage,sharp peaks were found in the signal. This process performed with calculating differences between peaks [26]. The coordinates of the sharp peaks gave us the R points' coordinates [27]. Then, some special points which were located near R points was successfully found [28]. These points' coordinates gave us Q and S points, respectively [28].

❖ **Detecting Heart Rate:-**

At the final stage, the inference process was done. In this stage, beat value was calculated mathematically and before this process, when all of R points were found clearly, it was seen that the total number of beat value was equal to the number of R points [29].

Results and discussion:-

Processes which were mentioned in the flowchart above were started when an ECG signal was entered to the system.



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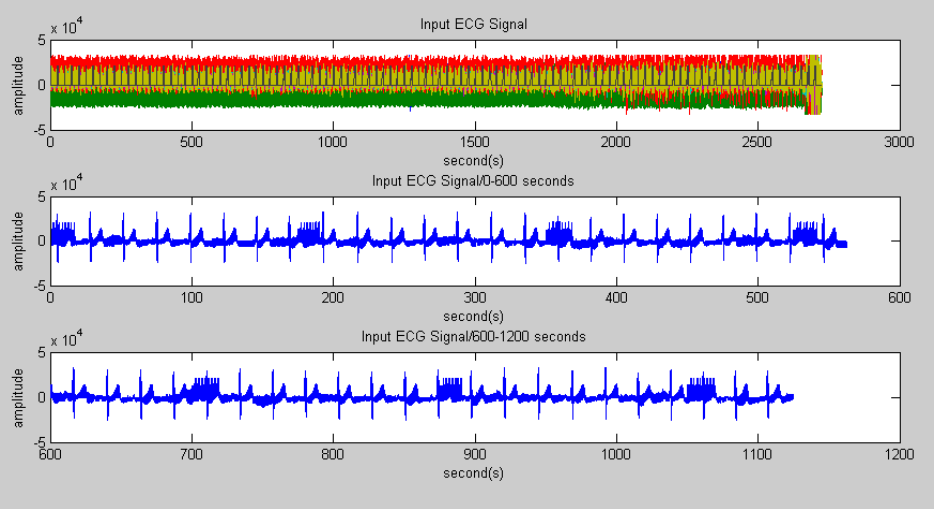
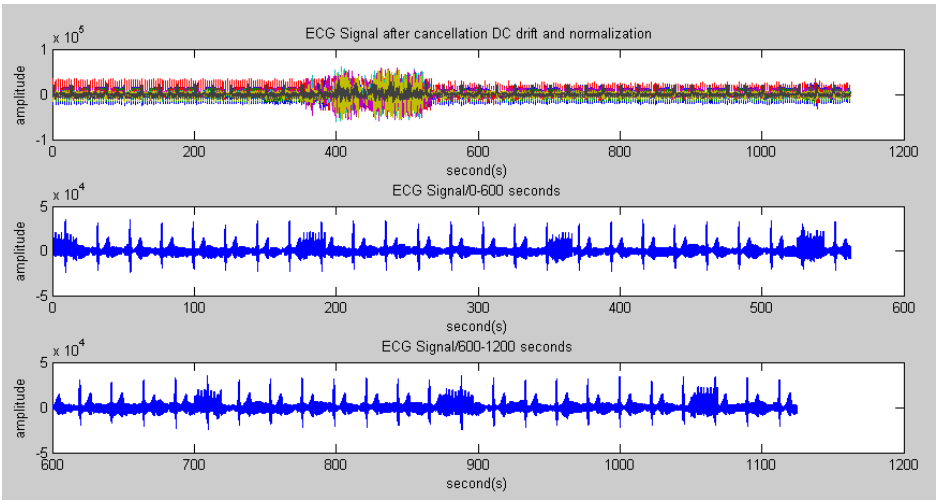


(b)

Figure 3: ECG signal examples; (a) The ECG recording of the fetal who was chosen randomlyand the representation of the two different environments' signals, (b) The ECG recording of the neonatal who was chosen randomly and the representation of the two different environments' signals.

When the ECG signals which were given in Figure-3 were analyzed, the duration of the signal recordings were approximately 1200 seconds (20 minutes) and the total sample value of the signalswas 225000. In addition, the sample value for each environment was 112500.Generally,for the fetal and the neonatal, data recording processes were achieved in the quiet environment and alpha music environment, respectively and the duration of the signals were 600 seconds for each environment. This duration value was standard for all ECG outputs and the distribution of each signal in the environments was given in the subplot format in Figure-3.



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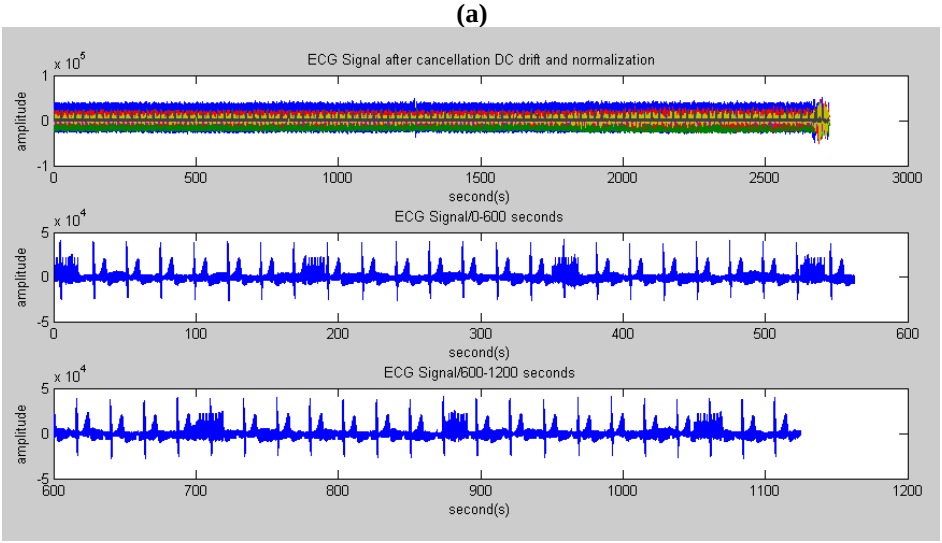
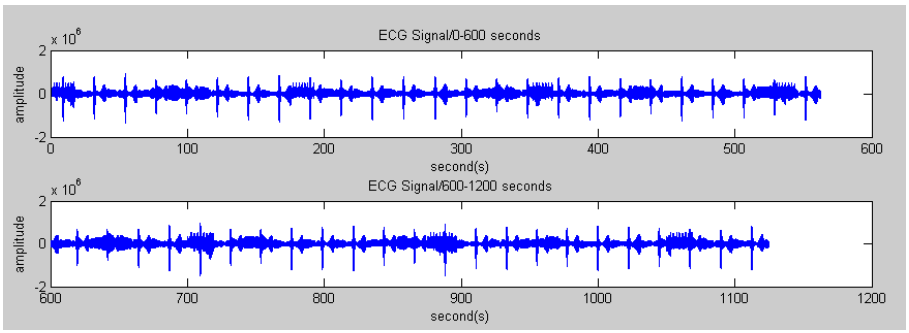


(b)

Figure4: ECG outputs whose noise was reduced and normalized; (a) The ECG output of the fetal who was chosen randomly and the representation of the two different environments' signals, (b) The ECG output of the neonatal who was chosen randomly and the representation of the two different environments' signals.

When the sample value of the signals was 112500, high frequency based noise was seen in the signals. To analyze these signals with a high accuracy, in the first stage of the process, eliminating DC based noise and normalization processes were successfully achieved. For this process, the signal outputs of the fetal and the neonatal were represented in Figure-4.



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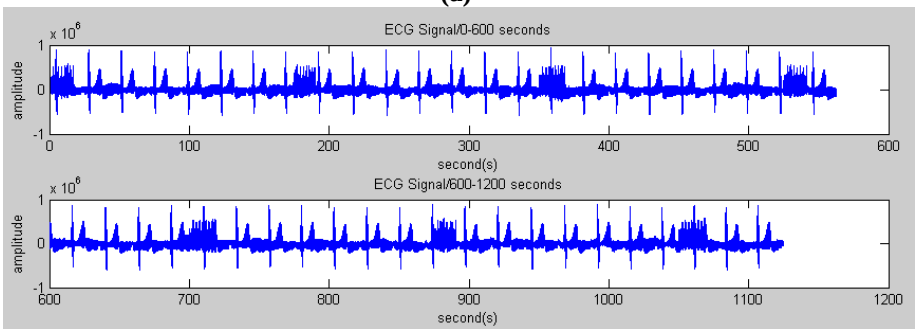
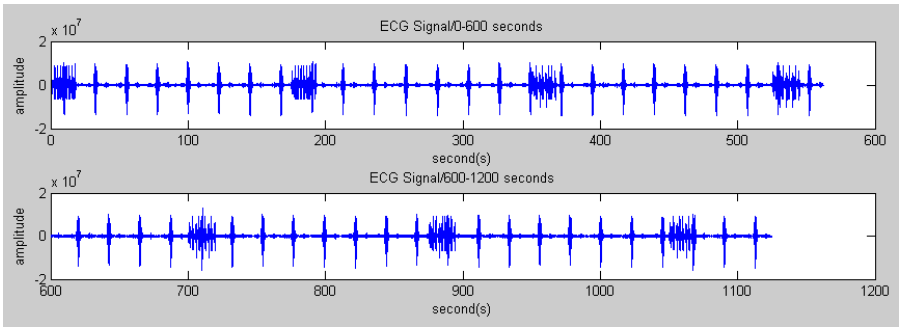


(b)

Figure 5: The signal outputs at the end of the Low Pass Filtering process and the representation of the two different environments' signals; (a) The ECG output of the fetal who was chosen randomly and the representation of the two different environments' signals, (b) The ECG output of the neonatal who was chosen randomly and the representation of the two different environments' signals.

According to the signal outputs which were given in Figure-5, with using a special Low Pass Filter, unwanted high frequencies and high frequency based noise were reduced in detail. When obtained results were analyzed, after low pass filtering, noise reduction was achieved correctly and the success rate was 90%. After the filtering process, in the other step, signal had to be smoothed in the range of sharp frequencies, so high pass filtering process was performed on the signal.



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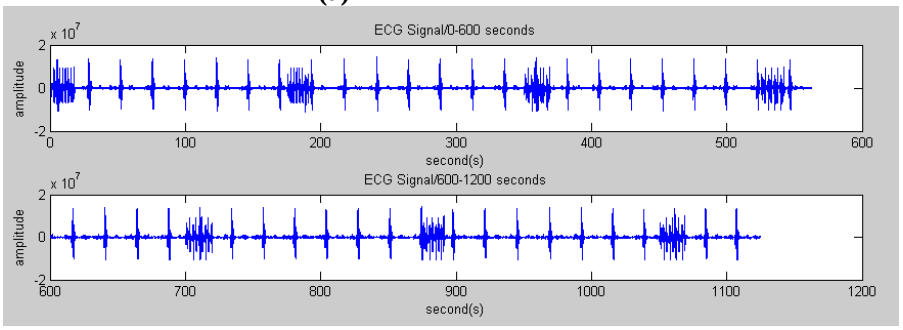
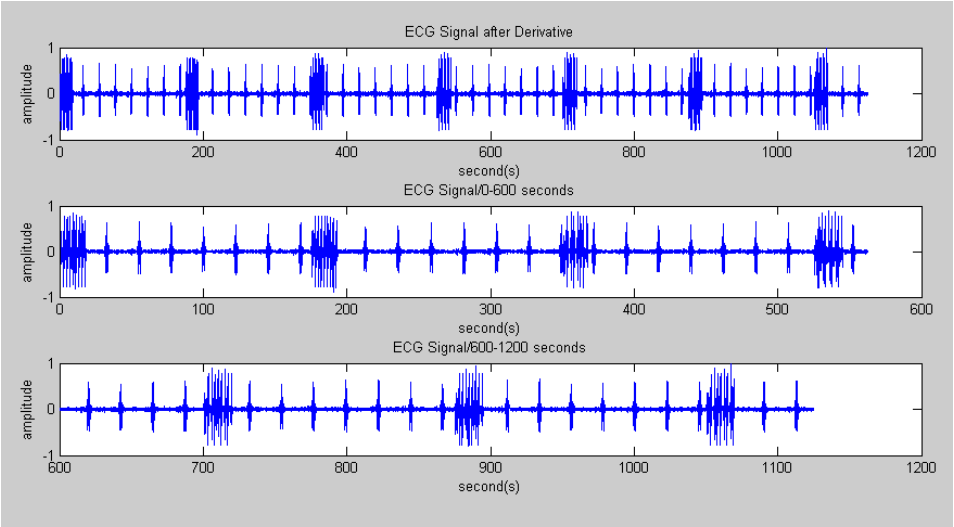


(b)

Figure 6: The signal outputs at the end of the High Pass Filtering process and the representation of the two different environments' signals; (a) The ECG output of the fetal who was chosen randomly and the representation of the two different environments' signals, (b) The ECG output of the neonatal who was chosen randomly and the representation of the two different environments' signals.

When obtained signals were analyzed, according to the signals' peak values, noise reduction was achieved correctly with using the high pass filter and the success rate was 90%. At this stage, signals were smoothed and all details were become visible.



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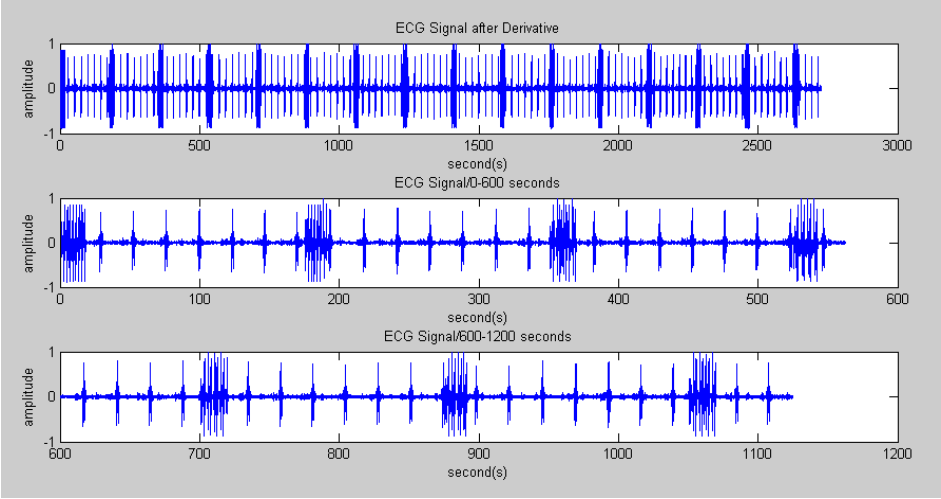
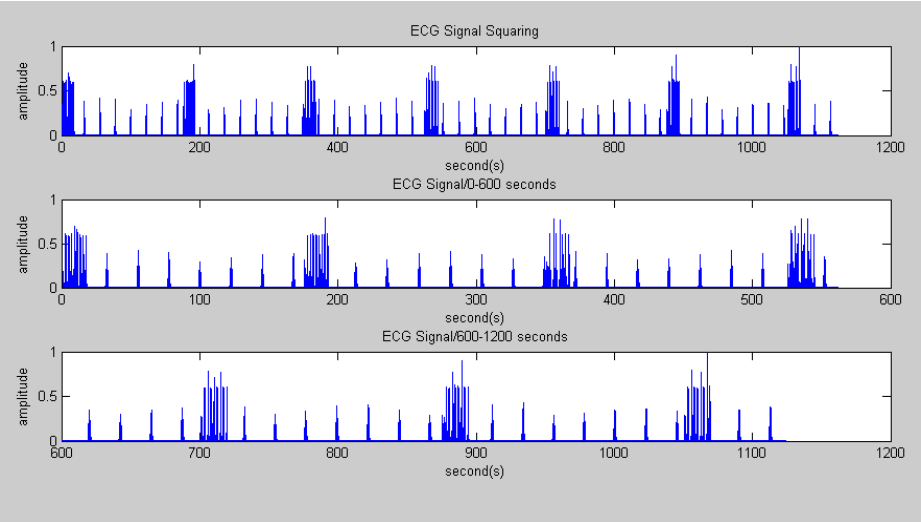


(b)

Figure 7: The signal outputs at the end of the Derivative Filtering process and the representation of the two different environments' signals; (a) The ECG output of the fetal who was chosen randomly and the representation of the two different environments' signals, (b) The ECG output of the neonatal who was chosen randomly and the representation of the two different environments' signals.

At the end of Derivative filtering, 50 Hz-noise were removed from the signals and the signals were become more visible. According to the representation of the signals for two environments, this type of noise was reduced successfully and the success rate was 100%.



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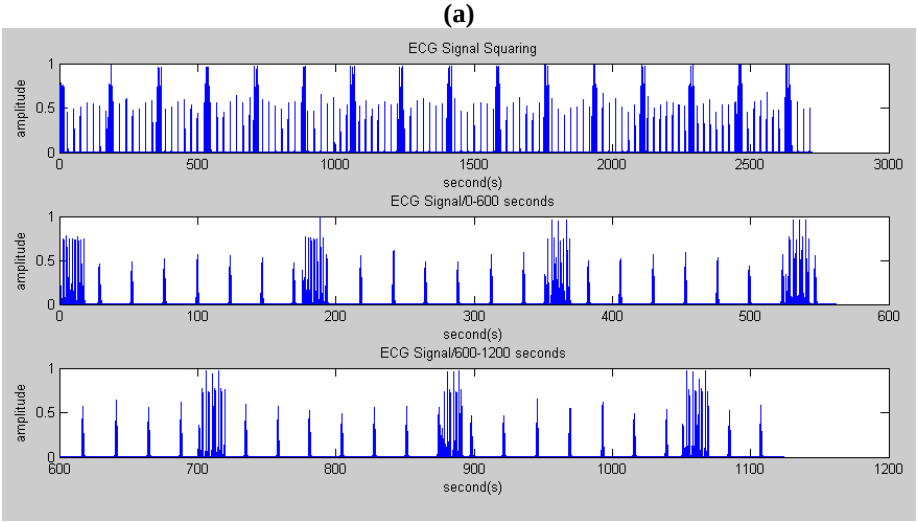
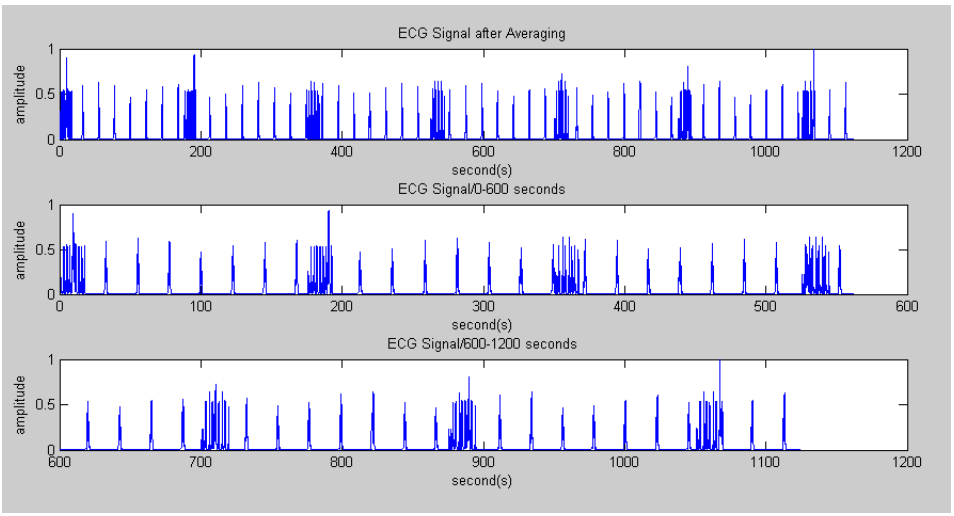


(b)

Figure 8: The signal outputs at the end of the Squaring process and the representation of the two different environments' signals; (a) The ECG output of the fetal who was chosen randomly and the representation of the two different environments' signals, (b) The ECG output of the neonatal who was chosen randomly and the representation of the two different environments' signals.

When Figure-8 was analyzed in detail, at the end of the Squaring process, the negative sides of the signals were eliminated. According to this, Squaring process led the signals to turn into the square view, so these signals could be easily processed. At the end of this stage, signals which belonged to the fetal and neonatal were ready for the other stage.



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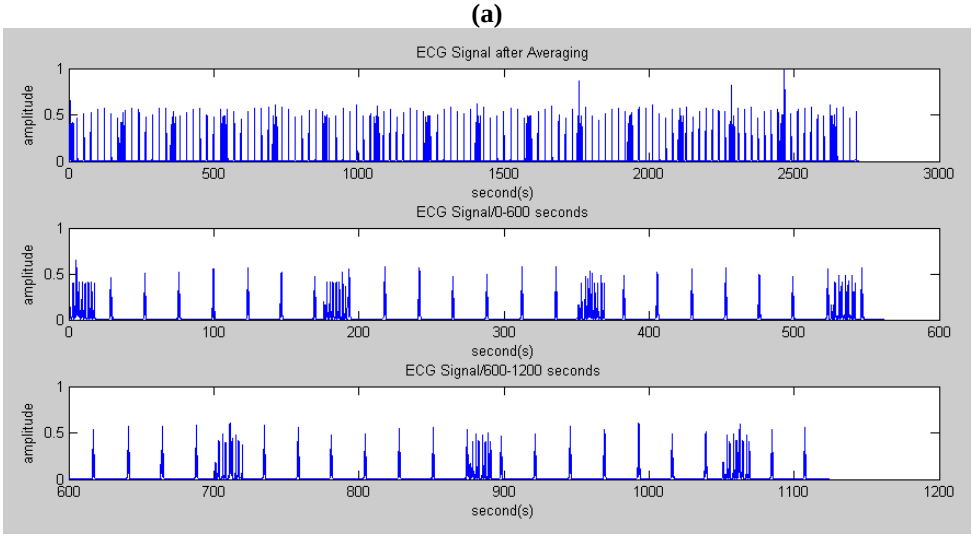
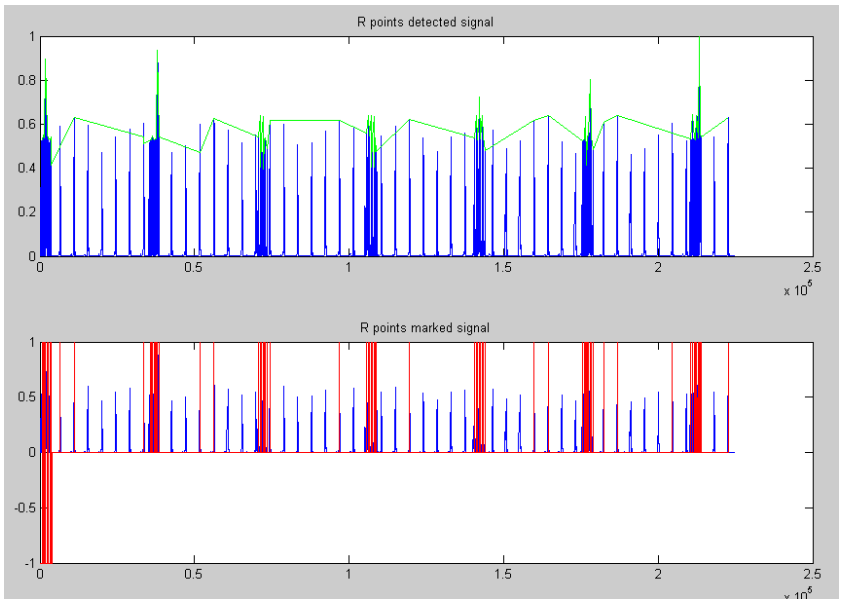


(b)

Figure 9: The signal outputs at the end of the Moving Window Integrator process and the representation of the two different environments' signals; (a) The ECG output of the fetal who was chosen randomly and the representation of the two different environments' signals, (b) The ECG output of the neonatal who was chosen randomly and the representation of the two different environments' signals.

For Figure-9, thirty special windows were chosen and each window had to have a standard value. With using these windows in detail, median and average filtering processes were performed on the signals. Indeed, to analyze the signalssimultaneously, a delay time was added to the signals and then the integration process was achieved on these signals.



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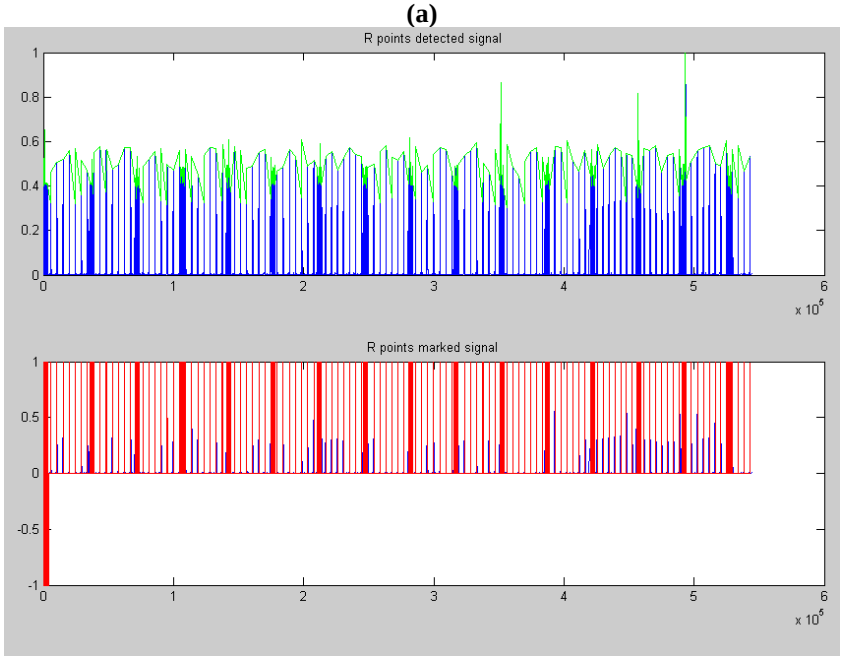

(b)

Figure 10: The output signals whose R points were combined and the representation of the two different environments' signals;(a) The R points output of the fetal according to the two different environments' signals, (b) The R points output of the neonatal according to the two different environments' signals.

For this stage, the signals were independent from the environmental noise types. For the smooth and visible signals, the next step was QRS point investigating. At this stage, first, differences between peaks were calculated and the total number of these sharp peaks was equal to the number of R points. Moreover, finding the points which were located near R points was successfully evaluated. These points' coordinates gave us Q and S points, respectively. The signals of the fetal and neonatal whose R points were combined were shown in detail in Figure-10. According to the signals that were given in Figure-10, the location of QRS complex could be determined. The necessary measurements can be obtained from these outputs easily.

For the final stage, analyzing and detecting the total number of beats processes were achieved. According to the flowchart, in the signal outputs, R points and their coordinates were determined. Also, the number of beats was equal to the number of R points. Obtained results (the number of beats, average value of RR interval and variance value) for the fetal and neonatal were given in Table-1 and Table-2, respectively.

Table1: The statistical results for the fetal's signal output.

Variables	Quiet Environment	Alpha Music Environment
Number of beats	**120**	**75**
Heart Rate	**6.0**	**3.75**
R-R average(msec)	**140,671**	**110,608**
Variance	**126,226**	**97,943**

Table 2: The statistical results for the neonatal's signal output.

Variables	Quiet Environment	Alpha Music Environment
Number of beats	**130**	**100**
Heart Rate	**6.5**	**5.0**
R-R average(msec)	**143,791**	**120,502**
Variance	**127,326**	**98,713**

When quiet environment data were based on, a rhythm decrease was clearly seen for all fetals' signal outputs in the alpha music environment. This rhythm fall could be associated with the rhythm understanding issue, so it could be said that alpha music was understood from the fetals perfectly. In contrast, a rhythm decrease could not be seen in the neonatals' signal outputs, so it is clearly said that, when brain based learning was based on, fetals in the womb could understand and learn the music types and rhythms of the musics much easier than the neonatals.

Results:-

20 fetals' and 20 healthy neonatals' data were processed separately through these processes that were stated in this work and the number of beats, heart rate, R-R interval average value and variance value of the participants were obtained. According to the obtained results, when the recordings that were taken in quiet environment were based on, alpha music environment results were investigated in detail. When the sample value was in the range of 80000-112500, a sudden decrease was obtained from each of the fetals' signals and this decrease took approximately 8,23 seconds. It was understood that alpha music was perceived by the fetals and the perception was achieved successfully.In contrast, when the variance data were analyzed for the neonatals, there were any abrupt changes in the signal outputs. In this study, generally, according to the results, it was obtained that fetals in the womb could understand and learn alpha music easier than the neonatals.

When this work is adapted to the different fields, this might give a chance to early diagnose the different types of diseases. Also, if the methods of this study are developed with using EEG signals, epilepsy and other brain-based diseases can be detected and diagnosed practically. Moreover, this can help doctors for diagnosing important diseases on time.

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