TECHNION – Israel Institute of Technology

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The Physiological Signal Processing Laboratory

Analysis of Music Influence on Physiological Signals of Newborn

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Abstract

Music influence on people was noticed long time ago. Psychologists look for visual and behavioral effects to explain music influence. Our work is one of the first that tries to view the topic from engineering side, find influence on physiological signals. The work deals with the ECG and Respiratory signals that were taken from newborn while they listened to music. We are applying different analysis techniques in order to find and commutate the influence of music on newborn. In the work we apply basic mathematical and statistical analysis techniques together with common signal processing techniques and more complex techniques like auto regressive model. The work shows that there is definitely a connection between some of ECG signal's energy/magnitude like parameters and music. We cannot commutate the connection and more importantly, we can not eliminate a possibility of indirect non physiological connection through the self noise of measurement setup. In our analysis no connection was found between Hart Rate and Hart Rare Variability and music. In addition Low SNR of Respiratory signal made it impossible to find a suitable parameter for analysis. We will explain the problems of self noise and insufficient data together with problems of short duration of time frames. We will explain how and where to improve the experiment in order to get a better results. Finally the issue seems promising and needs more research.

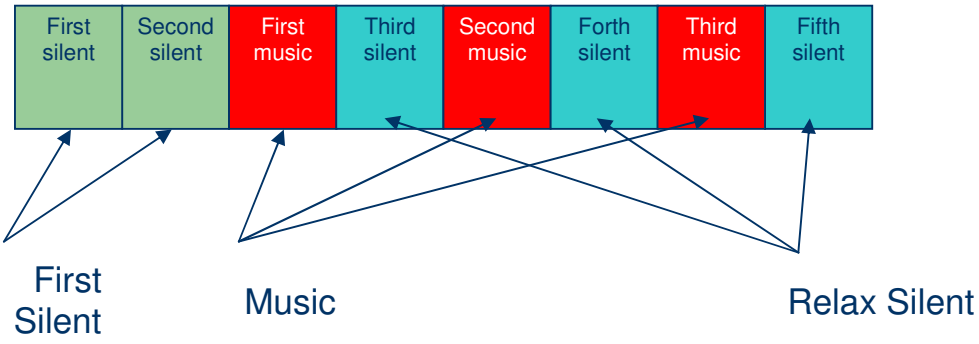
Introduction

Background

There are many conformations of music influence on infants. Many psychological and educational researches claim that music hearing has an influence as on immediate response and the current mood of the baby also on the babies' mentality and mind development. Our research project is part of an experiment which objective is to find an influence of other kind – physiological influence of biological signals in the babies' body.

Experiment description

The experiment takes place in the delivery department of Naharia hospital. Sample space includes ~40 infants. Each experiment was eight minutes long, while the baby was played music in part of the times, as shown at next figure (one minute each segment):



Experiment Time Segmentation

In parallel the ECG, EEG and respiratory signals where recorded.

Project description

Our project focuses in ECG and respiratory signals. Its objective is to find and commutate the possible influence on those biological signals.

Analysis and Results

Methods

Most of the project is based on analyzing the difference of the signals, separated to time chapter segments, silent and music segments. Analyzing each segment separately we use variety of methods in signal processing to achieve wanted visual presentation or (more importantly) to extract typical parameters of the given signals. Later on extracted parameters are used for statistical analysis. Statistical analysis usually is done by comparison of averaged parameters extracted from different groups of segments. Sometimes it is done separately for each subject and sometimes distribution for all subjects is checked. In some cases we also apply statistical hypothesis tests and more complex models.

ECG Analysis and Results

- Visual analysis at time and frequency domain appeared to be not applicable, and hasn't shown possible direction to follow. The visual difference is in the scale of self noise of the system.
- Analyzing the total energy of the signal in most cases hasn't shown a significant difference between silent and music slices. However histogram of energy distribution on all subjects shows that ECG in time segments where music is played has less energy than in silent time segments.
- Heart Rate, Heart Rate Variability, ECG Peak Amplitude and ECG Peak Amplitude Variance were extracted from row ECG data using signal processing methods for Random Point Processes. Statistical analyze of Heart Rate, Heart Rate Variability, ECG Peak Amplitude showed no connection of this parameters to music playing. However ECG Peak Amplitude Variance found to be smaller during the starting time segments (before first music episode was played) then during all the following segments (musical and silent as one). In other words music playing might cause instability in ECG Amplitude.
- Typical ECG Period Shape for each segment was created by averaging all ECG period shapes in this segment. Comparison of Typical ECG Period Shape of different segments showed that the Typical ECG Period Shape of starting time segments (before first

music episode was played) is different from those of following segments, when the differences between Typical Shapes of following silent and musical segments are negligible.

Respiratory Analysis and Results

- Time visual analysis of respiratory signal was made after LPF filtering while expecting 0.3Hz frequency. Analysis hasn't shown any usable difference between slices and different babies.
- Frequency visual analysis was made applying different windows, rectangular, triangular, Kaiser and Hamming with different parameters. The results didn't show similarity in expected parts. In general most of the signal energy concentrated at first 1.5Hz of the frequency axis, main harmony couldn’t be noticed.
- Analyzing the energy between segments has shown totally random results, as expected due to very high mechanical noise in the signal which lays exactly in the range of expected respiratory frequency
- Respiratory signal analyzing using Auto-Regressive model to reduce the heavy noise. The maximum peak in frequency domain varies from 0 to 2.5Hz (0 to 60 breath per minute) so it can't indicate the respiratory frequency. AR model analysis failed due to heavy noise, and its results were unusable.

Conclusions

It is possible to summarize the results of the project as "Found an evidence for music influence on physiological signals of babies". We have found influence on energy, amplitude stability and typical cycle shape of ECG. We didn't found any evidence for music influence on Hart Rate or Hart Rate Variability, which are the main physiological parameters derived from ECG.

Poor statistic significance of the results is caused by low number of subjects in experiment. For most of the parameters where influence was noticed, the differences are between the first two silent segments and the rest of the segments, and not between the music and relax periods. It implies that the influence dynamics (if it true and physiological) are more slow than time periods in the experiment. From the other hand, it also possible that the influence that found is a simple side effect of the motor activity increase after the experiment starts and the subject is aroused by the music.

Any attempt to extract a suitable data for statistical analysis from respiratory signal failed because of very high motor movement noise. It concludes that respiratory signal, achieved the way it was in this experiment, is not suitable for analysis.

Future research possibilities

We are convinced that in order to provide better and statistically significant results it is necessary to repeat the experiment. The new experiment has to include more subjects under test. Increasing the time segments duration is necessary to check the hypothesis of slower influence dynamics. Following analysis of ECG signal should be repeated with the new experiment's ECG data: Energy parameter analysis, Statistical analysis in time domain, typical cycle shape.

In the new experiment there is no need to record respiratory signal with the "respiratory belt", but it should be considered to use "Acoustic Respiratory Signal" recording. It should reduce the movement noise influence on the signal and make it possible to analyze in frequency domain.

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Bibliography

[1] Porat Boaz "Digital Processing of Random Signals", Prentice-Hall 1994.

[2] "Random Data: analysis & measurement procedures", Bendat & Piersol John Wiley, 2001

[3] "A point-process model of human heartbeat intervals: new definitions of heart rate and heart rate variability" , Riccardo Barbieri, Eric C. Matten, AbdulRasheed A. Alabi, and Emery N. Brown, 2004

[4] " Heart-rate Variability", Christoph Gugar, 2004

[5] "Circumferential measurement of thoracic wall using a standard respiratory belt", Tervonen O, Suominen K, 1996