Study of the Effect of Music and Meditation on Heart Rate Variability

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1. INTRODUCTION

The general perspective of the article is to study the effect of music through analysis of HRV data collected in pre-music and on-music state. The perspective is also to find the effect of meditation on HRV data collected from the Internet in pre-meditative and meditative conditions. In order to obtain better results, it develops some modifications of the standard methods of global analysis of HRV signals as and when necessary.

2. BACKGROUND

We make the literature survey sequencialy, first with the effect of music and next with the effect of meditationon on autonomic nervous system:

On Effect of Music

Chiu, H.W. et.al. (2003)studied the anxiety reduction of patients through their HRV data by using the standard methods of SDRR and HF. This study demonstrated that listening to music had influences on autonomic control. Iwanaga,M. et.al.(2005) observed that the LF/HF ratio of HRV increased during SM and EM sessions but decreased during NM sessions. Urakawa,K.,& Yokoyama, K. (2005) also used the same parameter to describe whether music affects the exercise-induced changes in the autonomic nervous system activity in twelve healthy female college students.They showed that ratio of LH/HF of HRV significantly increased with the effect of music. The same quantifyng parameter was used by Peng, S.M.(2009) to study the effect of soft music on HRV. Nakahara, H., et.al.(2009) investigated the differential effects of emotions evoked by music on heart rate (HR) and its variability (HRV) during the playing of music on piano to the persons listening to the same music. The expressive conditions produced significantly higher levels of HR and low-frequency component of HRV, as well as a lower level of its high-frequency component. Orini, M., et. al.(2010) present a methodology for characterizing music-induced effects on the dynamics of the heart rate modulation. They propose three steps- the smoothed pseudo Wigner-Ville distribution for time–frequency representation of HRV; parametric decomposition for robustly estimating the time-course of spectral parameters; and finally statistical population analysis for continuously assessing whether different acoustic stimuli provoke different dynamic responses. Trappe, H.J. (2012). describes that listening to music while resting in bed after open-heart surgery leads to significant differences in cortisol levels between the music and the non-music group. Roy, B., et.al.(2012) describe how rotating acoustic stimulus can change the autonomic balance of the cardiac system. They have used HRV as an indicator of autonomic modulation of heart, both in time and frequency domain. They show that in the

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Poincaré Plot, SD1,SD2 and the ratio (SD1/SD2) increase after the stimulation. Moreover value of exponent alpha of DFA of HRV is found to decrease. It appears that rotating acoustic stimulus may be beneficial for the sympathovagal balance of the heart.

On the Effect of Meditation

Lee, M, S., et.al. (2002) studied the effects of Qi-Training on HRV to investigate changes in autonomic nervous function. Power spectrum of HRV used to determine that Qi-training in healthy young subjects during controlled respiration increases the HF power and decreases the (LF/HF) power ratio of HRV. The same quantifying parameter is used by LU, W.A., & Kuo, C.D. (2003) to study the effect of chi meditation on autonomic nervous modulation in older persons. Again the same parameter is used by Murata, T., et.al. (2004) to describe the effect of Zen meditation on HRV. They conclude that lower trait anxiety more readily induces meditation with a predominance of internalized attention, while higher trait anxiety more readily induces meditation with a predominance of relaxation. Sarang., Patil., Telles., & Shirley. (2006). describe the effect of cyclic meditation (CM) and supine rest (SR) on HRV. They prove that predominantly sympathetic activation occurrs in the yoga posture phases of CM while parasympathetic dominance increase after CM. Sarkar, A., & barat, P. (2008) describe that meditation induces periodic behavior in the heart beat. The complexity of the heart rate variability is quantified using multi-scale entropy analysis and recurrence analysis. The heart beat during meditation is found to be more complex. Goshvarpour, A. et.al.(2011)describe the effect of different lags on the width of the Poincaré plots in heart rate signals during meditation. It is found that the simplicity of the width of Poincaré plot calculation and its adaptation to the chaotic nature of the biological signals may be useful to evaluate heart rate signals during meditation. Madhavi,R. (2010) uses Approximate entropy (ApEn) of HRV data of a few healthy subjects before and after meditation. It is found that the entropy parameters improve cardiac health after meditation suggesting that the heart rhythm is more dynamic after meditation. Goswami,D.P.et.al.(2011) shows the effect of meditation on HRV using second order difference plot. The study indicates that meditative state has a completely different physiology and that it may be achieved by any type of meditation technique, and it may redress stress and hypertension related problem.

Phongsuphap,S. & Phongsuphap,Y. (2011) describe patterns of heart rate variability during meditation to understand its effects on health using K-mean clustering method. It is seen that meditation has different effects on health depending on frequency of the resonant peak that each meditator can achieve.

From the aforesaid literature survey it is clear that for both music signal and signal of meditation the analysis is mostly a local one. But to get a complete knowledge of the signal, analysis is to be made from the phase space and not from the signal itself. This is the motivation of writing the article.

3. MAIN FOCUS ON THE ARTICLE

- **Issues:** The effect of music and meditation on HRV is an important social issue, as it relates to relaxation of stress of mind. So it is necessary to develop corresponding proper quantification measures.
- **Controversies:** The main controversies in this connection arise because the conclusions are always based on local analysis of the signal, either on LF of the signal or LF/HF ratio of the signal or some frequently used HRV measures as found in Kubius software.
- **Problems:** To develop different methods for the study of the phase space of the signal (in place of signal itself) and execute their modifications for the betterment of the results, if and when necessary.

Solutions and Recommendations

To execute global analysis of HRV signal in time domain, Average Mutual Information AMI, 2D and 3D Poincaré plot may be used for music signal and 2D Poincaré plot, Angle map, Modified Angle map, Generalized Angle Map may be used for signal on meditation. Of course, best results on music and meditation are obtained from 3D Poincaré plot and generalized angle map respectively.