Influences of Cognitive and Affective Components of Emotions on Heart Rate Variability and Respiratory Pattern in Condition of Evoked Psychoemotional States

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***Abstract* — influence of cognitive and affective components of emotions on heart rate variability and respiratory pattern are investigated in condition of psychoemotional states. We detected, that heart rate variability decreases when individual's perception of emotional states is the cognitive component prevalence towards the affective one.**

***Index Terms* — heart rate variability, respiratory pattern, evoked psycho-emotional state, cognitive and affective component, active and passive imaging.**

I. INTRODUCTION

21st century is era of informational technologies and stresses which inevitably affect the psycho-emotional sphere of a person as quickly, as the heart rate variability (HRV) is often haven't time to adapt, responding with decreased HRV, which is an unfavorable prognostic factor. Therefore, is growing in popularity complementarity of drug treatment by drug-free treatmentmethods. Among the last, efficiently manifest themselves modern methods of respiratory psycho techniques, since the close cardio - respiratory interactions. Each consciousness state, any emotional experience, and any inner reality are associated with a particular respiratory pattern, or quality of breathing. Neuronal respiratory bio feed-back is a technology that allows modeling independent psycho-emotional state with breathing psycho techniques which are based on feed-back mechanisms.

II. AIM OF RESEARCH AND METHODS

Determining changes in the heart rate variability (HRV) and respiratory pattern in condition of positive and negative psycho-emotional state, in comparison with the individual background state.
Tasks to be resolved:

1. Analysis of HRV parameters and breathing pattern at rest and after evoked psycho-emotional states.
2. Conducting questionnaires in order to objectify the availability of appropriate.
3. Identifying individual images, which may introduce a person into a positive and negative state.

37 persons of both sexes were investigated, aged 18-28 years, average age 23. Studies were performed at the Department of Human Physiology and Biophysics, for the time period October 2011 - May 2012. The selection of investigated persons was made according to the inclusion and exclusion criteria of Task Force (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology). Heart Rate Variability, Standards of Measurements Physiological Interpretation, and Clinical Use Circulation 1996. 1996, 93:1043-1065).
Methods of this study were: HRV evaluation using cardiac rhythm-graphical samples that include background samples, consisting of a sample in a horizontal position and the active orthostatic test. Statistical methods are used for the HRV direct quantification in the analyzed period of time.

III. PARAMETERS OF THE RHYTHMOGRAM ANALYSIS

a) *Time domain.* During temporary analysis method, the statistical characteristics of the dynamic cardio line intervals include: SDNN, RR, RMSSD, PNN50, CV. SDSI - the standard deviation of the consecutive intervals RR, RMSSD - standard deviation of the difference consecutive intervals RR, PNN50 - frequency consecutive intervals RR, the difference between the RR, which exceeds 50 ms;
b) *Frequency domain method.* Spectral analysis application quantifies the frequency components of cardiac rhythm fluctuations and allows to represent graphically the different CP ratio components reflecting certain parts of the regulatory mechanism. Spectral analysis was performed using the Fourier fast transforming method. Were calculated such spectral indicators of heart rhythm, which ranges corresponds to respiration waves and slow waves of the 1st and 2nd order, as: VLF (Very Low Frequency) - power spectrum of frequency less than 0.05 Hz, LF (Low Frequency) - power spectrum frequency of 0.05-0.15 Hz, HF (High Frequency) - power spectrum with frequency of 0,16-0,4

Hz, TR - total power spectrum. The LF / HF are low- and high-frequency components ratio, the sympathetic and parasympathetic parts of the ANS balance indicator.
The SDNN and TP reflect the general variability. The SDNN is a summary measure of RR intervals values variability for the entire period under review. The SDNN is in a direct proportion to the LF and HF, and is proportionally to the RMSSD, PNN50. In order to assess the high-frequency component (parasympathetic contribution of the rhythm structure) - RMSSD, PNN50 and HF, HF has a stronger correlation with the HRV time domain than LF, reflecting the parasympathetic influence on HRV and the overall HRV. The RMSSD is proportional to PNN50 and SDNN, as well as HF and TP [1]. The VLF is the total power spectrum component, which reflects the suprasegmental structures influence and humoral-metabolic effects on the heart rhythm. The CV is the correlation coefficient. The RRNN (NN - a number of normal intervals, "Normal to Normal", with the exception of the extrasystoles), is the value inversely proportional to the heart rate [1, 6].

Informational samples execution was performed by using managed mental stress, in order to introduce into the necessary psycho-emtional state.
a) Active Imaging - actually experienced fear visualization (memories) and virtual fear visualization, i.e. potentially caused by fear situation, but not experienced (imagination) [2];
b) Passive Imaging - Image presentation, which causes induction of positive psycho-emtional state.

Objectivity of presence of the neessary psycho-emtional state was performed by using:
a) Monitoring changes in rhythmogram;
b) Questionnaires - the Oxford Happiness Inventory (OHI) for the positive state and Spielberger - Hanin State and Trait Anxiety Inventory (STAI) for the fear state.
4. The analyzing parameters of the breathing pattern:
Ti – inspiration duration;
Te – expiration duration;
T = Ti + Te – respiratory cycle duration;
FR – respiratory frequency;
TIT%-th inspiration ratio to the entire respiratory cycle;
VITI - respiratory drive (inspiration volume rate);
VIF - respiratory minute volume, intended for one respiratory cycle.

The research was conducted in two steps. The first step was conducted to establish the psycho emotional factors which influence on HRV, the second step - completed with the studying of respiratory pattern. How is modifying the respiratory pattern in a certain psycho-emotional state, and the HRV response on their combined impact. The first phase was conducted in order to identify psycho-emotional state, which negatively affects the HRV, thereby modelling stressful situations that a person encounters in his daily life and hereby can be concluded about the individual impact of fear on the HRV. The second phase was conducted to identify factors that can enhance the HRV. For this purpose we simulated a situation in which a person experiences gladness. At this stage, we have also examined the factor that not only influences the HRV, but also the ability to consolidate the necessary positive psycho-emotional state of the individual for the required period of time - respiratory pattern. Both stages were held on different days.

III. RESULTS AND DISCUSSION

HRV changes in condition of evoked negative psycho-emotional state

The HRV reduction, as a response to real fear, was observed in the following investigated groups: 70% LF, 60% HF, 40% VLF + HF ($p < 0.001$). The HRV reduction, as a response to a virtual fear was observed in the following investigated groups: 80% VLF + LF, 30% LF, 10% HF ($p < 0.01$). The increase of HRV as a response to a virtual fear was observed in the following investigated groups: 60% VLF + HF, 30% HF ($p < 0.001$). Changes in the group VLF + LF were not statistically significant. According to received data, we may conclude that the response to the real and the virtual fears, as well as stress-emotions that we feel every day are the situations of the past, or situation, based on miss-information [6, 3]. These are individual and depend on the dominant vegetative state, suprasegmental structures activity level and initial HRV of a person. [4] Thus, the response to fear is not always necessary consisted of the HRV reducing. In the group VLF + HF was an increase of HRV. HRV increase was observed in a VLF+HF group. The results are presented in Tables I and II.

TABLE I. PHASES SEDATION, DELAY OF EXPIRATION

Parameters	**Back-ground**	**I Image**	**II Image**
Vt	0.374 ± 0.05	0.614 ± 0.18 ***	0.639 ± 0.17***
Ti	1.53 ± 0.15	2.34 ± 0.44****	2.38 ± 0.48****
Te	1.95 ± 0.37	3.57 ± 0.83****	3.07 ± 0.81****
T	3.48 ± 0.43	5.91 ± 0.98****	5.45 ± 1.26****
FR	17.46 ± 1.99	10.41 ± 1.78****	11.47± 2.27****
TIT	0.442 ± 0.04	0.399 ± 0.06**	0.441 ± 0.03
VITI	0.244 ± 0.03	0.257 ± 0.04	0.290 ± 0.07*
VIF	6.5 ± 1.09	6.24 ± 1.71	7.6 ± 1.62*
P < 0,05*	**P < 0,01****	**P < 0,001*****	**P < 0,0001******

TABLE II. ACTIVATION, DELAY OF BREATH IN INSPIRATION

Parameters	**Background**	**I Image**	**II Image**
Vt	0.380 ± 0.1	0.260 ± 0.04****	0.247 ± 0.05****
Ti	1.73 ± 0.28	1.31 ± 0.1****	1.31 ± 0.17****
Te	2.92 ± 0.78	1.95 ± 0.5***	1.89 ± 0.37***
T	4.65 ± 0.1	3.26 ± 0.54****	3.2 ± 0.51****
FR	13.47 ± 2.88	18.78 ± 2.63****	19.2 ± 3.11****
TIT	0.377 ± 0.04	0.41 ± 0.05**	0.413 ± 0.03**
VITI	0.216 ± 0.03	0.19 ± 0.02**	0.186 ± 0.02***
VIF	4.86 ± 0.82	4.82 ± 0.65	4.61 ±0.56
< 0,0001*****	P < 0,001*** P	< 0,01** P	< 0,05*

HRV changes in condition of evoked positive psycho-emotional state

According to the HRV influence image analysis, viewed pictures are subdivided into two large groups: images that create a desire of active interaction with the images' context, which statistically significant corresponded with the HRV increase in HF group ($p < 0.001$). The second group - pictures, causing state of quiet contemplation. A statistically significant HRV increase on the presented images has corresponded VLF + LF and LF group ($p < 0.001$). A statistically significant HRV increase in the VLF + HF group was observed only after the sequential viewing of both pictures - the active cooperation and quiet contemplation ($p < 0.05$). Thus, we may conclude that an individual who have a dominating cognitive perception of positive emotions, reacts with HRV increasing only when viewing the quiet contemplation pictures.

Changes in respiration pattern in condition of evoked positive psycho-emotional state

The sedation was held in two stages. At the first stage of the sedative reaction indicates slowing of FR and elongation phase of respiration (Ti, Te), as well as the entire duration of the respiratory cycle (T). The fact that this is the initial relaxing stage indicates that, contrary to the above-mentioned changes in the parameters, tidal volumes were not significantly changed (VITI, VIF) – this indicates the current muscles tension involved in respiration, particularly - in the chest (Nikondorova S. 2011). With a further view of the second picture, the second relaxation stage: tidal volumes (VITI, VIF) is beginning to increase, which is accompanied by the relaxation of the chest muscles participating in breathing and probably takes place a connection to abdominal breathing. [5] The delay of breath presence at the height of the elongated expiration indicates the initial reduction percentage inspiration to the entire respiratory cycle (TIT) and increasing expiration duration (Te) towards to the initial duration at rest. In addition to enumerated changes, on the fact that it's situational changed breathing pattern, indicates the dynamics of changes in the ratio of inspiration to the entire respiratory cycle (TIT): Decreases in the first relaxation stage. Responding to the images context, breathing pattern changes, according to a new psycho-emotional state [2], connects the delay of breath in the expiration. In the second stage TIT tends to the primary level, to his habitual pattern of breathing.

Delay of breath in inspiration indicates the following modifying parameters: reducing the duration of inspiration while increasing the inspiration percentage to the entire respiratory cycle (TIT) and decrease respiratory drive (VITI); the inhaled volume reduction (Vt) and the significant changes absence of a minute breath volume for one breath cycle (VIF).

Based on a received data on the respiration pattern changes induced by positive psycho-emotional state, it may be concluded that respiration pattern changes include not only the frequency and duration of respiratory cycles changes, the volume [2], but also signs presented of breath delay (Nikondorova S. 2011). This, in turn, depends on: the existing emotional condition [1], which should be designed to support, or such a psycho-emotional condition that introduce the individual (breathing pattern can help here to enter into necessary state and to fix it at the right time for the individual) (Boiten F. 1993). Proceeding from the data results, **practical value** of this work consists in possibility of changing emotional state of the person. In addition, respiration pattern changes that arise when viewing similar images, follows a possible clinical use proposal: According to the bio-feed-back principles (Boiten F.1993), when a person will need an equilibrium and calm state, or in case of breath shortness, not related to organic pathology [2], the person will be advised to breathe, according to the breathing pattern changed during a test-image show. When a person will need an activation of VNS resources, to active psycho-emotional state, mobilization, and to eliminate hyperventilation, as a result of increased anxiety [2] (to stop in time to avoid progression in a panic attack [4]), it will first be asked to breathe according to breathing pattern, when viewing the images that create the desire of active interaction. This would allow switching away from negative induced emotions primarily of fear, anxiety and panic attacks, to the interaction with the surrounding reality, to recognise a problem's solution. [5] Next, he will be offered a picture of his quiet contemplation, with a corresponding breathing pattern, in order to complement and balance its state. It is very important because a person in a positive psycho-emotional state with equilibrium is able to eliminate on his own the cause of his emotional distress and related manifestations of the respiratory system [1, 5].

IV. CONCLUSION

II. Heart rate variability decreases when individual's perception of emotional states is the cognitive component prevalence towards the affective one.

III. During induced psycho-emotional states were changes in respiratory pattern: individual's activation lead to delay in inspiration and in case of sedation – delay in expiration.

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