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BIOFEEDBACK RELAXATION TECHNIQUES IN ADDRESSING CORTEX-HYPOTHALAMUS CONTROL LOOP FOR MOTIVATION OF OBESITY AVOIDANCE

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Abstract

This research explores how the achievement motivation pathway in the cortex influences hypothalamic activity, which could influence appetite control and obesity avoidance. The objective was to examine the sympathetic/parasympathetic feedback loop, and the influence of various biofeedback relaxation techniques on lowering heart rate (HR) and electrodermal activity (EDA). The methodology used was a standard biofeedback mechanism with visual representation of the measured physiological parameters. The feedforward part of the said feedback loop is controlled by hypothalamus while the feedback part is evaluated by the cortex. The participants were young adults and the sample size was ten. The results revealed that three (posture relaxation, breathing in and out very slowly, and closing the eyes) of five techniques used contributed more in controlling physiological parameters than the other two. The results imply that the energy balance feedback loop, which is also controlled by the hypothalamus, can be used to influence obesity avoidance.

Keywords: Achievement Motivation, Cortex-hypothalamic Control, Biofeedback, Sympathetic/Parasympathetic Feedback Loop, Energy Balance Feedback Loop

Introduction

The study focused on biofeedback investigation exploring several techniques in controlling physiological parameters such as heart rate (HR) of the participants and electrodermal activity (EDA) of the human skin. Another term used for EDA is galvanic skin response (GSR), and these terms are used interchangeably in this paper. Easily measured and relatively reliable, GSR has been used as an index for those who need some measurable parameter of a person's initial state, arousal, and relaxation. HR is a more stable parameter compared to GSR. The activity of sweat glands in response to the sympathetic nervous system (due to increased sympathetic activation) results in an increased level of conductance. In addition, there is a relation between sympathetic activity and emotional arousal. Decreased tonus of the sympathetic nervous system results in relaxation. HR is regulated by both parts of the autonomic nervous system, the sympathetic and parasympathetic. The sympathetic increases HR, while the parasympathetic decreases it.

Biofeedback is a tool for creating change in the habitual activities of the nervous system. Biofeedback methods have been used for various intentions related to improving physiological and mental conditions of a subject. One of the parameters that can be improved is motivation for self-control. Self control of one's own physiological parameters is a manifestation of willpower of a subject which is used in dealing with various life challenges, including avoiding/preventing obesity.

The purpose of this study was to investigate the ability of an individual's willpower to control physiological parameters. The objective was to examine the sympathetic/parasympathetic feedback loop, and the influence of various biofeedback relaxation techniques on lowering HR and EDA.

The conceptual model followed in this investigation is shown in Figure 1 (Bozinovska, 2013). According to this conceptual model, the hypothalamus is the center of important features of personality such as willpower, confidence, and self-control. The hypothalamus has several control loops, one of them being through the (conscious) achievement motivation center of the cortex. An external feedback mechanism can be used to monitor, on a computer screen, some parameters of a participant's physiology which are below the threshold of conscious awareness of the subject. The success of willingly changing the observed parameters enhances achievement motivation, willpower, and confidence of the subject at a sufficient level, resulting in the expectation that the achievement motivation system and hypothalamic self-control will be able to influence both sympathetic and energy balance (metabolism) loops, which are in the feedforward part of the hypothalamus control loops.

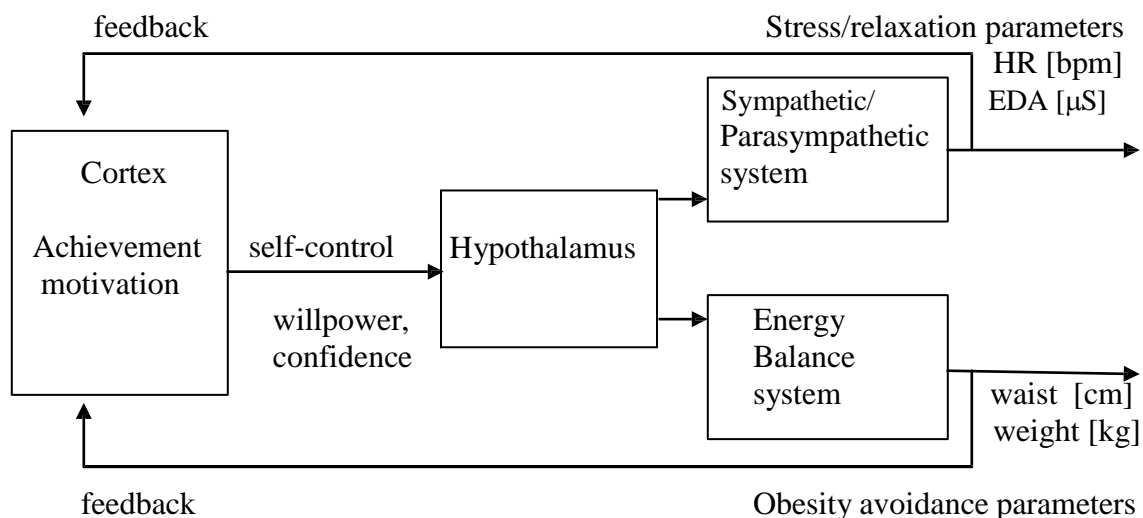


Figure 1. The Conceptual Model of Cortex-Hypothalamus Control Loop for Stress/Relaxation and Obesity Avoidance

Literature Review

Appetite related disorders are a dominant focus of society. Obesity is a recognized appetite related disorder as it relates to human appearance, behavior, and health (Harcombe, 2010). Among various approaches to deal with obesity this study focuses on achievement motivation.

The concept of achievement motivation followed the concept of needs (McClelland et al., 1949) and was introduced by Atkinson (1950). As pointed by Atkinson (1974), the guide for research in achievement motivation (as of 1965) bears a resemblance to the work of Lewin (1946). Achievement motivation was introduced as learned variable in a brain-like neural network (Bozinovska and Ackovska, 2013).

Biofeedback techniques have been widely used in dealing with changes in behavioral habits since the introduction of the concept (Miller, 1973). Since then biofeedback and self-regulation techniques have been used in clinical practice (Pepper et al. 2009) and rehabilitation (Giggins et al. 2013). Practitioners guides are available (Schwartz and Adrasik, 2003). Biofeedback has been also considered in relation to obesity (Mahoney, 1976; Miller, 1980). Recently, an experimental work was presented that uses a feedback setup where instead of a physiological variable (as is the case of a biofeedback setup) a robotic arm is controlled by brain signals, a method which is believed to influence achievement motivation in a subject (Munnerlyn et al., 2011).

Methodology

The population used in this study consisted of young adults between the ages of 19 and 34. A sample of ten subjects was used in the study. The ten subjects were those that responded to the call for participation and passed the inclusion and exclusion criteria. The equipment used consisted of a Biopac MP35 biopotential amplifier connected to a personal computer and a software program for collecting and analyzing the obtained measurements. HR was measured using electrocardiogram (ECG) Lead II standard setup (both leg ankles and a wrist), as shown in Figure 2. The setup for EDA measurement is shown in Figure 3. A 0.5 V voltage source was applied between two fingers and conductance in micro Siemens [μS] was measured.

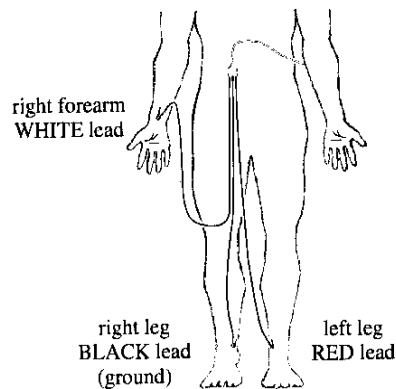


Figure 2. The ECG Heart Rate Measurement Setup

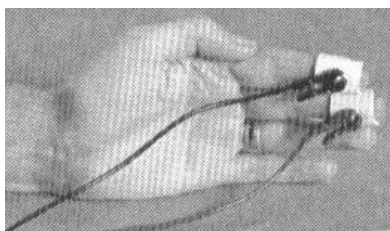


Figure 3. The EDA Measurement Setup

Both HR and EDA were shown on the screen to a subject as a bar graph. The height of the bars changed according to changes in HR and EDA. Figure 4 shows the screen shown to the subject. A measurement session was recorded on a screen, an example of which is shown in Figure 5.

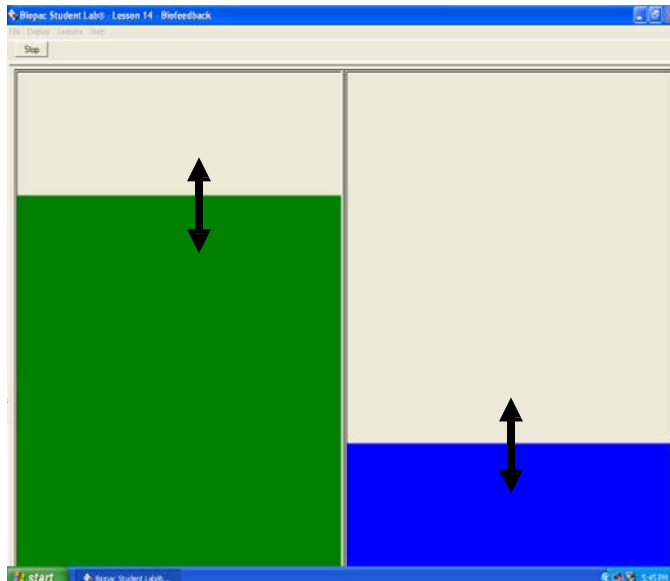


Figure 4. Computer screen shown to a subject. The left part (green) shows the level of HR and the right part (blue) shows the EDA



Figure 5. Example of a screen showing a measurement session. ECG is shown in the upper part of the screen, HR at the middle, and EDA at the bottom part of the screen

Five methods of relaxation were used in the control of the physiological parameters considered in this study: These were biofeedback (BF) 1: relax your posture; BF2: breathe in and out very slowly; BF3: imagine yourself at a warm, relaxing seashore; BF4: smile; and BF5: close your eyes. At the beginning of each session, an initial value of the parameters HR and EDA was taken

and denoted as INIT. In addition to the relaxation techniques, arousal techniques were also used but that aspect of the study falls outside the scope of this paper.

Data were collected for all 10 subjects for each session. There were 6 sessions administered during six weeks. Therefore, the data collected were: 10 subjects x 2 parameters (HR and EDA) x 6 methods (INIT+BF1,...,BF5) x 6 biofeedback sessions (weeks) = 720 entries in an Excel spreadsheet.

Results and Discussion

Two types of analyses were carried out: analysis for a single session and analysis for all sessions.

Analyzing a Single Session

Each session consisted of the initial value (INIT) of HR or EDA and end values after applying the 5 relaxation techniques (BF1, ..., BF5). Figure 6 shows an example of a session analysis for 10 participants.

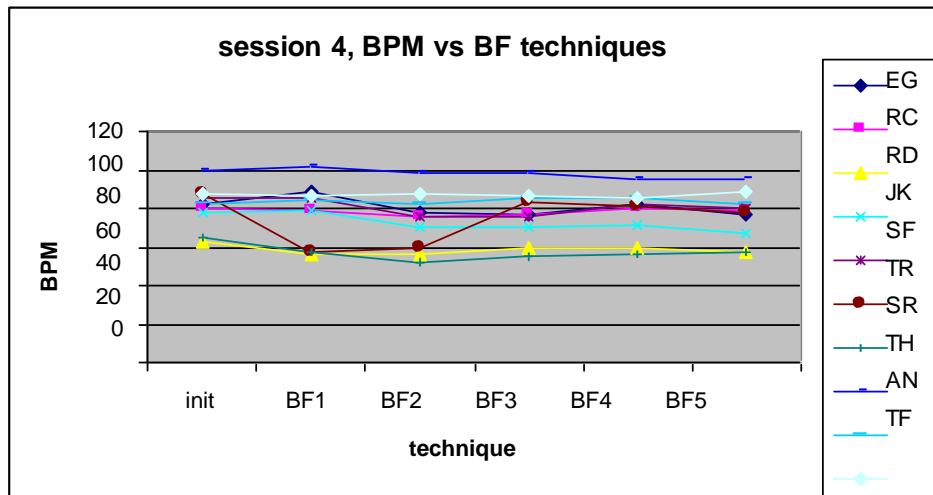


Figure 6. Heart Rate [BPM] across Biofeedback Relaxation Techniques, for a Particular Session (session 4), for all Participants. Each participant is represented by two letters, such as EG, RC, etc.

Figure 7 shows the average value curve for all participants in the same session. It depicts that some techniques contributed more in lowering the controlled variable, HR, than the other techniques. The techniques that contributed more in lowering were BF1: relax your posture, BF2: breathe in and out very slowly, and BF5: close your eyes.

Analyzing All Sessions

Table 1 shows analysis of all sessions for the parameter HR. Each entry is the average value obtained from the 10 participants. The Table indicates averages, standard deviations, and maximum and minimum values obtained for each relaxation techniques across all sessions.

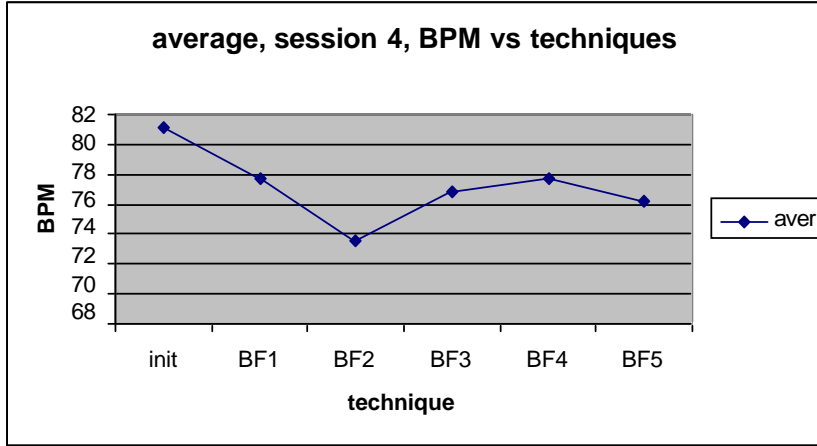


Figure 7. Average Value of Heart Rate for all Participants in a Particular Biofeedback Session

Table 1: Heart Rate [BPM] Lowered from Initial Value (INIT) Using Various BF Techniques

Session	Techniques					
	INIT	BF1	BF2	BF3	BF4	BF5
Ses1	82.50	74.40	74.96	74.39	73.98	75.63
Ses2	85.76	75.01	75.38	74.93	74.84	74.67
Ses3	83.90	76.56	75.30	73.65	77.38	75.76
Ses4	81.10	77.68	73.50	76.79	77.77	76.18
Ses5	79.17	77.87	74.50	72.85	74.89	77.65
Ses6	78.04	69.81	70.30	72.94	74.29	72.65
Aver	81.75	75.22	73.99	74.26	75.52	75.42
Stdev	2.90	2.99	1.93	1.48	1.63	1.67
Max	85.76	77.87	75.38	76.79	77.77	77.65
Min	78.04	69.81	70.30	72.85	73.98	72.65

Figure 8 is a graphical representation of Table 1. It shows the average value of HR of all participants (middle curve) and ranges (\pm) of standard deviation (upper and lower curve). From the observed results, it can be confirmed that the relaxation techniques which achieved the best performance on the considered sample are BF1, BF2, and BF5:

The relaxation techniques used were able to reduce the heart rate in average from an initial value of 82 beats per minute (BPM) to 74 BPM. The maximum value of initial HR was 85.76 BPM, and the minimum value was achieved using the relaxation technique BF2, with a value of 70.3 BPM.

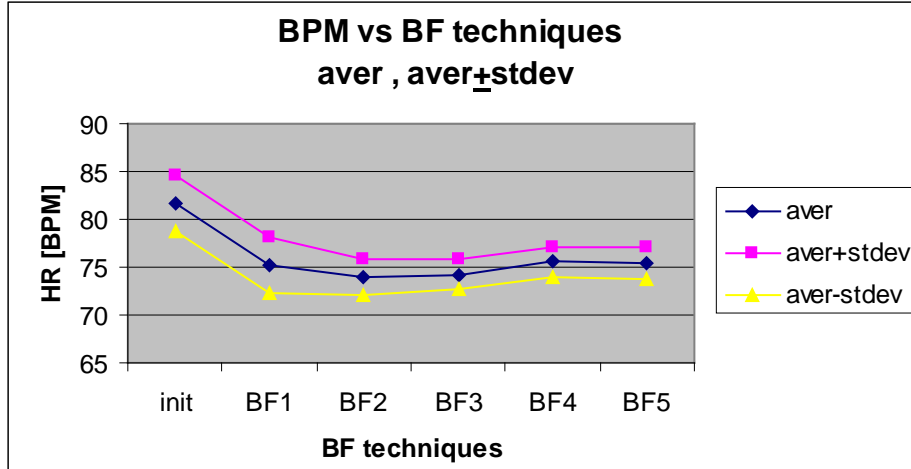


Figure 8. Heart Rate Results from all Sessions and all BF Techniques, given as Average \pm Standard Deviation Ranges

The results imply that the cortex-hypothalamus loop can willingly control the variation of heart rate from an average 82 BPM to an average 74 BPM. The results also imply that the hypothalamus, when controlled by the achievement motivation center of the cortex, can reduce heart rate to 70.30 BPM.

Table 2 shows analysis of all sessions for the parameter EDA. Each entry is an average value obtained from 10 participants. It reflects averages, standard deviations, and maximum and minimum values obtained for each relaxation technique across all sessions. The controlled variation of average EDA was from 0.63 μ S to 0.28 μ S. The minimum value that can be achieved is 0.03 μ S. Figure 9 shows the graph corresponding to Table 2.

Table 2: Electrodermal Activity [μ S] Lowered from Initial Value (INIT) Using Various BF Techniques

Session	Techniques					
	INIT	BF1	BF2	BF3	BF4	BF5
Ses1	0.64	0.43	0.42	0.43	0.44	0.46
Ses2	0.93	0.72	0.5	0.19	-0.10	0.15
Ses3	1.82	1.35	1.06	1.01	0.93	0.92
Ses4	-0.15	-0.14	-0.03	-0.08	-0.01	-0.21
Ses5	0.03	0.34	0.31	0.15	0.23	0.15
Ses6	0.49	0.73	0.74	0.70	0.68	0.21
	INIT	BF1	BF2	BF3	BF4	BF5
Aver	0.63	0.57	0.50	0.40	0.36	0.28
Stdev	0.71	0.50	0.37	0.40	0.40	0.38
Max	1.82	1.35	1.06	1.01	0.93	0.92
Min	-0.15	-0.14	-0.03	-0.08	-0.10	-0.21

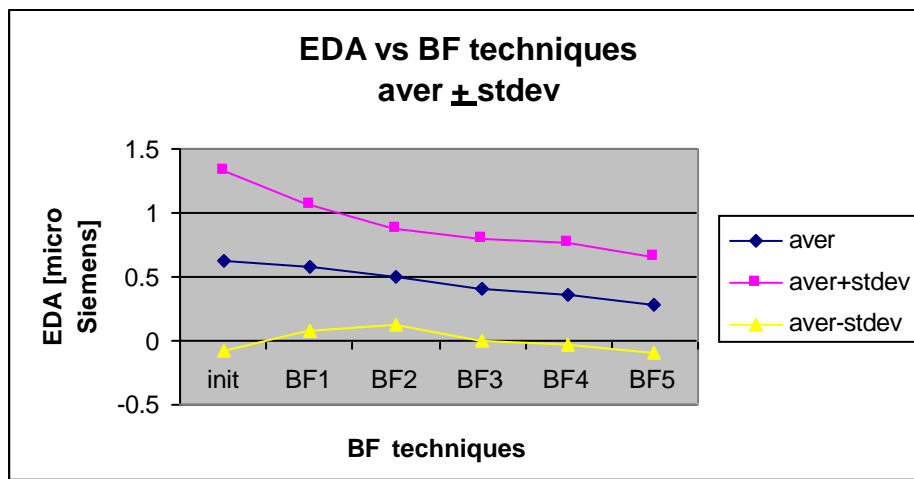


Figure 9. Electrodermal Activity and Various BF Relaxation Techniques Applied. Shown are Average Value \pm Standard Deviation Ranges

The results can be discussed in a broader context, using the conceptual model as shown in Figure 1. The results obtained on the Sympathetic/Parasympathetic feedback loop suggest that it is possible to address the other feedback loop shown in Figure 1, the Cothex-Hypothalamus-Energy Balance feedback loop, and use the cortex-hypothalamus control system in influencing behavior that would lead to obesity avoidance.

Conclusion

The research task was to observe the biofeedback-based control of the hypothalamic sympathetic/parasympathetic pathway using five relaxation techniques, namely, relax your posture; breathe in and out very slowly; imagine yourself at a warm relaxing seashore; smile; and close your eyes. The preliminary results of this study carried out on 10 subjects showed that:

- 1) The most effective relaxation techniques were: posture relaxation, breathing in and out very slowly, and closing the eyes.
- 2) Through the cortex-hypothalamus control loop the subjects were able to willingly control the variation of HR from an average of 82 BPM down to an average of 74 BPM. The minimum value of HR achieved was 70.30 BPM.
- 3) The controlled variation of average EDA was from 0.63 μ S down to 0.28 μ S. The minimum value achieved was 0.03 μ S.

Following the conceptual model of the study, the results obtained regarding the Sympathetic/Parasympathetic feedback loop suggest that it is possible to address the other feedback loop shown in Figure 1, the Energy Balance feedback loop, and use the cortex-hypothalamus control system in influencing obesity avoidance.

Acknowledgement

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