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The Use of Biofeedback to Increase Resilience and Mental Health of Supersonic Pilots

Kloudova Gabriela[1], Kozlova Simona[2], Stehlik Miloslav[3]
[1,2,3]CASRI-Czech Army Sport Research Institute
([1]kloudova@casri.cz, [2]kozlova@casri.cz, [3]stehlik@casri.cz)

Abstract- Pilots operate in a high-risk environment rich in potential stressors, which negatively affect aviation safety and the mental health of pilots. In the research conducted, the pilots were offered mental training biofeedback therapy. Biofeedback is an objective tool to measure physiological responses to stress. After only six sessions, all of the pilots tested showed significant differences between their initial condition and their condition after therapy. The biggest improvement was found in decreased heart rate (in 83.3% of tested pilots) and respiration rate (66.7%), which are the best indicators of anxiety states and panic attacks. To incorporate all of the variables, we correlated the measured physiological state of the pilots with their personality traits. Surprisingly, we found a high correlation with peripheral temperature and confidence (0.98) and with heart rate and aggressiveness (0.97). A retest made after a one-year interval showed that in majority of the subjects tested their acquired self-regulation ability had been automatized.

Keywords- *Aviation, Biofeedback, Mental Workload, Performance Psychology*

I. Introduction

Military pilots are often exposed to a very stressful working environment due to high risk and potential stressors such as noise, vibration, temperature, hypoxia, motion sickness, acceleration and decompression sickness. These stimuli induce impairment of performance and therefore have a negative effect on flight safety and can lead to aviation accidents that are from 80-85% caused by human error [27]. To decrease this number, it is vital to work with pilots on their abilities, not only the technical side, but also on mental readiness and reduction of the impact of their mental workload. Real-time measurement of their bodily processes can help monitor the physical and psychical states of the pilot and alert him or the ground personnel about the possibility of upcoming danger. Biofeedback works with these processes and is already used in many military settings worldwide, like in the Chinese army [8] or in the Israeli army where it is called the Mental Gym Project [18]. This research is primarily focused on pilots and increasing their psychophysiological and cognitive flexibility. Especially in supersonic pilots, biofeedback therapy helps to better handle the high levels of acceleration called g-force, which moves blood away from the brain and can cause g-induced loss of consciousness (G-LOC) that is known as a source of many fatal aircraft accidents [9].

Biofeedback works on the principle of feedback that can help develop a greater awareness and ability to regulate physiological functioning by using body signals. Biofeedback training (BFT) is a process by which we can learn to identify autonomic nervous system (ANS) functions by monitoring physiological responses to stress [3]. It improves awareness of physiological, cognitive, and emotional processes, while it teaches how to self-regulate and generalize the skills needed in an everyday environment. The main purpose of biofeedback is to help in retraining the nervous system and the brain to produce more helpful responses over the long term [10]. BFT techniques typically encompass three stages: 1. become aware of maladaptive physiological responses, 2. learn to control them, and 3. transfer this control to everyday life [3]. BFT is often implemented in the context of stress exposure strategies. In the military, it is primarily used to reduce stress [2], for the treatment of post-traumatic stress disorder [12], [21], [26] and for increasing the resilience of soldiers [4]. As a part of stress management training (SMT) in soldiers of the Canadian Armed Forces, biofeedback using Practising SMT has been shown to be effective in improving the ability to cope with stress and to reduce its negative impacts [2], [3].

Physiological signals are measured by a specific device and are transformed into a viewable form on a computer screen. A biofeedback device measures cardiovascular modalitites like heart rate, heart rate variability (HRV) and blood volume pulse (BVP) as well as respiratory modalities, including respiration rate and breathing patterns. It also includes surface electromyography in measuring muscle tension (EMG), the measurement of skin conductance, and the peripheral skin temperature. These parameters are the best physiological indicators of stress responses. The theory is based on ANS functioning which maintains homeostasis in the body. It is divided into the sympathetic nervous system (SNS), corresponding with arousal and energy generation, and the parasympathetic nervous system (PNS), promoting calming of the nerves and attenuation. The prevailing scientific viewpoint for several decades has held that the ANS functioned automatically beyond conscious awareness and voluntary control. Later, studies with humans and animals showed that operant conditioning can produce changes in several body responses. This is the basis of the biofeedback method [23]. Stress is the main trigger of the sympathetic stress response which causes overarousal and forces the body to react in a “fight or flight” manner. Moderate acute stress is associated with improved performance. However, if it’s a long-acting stress, it can have a negative impact, resulting in disorders of the immune system, inflammation, cardiovascular diseases, loss of muscle mass, reduction of fine motor performance, reduction of attention and cognitive functions, depression, infertility, diabetes or cancer [3], [22]. Environmental flight stress positively correlates with job satisfaction, which is a significant contributor to mental health [1]. The positive relationship between stress and job satisfaction among military pilots confirms an estimation that providing mental training biofeedback therapy is useful in decreasing the impact of stressors. This leads to increasing their job satisfaction, thus increasing their mental health as well as their resilience to stress. Overall, a reduction in environmental flight stress results in both the improvement of flight performance and safety.

Stress management skills, such as paced breathing, can be learned with the use of biofeedback. Deep-breath biofeedback can increase heart rate variability and reduce heart rate and blood pressure at high altitudes. It is an important assistance method used to acclimatize to high altitudes which can provide positive psychophysiological benefits to military operators [14]. Most people don’t have the ideal respiration pattern and tend to overbreathe, which is the common type of dysfunctional breathing. It refers to the behavioral mismatch of the rate and depth of breathing resulting in ventilating out too much carbon dioxide, lowering blood levels of CO_2 and leading to hypocapnia [6], [13]. Acute hypocapnia affects the central nervous system similarly as SNS. It is known that emotions can increase or decrease ventilation inducing hypo- or hypercapnia just as breathing can affect emotions in terms of calming [25].

To alleviate anxiety patterns by reducing the level of muscle tension, EMG biofeedback is used. In this technique, sensors detect muscle tension caused by mental stress. A stress-induced increase in muscular tension is more devastating than a physical load [15]. This tension is most often measured on the trapezius muscles, but it can also be placed on other muscle groups.

The measurement of electrodermal acitivty (EDA) and peripheral skin temperature is used to indicate psychological or physiological arousal. This physical and psychological stress detection system provides measurement of sympathetic activation. The sensors measure the electrical resistance of the skin from the salts that are excreted during sweating. With stress, anxiety, or any emotion-related arousal, skin conductance increases [10]. The results suggest the potential of the condensed BFT method; however, for more effective utilization and more significant reductions in physiological stress responses, additional practice time in the technique may be required [3].

Peripheral temperature, as measured at the extremities, varies according to the amount of blood perfusing the skin. So, as a person gets stressed, their fingers tend to get colder. BFT focused on peripheral temperature involves learning to voluntarily increase finger temperature, and it is most vulnerable to “trying too hard” and frustration resulting from lack of fast progress [10].

Heart rate variability (HRV) biofeedback works with the time interval between heartbeats called R-R, and it reflects the rhythmic accelerations and decelerations of heart rate oscillations. R-R is the difference between the maximum and minimum heart rates that occurs during a full breath cycle [10]. The amplitude and pattern of these oscillations are an indication of the ability to self-regulation. Basically, the greater the amplitude of oscillations is the healthier and more adaptive the person can be, so the goal of HRV biofeedback is to maximize this amplitude. This can be done by breathing at a particular resonance frequency breathing rate that will stimulate the heart rate to produce maximum oscillations. HRV biofeedback is known to have multiple effects on the cardiovascular system, the respiratory system, and emotional reactivity [11].

In both populations (civilian and military), biofeedback has become useful in the treatment of traumatic brain injury. This approach to treatment significantly improves the motivation of the patients, increases their concentration and mindfulness and also decreases depressive symptoms, if any [7]. Studies also use biofeedback as a successful treatment for anxiety, insomnia, drug addiction and especially depressive symptoms, and they also teach patients how to control their internal physical settings. The results report decreasing heart rate variability and respiratory rate as well as improved functions [12].

The current study examined the long-lasting effects of biofeedback in the case of PTSD military patients. The results have shown continuing progress despite a three-month break from the therapy sessions [19]. A study aimed at improving PTSD symptoms explored the influence of HRV biofeedback. HRV biofeedback, as a treatment for a variety of disorders (including PTSD, insomnia, depression, chronic muscle pain, hypertension, anxiety) and for performance enhancement, is a form of cardiorespiratory feedback training [11]. Training altered the parasympathetic regulation of cardiac activity with greater HRV, that is, less arousal during a combat simulation designed to heighten arousal [12]. Aggregate measures of HR and EDA were used to examine the effectiveness of a condensed BFT method at reducing acute stress responses and improving performance under stress.

Professionals in high-risk organizations, such as the military pilots who are frequently exposed to acute stressors, cope with these situations differently from one to another. How people cope or recover from stress is influenced by their personalities. The relation between stress responses and pilot personality traits is receiving increasing attention among the military. A recent study indicated the influence of coping style, coping self-efficacy and appraisal emotions on coping with acute stress in the military [5]. In the aviation community, it is recommended to use ALAPS (The Armstrong Laboratory Aviation Personality Survey) for the assessment of an aviator´s personality [20]. Managing a personality questionnaire is key to determining a pilot's ability to fly and his or her psychological resilience.

II. SUBJECTS

The group tested consisted of six military pilots who were voluntarily assigned to biofeedback training. All of them are in the highest stage of training, flying the Gripen supersonic airplanes. The subjects are men aged 36-43 in good physical and mental condition, and they passed a regular full examination which means that they have no cardiac disease, vision defects, brain damage or suffer any mental illness. All of them were flight status ready, non-smokers, right-hand dominant and didn't take any medications. They claimed their family situations and social networks were stable. To ensure anonymity of the pilots, they were all assigned an identifier, so they could speak freely during the biofeedback sessions.

III. METHODS

Biofeedback: For this study we used a ProComp Infiniti 8-channel biofeedback system from Thought Technology, which gave us the ability to conduct classic physiological biofeedback, including heart rate and HRV, skin conductance, BVP, respiration, peripheral temperature and muscle tension. It consists of a multi-modality encoder which connects to a Windows desktop or laptop PC via a fiber optic cable, a TT-USB receiver and a cable-to-USB port. The hardware is supported by Physiology Suite software which offers the monitoring and assessing of physiological data, artefact rejection and computerized biofeedback sessions. This system combines the versatile ProComp Infiniti 8-channel device with a full array of sensors. They are completely non-invasive and require no skin preparation when used for feedback purposes.

We used two sensors for abdominal and thoracic breathing which compute the difference in the amplitude of expansion and contraction of the rib cage, or abdominal area, to a rise and fall of the signal on the screen. The sensor consists of a long Velcro strap that is stretched around the client's chest, just above the breasts, and one at the level of the navel. From this measurement, it's possible to obtain information about the rate of breathing, its pattern, the proportion of inhalation to exhalation and the depth of breathing. These data are later used for BFT that is focused on shifting breathing from the chest to the abdomen, coordinating the rate and size of the breath including the proportion of inhalation to exhalation.

HR and BVP are measured by the same sensor placed on the middle finger. BVP, also called plethysmography, is scanned as infra-red light bounces against a skin surface and measures the amount of reflected light.

The peripheral temperature sensor was strapped to the palmar side of the little finger using a short strip of Velcro. It detects peripheral temperature, and the lower it is the more stressed the client feels.

Skin conductance, as in the Infiniti software called SC-Flex/Pro, works on a principle of electrical voltage that is applied through two electrodes strapped to two fingers of one hand, in order to establish an electrical circuit where the client becomes a variable resistor.

Finally, the surface EMG sensors were placed on the pilots' trapezius, and they measure muscle activity by detecting and amplifying the electrical impulses that are generated by muscle fibers when they contract. The number of muscle fibers that are involved during any contraction depends on the force and mental effort required to perform the movement. Thus, the amplitude of the resulting electrical signal is proportional to the force of contraction.

HRV is obtained from the respiratory and BVP sensors, and it shows the variation in the time interval between heartbeats.

ALAPS: The ALAPS is a 240-item test with 15 final test scales to assess personality, psychopathology, and crew interaction styles. The personality scales include confidence, sociability, aggressiveness, orderliness, and negativity. The psychopathology scales include affective lability, anxiety, depression, and alcohol abuse. Finally, the crew interaction scales include dogmatism, deference, team orientation, organization, impulsivity, and risk taking [20].

IV. STUDY PROTOCOL

Participants of the study were assessed and trained by biofeedback in their workspace on a 211.TL Caslav, which is specialized to train Gripen pilots. All of them were measured and did BFT together with the ALAPS questionnaire separately in a quiet examination room. Six BFT sessions were scheduled for every pilot lasting around fifty minutes. At the first meeting, the pilots completed the ALAPS test, and then they had to fill out a special form covering their mental and physical health, recent stressful events, consumption of caffeine, nicotine or any other prohibited substances, and the amount of sleep they had had recently. The form is needed to exclude any possible interference that could influence the measurement and the BFT. Then a biofeedback script session called a stress profile was presented on a laptop. It's necessary to conduct a psychophysiological stress assessment to know which areas of the client's physiology need to be addressed and how to improve them. It may reveal unhelpful physiological reactions to stress and a certain pattern of responses that needs to be changed for optimal performance. The first step is to record a baseline that takes five minutes, and it is important to see how readily the person relaxes. It is followed by two-minute stressor called a color words task, which is based on the Stroop effect. A list of color names written in different colors is presented on a PC screen in front of the client, and his task is to read the written word not the color. After the stressor, a recovery break follows where the client is instructed to sit quietly with eyes open, and we observe how he recovers from the stressors. Then we move on to the next stressor called mental arithmetic. In this task, we ask the pilot to repeatedly subtract 7 starting from 1000, and his task is to count as fast as possible. When the two minutes are over, we say stop, and the subject answers with his final number. It's not important how fast the person counts; it only works as a stressor. A two-minute recovery break follows with the same instructions as provided in the previous session. The last stressor is called a stressful event recall. In it, the pilot is asked to visualize a recent stressful incident that he remembers well, including all the details of the event and his thoughts and emotions. It again takes two minutes, after which we interrupt the client even if the recollection wasn't over. Then we move on to the final break, which is five minutes long, and ideally the physiological measures should look the same as in the baseline. When the five minutes are over, we stop the recording, save the data, and let the participant know that it is the end of the assessment. This is all for the first session, so the pilot can continue with his daily routine. The therapist later rejects all the artefacts and compiles the stress profile of the client. A second biofeedback session began with interpretation of the data that were obtained during the first session, including an introduction to psychophysiology, so the client clearly understands all the information provided. Then we choose modalities that could be improved to meet the norms and set goals for the therapy. It's essential to plan the therapy sessions, so the pilot is compliant with the BFT. Then we start with training the chosen modalities, which continues for another five sessions. In the last meeting with the pilots, we again present the stress profile as described above and compare their progress. In total, the pilots had two control meetings and six BFT sessions. After a one-year break, the stress profile was conducted again in the same form as before.

V. RESULTS

Pilots usually deal with major environmental differences followed by stressful tasks, where it's necessary to control the physiological reactions of the body. To verify the effectiveness of BFT in increasing the resilience of the supersonic pilots, we compiled a relatively homogenous group flying the same type of airplane with very similar workloads.

First, the ALAPS personality questionnaire was presented to check each pilot's actual mental state and his coping mechanisms. Another purpose of the study was to find a possible linkage between the physiological state of the pilot and his mental health and to use the diagnostics of psychological resilience based on physiological measures.

TABLE I. ALAPS PERSONALITY SCALES

ID	A	B	D	F	L	M
CONFIDENCE	7	8	10	8	10	9
SOCIABILITY	12	15	14	14	16	15
AGGRESSIVENESS	8	7	7	12	7	8
ORDERLINESS	16	14	16	14	14	14
NEGATIVITY	1	1	3	4	1	2
AFFECTIVE LABILITY	1	3	3	3	3	4
ANXIETY	0	1	0	0	0	0
DEPRESSION	0	0	0	0	0	0
ALCOHOL ABUSE	6	4	10	2	10	7
DOGMATISM	3	3	4	5	4	3
DEFERENCE	3	5	8	4	6	4
TEAM ORIENTED	12	15	16	15	15	16
ORGANIZATION	16	16	16	14	15	14
IMPULSIVITY	0	3	4	1	4	1
RISK TAKING	9	5	5	6	9	4

During a stress assessment called the stress profile script, the psychologist records a baseline for physiological readings, and then presents the client with cognitive, physical and emotional stressors. This assessment is presented in order to determine a person's stimulus-response specificity and to formulate a biofeedback treatment plan. To set goals for the therapy, it was necessary to create guidelines for the target group. Norms commonly presented in the literature (Schwartz & Andrasik, 2003; Khazan, 2013) are not adapted to high-performance individuals, so we modified them based on empirical experience. These norms are valid for healthy men aged 30-50 who are practicing sports on a daily basis.

TABLE II. STRESS PROFILE INTERPRETATION NORMS

Description of the measured features	Norms
(BVP) B: BVP amplitude mean (Rel) – blood volume pressure	>10
(HR) B: BVP HR mean (beats/min)- heart rate	<65
(HRV) B: BVP IBI std. dev. (SDRR)- HRV	>100
C: EMG mean (uV) – muscle activity on left trapezius	<2
D: EMG mean (uV) – muscle activity on right trapezius	<2
(SC) E: Skin conductance mean (uS)	<5
(Temp) F: Temperature mean (Deg)	>30
(Resp) G: Resp rate mean (br/min)	<10
G&H: Abd-tho ampl diff (means) – ratio of abdominal and thoracic breathing	>0 abdominal

To set goals for the training sessions, we chose physiological parameters that need to be addressed based on the above data range. If a sensor reading at the baseline is higher or lower than the norms the pilot should meet, the treatment goal is to help him bring that physiological parameter to normal in a non-stressful environment. Then another important parameter is if the sensor reading during down time indicates a lack of recovery. This means that the client can't cope effectively with stress. The treatment goal is to help him bring those specific physiological parameters to a normal level as soon as possible following a stressor.

To verify the use of biofeedback, we measured the stress profile of the participants before and after the BFT. A psychologist then evaluates the profile based on sudden changes in the course of the measurement at first in graphical form (see Fig.1). The graphical form helps to visualize the tendency of the stress response of the pilot and how fast he is able to recover after stressful events. In the case presented in Fig. 1, the pilot's reaction toward stress is very quickly followed by physiological activation, and he can effectively recover during his down time. However, the baseline shows an elevated heart rate and respiration rate which might indicate chronic stress or an inability to relax. The table form shows the exact numbers that can be compared to norms set for the target group. The effect of the therapy can be counted from the data obtained before and after the BFT (see Tables III and IV). The retest data after the one-year break measured by the stress profile is shown in Table V.

Figure 1. Graphical presentation of the stress profile of Pilot B

TABLE III. STRESS PROFILE OF PILOT B AT THE FIRST SESSION

Stress profile 1	Baseline	Color words	Rest 1	Math task	Rest 2	Stressful event	Rest 3	Mean
B: BVP amplitude mean (Rel)	22.25	10.66	21.85	21	21.9	19.44	19.19	19.47
B: BVP HR mean (beats/min)	73.24	87.86	74.75	78.59	70.69	68.43	70.82	74.91
B: BVP IBI std. dev. (SDRR)	56.29	42.71	113.05	72.13	68.38	53.31	67.71	67.65
C: EMG mean (uV)	4.94	9.01	4.86	5.27	9.14	12.29	4.3	7.12
D: EMG mean (uV)	1.56	12.36	12.21	8.28	12.03	7.59	16.75	10.11
E: Skin conductance mean (uS)	10.94	18.91	15.39	16.5	15.47	15.22	13.92	15.19
F: Temperature mean (Deg)	34.91	34.23	34.42	34.57	34.72	34.61	34.72	34.60
G: Resp rate mean (br/min)	15.02	11.93	15.73	18.06	13.98	16.14	14.54	15.06
G&H: Abd-tho ampl diff (means)	1.07	0.81	1.05	0.73	1.2	1	0.93	0.97

TABLE IV. STRESS PROFILE OF PILOT B AT THE LAST SESSION

Stress profile 2	Baseline	Color words	Rest 1	Math task	Rest 2	Stressful event	Rest 3	Mean
B: BVP amplitude mean (Rel)	24.31	16.72	22.91	20.63	20.76	18.89	22.7	20.99
B: BVP HR mean (beats/min)	57.98	64.76	59.77	63.38	62.35	61.8	61.42	61.64
B: BVP IBI std. dev. (SDRR)	107.64	118.47	91.62	112.9	140.31	56.13	138.81	109.41
C: EMG mean (uV)	7.3	5.23	4.91	3.02	2.99	3.44	3.12	4.29
D: EMG mean (uV)	0.85	0.84	0.76	0.72	0.81	0.71	0.72	0.77
E: Skin conductance mean (uS)	3.25	5.53	4.97	5.43	5.31	5.18	4.38	4.86
F: Temperature mean (Deg)	35.19	35.16	35.23	35.33	35.37	35.38	35.47	35.30
G: Resp rate mean (br/min)	6.09	11.19	7.28	12.9	7.27	10.02	6.7	8.78
G&H: Abd-tho ampl diff (means)	3.43	0.51	3.5	2.21	3.13	2.28	3.24	2.61

TABLE V. STRESS PROFILE OF PILOT B AFTER ONE YEAR

Stress profile 3	Baseline	Color words	Rest 1	Math task	Rest 2	Stressful event	Rest 3	Mean
B: BVP amplitude mean (Rel)	24.98	15.9	22.6	18.7	20.01	19.13	15.3	19.52
B: BVP HR mean (beats/min)	63.64	67.94	63.52	68.79	63.78	66.76	69.03	66.21
B: BVP IBI std. dev. (SDRR)	74.28	89.03	120.72	94.99	105.89	57.77	113.03	93.67
C: EMG mean (uV)	3.37	2.87	3.34	4.49	3.38	2.6	2.83	3.27
D: EMG mean (uV)	2.3	2.19	1.89	1.85	1.86	1.61	1.61	1.90
E: Skin conductance mean (uS)	5.27	10.2	9.56	9.82	9.67	10.29	10.3	9.30
F: Temperature mean (Deg)	34.21	34.56	34.61	34.73	34.76	34.86	34.99	34.67
G: Resp rate mean (br/min)	7.98	10.07	7.91	16.05	8.02	12.39	8.81	10.18
G&H: Abd-tho ampl diff (means)	5.63	2.25	5.66	2.79	5.88	5.09	5.3	4.66

The mean of each feature from stress profile 1 was compared to the average data from stress profile 2, and a t-test showed significant differences between the two measures at a significance level of $p < 0.01$ in all of the pilots tested. For a better overview of therapy success, we provide a graphical presentation of the most important parameters referring to stress (see Figs. 3, 4, 5 and 6) based on the values obtained during all of the six sessions. To see a long-lasting effect of the BFT, the measurement of stress profiles, after one-year break as a retest, is also included in the graphs.

To sum up the data, the percentage improvement is shown in Table VI. It refers to the number of pilots that were able to improve the preset physiological measures trained in the BFT.

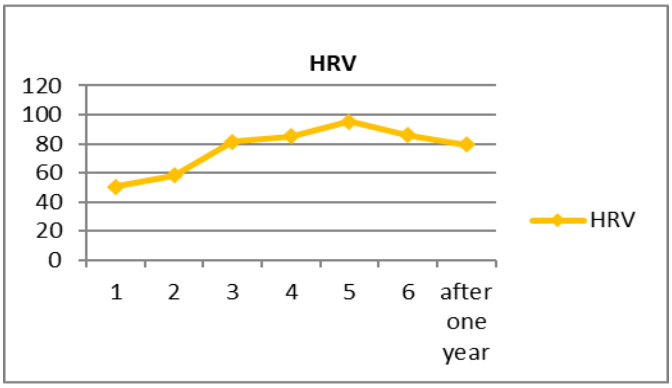

Figure 3. The progress of BFT on HRV

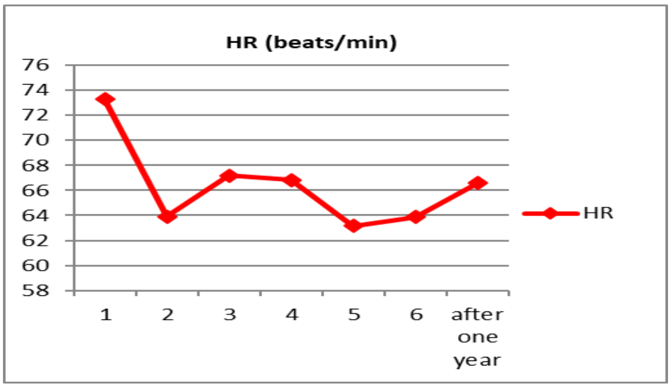

Figure 2. The progress of BFT on HR

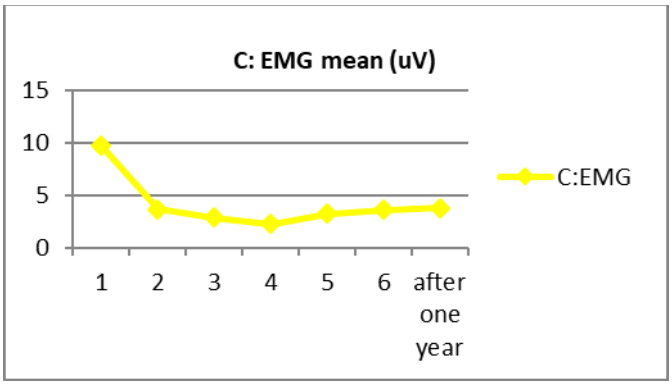

Figure 4. The progress of BFT on C: EMG

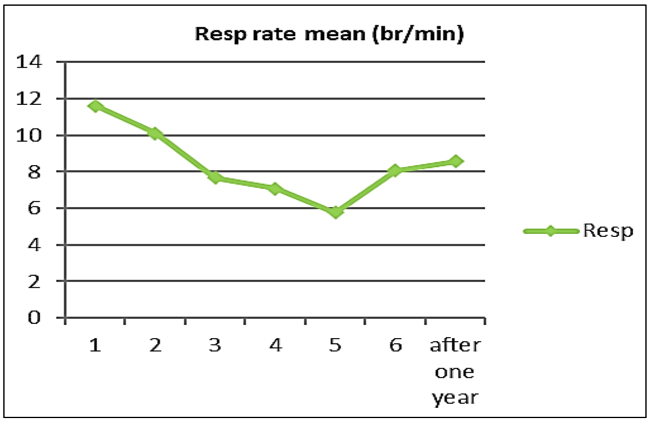

Figure 5. The progress of BFT on respiration rate

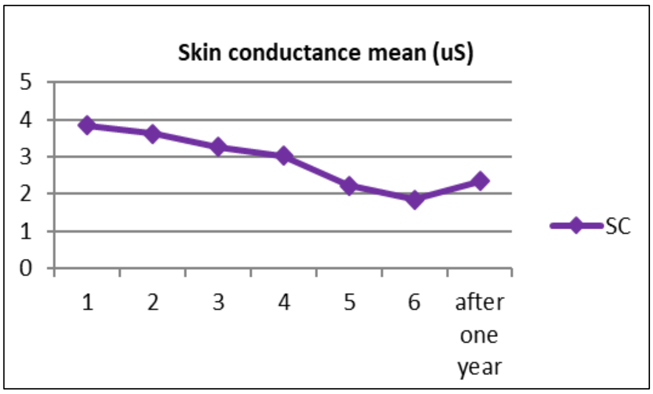

Figure 6. The progress of BFT on skin conductance

TABLE VI. IMPROVEMENT OF THE PHYSIOLOGICAL FEATURES

Features	Percentage of progress
B: BVP amplitude mean (Rel)	100%
B: BVP HR mean (beats/min)	83.3%
B: BVP IBI std. dev. (SDRR)	90%
C: EMG mean (uV)	83.3%
D: EMG mean (uV)	90%
E: Skin conductance mean (uS)	100%
F: Temperature mean (Deg)	90%
G: Resp rate mean (br/min)	66.7%
G&H: Abd-tho ampl diff (means)	66.7%

After proving the effectiveness of biofeedback in the improvement of the physiological parameters of stress in the supersonic pilots, we decided to correlate the measured physiological state of the pilots with their personality traits to see any possible connection. For this purpose, we used a correlation study of the ALAPS scales and physiological features measured by biofeedback. High correlations are highlighted (see Table VII).

The correlation study showed some interesting facts about the connection between personality and the physiological state of the person. For example, peripheral temperature highly correlates with confidence (0.98), which refers to handling stress as stated before. The higher the temperature is at the extremities, the calmer and more relaxed the person feels. The data from HR also support the theory about the type of personality reflecting the physiological state. More aggressive people tend to be more at risk of cardiovascular diseases, which correlates with heightened HR. Another important data item provides anxiety as a personality trait which positively correlates with the left trapezius (0.95), skin conductance (0.99) and respiration rate (0.82). These are some of the main parameters referring to coping with stress. Mental stress plays a role in musculoskeletal disorders by increasing muscle tension in low-load work situations as well as in the absence of a physical load. Skin conductance is an indicator of mental peace and sympathetic deactivation which changes with stress, anxiety, or any emotion-related arousal. Breathing is also closely related to stress and overbreathing is one of the symptoms of anxiety. Respiratory abnormalities are also associated with panic attacks, fear and other autonomic symptoms. A high positive correlation with breathing and it's thoracic and abdominal ratio appears with risk taking (0.96).

VI. CONCLUSION

Biofeedback is usually used for the treatment of stress, anxiety, mood and panic disorders. Research has shown the extent when it's mentally achievable to influence the functioning of the ANS, previously considered to be outside of conscious control. We tried to use this method to increase the resilience of highly loaded pilots. It has already been incorporated in military applications with good results, but its usage for the enhancement of the performance of supersonic pilots is unique. This outcome is promising, considering the improvement in most of the physiological parameters in all of the pilots who participated. Also, the correlation study of the personality traits and physiological state demonstrates the possible application of physiological data in diagnostics.

Biofeedback enabled pilots to develop a greater awareness of their physiological and psychological reactions toward stress and to learn how to modify these reactions. It helped to increase their mental resilience where it is essential to cope with stress, reduce fatigue, stay focused, control emotions and to make precise and quick decisions. All of the sessions and measurements were done on the ground in simulated stress situations. So, future effort now calls for the in-flight investigation of this method that should lead to the optimal performance of the pilots.

TABLE VII. IMPROVEMENT OF PHYSIOLOGICAL FEATURES

Pearson correlation (p < 0 ,05 N=6)											
	Mean	St. Deviation	BVP	HR	HRV	C:EMG	D:EMG	SC	Temp	Resp	Abd-Tho
CONFIDENCE	8.7	1.2	0.16	-0.48	0.15	-0.13	-0.72	-0.28	0.98	-0.02	-0.02
SOCIABILITY	14.3	1.4	0.60	-0.46	0.64	0.42	-0.38	0.19	0.75	0.34	-0.21
AGGRESSIVENESS	8.2	1.9	-0.05	0.97	-0.22	-0.40	-0.28	-0.40	-0.07	-0.23	-0.28
ORDERLINESS	14.7	1.0	-0.55	0.39	-0.67	-0.45	0.11	-0.22	-0.65	-0.35	0.37
NEGATIVITY	2.0	1.3	-0.04	-0.72	-0.61	-0.47	-0.60	-0.51	0.21	-0.05	-0.49
AFFECTIVE LABILITY	2.8	1.0	0.32	-0.52	0.19	0.29	-0.41	-0.02	0.91	0.50	-0.71
ANXIETY	0.2	0.4	0.73	0.11	0.14	0.95	0.63	0.99	0.47	0.82	-0.24
ALCOHOL ABUSE	6.5	3.2	-0.24	0.10	0.12	-0.25	-0.38	-0.30	-0.08	-0.30	0.39
DOGMATISM	3.7	0.8	0.25	-0.90	-0.17	-0.53	-0.82	-0.50	0.04	-0.36	0.03
DEFERENCE	5.0	1.8	0.34	-0.48	-0.22	-0.01	-0.54	0.00	0.35	0.14	0.04
TEAM ORIENTED	14.8	1.5	0.36	-0.63	-0.03	0.20	-0.53	-0.04	0.88	0.49	-0.65
ORGANIZATION	15.2	1.0	0.13	0.42	-0.27	0.27	0.45	0.52	-0.32	0.13	0.45
IMPULSIVITY	2.2	1.7	0.61	-0.46	0.15	0.25	-0.43	0.24	0.44	0.23	0.15
RISK TAKING	6.3	2.2	-0.16	0.23	0.40	-0.40	-0.04	-0.21	-0.80	-0.78	0.96

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