The ‘Healthy Worker‘ study proves the stress-reducing effects of the audiovisual brainLight relaxation system

In the study ”The Healthy Worker“, it was tested whether stress could be reduced through the use of audiovisual stimulation in combination with a Shiatsu massage. During the study, the company brainLight provided the systems that were used. In order to determine the stress level of the subjects, the stress index of Banzer et al (1) was applied. The stress index was calculated based on a five-minute heart-rate variability (HRV) measurement. The results of the study show a significant reduction in stress levels of the subjects after the sessions.

Stress plays an ever increasing role in today‘s performance-orientated society. Many people feel under much pressure from the demands placed on them, resulting in a higher stress index. In a study carried out by the University of Furtwangen, before and after every therapy session a five-minute HRV of each subject was recorded and their stress index was calculated. The aim of the study was to investigate the stress-reducing effects of the audiovisual brainLight system on healthy subjects through the analysis of their heart-rate variability.

The study was divided into a pilot and a main study. The aim of the pilot study was to clarify open issues and the number of cases for the main study before it commenced. 34 subjects from different occupational fields took part in the main study. The average age of the subjects was 40 years. The short-term HRV measurement was taken before and after a 40-minute session with the brainLight relaxation system.

Physiology of stress

Stress is caused by stressors acting on the body in a neural or direct manner. The signals of the stressors are conducted and processed through the spinal cord and the ascending path to the Central Nervous System. There, the limbic system is a neurobiological control centre especially important for stress response (2).

Constant stress or traumata lead to damage of the neural systems that are responsible for processing, which can cause temporary or even irreversible diseases (2).

In stressful situations, in order to adapt to responding to stress, the organism utilises the neurotransmitters adrenaline, noradrenaline and cortisol. These are released from various stress hormone axes that ensure a differential response to stress. On the one hand this is the SAM axis, which consists of the sympathetic nervous system and the adrenal medulla. It is immediately activated and causes through CRH, adrenaline and noradrenaline physiological reactions such as vasoconstriction, an improved nourishment of the heart muscle and increased glycogenolysis. On the other hand the HPA axis is especially critical in chronic stress. It is composed from parts of the hypothalamus, the pituitary and the adrenal cortex. Through the activation of CRH and AVP, ACTH is released, which in turn stimulates the secretion of cortisol. This can increase heart contractility, but the blood sugar level is also increased and inflammation is stopped. However, an effective stress response can only be constructed through a connection of all signal paths.

The physiological stress response plays an important role in stress at work. If the organism is exposed to long-term stress, the neurobiological and neuroendocrine metabolism changes. Through these changes, it is possible to develop pathological conditions. This in turn can manifest itself in hypertension or depression. To prevent this, stressful situations should be avoided and the body should be allowed time for rest (2, 3).

Heart-rate variability

The heart has an influence on the central nervous system, in that it can affect the activity of the brain through the afferent nerve fibers (4). Because of this, the heart is able to respond immediately to emotional and physiological needs through a change in heart-rate. The heart therefore has the opportunity to adapt to the requirements. It will beat faster when under high demand, and slower under low demand. It can then be said, that the interval between two consecutive heart beats is never the same, because the heart adapts to the current situation (5). This change is very important because it is a sign of a healthy functioning balance between the sympathetic and parasympathetic nervous system, and shows that the body is able to react timely to changing demands (6).

The heart-rate variability, also know as the heart-frequency variability, is the variable interval between individual heartbeats. In the ECG, this is shown through the R-wave, or the interval between two R-waves, which is shown below in Figure 1. The interval between two R-waves is called the RR interval (7).

Figure 1: ECG showing the variable intervals between the individual heartbeats

A suitable method to measure stress

The principle of heart-rate variability measurement is based on the fact that you try to bring the system out of balance in order to observe, or measure, the reaction of the orgamism to this.

Nowadays, it is possible to make precise statements about the stress level and regulatory balance according to the heartbeat variability. It is also possible to make a reliable interpretation regarding the extent to which the body of the subject answers to stimuli of any kind, whether they be positive or negative. Depending on how intense this answer proves, it can be concluded how well the body is able to regulate this stimulus influence again, and how long this takes (8). Hence, a good heart-rate variability is important for health. It has also been scientifically proven that people with a bad HRV have a higher mortality rate after a myocardial infarction than those with a good HRV (9). People with mental illnesses such as depression also have a poor measurable HRV. This suggests that heart-rate variability is also an indicator of a psyche-heart interaction. It is furthermore an explanatory approach about the relationship of pathophysiological interaction mechanisms between depression and cardiovascular diseases. In fact, states of depression can influence neuro-cardial capabilities through inhibiting vagal influence (10).

An advantage of stress measurement by means of a heart rate variability scanner is that it is a non-invasive, relatively easy to use and fast method in which no side-effects or dangers exist.

The brainLight System

brainLight advertises itself with the concepts of Shiatsu and vibration massages, autosuggestion and fantasy journeys, wellness and trance music and mental as well as visualisation techniques. Of these, the first two techniques belong to physical relaxation while the rest are aimed at mental relaxation, which is to be achieved through audiovisual stimulation.

Audiovisual stimulation
Audiovisual stimulation brings the brain into a certain state of consciousness. For this, brainLight uses special glasses with LEDs that generate light impulses in the desired frequency, and headphones that also produce this frequency, usually in the form of binaural beats embedded in soothing music.
brainLight Systems operate based on the frequency following response, which means that the brain adapts gradually to the frequency of stimulation. Therefore certain states of consciousness, such as relaxation, can be evoked.

Material and methods

For the study, 34 subjects from different professional backgrounds were selected. For the audiovisual treatment, the subjects each spent 40 minutes, between 7 and 10 times, on a brainLight massage chair. Before and after the therapy, a short-term HRV was taken by the BioSign HRV-Scanner. The short-term HRV was measured through ECG electrodes and a pulse sensor in the ear. The pulse wave latency and stress index were calculated using a software.

Study design
In order to determine a suitable parameter, a pilot study was carried out beforehand, in which 8 subjects each took 6 therapy sessions. Furthermore, the sample size for the main study was calculated using the pilot study. In the main study, 34 subjects were each treated 7-10 times with the audiovisual brainLight relaxation system. To carry this out, the workers represented in the subject pool had to be from different occupation fields, so that the dependence of the effect of the system could be better assessed.

Measurement
The HRV scanner includes two electrodes that you connect to each wrist of the subject. The scanner is connected to a computer with appropriate software so that the measured values can be calculated and evaluated immediately. A five-minute ECG measurement is then taken of the subject in a lying position, using the program „short-term HRV“. This then, in connection with the measurement through the ECG evaluation, provides different parameters such as the stress index. The stress index is a parameter that is specified according to a measurement and with this, the stress level of the subject can be assessed and compared. The following equation, 1, shows how the software of the HRV scanner calculates the stress index:

$$SI = \frac{n_D}{(2 * D) * (Max_{RR} - Min_{RR})}$$

Equation 1: „SI“ is the abbreviation of stress index, which is the frequency of the modal value number taken from the RR intervals of all measured values. „D“ represents the average density, which corresponds to the number of the most commonly occuring RR interval. Max-RR indicates the maximum value of the RR interval, while Min-RR indicates the minimum interval. If you subtract the smallest RR value from the biggest, you will receive the variability width of all RR values (1).

The results
The results of the pilot study showed a general reduction in stress levels of the subjects after the relaxation therapy. Here, our main parameter „stress index“ showed a significant decrease after the therapy unit. The calculation of the sample size, based on these results, revealed a sample size of 26 with a power of 90% and significance level of 5%. Based on a default rate of 10-20%, it was planned to include at least 30 patients in the main study. In this case, a low stress index indicates a healthy heart-rate variability. In addition, we were able to observe from the measurements a considerable improvement in the general biofeedback of the subjects, which proves a long-term effect of the therapy. According to the evaluation of the pilot study, a comparison between 20 and 40 minute therapy sessions showed no great differences with regard to the short-term measurement. A before and after measurement of the short-term HRV is the most appropriate method to measure relaxation immediately after the therapy compared to before the therapy (11).

The results of the pilot study were proven correct in the main study. It showed a highly significant reduction of the stress index at 80% of the initial value. 22 of the 27 subjects (81.5%) showed on average a reduction in the stress index after the session (12). The following Figure 2 shows a comparison of a rank diagram and an RR histogram before and after the therapy unit. As can be seen in the rank diagram, the histogram shows a significant improvement in the heart-rate variability, which suggests healthy biofeedback.

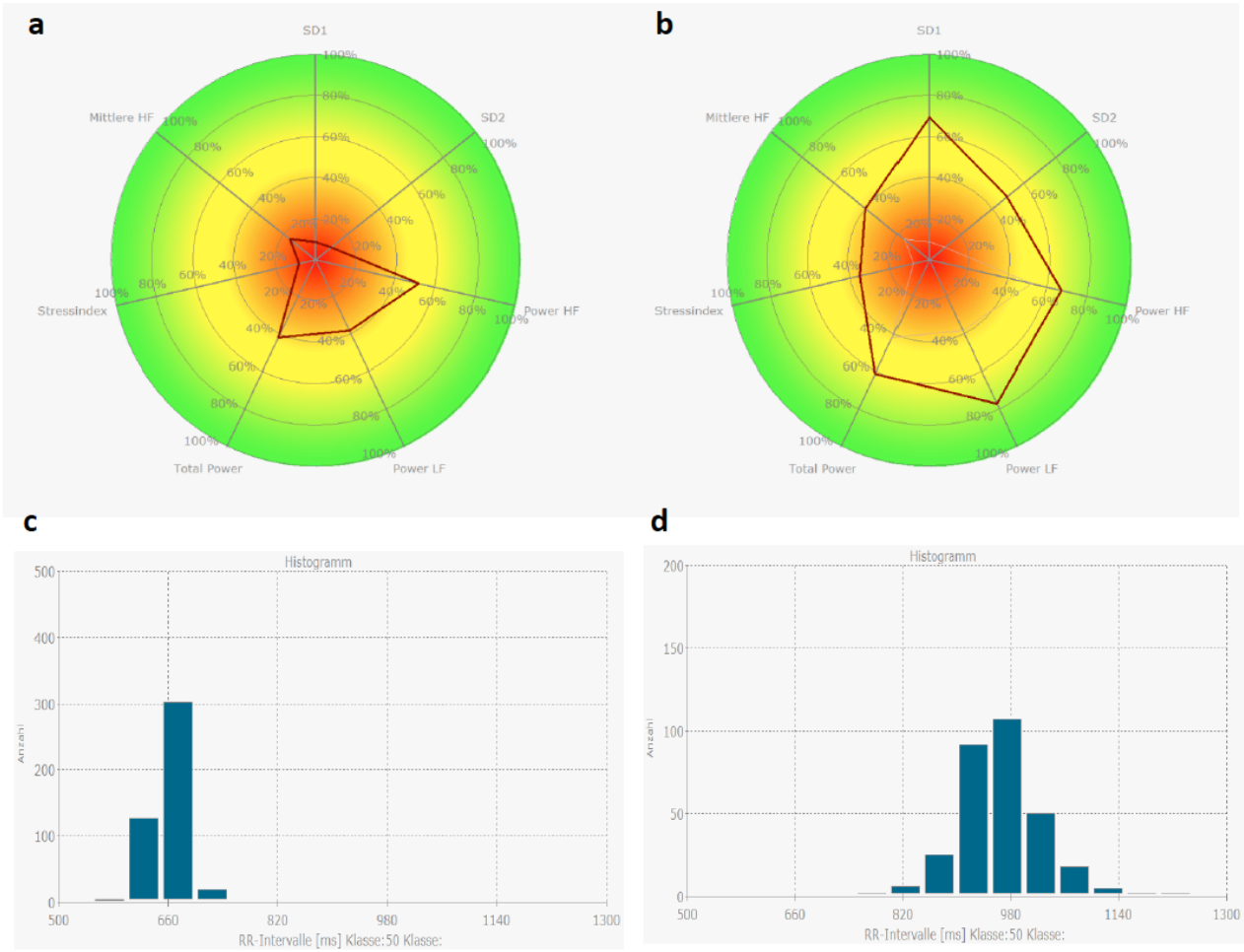

Figure 2 (a) Rank diagram of a subject before the therapy unit (b) Rank diagram of the same subject after the therapy unit. Looking at the stress index between a) and b), an improvement of the stress index can be noted in percentage. (c) Histogram of a subject before the therapy (d) Histogram of the same subject after the therapy unit. Here, a substantial improvement of the RR interval is to be recognised. A low distribution and high quantity indicates a poor heart-rate variability and thus an imbalance between the sympathetic and parasympathetic nervous system, which manifests itself as stress.

Discussion

According to current research findings, brain waves can be divided into four frequency groups, the beta, alpha, theta and delta waves, which are observed in an EEG frequency spectrum according to the mental state of activation between 0.5 and 50 Hertz (13). Each outer sensory stimulus causes a change of the electrical potential, in this case known as evoked (=generated) potential. For example, if the ear perceives an acoustic signal, after redirection via the auditory nerve and about 10ms, an electrical potential change is measurable in the brain (14). If you provide the ear with sound at regular intervals, the brain waves adjust to the frequency of this external signal. This is known as the frequency following response or Brainwave-Entrainment. A problem with this method is that the frequencies of the brain waves are not in the human audible range, so it is not possible to simply simulate the exact sound of each frequency (the human ear can only detect frequencies from about 30 to 18,000 Hz). However, simple physical effects allow the necessary frequencies to be produced.

Monaural and binaural beats

Monaural beats make use of the physical phenomenon of the beat. Two different, but very closely spaced frequencies are played. Through the superposition and cancellation of the amplitudes in the occuring phase

shift, a beat frequency is formed which is equivalent to the difference between both fundamental frequencies. If both frequencies are equally loud, an explanation of the stress-reducing effects of the brainLight system can be produced. If the sounds are played through headphones individually into each ear, this is known as a binaural beat. This means that before coming into hearing, the beat cannot be produced. The brain now tries to blanket these two tones and produces its own sound in the superior olivary nucleus. Binaural beats have the lowest efficiency in the production of AEPs, which is due to their low modulation depth of 3 dB (14). A special effect of the binaural beats is the synchronisation of the hemispheres, which can only be observed in this key.

Synchronisation of the hemispheres

The synchronisation of the hemispheres is based on the frequency following response, according to which the brain waves adjust to the external frequency and is produced through binaural beats.
While the left half of the brain is responsible for logic, reason and analysis, the right half of the brain is intuitive, emotional and uncontrolled. Corresponding to this, beta and alpha waves are primarily found in the left hemisphere, whereas theta and delta waves locate themselves rather in the right hemisphere. Under a very varied distribution of frequencies through the cerebral hemispheres, a person will often feel unbalanced and less resilient (15). With depression, for example, the emotional right hemisphere is significantly more active than the logical left half, which leads to irrational and exaggerated reactions to harmless causes (16).
Conversely, a sychronisation of the hemispheres increases mental clarity and therefore leads to an increase in performance and concentration, but also to a noticeable increase in self-confidence (15). Through a hemispheric synchronisation, the heart and mind work hand in hand.

References

1. Banzer W, Lucki K, Bürklein M, Rosenhagen A, Vogt L. Sportmedizinische Aspekte kardialer Risikostratifizierung. Herzschr. Elektrophys 2006; 17(4):197–204.
2. L. Rensing MKBRVR. Mensch im Stress – Psyche, Körper, Moleküle. 1. Auflage. München: Spektrum
Akademischer Verlag; 2006.
3. LS Köster. Dissertation – Das Stresshormonsystem bei situativ induzierten Panikattacken – Eine Untersuchung im Rahmen therapeutischer in-vivo Expositionen. Berlin; 2010.
4. Gahery Y, Vigier D. Inhibitory effects in the cuneate nucleus produced by vago-aortic afferent fibers. Brain Research 1974; 75(2):241–6. Available from:
URL:http://www.sciencedirect.com/science/article/pii/0006899374907446.
5. Servan-Schreiber D. Die neue Medizin der Emotionen: Stress, Angst, Depression : gesund werden ohne Medikamente. Taschenbuchausg. München: Goldmann; 2006.
6. Akselrod S, Gordon D, Ubel FA, Shannon DC, Barger AC. Power Spectrum Analysis of Heart Rate Fluctuation: A Quantitative Probe of Beat-to-Beat Cardiovascular Control. Ft. Belvoir: Defense Technical Information Center; 1981.
7. Hick C, Hick A. Intensivkurs Physiologie: Seite 61: Urban & Fischer bei Elsev; 2009. Available from:
URL:http://books.google.de/books?id=i24RdZqg5ngC.
8. HRV-Allgemein: Einführung [Die Herzratenvariabilität]; 2011 [cited 2012 Feb 24]. Available from:
URL:http://www.hrv24.de/HRV-Einfuehrung.htm.
9. Bauer A, Kantelhardt JW. Deceleration capacity of heart rate as a predictor of mortality after myocardial infarction: Cohort study. The lancet 2006; 367(9523):1674–81.
10. Mück-Weymann M. Depressionen und Herzratenvariabilität - Seelentief zwingt Herzschlag in enge
Bahn. Der Hausarzt 2005; 3:64–9.
11. Prof. Dr. Matthias Kohl. Fallzahlplanung für die Studie "Entspannter Gesundarbeiter"; 2011.
12. Prof. Dr. Matthias Kohl. Statistische Analyse der Daten aus der Studie "Die Gesundarbeiter"; 2012.
13. Schandry R. Biologische Psychologie. Weinheim: Beltz/PVA; 2003.
14. alphabrain. Technologie und Wirkung [cited 2012 Jul 11]. Available from:
URL:http://www.alphabrain.de/Technologie:_:11.html.
15. BRAIN-mentalsystems. Das Elektroenzephalogramm (EEG) und die Bedeutung der einzelnen Gehirnwellen sowie Hemisphären-Syncronisation; 2012 [cited 2012 Nov 7]. Available from:
URL:http://www.brain-mentalsystems.de/aktuelles.php?id=2.
16. Mind Programming. Synchronisierung; 2012. Available from: URL:http://www.neuroprogrammer.de/gehirnwellen/synchronisierung/.