ARCHIVES OF ACOUSTICS
32, 4 (Supplement), 123–128 (2007)

THE EFFECTS OF LOW FREQUENCY SOUND ON THE LEVELS OF ACTIVATION

Cezary KASPRZAK

AGH University of Science and Technology
Faculty of Mechanical Engineering and Robotics
Al. Mickiewicza 30, 30-059 Kraków, Poland
e-mail: cekasp@agh.edu.pl

(*received July 15, 2007; accepted November 13, 2007*)

The paper summarises the research data showing how low frequency sound affects the level of activation in humans. Activation levels were measured with the use of the self-assessment questionnaire, known as the Activation-Deactivation Adjective Check List (AD ACL). The research program involved three independent stages and three types of acoustic stimuli were applied. The acoustic stimulus applied in the first stage had frequency $f = 7$ Hz, sound pressure level $\mathrm{SPL} = 120$ dB (HP). In the second stage participants were exposed to an acoustic stimulus $f = 18$ Hz, sound pressure level $\mathrm{SPL} = 120$ dB (HP). In the third stage a acoustic stimulus was applied $f = 40$ Hz, sound pressure level $\mathrm{SPL} = 110$ dB (HP). The exposure time in each experiment was constant (20 min). Results indicate a statistically significant increase of the deactivation – sleep effect following the low-frequency sound exposure.

Keywords: infrasound, low frequency sound, Thayer test, activation.

1. Introduction

The term "activation" is associated with physiological conditions of stimulation and energy release processes in the human body, aimed to get the organism ready to start a given activity. Underlying the theory activation is the fundamental hypothesis that distinguishes two independent aspects of human behaviour: direction and intensity. Activation is associated with intensity and its main function is to prepare the human body to start an external action. Broadly speaking, activation is understood as the body condition controlled by subjective and situational factors and described by a single-dimensional continuum.

The influence of the low-frequency sound on the levels of activation was investigated using the Thayer test (The Activation-Deactivation Adjective Check List AD ACL), developed on the basis of participants' self-assessed, subjective feeling of well-being. A major advantage of the Thayer test lies in its approach to measurement of activation

levels. Thayer was among the first researchers who appreciated self-assessment as an important technique to study the overall level of activation.

Accordingly, Thayer distinguished four basic dimensions (scales) of activation:

- General Activation;
- Deactivation – Sleep;
- High Activation;
- General Deactivation.

General Activation and Deactivation-Sleep scales are associated with excitation due to energy release, identified by the author of the test. High Activation and General Deactivation scales correspond to excitation from tension. Each dimension encompasses five adjectives describing the person's subjective feeling of well-being.

The level of activation is indicated by a number of scored points. Tests conducted by Thayer and other researchers led them to the following conclusions:

- General Activation scale measures readiness to work, the result well predicts the effectiveness of cognitive actions;
- Deactivation – Sleep scale measures tiredness though daily variations of the test data might be the consequence of varied sleepiness effect;
- High Activation scale is a measure of tension and anxiety;
- General Deactivation scale provides information about the adaptive processes (when the body adapts itself to the applied stimuli), measuring the response to external or internal stimulation [4, 8].

2. Experiments

Experimental tests were performed in the Laboratory of Structural Acoustics and Biomedical Engineering at the Faculty of Mechanical Engineering and Robotics AGH-UST. The experimental program involved 96 tests, in three independent test conditions. Those taking part in the tests were 33 healthy persons (9 females and 24 males) aged 20–30 years. The experiment involved a threefold exposure to low frequency acoustic stimulus with the following parameters:

- $f = 7$ Hz, $\mathrm{SPL} = 120$ dB,
- $f = 16$ Hz, $\mathrm{SPL} = 120$ dB,
- $f = 40$ Hz, $\mathrm{SPL} = 110$ dB.

The parameters of the applied stimuli were adapted in accordance with the pertinent standards and available literature on the subject of infrasound exposure [1, 5–7], an assumption was made that the exposure must be safe and must not be perceived as annoying. The effects of low frequency sound exposure on the selected human biopotentials (EEG, ECG, and EDA) were explored [2]. Those taking in the test part were categorized into groups depending on the Eysenck and Zuckerman test results.

Participants qualified for the experimental program did not report any prior ear disease or other chronic illnesses in their medical history.

The experimental procedure:

1. Thayer test.
2. A participant remained inside a pressure cabin – no stimulus for 5 minutes.
3. In the fifth minute the 20 min low frequency noise exposure began.
4. In the 25-th minute the exposure was over.
5. For the next 10 minutes the participant remained inside a cabin – no low frequency sound exposure.
6. Thayer test is repeated after those 35 minutes.

Acoustic signals were generated from the WAV file, using a computer. These signals are amplified in a power amplifier ELMUZ 2158 M and fed to the six speakers GDN 30/80 mounted in the cabin roof. The pressure (infrasonic) cabin is a rectangular prism, made from aluminium, with a self-supporting frame and lateral reinforcements. The main purpose was to raise the sound pressure levels through restricting the control volume and to isolate the participant from the external conditions in the laboratory. There were amplifiers installed in the cabin roof. In order to minimise the impacts of electromagnetic fields each cabin is secured with the Faraday's cage on the inside. Each experiment involved 20 min exposure to low frequency sound.

3. Analysis

Thayer test data were treated statistically. Table 1 shows the descriptive statistics of the four scales, providing the mean value, 95% level of confidence and error before and after the low frequency sound exposure. Results are tabulated for the three test conditions: $f = 7$ Hz; $\mathrm{SPL} = 120$ dB (HP), $f = 18$ Hz, $\mathrm{SPL} = 120$ dB (HP), $f = 40$ Hz, $\mathrm{SPL} = 110$ dB (HP).

Table 1. Descriptive statistics.

Hz		N	Mean before	Mean after	Std. error before	Std. error after
7	General Activation	33	13.000	12.091	0.515	0.541
	High Activation	33	8.788	8.242	0.520	0.477
	Deactivation – Sleep	33	10.667	11.727	0.412	0.440
	General Deactivation	33	14.697	15.121	0.453	0.482
18	General Activation	32	12.750	12.313	0.512	0.576
	High Activation	32	7.969	8.219	0.499	0.567
	Deactivation – Sleep	32	10.969	11.656	0.457	0.527
	General Deactivation	32	15.250	15.375	0.386	0.582
40	General Activation	31	12.968	12.129	0.623	0.609
	High Activation	31	8.129	8.774	0.475	0.642
	Deactivation – Sleep	31	10.968	12.000	0.505	0.543
	General Deactivation	31	14.903	14.548	0.467	0.577

Statistical significance of test data obtained for particular test scales was analysed using a Wilcoxon's non-parametric pair ordering test. The results are summarised in Table 2.

Table 2. Wilcoxon's test statistics.

Hz		N	Z	p
7	General Activation Before & General Activation After	33	1.473	0.140
	High Activation Before & High Activation After	33	0.732	0.463
	Deactivation – Sleep Before & Deactivation – Sleep After	33	2.151	0.031
	General Deactivation Before & General Deactivation After	33	0.955	0.339
18	General Activation Before & General Activation After	32	0.600	0.548
	High Activation Before & High Activation After	32	0.373	0.708
	Deactivation – Sleep Before & Deactivation – Sleep After	32	1.720	0.085
	General Deactivation Before & General Deactivation After	32	0.683	0.494
40	General Activation Before & General Activation After	31	1.581	0.113
	High Activation Before & High Activation After	31	1.338	0.180
	Deactivation – Sleep Before & Deactivation – Sleep After	31	1.775	0.075
	General Deactivation Before & General Deactivation After	31	0.822	0.410

N – group size; Z – Wilcoxon test value; p – statistical significance.

It appears that 20 min exposure to LFN wave with frequency $f = 7$ Hz and sound pressure level $\mathrm{SPL} = 120$ dB (HP) is responsible for a statistically significant increase of the Deactivation-Sleep effect. Similar results are reported for the two other applied frequencies, though the increase was not statistically significant. Figures 1, 2, 3 show the

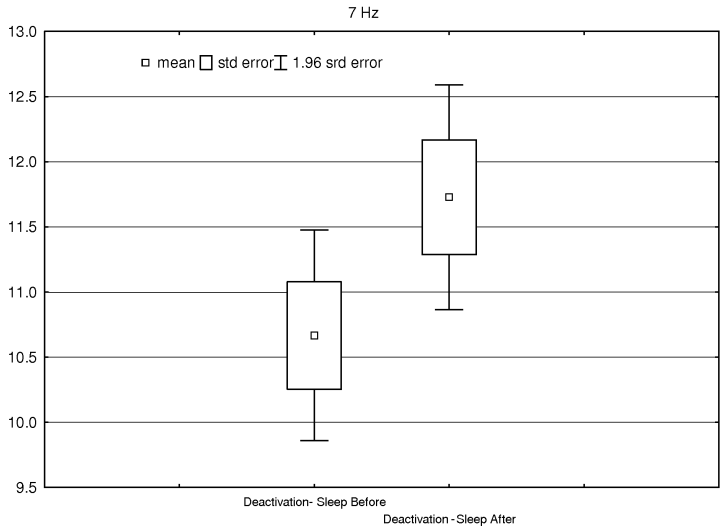

Fig. 1. Variations of Deactivation – Sleep level ($f = 7$ Hz, $\mathrm{SPL} = 120$ dB).

plot of Deactivation-Sleep scale variations in the three test conditions. No statistically significant variations of the remaining Thayer test scales were found.

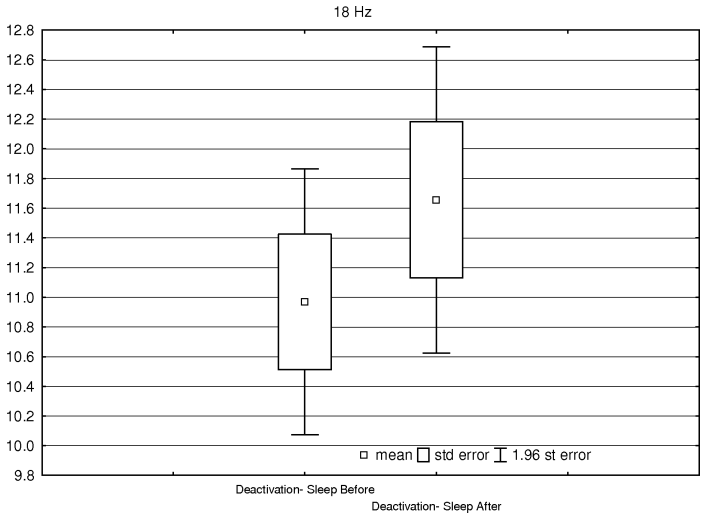

Fig. 2. Variations of Deactivation – Sleep level ($f = 18$ Hz, $\mathrm{SPL} = 120$ dB).

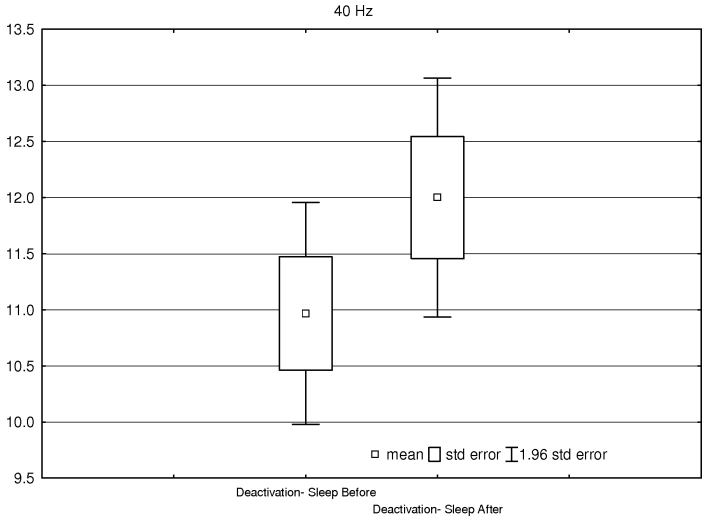

Fig. 3. Variations of Deactivation – Sleep level ($f = 40$ Hz, $\mathrm{SPL} = 110$ dB).

4. Discussion and conclusion

According to Thayer, self-assessment gives better information about the activation levels than single measurement of psycho-physiological parameters and, as such, might

be used as an excellent indicator in practical applications. Activation, as defined by R. E. Thayer after long years' research, involves single-dimensional aspects. Each dimension is associated with a separate physiological mechanism in various external conditions, each has its own dynamics. These two types of activation are treated as integrated psycho-physiological responses of the human body.

One dimension, underlying physical and cognitive activity, stretches from subjective feelings of energy and vigour right through to the opposite feeling: of sleepiness and weariness. This dimension prompts human activity, makes the human body ready for action and varies regularly, according to a 24 hours' rhythm. The other dimension stretches from subjectively felt tension right through to relaxation and quietness. It occurs in emergency and hazard situations and is associated with subjective feelings of anxiety and tension. This type of stimulation prepares the human body to act under stress. When the tension is released, the person will feel relaxed.

Research data are indicative of a statistically significant enhancement of the deactivation – sleep level in the conditions of low-frequency sound exposure ($f = 7$ Hz, sound pressure level $\mathrm{SPL} = 120$ dB (HP). The number of points scored in this scale goes up from 10667 to 11727. A similar trend is reported for $f = 18$ Hz and 40 Hz, though these variations are statistically insignificant. No statistically significant variations of the remaining Thayer test scales were found.

References

[1] AUGUSTYŃSKA D., ZAWIEJSKI W. M. [Ed.], *Ochrona przed hałasem i drganiami w środowisku pracy*, Central Institute for Labour Protection, Warszawa 1999.

[2] DAMIJAN Z., KASPRZAK C., PANUSZKA R., *Low-frequency sounds and psychological tests at 7, 18, and 40 Hz*, The Journal of the Acoustical Society of America, **115**, 5, 2388 (2004).

[3] JOB R. F., *Psychological factors of coinmunity reaction to noise*, [in:] *Noise as a Public Health Problem*, VALLET M. [Ed.], vol. 3, pp. 48–70, INRETS, Arcucil Cedex, France 1993.

[4] KAISER J., WOJTASZEK Z., *Skrypt do psychofizjologii*, Kraków 1988.

[5] KACZMARSKA A., AUGUSTYŃSKA D., *Ocena zagrożeń hałasem infradźwiękowym*, Bezpieczeństwo Pracy, 3, 1–4 (1991).

[6] KASPRZAK C., DAMIJAN Z., PANUSZKA R., *Method of assessment of low-frequency noise annoyance in the working environment*, Polish Journal of Environmental Studies, **13**, suppl. 3, HARD, Olsztyn 2004.

[7] PANUSZKA R., DAMIJAN Z., KASPRZAK C., MCGLOTHLIN J., *Infrasound and biorhythms of the human brain*, The Journal of the Acoustical Society of America, **111**, 5, 2335–2336 (2002).

[8] STRELAU J., *Psychologia różnic indywidualnych*, Scholar, Warszawa 2002.