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The relationship between psychomotor efficiency and selected personality traits of people exposed to noise and vibration stimuli

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Abstract

Physical factors of an environmental nature are taken into account during testing risks in the workplace of machine operators. The influence of these factors on the human body has both physiological and functional effects. Among the environmental factors vibration and noise are the most frequently observed. The power and scope of impact of noise and vibration stimuli depend largely on individual differences of human. The worth mentioned differences resulting from both the body structure, the specificity of the nervous system and the level of fitness, as well as differences in the psychological sphere.

In this article, the pilot studies with participation of 30 young man are described. The experimental studies were conducted in the laboratory. The importance of certain personality traits and characteristics for perceptual efficiency level under the impact of increased noise and vibration stimuli was tested.

The experimental conditions were based on the theory of H.J. Eysenck, according to which basis of scheme of human action are the inborn properties of the central nervous system, determining the balance between the process of stimulation and inhibition.

During experimental studies, participants were subjected to the influence of local and whole body vibration in the low frequency range. Participants were also subjected to the cumulative effect of these vibrations with noise. They performed the original test used to assess their motor skills, which consists in converting by participants, in the shortest possible time, the movement of cursor along the path displayed on monitor. The number of exits out of the path and the time remaining cursor on the path was registered. The collected data were used to determine the correlation between accuracy in performing actions, physiological parameters and the level of extraversion - introversion as a model of personality of experiment participants under the influence of noise and vibration.

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1. Introduction

Low frequency vibration and noise are specific to the profession of the machine operator. Long-term impact of these physical factors results in specific psychophysiological effects of the operator's body [1, 2]. Few reports of mechanism of vibroacoustic influences on the accuracy of work of the machine operator indicate the need for experimental research in this field. Additionally, the accuracy of the work of people exposure to vibrations or vibrations including noise, may largely depend on the personal characteristics of the operator and his need for stimulation

Individual differences are the subject of many psychologist's research. As a basic component of individual differences can be mentioned personality, which modern definition dates back to the forties of the twentieth century. Eysenck was one of researchers, who proposed a hierarchical approach of personality. His theory rests on the existence of three mutually independent dimensions: Extroversion / Introversion (E) - understood as sociability, vitality, activity, assertiveness and risk-seeking, Neuroticism / Stability (N) - emotionality, which consists of depression, anxiety, low self-esteem, feelings of guilty and Psychoticism / Socialization (P) - the opposite of willingness to control impulses. Component of this dimension is aggression, emotional coldness, self-centeredness, impersonal attitude towards people and impulsivity [3]. What is more important from the point of view of Eysenck research extrovert characterized to the existence of a lower level of cortical arousal than introverts [4]. This would mean, that extroverts should have a higher level of stimulation that would be optimal for them [5], and thus the need for greater stimulation to provoke them [6]. In studies on the positive effects of distractors Von Gehlen and Sachse [7] describe the results of author's experiment, in which the main objective was to demonstrate if activation of cognitive function improves productivity and, if so, whether extroverts extract greater benefit from that kind of activation than introverts.

Results of this study indicate a positive relationship between extraversion and results in a test of attention in a group of cognitive activated. In turn, the research on habits for learning in introverts and extroverts have shown that extroverts prefer during learning a higher noise level than introverts [4, 8]. Doucet and Stelmack [9] in their studies demonstrate that the people with extroverted personality type show a significantly faster time of reflexes than people with introverted type. This is somehow related to the sustain characteristics of this type of personality. In the study dedicated to the relationship between the level of extraversion and executive functions has shown that degree of extraversion has an impact on the efficiency of the tasks. This efficiency depends on the type of executive function [10].

On the accuracy of working of machine operators, except of the vibroacoustic influences, individual characteristics of participant may have significant impact.

Nomenclature

ff	the value of the chair frequency, (Hz)
fp	the value of the control panel frequency, (Hz)
Af	the value of the chair amplitude, (mm)
Ap	the value of the control panel amplitude, (mm)
r	correlation coefficient [-]
p	probability value [-]

2. Purpose and methodology of research

The main purpose of this research was to determine, in laboratory conditions, relationship between accuracy of the work and the level of extraversion or introversion as a model of personality during exposure to vibrations and/or noise.

Research participants were 30 young males aged from 21 to 30. All of them were students and after physician examination they were accepted for the experiment. Age restrictions resulted from the fact that twenty years of age is the limit of the end of formation of the central nervous system, and the process of natural aging is characterized by physiological hearing loss.

The effect of selected vibroacoustic factors on work efficiency was not possible using known research tools such

as cross-apparatus or thermometer. Their construction and mode of operation do not match the assumptions and the purpose of the planned research. So, authors test tools have been developed. The person performing the test was supposed to lead the joystick cursor moving the track in such a way that it does not fall out beyond the sides of the track. After the pilot studies, it was decided that the duration of the test should be constant. Participant in the experiment saw the coming changes in the shape of the track and was able to plan his response. The criterion for assessing the accuracy the work was the number of exits of the cursor off the track (LCF) and the time remaining of the cursor off the track (CPT).

Laboratory stand was also built. This stand was able to excite whole body vibration and hand-arm vibration in the low frequency tests. Additionally, source of the noise was added to this laboratory stand.

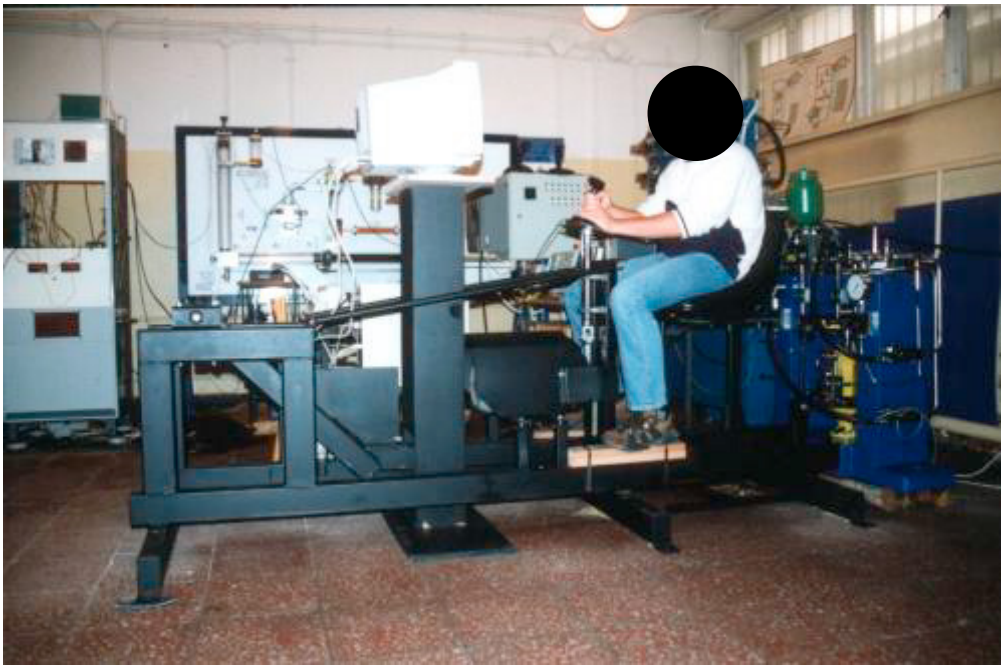

Fig. 1 Laboratory stand.

One of the basic element of laboratory stand was electro inductor, which actuator was double-acting hydraulic cylinder. The actuator is controlled with a servo valve and powered hydraulic unit with variable capacity, controlled by an inverter. This system provided a vertical low-frequency vibration excitation on a chair. The control panel was located on the frame. It consisted of a plate with a joystick, fence of the pusher and the asynchronous motor. Inverter were used to regulate the engine. Additionally, the stand is equipped with a computer with software that includes the test to examine the accuracy of the work

The laboratory stand allowed to excite on the chair and on the control panel harmonics vertical displacements of specific amplitudes and frequencies. For research the following frequencies of the chair (ff): 0 Hz, 2 Hz, 5 Hz, 8 Hz and 12 Hz and the corresponding amplitudes (Af): 0 mm, 8.5 mm, 4.6 mm, 2.9 mm, 1.9 mm were selected. The choice of these values dependent on the technical possibilities of the inductor. For control panel following frequencies (fp): 0 Hz, 2 Hz and 16 Hz respectively with amplitudes (Ap): 0 mm, 5 mm and 5 mm were chosen.

Working conditions will be a combination of described above frequency values of the chair and control panel, which were arranged in pairs (ff, fp).

Each of the objects performed the basic task of the experiment in two cycles. In the first cycle the main stimuli was vibration, and in the second cycle vibration together with noise. Both cycles last 60 minutes. The sequence of stimuli was random for each participant.

Before starting the proper research, each participant was informed of the conditions of the experiment, and after obtaining the conscious consent he should passed qualifying medical examination. Psychological research was then

conducted. Participants were asked to fill out, among others, test to determine Eysenck ‘s personality type (EPQ-R). All results from the EPQ-R test were referenced to standards. For each dimension (extraversion, neuroticism, psychoticism and lie) researchers applied normalized sten standards for polish adults. The results on the lie scale were within normal limits and were found to have no significant effect on the other scales.

3. Results

The results of experiment were divided into two groups. The first concerned the criteria to evaluate the accuracy of the work and it consist of number of exits of the cursor off the track (LWK) and the time of remaining of the cursor off the track (CPT). The second group of data was related to the personality characteristics of individuals.

LWK criterion allowed to assess which of the investigated frequencies of the chair and control panel were the most troublesome for person pursuing the test. On the other hand, in the case of CPT criterion relationships were inconclusive. Therefore, CPT criterion was not included in further comparative analysis.

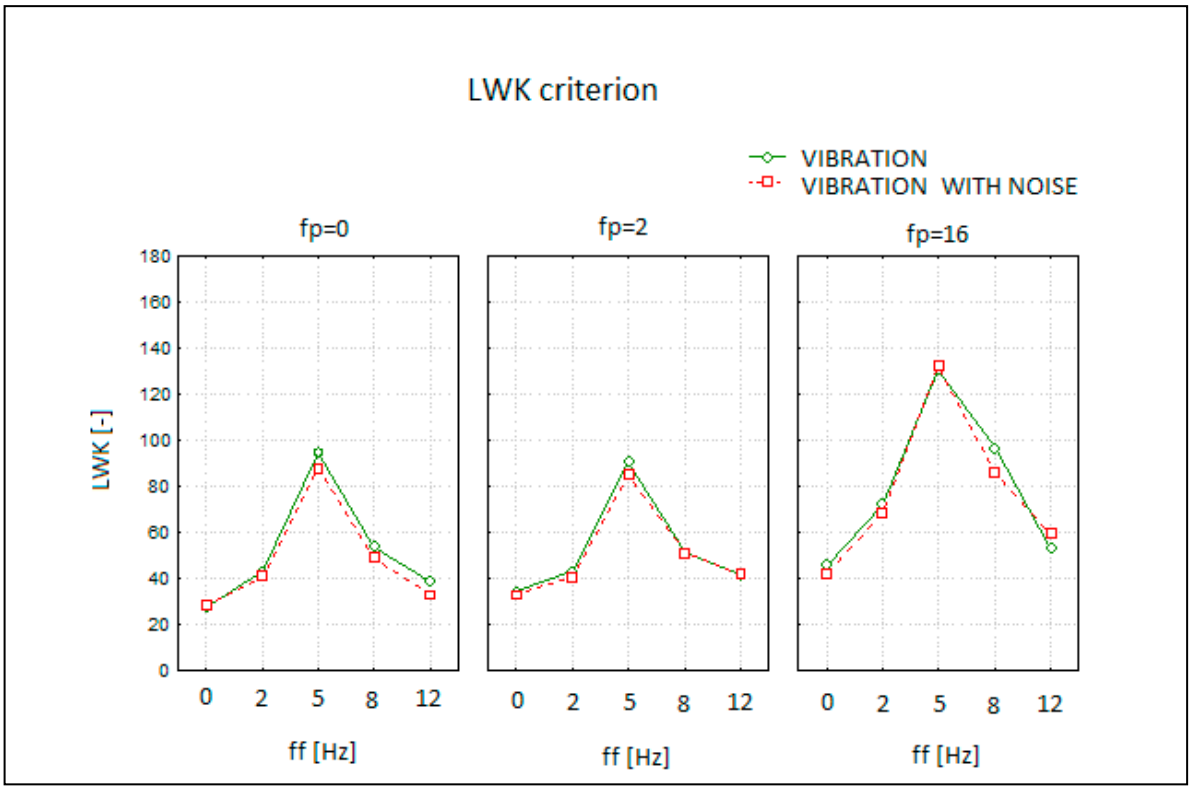

Fig. 2 LWK criterion for vibration and for vibration with noise

On the fig. 2 there are shown registered changes in LWK criterion depending on working conditions and the type of stimuli. As could be seen from above figure results for LWK criterion are very similar when vibration is considered alone and when it is considered with noise. Visible differences are statistically insignificant ($p<0,2827$). This means that the kind of stimulus, if there is vibrations or vibrations including noise had no significant impact on changes in LWK. Frequency of chair equal 5 Hz for all control panel frequencies was the most negatively affected on working accuracy. The number of exits of cursor outside the trajectory was similar in the case of an immovable chair and for chair frequency equal 12 Hz. For chair frequency, equal 2 and 8 Hz results also were very similar. In the situation of immovable control panel and for panel frequency equal 2 Hz results are very similar, but for control panel frequency equal 16 Hz results are much worse.

Analysis of the results based on the Spearmann rank correlation coefficient showed a statistically significant relationship between extraversion and the number of mistakes made by people during the performing the task. It is

worth mentioning, that extraversion was the only dimension that indicated statistically significant correlations with psychomotor efficiency. It should be also mentioned that this relationship revealed only at specific combinations of the chair and control panel vibrations. Persons with a higher degree of extraversion committed less mistakes than those with the introverted characteristics. Number of errors made by the examined persons during the impact of specific vibrations is negatively correlated with extraversion. The explanation may be that people who show higher levels of extraversion are focused, unlike introverts, to search for stimulation which for them affects mobilizing. The fact is that this effect occurred when specific frequencies of vibration of chair and control panel. Negative relationship between extroversion and the number of mistakes due to vibrations with and without noise, from one hand' demonstrates the need for stimulation which results from the nature of this dimension, and on the other hand demonstrates disturbing impact of these stimuli on introverts, whose natural level of arousal bark is higher and further, external stimulation disrupts functioning. The most significant relationship between the vibration of control panel and the number of mistakes occurred at a frequency equal 16 Hz; and in the case of vibration of the chair can be observed a significant relationship between the vibration frequency equal 8 Hz and the mistakes of the objectives (see Table 1).

Table 1. The correlation of selected conditions of exposure to vibration for extraversion

	fp = 0 Hz	fp = 2 Hz	fp = 16 Hz
ff = 2 Hz	-	-	r = - 0,38 / p = 0,040
ff = 5 Hz	-	-	r = - 0,36 / p = 0,051
ff = 8 Hz	r = - 0,40 / p = 0,027	r = - 0,54 / p = 0,002	r = - 0,48 / p = 0,007
ff = 12 Hz	-	-	r = - 0,46 / p = 0,011

Because in both cases the correlations are negative, it means that at the specific vibration frequencies (for panel and chair) task efficiency of extroverted persons increases. The introduction of the disturbance variable as noise allowed to extract the frequency at which extroverts committed less mistakes. However, these are negligible differences (see Table 2). These differences can be explained by the increased need for stimulation by extroverts in the situation of an additional noise distractor. In other words, in the event that an additional disturbance variable occurred, extroverted person will need a greater cognitive stimulation, in this specific case it is a vibration.

Table 2. The correlation of selected conditions of exposure to vibrations including noise for extraversion

	fp = 0 Hz	fp = 2 Hz	fp = 16 Hz
ff = 0 Hz	-	-	r = - 0,39 / p = 0,034
ff = 2 Hz	-	-	r = - 0,54 / p = 0,002
ff = 5 Hz	-	-	-
ff = 8 Hz	-	r = - 0,56 / p = 0,001	r = - 0,47 / p = 0,009
ff = 12 Hz	r = - 0,42 / p = 0,019	r = - 0,47 / p = 0,010	-

The introduction of additional distractor, however, did not result in significant improvement in the execution of tasks in relation to the other test conditions. These results are coherent with studies of Franklin, Johnson, White, Franklin, and Smith-Olinda [11], showing insignificant relationship between selected personality features and acceptable noise level. Persons with a greater openness to experience have a greater ability to tolerate the noise. Authors mentioned above show, however, that this tolerance is multidimensional and it becomes difficult to establish a single factor responsible for the treatment of noise as a less destructive. Similarly, Shepherd, Heinonen-Guzejev, Hautus, Heikkilä [12] point out in their study to the complexity of noise tolerance. Apart from personality features, they listed the variables such as gender, or age. An interesting and noteworthy it seems to be a correlation of

neuroticism in the case of one variant of the study: ff = 2 Hz, and fp = 0 Hz. In the absence of exposure to noise, the number of errors decreased with increasing levels of neuroticism (r = - 0.45 / p = 0.013). This effect was completely eliminated when the examined persons were exposed to the influence of noise. Whole body vibration (WBV) in this case with a specific low-frequency equal ff = 2 Hz, could have calming effect on the examined persons, manifested a higher level of neuroticism. However, this is a hypothesis which should be checked in further studies. Apart from this case, there was no statistically significant correlation between neuroticism and efficiency to complete a task, also on a Psychoticism scale there was no significant correlation.

4. Conclusion

Results obtained during the experiment described in this paper allow to conclude that during an hour lasting test the type of stimulus has no significant effect on the obtainable accuracy of work (LWK criterion). For the whole-body vibration frequency, equal 5 Hz has the most negative influence on working efficiency. In the case of hand-arm vibration frequency equal 16 Hz was the most troublesome.

Conducted study highlights the multidimensional nature of correctness and accuracy of tasks conducted by objectives. Proper execution of the tasks may in fact depend not only on the physical efficiency of individuals. Psychological aspects play a significant role in these processes. Only an appropriate combination of physical ability and adequate psychological predispositions may result in a better fit to the situation of task and thus lead to better work of individuals. Future research should include wider psychological aspect of the individuals. Relationships between the selected frequencies of vibration and a reduced number of mistakes in people with extroverted personality type observed in the study may lead to propose a hypothesis about the existence of such a vibration frequency which may affect in a positive way on the functioning of individuals. Mentioned 8 Hz for whole-body vibration (WBV) in extroverted people indicates that it can provide the optimal level of arousal in a task situation. In the case of control panel vibration (hand-arm vibration) improvement of the results (fewer mistakes) usually occurs at fp equal 16 Hz. Perhaps this is due to a weaker hand-arm vibration effects. The results indirectly confirm the biological durable of extraversion and encourage to further, more precise studies on the personality association with psychomotor efficiency. Cognitive abilities in an overall (holistic) psychic functioning model can be realized to varying degrees depending on personality traits. In the same stimulus situation, the extreme extrovert works differently than the extreme introvert. Personality in the case of vibration impact can act as a disturbing variable, which need to be controlled. It is obvious that the ability is not a one-dimensional variable, and this fact can explain not very high correlations that occurred in the present study. The involvement of personality factors in human behavior requires further research. The results show that such participation is likely, especially for certain dimensions of personality.

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