Conference Paper

Experimental Study of the Correlation Between the Level of Professional Training and the Dynamics of Changes in the Psycho-emotional and Functional State of a Person During Testing

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Abstract

The urgency of the objective assessment of the professional training level of hazardous objects workers is shown. The ability to act quickly and correctly in abnormal and emergency situations is highlighted as one of the important competences. An experimental study of the correlation between the level of professional training and the dynamics of changes in the functional and psycho-emotional state during testing is carried out. Remote and non-contact technologies is used to monitor the current functional and psycho-emotional state. Such technologies allow in completely passive mode to register the main bio-parameters of the test person. To visualize the current state, it is suggested to use pie charts. The carried out experimental researches have allowed to allocate the most informative factors, correlating with a level of professional training. Such factors, first of all are: the final level of mental and physical fatigue of the tested; the total amount of physical and mental forces spent on the test; the level of manifestation of the state of fright, fear and confusion when acquainted with the test task. The comprehensive consideration of the aforementioned factors will increase the objectivity of assessing the level of professional training.

Keywords: human factor, bio-parameters registration, psycho-emotional state

1. Introduction

The reason for most technogenic accidents and recent disasters is the so-called human factor. One of the main components of this factor is the level of professional training [1]. First of all, this refers to the dangerous objects operational staff. Typical examples of hazardous facilities are nuclear and thermal power plants, chemical plants, high-speed passenger transport.

Speaking about the level of professional training, it is necessary to distinguish the following two principal aspects. First, it is the systematic and integrity of the acquired theoretical and practical knowledge, competences and skills. Secondly, it is the ability to apply the knowledge gained in practice. Especially important is the ability to apply the knowledge gained in extreme conditions. For example, in case of abnormal or emergency operation of a dangerous object.

It should be noted that such personal characteristics and skills as well as stress resistance and self-control also largely determine the possibility of effective, that is, quick and correct, application of the acquired skills in practice.

At present, methods for evaluating theoretical knowledge, skills and competences are developed quite well. First of all, these methods should include oral responses of students, all types of testing, performance of qualification works, writing abstracts. The most promising, in this regard, should be considered automated computer testing. Such testing can be built into almost all types of educational and training sessions, and also carried out remotely.

The level of possession of a number of practical skills and competences can be assessed when conducting laboratory work and training sessions. For complex and dangerous facilities, it is most effective to conduct training sessions on full-scale simulators. Such simulators practically completely simulate a real, as a rule, dangerous control object in real production conditions. This allows, among other things, to comprehensively assess the level of ownership of the management skills of such facilities in abnormal or emergency modes of their operation. At the same time, when simulating such modes of work, students can be in a state of strong psycho-emotional stress, fright or stupor.

Analyzing the dynamics of changes in the current functional and psycho-emotional state of students in the process of performing test or training tasks, it is possible to obtain additional objective information about the level of personal professional training.

The purpose of the research work is an experimental study of the correlation between the level of professional training and the dynamics of changes in the psycho-emotional and functional state of a person during testing.

2. Technologies and Methods

When conducting experimental studies to evaluate the current functional and psycho-emotional state of a person, author's remote non-contact technologies were used.

Such technologies [2, 3] make it possible in a completely passive mode to perform remote registration of the main human bio-parameters. The analysis of these bio-parameters allows to draw an objective conclusion about the current functional and psycho-emotional state of the tested person. As such technologies were used acoustic [4–6], optical technologies of the visible range, as well as long-wavelength infrared technologies [7]. These technologies were used only to record natural radiation from the human body in the corresponding spectra. The advantage of such technologies is the absence of any sensors on the body and clothing of the tested, as well as the possibility of real-time registration of bio-parameters.

It should be noted that the independent application of the aforementioned technologies is known in practice. Thus, the technologies of the visible optical range are now widely used to recognize a person's emotions by expressing his face [8–16]. The most active such studies are, for example, in the field of monitoring the driver's condition for ensuring safety in transport [17–20]. Multilevel analysis of spectral, temporal and semantic characteristics of speech makes it possible to assess the level of stress [21–23]. Unfortunately, when managing a dangerous object, short enough speech commands are usually used. This circumstance makes it difficult to conduct a constant analysis of speech at the semantic level. Well-known infrared technologies are focused mainly on the registration and processing of the image of the face of a motionless person [24]. A common disadvantage of independent use of the technologies under consideration is the presence of so-called dead time intervals. During these intervals, registration of bio-parameters is difficult or impossible.

The developed author's approach makes it possible to carry out reliable registration of human bio-parameters during its movement, including the presence of slopes and turns of its head [2, 3, 7]. The essence of the approach lies in the parallel registration of the bio-parameters of the tested in all ranges of radiation with their subsequent integral evaluation.

As a result, this approach allows the effective use of remote non-contact technologies for realizing the so-called biological feedback. This relationship is used in practice for the development of stress resistance and skills of self-control and self-regulation [25].

During the research, the author's technology of visualizing the monitoring results of the current psycho-emotional and functional state of the tested person was used [2, 3, 7]. This technology allows visualization of monitoring results in the form of pie charts. To describe the current state of the tested person, the integral function Q(t) [2, 7] is used. The values of the argument and the function are represented in relative units. This allows you to represent the results of testing of different duration in a unified form. Figure 1 shows an example of such a diagram.

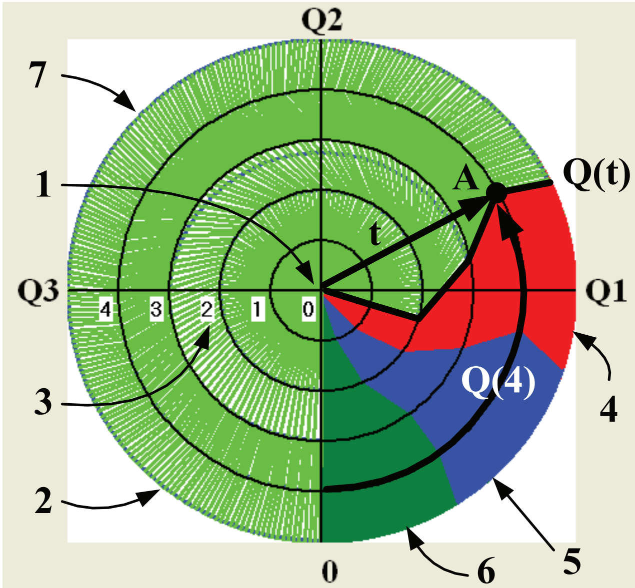

Figure 1: Example of the testing process visualization.

Thus, for a point A belonging to the curve Q(t), the distance from the center of the diagram corresponds to the time *t* = 4. The angle to the point A (Q(4)) corresponds to the value of the integral function. The center of the pie chart (1) corresponds to the beginning of the test. The end of the testing procedure corresponds to the peripheral zone of the diagram (2). The intermediate moments of time are marked on the diagram by circles (3). Typically, the chart displays times that are multiples of, for example, 10 minutes.

Calculation of the function Q(t) values is carried out on the basis of an analysis of the dynamics of changes in the basic human bio-parameters [1–3]. The components of the function Q(t) are shown in the diagram in different colors. Thus, the contribution of parameters characterizing the work of the cardiovascular system, the respiratory system and the nervous system is shown, respectively, in red (4), blue (5), and green (6). The light green area (7) is the background. The entire range of possible values of the function Q(t) is divided into four subbands: $0 \leq Q(t) < Q1$, $Q1 \leq Q(t) < Q2$, $Q2 \leq Q(t) < Q3$, $Q3 \leq Q(t)$. These sub-ranges correspond to the relaxed, working, strained and very stressed state of the tested person [2–7].

During the research, the following assumptions were made:

1. all tested persons have a normal functional and psycho-emotional state before testing;

2. all test assignments check persons' knowledge only within the framework of the discipline under study;
3. teachers do not have a personal bias toward any of the tested persons;
4. the influence of external irritant factors is minimal;
5. the test room has normal climatic conditions;
6. the applied tests were not previously used and are original;
7. all tested persons perform test tasks of equal complexity; and
8. the quality of the test assignments was assessed by three independent teachers.

Figure 2 shows the most expressive results of visualization of the testing process. The difference in the dynamics of the functional and psycho-emotional state of the test subjects is clearly visible. The diagram in Figure 2(a) corresponds to a large voltage in the test task. The diagram in Figure 2(b) corresponds to the unstressed testing mode.

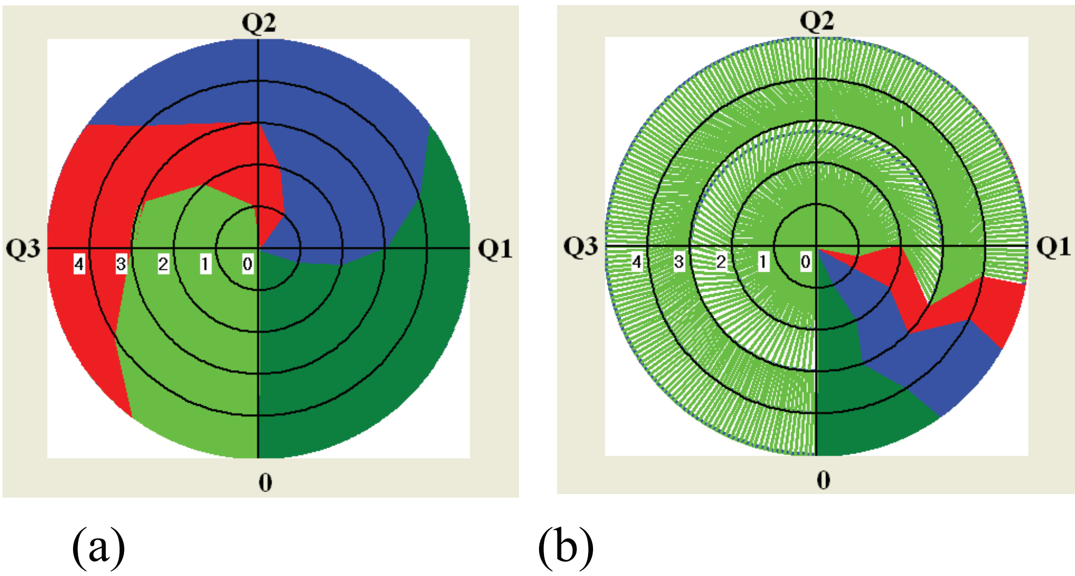

Figure 2: Typical test results.

3. Results and Discussion

In conducting experimental studies, 78 tested persons participated. Table 1 shows the distribution of the number of tested M(S, L) depending on the code of the obtained estimate S and the range number L of the final value of the function Q(t) at the end of testing. Assessment of knowledge was carried out on a four-point scale: 'Excellent' (5), 'Good' (4), 'Satisfactory' (3), and 'Unsatisfactory' (2). The range number L corresponds to the quadrant number in the pie chart: L = 1 if 0 ≤ Q(t) < Q1; L = 2 if Q1 ≤ Q(t) < Q2; L = 3 if Q2 ≤ Q(t) < Q3 and L = 4 for Q3 ≤ Q(t). In Table 1, the data about the time of execution of the test t_E (normalized for a maximum test time of about 50 minutes) are presented in parentheses.

Table 1: Distribution M (S, L).

S	L			
	L = 1	L = 2	L = 3	L = 4
5	2 (1,0; 0,8)	15 (1,0; 0,9; 0,9; 0,8; 0,8; 0,8; 0,8; 0,7; 0,7; 0,7; 0,7; 0,6; 0,6; 0,6; 0.5)	3 (0,8; 0,7; 0,3)	1 (0,5)
4	1 (1,0)	13 (1,0; 0,9; 0,8; 0,7; 0,7; 0,7; 0,7; 0,6; 0,6; 0,6; 0.5; 0,3; 0,3)	15 (1,0; 0,8; 0,8; 0,7; 0,7; 0,7; 0,6; 0,6; 0,6; 0,6; 0,5; 0.5; 0,5; 0,4; 0;3)	3 (0,8; 0,7; 0,5)
3	0	1 (1,0)	10 (1,0; 1,0; 1,0; 1,0; 0,9; 0,9; 0,9; 0,8; 0,8; 0,6)	7 (1,0; 1,0; 1,0; 0,9; 0,9; 0,8; 0,7)
2	1 (1,0)	0	2 (1,0; 0,7)	4 (1,0; 1,0; 0,8; 0,5)

Figure 3: The initial field of probabilities for the case under consideration.

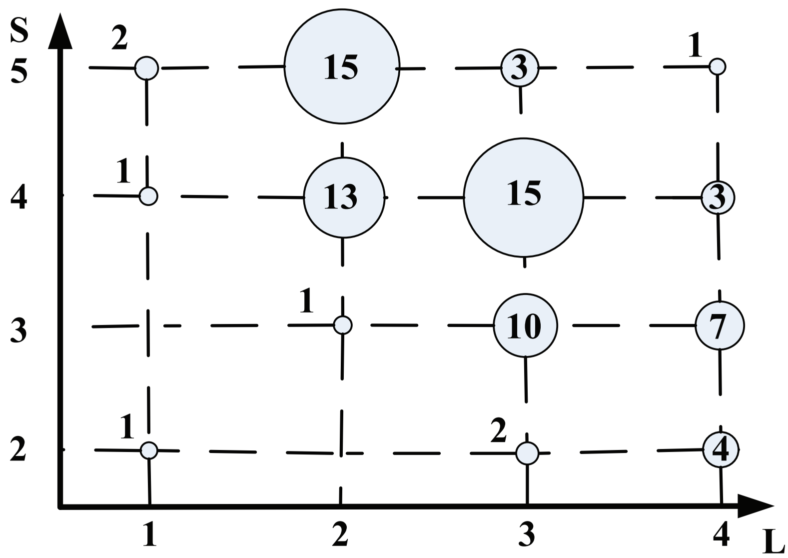

Figure 4: Graphical illustration of the distribution M(S, L).

Analysis of the initial experimental data revealed the presence of 'emissions' in the value of the function Q(t) at the beginning of testing. This effect should be interpreted as the appearance of fright, fear, uncertainty when acquainted with the test task. The presence of the effect is most likely either due to an unsatisfactory level of basic knowledge or insufficient experience of practical work. Figure 5 shows a typical example with an ejection (1). The magnitude of the ejection is 2 quadrants relative to the initial normal state.

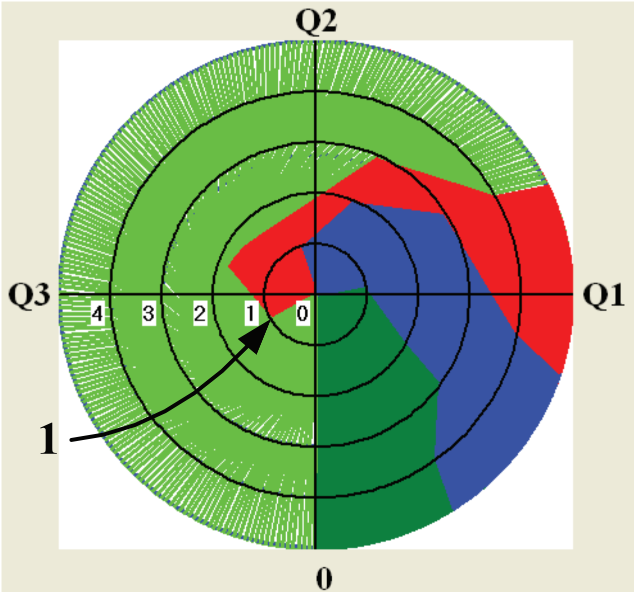

Figure 5: Presence of ejection (1) at the beginning of testing.

Table 2: Distribution of the number of tested K(S, ΔL) as a function of the estimate S obtained and the amplitude of the ejection ΔL.

Distribution K (S, ΔL)				
S	ΔL			
	ΔL = 0	ΔL = 1	ΔL = 2	ΔL = 3
5	15	5	1	0
4	6	21	5	1
3	1	3	10	4
2	1	1	1	4

Table 3 shows the results of the studies. Three variants of correlation of the obtained estimate S were considered with:

1. the total level of mental and physical fatigue of the tested person (proportional to the quadrant number L, which belongs to the values of the function Q(t) at the time t_E of the end of testing Q_E = Q (t = t_E));
2. the total volume of physical and mental forces spent on the test (proportional to the area Lt_E); and
3. the level of manifestation of the state of fright, fear and confusion when acquainted with the test task (proportional to the amplitude of the release ΔL).

Table 3: Research results.

No.	Type of the analyzed correlation function*	Correlation coefficient r	Correlation force
1.	$S_1(L) = A_1 \cdot L + B_1 + \varepsilon_1$	0.52	Weak
2.	$S_2(L \cdot t_E) = A_2 \cdot (L \cdot t_E) + B_2 + \varepsilon_2$	0.63	Conditionally strong
3.	$S_3(\Delta L) = A_3 \cdot \Delta L + B_3 + \varepsilon_3$	0.65	Virtually strong
Note: The parameters A_1, B_1, ε_1, A_2, B_2, ε_2, A_3, B_3 and ε_2 are determined by linear regression analysis.			

4. Summary

Qualitative studies of the correlation between the level of professional training and the dynamics of changes in the psycho-emotional and functional state of a person during testing have confirmed its presence. The most informative factors should be considered – the total amount of physical and mental forces spent on the test, as well as the manifestation of a state of fright, fear and confusion when acquainted with the test task. The comprehensive consideration of the aforementioned factors will increase the objectivity of assessing the level of professional training.In the framework of further research in this area, it is expedient to solve the following problems related to the study of correlation:

1. to analyze experimentally the influence of gender and age factors;
2. to investigate the influence of the type of character of the tested; and
3. to study the influence of more differential systems of professional skills assessment on the degree of correlation.

Among the most important metrological problems, one should note the practical absence of official standards for determining the degree of stress in the test subjects.

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