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APPLICATION FEATURES OF VIRTUAL REALITY IN DIAGNOSTICS OF HUMAN PSYCHOPHYSIOLOGICAL CHARACTERISTICS

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Abstract

The paper discusses possible application of high technology, including virtual reality (VR), in diagnostics of individual typological features of the person. The authors have revealed application features of virtual reality in diagnostics of psychophysiological professionally important qualities that determine potential or actual abilities for a certain effective professional activity. They have classified psychophysiological features as well as application features of virtual reality in diagnostics of the former. The main methods of medicine, diagnostic medicine, virtual reality technology aimed at diagnostics, identification of respondents' state, professional orientation are determined on the base of an integral methodological approach.The research is focused on increasing the effectiveness of occupational orientation processes and psychophysiological rehabilitation in case of retraining or returning to profession. Achievement of an objective provides a qualitatively new level of determining how a person corresponds to the selected profession and social integration after retraining. Special attention in the article is paid to methods choice and ways of obtaining information on a status of the trainee realizing the consolidated methodological approach to the pursuance of the research. For instrumental realization of the developed approaches and their approbation, soft hardware of the pursuance of the multiple diagnostic research and intellectual simulator complexis provided.

1. Introduction

Nowadays information technology is vigorously developing and penetrating into all sectors of human activities - from everyday life to industrial and defense enterprises. Engineering psychology is no exception. It studies psychological patterns of the working activity of a person in management and control systems, and a person's information interaction with technical devices of the mentioned systems. The systems of so-called virtual reality, where a person has an opportunity to find oneself in a different environment that does not greatly differ from the real one by cognitive dimensions, are currently becoming more prevalent.

The concept of virtual reality is treated differently in the scientific community. Some authors (Averbukh, 2011) refer virtual reality to a computer-generated environment that creates an illusion of the user's presence in the world offered by a software system. However, the majority (Selivanov & Selivanov, 2014; Chernyshova et al., 2015) define virtual reality as a technology of human-computer interaction, which ensures immersion of the user into a 3D interactive information environment. In this paper,the authors use the second definition. Application of high technology including virtual reality is an effective means both for training and for diagnostics of individual typological features of the person.

2. Problem Statement

2.1. Types of human psychophysiological characteristics

Psychophysiological dimensions are found to be one of the greatest interests among human individual typological features. In terms of engineering psychology it deals with psychophysiological professionally important qualities that refer to human individual features determining potential or actual abilities to a certain effective professional activity. The mentioned qualities are formed by genetic, medical, biological, social and psychological factors. Requirements for psychological and psychophysiological professionally important qualities are raising along with increasing extremeness of operational environment. Optimal staff recruitment and a degree of work efficiency are in line with correlation between the personal dimensions determined by a diagnostic process and demands of the occupation.

A maturity level of professional activity and capabilities to improve psychophysiological characteristics are conditioned by the type of higher nervous activity (Vainer, 2011). I.P.Pavlov's classification is believed to be the most authoritative typology of higher nervous activity. The key parameters of this classification are intensity of processes of excitation and inhibition, their balance and flexibility. The correlation of these processes gives four temperament types: sanguine, choleric, phlegmatic, and melancholic. The diagnostics of professionally important qualities should take into account the mentioned types which are to be defined beforehand by using special methods (Eysenck Personality Questionnaire, N.N.Obozov Personality Questionnaire). The outcomes of these tests can eventually help to make final diagnostic conclusion more complete.

The main psychophysiological characteristics relating to professional activity of a person are believed to be adaptive, tracking, measured by eye neuroticism, extroversion, responsiveness, etc. (Tatjanenko, 2014; Petukhov et al., 2016). At the same time, a set of key qualities is determined by a

specific professional activity. Identification of professionally important qualities is necessary as it allows us to construct a specialist's competency model, to reveal professional activity peculiarities important for understanding the specific character of such professional training. It sets out the relevance of this work.

2.2. Diagnostics of psychophysiological characteristics

Nowadays there are a number of computer-based methods for evaluation of professionally important qualities. A system of measures, which helps to identify people who are most suitable for training and further professional activity in a certain occupation due to their personal traits, plays a special part in evaluation of the professional aptitude. Diagnostics of psychophysiological characteristics is aimed at defining people whose abilities and individual psychophysiological capacities meet requirements set out by the specificity of training and professional activity in a certain occupation.

The information of psychophysiological features of any given profession is generalized in a professiogram that outlines peculiarities of this professional activity. First of all, it is necessary to present what operations and main working actions and functions are to be performed in case of mastering a chosen profession. These data are initially included both in the principal educational program of speciality training and in the work programs in each subject. The professiogram should include knowledge and skills required for certain operations, typical psychophysiological states such as emotional tension, fatigue, monotony of actions, physical and intellectual job complexity, algorithms of actions to be performed by a person. Then, significance of different psychological attributes and personal qualities for effective performance of this activity should be estimated. For this purpose, in accordance with the given description of professional operations, it is necessary to define personal attributes that ensure performance of each such operation and determine the degree of importance of different psychic functions for attaining a final effect of a working process, the charging time of a psychic function throughout a working process. The outcome of such analysis is definition of the most significant parameters that characterize the human ability to professional activity.

Construction of a professiogram helps to define professional aptitude as it is based not only on evaluation of psychic processes, but also on evaluation of a number of professional working operations.

Psychophysiological diagnostics of professional orientation with the use of different types of tests implies examination and evaluation of some psychological parameters of attention, memory, motor coordination, etc. important for successful training and professional activity in a chosen occupation as well as an analysis of completed professional operations. One of the prevailing methods for evaluation of personal psychological characteristics is Sixteen Personality Factor Questionnaire, 16PF, developed by Raymond Cattell. Cattel's method is commonly used in psychodiagnostic practice both abroad and in Russia. This Questionnaire is universal and practical, reveals comprehensive information of a personality. Professional Self Identity Questionnaire on the basis ofJ.Holland's theory of career choice is also widely used. The Questionnaire is based on the belief that any successful career directly depends on how much one's personality corresponds to the type, spirit and demands of the profession. Statistics proves that all successful people achieve their highest and fullest development only in the professional environment that conforms to their personality type. The people of integrity and consistency are those who have managed to realize their core values (Samoilik, 2016).

The comparison of professional diagnostic methods shows 60% effectiveness of such evaluation method as professional aptitude tests. Thus, Bennett Mechanical Comprehension Test is used to reveal abilities of engineering professions.

Among psychodiagnostic methods, applied within a social psychological approach of evaluation, instrument methods are becoming more prevalent. They are used for investigations of attention capacity, short-term and permanent memory, reaction rate, reaction accuracy, etc.

Diagnostic means with virtual reality interfaces play a special part in application of instrument methods.

3.   Research Questions

3.1.   The possibilities of virtual reality in learning

Virtual reality is characterized by a number of peculiarities that facilitate more effective diagnostics. ZinchenkoYu.P et al. consider a possibility of complete control over an observer's attention and system customizability to be the main advantage of virtual reality technology (Zinchenko, 2010).

In addition to it, such factors as a possibility of motivation, control and interaction, practicability, interactivity, spatial orientation, and multisensory activity are also described in the literature as advantages of virtual reality systems (Zinchenko, 2010). It is noted that the virtual reality interface is an effective teaching tool for people with limited health capacities.

Selivanov V.V. believes that application of virtual reality in teaching can help implement a principle of visualization more effectively and establish better relations with real situations (Selivanov & Selivanova, 2014).

Besides a big number of outlined advantages, there are some restrictions connected with financial, technical and conceptual difficulties (Zinchenko, 2010). It is also reasonable to assume (Averbukh, 2011) that the effect of presence in the virtual reality depends on the individuality and can be observed not in every instance. Moreover, it is shown by experiments (Averbukh, 2011) that an output device (a screen or 3D glasses) does not affect the time of test completion, and on the contrary, it makes a great impact on correctness of task performance - a screen image causes a less number of errors.

In diagnostics of human psychophysiological characteristics, the study of interaction between visual perception and motor activity is of the greatest interest as in modern technical systems an operator plays a key role (Tatjanenko, 2014) and should have highly developed visual and motor skills, especially in cases of hazardous situation risks.

Virtual reality technology makes it possible to study different ways of interaction between the person's perception of the events going on around and their actions. The non-existing (virtual) reality, which surrounds a person and into which a person gets immersed, integrates with one's real actions and movements in the "non-existing" space.

Virtual reality technologies suppose an effect of presence in the virtual reality and communicate the effect of immersion into the virtual environment to test persons in different ways depending on the equipment (Selivanov & Selivanova, 2014; Feschenko et al., 2015):

- a virtual reality program is displayed on the PC monitor and special glasses are used, in this case the degree of immersion is the least, only individual sessions are possible;

- a program uses a big inclined screen, the image is projected to the back side of the screen, special glasses and a remote control device are necessary;

- a virtual room with projections on three walls and the floor, semitransparent 3D glasses combining VR image with real image, additional accessories such as a sensor glove for tactile perception or a joystick for control of one's movements in the virtual reality. The room can be used individually or by student or test groups.

Thus, application of virtual reality implies instrument methods and at the same time promotes a search for new methods aimed at recording human reactions. VR interface diagnostic devices play a special part, they help to identify reactions characterizing human professional features and capabilities.

3.2. Features of virtual reality for diagnostics of psychophysiological characteristics

In this connection, evaluation of conformity of the individual possibilities to certain professional activities taking into account individual peculiarities of sensor, cognitive and motor reactions becomes more relevant.

Now, Volga State University of Technology is developing an intelligent training system for career guidance and professional rehabilitation. The system comprises methods of psychology, diagnostic medicine and virtual reality technology and is aimed at diagnostics, career guidance, inclusive teaching and learning and professional rehabilitation within an integral methodological approach.

The intelligent training system performs a complex investigation of human psychophysiological characteristics and cognitive mechanisms and focuses on identifying the professional potential of test persons and their professional orientation, on their professional training and further training.

The intelligent training system implemented as a complex smart expert system on the base of uniquely designed methods of studying human psychophysiological state with the use of fuzzy logic and a fuzzy set device will make it possible to construct an individual psychophysiological portrait of a test person and develop an individual program of professional training, which can be implemented with the use of the developed system.

In addition to it, it is supposed to make a comprehensive evaluation of human professional efficiency on the base of learning outcomes using this intelligent training system. The evaluation outcomes help to make scientifically valid recommendations for professional rehabilitation with the use of information technology and virtual reality systems.

Application of methods combining traditional techniques of experimental psychology and modern VR technologies becomes more relevant. Virtual reality used for examination of cognitive functions such as memory span, perception and attention makes it possible to estimate their parameters in the conditions of noise pollution of the space or a short-term stimulation.

In order to observe manifestation of psychophysiological features in the conditions of solution of complex cognitive tasks, it is necessary to immerse test persons in the virtual environment demanding motor activity and space orientation. This can be a base for the development of tests aimed at revealing professional capabilities and professional aptitude to a number of occupations such as operators, drivers,

pilots, sportsmen, engineers (Tatjanenko, 2014), marine engineers (Boguslavets, Bavula, & Karpenko, 2016), etc.

The development of such methods has become real due to the innovative technology of virtual reality which gives not only more realistic 3D incentives, but provides a test person with greater mobility in task solution. The proposed method uses the following techniques for organization of incentives and test person's actions. All activities of the test person are followed by recording an electroencephalogram, a galvanic skin reaction, an electrocardiogram, etc. It is supposed that in some possible situations, the cognitive processes (perception, memory, thinking) can prevail over one's own motor activity, as well as in other situations the subject's activity is added with one's own motor activity actualized as goal motor actions while the degree of interaction between the cognitive processes and motor activity can be adjusted by "misalignment" of the visual and motor components. As a result, interaction of the cognitive processes and actions can cause a significant change in efficiency of task solution.

4. Purpose of the Study

The purpose of the study is to increase the effectiveness of professional orientation processes in choosing a profession and psychophysiological rehabilitation while retraining or returning to the profession. The achievement of this purpose will provide a qualitatively new level of determination of a person's compliance to the profession he/she has chosen, as well as integration of individuals into the social life of society after retraining. The study will expand the theoretical and methodological basis of vocational guidance psychology and psychophysiology, at a fundamentally new level, to develop adaptive interfaces and intelligent simulators targeted at a particular trainee, develop an arsenal of methods of vocational guidance and training. As local purposes, it is possible to single out the development of the theory and methodological foundations of professional rehabilitation, the development of an intelligent simulator system that enables one to provide individualization of training and rehabilitation, the personification of the trainee in the structure of the production system.

5. Research Methods

The study of the features of virtual reality application in psychophysiological diagnostics of a person is based on interdisciplinary research in the field of rehabilitation psychology, pedagogical psychology, engineering psychology, cognitive psychology, models and systems of training, cybernetics and human ecology.

The study examines the dependence of the development of certain types of professional activity on sensory-motor and cognitive learning mechanisms and features of the surrounding space cognitive model formation and the cognitive response pattern.

Comprehensive study of the investigated problem, of all its aspects and parameters, is possible only through the application of a whole set of methods. Obtaining scientific information about the trainee's personality for establishing regular connections, relationships and building scientific theories is possible with the use of testing methods, methods of theoretical research and mathematical methods.

When studying the trainee's experience, methods such as observation of the training process, conversation and questioning, studying the process and results of activity in a virtual environment will be used.

A special role will be assigned to experimental research. They serve as a means of gathering scientific and psychological facts that will be subjected to theoretical analysis. Through the theoretical analysis, the systematization of the facts of behavior will be carried out, a conceptual model of the process of the surrounding space cognitive model formation and the cognitive response pattern will be synthesized.

The mathematical and statistical methods will be used to determine the quantitative dependencies between the studied phenomena and the processing of the obtained data by the experimental methods.

In addition, research methods use methods of system analysis, object-oriented analysis and modeling of information systems, the apparatus of the theory of fuzzy sets, methods of expert evaluations, the theory of random processes, methods of data mining, thetheory of reasoning under uncertainty.

Based on the methodology of structural-semantic analysis, models of the process of interaction of objects, represented in the form of semantic networks, will be developed.

When studying the mechanisms of sensory-motor and cognitive interaction of a trainee with a technical system, it is proposed to use the methods of experimental psychology, psychophysiology, occupational medicine and cybernetics. At the same time, the main problem is the correct choice of tests of the individual current state studying and predicting its potential. It is known that the results of psychophysiological tests largely depend on the current psycho-functional state of the subject, one's motivation and emotional mood, and, therefore, may be different for the same subject when testing at different times.

Obviously, to increase the reliability of the assessment, it is necessary to conduct multiple testing. However, when using this approach, most of the known tests, especially the questionnaires, become unsuitable. In addition, there are a number of psychological problems associated with self-awareness and self-determination, because each subject wants to look better than what he/she is.

In this regard, particular attention in this research is given to the choice of methods and ways of obtaining information about the state of the trainee, implementing a unified methodological approach to research conducting.

As a test task, the use of the test of visual-motor tracking and visual-motor coordination is proposed. On this basis, it is proposed to develop the way to assess the ability to adjust one's own actions, the way to assess the capacity to study, the way to determine the objective function of the action and the functional of the quality of the activity. For the instrumental implementation of the developed ways and their approbation, it is supposed to develop software and hardware for carrying out the complex diagnostic research and the intellectual training complex.

6. Findings

Application of modern computer technologies makes possible the objective psychophysiological diagnostics revealing test persons' psychic characteristics relating to their professional orientation. The proposed method makes it possible to conduct multifactorial psychological and psychophysiological

experiments for research into: 1) interaction between the cognitive processes (perception, memory, thinking) and behaviour (actions); 2) influence of degrees and forms of motor-cognitive cooperation on the subject's successful practical activities; 3) particularities of brain and autonomic nervous system activities in the context of an actual goal behaviour.Virtual reality becomes a new effective research method of experimental psychology. Virtual reality technology gives unique opportunities for attaining new objectives of innovative higher education.

7. Conclusion

Methodology of the research of psychophysiological human activity characteristics while performing professional functions by acquisition, processing and representation of knowledge is based on integration of the system principles and general scientific approaches to the complicated multilevel control system construction. The developed methodology differs in that it allows considering "Trainee – Intellectual simulator system - Environment" as a united multilinked system of communication channels of sensory, cognitive, motorial levels of interaction, which identification and optimization are conditioned by the trainee's actions analysis over the course of training or professional activity.

The conceptual model of environment and the cognitive reaction scheme, cognitive model formation will allow one to describe the process of environment cognitive model formation and the trainee's reaction scheme under conditions of changing sensory, cognitive or motorial mechanisms, working compensatory mechanisms and specific behavior strategies with the application of virtual reality.

Acknowledgments

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