

PREVENTING MENTAL AND PHYSICAL FATIGUE IN ADOLESCENTS' REPRODUCTIVE SYSTEM DEVELOPMENT BY MODERNISING EDUCATIONAL TECHNOLOGIES

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Abstract. *The purpose of this paper is to review and synthesize data on educational technologies aimed at facilitating perception, deeper understanding of mechanisms and apply a method of emotional state detection based on facial action coding system (FACS). The review demonstrates the demand and attractiveness for investment of modernized visualization, computer simulation and virtual immersion techniques in understanding complex fundamental mechanisms of living systems at different levels of organization. The described conceptual solutions have a great potential to facilitate, increase the productivity of the educational process and prevent mental and physical fatigue of schoolchildren, especially in the period of their puberty against the background of increased risk of formation of stressogenic suppression of neuroendocrine mechanisms and reproductive failure in the future mature organism. In the practical part, testing of virtual immersion in conditionally neutral, safe and threatening environments on adolescent volunteers after the end of training sessions showed that viewing threatening video content is accompanied by an increase in mimic movements in the area of localization of musculus corrugator supercilii on the background of minimization of movements in the area of musculus zygomaticus major and minor. We assume that immersive virtual reality technologies can be successfully applied to solve various tasks related to the modernization of science education. Qualitative and quantitative assessment of the expression of emotions in schoolchildren can be successfully used to identify the degree of purposefulness, concentration, the presence of motivation and satisfaction or, conversely, dissatisfaction and disgust, as well as for early detection of manifestations of mental or physical fatigue.*

Key words. *3D modeling; immersive virtual environment; facial action coding system.*

Introduction

The clear evidence that mental and physical fatigue; a violent shift in the diurnal sleep-wake cycle; and exposure to artificial light at night due to intense educational, work and service activities are often associated with neoplastic degeneration of hormone-dependent tissues of the reproductive glands, prostate and mammary glands, especially in young men and women, is of great concern [2, 5, 8, 10, 12]. Psychoemotional stress caused by educational, labor or service activity is accompanied by immunosuppression and suppressive effect on the reproductive system, characterized by irregularity of monthly sexual cycle, deterioration of ovo- and spermatogenesis against the background of insufficient production of sex hormones. According to our working hypothesis: a complex of factors of external and internal environment of the organism, associated with intensive daily educational activities of individuals during the development and formation of reproductive structures and functions in puberty, can have a destructive effect on hormone-dependent tissues and cause subsequent insufficiency of neuroendocrine regulatory mechanisms. The solution to such a socio-economic problem of health-saving human resource is possible by finding ways to modernize educational technologies, particularly in the field of natural sciences. Currently, there is a significant leap in the development of information technologies for computer modeling and virtual visualization of hidden processes of life activity of living systems at the nano- and microlevel. For example, outstanding companies (*3DforScience*; *O2Labz*; *The Visual Marketing Agency*) creating 3D/2D biological, biomedical, and various scientific animations are realizing amazing concepts (Figure 1.) [4]. Against this backdrop, there is a surge of interest in the introduction of immersive virtual reality (*Immersive Virtual Reality, IVR*) into educational technologies, which provides for increased investment in numerous studies in this direction [3, 4]. IVR technologies contain a huge potential to accelerate, optimize, improve the efficiency and fruitfulness of modern educational technologies in the field of natural sciences [7]. It is obvious that digital technologies can ensure the modernization of education.

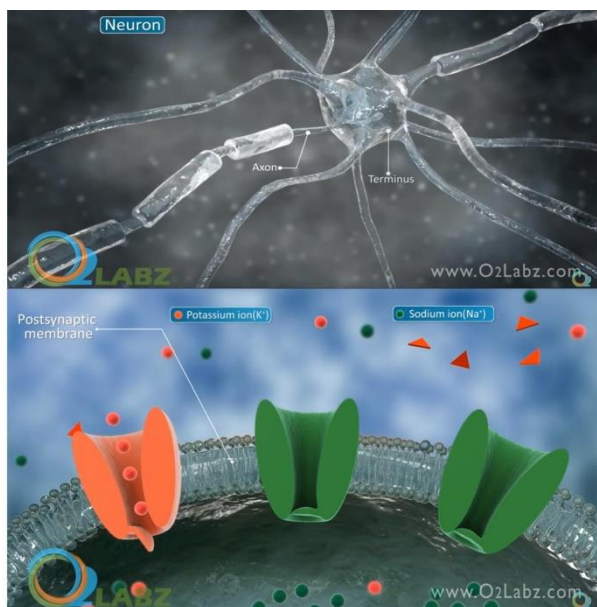


Figure 1. Three-dimensional modeling of a neuron (microscopic) and transmembrane ion flux (nanoscopic) through ion channels (K^+ -channels, Na^+ -channels) [Extraordinary 3D/2D medical animation and scientific animation company O2Labz, <https://www.youtube.com/c/O2Labz>]

There are already predictions that virtual reality (VR) and related technologies will reach an ever-increasing multi-million dollars audience of learners. Naturally, investment in VR-based education, research and development programs is growing rapidly [6]. It is now important to develop a conceptual model and software action algorithm that integrates the results of multiple research studies and provides insights into immersive virtual reality learning to modernize educational technology. This is necessary so that stakeholders: students, instructors, curriculum developers, or educational policy makers, know what to consider when selecting, using, designing, developing, and purchasing IVR-based learning applications. From a psychophysiological perspective, IVR is defined as a complex media system that includes a specific technological setup for sensory immersion of the individual, and as a means of complex content presentation capable of modeling and simulating real as well as imagined environments and conditions [9].

Taking into account the above mentioned, the aim of the work is to build a conceptually updated approach in educational technologies in the

field of natural sciences, aimed at preventing mental and physical fatigue in the period of sexual development, increasing the risk of reproductive failure in the future mature body.

Materials and methods

Synthesis of the concept of modernization of the practical approach in educational technology by the help of IVR is made on the basis of literature review and own experiment. The experiment with the use of IVR is taken as an illustrative example of increasing the productivity of learning processes. For example, the experiment is conducted over two days and is based on solving the so-called "Loci" task on the first day and the "Cupboard" task on the second day. Before performing the "Loci" task, each participant performs concentration exercises in an IVR for 15 minutes in order to best prepare for the task. When performing the task, the learner uses a laser pointer to virtually open the cupboard doors and select objects [11]. The total time to complete the tasks for each learner is 30 minutes per task. Trainees participating in the experiment use an immersive virtual reality device with a Head Mounted Display (*HMD*, "*Oculus Go Standalone Virtual Reality Headset-32GB*") and a handheld controller that allows them to interact with the system. The general layout of the system based on IVR demonstrates its technological sophistication and, at the same time, simplicity. The generated results are stored in a local database and sent to a remote server in the network for further analysis [11].

In our own experiment, we immersed schoolchildren (boys: 14 years old; $n=10$) in a conditionally "neutral" ("Control") virtual environment, as well as in a "Threatening" ("Safety NO") and "Entertaining" ("Safety YES") virtual environment. The adolescents' psychomotor reactions were assessed using the technique used in the Facial Action Coding System (FACS), which allows for a qualitative and quantitative evaluation of facial muscular activity of a person when his emotional state changes. Each facial psychomotor reaction is defined as a motor unit (MU) and a motor descriptor (MD). The FACS arsenal has a list of basic MUs and MDs, where each is assigned a different code: AC 16, AC 22, etc. Statistical analysis methods are implemented using LabChart for Research (*ADInstruments Pty Ltd, Australia*). The minimal level of statistical significance was 0.05 (p -value <0.05).

Results and discussion

In the practical part of the experiment on adolescent volunteers (male sex, age 14 years, $n = 10$) showed that virtual immersion in a conditionally “threatening” environment by watching video content after the end of classes compared to determinations in the same individuals on a weekend day without classes is characterized by the dynamics of increased movements in the area of *musculus corrugator supercilii* on the background of suppression of activity in the area of *musculus zygomaticus major and minor* (Figure 2).

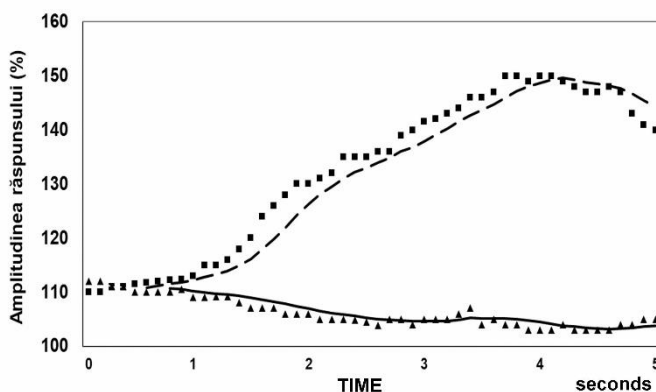


Figure 2. Dynamics of psychomotor reactions manifested in the form of contraction of facial muscles: '■' – *m. corrugator supercilii*; '▲' – *m. zygomaticus major and minor*

The diagram constructed based on the results of using the facial acting coding system (FACS) allows us to trace the opposite direction of motor activity in the areas of the *musculus corrugator supercilii* and *musculus zygomaticus major and minor* in dynamics during a 5-second recording period. During the period of recording facial movements, the activity in the area of the *musculus corrugator supercilii* increases to 150%, and then shows a tendency to decrease to 140%. While the activity in the areas of the *musculus zygomaticus major and minor* is minimized and does not show significant changes. We assume that such dynamics may reflect a characteristic change in the emotional state of the subjects examined, caused by watching video content on the background of the study loading. Obviously, polygraphic registration with the inclusion of EEG, ECG, EMG, respiration, arterial blood pressure and galvanic skin

response (GSR) can be used to increase the objectivity of measurements, but the conditions of such registration themselves have a mental impact. Increased levels of anxiety hinder the productive educational process and promote mental trauma, negative attitudes and loss of motivation towards the learning process itself. This experimental model also allows to objectify and to modernize psychological and psychophysiological laboratory tests, as well as in combination with other methods presents the possibility of early diagnosis of mental and physical fatigue. Other experiments used as illustrative examples focus on adequate assessment of the performance of everyday activities that were not memorization tasks per se, e.g., training on a simulator, vehicle driving simulator [11]. The learning content can be varied and made more complex, for example, by presenting animations of complex molecular or cellular interactions hidden in biological systems, as well as processes in ecosystems. Some IVR-based tasks involve cognitive training and memory assessment to detect memory impairments. The introduction of IVR methods potentially provides an opportunity to prevent mental and physical fatigue by facilitating learning processes, early objective assessment of memory and cognitive performance of adolescent learners, and optimizing the management of mental and physical disorders. Moreover, IVR technologies are becoming widespread in clinical settings, enabling neuropsychologists and psychotherapists to manage a variety of mental disorders and diseases. Especially, it is relevant that IVR technologies can be used to address cognitive impairments caused by brain injuries or neurodegeneration. Currently, severe cognitive disorders, dementias, are also being fought with the help of new IVR technologies being developed. For all its productivity and effectiveness, IVR is becoming a relatively affordable approach to cognitive rehabilitation. Memory training methods using VR have good results [1].

Thus, immersive virtual reality techniques open new ways to modernize educational technologies for the prevention and early diagnosis of mental and physical fatigue, preventing possible harmful effects on the developing structures and functions of the adolescent reproductive system. Science education based on modeling and immersive virtual reality provides new opportunities for the development of simulations in medicine, telemedicine, art history, humanities and, of course, in engineering education.

Conclusion

A review of modern achievements in 3D/2D computer modeling of complex fundamental mechanisms of vital activity of living systems for solving research and educational problems demonstrates their potentially high efficiency in facilitating and productivity of perception and assimilation processes, increasing motivation, innovation, creativity and satisfaction. Conceptually, such advantages of using modeling technologies and virtual reality (VR) should ensure prevention of development of mental fatigue and psycho-emotional stress in subjects during puberty during the implementation of the educational programs.

The use of the facial acting coding system (FACS) allows non-invasively and without additional mental influences to monitor characteristic shifts in the emotional state associated with sensory perception of threatening environmental impact, based on the first manifestations of psychomotor reactions in the areas of the musculus corrugator supercilii, musculus zygomaticus and other groups of facial muscles. Quantitative mathematical assessment of such reactions is successfully implemented by determining the displacement of points in the coordinate system.

References

1. Alashram A.R., Annino G., Padua E., Romagnoli C., Mercuri N.B. Cognitive rehabilitation post traumatic brain injury: a systematic review for emerging use of virtual reality technology. In: *Journal of Clinical Neuroscience*. 2019, 66, pp. 209-219. doi: 10.1016/j.jocn.2019.04.026.
2. Bustamante-Montes L.P., Flores-Meza B., Hernández-Valero M.A. Night shift work and risk of breast cancer in women. In: *Archives of Medical Research*. 2019, 50(6), pp. 393-399. doi: 10.1016/j.arcmed.2019.10.008.
3. Corriveau Lecavalier N., Ouellet É., Boller B., Belleville S. Use of immersive virtual reality to assess episodic memory: a validation study in older adults. In: *Neuropsychological Rehabilitation*. 2020, 30(3), 462-480. <https://pubmed.ncbi.nlm.nih.gov/29807474/>
4. Dick E. The Promise of immersive learning: augmented and virtual reality's potential in education. Information Technology & Innovation Foundation (ITIF). 2021. <https://itif.org/publications/2021/08/30/promise-immersive-learning-augmented-and-virtual-reality-potential/>
5. Garcia-Saenz A., Sánchez de Miguel A., Espinosa A. Evaluating the association between artificial light-at-night exposure and breast and prostate cancer risk in Spain (MCC-Spain study) Environ. In: *Health Perspect*. 2018; 126(4): 047011. doi: 10.1289/EHP1837.

6. Makransky G., Petersen G.B. Investigating the process of learning with desktop virtual reality: a structural equation modeling approach. In: *Computers & Education*. 2019, 134, pp. 15–30. DOI:[10.1111/jcal.12335](https://doi.org/10.1111/jcal.12335)?af=R
7. Makransky G., Borre-Gude S., Mayer R. Motivational and cognitive benefits of training in immersive virtual reality based on multiple assessments. In: *Journal of Computer Assisted Learning*. 2019, 35(6), pp. 691–707. doi:[10.1111/jcal.12375](https://doi.org/10.1111/jcal.12375)
8. National Toxicology Program. NTP cancer hazard assessment report on night shift work and light at night. National Toxicology Program; Durham, NC: official site. <https://pubmed.ncbi.nlm.nih.gov/34197056/>
9. Reggente N., Essoe K.Y., Baek H.Y., Rissman J. The method of loci in virtual reality: explicit binding of objects to spatial contexts enhances subsequent memory recall. In: *Journal of Cognitive Enhancement*. 2020, 4(1), 12-30. doi:[10.1007/s41465-019-00141-8](https://doi.org/10.1007/s41465-019-00141-8)
10. Salamanca-Fernandez E., Rodriguez-Barranco M., Guevara M. et al. Night-shift work and breast and prostate cancer risk: updating the evidence from epidemiological studies. In: *Sistema Sanitario de Navarra*. 2018, 41(2), pp. 211-22641. <https://pubmed.ncbi.nlm.nih.gov/30063040/>
11. Varela-Aldás J., Buele J., Amarioglio R., García-Magariño I., Palacios-Navarro G. The cupboard task: An immersive virtual reality-based system for everyday memory assessment. In: *International Journal of Human-Computer Studies*. 2022, 167, P.102885. doi.org/10.1016/j.ijhcs.2022.102885
12. Zhu Y., Brown H.N., Zhang Y. et al. Period3 structural variation: a circadian biomarker associated with breast cancer in young women. In: *Cancer Epidemiology, Biomarkers & Prevention*. 2005, 14(1), pp. 268-70. <https://pubmed.ncbi.nlm.nih.gov/15668506/>