TECHNOLOGIES OF VIRTUAL REALITY IN THE CONTEXT OF WORLD-WIDE AND RUSSIAN PSYCHOLOGY: METHODOLOGY, COMPARISON WITH TRADITIONAL METHODS, ACHIEVEMENTS AND PERSPECTIVES

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The paper introduces virtual reality systems as a new methodolology of carrying out both traditional and originally designed experimental studies in psychology and in a broader context – in neuroscience. This methodology, often differing from classical approaches toward planning and performing a study in cognitive, social, educational, organizational and numerous other disciplines within psychology, is placed in the context of genuine Russian and at the same time of world-wide psychological theories, conceptions and traditions. Advantages, currently available results, challenges and perspectives of the virtual paradigm in experimental psychology, psychotherapy and psychological rehabilitation are thoroughly described and analyzed. The ideas of immersive virtuality are also shown to play a profound role at diverse levels of innovative learning and teaching, including special, extracurricular, and college education. Besides, applied virtual reality systems are presented as being of serious importance for the university students' training: it is expected that new generations of professional psychologists will use these systems extensively. The multifaceted theoretical activities and applied work of the staff and students affiliated with the Psychology Department, Lomonosov Moscow State University, aimed at development and usage of immersive virtual reality systems are fully presented in the paper.

Keywords: experimental psychology, neuroscience, psychotherapy, psychological rehabilitation, methodology, virtual reality, immersion, modality, innovative education, motor activity, psychophysics, cognitive psychology.

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I. Virtual reality as a new technology in experimental psychology

1. Distinctive features and advantages over traditional methods

The last decades have seen a rise in usage of a new experimental "virtual reality" technology in psychological research. By now its effectiveness has been proven by medicine, neuropsychology, cognitive and social psychology data. The virtual reality technology equips experimental psychology with methods that have certain differences from traditional laboratory instruments. A heated dispute of the advantages and disadvantages of the use of virtual reality systems in psychology has been and is being held in all experimental and review works carried out within this new methodology (Yee, 2007; Ducheneaut, Yee, Nickell, & Moore, 2006; Khan, Xu, & Stigant, 2003; Morganti et al., 2003; Optale et al., 2001).

In the paper some of the obvious advantages of this technology will be enumerated.

1.1. Methods based on the use of virtual reality can be favorably compared to traditional experimental psychology methods because of high level of *ecological validity*. Classical methods of dealing with questionnaires and tests are not quite adequate for measuring a number of psychological parameters such as practical intellect or complicated dynamic scene perception. A number of works (Neisser, 1981; Rock, 1995) discusses the question of reliability of traditional methods of cognitive functions evaluation simple stimuli are presented on a screen. Some abstract problems, such as "odd one out," "find common features" etc. are admitted to be too "narrow" and artificial compared to the problems people regularly face in real life. An even more simplified variant of cognitive process analysis uses standardized pen-and-paper tests and the cognitive / functional processes evaluation is based on two criteria: reliability and validity. But there are a lot of factors that reduce the reliability and the validity of the traditional methods, for example: variability of the experimental procedure depending on the particular expert and also the possibility of several cognitive functions being simultaneously active while doing the test which leads to ambiguousness of the conclusion which of them is being evaluated. Such notions as *practical intellect* and *emotional intellect* have been introduced recently. They denote intellect not as an ability to solve problems but as an ability to understand another person. Testing of these notions requires a new stimulus environment which is similar to the natural environment. It should be a number of complicated and changing in time and space scenes that provoke natural behavior of the viewer within virtual environment (going round objects, turning and touching them).

1.2. A highly important advantage of virtual environments is introduction of the *time factor* – *"time arrow"* in the psychological experiment structure. A subjective time scale, filled with "past," "present" and "future" experiences is one of the systemic "psychological stems" of a real purposeful behavior. The transition of experimental psychology from laboratory "stimulus" (test) paradigm to studying the subject's psychic processes and states in time, in dynamics is a step forward in developing the methodological base of contemporary psychology and setting up a "methodological dialogue" with contemporary natural science. The latter implies a search for basic analogues between the behavior of living (including social) and nonliving systems and consequently unification of research and description of them. Steps in this direction open up a way for answering the following important for the cognitive methodology question: are living and nonliving systems two different types of matter with their own law types? Or does the organization of matter in these two forms follow some common universal laws? Nobel prize winner I.R. Prigogine (1917-2003), developing the theory of nonlinear dynamic systems, suggested regarding any body-system of living or nonliving nature as unstable (Prigogine & Stengers, 1984; Nicolis & Prigogine, 1989). Stable systems are individual cases of unstable systems that have functions with a long period of predictability (an example of such a globally unstable system is our Universe). If that is true, the solution of the equations describing an unstable system should be functions leading to "chaos" (unpredictable behavior) with the change of time and thus leading to non-reversible behavior of the system, i.e. a "time arrow" (from "past" into the "future"). Considering all the systems – both living and nonliving – as unstable opens way for applying methods used in physics of non-linear phenomena (methods of non-linear and chaotic dynamics, the theory of probability and multivariate statistical analysis) in psychology and brain sciences.

1.3. Virtual reality technology also differs from the classical methods in allowing *total control of the viewer's attention*. Virtual environment is bright, dynamic and interactive and thus getting distracted by other stimuli of real environment is highly unlikely.

1.4. Virtual reality environment is programmed which makes it flexible and allows to change the parameters of virtual objects and events occurring to them. There is a possibility of presenting a variety of stimuli (both fixed and moving) with controllable parameters (brightness, color, shape etc.) of the stimulation. Besides you can programme the structure of the presentation of the stimulation and adaptation of this structure according to the viewer's reaction. We should also mention that the notion of flexibility includes the possibility of not only creating environment "close to the real world" but also unreal ("Moon") worlds with unusual characteristics of virtual objects. Such worlds give a possibility of putting participants in the conditions that in the real world could be unobtainable, dangerous or stressful.

1.5. One more characteristic of virtual reality is a possibility of selection of needed stimulation. There are a lot of tasks in experimental psychology where the experimenter needs to draw the participant's attention to key stimuli. When you write the script for a programmed virtual reality you can include special visual means of "stressing" the key stimuli by increasing the frequency of their appearance, increasing brightness or marking them with the colour which will draw the viewer's attention. It is possible to use not only sensor characteristics of stimulation, but also include stimuli that will cause strong associative reactions: close people's portraits, the furniture of the room where the participant spent his childhood etc.

1.6. An important advantage of virtual reality is *the opportunity of having a real time feedback*. Fast computer systems can calculate and give a resulting visual representation in mere several milliseconds which allows to programme a faster interaction between the virtual reality environment and the viewer. For that cause there is a special computer monitor, which allows actions with virtual objects the result of which can be perceived in real-time mode.

1.7. Unlike the classical methods of experimental psychology VR gives *a possibility of creating polymodal stimulation*. The feeling of physical reality is constructed on a set of basic senses – sight, touch, hearing and smell. The most important for researchers are visual, hearing and haptic (tactile) modules of perception. There are studies of olfactor perception (or "teleolfaction") the main point of which is "smelling a mixture of odorants whose composition is related to a mixture present in a remote place" (Riva, 2006, p. 5). Some simpler levels of sensory support in a virtual environment are also of great interest, for example the study of the role of the kinesthetic senses while moving in the situation of delayed visual reinforcement. Among considerably new areas of application we can name the development of advanced systems of "eye control" which is useful as an additional interface control system during manual manipulation with objects under conditions of noise pollution. Similar systems are useful with organization of computer videoconferences (Velichkovsky, 2007; Velichkovsky & Hansen, 1998). It is an example of so-called "attentive to attention" technologies of registration and remote transportation of communication partners' gaze direction – technologies which are being developed for "coordination of the attention resources" (Velichkovsky, 2003; 2007).

Nonverbal communication, including "eye contact" and synchronisation of the speakers' micro movements, signals of "holding the floor" while speaking, as well as proxemics and specifics of intrusion into and protection of one's "personal space" is an essential part of psychology of communication. Thus virtual reality systems make it possible to imitate visual, tactile and acoustic images simultaneously, which is unlikely to accomplish within the traditional paradigm of experimental psychology and which reinforces the "truthfulness" of virtual reality environment. Such an advantage is helpful with cognitive abilities rehabilitation. Classical approaches in cognitive rehabilitation are divided into two main groups: "remedial" which pay attention to systematic reconstruction of cognitive processes, and "functional," which place special emphasis on recovery of patient's everyday functions (Rizzo, Buckwalter, & Van der Zaag, 2002). Critics of remedial approaches warn against excessive trust to test materials and stress the inability of this approach to make the patients adapt to the real world. Functional approaches are being criticised because the use of certain rehabilitative procedures leads to the patient living in a static world, where live conditions don't change. But the possibility to create multimodal stimulation in a VR environment, to fully immerse the participant into virtual reality allows to model complex behavior in a much more effective way (Ignatiev, Nikitin, & Voiskounsky, 2009; Voiskounsky & Smyslova, 2006).

2. Virtual reality as source of new challenges facing experimental psychology

2.1. Application of VR technologies not only allows to solve "old problems" but also discovers new ones, which require special theoretical and methodological analysis. To begin with, we should mention the need for development of new conceptual framework which follows the introduction of VR into experiment. First of all it concerns such key notions as "virtual worlds" and "virtual conscience." The problem is that these terms are already being used in psychology in a different context, namely in connection with the study of altered states of consciousness (Rossokhin, 1998). For example it can be applied to works in postmodernist cultural studies (Rudnev, 2000; 2001). They support the idea according to which "any reality is virtual" if you understand the latter as psychotic or schizophrenic paranoid delirium, narcotic or alcohol intoxication, altered perception under hypnosis or narcosis. The feeling of virtual reality can be experienced by hypersonic speed pilots, prisoners ("movie prisoners"), submariners, people under stress (for example during a plane or a car crush); people suffering from claustrophobia – all people who are limited in their movements for a long period of time. A syntonic sanguinic has one reality, an aggressive epileptoid a different one, a defensive psychastenic a third one, a schizoid-autist a fourth one (http://rudnev-vadim.viv.ru/cont/slowar/23.html, http://rudnev-vadim.viv.ru/cont/slowar/24.html). On the other hand there is another well-spread point of view according to which "... the usage of term 'virtual reality' is too tightly connected to the world of computer technology..." (Spirionov, 1998, p. 185). The recently published book by Antonova and Soloviev (2008) states an idea according to which neither computers nor the Internet with all the net technologies have brought anything new into the philosophical problematics of virtuality. The continuum of virtual realities and transitions between virtuality and reality have been thoroughly described by N.A. Nosov (1997; 2000). N.B. Mankovskaya and V.V. Bychkov (2007) call this problematics "natural virtuality" and separate it from "art as virtual reality" and also from "para-virtual reality" (psychodelic art) and "proto-virtual reality" created with the help of computer programmes and used in film making for creating special effects (Ignatiev et al., 2009; Voiskounsky, 2001).

2.2. Along with the problem of VR definition there is also a classification problem of the methods (forms) of immersing the subject into the virtual world. V.B. Dorokhov (2006), speaking about the physiological aspects of this problem, notes: "The meaning of immersion is that the subject plunges into the world of virtual reality and recognizes himself and the objects he sees as part of this world. There are three types of immersion: direct, mediated and mirror, when the person respectively feels as part of the virtual world, see themselves or part of themselves in the virtual world or see the virtual world and themselves as if in a mirror." This opinion should be taken as valid even if the practice of a VR application shows that there are more types of "immersion" than the ones listed here.

2.3. One more problem that arises in connection with using VR is the problem of effective presentation of objects in virtual reality, i.e. determination of the minimal set of features enough for recognizing the object and "accepting" it as a real one (Reddy, Watson, Walker, & Hodges, 1997). The solution of this problem is closely connected to the solution of another important problem – the task of developing technologies for psychophysical measurement of "virtual features" in order to organize purposeful influence of VR on the subject and the objective evaluation of the effect of such influence (Meehan, Insko, Whitton, & Brooks, 2002; Whitton, 2003).

2.4. Organizational psychology is seriously working on development and implementation of the new generation of VR systems, designed for holding videoconferences and distant work meetings. In such sessions the speaker sees several virtual interlocutors each of whom in their turn sees and hears the virtual speaker. Thus there arises a problem of management of interactions and effective exchange of opinions under conditions of "virtual contact," i.e. without real "eye to eye" contact. To solve this problem it's important to develop new psychological methods of discussion organization. For example contemporary research pays more and more attention to nonverbal signals such as mimics which shows who of the participants are ready to "take floor" and speak or gaze fixation which invites the participants to pay special attention to the particular blueprint details, those the speaker is actually referring to (Bente, Eschenburg, & Kraemer, 2007; Panteli & Dawson, 2001; Velichkovsky, 1995). New opportunities for organizational psychology bring "virtual avatars" which are already used to mediate commercial advertising, i.e. in demonstration of new products, fitting of consumer goods, arranging furniture in a given space. How well do these avatars serve their purpose, do they advertise the products convincingly, does the potential buyer trust them? These are just some of the questions psychologists are going to answer.

II. Virtual reality as an effective method of psychotherapeutic treatment for physiological and mental disorders

The socially important and most developed at the present time field of VR systems applications in psychology and medicine is the psychotherapeutic help and psychological rehabilitation for people with fears, phobias, post-traumatic stress disorders, chronic pain syndrome, narcotic addiction, etc. (Ignatiev et al., 2009; Voiskounsky & Menshikova, 2008; Hoffman, 2004; Brooks, Attree, & Rose, 1997; Bullinger et al., 2005; Attree, Rose, & Brooks, 1998; Bordnick, Traylor, & Graap, 2005; Calhoun, Carvalho, & Astur, 2005; Voiskounsky & Smyslova, 2006; Selisskaya, Voiskounsky, Ignatiev, & Nikitin, 2004; Forman & Wilson, 1997). A number of American clinics have for several years been using virtual technologies as a nonpharmacological painkiller. Effectiveness of such psychotherapeutic "virtual medicine" which surpasses the effectiveness of classical opioid painkillers (it is two or more times more effective) was demonstrated on patients with severe burns (Hoffman, 2004). The same research revealed an important for VR technologies fact: immersion into two-dimensional virtual world (of a video game) is less effective for overcoming serious pain, compared to immersion into three-dimensional virtual environment. The three-dimensional environment was created using a special analgetic therapeutic computer programme *Snow World*, which was developed by Microsoft and National Institute of Health (USA) staff to treat ambustial patients. The programme reduced the feeling of pain, absorbing their attention with the illusion of a flight over a snow-driven canyon with penguins, snowmen etc. In the control series of experiments healthy volunteers were exposed to pain (heat) and then "immersed" into the interactive version of *Snow World* with a VR helmet, headphones, fiber optic computer connection and a sensor that controlled the position of the head. fMRI checking showed that the decrease of pain level attained with the use of *Snow World* was accompanied by a decrease of brain activity in the segments of the brain that are connected with pain perception: insula, thalamus, primary and secondary somatic sensory zones, cingulate cortex. The experiment revealed positive correlations between the power of illusion, i.e. the patient's conviction in being in a virtual world and the lessening of pain. In a number of studies it was established that VR relieves the patients' suffering caused by any kind of nosology – during painful urological procedures, during after-surgery physiotherapy for muscles and tendines, during stomatological treatment.

One more therapeutic area where VR is used is phobia treatment by way of demonstrating virtual representations of the objects causing the phobia to the patients. This technique was first used in the 1990s by American scientists to people, who were afraid of height, flying, driving a car after an accident, and public speaking, as well as to help Vietnam war veterans with chronic post-traumatic stress disorder. As other forms of expositional therapy, treating fears with VR follows the line of operant conditioning: the person is gradually accustomed to the objects and situations that cause his or her fear. As the patient gets used to it, the fear disappears and the patient goes back to normal life. This idea is the basis of special training programmes created by Virtually Better company for psychologists and psychiatrists engaged in public speaking fear treatment (Hoffman, 2004; Cornwell, Johnson, Berardi, & Grillon, 2006). Immersion into a VR world is helpful in overcoming the fear of insects – for example spiders. A special VR programme *Spider World* allows the patient to approach a virtual spider, touch it with a "cyberhand" and feel these touches. The display installed in the head-mounted helmet shows the image of the illusory spider. To provide tactile feedback the programme follows the position of a toy spider (in the therapist's hand) thanks to which the patient can "touch" the virtual tarantula (Hoffman, 2004). During a study (23 patients with a diagnosis "clinical phobia") in 83% of the cases there was registered a considerable weakening of the fear of spiders after 10-15 VR sessions.

VR programmes can also be used for treating such serious cases as post traumatic stress disorder (PTSD). The symptoms of this illness include haunting memories of the traumatic event (rape, death of a close person etc.); powerful emotional reactions to any objects or situations that remind of the trauma; unsociability, emotional deafness and chronical irritability. The wearisome PTSD condition in a highly dramatic way influences the person's life and work and, unlike phobias is rarely curable by traditional psychiatric and psychotherapeutic methods. VR programmes allow the patients to realize and weaken the emotions connected with the memory of the traumatic event. Gradually the patients get used to the realistic images and sounds characteristic of the traumatic situation which as a result helps them combat the memories torturing them.

Since 1980-90s VR technologies are used in neuropsychology for movement and cognitive functions recovery of patients with brain damage. An important advantage of VR usage in rehabilitation practice is the active interaction of the patients with the virtual environment, which increases their motivation to getting better (Brooks et al., 1997; Attree et al., 1998; Rose, Attree, Brooks, & Andrews, 2000; Schultheis, Himelstein, & Rizzo, 2002).

Thus the available positive experience of clinical usage of VR opens way for wide usage of this method in other areas of psychotherapy and medicine, which is promising for development of this section of the market. The American company Virtually Better and Spanish firm PREVI specialize in development of VR programmes for treating anxiety disorders: a fear of height, flying and public speaking. The companies supply psychologists and psychiatrists with the programmes for $400 a month and let them use them for treating their private patients (Hoffman, 2004).

III. Application of virtual reality in engineering and labor psychology, sport psychology and security psychology

Introduction of VR technologies in the applied psychology sets new tasks to engineering (human factors) and labor psychology dealing with analysis and development of ergonomic standards for various specialized VR systems: operator training simulators, virtual environments for the disabled. Galimberti et al. (2006) mention that the studies in usability and in development of normative techniques of quality and safety evaluation of VR system usage constitute a separate line of research in contemporary labor psychology. An important field of applied work in contemporary ergonomics and engineering psychology is development of simulators based on virtual environment for training numerous specialists (operators) working with complex technical systems (atomic plants, aircrafts, missile launchers) in standard and non-standard situations (Zakharevich, Surzhenko, Saprunov, & Shapoval, 2001). As a rule such simulators are equipped with sensors and special programmes for monitoring the operator's functional status (electroencephalogram, electrocardiogram, electromyography, posturography, rheography, oximetry).

The research and development work in application of VR systems to organize the three-dimensional environment and examine the effectiveness of the user's productive (for example engineering) activity is not less important. Designing prototypes of new objects and exploring ways of their future exploitation is of much interest to industrial companies that design vehicles, aircrafts and architectural modules. In fact it is for the needs of companies engaged in industrial and architectural design that the most modern 3D models are created, and the most powerful programming languages are used. For example, a viewer can visualize a virtual model of a plane, a car, or a building in a 3D environment. And in a few minutes he can dismantle it, change its design, add new components, i.e. do what would take a lot of time and money if perform in reality. Besides in virtual reality one can test any parameters of the just made model.

The new area of application of educational VR systems is managing of sport trainings, for example associated with modeling and performing tactic confrontations. The University of Michigan has developed a CAVE-system (http://www-rl.umich.edu/project/football/index.html) to help training soccer players. It allows players to monitor variants of placing the players of their own and the other teams on the arena, learn to identify particular players and their signals and also the off-arena coach's signals. The other area of VR systems application in sport is directly connected to advertising and exhibiting: as an example you can take different popular shows starring the most popular chess-players who compete against computer programmes looking at the playing area through VR glasses (without a real chessboard and figures).

Special attention should be paid to the so far not numerous but very promising studies devoted to combining VR technologies with *biological feedback technologies* (Pugnetti, Meehan, & Mendozzi, 2001) *and concealed information detection using evoked brain potentials* (Mertens & Allen, 2008).

IV. Psychophysiology at the frame of virtual reality

1. The methods of psychophysiology facing the problems of virtual reality

Psychophysiology occupies a special place in diverse VR systems (Pugnetti et al., 2001; Parsons, Iyer, Cosand, Courtney, & Rizzo, 2009). According to some preliminary studies, within virtual systems it is possible to register the most widespread psychophysiological parameters, such as electrocardiogram, galvanic skin response, electromyogram, electroencephalogram, plethysmogram (Kim, Kim, Ko, & Kim, 2001; Pugnetti et al., 2001; Wiederhold, Jang, Kim, & Wiederhold, 2002; Walshe, Lewis, Kim, O'Sullivan, & Wiederhold, 2003; Cote & Bouchard, 2005; Wiederhold & Rizzo, 2005; Wilhelm et al., 2005; Astur et al., 2005; Mühlberger, Bülthoff, Wiedemann, & Pauli, 2007; Baumgartner et al., 2008). The tasks of psychophysiological maintenance of VR programmes include: 1) objectification of the level of the person's immersion into the virtual world and his or her adaptation to the new reality and 2) objective evaluation of the effectiveness of the patient's attention concentrated on certain "targets" for virtual impact (fears, pains, learning processes).

According to available data, registration of electroencephalogram and event-related potentials allows to distinguish between automatic and consciously controlled actions of the patient in the VR environment. Parameters of autonomic (vegetative) nervous system (first of all, skin galvanic response) can be used as easily registered objective indicators of "presence effect" and the character of impact of the VR on the patient (Kim et al., 2001; Cote & Bouchard, 2005).

By the present moment there is no information that psychophysiological equipment (sensors, cables) disturbs registration of physiological reactions, discomforts the participants or decreases the "presence effect," even when the functional Magnetic Resonance Tomography is used, with the patient's head fixed (Kim et al., 2001; Cote & Bouchard, 2005).

2. The methods of virtual reality facing the problems of psychophysiology and neuroscience

2.1. *Problems of the soul and the body, the brain and the body, the mind and the body* are traditional for the human science on the whole and psychophysiology in particular. From time to time they become top-priority and then again go into the background. Once again this problem became highly important in the last couple of years in connection with the experiments in out-of-body experiences using the VR technologies. Such experiments carried out mostly in Sweden are connected with testing the importance of visual and proprioceptive information in perception of one's own body (Ehrsson, 2007; Ehrsson et al., 2008; Costantini & Haggard, 2007; Ehrsson, 2009; Petkova & Ehrsson, 2008; 2009). Experimenters placed two video cameras corresponding to the left and the right eyes of a human-like mannequin and the images registered by these cameras were sent separately to the left and the right eyes of the person wearing the VR helmet. As a result, instead of viewing his own body the viewer got a visual image of the mannequin's body with eyes directed slightly downwards. When his own stomach (the person couldn't see it) and the mannequin's stomach (the person could see it) were touched synchronously, the participant started to perceive the body of the mannequin as his own. It is revealed in post-experiment talks and questionnaires and especially in a series of studies when the experimenter touched the mannequin's stomach with a knife (the test person saw it): in this case there is a characteristic rise of galvanic-skin reaction as compared to control measurements. If the rhythms of touching the stomach of the mannequin and that of the participant don't coincide, the effect of perceiving the mannequin's body as one's own is much less pronounced. This effect also doesn't take place if the video cameras show instead of the mannequin's body a square object (a big box) which doesn't resemble a human body. In a different series of experiments the participant stood in a VR helmet in front of the experimenter and got the visual signals were transmitted from the video cameras fixed on the experimenter's head. In this case the participant saw his own body (from knees to shoulders) and recognized it. When both the experimenter and the participant stretched forward their right hands and touched each other (as in a handshake) the participant felt as though he was standing in front of himself and shook his own hand. When a knife was traced against the participant's and the experimenter's hands (in a threatening but painless manner), in the second case the rise of galvanic-skin reaction was much higher, i.e. the participant was much more afraid for the hand of his phantom "new" body than his own real hand. The studies on the virtual out-of-body phenomenon raise the question of the role of polimodal stimulation in the forming of the person's idea of his own "physical Ego" and in a broader sense of the mechanisms of "self reflection" and "self comprehension."

2.2. The usage of VR technologies in brain studies is highly important for fundamental psychology and neurosciences (Chernigovskaya, 1998). Combining VR methods with contemporary methods of noninvasive brain activity visualisation (PET and fMRI) especially perspective. There is a number of works that testify the possibility of combining VR sessions with noninvasive brain activity registration via fMRI in real-time mode (Hoffman, 2004; Wiederhold & Rizzo, 2005; Baumgartner et al., 2008). Baumgartner et al. (2008) administered fMRI in experiments with children (aged 6-11) and adults (aged 21-43) and discovered brain correlates of the subjective feeling of "immersion into the virtual environment" ("presence," or "being there"). Using two types of virtual environments that provoke High and Low Presence experience of VR immersion the authors found that the key factor denoting both children's and adults' ability to experience effects of "presence" is the activity of two homological dorsal lateral sections of prefrontal cortex in right and left hemispheres (rDLPFC and lDLPFC correspondingly). RDLPFC influences the experience of "presence" by controlling visual information flowing into the posterior portions of parietal cortex that are responsible for perceiving the position of one's own body (and its parts) in the environment. On the other side lDLPFC influences the quality and intensiveness of "presence" experience through its connection to medial prefrontal cortex that takes part in regulation of self-reflexion processes and "flows of consciousness directed inwards" (Baumgartner et al., 2008). By fMRI-analysis of brain activity they discovered negative correlation of rDLPFC and lDLPFC activity with the intensity of VR immersion perceptions which participants evaluated on five-score Likert scale. It turned out that the higher was the lDLFPC and rDLPFC activity the weaker was the intensiveness of "presence" experience (Baumgartner et al., 2008). It's interesting that children aged 6-11 on the whole have a more pronounced ability to quick and deep immersion into virtual reality than adults. According to the data received by Baumgartner et al. (2008), it can be logically explained by the long period of structure development in prefrontal cortex during postnatal development.

The development of fMRI techniques on the one hand and computer technologies on the other would afford the opportunity to evolve such a new field as the computational neuroanatomy. It opens a new outlook in n*eurosurgery* training programs, comparative diagnostics, planning of neurosurgeon operations. One of the most actual problems of computational neuroanatomy is the development of the neurosurgical simulators which can be efficiently used for virtual operations on the patient's brain. Using the new technology neurosurgeons can carry out virtual operations at the stage of real operation planning. The preliminary training is necessary to facilitate the operation complexity. The model of the neurosurgical simulator includes 3D brain mapping, the prediction of patient's reactions in the operation course as well as marking of problem brain areas. The neurosurgical simulators may be used by medical students for primary skill training and also by trained n*eurosurgeons for strategy planning and practicing of the operation details. It* allows skill training even in non-standard, critical situations without risks to life and health of real patients. So, brain surgery becomes more safety for the patients. One of the important problems for the development of a neurosurgical simulator is the uniqueness of the brain topology of the real patient. In order to account for any type of the uniqueness it is necessary to develop a new method for atlas personalization (Pitskhelauri, Galatenko, Bayakovsky, & Samborsky, 2008). This method is based on the "deformation" of the atlas constructed on average statistical characteristics in line with scanning data of the real brain (Christensen, Miller, Vannier, & Grenander, 1996). The brain atlas of the particular patient is constructed in the issue of the new method application. The development of this technique allows creating 3D-visualization of brain structures using several plane sections (Zhu & Belkasim, 2005) or easy measured "invariants" (for example, skull sizes).

V. Virtual reality as an effective tool for innovative education

Rapid development of virtual reality (VR) technologies has had its impact on almost all spheres of human activity. But their non-commercial use – in education for example – is quite limited. At present VR technologies are used not so much in education on the whole but mostly for training specific skills such as learning to drive a vehicle or an aircraft, to operate a special surgery robot, shooting aims etc. Actually the first in history virtual environments created by the American expert in information technologies, musician and businessman Jaron Lanier were real-time simulators for surgeries and telesurgery, visual programming (Brockman, 1996; Chastikov, 2002). Virtual environment is modeled for specific tasks and allows to train the required skills with minimal risk. But it is important to differentiate between the tasks of a training and the tasks of education which include the process of forming and learning a certain amount of information.

It is obvious that usage of VR technologies in high-school, college and after-college levels of education is limited by exclusiveness and high costs of equipment. Nonetheless VR technologies have a number of obvious advantages compared to the traditional means of education and thus the perspectives of their usage are quite reasonable. In spite of the fact that there are very few studies in the field and most of them have the status of a pilot work, the key points and concepts have already been marked. So we are able to name the following advantages of using VR in education: motivation, control, interaction, practicability, interactivity, orientation in space, multisensory activity etc. (Roussou, 1999; Kaufmann, Csisinko, & Totter, 2006).

Experiments have shown that:

1) VR technologies as compared to traditional forms of education have a great motivational impact (Bricken, 1991). This impact is explained by the effects of immersion and presence in what occurs in real time (Winn, 1993; Slater & Wilbur, 1997).

2) VR allows to explore the reality which under otherwise – because of time, space or scale etc. limitations, as well as safety reasons – can not be explored. It especially concerns children with limited abilities (Cromby, Standen, & Brown, 1995).

3) Using VR technologies at the early stages of education can both increase the volume and the quality of studying the material required and also prepare grounds for further development (Dede, 1998).

4) Children perceive distract graphic abstractions (for example cartoons) much easier than adults and often have a better experience in 3D virtual game environment and in using the capacities provided by the interfaces (Provenzo, 1991).

As a rule the VR technologies used in educational projects can be divided into three classes according to the intensiveness of the immersion effect. The first class represents programmes that are perceived on a PC screen using special glasses. The immersion effect is minimal, it can only be used for individual classes but the cost of this equipment is quite attractive for low-budget projects and institutions. The maximal degree of immersion is achieved in the programmes of the third class. Here we can name projection glasses (needed as a platform to form the image) with additional gadgets, such as a sensor glove for getting tactile feedback or a joystick for controlling one's own movement. This system variant can also be used only individually. Virtual CAVE® room (with projections on three walls and the floor) is designed to accommodate a group of students. Each visitor puts on special semitransparent stereo glasses that combine VR image with real sight and uses special remote control that allows to control one's movement in this virtual reality. An example of a transitional second class system is a simpler and more compact ImmersaDeskE™ system, that looks like a big slanting (as an easel) screen onto which the image is backside projected. It also involves using special glasses and a remote control.

At present we can mark the following main areas of using VR technologies in education:

- Out-of-school (extracurricular) education;
- Special education;
- College education.

Out-of-school (nonformal, extracurricular) education (museums, exhibitions etc.). Of special interest for the museums is the ability of VR technologies to transfer people in time and space without leaving the building. For example, it can be done by detailed reconstruction of the environment, events and particulars of a given epoch (Roussou & Efraimoglou, 1999). One of the last examples are interactive immersive (creating immersion effect by using not only the video sequence but also smells, stereo sound and special sensor tactile gloves) VR technologies for children and teenagers, for example historical projects Foundation of the Hellenic World (FHW) (cultural and historical reconstruction of the central part of ancient Athens with the area of 35000 m^2), Magical World of Byzantine Costume, cultural reconstruction of the ancient town Miletos (Roussou, 1999).

Special education. In the recent years there started to be developed programmes based on VR technologies, designed for the disabled. It has been shown that using VR technologies can be an effective addition in the process of rehabilitation and teaching people with a variety of disorders. For example an experience of solving a number of specific problems on orientation and exploration in a virtual 3D audioroom by blind and starblind patients helps them in forming a system of spatial images (Sánchez & Lumbreras, 2000; Sánchez, Barreiro, & Majojo, 2000). A virtual space organized in the form of a labyrinth (Stanton, Wilson, Foreman, & Duffy, 2000), allows children with locomotor disorders compensate the lack of active locomotion which is helpful in forming cognitive maps and developing capabilities in spatial orientation. Expansion of the playing area and introduction of additional elements (such as zebra crossing, a busy street with pedestrians etc.) gives such children a chance to learn adequate behavior and acquire skills in a safer way. In some cases of movement disorders (for example hypotonia – weakening of muscular tone) it is useful to use semitransparent VR glasses that don't replace but augment the existing reality with virtual objects. In this way virtual musical instruments not only allowed to teach children music but also reinforced control over one's movements for people with such diseases (Chau, Eaton, Lamont, Schwellnus, & Tam, 2005).

Using virtual environments is promising in the education of children with autism, attention deficit hyperactivity disorder, social disorders, phobias. Using avatars as teachers or co-students decreases anxiety; the possibility of modeling the environment with different levels of intensity and detailization helps better concentrate on the subject being taught; using multimodal presentations enhances the ability to understand and remember; involving the child in controlling the processes of learning and solving problems forms his or her own cognitive activities and self-regulation skills; feedback will keep the child interested in the process which will positively influence the result (Sik Lányi, Geiszt, Károlyi, Tilingerand, & Magyar, 2006).

College education. There are three functional possibilities of VR technologies that are important in college education. Firstly, the object of study can be presented in space and time scales compatible to a human, which is impossible in other forms of material presentation. This way the student can "replace" atoms and electrons and "travel" from one galaxy to another in the process of education. Secondly, virtual reality gives an opportunity of making the information that is not usually sensed available to senses. For example, the volume of sound can correspond to the level of radiation in the environment and the saturation of the color represent the temperature of special areas. Combination of the first and second possibilities makes it possible to create and visualize objects and events that don't have any material form in nature.

All of this combined presents great material of study, since college students often have to operate with abstract notions that have no object representation (Fällman, Backman, & Holmlund, 1999). In the classical educational process students get already generalized knowledge from textbooks, lectures, manuals and handbooks. But some authors (Dede, Salzman, Loftin, & Ash, 1997) don't think that such education always leads to the best result. Students have to form mental representations of abstract notions, which often include non-evident and elusive conjunctions and concepts. As a result the person not always has an exact and clear understanding of the subject being learned. On the other hand in everyday experience a person often forms false understanding of laws functioning in the outer world. It's difficult to overcome these false understanding with the help of traditional means of education, and in result full understanding and using correct science models meets problems. Virtual reality technologies allow to realize constructivist approach in education. Immersing into the virtual environment, visualizing both physical objects and effective forces, operating them, actively changing and studying allows to overcome these difficulties.

High-school education. We should mention some developments, created in the Virtual Reality laboratory in Vienna Technological Institute, Austria. The specialists of this laboratory created programme modules for the school course in solid geometry (Kaufmann, Steinbügl, Dünser, & Glück, 2005; Kaufmann & Dünser, 2007) that is helpful in developing spatial thinking skills. They used *D*STAR* and *Iotraker* systems that realize virtual objects presentation in real environment. A person sees in the glasses of "augmented" virtual reality an object hanging in the air, one can walk around it and change according to a special programme. At the same time through the semitransparent glasses the person can see the real objects surrounding him or her. For learning intersection of 3D objects with planes (course of solid geometry, 11th grade) as a virtual object the students were presented a 3D object which could be intersected with virtual planes.

It's obvious that using VR technologies in the system of education is a perspective direction of development. But their use is connected not only with financial and organizing difficulties. It's important to take into consideration the fact that besides technical specialties of space organization the programmes should follow certain ethical and conceptual educational standards and be fit for abilities and needs of different groups of students (Roussou, 1999). Firstly, VR technologies should be built into the context. They should take into consideration the features of the context, teacher's possibilities, and heterogeneity of the group of students (by age, level of training, interests and individual learning strategies). The programme should allow simultaneous work of several people and the interaction capabilities built into the programme should serve as hints for the students' interaction. Secondly, the technology shouldn't be the "object of attention" by itself. It's just a shell for learning certain aspects of a certain subject – History, Biology, Geography or Physics. Thirdly, the programme should give immediate feedback and serve as an "invitation" to further study. D. Norman stated four principles of clear nonfrustrating information environment: demonstrativeness, qualitative conceptual model, good topography and availability of feedback (Norman, 1988). If children don't get immediate feedback they usually lose interest. At the same time quick and detailed reactions to all requests can be bulky in terms of software and real time realization. A possible solution to this problem can be combining the principle of quick (but not very detailed) feedback with an "invitation" to a more detailed study of the subject in future for those students who are interested. Fourthly, VR educational programmes should be created not only by professional programmers and designers, but also subject specialists, otherwise the content of the programme will fall behind its technical realization. Finally, VR technologies in education should first of all be convenient for the users from all points of view: starting with the size of the helmet (it's usually too big for children), convenient placement of children for a better view for everybody and convenient and simple interface without any side effects (such as kinesia from virtual movement).

We should innumerate the immediate problems that can be solved with the help of innovative education using virtual reality technology, including innovative education at the Department for Psychology, Lomonosov MSU:

- Holding video conferences, distant work meetings and teleconference bridges. This possibility provided by virtual reality technology becomes especially important with new branches of MSU opening in different countries (Ukraine, Sevastopol; Uzbekistan, Tashkent; Azerbaijan, Baku).

- Creation of a classical lectures bank for distant education of bachelors, masters, post graduate students and teachers.
- Recreation of classical experiments in virtual reality – those belonging to the "golden fund" of Russian and foreign psychology. An example of recreation of such experiments can be the work on reconstruction of Stanly Milgram's social psychology experiment.

VI. Virtual reality as an effective tool for research into interaction between cognitive processes and motor actions ('active perception')

The advantages of VR technology stated above (Section I) let us consider it as an important tool for getting new knowledge about human beings. Development and implementation of VR methods in psychological experiment leads to introduction of such an important "ecological variance" (factor) as "the subject's intristic motor activity" into the laboratory experiment. And this can lead to conceptual reconsideration of the existing understandings of human's cognitive processes, which are closely related to movement in real life (Gregory, 1970; Gibson, 1988; Poincaré, 1990). Below we shall turn to a discussion of possibility of using VR technologies for studying coordination between cognitive processes and motor activity in processes of visual perception as part of the approach called "active perception." This direction of psychological research seems to us to be methodologically important for experimental verification and development of such internationally acknowledged Russian psychological theories as "activity theory" by A.N. Leontiev (Leontiev, 1975), "vector psychophysiology theory" by E.N. Sokolov (Sokolov, 2003), "functional systems theory" by P.K. Anokhin (Anokhin, 1968; Aleksandrov, 1998). Each of these theories offers its own approach to explaining the high level of coordination between sensor and cognitive processes on the one side and actuating mechanisms of behavior on the other.

1. Investigations of interaction between visual perception and motor activity based on traditional methods of psychophysics and neuropsychology

Studies carried out as part of the "active perception" approach are aimed at revealing the interaction between visual information and motor activity of the viewer in the process of solving complex cognitive problems. Solving such problems is especially actual with the arrival of new areas of practical psychology in the recent time – such as security, sport and transport psychology. Appearance of new areas of knowledge lead to development of new theoretical and methodological solutions for researching cognitive processes in conditions closest to the natural. It's worth noting that ideas of close interaction of cognitive (perception, attention, thinking) and motor functions were actively developed in the works of such Russian psychologists as I.M. Sechenov, P.K. Anokhin, N.A. Bernstein, A.V. Zaporozhets, A.N. Leontiev. These works stressed the important role of the subject's motor activity in the process of forming an adequate visual image. One of the most important basic principles of perception was formulated – the principle of assimilation of motor components of perception process to the qualities of the extrinsic stimulus (Leontiev, 2000).

The problems stated and discussed within the activity approach are still actual. Interest to "active" perception arose again because of the huge number of experimental studies in neurophysiology, neuropsychology and psychophysics arising in the last 40 years that brought up some new ideas. One of them is the assumption of existence of two ways of processing information in a human visual system that are different in their functions. These ways were called ventral (focal) and dorsal (ambient) (Schneider, 1969; Ungerleider & Mishkin, 1982; Smith, 2000; Nicholls, Martin, Wallace, & Fuchs, 2001; Norman, 2002). On the ground of different functions of ventral and dorsal pathways Milner and Goodale (1995) introduced a model, in which they suggested dividing the visual system into two subsystems: the main function of the ventral subsystem is identification and recognition of objects, while the dorsal one is responsible for visual control of the viewer's movements in the process of interaction with the objects. It's worth mentioning the most interesting studies and methodological approaches which confirmed the existence of two parallel systems of information procession in human visual system. Neuropsychological studies of patients with injuries in parietal and mesotemporal regions of the brain (Milner & Goodale, 1995; James, Humphrey, Gati, Menon, & Goodale, 2002) have shown that the stated types of injury lead to different visual perception disturbances. Problems with mesotemporal region lead to visual ataxias when people have problems executing exact movements in response to a visual stimulation. Problems with parietal region lead to agnosia when people have problems recognizing objects or their parts but can quite accurately perform tasks connected with manipulating these "unidentified" objects, such as taking, replacing or pointing at them. The main methodological technique in psychophysics experiments demonstrating the difference between ventral and dorsal systems was comparing the verbal judgment and motor reaction of the participants to one and the same visual stimulus. Most of the experiments used different visual illusions. The main idea of the experiments was to illustrate the difference in perceiving different qualities of objects in a verbal and a motor reaction of the viewer. It was assumed that a verbal answer suggests the use of a ventral subsystem and a motor one – the use of a dorsal subsystem.

Let's illustrate this phenomenon with several experimental researches. Bridgeman and his colleagues (Bridgeman, Kirch, & Sperling, 1981) used an illusion of induced movement. A fixed test stimulus was shown on the screen surrounded by a moving frame. The point of the effect is that the viewer perceived illusory movement of the test stimulus in the direction opposite to the direction of the frame's movement. It was shown that the verbal evaluation of the movement direction was influenced by the illusory effect while the movement of the eyes or the finger pointing at the stimulus corresponded the reality – demonstrated the immobility of the test stimulus. Further studies (Bridgeman, Peery, & Anand, 1997) showed the difference between verbal and motor reactions in perception of the stimulus's location. In the experiment the participant had to evaluate verbally or by pointing with a finger the degree of shift of the stimulus at different shifts of the frame. One of the parameters was the time delay (0 s, 4 s, 8 s) between the presentation of the stimulus and the moment when the person was asked to evaluate its position (verbally or by pointing a finger). It was assumed that a longer delay will lead to evaluation using memory, which means larger use of ventral subsystem in the process of perception. The experiment showed that: firstly, the verbal evaluation is prone to illusory effect and the motor reaction is indifferent to it; secondly, increased delay time for both verbal and motor reactions become prone to illusory effect. These results have shown that the information processing time in dorsal system is limited. Similar results were received while studying perception of size (Servos, Carnahan, & Fedwick, 2000). The results showed that in verbal evaluation the vertical line was overestimated in size while motor reaction namely, the space between fingers – accurately corresponded to the size of the line no matter whether the person saw his or her hand or not.

These studies carried out using psychophysical and neuropsychological methods have shown that cognitive and motor activities are formed according to different rules and are realized through different physiologic structures of the brain. It's worth mentioning that division of information processing into two subsystems is quite conventional since a number of experiments have shown that some functions typical of the ventral system can be performed by the dorsal system and vice versa (Binsted, Chua, Helsen, & Elliott, 2001). It is probable that ventral and dorsal systems functions are not strictly separated according to a rigid scheme "either ventral or dorsal." Most likely the processes of the visual system can't be independent and strictly fixed, they interact and complement each other. While creating the model of the vision system it's important to take into consideration one of its basic qualities – plasticity, adaptability of different (fixed as it may seem) physiological functions to perform the task at hand.

2. Investigations of interaction between visual perception and motor activity based on technology of virtual reality: scientific research and proposal to collaboration

Virtual reality technology presents new possibilities for researching the interaction between perception and action allowing the subject on the one hand to see complicated virtual visual scenes and on the other hand to move freely in the real environment. Psychology Department of Lomonosov MSU is developing a method based on a combination of classical techniques of experimental psychology and modern VR technologies for realizing such research tasks. As classical techniques were used such techniques as tachiscopic (short-time) presentation of the stimulus, method of changing noise / signal balance, masking method etc. Using them researchers got a decrease of cognitive parameters (memory volume, perception and attention parameters) depending on the "noisiness" in the environment or the shortness of the stimulation. Traditionally such studies were carried out in a dark room, the stimulation appeared on the screen of a two-dimensional monitor and the participant had to solve problems like "whether there was a stimulus or not" and "whether one stimulus differed from another." But the results of such studies not always help predict answers of real scene viewer as in a real situation the scenes are much more complex and require solving behavioral problems. Such problems require not just an answer "whether there was a stimulus or not" but a set of actions which are coordinated with solution of a difficult cognitive task (remember certain virtual objects you see on the way, look through all the stimuli and find the correct one). It means that besides classical cognitive recognition tasks the experiment situation includes additional tasks on space orientation, diversion of attention to inappropriate stimuli, forming a cognitive map of the environment.

The task of finding a technique that could stimulate such problems is actual and sought-for. For example development of such areas of psychology as transport and sport psychology requires development of new experimental techniques including not only verbal evaluation but also action coordinated with the task. Development of such techniques became possible with appearance of new virtual reality technology that allows not only to form more realistic 3D stimuli, but also allows more mobility for solving the problems. The method proposed is based on the following methodological techniques of stimulating material and the participant's action[1]. The participant is instructed to perform a difficult

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1 **Application script**
The user's task is to walk through a *virtual labyrinth* which consists of a number of rooms (tree of rooms) each of which has exits (2-3) that lead in different directions. Some of the exits lead to other rooms, others lead to rooms with no other exits. The labyrinth net consists of several (8, 10, 15) rooms that are interconnected. Each room has different objects: a table, a flower pot, books, pictures or maps on the walls. There is a possibility of creating an object library, so that you can put these objects into different places in the rooms of the virtual labyrinth. There will be developed a parameters menu where it will be possible to change the following parameters of the labyrinth: the total number of rooms, size of the rooms (big – small), illumination of the rooms (dark – light), windows (windows – no windows), number of floors (one floor – all rooms are on one floor, two floors – rooms are on different floors). Other changeable parameters are a) possibility to change the user's height (he can be a "giant" looking at the room from a height of 2 meters or a "dwarf" looking at all the objects from below), b) speed (slow – fast), c) changing of binocular parallax of rooms and objects (2D / 3D).
The experiment starts with an interface where you state the name of the experiment, the date, the name of the user, the date of his / her birth, sex. Then the user is presented with the instruction where the task is stated. For example, "You can move across the rooms with the help of keys 1... . Find a room with a red carpet on the wall. When you find it, press Enter." The user should have a possibility to take some interactive actions with the labyrinth environment. For example, a possibility to click an object that is an attention level marker, ability to arrange objects in a room in the required order, copy or delete objects. The user should be able to change the way of going through the labyrinth with the help of the keyboard.

cognitive task (for example to remember "virtual" objects, finding "hidden" objects) and go through a 3D virtual labyrinth that is presented through a VR eMagin Z800 3D Visor helmet. The task is made more difficult by introduction of a number of stress factors, that increase the time of solving the problem. Such factors can be a gap in the virtual path of travel, appearance of scary virtual objects, unpleasant sounds. Solution of the task is done in two consequent experimental situations of passive / active walk through the labyrinth. In the situation of *passive walkthrough* (PW) the participant solves the problem without any movements. In the situation of *active walkthrough* (AW) the solution of the problem is accompanied by motor activity which is assimilated / not assimilated by visual stimulation. For example, the experimental situation for an AW is designed in two variants: in the first one the motor actions of the person are assimilated with the virtual labyrinth spatial structure (his actions copy the turns of the labyrinth), in the second one they are not (i.e. he should turn in the opposite direction). In the latter case the participant should train to overcome this "dissimilation" by forming a corresponding visual-motor skill.

As a result of virtual labyrinth walkthrough the following parameters can be taken: finished / not finished the labyrinth, total time, time spent in each room, walkthrough pattern, registration of actions (clicking / not clicking the mouse button on the correct object). All types of the participant's activity in both situations (PW, AW) are accompanied by registering an encephalogram, skin galvanic reaction, electrocardiogram, photoplethysmogram and myogram. It's supposed that in a PW situation the participant's cognitive processes (perception, memory, thinking) dominate over the reduced motor activity. In the AW situation the participant's cognitive activity is supplied by motor activity in form of purposeful motor actions and the level of coordination of cognitive and motor activities can be modified by mismatching of visual and motor components. As a result, coordination of cognitive processes and actions can lead to sufficient changes in the problem solution effectiveness. The suggested method allows to hold multifactor psychological and psychophysiological experiments for researching: (1) coordination of cognitive processes (perception, memory, thinking) and behavioral acts (actions); (2) influence of the degree and form of motor-cognitive cooperation on the subject's success in different kinds of practical activities; (3) special features of brain and autonomic nervous system activity in real-life purposeful behavior. This method can be used in such areas of practical psychology as sport, transport, engineering and security psychology.

Conclusions

1. Virtual reality is becoming a new effective research method in experimental psychology and as it can be expected it can lead to a revision (modernization, improvement) of the psychological science framework. It means that it's important to carry out systematical studies on such important issues as methodology, ethical norms, technical equipment for development and implementation of this unique new technology in theory and practice of experimental psychology.

2. Analysis of "virtual reality" experimental technology shows that this technology possesses a number of methodological features that differ it from the methods of traditional psychological laboratory experiment. Some of these VR features can be seen as "advantages" over the methods of classical experimental psychology, others – as new problems which require special (including methodological) analysis.

3. Virtual reality technologies are actively and effectively used in such areas of practical psychology as engineering, labor, clinical, social, occupational, sport, security and educational psychology.

4. Psychophysiology occupies a special place in VR systems. On the one hand using psychophysiological parameters allows an objective evaluation of the person's immersion into the virtual world and his adaptation there. On the other hand, VR technologies open up new opportunities for psychophysiology in researching correlation between the soul and the body, brain and psychics.

5. Virtual reality technology presents unique possibilities for solving new tasks in the innovative education in college education. The Psychology Department of Lomonosov MSU is working on development of such new areas of education as video conferences, creation of a lectures bank for distant listeners, creation of virtual classical experiments.

6. VR technologies can be effectively used for studying interaction between cognitive processes and motor activity in the process of visual perception as part of the approach called "active perception." The method of studying this interaction being developed in Lomonosov

MSU is based on a combination of modern VR technologies with classical methods of experimental psychology. Realization of this method allows to study the interaction between cognitive processes and behavioral acts, evaluate the influence of motor-cognitive cooperation on the success in solving different problems and also study the special features of brain and autonomic nervous system activity in real-world purposeful behavior.

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