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International Journal of Biomed Research

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Research Article

About the Nanotechnological Approach to The Brain

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Received date: June 19, 2023; Accepted date: July 17, 2023; Published date: July 24, 2023

Citation: Ramil Garifullin, (2023), About the Nanotechnological Approach to The Brain, *International Journal of Biomed Research.* 2(4): **DOI:**10.31579/2834-8087/025

Abstract

Background: The program-problem article on nanopsychology, as a new science with its own subject, tasks and goals, put forward by us earlier, proved useful for the development of psychology under the influence of nanotechnology.
Aim: The article presents and analyzes the main contours of nanopsychology as a science that studies correlations between nanostructural transformations of the brain and mental processes generated by these nanostructural transformations in the "here and now" conditions. The subject of nanopsychology as a science, its goals, objectives, problems and research program are substantiated.
Materials and Methods: Review-analytical method. The analysis of the works and publications that followed after our substantiation of nanopsychology as a science, which was published earlier, was carried out.
Results: It is shown that there are scientific publications that disorient researchers from the real tasks of nanopsychology formulated by us. In essence, there is a substitution of the subject of nanopsychology. The analysis of these works has shown that they are only indirectly related to psychology and brain processes and disorient researchers interested in the real directions of nanopsychology put forward by us. The analysis showed that nanopsychology as a science can be divided into several areas. The first area studies mental processes caused by the influence of artificially created nanostructures that are embedded in the brain, nervous and neurohumoral systems, and are controlled from the outside in the conditions of "here and now" or lag. The second area is related to uncontrolled nanostructures. which are embedded in the brain, nervous and neurohumoral systems. In addition, there is an area that studies mental processes caused by the influence of systems (devices, chips, nanochips, nanobots, micro-emitters, microswitches, microcomputers, coding and decoding microsystems etc.) created on the basis of nanotechnology achievements.

Conclusions: Thanks to the developed program and the problems of nanopsychology as a new science, it may be possible to control the nanostructural processes of the brain in the "here and now" mode and observe how this control affects mental processes. When this possibility is realized, ambiguity in the interpretation of the causes of certain mental processes will disappear, which is very important for the study of nanomolecular bases of mental processes. Nanopsychology can become one of the newest approaches to the study of mental processes, which will strengthen the study of the correlation of molecular transformations and mental processes in the "here and now" mode.

Keywords: nanopsychology; nanotechnologies; areas of nanopsychology; correlation; nanostructures; nanostructural processes; mental processes; brain

Introduction

The inescapable and universally accepted fact is that brain research and psychology development have become highly dependent on the advance of nanotechnology [Garifullin, R.R. (2006)]. The latter qualitatively alters the very conditions under which brain-related and mental problems are studied, forcing the need to reconsider and update our understanding of the basics of cognitive science and psychology. Therefore, in 2006 [Garifullin, R.R. (2006)] we substantiated nanopsychology as a science that studies correlations between nanostructural transformations of the brain and mental processes generated by these nanostructural transformations in the “here and now” mode. Its focus also falls on subtle psychophysiological transformations and brain switching, both significantly influencing the “here-and-now” mental processes.

The impact of molecular and nanostructural processes on the mental functions of humans has already been described [Roco, M.C., Williams, R.S., & Alivisatos, P. (Eds.). (2002)]. However, little is known about how to control these nanostructural brain processes in the “here-and-now” mode and to simultaneously observe the effects caused by that control in mental processes. If this becomes possible, the causes of certain mental processes are expected to be identified unequivocally, which is vital for recognizing and interpreting the nanomolecular bases of mental processes. In physics, an analogy is the tracer method that allows clear interpretation of experimental results. Therefore, as shown in [Garifullin, R.R. (2015)], nanopsychology may offer the most advanced psychological methods for brain science and psychology to fill the existing huge gap between mental and psychophysiological processes as they are commonly perceived.

This proposed by us above program of nanopsychology as a science

[Garifullin R.R. (2006)], aroused sufficient interest among various authors of scientific publications [Caluschi, M. (2011); Engineering psychology; Berezina, T.N. (2009); Vanesyan, A.S. (2012); Valieva, E. (2008); Bushmanov, Z.V. (2009)] in this new field of science. The program- and problem-oriented our article of 2006 elevated nanopsychology to the status of a science with particular subject, objectives, and tasks. The term "nanopsychology" has become widely used by both psychologists and representatives of other sciences [Engineering psychology]. In addition, the above article on justification of nanopsychology as a science received a wide coverage in the media [Valieva, E. (2008)]. Some of the key articles and studies based on the ideas of nanopsychology and published after its validity as a science has been demonstrated are discussed and analyzed below.

Many articles addressing the problems of nanopsychology have tried to match it to the already known branches of psychology [Berezina, T.N. (2009); Bushmanov, Z.V. (2009)]. For example, a number of scientific articles and encyclopedic dictionaries on engineering psychology refer to nanopsychology, citing the original research of 2006, as a separate field of engineering psychology [Berezina, T.N. (2009)], i.e., the authors of these publications have all recognized some elements of engineering psychology in nanopsychology, which is not surprising given that one of the important tasks of nanopsychology is gaining control over the brain and mental processes using either implanted or natural brain nanostructures [Garifullin, R.R. (2006)]. However, it would be incorrect to narrow nanopsychology to engineering psychology. Neuroengineering [Neural engineering], as a scientific discipline falling within biomedical engineering and using various engineering methods to study, restore, replace, or strengthen the nervous system, has little in common with nanopsychology. Neuroengineering focuses more on the problems of combining living and synthetic neural structures.

In one of the foreign articles [Caluschi, M. (2011)], the nanopsychology program developed by us is widely analyzed, and it is shown how psychology, in its development, starting from the 19th century, approached the nanopsychology program formulated in our articles [Garifullin, R.R. (2006)]. In addition, the substantiation of nanopsychology, carried out by us, is analyzed in detail in a scientific monograph [19]. Moreover, in this publication, our program for the development of nanopsychology is noted as fundamental in terms of the development of nanopsychology as a science [Dobren'kov, V.I. (2018)]. The above publications do not distort the subject and value of nanopsychology as a science, unlike the ones analyzed below.

Some works reduce nanopsychology to the study of vibration images recording micromovements and spatial vibrations of an object (nanometer displacement of the center of gravity) [Minkin, V.A., & Shtam, A.I. (2006)]. Their authors use a vibration imaging system to assess a person's emotional state by remote and non-contact scanning of the head micromovements. Notably, it has nothing to do with nanopsychology, being linked only to psychodiagnostics of emotional states using the analysis of micromovements.

In addition, attempts have been made to limit nanopsychology to the problem of influencing nanotechnology processes through odorants (chemical substances emitted by humans in the form of odors when their functional states change) [Berezina, T.N. (2009)]. This approach to nanopsychology contradicts its subject and tasks.

The situation with the misinterpretation of the actual subject of nanopsychology is similar to that in nanophysics [Garifullin, R.R. (2010)]. Many nanophysicists are actually engaged in developing composite materials based on the principles of traditional colloid chemistry. This, of course, is not nanophysics, but rather colloid chemistry and molecular physics branches. The true nanophysics is concerned with controlling the motion of a single molecule (not many molecules) in the "here-and-now" mode, which means while observing a single molecule.

It appears from the analysis performed in this article that nanopsychology faces similar challenges. Some researchers [Minkin, V.A., & Shtam, A.I. (2006); Berezina, T.N. (2009)] have felt a connection between their research and nanoscience and rushed to qualify their investigations as nanopsychological, although they are not.

It should be admitted that the program- and problem-oriented article published in 2006 on nanopsychology as a new science with its own subject, tasks, and objectives has had a positive impact on the development of psychology as nanotechnology advance. At the same time, certain articles published by other researchers after 2006 are misleading when it comes to the actual tasks of nanopsychology. These authors refer to nanopsychology as something different from what was suggested earlier. They reduce it to the science of the psyche under the influence of nanotechnology [Vanesyan, A.S. (2012)], to the sociology of nanogroups [Lifshitz, V.], as well as to the study of vibration imaging [Minkin, V.A., & Shtam, A.I. (2006)] or olfaction [Berezina, T.N. (2009)]. The analysis showed that the above studies are only indirectly related to psychology and brain processes and confuse researchers interested in the problems of nanopsychology from the earlier works [Garifullin, R.R. (2006)].

The developed program and problems of nanopsychology as a new science may help to achieve control over nanostructural processes in the brain using the "here-and-now" mode and to simultaneously observe how that control affects mental processes. Nanopsychology may evolve into one of the newest approaches to the study of mental processes, which will promote the research on correlations between molecular transformations and mental processes in the "here-and-now" mode.

2. Materials and Methods

The article uses the method of analytical review to analyze the works published after nanopsychology was introduced to the scientific community in the original article of 2006 [Garifullin, R.R. (2006)].

3. Results and Discussions

It has already been 17 years since we substantiated nanopsychology as a new direction in science, as well as the proposed above program for the development of nanopsychology [Garifullin, R.R. (2006)]. Therefore, as a result, we will analyze the work that corresponds to the implementation of our program.

Previously, we [Garifullin R.R. (2006)] proposed three major fields of nanopsychology:

1. The one that studies mental processes caused by the natural nanostructures of the brain, the nervous and neurohumoral systems. This field, in turn, is subdivided into the studies of:

a) mental processes initiated by the natural processes in natural nanostructures (uncontrolled nanostructures). Currently, a sufficient number of studies in nanobiology have already accumulated [N. Agrawal, 2021] devoted to the study of structural, biological, biophysical processes in natural biological structures or their nanobiological analogues, the laws to which biological systems are subject. The creation of active nanomodels of biological structures on this basis today forms the basis of nanobiology. The achievements of the science of nanobiology form the basis for the development of such areas of nanoscience as bioorganic nanochemistry, nanopharmaceuticals, nanosensory, nanomedicine and the like. Consequently, there is a need to identify the connection and correlation of patterns found in all of the above directions and psychological processes;

b) mental processes caused by artificial processes and impacts on natural nanostructures (the impact is controlled by the operator in the "here-and-now" or lag mode). In this regard, a sufficient number of studies have also accumulated on the effects of various physical fields (magnetic, electric, ultrasonic, etc.) on the brain [Yu. Lebedev. A, 2012].

2. Next, it is necessary to highlight exploration of mental processes caused by either synthetic and controlled nanostructures (in the "here-and-now" or lagging conditions) or uncontrolled synthetic nanostructures that are embedded in the brain, in the nervous and neurohumoral systems. It must be recognized that metal nanoparticles controlled by an external magnetic field have become the main tool for controlling the body and mind with the help of controlled nanostructures.

In 2015, an article was published [Chen, R. (2015)] on wireless deep brain stimulation of mice using magnetic nanoparticles injected into the brain. This became possible due to the effect of nanoparticles in an external alternating magnetic field. When exposed to alternating magnetic fields, these nanoparticles, embedded in certain groups of neurons, dissipated heat, which excited the neurons.

This article, perhaps, is one of the first to correspond to the program for the

development of nanopsychology proposed by us in 2006, as the science of controlling nanoparticles that control behavioral reactions, which are a manifestation of mental processes. In fact, in the work [Chen, R. (2015)], these behavioral responses were studied in mice, although initially the authors of this article did not set the task of controlling the behavior of mice with the help of nanoparticles. Thus, the value of this study turned out to be not only in the possibility of wireless research of the brain, but also in the opened possibility of influencing and activating neurons using nanoparticles controlled by a magnetic field. This became possible without damaging the neurons.

3. The field studying mental processes resulting from the influence of systems (devices, chips, nanochips, nanobots, microemitters, microswitches, microcomputers, coding and decoding microsystems, DNA computers, etc.) created with the help of various nanotechnology achievements. Such systems are either embedded in the brain, the nervous and neurohumoral systems or they exert their influence from the outside. In [Golovin Yu. I. (2011), Sokolsky M. (2011)], a new nanomechanical approach was proposed to control the biochemical properties of macromolecules (eg, proteins) attached to magnetic nanoparticles using a low-frequency nonheating magnetic field. In this concept, magnetic nanoparticles are used not as heat sources, but as converters of magnetic field energy into deformation and change in the conformation of macromolecules attached to them. In [Oberhauser A.F. (2008)], the first encouraging results obtained within the framework of this nanomechanical approach are described. It can be considered as the basis of an innovative technological platform for targeted drug delivery, in particular, for remotely controlled drug release from nanocontainers and nanogels, as well as for controlling the activity of drugs and the kinetics of biochemical reactions in vitro and in vivo. In this regard, a number of questions arise concerning the optimization of the parameters of magnetic nanoparticles, the design of aggregates based on them, and the characteristics of magnetic fields that provide the most effective nanomechanical effect of the field on the structure and biochemical properties of macromolecules.

Moreover, we [Garifullin R.R. (2006)] identified the following problems of nanopsychology:

1. Problems of the impact produced by nanoparticles (nanoblockers, nanoscreens, nanochips, and various nanoenergetic structures) on mental processes. There is already a sufficient number of works on these above-mentioned nanostructures [Roco M.C. (2000)], but there are no works related to their influence on mental processes. It includes:

a) the problem of transforming the bioinformational fields of the brain by using nanoparticles incorporated in its different parts;

b) the problem of investigating mental processes caused by the influence of nanoblockers, nanoscreens, nanochips, and various nanoenergetic structures;

c) the problem of managing the above processes;

The authors came close to solving the above problems, who devoted themselves to the use of magnetic nanoparticles in biomedicine as magnetic biosensors, for targeted drug delivery, in tissue engineering and magnetic resonance imaging [Dobson, J. (2008)]. Of particular interest is the study of the effect of a magnetic field, since it can penetrate deeply into living tissues and noninvasively affect magnetic nanoparticles located in them. In early studies, it was shown that a constant magnetic field can cause displacement of magnetic nanoparticles internalized in the cell culture of motor neurons, thereby causing the activation of mechano-sensitive N-type calcium channels and the entry of calcium ions [S. Fedorenko. (2019)]. Future treatment of diseases or conditions based on remote manipulation of certain ion channels in certain organs and tissues is certainly within the realm of possibility. There are data stating that due to the local gradient of the magnetic field created with the help of electromagnetic needles, it is possible to manipulate and control individual microparticles [Z. Cenev (2018), Seon, J. (2018]. So far, the ability to target and manipulate cellular structures with such elegant precision has already opened up new possibilities in biomedical research. A better understanding of axon guidance mechanisms could lead to new treatments for neurological conditions such as spinal cord injury or peripheral neuropathy [Kilinc, D. (2015)]. Obviously, all these achievements in neurology are the basis for influencing mental processes.

2. The problem of studying processes that take place in nanoparticle solutions (both the ideal and real ones). Transition to the macrolevel through nanoparticle solutions. The problem of interaction with the solvent. There are few works on the use of conformational transformations of biological macromolecules in solutions [Golovin Yu. I. (2013), Thomas C.R (2010)]. These works are related to the nanomechanical effect of controlled magnetic nanoparticles on macromolecules. These works do not yet consider the correlation between conformational transformations, psychophysiological and mental processes. For example, an analysis was made of the mechanical factors of the action of an alternating magnetic field on macromolecules [Magnetic Nanoparticles. (2012)] attached to single-domain magnetic nanoparticles and aggregates composed of them, which are part of a suspension or gel. The conditions providing the most effective nanomechanical control of biochemical reactions in suspension by an external magnetic field are determined.

In addition, a method for controlling biochemical reactions in suspensions, magnetic nanoparticles and macromolecules sewn to them are described [Microfluidic Technologies for Human Health (2013)]. It is based on nanomechanical processes induced in reaction cells near magnetic nanoparticles by a low-frequency (non-heating) magnetic field and reduced to deformation, change in formation of macromolecules attached to them, change in their mutual position, acceleration of molecular diffusion. From a practical point of view, the implementation of nanomechanical approaches in medicine makes it possible to create new methods of targeted delivery of new generation drugs to the body and brain.

Reviews and generalizing works [M. Rabanel, (2020), Bu T. (2012), Hamdan S.M (2007), Perlmutter J. S. (2006), Tufail Y.2010] provide various information about changes in the conformation of individual macromoleculs under the action of an applied force and, as a consequence, changes in the pathways and rates of reactions in which they participate.

One of the areas of application of magnetic nanoparticles is targeted drug delivery [Leary S. P. (2006), Hofmann A. (2009)]. Its main advantages include the ability to significantly reduce the toxic effect of drugs on other organs and systems of the body, the ability to direct and hold drug-containing nanoparticles in a certain place using a magnetic field, and visualize them using magnetic resonance imaging. An important property of magnetic nanoparticles is the possibility of their local heating by a high-frequency magnetic field to initiate the drug desorption/decapsulation mechanism or to conduct magnetic hyperthermia. For targeted drug delivery, superparamagnetic particles are usually used as a magnetic carrier, since they do not aggregate after exposure to a magnetic field.

And finally, there are already studies devoted to changes in the conformation, secondary, tertiary, quaternary structure of macromolecules, which can occur when the critical value of the force of action of controlled magnetic nanoparticles is reached [Microfluidic Technologies for Human Health (2013)].

3. The study of mental processes associated with the process of nano-removal of various structures of the brain and nerves. The problem of nanoelimination of the brain structures and nerves. Influence of the nanoelimination on mental processes. With the help of thermomagnetic particles, remote nanoremoval of individual brain structures is already becoming possible [Chen, R. (2015)].

The effect of nano-removal on mental processes is an actual problem. It would seem that destroying is less difficult than building, but selective removal is a big problem. Therefore, nanoparticle control theories are being created. Studies devoted to the physical theory of control of metal nanoparticles in a magnetic field have proved to be very useful. In these works, the parameters of the magnetic field and various factors contributing to more efficient control of nanoparticles are calculated [Chen, R. (2015)].

Conversely, it seems that it will be possible to study the psyche as artificial nanostructures grow into systems of vision and perception. This is not a rough removal and observation, but the introduction of nanostructures (nanobots) that produce hormones, drugs, etc.

All this can allow the use of artificial nanostructures as a tool for creating new methods and techniques for studying mental processes. In this case, it will be necessary to solve the problem of the relationship of artificial

nanostructures implanted in the brain and nerves with natural brain nanostructures.

Nanopsychology is the science of very subtle psychophysiological switches in the work of the brain. Nanopsychology can become one of the modern psychological methods (in psychology). As a method of labeled atoms.

Currently, there is already a sufficient number of works on the implantation of nanostructures into the brain [Dobson, J. (2008)], but there are no studies concerning the effect of such implantation on mental processes. The resolution of these problems would allow for a new basis to study the starting natural nanoprocesses, and the simulation of these processes with the help of artificial nanostructures.

Therefore, it is necessary to recognize that at present there is a gap between nanostructural research and mental processes, since the molecular mechanisms of thinking and memory are still poorly understood. Maybe it's better to look for trigger, culmination, bifurcation, synergetic mechanisms in the brain that determine mental processes?

4. Discussions

The above analysis showed that it is necessary to direct thermomagnetic nanoparticles to the zone of biomolecules that change their conformations with a local increase in temperature caused by the influence of these nanoparticles. In any case, thermomagnetic nanoparticles can become a factor and trigger for the creation of local thermokinetic conditions for molecular conformations and biochemical reactions that underlie key cognitive, emotional, and other brain processes. Thus, it is necessary:

1. Pay more attention to studies of biomolecular structures that change their conformations under the influence of thermomagnetic nanoparticles.

2. To study the processes of key destructive molecular mechanisms that cause dysfunctions of the body and psyche, and the possibility of molecular correction and elimination of these disorders using the influence of thermomagnetic nanoparticles.

The relevance of research in the field of control of magnetic nanoparticles is associated with the problem of controlling cognitive and emotional-volitional processes of the brain, in particular, with controlling the synaptic plasticity of substances and stimulating the electrical activity of neurons.

In the future, the control of nanoparticles, in particular magnetic nanoparticles, should become a means of restoring the molecular mechanisms of the brain, allowing you to correct mental processes, eliminate mental disorders and various psychophysiological dysfunctions.

The relevance of research in the field of control of magnetic nanoparticles is associated with the problem of controlling cognitive and emotional-volitional processes of the brain, in particular, with controlling the synaptic plasticity of substances and stimulating the electrical activity of neurons. Therefore, the relevance of research and observation of correlations between mental processes and nanomolecular transformations caused by controlled nanoparticles will increase, and this is the area of a new direction in psychology - nanopsychology.

Thus, based on the analysis of the above works, we can conclude that the relevance of finding correlations between the indication of mental processes and indications of molecular transformations in the "here and now" mode, that is, in conditions of parallel simultaneous observation of mental and molecular processes, is ripe. Molecular transformations, which are considered within the framework of nanopsychology, are not associated with the transformation of biological molecular systems studied by molecular physiology, but are associated with the artificial introduction of simpler non-biological molecular formations introduced into the brain and neurohumoral system. Due to the fact that mainly in nanopsychology it is supposed to study mental processes caused by molecular transformations, this will be the direction of psychology - nanopsychology, which we substantiated in 2006. In essence, nanopsychology is the science of the possibility of controlling the brain and mental processes in the "here and now" mode by controlling nanoparticles and nanomolecular structures.

Acknowledgements

This paper is performed as part of the implementation of the Kazan Federal University Strategic Academic Leadership Program.

Conflicts of interest

The author declares no conflict of interest relating to the material presented in this paper.

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