

Tetiana Nazarovets

Vinnitsia Mykhailo Kotsiubynskyi State Pedagogical University
Postgraduate student of the Department of Psychology and Social Work
bashmachok_57@i.ua
<https://orcid.org/0009-0000-2268-9804>

Alona Nastoishcha

Vinnitsia Mykhailo Kotsyubynskyi State Pedagogical University, Student of
Department of Psychology and Social Work
alenalablyk@gmail.com
<https://orcid.org/0009-0003-5825-6383>

NEUROPSYCHOLOGICAL ASPECTS OF STRESS MANIFESTATION

Сучасне життя, на жаль, не позбавлене стресових ситуацій. Ця стаття досліджує, як стрес, впливає на різні когнітивні функції людини, роблячи нас більш вразливими. Пам'ять, увага, прийняття рішень, гальмування, абстрактне мислення - ось лише деякі аспекти прояву стресу. Дослідження показують, що тривалий або повторний стрес може послабити імунітет, посилюючи запальні процеси та навіть руйнуючи нейрони в гіпокампі, відповідальні за пам'ять. Дозрівання лобової кори головного мозку, яке супроводжується збільшенням об'єму сірої речовини та кількості синапсів, може бути порушено під впливом стресу, що призводить до погіршення когнітивних функцій.

Останні дослідження у галузі впливу стресових ситуацій на психологічне і фізичне здоров'я відзначається широким спектром методологічних підходів та різноманітністю джерел.

Сапольські Р. висвітлює вплив стресу на процеси пов'язані із пам'ятю, а також на процеси формування окремих відділів головного мозку. У праці Наказави Д. ми ознайомлюємось із нейронним розвитком і природними процесами пов'язаними із цим розвитком. Таким чином, останні дослідження та публікації в галузі психології стресу є важливим внеском у наше розуміння цієї складної проблеми та розвиток практичних рекомендацій для подолання негативних наслідків стресу.

Сон, життєво важливий для відновлення енергії та консолідації пам'яті, стає жертвою стресу. Недосип та погіршення його якості роблять нас більш вразливими до негативного впливу стресу. Діти, які пережили стрес, ризикують втратити ще більше нейронів, ніж їх однолітки, адже природне обрізання нейронів у пубертатному віці може посилитися.

Хронічний стрес може призвести до невротичних реакцій, психофізіологічних симптомів та психосоматичних захворювань. Це підкреслює важливість реабілітації нервової системи та нейропсихологічних інтервенцій.

Ключеві слова: стресові ситуації, стрес, пам'ять, інтелект, порушення сну.

Modern life, unfortunately, is not devoid of stressful situations. This article explores how stress affects various cognitive functions, making us more vulnerable. Memory, attention, decision-making, inhibition, and abstract thinking are just some aspects of the effects of stress. Studies show that prolonged or repeated stress can weaken the immune system, increasing inflammation and even destroying neurons in the hippocampus responsible for memory. Maturation of the frontal cortex, which is accompanied by an increase in gray matter volume and the number of synapses, can be disrupted by stress, leading to cognitive decline.

Recent research on the impact of stressful situations on psychological and physical health is characterized by a wide range of methodological approaches and a variety of sources.

Sapolsky R. highlights the impact of stress on memory-related processes, as well as on the formation of certain parts of the brain. In the work of D. Nakazawa, we get acquainted with neural development and the natural processes associated with this development. Thus, the latest research and publications in the field of stress psychology are an important contribution to our understanding of this complex problem and the development of practical recommendations for overcoming the negative effects of stress.

Sleep is crucial for restoring energy and consolidating memory, but it also becomes a victim of stress. Lack of sleep and deterioration in its quality make us more vulnerable to the negative effects of stress. Children who have experienced stress risk losing even more neurons than their peers, as the natural neuronal pruning at puberty can be intensified.

Chronic stress can lead to neurotic reactions, psychophysiological symptoms, and psychosomatic illnesses. This emphasizes the importance of nervous system rehabilitation and neuropsychological interventions.

Keywords: stressful situation, stress, memory, intelligence, sleep disorders.

Formulation of the problem. One of the key issues is understanding how stress factors affect cognitive functions such as attention, memory, and sleep, which can lead to a variety of problems. It is important to understand the impact of physiological and psychological stress factors on individuals.

Analysis of recent research and publications. Recent research on the impact of stressful situations on psychological and physical health is characterized by a wide range of methodological approaches and a variety of sources.

Sapolsky R. highlights the impact of stress on memory-related processes, as well as on the formation of certain parts of the brain. In the work of D. Nakazawa, we get acquainted with neural development and the natural processes associated with this development. Thus, the latest research and publications in the field of stress psychology are an important contribution to our understanding of this complex problem and the development of practical recommendations for overcoming the negative effects of stress.

The purpose of the article is to explore how stress affects various aspects of human cognitive functions and to point out the possible consequences of prolonged or repeated stress for our health. Also, to emphasize the importance of nervous system rehabilitation and implementation of neuropsychological measures. Through a review of current research, the article discusses the impact of stress on various aspects such as memory, attention, decision-making, and others, as well as the possible consequences for physical and mental health.

Outline of the main material.

Research on humans and animals has demonstrated that stress has a significant impact on various physiological systems. Probably, these changes have evolved to support survival behaviors in the face of threat, such as fight or flight. For the body to respond effectively, the physiological systems that are necessary to overcome the threat are activated and those that are not of priority are suppressed. For example, the body raises glucose levels to provide energy for physical activity in the face of a threat, but it may also inhibit processes that promote growth and reproduction.

Although the body is adapted to short-term mobilization in response to stress without significant consequences, prolonged or repeated activation of threat-response systems can lead to negative physiological consequences for health in the long term.

Exposure to stressful experiences can weaken various immune functions. For example, stressful life experiences, such as bereavement, job loss, and even exams, can reduce the levels of circulating classes of immunological cells called lymphocytes; inhibit various lymphocyte functions, such as the ability to proliferate when exposed to a foreign substance; and slow down integrated immune responses, such as wound healing. A person's vegetative reactivity to stressors correlates with the degree of exposure to acute laboratory stressors. Numerous evidences that autonomic nerve fibers innervate (penetrate) immune organs and change the function of immune cells located there confirm the connection between the vegetative nervous system and the immune system. In addition, some of the immunological effects of stressors are explained by the powerful suppressive effect of cortisol on immune cells. Cortisol can inhibit the production of certain cytokines (chemical mediators secreted by immune cells to regulate the activity of other immune cells) and suppress various immune functions.

Exposure to stressors can also increase certain immune processes, such as those closely related to inflammation. Inflammation is an organized response to pathogen exposure that creates local and systemic changes that promote pathogen destruction (e.g., fever). However, chronic, inadequate inflammation underlies many diseases, including some autoimmune diseases such as rheumatoid arthritis, and may play a role in others such as cardiovascular disease. There is currently a great deal of interest in the factors that contribute to inappropriate inflammation outside of the normal context of infection. Exposure to certain psychological stressors can increase circulating levels of inflammatory cytokines,

possibly because stressful experiences can reduce the sensitivity of immune cells to the inhibitory effects of cortisol.

The activation, of physiological systems in response to a stressor is useful and adaptive in the short term in certain situations. However, it can become unhelpful or even harmful if these systems are activated repeatedly or for a long time, or if they are not turned off after the threat has passed. For example, scientific evidence suggests that prolonged exposure to stressors or a state of distress, such as post-traumatic stress disorder and chronic depression, can lead to a decrease in the volume of a part of the brain known as the hippocampus, resulting in memory impairment. Chronic stress has also been found to increase vulnerability to upper respiratory tract infections in people exposed to the virus. Scientists are also investigating the impact of stress on other health indicators, but complete models describing all the mechanisms from the central nervous system's response to the pathophysiological processes that regulate the development of the disease have not yet been fully developed [5].

It is important to note that the process of forming and recovering memories can be disrupted by prolonged or severe stress. According to experts in the field of learning and memory, this phenomenon is known as the "inverted horseshoe". Moving from a calm state to a state of moderate temporary stress, which is a form of stimulation, can improve memory. However, going into a state of high stress can lead to memory impairment.

Research has also shown that stress can disrupt executive function, which includes processing and structuring information, and affects judgment and decision-making. This function is located in the prefrontal cortex of the brain.

First of all, hippocampal neurons stop working. Stress can disrupt long-term potentiation in the hippocampus even without glucocorticoids. This is due to overactivation of the sympathetic nervous system. The effect of glucocorticoids is the subject of most research in this area. High levels of glucocorticoids in the blood, exceeding the normal range for mild to moderate stress and reaching levels seen in severe stress, can inhibit long-term potentiation. This process helps to strengthen the connection between two neurons and helps to memorize information. Glucocorticoids can disrupt this process. Similarly, high levels of glucocorticoids can cause long-term depression, which can contribute to forgetting. The hippocampus provides comprehension, not forgetting [1].

It is important for understanding the relationship between frontal cortex maturation and behavior to investigate how this process affects cognitive function.

According to the scenario, delayed maturation of the frontal cortex implies that the number of neurons, dendritic spines, and synapses in the frontal cortex increases with age, reaching the required volumes somewhere between 20 and 30 years. However, in reality, it decreases.

It's related to the intelligent evolution of the mammalian brain. The embryo brain has many more neurons than the adult brain. The reason for this phenomenon is unclear. During the embryonic period, neurons compete to grow faster in the right direction, allowing the axon to reach the appropriate site and form the largest number of synaptic connections with other neurons. It is important to take into account those neurons that may lag in this process. Programmed cell loss occurs when certain genes are activated, causing cells to shrivel and perish, and their organic remains are recycled. Neural Darwinism - competition resulting from the overproduction of neurons allows for the development of efficient neural networks.

The frontal cortex of the adolescent brain goes through a similar process. During adolescence, the volume of gray matter in the frontal cortex and the number of synapses increase. However, with age, the thickness of the gray matter decreases due to the death of additional dendritic processes and synapses. The frontal cortex consists of different areas, with the oldest part maturing first and the reasoning area not losing its excess neurons until late adolescence. A classic research showed the importance of this delayed process. The volume of gray matter in the frontal cortex of the brain was measured in children as they grew up, and an IQ test was administered at the same time. It turned out that there was a positive correlation between slower maturation of the frontal cortex in adolescents and higher IQ scores in mature young adults.

During puberty, there is a gradual improvement in working memory, decision-making flexibility, task list formation, and inhibition efficiency during frontal regulation, which is crucial for switching from one task to another. In general, improved performance is accompanied by an increase in frontal cortical activity during task performance. The greater the activity, the more accurate the execution.

In addition, in adolescence, people are getting better at dealing with the problems associated with understanding someone else's point of view. This refers to the abstract position of another person, not their emotional state, and how the situation might look from their point of view. Improved perception of irony by adolescents indicates improved abstract thinking [3].

It is also appropriate to cite the results of other studies. At the age of 12-14, there is a natural process of neuronal pruning. This process reduces the number of neurons and allows the brain to filter out unnecessary information. The brain becomes highly specialized, and we gain experience and hone our skills by focusing on what interests us, such as baseball, singing, or poetry.

Children who have experienced stress can suffer from neuronal loss, which can be exacerbated by natural circumsion.

Dr. Dan Siegel, a pediatric neuropsychiatrist and professor at the University of California, Los Angeles, explains that stress can damage neurons and nervous system pathways that connect different parts of the brain. During adolescence, if the excess is removed, the integrated circuit between different parts of the brain can fail, which can affect cognitive abilities. If there are not enough integrating fibers, adolescents may experience mood swings and have difficulty with self-control.

To illustrate, let's hypothetically assume that nature has allocated 4000 neurons to children for normal development. Let's take two five-year-old boys, Sam and Joe. Sam had a negative experience early on, but Joe did not. Due to stress, Sam's nerve cells slowly destroyed, and by the time he was twelve, he had only 1800 of the original 4000 neurons. Despite this, he is a normal boy and has not lost any function because nature initially provides children with more cells than they need.

However, the transition age is approaching. The program requires a decrease in the number of nerve cells. For example, suppose that Sam and Joe, like all children, hypothetically lose an additional 1,000 cells. Sam's brain, which developed under conditions of chronic stress, will be significantly different from Joe's. Joe, who grew up without traumatic experiences, has 3,000 nerve cells left, which is enough to lead a healthy and happy life. Unfortunately, poor Sam has only 800 nerve cells left, which is not enough for healthy brain function.

"When the number of cells decreases during adolescence, the remaining cells may not be enough to maintain a healthy balance. If the stressors are severe, the process of cell destruction can intensify, causing most of the brain to partially lose its functionality," Siegel explains.

Perhaps the decrease in the number of neurons is the cause of the first signs of depression or deviant behavior in high school students, and even in those who seemed completely healthy a year or two ago [2].

We also concluded that it is necessary to consider the topic of sleep during stressful times. Due to the war factor, constant nightly air alarms, and sometimes loud sounds of explosions, nighttime rest has also become a focus of our attention.

Approximately 75% of insomnia cases are associated with significant stress. In addition, some studies show that people who sleep poorly have elevated levels of sympathetic nervous system arousal or glucocorticoids in their blood.

Thus, high levels of stress can lead to sleep deprivation. However, stress not only reduces the total amount of sleep but also impairs its quality. For example, if a CRH injection reduces sleep duration, it mainly affects REM sleep, which is important for energy recovery. As a result, sleep becomes more superficial, which makes it easier to wake up - it becomes fragmented. In addition, even when slow-wave sleep is achieved, its benefits are not fully realized. During slow wave sleep, an algorithm called delta rhythm occurs that can be recorded using electroencephalography and helps to replenish energy reserves.

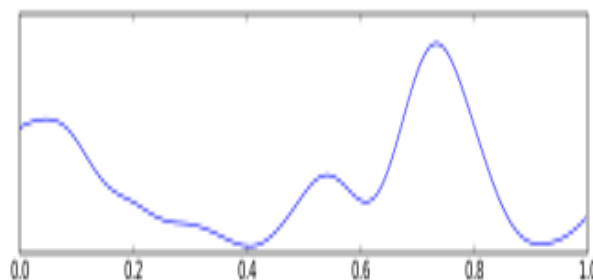


Fig. 1. Delta rhythm(δ -rhythm or delta waves) is an element of electroencephalography that represents fluctuations in electrical potential with a frequency of 1 to 4 Hz with different periods arranged in random order

However, if a person was stressed before going to bed or received a dose of glucocorticoids during sleep, this algorithm will be much shorter during REM sleep.

In addition, glucocorticoids can affect other aspects of good sleep. Jan Born, a researcher at the University of Lübeck in Germany, has demonstrated that the introduction of glucocorticoids into a sleeping person's body can disrupt the process of memory consolidation that occurs during slow-wave sleep [1].

Next, let's consider the impact of chronic stress. In this case, a person may experience neurotic reactions characterized by fears and anxiety, as well as psychophysiological symptoms such as fever, sweating, and changes in blood pressure, which may signal underlying systemic organ dysfunctions at the neurohormonal level. The nervous system is undoubtedly depleted in psychosomatic disorders, affecting various body systems and requiring long-term psychotherapy and treatment lasting several years. Therefore, priority attention should be given to the rehabilitation of the nervous system and the introduction of neuropsychological interventions along with personality-oriented methods of psychocorrection for psychosomatic patients, which is an urgent problem in neurology. Persistent negative emotional states fueled by anxious thoughts maintain an unfavorable hormonal balance in the body, which leads to the development of persistent psychosomatic diseases [4].

It should be added that social support certainly has a positive impact on people, even in the short term. For example, participants in studies who were exposed to stressful situations, such as public speaking or solving math problems, showed a less pronounced stress response when they had social support compared to participants who were alone. According to the research, deep and persistent differences in the level of social support can also affect physiological health indicators. For example, children raised in foster care may have significantly higher levels of stress hormones in their blood than children raised in biological families.

Loss of control and lack of predictive information are closely related. Some researchers believe that both of these factors have a common feature - novelty in the situation that the body is exploring. When you have the impression that you understand how to manage a situation and you can predict what will happen next, but the reality turns out to be different, this can lead to a stressful reaction. This factor has been confirmed in studies on primates: simply by transplanting an animal into a new cage, scientists observed a suppression of its immune system. Some scientists believe that this kind of stressor excites the nervous system and increases anxiety levels as you try to find new rules of control and prediction again. Both approaches address different aspects of the same problem.

Thus, some strong psychological factors can cause a stressful reaction or increase the impact of other stressors: loss of control or predictability, loss of opportunities to get out of difficult situations or loss of support, and the awareness that the situation is getting worse. Some of these factors may overlap. As shown, control and predictability are closely related; when you add in the perception that the situation is deteriorating, you find yourself in an environment where unforeseen and uncontrollable events occur [1].

Conclusions and Prospects for Further Research. Stress constantly accompanies us in modern life, affecting various aspects of our existence. Its negative impact on human cognitive functions cannot be underestimated.

Researches show that prolonged or repeated stress can lead to a weakening of the immune system, increased inflammation, and a decrease in hippocampal volume, which negatively affects memory, as well as disorders in the frontal cortex, which is responsible for decision-making, inhibition, and other cognitive functions.

Lack of sleep and deterioration in its quality caused by stress make us more vulnerable to its negative effects.

Children who have experienced stress are at risk of losing even more neurons, which can lead to serious problems in the future.

Chronic stress can lead to neurotic reactions, psychophysiological symptoms, and psychosomatic illnesses. Therefore, nervous system rehabilitation and neuropsychological interventions are key to improving persons lives.

It is important to remember that stress is not only an emotional state but also a powerful factor that can affect our physical and mental health. Understanding its mechanisms and finding ways to minimize its negative impact is an important task for society.

We see the prospects for further research in understanding the physiology and psychology of stress, as well as developing effective strategies to support the health and well-being of individuals.

References

- [1] Sapolsky R. (2023) Why zebras do not suffer from an ulcer Kharkiv, Ranok, 224-228 pp.
- [2] Nakazava D. (2023) Fragments of childhood trauma. Kyiv, Bookchef, 95-97p.
- [3] Sapolski R (2023) The biology of behavior. Causes of good and bad in us. Kyiv, Nash format, 136-140 pp.
- [4] Pylypenko N., Liasch O., Chorna I., Kompanovych M., Levina N., Chystovska Y., Neuropsychological Correction Technologies of Psychosomatic Disorders and Diseases WoS BRAIN. Broad Research in Artificial Intelligence and Neuroscience 2022, Volume 13, Issue 2. P. 113-129.
- [5] Kemeny, M. E. (2003). The Psychobiology of Stress. Current Directions in Psychological Science, 12(4), 124-129. <https://doi.org/10.1111/1467-8721.01246>

Review received 05.03.2024