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Review Article

Neuroscience and Brain Health

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Abstract

Various genetic factors influence on the brain size and the speed of its changes. Mental health is determined by a complex interplay of physical states related to the body which is strongly influenced by environmental factors (many of which can be controlled by us). Humans can improve their mental health by specific physical changes. Obesity is positively associated with broad impairments on executive functions including decision-making, inhibitory control, as well as in reward valuation. Exercise can significantly improve the structure and function of the brain in older adults. Trillions of bacteria and microbiome are in complex relationships with the brain, the whole body, the environment, and the individual's food.

Keywords: Neuroscience; Brain health; Nervous system

Introduction

With all its wonders and capabilities, the brain is a complex and strange organ. Its responsibility as a central nervous system is leading and controlling the functions of other body systems. In particular, the interaction of the brain with the digestive and nervous systems is very striking [1,2].

Functional Gastrointestinal Disorders (FGID) affect people's health and quality of life. Studies have found that the changes in the release of hormones and its connection with the regulation of appetite by the brain can cause mental and emotional changes. In addition, one of the important factors to keep brain healthy is regular exercise and physical activity that enters the muscle system through neurotransmitters [3].

It is of great importance to keep the health of the brain and regulate its function. The improvement of the general and organic health of the brain using various methods from eating a balanced diet and taking brain supplements to cognitive exercises and counseling therapies have been observed [4].

Furthermore, the brain-mind-body trichotomy, as a new approach to neuroscience research, indicates that these systems, the brain functions, and their effects on body health and mental performance are connected to each other [5,6].

This paper is to investigate the role of enigma and neuroscience, functional disorders of the digestive system, appetite regulation and exercise on brain health. The methods to evaluate and improve the general health of the brain, especially against the Covid-19 and its effects on the health of human nerves are discussed. Then, the concept of brain-mind-body trichotomy and its role in the study of neuroscience is presented.

Discussion

Enigma and Neuroscience

Enigma, the study of the human brain in health and disease, has determined the heritability of brain developments over time. It has shown that genetic factors influence brain size and the speed of its changes. It also has examined the relationship of the development and aging genes and how they are connected with the genetic loci associated with lifetime risk of psychiatric and neurological diseases [6,7].

The results obtained from the investigation of the state of the brain in various neurological disorders were as follows:
- Hippocampus, amygdala, thalamus, and total intracranial volume is smaller in people with schizophrenia. Pallidum,

lateral ventricle volume is larger. The cortex (left and right hemisphere) is thinner and the total area of the cerebral cortex is smaller. The largest effect size is seen in the frontal and temporal regions.

- Thalamus and hippocampus volume is smaller in people with dipole depression but the volume of the lateral ventricle is increased.
- Hippocampus shows a smaller volume in people with MDD. The hippocampus of adolescent patients in the first episode of the disease shows no difference in the subcortical volume; in adult patients, the cerebral cortex is reduced.
- In people with PTSD, hippocampus has a smaller volume [7].

The relationship between religion, theology and mental health

The Science and Religion Forum (SRF)

In this Forum, the researchers address mental health, neuroscience and religion. Mental health is different for everyone. Some consider dementia as a mental health problem and for some, mental problem shows itself in the form of loneliness. The studies have shown that people who regularly have frequent social engagement are more able to resist the effects of dementia [8,9]. Scholars have addressed theological understanding of depression for example; they have tried to find the sources of hope and endurance of unhappiness. They have also argued that depression can be part of a spiritual journey. A spiritual approach to psychosis complements the medical approach. A religious perspective can fruitfully challenge and complement current assumptions about mental health [10].

Neuroscience, functional gastrointestinal disorders (FGID) and appetite regulation

The gut-brain connection is complex and bidirectional. In other words, the sympathetic and parasympathetic efferent branches of the autonomic nervous system directly connect emotional arousal and the enteric nervous system. Spinal afferent neurons and vagus send some signals from the digestive system to the brain stem and sensorimotor brain circuits. In these gut-brain signaling mechanisms, a large number of peptide hormones secreted by endocrine glands scattered throughout the gut plays a key role. Hypothalamus, hedonic reward processes, midbrain areas such as: ventral tegmental area (VTA), substantia nigra, and putamen and caudate nuclei take part in the process of appetite and receiving the necessary food [11]. A large body of research has examined the critical interactions between the gut microbiome and mental health problems including depression, anxiety, gene expression, and stress responses. Mental health is determined by a complex interplay of physical states related to the body which is strongly influenced by environmental factors (many of which can be controlled by us).

Scientists believe that science and religion can contribute to scientific research in this field [12]. Science and religion are complementary to each other and provide an answer to mental health problems [10]. As the scientists put it, the brain is the most structure in the known universe. Besides the brain, trillions of bacteria have a complex relationship with the brain, the whole body, the environment and the food we eat. Research on the gut microbiome shows that many variables and behaviors influence people's experience of themselves and the world. Humans can improve their mental health by making specific physical changes [12].

Obesity and brain functional network organization

Obesity is a threat to public health. It is associated with increased risk of physical and mental diseases. It is also associated with broad impairments on executive functions including on decision-making, inhibitory control, as well as in reward valuation, which, in turn, can cause the difficulty in maintaining healthy lifestyle behaviors such as healthy diet. Evidence shows that these disorders are related to other disorders in functional brain networks, especially those that support self-regulation, reward valuation, self-directed thinking, and homeostatic control. Weight-related differences in task-evoked and resting-state connectivity have most frequently been noted in the Executive Control Network (ECN), Salience Network (SN) and Default Mode Network (DMN), with obesity generally being associated with weakened connectivity in the ECN and enhanced connectivity in the SN and DMN. Similar malfunctions have been observed related to the diet and disordered eating behaviors in the functional network organization [13].

Exercise and the brain health

Today, the connection between Kinesiology and the public health issues is more visible. At present, the effect of exercise on normal brain aging has been studied. The recent attempts have focused on neurocognitive benefits for brain development in children [14].

Adaptive Capacity Model (ACM) is an evolutionary neuroscience approach that connect exercise, cognition and brain health. The recent studies have shown that exercise can significantly improve the structure and function of the brain in older adults. Using evolutionary neuroscience approach, it can be seen that physiological systems, including the brain, respond to activity-related stress by increasing capacity, and decreased capacity is a strategy to reduce energy in response to inactivity. From the perspective of evolutionary neuroscience, physical activity is effective on the brain function. The study of the past shows that our ancestors engaged in aerobic physical activities. ACM makes a connection between evolutionary theory and cognitive neuroscience to demonstrate that exercise is useful for brain structure and its function. By this way, it can prevent age-related decline and diseases. In this study, the role of the exercise therapy in some of the major brain disorders among adults and children has been investigated [15]. Of these disorders, we can refer to dementia, stroke, traumatic brain injury, TBI, PTSD, and ADHD [14].

The point is that using the principle of energy minimization to the evolution of the human brain, ACM showed that brain atrophy in neurologically healthy aging is a neuroplastic adaptive response to low energy cognitive/physical activities during the life which causes brain aging and it is different from neurological diseases and brain damages [15].

Assessing and improving the organic health of the brain and its functional ability

Using manipulations of inputs of the body's senses, scientists have recorded significant changes in the human brain. They repeated the Pavlov's conditioning experiment and found that training an animal to acquire or improve a skill refined the nervous system of its brain. Using the gradual brain regeneration, they showed in their studies how the elementary brain apparatus had progressed physically and functionally from primitive to specialized, from slow to fast, and from an unreliable and erroneous information level to an almost flawless level of information processing. Physical regeneration of the brain, plasticity of the brain means behavioral/functional change, which is an

operation in our brain before birth to the end of life. The brain develops so that it takes control of the plasticity processes. As the brain develops in early infancy, a flexible control system develops that allows change only when the brain interprets that change. As scientists have put it, the neural processes of the brain are possible to improve. Neuroscientists have defined the rules govern neuroplasticity in adults [16].

The scientists addressed the reversibility of plasticity in a different way by comparing the physical and functional state of a healthy brain and a struggling brain. They examined the struggling brains and the normal developing brains (young versus old and normal childhood versus environmentally challenged childhood). They concluded that by every measure, struggling brains were physically, chemically, and functionally weaker compared to normal (developing) brains.

In an experiment, it was found that people with high functioning brain could identify a visual representation of a familiar object in about 1.30 seconds. This time was a minute for a large number of objects. This result informs us about the state of myelination in the brain system because well-insulated axons are faster. It also give us information about the bottom-up connectivity strengths of the visual perception/reception system since fast systems are strongly surface-to-surface connected while slow systems are not.

Other experiments have found that a fast brain at operations mentioned above, has a better function at almost every basic, limited visual ability. Fast, high-precision brains have better memory and stronger reasoning power. In fact, a fast, high-precision brain is organically healthier while a slower brain suffers less health. Speeding up neural processes is rather easy even when we increase performance accuracy through progressive training on computers and phones. It was seen that the training is effective and the participants improved because of the computer training [16].

Brain HQ: As an example, among people with MDD, treatment-resistant patients participated in 30 hours of progressive computer training and the results were compared with the best drug treatment methods. Behavioral improvement had two exceptions: First, training based on brain plasticity significantly improved executive control. This benefit has not been observed in patients using drug therapy. Second, training is based on plasticity and there is no need for long-term use of drugs, whereas patients using drug therapy may need to continue their therapy for the unpredictable future. It was also observed that these focused computer trainings are effective in preventing and delaying Alzheimer's. They can be used to prevent functional losses due to the traumatic brain injury (TBI-Traumatic brain injury) and the negative neurological consequences of chronic stress. Many studies have shown that that the negative neurological consequences of chronic stress are largely reversible. We came to this conclusion that this science and new strategies are tools to evaluate and improve human performance abilities [16].

Brain Health Registry (BHR): is an online platform for Recruitment, assessment, and longitudinal monitoring of participants for neuroscience studies. Participant data collection is the most important aspect of BHR that allows us to identify signs of cognitive decline. The results show that a properly designed and valid research website can effectively collect valuable data from a number of participants [17].

The relationship between mental health and traumatic brain injury

People with TBI may experience a condition called coagulopathy which is often broadly defined as any derangement of hemostasis resulting in either excessive bleeding or clotting. Scientists explain that TBI has is strongly connected with modern society because it is often caused by road accidents, construction accidents, sports injuries and violence. Brain injuries cause dramatic blood loss, and fluid infusions are used to reduce the brain swelling. However, in patients suffering TBI, coagulation may continue. It suggests that the pathogenesis of coagulopathy from brain injury is different from that due to the organs and trunk injury. In their research, the scientists found that the mechanism of TBI in causing coagulation are not fully understood, and they hope that new and targeted treatments can be achieved. In 2015, TBI in mice led to the systemic release of BDMPs, which expressed pro-coagulant molecules such as tissue factor on their surfaces. Microparticles were responsible for coagulation abnormalities after concussion. This finding is a new mechanism for coagulation due to the brain trauma.

In addition to BDMPs, the scientists have recently discovered organelle-derived brain microparticles released into the systemic circulation of mice when concussion occurs. In particular, they found mitochondrial microparticles in the systemic circulation of mice. They discovered that a phospholipid called CL on the surface of mitochondrial microparticles produced systemic coagulation in mice. Moreover, the mitochondria in these microparticles produce some kind of reactive oxygen species that activate platelets and act as a source of oxidative stress, which leads to inflammation [18].

The scientists found that PTSD could occur simultaneously with brain damage in people exposed to blasts. Certain areas of the brain are more susceptible to blast damage. Particularly, damage to the frontal cortex can lead to disinhibition of brain structures responsible for the control of fear and anxiety. Inflammatory processes associated with TBI can also affect mental health. Impaired mental health may lead to many psychological disorders, which, in turn, disrupt brain repair due to the release of stress-related hormones. Since the external environment affects strongly the internal environment of the body, improvement of the external environment can reduce anxiety and increase the chance of the neuroplasticity of brain cells. As a result, it improves performance after TBI. In this regard, computer training (Brain HQ) and exercises can improve functional losses due to the traumatic brain injury [16,19].

Meditation and neuroscience

Using whole-brain computational frameworks to describe and diagnose different brain states and MRI and DTI neuroimaging techniques, the scientists have found that different levels of brain dynamics show brain states, in health or disease, differently. They say that different states of the brain are characterized by its underlying dynamic complexity. They notably could distinguish low-level states of consciousness. Moreover, they have shown that a whole brain model can be adapted to different brain states and it can be used to promote a transition e.g., from disease to health. They applied an approach to study differences in dynamic complexity between meditator group and healthy control group during resting and meditative states using MRI. Their results evidenced that the dynamical complexity underlying meditation shows less complexity than during resting-state in the meditator group. This result is

in consistence with the recent studies including a study using electroencephalography that shows the transition from more complex dynamics of the brain during resting-state to a state of reduced information diffusion during meditation. In addition, they showed that during resting-state, the metabolism of the meditator group is higher than that of the control group. The reason is this fact that the brain dynamics of the first group during resting-state is more complex. These results are consistent with the theories of brain dynamics, showing metastability as an optimal state of neural activity at rest. It can be concluded that the professional meditators can moderate the dynamic set of the brain, limit it during meditation and boost it during resting- state [20]. Cognitive neuroscience plays key roles in mental health and stress management. An experiment on university students, it was seen that yoga and other contemplative classes offered by university health departments and centers could influence on self-care and stress reduction, positively [21].

Preserving brain health in a toxic age

Scientists have addressed many effective chemical and biological toxic agents on the brain and its function. They have focused on diseases such as chronic traumatic encephalopathy, dementia, autism, chronic fatigue syndrome, disorders and violence. They have done many researches on the chemicals known to damage brain function and lower IQ (such as lead and cadmium. Many toxic effects on the brain are due to the inflammation and direct interaction between central and peripheral neurons, the immune system, and glia. The scientists have studied how microbiome, fatty liver disease and kidney disease alter the nervous system.

Various approaches to brain health and treatment by allopathic medicine doctors: An allopathic doctor has a medical degree and the title MD (Doctor of Medicine) who practices modern, evidence-based medicine. Naturopaths, acupuncturists, chiropractors, and homeopaths practice integrative medicine, known as alternative or complementary medicine. In general, these branches of medicine focus on diet, nutrition, exercise, vitamins, yoga, meditation and better lifestyle. The goal is to use natural remedies to heal, such as herbs, massage, exercise, acupuncture, and better nutrition. Traditional Chinese medicine (TCM) is one of the methods. In Chinese medicine, Qi manages the body's current relationship with time and space. Qi (energy) in Chinese medicine is different from the concept of energy in medical science. If “being in the moment” is disrupted then the heart Qi is blocked and mental illness or various neurological disorders occur [22,23].

Covid-19 and its effect on nerve health

The COVID-19 pandemic is an almost unprecedented global health crisis. This crisis as a mental health challenge causes both the direct effects of the disease, such as the emergence of psychopathology or psychiatric disorders in patients with Covid-19, and the indirect effects associated with forced or self-imposed quarantine. In previous analyses, psychiatric disorders, such as anxiety and insomnia have been reported at higher rates in people with Covid-19 (compared to the flu or other health problems). The psychiatric consequences of the COVID-19 pandemic are not limited to the infection and the short- and long-term outcomes in survivors. In fact, the mental health outcomes of quarantine measures by the community or government, such as avoiding crowding have been studied across the general population (and not just survivors of Covid-19). The evidence obtained from the international studies showed the increased mental health problems, including depression, anxiety and distress. One solution to stress is exercise. According to the studies, the exercise has a significant effect on improving brain function and increasing energy [15]. Another strategy to overcome isolation is to replace direct social interaction with online conversation. Researchers have analyzed the relationship between the volume of brain regions and psychopathology using structural brain imaging. In this study, new evidence is provided which shows brain structure, especially insular cortex thickness, predicts increased anxiety during a pandemic. The volume of brain regions is quantified using powerful imaging techniques. Abundant data obtained from basic neuroscience studies and brain imaging in humans helped researchers to identify specific areas and networks of the brain that play a key role in regulating stress and processing emotions. Particularly, they focused on the amygdale, hippocampus, insula, as well as the caudal rostral anterior cortices, as the brain regions in the studies on the depression and anxiety disorders and the studies on the processing emotions using imaging. These areas are particularly susceptible to stress and can be affected by social quarantine. Recent basic neuroscience studies in rodents have shown short-term (as well as long-term) plastic changes in the inner parts of the amygdala due to the quarantine. The analyses were done on individuals with a previous or current diagnosis of depression or anxiety disorders. The results showed that that both previously healthy individuals and those with a history of mental health problems may develop transient or persistent symptoms in a subclinical range [24].

Brain-mind-body trichotomy

In their researches, the scientists have found how environmental and genetic factors affect the brain and regulate behavior in interaction with the body. Research provides a conceptual framework combining genetic, developmental, and social factors. Thus, it is an example of successful interaction between neuroscience and mental health. As studies show, the results of the increased activation of the peripheral immune system (body) are as follows: (1) the production of neurometabolites from the tryptophan cascade activated both in the brain and the liver, (2) increased activation of microglia cells (immune cells of the brain) by circulating cytokines and (3) changes in brain function via local afferent pathways in the peripherally stimulated vagus nerve. These three changes can, in turn, lead to the changes in the function of neurotransmitters (increased glutamatergic and decreased serotonergic and dopaminergic activity) and inhibition of neuroplasticity and neurogenesis, that is, the birth of new neurons and the formation of new dendrites and synapses. Some gene variants associated with increased immune system activation can increase the risk of psychopathology. Research has shown that the effects of the immune genes on behavioral outcomes are more than the effects of the psychiatric genes. Other patients show increased immune activity not due to the genetic predisposition but due to the environmental factors, including exposure to injury, social deprivation, or unhealthy diet. Exposure to trauma in early life is one of the most consistent environmental factors that increases the risk of developing mental disorders. As researches have shown, early childhood trauma activates the immune system in young adults who may expose to higher risk in their later life. Moreover, immune system activation can increase due to a variety of social adversities, such as exposure to personal mistreatment or violence, socioeconomic disadvantage or isolation, and other chronic stresses. The studies found that fish consumption is effective on the treatment of mild/moderate

forms of depression and protection against psychosis (Fish is a rich source of long-chain omega-3 fatty acids, which strengthen the brain cells and increase serotonin production). In addition, high levels of inflammation in healthy individuals predict the future development of psychopathology in later years. An immune activator for experimental or therapeutic purposes can produce neuropsychiatric symptoms, from transient sadness to depression, anxiety, or even (rarely) psychotic symptoms. It has been identified that both antidepressants and antipsychotics are immunosuppressive and anti-inflammatory. The studies on neuroscience and mental health on a medical base showed that while the brain is influenced by the body, the mind is a product of the brain. The brain is a complex organ influenced by many factors such as genetic structure, womb environment, social experience, upbringing, nutrition, poverty, social support, urbanization. However, all these factors have effects on the mind by the brain [25]. Research shows that besides the brain, trillions of bacteria and microbiome have complex relationships with the brain, the whole body, the environment and the food of the individual. Studies on these microbiomes show that humans may can influence their mental health by making specific physical changes [12].

Conclusion

Individuals who regularly do physical exercises can resist the effects of dementia in a better way. Obesity and the organization of the brain's functional network are connected. Yoga and other contemplative classes can influence self-care and stress reduction in a positive manner.

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