

Brain health: Disease correlation and artificial intelligence

Bowei Chen

Zhongshan School of Medicine, SUN YET-SEN University, Guangzhou, Guangdong, 510080, China

chen243@mail2.sysu.edu.cn

Abstract. The brain is one of the most vital organs for us to perform through daily activity. But due to the lifestyle changes within modern society as the consequences of advancement of technology, more health issues have got into the public. Dementia and stroke are the two leading disability causes that are highly associated with the changes in modern society and the lack of brain health concepts for the general population. This article focuses on the two diseases, and how does it impact on brain health and correlate with daily lifestyle, moreover, the aim is to prevent the occurrence and promote healthier brain health to fulfill the performance. Artificial intelligence (AI) is a revolutionary technology that can help improve brain health from many perspectives. AI can not only help doctors diagnose neurological diseases, but also assess an individual's cognitive function. Advances in AI can deepen our understanding of neuroscience, making it possible for stroke and dementia patients to recover through devices implanted in the brain that coordinate all signals and function normally, just like a normal brain. Advances in AI bring hope to neuroscience research. Also, with the development of AI techniques, it can lead to changes in perspective of the ways to develop in the future neuroscience industry as well as assist in brain health.

Keywords: Brain health, stroke, dementia, Artificial intelligence.

1. Introduction

The brain, one of the most vital organs in the human body, plays a major role in motor movement, cognitive status, memories and other vital signs, together, they function in different variety of aspects that are coherently in daily life. With the overall improvement in living conditions and the changes in social habits, the mean age of death has gradually increased, which also leads to an increase in the elderly population as well as higher incidence of obesity and hypertensive population. These factors played a major role in the rising cases of neurodegenerative disease and stroke, as well as several other neurologic-related conditions. Under these circumstances, the concept of brain health has got into the public's eye. With the early prediction and intervention of brain health, it can prevent most of the neurological and psychiatric illness, which turns out to have a more favorable lifestyle and better quality throughout the later stage of life. Several research show that with optimistic attitude, positivity, and purpose in life will gradually reduce risk of dementia [1].

As far as the complexity of the brain, with its function covering multi-aspect of daily life, the understanding of the brain is still challenging, but as technology has more advanced in recent years, and the understanding of the cellular biology of the brain is getting more mature, brain health, nowadays, can not only detect several psychiatric disorder as well as structural disorders, but can also boost the

cognitive function and also the physiological activity, as well as the release of AI technique, which will ultimately lead to greater change on brain. AI and neuroscience are interrelated, as computer scientist develops algorithms for learning in AI techniques, this further helps AI to build up complex applications, such as robotic surgery, vehicles, etc., This trait is a perfect fit for the study of neuroscience, as it can also help in detection of neurologic disorders. As a recent study from Harvard Medical School shows that it can successfully identified cryosection with malignant tissues and classified the histologic grade of glioma during neurosurgery [2], especially when pathologist have load amount of work, chances of misdiagnosis increase. But with the help of AI, it can also help reduce the occurrence of misdiagnosis.

This article will talk about the benefits of brain health and how AI techniques will revolutionize the brain and to maximize the benefits of human life.

2. Approaching to brain function and its related disease

The National Institutes of Health (NIH) defines brain health as functioning across several key areas: 1) cognitive functioning, including thinking, planning, and memory processing; 2) motor functioning, involving physical activity; 3) emotional functioning; 4) Tactile functions, including sensations of touch, pain, temperature, and pressure. To better understand these functions, imagine a person traveling: first, making travel plans involves cognitive functions; second, traveling to the destination involves motor functions; and finally, the pleasant emotions felt during the trip involve Emotional functions. Through this example, it can be seen that the importance of brain functions in daily activities, because these functions are interrelated, and the loss of any one part can have a significant impact on daily life. Of all these functions, two are highly associated with disease and are experiencing a significant increase in cases worldwide: cognitive function, which is associated with dementia; and motor function, which is associated with stroke.

2.1. Dementia

Diagnosis of dementia requires number of tests to complete, based on Mayo Clinic's guidelines for diagnosing dementia, the clinician will approach first by starting with cognitive/neuropsychologic tests to evaluate the patient's ability to process the memory or reasoning. Second, brain scan to determine if there is any underlying etiology, different types of dementia will present entirely different from others. Third, psychiatric evaluation and lab testing might be required as well. Diagnosis of dementia needs to be precise considering that there are other factors that also share a common interest but are not considered pathophysiological changes or may be due to associated symptoms. Aging is one of the bigger roles that needs to be differentiated. In aging, patients might also experience loss of memories and different degrees of declining cognitive function, but the distinction between aging and dementia is that dementia would have a significant loss in daily basic skills such as brushing teeth or utilization of utensils to assist in food consumption. In addition, dementia patients may also experience altered mental status, loss of communication skills, or other behavioral changes. Other subtypes such as Lewy body dementia may also present with movement disorders such as muscle stiffness, difficulty swallowing or walking, frequent falls, etc.

2.2. Stroke

Stroke is the second leading cause of death and one of the major causes of disabilities worldwide [3], is considered one of the most burdensome disease throughout the globe, and it can impair not only cognitive function but also motor and sensory function, social abilities and more. It mainly affects the blood vessels within the brain, whether ischemic or hemorrhagic, the ultimate consequence is a lack of blood supply to specific lobes or area of the brain, in which its correlated supplemental area will all be affected. The impact on individuals and caregivers as well as their family members also raised concerns by causing a high incidental rate of anxiety and depression among the caregivers [4]. A scientific report from Nature shows that numbers of 297 family caregivers among 819 total cases had anxiety, with 192 cases experiencing depression [4]. Moreover, the impact of stroke on global economics is also non-negligible, as the American Heart Association (AHA) collected the database for overall stroke and its

subtypes from Global Burden Disease (GBD) study, and PPP data from World Bank. These two data were combined to estimate macroeconomic loss via value of lost welfare (VLW) approach; the result shows that VLW due to stroke accounts for \$2059.67 billion, or 1.66% of global GDP [5]. These data pointed out the severity of stroke impact among individuals as well as societal aspect. To improve stroke services and address the issue, WHO conducted a survey about the stroke services status throughout the global, high-income and low-income countries [6]. The results turn out to be astounding. The overall global score for stroke prevention is only 40.2%. Unsurprisingly, stroke units in high-income countries present 91%, in contrast, only 18% are present within low-income countries. Even in high-income countries, acute stroke treatment was offered only 60%. Lack of stroke awareness, shortage of stroke units, delays in appropriate treatment and household income, etc. factors contribute to further stroke management. Approaching stroke management is complex, but prevention methods are still the priority goal among all the treatment and critical care for stroke. Nevertheless, brain education nowadays is still unrepresentative, as stroke occurrence among young adults is still rising globally, due to several factors such as illicit substance use or unhealthy lifestyles [7]. Based on the above review, consequences of both dementia and stroke are usually predicted to be non-favorable, and the chances of full recovery are as near impossible, eventually, patients will carry certain degrees of complications through their later lives. As an affected individual, patients are likely unable to perform daily basic tasks to maintain their living conditions, with familial caregivers experiencing certain amount of stress upon taking care of the patients, simultaneously, the household expenses for medical bills will increase, which further worsen family burden. Promoting wealthy brain health is still the primary goal for every individual.

3. Brain health maintenance

As modern techniques advance, brain testing is getting more mature, with MRI and CT imaging can help doctors for a brief evaluation for structural disease, the utilization of EEGs, EPs, or nerve conduction studies also helps with understanding of the neurophysiologic pattern of the brain. Beside the structural aspect, evaluation of one's cognitive function can also be accomplished by performing certain simple tasks such as answering questions, repeating a list of words or the way you respond with the testers. Cognitive test is one of the most important, non-invasive pathways to rapidly assist doctors to evaluate patients' cognitive function, hence, patients are more willing to participate in assessing one's brain health condition as the testing is likely to be more affordable, convenient, and more easily to follow the instructions. With that said, assessment of one's brain health are not as considered to be as complicated toward general population's opinion. Despite the medical approach, in the prevention of dementia, even there are some subtypes of dementia that are not preventable, but the goal in brain health is to not only prevent the disease, but to maintain a healthy brain. The Lancet Commission provided a model approaching modifiable risk factors, it estimates the attributable fraction and assists general population in understanding reduction of new cases of dementia if specific risk factors were eliminated [8]. This model was divided into 3 subgroups, early life factors (age < 18 years), mid-life factors (age 45-65 years), and late-life factors (age > 65 years). In early intervention, education is still the major executive plan; in mid-life intervention, the modifiable risk factors are hearing loss, hypertension, and obesity. In late-life modifiable factors, smoking, depression, physically inactive, social isolation, DM are the major risk factors. These 9 models account for one-third of the dementia cases that are preventable [8]. In other words, promoting a healthy lifestyle such as losing weight, maintain normal blood pressure and blood sugar, as well as staying physically active, eating healthy diet, cutting bad habits such as smoking, using illicit drugs or alcohol. These factors are so intertwined with the daily life, that a subtle change of one's own habit can significantly reduce the later occurrence of future dementia.

To prevent the incidence of stroke, certain risk factors should be addressed. Under the review of stroke by John Hopkins Medicine article indicates that risk factors include: (1) Hypertension, (2) heart disease, (3) Diabetes, (4) Smoking, (5) Oral contraceptives, (6) High blood cholesterol and lipids, (7) smoking/alcohol/substance use, and finally (8) Obesity. Exposure to hypertension, high plasma glucose levels, high lipids, obesity, and smoking are predominantly the leading cause for further progression of stroke incidents [9]. In regards to the risk factors, prevention of stroke is possible. Lifestyle changes can

really help in reducing the risk of stroke. Physical activity is one of the most power, executable activity in preventing stroke as well as cardiovascular risks. It not only lowers the rate of obesity but also regulates the blood lipid and glucose levels as well as reduction of blood pressure. Studies show that engaging in moderate intensities of physical activity such as swimming, jogging, or other aerobic activities was associated with reducing risk of stroke, but light activity did not have the same effect [10]. Another lifestyle change can be approach to daily diet. Study shows that DASH diet significantly reduces the risk of obesity and hypertension. It recommends consuming vegetables, fruits, whole grains, as focus on fat-free or low-fat products such as fish, nuts, and vegetable oils. It also recommends the limitation of craving products that are high in saturated fat or sweet [11]. Other habitual changes such as withdrawal of alcohol, smoking, also lower the risk of stroke.

4. AI and the correlation to neuroscience

The advancement of technology has grown rapidly in recent years, one of the most topical subjects is AI, as it revolutionized multiple aspects throughout various disciplines. Several key components in AI such as machine learning, artificial neural networks, or deep learning, develop these fields not only to intelligently analyze the patients' data, but also to help understand complex information, and extract hidden patterns and assist humans for better understanding the mysterious of neuroscience [12]. Spatially embedded recurrent neural networks (seRNNs) lead by University of Cambridge, is a special regularization function which embeds them in a 3D box space with local communication constraints, which is intended to model a very simplified version of the brain. They design the system by placing physical constraints on an AI as the same way of human brain must develop and operate under constraint condition. They found that there are several key characteristics that are similar to brain, in which they replace neurons as computational nodes, and they take inputs, transform into outputs and send it to other nodes, this process is known as neural impulse in neuronal function. Each node was given with a specific location in the virtual space, as the two nodes are further away from each other, the harder to communicate, this is the physical constraint in the system. Initially the system does not perform the task successfully, but when given with feedback, they found out the system would also utilize how human brain would do – highly connected nodes that act as channel for passing information across the network [13]. Not only AI can help with brain development, but also assists in mental health and diagnosis of neurological disorders. The inaccuracy and subjectivity in cognitive assessment, and the lack of standardized screening and guidelines often lead to mis/undiagnosed of cognitive impairment, but with AI, systems such as ANN, MLP, RNN, etc., help increase the accuracy of diagnosis of neurological disorders [14]. Additionally, it also helps with neuroimaging. Imperial Biomedical Research Centre collaborates with the University of Edinburgh for detecting small vessel disease within the brain, which is the leading cause of stroke and vascular dementia. The researchers collected data from 1082 CT scans of stroke patients across 70 hospitals in the UK between 2000-2014 and compared the results from AI and expert doctors who estimated SVD severity from the same cases, it turns out that AI has an accuracy of 85% at predicting the disease severity [15].

5. Conclusion

In conclusion, due to the aging of the population as well as lifestyle changes through the past few decades, dementia and stroke occurrence have inclined throughout the year. Numerous studies show that certain risk factors are highly associated with stroke and dementia, as they both are highly burdened diseases throughout the global. Moreover, stroke and dementia would also lead to a non-favorable lifestyle in the individuals, more likely to suffer different symptoms causing them unable to perform the basic tasks to survive, which would put a more stressful situation for the caregivers. In this article aims for healthy lifestyle such as maintaining aerobic activity, healthy diet to prevent the later occurrence of dementia and stroke as these two diseases share common interests of risk factors. The maintenance of brain health can also be accomplished by setting goals, being social, which can also optimize for further brain health as well. Prevention is still the key to any neurological disease if possible. Despite the daily approach, AI is a revolutionized technique that can assist brain health from multiple perspectives. It can help

doctors diagnose neurological diseases as well as assess one's cognitive function, furthermore, the advancement of AI can lead to a better understanding of neuroscience, and the connection between AI and neuroscience making it possible for stroke patients as well as dementia patients to recover from the disease if there's a device that is able to put in one's brain, coordinate all the signals, as well as to function properly as the usual brain is. The advancement of AI puts hope into further study of the neuroscience industry, but most importantly, in order to have a quality life, maintaining a good habit should not be neglected.

References

- [1] Mintzer J Donovan K A Kindy A Z Lock S L Chura L R & Barracca N 2019 Lifestyle choices and brain health *Frontiers in Medicine (Lausanne)* 6 204
- [2] Nasrallah et al 2023 Machine learning for cryosection pathology predicts the 2021 WHO classification of glioma *Med*
- [3] Katan M & Luft A 2018 Global burden of stroke *Seminars in Neurology* 38 2 208-211
- [4] Zhao J Zeng Z Yu J Xu J Chen P Chen Y & Ma Y 2021 Effect of main family caregiver's anxiety and depression on mortality of patients with moderate-severe stroke *Scientific Reports* 11 1 2747
- [5] Gerstl J V Blitz S E Qu Q R Yearley A G Lassarén P Lindberg R & Bernstock J D 2023 Global regional and national economic consequences of stroke *Stroke* 54 9 2380-2389
- [6] Owolabi M O Thrift A G Martins S et al 2021 The state of stroke services across the globe: Report of World Stroke Organization–World Health Organization surveys *International Journal of Stroke* 16 8 889-901
- [7] Bukhari S Yaghi S & Bashir Z 2023 Stroke in young adults *Journal of Clinical Medicine* 12 15 4999
- [8] Orgeta V Mukadam N Sommerlad A & Livingston G 2019 The Lancet Commission on Dementia Prevention Intervention and Care: A call for action *Irish Journal of Psychological Medicine* 36 2 85-88
- [9] The rising global burden of stroke 2023 *clinical medicine*
- [10] Gallanagh S Quinn T J Alexander J & Walters M R 2011 Physical activity in the prevention and treatment of stroke *ISRN Neurology* 2011 953818
- [11] National Heart, Lung, and Blood Institute. (n.d.). DASH Eating Plan <https://www.nhlbi.nih.gov/education/dash-eating-plan>
- [12] Surianarayanan C Lawrence J J Chelliah P R et al 2023 Convergence of artificial intelligence and neuroscience towards the diagnosis of neurological disorders-A scoping review *Sensors* 23 6 3062
- [13] Achterberg J & Akarca D et al 2023 Spatially embedded recurrent neural networks reveal widespread links between structural and functional neuroscience findings *Nature Machine Intelligence*
- [14] Thakkar A Gupta A & De Sousa A 2024 Artificial intelligence in positive mental health: A narrative review *Frontiers in Digital Health* 6 1280235
- [15] Imperial College London 2018 Artificial intelligence (AI) improves stroke and dementia diagnosis in brain scans. *Brain Sciences*. <https://imperialbrc.nihr.ac.uk/2018/05/23/artificial-intelligence-ai-improves-stroke-and-dementia-diagnosis-in-brain-scans/>