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THE CRUCIAL ROLE OF CEREBRAL PLASTICITY IN THERAPEUTIC STRATEGIES FOR COGNITIVE ENDINGS IN AGING

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Abstract:
Objective: This essay critically examines the relevance of cerebral plasticity in the therapeutic approach to cognitive decline associated with normal ageing and neurodegenerative conditions such as Alzheimer's disease. The primary focus is on investigating whether interventions aimed at enhancing brain plasticity can offer therapeutic benefits in mitigating cognitive impairments related to ageing.

Methods: Current neuroscientific studies form the foundation of this analysis, with an emphasis on exploring the potential advantages of modifying brain plasticity to address cognitive limitations in elderly individuals. The essay reviews existing literature to discern the effectiveness of interventions targeting the nervous system's plasticity, even in advanced age, as a means to alleviate or prevent cognitive decline.

Results: The findings suggest that the retention of the nervous system's plasticity in older individuals provides a basis for therapeutic strategies. The essay delves into scientific evidence supporting the hypothesis that interventions leveraging brain plasticity can contribute to healthier ageing, considering factors such as nutrition, physical activity, health status, and cognitive training.

Conclusion: This work supports the proposition that cerebral plasticity stands as a crucial element in promoting a healthier old age. The evidence presented implies that interventions addressing brain plasticity through various means, including physical exercise, cognitive training, and other interventions, may offer a promising avenue for preventing or ameliorating cognitive decline associated with ageing and neurodegenerative diseases.

Keywords: training; physical exercise; intervention; Alzheimer's disease; satisfactory ageing; cognitive decline.

INTRODUCTION:

Different alternates connected to a neuron and its connections were called "plasticity". Plasticity is the capacity of a neuron to adjust to alterations in its internal or external environment, as well as to past experiences or traumas. Several experimental studies demonstrate that the nervous system undergoes morphological changes in response to various experiences. Accordingly, one of the main goals of neuroscientific research is to ascertain whether modifying and improving plasticity can be therapeutically beneficial in treating cognitive deficiencies linked to various neurodegenerative disorders and normal ageing. The subject that is actively addressed is how much behavioural, pharmacological, or other types related to plasticity can aid in the recovery of cognitive functioning (Muñoz et al., 2020).

However, the first issue that needs to be addressed for these interventions to be effective is whether or not this plasticity is preserved as we age. As recently noted, it is imperative to recognize the problems raised for the central nervous system during the ageing process to ascertain the aspects that may be significant to achieve a more fulfilling ageing process. But while a great deal of research has been done recently on the neurobiological alterations brought on by ageing, relatively little of it has addressed the variables that are thought to be significant in other facets of ageing (experience, nutrition, exercise, effects of effort, etc.). Recent articles on this topic indicate a growing number of changes in the situation (Glinert et al., 2022).

In this work, we aim to make the scientific tests that support our hypothesis available: cerebral plasticity may play a significant role in treating cognitive changes linked to pathological and normal ageing. This paper will examine a few broad issues regarding cerebral plasticity and ageing in keeping with this objective. Next, the different therapeutic variables and approaches related to plasticity that may be alleviated in managing age-related cognitive impairments will be discussed. Lastly, a brief discussion and broad conclusions will be presented (Ali & Kunugi, 2020).

Table 1: Introduction and Objectives

Topic	Key Content	References
Definition of Plasticity	Capacity of neurons to adjust to internal/external changes, past experiences, traumas	Muñoz et al., 2020
Research Goal	Explore therapeutic benefits of modifying/improving plasticity in treating cognitive deficiencies	Muñoz et al., 2020
Plasticity in Ageing Process	Address preservation of plasticity during ageing, recognize challenges for the central nervous system	Glinert et al., 2022

Neuronal adaptability

The tremendous flexibility exhibited by mammals, particularly humans, is associated with plasticity, which accounts for the remarkable capacity for adaptation of living things. Much of this topic's

research has been devoted to understanding how synaptic plasticity affects how neurons react to prior experiences. The idea is still crucial to comprehending synaptic plasticity and the alterations brought on by ageing and Alzheimer's disease. Through the use of deprivation and stimulation techniques, it has been shown in both humans and animals that the way the body interacts with its surroundings is a model of the brain (Moussaoui et al., 2023).

As a result, it has been noted that in rodents, for instance, both formal training and unofficial experience in a variety of settings can result in neuroanatomical and chemical changes that can be measured in the brain (such as an increase in the occipital cortex's cortical thickness, an increase in the size of the bodies and cell nuclei of neurons, an increase in the number of neural synapses, and an increase in synaptic contact areas). These modifications point to a significant improvement in the capacity to process various kinds of data. In human subjects, the benefits of an enriched environment have also been demonstrated (Espino de la Fuente-Muñoz et al., 2020).

Research has demonstrated that exposure to rich experiences during early life enhances brain function in later life. These variations brought on by varying experiences may be connected to changes in the brain that occur throughout life. This is consistent with the finding that learning is the cause of these effects (Kodali et al., 2021).

Table 2: Plasticity and Environmental Experiences

Topic	Key Content	References
Plasticity in Neurotransmitters	Preservation of neurotransmitter receptors' plasticity, cognitive benefits in ageing	Crispino, Volpicelli, et al., 2020
Flexibility Across Age Groups	Degree of plasticity in response to experiences varies across age groups and brain systems	Zhou et al., 2022
Importance of Active Use	"Use it or grant it" concept, potential for improved circumstances in ageing through active plasticity	Sochal et al., 2022

Table 3: Lifestyle and Aging Intervention

Topic	Key Content	References
Lifestyle Changes	Attempts to prevent physical and cognitive deterioration through lifestyle changes	Stuyvenberg et al., 2021
Limitations of Preventive Measures	Debates on whether medical care or preventive measures can stop the inevitable degeneration in ageing	Stuyvenberg et al., 2021

Ageing and plasticity

In addition to cell death, the ageing brain exhibits neuronal shrinkage and functional impairment features. The brain experiences quantitative and qualitative changes as it ages, including modifications to the number of neurons, dendritic expansion, and the number and structure of synapses. These particular structural changes in specific regions (cortex, hippocampus) are likely linked to ageing-related behavioural capacity declines and plasticity declines. Several alterations that could at least partially explain the ageing-related decline in physiology and cognition indicate this decrease in plasticity. On a cellular and systemic level, the ageing brain is less adaptable to environmental and physiological cues (Penna et al., 2020).

Based on the current research, it is underlined that the ageing brain loses some of its adaptability. Furthermore, it has been proposed that abnormal forms of neuroplasticity may facilitate certain neurodegenerative disorders. Nonetheless, some scholars have suggested that a certain degree of flexibility persists throughout an individual's life, albeit in lesser doses. Thus, it has been noted that both normal ageing and Alzheimer's disease preserve adaptive growth and regeneration responses. The investigation into the neuropathological alterations linked to advanced ageing has shown that certain highly developed subjects (those classified as "the old, old man" or "elderly people among the old") exhibit, at the brain level, a complete lack of senile plates and a low density of neurofibrillary

in the training of hippocampi, which are connected to an unexpected preservation of cognitive abilities (Murawska-Ciałowicz et al., 2021).
These individuals have been dubbed "super normal centenarians" because they appear to be able to surpass the lowest bound of typical brain ageing. It has also been shown that neurotransmitter receptors are plastic. For instance, a similar rise in postsynaptic receptor number or affinity is seen following the death of corresponding neurons, as with antagonist medication delivery. At the cognitive level, findings from long-term research on variations in intelligence throughout a lifetime indicate that a significant degree of plasticity is preserved with ageing: in highly skilled individuals, a certain degree of flexibility in the neural system related to learning is retained (Crispino, Volpicelli, et al., 2020).

However, the brain consequences of diverse environmental experiences manifest in younger individuals slightly earlier than in older individuals, and the difference is also more pronounced in younger individuals. It has been underlined that not every brain system and experience type maintains this ongoing plasticity. Consequently, it appears that the degree to which the adult brain retains its plasticity in response to a particular kind of experience will vary depending on the area of the brain that is affected, the nature of the event, and the factors that either strengthen or weaken this plasticity (Zhou et al., 2022).
However, it is considered that this flexibility depends on how it is used, which may be confirmed by saying, in the words of other writers, "Use it or grant it." This prompts us to speculate that the individual may experience improved circumstances when the inevitable losses of ageing become apparent if he exercises this kind of plasticity throughout his life or can put tactics into place to strengthen it. Thus, some automorphisms have suggested that ageing refers to "disuse." This creates opportunities for intervention since neurons respond to active use in the same way that arteries, bones, muscles, and so on (Sochal et al., 2022).

Vast amounts of time and money are being invested, which speaks to the significance of this issue and its ramifications. Meanwhile, some individuals attempt to prevent normal aging-related physical and cognitive deterioration by adopting specific lifestyle changes (e.g., eating a balanced diet, exercising frequently, reducing stress, etc.). When faced with this, some authors believe that even medical care or alternative preventive measures cannot stop the inevitable degeneration of the brain that occurs with ageing as the last stage in an evolutionary process (Stuyvenberg et al., 2021).

Table 4: Cerebral Plasticity and Ageing

Topic	Key Content	References
Cerebral Plasticity Overview	Role in treating cognitive changes linked to pathological and normal ageing	Ali & Kunugi, 2020
Structural Changes in Aging	Quantitative and qualitative changes in the ageing brain, impact on behavioural capacity and plasticity	Penna et al., 2020
Adaptive Growth in Aging	Preservation of adaptive growth and regeneration responses in normal ageing and Alzheimer's disease	Murawska-Ciałowicz et al., 2021

Alzheimer's illness and plasticity

Neural loss in Alzheimer's disease appears to be location-, size-, and chemistry-specific. Most losses in neural perceptions occur in the "large neurons" that link cortical areas (cortical-cortical association highways). These reductions surpass those seen in normal ageing. The hippocampal connections with the thalamus, cortex, hypertrophic region, and brain trunk are also changed, which may be the reason for the disease's cognitive abnormalities. The hippocampal neuronal loss in Alzheimer's disease patients' brains is higher than that seen in healthy ageing. Data, however, suggest that Alzheimer's

disease also exhibits some degree of use-dependent plasticity, albeit in a different way than typical ageing (Crispino, Trinchese, et al., 2020).

Neuritic development and remodelling after neuronal degeneration may be advantageous, supporting the pathophysiology of cognitive decline, or detrimental, aiding in maintaining cognitive function and restoring efficient synaptic connections. Certain types of plasticity have been proposed as potentially compensatory in the early stages of the disease and as post-riverly factors that contribute to neurite plate formation, other neuropathological alterations, and the demise of susceptible neurons. The potential therapeutic benefit of neurotrophic factors, such as nerve growth factor, which promotes the development and maintenance of neurons, makes this topic especially crucial (Colucci-D'Amato et al., 2020; Crispino, Trinchese, et al., 2020).

Behavioural techniques that stimulate brain activity to promote neuroplasticity may be another helpful intervention. For instance, research has demonstrated that exercise, which is well-recognized to have numerous health advantages, may boost the expression of neurotrophic factors. This rise occurs in the hippocampus and other brain regions linked to higher cognitive abilities in a few days (Schroyen et al., 2020).

Treatment ramifications

As mentioned above, evidence exists that the brains of the aged typically and those suffering from Alzheimer's disease exhibit structural alterations consistent with neuroplasticity models. Improving this plasticity through various forms of intervention could be a valuable strategy for treating cognitive deficits and neurodegeneration linked to ageing and Alzheimer's disease. If, as multiple studies have shown, synaptic plasticity plays a role in learning and memory, then we can presume that synaptic plasticity changes in response to memory deficits (Joushi et al., 2021).

There appear signs that the loss of previously created Sinapsi may be connected to the cognitive changes ageing brings. Research helps us to pinpoint ways to stop and enhance these memory changes; for instance, it has been proposed that daily exercise in the early stages of Alzheimer's disease could stop the disease's sufferers' memory from getting worse. Studies in favour of this kind of intervention are still complex to come by, though (Gerber & Matuschek, 2023).

Elements that support acceptable cognitive ageing:

The idea that people who score higher on measures of life satisfaction, social status, social participation, or cognitive performance will have less cognitive decline than people who score lower on these measures is expected in the literature on ageing. In these proportions. There is still a dearth of empirical evidence supporting this theory, but more expert research and epidemiological data indicate its potential validity (Gudkov et al., 2023).

It is thought that cognitive ageing is a crucial component of ideal ageing. As a result, a lot of research attempts to pinpoint the elements that can support an individual's cognitive functioning and make corrections as they age. Some elements that appear to promote a more contented ageing process at the cognitive level are listed below; their benefits may be partly attributed to the nervous system's lifetime plasticity. The following are some of the most significant variables that have been shown to have a remarkable impact on contented ageing: one's personality, cultural experiences, cognitive training, work, exercise routine, education, and IQ at the start of adulthood; and others (Mut-Arbona & Sperlágh, 2023).

- ***Medical status***

Numerous physiological markers have been linked to the risk of cognitive deterioration. Cognitive performance in old age is connected to the state of health (number of illness episodes, chronic diseases, physical exercise), the subjective month of health, and health-related activities (e.g., alcohol

and tobacco usage). One of the characteristics that lowers the risk of cognitive decline in senior age is, for instance, the absence of chronic conditions such as cardiovascular disorders. It should be highlighted, nevertheless, that this does not mean that the two variables are causally related (Bae et al., 2020).

According to epidemiological research, an accurate sense of time is positively connected with an older person's degree of intelligence (see the "Berlin study on ageing"). Additionally, it has been proposed that age-related cognitive alterations can be mediated by sensory acuity. The "McCarthur Study on Satisfactory Aging" found that participants with greater levels of cognitive functioning smoked less. Additionally, clinical data derived from increased activity showed a link between high blood pressure and poorer performance on cognitive tests. It was demonstrated in the "Honolulu ageing study" that elevated systolic blood pressure was associated with lower cognitive functioning twenty years later (Bae et al., 2020; Speranza et al., 2021).

The physical underpinnings of this cognitive detention may be explained by a variety of physiological and structural alterations in the brain connected to hypertension. These findings have significant intervention implications since medication and dosage adjustments can alter blood pressure. Thus, blood pressure maintenance and management programs may play a significant role in preventing age-related cognitive delay. Several disorders and treatments might adversely affect older adults' cognitive ability. The most crucial medical approach for treating older individuals is the appropriate administration of medications. The key to treating acute diseases, preserving present health, and averting further deterioration, three crucial elements of satisfying ageing, is optimal pharmacological therapy (Błaszczyk, 2020).

Consumption patterns may also have a significant impact on cognitive performance. The "Student of Rotterdam" epidemiological data revealed that a diet richer in antioxidants, especially carotene, may protect against age-related cognitive decline. However, interpreting these kinds of studies is complicated because these are transversal projects whose results could be referenced by various variables (health conditions, disorders, etc.). It has been confirmed in a recent study with a 6-year follow-up that the content of many nutrients (proteins, vitamins B-6 and B-12, foals, riboflavin, etc.) was connected to the performance on cognitive tests. Given that the data are correlative, they do not necessarily indicate a cause-and-effect relationship and do not rule out the potential impact of unknown variables. However, they highlight the necessity for a more thorough examination of the potential impacts of the participant's nutritional status on cognitive function (Sharma et al., 2021).

- ***Exercise***

Daily exercise is considered crucial for maintaining mental health, improving cognitive performance, and leading a healthy life. According to a 1992 International Sports Psychology Society research, regular exercise can help treat conditions like osteoporosis, diaosthe, and hypertension, which have a high incidence index among the elderly. Additionally, there is proof that physical activity enhances psychological health and can be cognitively stimulating. Cognitive functions involve numbers. According to epidemiological research conducted on older people, regular physical exercise is linked to survival and cognitive function in ageing, both in men and women (Nguyen & Ehrlich, 2020).

They found that regularly engaging in physically demanding activities, like gardening, is a strong indicator of considerably higher scores on separate cognitive operating tests for individuals aged 70 to 79. These findings support the notion that "it's never too late to start" fitness regimens. Frequent engagement in moderately intense physical activities (bike riding, walking, etc.) can maintain physical functioning and independence by promoting muscle strength, coordination, and flexibility. These results suggest that regular physical activity may help prevent age-related deterioration in cognitive function. A small amount of study was also done to identify the processes that would account for the beneficial effects of physical activity on mental health (Shityakov et al., 2021).

Numerous hypotheses have been put up. However, they primarily concentrate on psychological elements (distraction, domain) rather than the physiological elements (endorphins, category, temperature). Additionally, it has been proposed that exercise affects the central chemical mechanisms supporting the brain's plasticity and upkeep. For instance, Ratti's research has shown that increased physical activity is linked to higher levels of neurotrophic factor expression in the cortex and hippocampus. Animal behaviour can, therefore, impact the composition and functionality of the nervous system and highlight any previously noted plasticity based on central nervous system activity (Bourgognon & Cavanagh, 2020).

- ***Educational attainment and IQ***

Evidence for the role these characteristics play in the so-called "cognitive reserve" comes from studies showing that people who are more intelligent and well-educated at the start of adulthood do better on cognitive tests. According to the study and its partners, highly educated individuals performed better on several cognitive tests. Early childhood educational experiences also appear to have some protective effects against dementia-related cognitive impairment. Nevertheless, assessing how intelligence levels throughout life affect cognitive performance in old age is challenging due to the lack of longitudinal research. Furthermore, some published results indicate that subjects with high IQs may retain cognitive and, more importantly, nonverbal skills (Zhao et al., 2020).

Education seems to be one potential defence against the ageing-related decline in cognitive abilities. The scientific community has not given this issue the attention it merits. It is still unclear how this component produces its advantageous benefits. Research indicates that early life learning may positively impact the development of neural networks and brain functioning. Another point of discussion is how education encourages intellectual pursuits throughout life, which support the preservation of cognitive function. Additional potential explanations pertain to the influence of education on employment and income levels and the educational trajectory's propensity to inculcate values that suggest a higher functional state after death (Gómez-Nieto et al., 2020).

- ***Character and emotional condition***

A lessening of cognitive deterioration was linked to a flexible personality. A further key predictor of cognitive performance is self-efficacy, the conviction that one's activities may have the desired result, and the ideas of dominance and control over one's actions. Research has demonstrated a connection between the preservation of cognitive abilities in old age and one's belief in executing tasks and maintaining structure. Reduced cognitive function is consistently linked to depression and anxiety (AlAzzam et al., 2021).

- ***Instruction in cognition***

Several studies have demonstrated that training and environmental factors can impact mental health and change the survival and function of different neuronal populations in the SNC. These consequences could be especially noticeable as one age. The adage "use or give them" is gaining more and more evidence to support the idea that being active as one age might help preserve memory and other cognitive abilities. For instance, it has been noted that training can increase the number of synapses, cortical thickness, or neuronal branches. Consequently, it stands to reason that environmental stimulus may excite atrophic neurons if neural plasticity is retained to some degree in the aged and Alzheimer's patients. It is essential to distinguish between situations where the subject is implicit in the selection, perception, and integration of stimuli and those where the subject is passively exposed to many stimuli when assessing the effects of environmental modification on the brain (Servili et al., 2020).

The subject must actively interact with its surroundings for plasticity to occur. This should be considered while designing plasticity in both Alzheimer's disease and normal ageing. As a result, research has shown that cognitive practice and training can partially reverse the effects of aging-

related cognitive loss. Intervention studies have generally concentrated on memory training programs that teach participants how to employ mnemonic devices. These studies show that while the benefits of memory entertainment diminish with age, it can still help older people perform better (Bennett & Bennett, 2020).

As a result, a growing body of research indicates that cognitive practice and training can partially counteract the effects of age-related cognitive decline. Intervention studies have generally concentrated on memory training programs that teach participants how to employ mnemonic devices. These studies suggest that engaging the memory can help older people perform better. However, the effects are task-specific and diminish with age (Lillicrap et al., 2020).

- ***Career and way of life***

A wide range of lifestyle factors (exercise, substance misuse, social interaction, etc.) can affect how well a person performs cognitive tasks. Engaging in social activities is generally linked to improved advanced memory performance. A satisfying ageing process appears to be influenced by social contact variables, such as the quantity of phone conversations or in-person interactions with friends and family. A decreased risk of cognitive decline is also linked to preserving an intact family.

It has been noted that engaging in activities typically available in complex and intellectually stimulating contexts (reading, travel, cultural acts, professional association membership) is a linked factor with a lower risk of cognitive decline in old age. Following a 2.5-year observation period, the "McCarthur Studio on Satisfactory Aging" determined that older persons who participated in voluntary activities performed better. However, participating in these activities in a timely or low-intensity manner does not appear to produce these advantages. The duration of these activities appears to be a significant determinant of the health advantages attained (Bourgognon & Cavanagh, 2020).

Table 5: Alzheimer's Disease and Plasticity

Topic	Key Content	References
Neural Loss in Alzheimer's Disease	Location-, size-, and chemistry-specific neural losses, especially in large neurons, surpassing normal ageing	Crispino, Trinchese, et al., 2020
Neuritic Development and Remodeling	Post-degeneration plasticity can be advantageous or detrimental, potential compensatory effects in early stages	Colucci-D'Amato et al., 2020; Crispino, Trinchese, et al., 2020
Behavioral Techniques for Neuroplasticity	Brain activity stimulation through exercises, such as physical activity, can promote neuroplasticity	Schroyen et al., 2020

Table 6: Treatment Ramifications

Topic	Key Content	References
Structural Alterations in Aged Brains	Brains of aged and Alzheimer's patients show structural alterations consistent with neuroplasticity models	Joushi et al., 2021
Loss of Synapses and Memory Changes	Evidence suggests the loss of previously created synapses may be linked to memory changes in ageing	Gerber & Matuschek, 2023

Table 7: Elements Supporting Cognitive Ageing

Topic	Key Content	References
Factors Promoting Contented Ageing	Life satisfaction, social status, social participation, cognitive performance as predictors of cognitive decline	Gudkov et al., 2023
Medical Status and Cognitive Deterioration	Physiological markers, health conditions, and lifestyle impacting cognitive decline in older age	Bae et al., 2020; Speranza et al., 2021; Błaszczyk, 2020
Impact of Nutrition on Cognitive Function	Diet and nutrient content linked to cognitive performance, complexity in interpretation	Sharma et al., 2021

Table 8: Exercise and Cognitive Health

Topic	Key Content	References
Importance of Daily Exercise	Exercise crucial for maintaining mental health, improving cognitive performance in ageing	Nguyen & Ehrlich, 2020; Shityakov et al., 2021
Physiological Mechanisms of Exercise	Exercise affects central chemical mechanisms supporting brain plasticity and upkeep	Bourgognon & Cavanagh, 2020

Table 9: Educational Attainment and IQ

Topic	Key Content	References
Cognitive Reserve and Intelligence	Role of education and IQ in cognitive reserve, protective effects against cognitive decline	Zhao et al., 2020; Gómez-Nieto et al., 2020

Table 10: Character, Emotional Condition, and Instruction in Cognition

Topic	Key Content	References
Personality, Self-Efficacy, and Cognitive Decline	Personality traits, self-efficacy, and their influence on cognitive function and decline	AlAzzam et al., 2021; Servili et al., 2020; Bennett & Bennett, 2020
Cognitive Practice and Training	Active interaction with surroundings necessary for plasticity, cognitive training's effects on ageing	Lillicrap et al., 2020

ANALYSIS AND CONCLUSIONS:

Through all of this work, we hope to demonstrate the scientific evidence that supports our hypothesis that the answer to the question posed in the article's title, that is, that brain plasticity may be affirmative in the sense that it turns out to be a crucial factor in connection to several variables. In terms of contented ageing at the cognitive level, playing a significant role in realizing what some people still perceive as an ideal. There is accumulating evidence that the brain's capacity to adapt to changes in growth, experience, ageing, and illness is a crucial component of brain function. While the evidence currently available indicates that the ageing brain loses some of its capacity for modification and reorganization, several observations lend credence to the theory that there is still some degree of plasticity present in both Alzheimer's disease and ageing that would be "dependent on the 'I use" (Haarbauer-Krupa et al., 2021).

Positive change capacity, or what is known as plasticity, endures throughout life and may be utilized to stop or slow cognitive decline with improved ageing and health operations. However, the subject must actively engage with its surroundings for plasticity. Furthermore, interactions between various resources are essential to sustain proper operation at various levels. This has significant ramifications for the topic at hand. They are connected to a poor quality of life and the requirement for more care. To lower the number of years that a person remains disabled, it is imperative to find the best preventative strategies and alternative treatment options (Miao et al., 2020).

This will lower the cost of care for this demographic group. We think several interventions can help slow down, and sometimes even reverse, the degenerative changes that come with brain ageing. A more optimistic and cheerful view of old age was proposed only a few years ago, and there is now enough scientific evidence to support it. Therefore, we believe there is a way to draw glimpses of several intervention possibilities that may result in a more fulfilling ageing process.

REFERENCES:

1. AlAzzam, M., Abuhammad, S., Abdalrahim, A., & Hamdan-Mansour, A. M. (2021). Predictors of depression and anxiety among senior high school students during COVID-19 pandemic: The context of home quarantine and online education. *The Journal of School Nursing*, *37*(4), 241-248.
2. Ali, A. M., & Kunugi, H. (2020). Royal jelly as an intelligent anti-aging agent—A focus on cognitive aging and Alzheimer's disease: A review. *Antioxidants*, *9*(10), 937.
3. Bae, S., Harada, K., Lee, S., Harada, K., Makino, K., Chiba, I., Park, H., & Shimada, H. (2020). The effect of a multicomponent dual-task exercise on cortical thickness in older adults with cognitive decline: A randomized controlled trial. *Journal of Clinical Medicine*, *9*(5), 1312.
4. Bennett, M. L., & Bennett, F. C. (2020). The influence of environment and origin on brain resident macrophages and implications for therapy. *Nature neuroscience*, *23*(2), 157-166.
5. Błaszczyk, J. W. (2020). Energy metabolism decline in the aging brain—Pathogenesis of neurodegenerative disorders. *Metabolites*, *10*(11), 450.
6. Bourgognon, J.-M., & Cavanagh, J. (2020). The role of cytokines in modulating learning and memory and brain plasticity. *Brain and neuroscience advances*, *4*, 2398212820979802.
7. Colucci-D'Amato, L., Speranza, L., & Volpicelli, F. (2020). Neurotrophic factor BDNF, physiological functions and therapeutic potential in depression, neurodegeneration and brain cancer. *International Journal of Molecular Sciences*, *21*(20), 7777.
8. Crispino, M., Trinchese, G., Penna, E., Cimmino, F., Catapano, A., Villano, I., Perrone-Capano, C., & Mollica, M. P. (2020). Interplay between peripheral and central inflammation in obesity-promoted disorders: The impact on synaptic mitochondrial functions. *International Journal of Molecular Sciences*, *21*(17), 5964.
9. Crispino, M., Volpicelli, F., & Perrone-Capano, C. (2020). Role of the serotonin receptor 7 in brain plasticity: From development to disease. *International Journal of Molecular Sciences*, *21*(2), 505.
10. Espino de la Fuente-Muñoz, C., Rosas-Lemus, M., Moreno-Castilla, P., Bermúdez-Rattoni, F., Uribe-Carvajal, S., & Arias, C. (2020). Age-dependent decline in synaptic mitochondrial function is exacerbated in vulnerable brain regions of female 3xTg-AD mice. *International Journal of Molecular Sciences*, *21*(22), 8727.
11. Gerber, C., & Matuschek, P. (2023). Neural Mechanisms of Mindfulness-Based Interventions in Anxiety Disorders: A Systematic Review. *Archives of Clinical Psychiatry*, *50*(6).
12. Glinert, A., Turjeman, S., Elliott, E., & Koren, O. (2022). Microbes, metabolites and (synaptic) malleability, oh my! T he effect of the microbiome on synaptic plasticity. *Biological Reviews*, *97*(2), 582-599.
13. Gómez-Nieto, R., Hormigo, S., & López, D. E. (2020). Prepulse inhibition of the auditory startle reflex assessment as a hallmark of brainstem sensorimotor gating mechanisms. *Brain Sciences*, *10*(9), 639.

14. Gudkov, S. V., Burmistrov, D. E., Kondakova, E. V., Sarimov, R. M., Yarkov, R. S., Franceschi, C., & Vedunova, M. V. (2023). An emerging role of astrocytes in aging/neuroinflammation and gut-brain axis with consequences on sleep and sleep disorders. *Ageing Research Reviews*, *83*, 101775.
15. Haarbauer-Krupa, J., Pugh, M. J., Prager, E. M., Harmon, N., Wolfe, J., & Yaffe, K. (2021). Epidemiology of chronic effects of traumatic brain injury. *Journal of neurotrauma*, *38*(23), 3235-3247.
16. Joushi, S., Esmaeilpour, K., Masoumi-Ardakani, Y., Esmaeili-Mahani, S., & Sheibani, V. (2021). Effects of short environmental enrichment on early-life adversity induced cognitive alternations in adolescent rats. *Journal of neuroscience research*, *99*(12), 3373-3391.
17. Kodali, M., Attaluri, S., Madhu, L. N., Shuai, B., Upadhya, R., Gonzalez, J. J., Rao, X., & Shetty, A. K. (2021). Metformin treatment in late middle age improves cognitive function with alleviation of microglial activation and enhancement of autophagy in the hippocampus. *Aging Cell*, *20*(2), e13277.
18. Lillicrap, T. P., Santoro, A., Marris, L., Akerman, C. J., & Hinton, G. (2020). Backpropagation and the brain. *Nature Reviews Neuroscience*, *21*(6), 335-346.
19. Miao, Z., Wang, Y., & Sun, Z. (2020). The relationships between stress, mental disorders, and epigenetic regulation of BDNF. *International Journal of Molecular Sciences*, *21*(4), 1375.
20. Moussaoui, B., Overcashier, S. L., Kohn, G. M., Araya-Salas, M., & Wright, T. F. (2023). Evidence for maintenance of key components of vocal learning in ageing budgerigars despite diminished affiliative social interaction. *Proceedings of the Royal Society B*, *290*(2000), 20230365.
21. Muñoz, P., Ardiles, Á. O., Pérez-Espinosa, B., Núñez-Espinosa, C., Paula-Lima, A., González-Billault, C., & Espinosa-Parrilla, Y. (2020). Redox modifications in synaptic components as biomarkers of cognitive status, in brain aging and disease. *Mechanisms of ageing and development*, *189*, 111250.
22. Murawska-Ciałowicz, E., Wiatr, M., Ciałowicz, M., Gomes de Assis, G., Borowicz, W., Rocha-Rodrigues, S., Paprocka-Borowicz, M., & Marques, A. (2021). BDNF impact on biological markers of depression—role of physical exercise and training. *International journal of environmental research and public health*, *18*(14), 7553.
23. Mut-Arbona, P., & Sperlágh, B. (2023). P2 receptor-mediated signaling in the physiological and pathological brain: From development to aging and disease. *Neuropharmacology*, 109541.
24. Nguyen, L. D., & Ehrlich, B. E. (2020). Cellular mechanisms and treatments for chemobrain: insight from aging and neurodegenerative diseases. *EMBO molecular medicine*, *12*(6), e12075.
25. Penna, E., Pizzella, A., Cimmino, F., Trinchese, G., Cavaliere, G., Catapano, A., Allocca, I., Chun, J. T., Campanozzi, A., & Messina, G. (2020). Neurodevelopmental disorders: effect of high-fat diet on synaptic plasticity and mitochondrial functions. *Brain Sciences*, *10*(11), 805.
26. Schroyen, G., Meylaers, M., Deprez, S., Blommaert, J., Smeets, A., Jacobs, S., Sunaert, S., Sleurs, C., & Uyttebroeck, A. (2020). Prevalence of leukoencephalopathy and its potential cognitive sequelae in cancer patients. *Journal of Chemotherapy*, *32*(7), 327-343.
27. Servili, A., Canario, A. V., Mouchel, O., & Muñoz-Cueto, J. A. (2020). Climate change impacts on fish reproduction are mediated at multiple levels of the brain-pituitary-gonad axis. *General and Comparative Endocrinology*, *291*, 113439.
28. Sharma, V. K., Singh, T. G., Garg, N., Dhiman, S., Gupta, S., Rahman, M. H., Najda, A., Walasek-Janusz, M., Kamel, M., & Albadrani, G. M. (2021). Dysbiosis and Alzheimer's disease: a role for chronic stress? *Biomolecules*, *11*(05), 678.
29. Shityakov, S., Hayashi, K., Störk, S., Scheper, V., Lenarz, T., & Förster, C. Y. (2021). The conspicuous link between ear, brain and heart–could neurotrophin-treatment of age-related hearing loss help prevent alzheimer's disease and associated amyloid cardiomyopathy? *Biomolecules*, *11*(6), 900.

30. Sochal, M., Ditmer, M., Gabryelska, A., & Białasiewicz, P. (2022). The role of brain-derived neurotrophic factor in immune-related diseases: A narrative review. *Journal of Clinical Medicine*, *11*(20), 6023.
31. Speranza, L., Di Porzio, U., Viggiano, D., de Donato, A., & Volpicelli, F. (2021). Dopamine: The neuromodulator of long-term synaptic plasticity, reward and movement control. *Cells*, *10*(4), 735.
32. Stuyvenberg, C. L., Brown, S. E., Inamdar, K., Evans, M., Hsu, L.-y., Rolin, O., Harbourne, R. T., Westcott McCoy, S., Lobo, M. A., & Koziol, N. A. (2021). Targeted physical therapy combined with spasticity management changes motor development trajectory for a 2-year-old with cerebral palsy. *Journal of personalized medicine*, *11*(3), 163.
33. Zhao, D., Feng, P. J., Liu, J. H., Dong, M., Shen, X. Q., Chen, Y. X., & Shen, Q. D. (2020). Electromagnetized-nanoparticle-modulated neural plasticity and recovery of degenerative dopaminergic neurons in the mid-brain. *Advanced Materials*, *32*(43), 2003800.
34. Zhou, R., Qian, S., Cho, W. C., Zhou, J., Jin, C., Zhong, Y., Wang, J., Zhang, X., Xu, Z., & Tian, M. (2022). Microbiota-microglia connections in age-related cognition decline. *Aging Cell*, *21*(5), e13599.