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A Review of Research on the Effects of Residential Environment on the Health of Older Adults from a Neuroscience Perspective

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Abstract: *Neuroscience has improved our understanding of how the brain perceives and reacts to the environment. It is significant to apply this knowledge to study the impact of residential environments on the health of the elderly, especially in the context of serious health threats. The article begins by summarising theories on residential environment and health. It then reviews studies on the effects of residential environment on the health of the elderly from a neuroscience perspective. Finally, it summarises technical methods of neuroscience and looks forward to interdisciplinary integration of neuroscience and environmental science.*

Keywords: *Neuroscience; Health of the Elderly; Residential Environment*

1. Introduction

The global population is ageing due to declining fertility rates and increasing longevity. Over the next three decades, this trend will continue to advance, and by 2050, the world's elderly population aged 60 years and over will reach 2.08 billion, comprising 21.4% of the total population[1]. As urbanisation deepens, an increasing number of elderly individuals are residing in cities. They encounter various issues associated with urbanisation, including inadequate social interaction and environmental pollution in their residential areas. These issues pose a significant threat to the physical and mental health of older people. The elderly often experience physical health issues due to the deterioration of their bodily functions and weakened immunity. They are more prone to chronic diseases, including diabetes, high blood pressure, heart disease, and gout. Furthermore, mental health issues have a significant impact on the well-being of elderly individuals who frequently experience physical ailments alongside psychological challenges [2]. Studies have demonstrated that urban areas have a higher prevalence of mood disorders and anxiety, with an increasing incidence[3]. The interaction between mental and physical health requires attention when considering the wellbeing of older individuals. Maintaining emotional stability and comfort at the settlement level can help prevent anxiety and stress[4].

Numerous studies have demonstrated the positive impact of the natural environment on human health, particularly in the elderly population [5]. Regarding physical health, physical activities such as exercise, walking, and gardening in natural environments[6] can effectively improve the physical function of the elderly and enhance their immunity. Additionally, plant sensory stimulation in natural environments can produce positive changes in heart rate and blood pressure. Concerning mental health, exposure to the natural environment can significantly enhance positive emotions and improve negative emotions in the elderly[5]. The natural environment can induce relaxation through sensory stimulation. Additionally, social activities in nature can alleviate negative emotions such as depression and loneliness. For the elderly, their residence is a crucial place for connecting with nature, engaging in social interaction, physical exercise, and other activities. A positive community environment can significantly enhance their physical function and mental health. This includes improving the quality of sleep, reducing mental stress, and increasing their overall sense of well-being[7, 8].

Neuroscience has enabled the exploration of brain mechanisms underlying human behaviour. The human nervous system is highly complex, with the brain comprising around 10 billion cells. Neuroscience instruments can be used to observe the intrinsic brain activity during different moods[9]. There is a continuous interaction between the residential environment and the brain. The way the brain responds to environmental information determines individuals' emotional, perceptual, and behavioural responses. The paper explores how theories and techniques from neuroscience can aid designers in

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understanding how humans experience and perceive different built environments, as well as the scientific reasons behind emotional perceptions. It specifically focuses on the impact of settlement environments on the health of older people from a neuroscience perspective, which is a relatively new approach. The aim of this review is to provide new insights for research related to settlement environments.

2. Review of relevant theories

2.1 Restorative Environmental Theory

Kaplan proposed the Attention Restoration Theory for the effective restoration of directed attention. The theory distinguishes between directed attention, which is top-down, and involuntary attention, which is bottom-up[10]. Processing information with directed attention requires cognitive effort and energy consumption, while involuntary attention does not. Human historical development is closely tied to the natural environment, leading to an innate appreciation for nature. Therefore, excessive top-down attention to the environment is unnecessary. As a result, the natural environment has a restorative effect on mental fatigue. According to attention recovery theory, a person's ability to focus attention weakens with the extension of concentration time, leading to difficulty in concentrating, agitation, and increased likelihood of errors when engaging in work that requires focus[11]. Excessive pressure in modern city life can deplete attention, leading to fatigue. In contrast, in natural environments, people only consume involuntary attention, allowing directed attention to be restored. Attention is a crucial factor in human cognitive and emotional functioning. Research has consistently demonstrated the restorative benefits of natural environments from both psychological and physiological perspectives[12].

Ulrich's Stress Reduction Theory proposes that exposure to certain natural environments can divert attention away from negative thoughts, allowing positive emotions to replace negative ones and restoring physiological equilibrium[13]. Stress Reduction Theory proposes that exposure to non-threatening natural environments, including viewing vegetation or water, can elicit a positive emotional response and promote sustained, sober, and relaxed attention[14]. The theory emphasises that the restorative effect is an immediate emotional response to the environment, rather than a direct restoration of attention. This preference for natural environments is believed to be innate and the result of long-term human evolution. Ulrich suggests that the physical environment can cause stress or provide relief. Recovery involves not only recuperation from stress but also recuperation from overexertion of psychological and physiological states. Psychological recovery involves a shift from negative to positive emotional states, such as a decrease in negative emotions (anxiety, panic, fear, etc.) and an increase in positive emotions[15].

Attention Restoration Theory and Stress Reduction Theory are two classic theories of restorative environment. Both theories are based on evolutionary theory and attempt to explain the role of the natural environment in people's psychological restoration from a psychological perspective[16]. Both authors assumed that humans have a strong positive inclination towards the natural environment. They believed that due to the extended period of time that humans have lived in natural environments, people are more adapted to the physical environment than to the city's natural environments. The authors explored the interaction between emotion and cognition[17]. Both theories emphasise that visual contact with the natural environment promotes recovery, and that recovery is contingent on the individual's functioning being below normal[13].

2.2 Neuroscience Theory

Neuroscience comprises various branches, including critical neuroscience, cognitive neuroscience, and environmental neuroscience. These branches aim to uncover the brain mechanisms that underlie human behavior. Critical neuroscience posits that human physiological and psychological phenomena are interrelated, and that the human body cannot be solely confined to the material realm. It advocates for a focus on neural mechanisms in various scenarios, spaces, and bodies[18], as well as the real-life environments in which the human body is situated and the cultural contexts in which neural activities occur[19]. Cognitive neuroscience aims to elucidate the brain mechanisms underlying cognitive activities. Cognitive neuroscience discusses how the human brain carries out cognitive activities and researches topics such as the formation of the mind, consciousness, and behavior, as well as the laws of mechanism at the level of the brain and nerves[20]. It also focuses on how the brain processes environmental information through the regulation of the internal neural system[21]. It expands the scope of psychological research beyond pure cognition and behavior to encompass the relationship between brain activity patterns and cognitive processes. This approach integrates behavior, cognition, and brain mechanisms.

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Environmental neuroscience studies the bidirectional relationships between organisms and their social and physical environments[22], emphasizing that brain function and behavior are influenced by environmental factors. It examines the effects of various environmental contexts on the brain and behavior at multiple temporal and spatial scales.

Neuroscience theories propose that human thoughts, emotions, and behaviors originate from the communication between neurons in the brain. Brain waves are generated by synchronized electrical impulses produced by a large number of neurons communicating with each other. Brain waves are categorized into several bandwidths (e.g., α, β, δ, and θ) to describe brain function. These brain waves vary according to people's feelings and behaviors and can be thought of as a continuous spectrum of consciousness[23]. Neuroscience theories can provide valuable insights into how the brain responds to environmental stimuli. This is particularly relevant for studying special groups such as the elderly, whose cognitive and behavioral abilities may differ from those of younger individuals due to age-related brain decline. Neuroscience research can examine the brain's structure and physiological mechanisms to better understand these differences[24].

2.3 Cognitive Neuroscience of Aging

The brain structure of older adults changes with age, as evidenced by atrophy of brain gray matter, reduction of white matter, and dilation of brain ventricles. Additionally, brain function declines in older adults, leading to a decrease in processing speed, working memory, and executive functioning. The Scaffolding Theory of Aging and Cognition[25]proposes that an overall rise in prefrontal activity with age is a characteristic of the adaptive brain. This brain engages in compensatory scaffolding to deal with the challenges caused by neurological structural and functional decline. The available evidence suggests that scaffolding protects cognitive function in the aging brain. Additionally, cognitive engagement, exercise, and low levels of default network engagement enhance the ability to use this mechanism. While it is true that many cognitive functions decline with age, research has shown that the brain maintains neuroplasticity throughout life. This means that some cognitive functions can be maintained or even improved with exercise, cognitive interventions, and lifestyle changes.

3. Research Progress on Residential Environment and Health of the Elderly from a Neuroscience Perspective

3.1 Residential Environment Suitability for the Elderly

The World Health Organization defines age-friendly communities as those that enhance the quality of life for older individuals and promote active aging by providing healthcare, social participation opportunities, and safe services. The eight aspects of age-friendliness are: The World Health Organization proposes an age-friendly community that includes transportation, housing, outdoor space and architecture, community support and health services, communication and information, social participation, respect and social inclusion, public participation, and employment[26]. These components are mainly reflected in the physical and social environment.The physical environment's important characteristics are transportation, housing, outdoor space, and architecture. These factors directly impact the elderly's travel mode, living quality, and outdoor sports and entertainment.The socio-spatial environment encompasses various aspects, including community support and health services, communication and information, social participation, respect and social inclusion, public participation, and employment. These aspects reflect the social environment in which older people live.

The ecological model of aging suggests that behaviors and outcomes result from the interplay between individual ability and environmental stress. Too much or too little stress can lead to undesirable adaptive behaviors and negative effects. The environment can not only exert pressure on the elderly but also serve as a compensatory mechanism to enhance their sense of stability and security when facing pressure[27]. Both the physical and social environments have a significant impact on the health of the elderly. Therefore, the adaptability of the residential environment should encompass both the physical and social aspects. Community environment research based on neuroscience can help identify risk factors affecting the health of the elderly and facilitate appropriate health interventions. The vulnerability, sensitivity, and dependence of the elderly on their residential environment make this research crucial.

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3.2 Health Needs of Older Adults

According to the World Health Organization, health is defined as a state of complete physical, mental, and social well-being, not merely the absence of disease or infirmity. The health needs of the elderly are divided into physiological and mental health needs. Physiological health needs mainly refer to medical care, as the elderly often suffer from chronic diseases and require adequate medical facilities. Mental health problems have become a significant factor affecting the physical and mental health, as well as the quality of life of the elderly. The lack of social communication and poor living conditions can negatively impact the mental health of older adults. The elderly have similar needs to the general population, but their psychological needs differ due to changes in their physiology, social role, and status. Fu Shuangxi[28] categorized the psychological needs of the elderly into four categories: physiological and security needs, communication needs, identification needs, and self-actualization needs, based on Maslow's hierarchy of needs and the psychological characteristics of the elderly. The mental health needs of the elderly include both material and spiritual needs.

3.3 Review of Research on Residential Environment and Health of the Elderly from a Neuroscience Perspective

The interdisciplinary research of neuroscience and community environment has become a popular topic. Scholars have proposed neurourbanism, an interdisciplinary approach that links public mental health with urban planning. Its aim is to investigate the impact of urban architecture and social environment on mental health and ultimately on the brain[29]. Neale et al. (2020) conducted a study using electroencephalography (EEG) to record changes in brain activity of elderly individuals while walking in various urban environments. The study aimed to investigate the impact of different urban environments on the brain activity of elderly people. The results showed that walking in urban green spaces elicited higher levels of engagement compared to walking in busy urban commercial streets and quiet residential areas. The level of excitement experienced when walking in busy urban spaces is higher, indicating that green spaces have a restorative effect on the elderly. This finding provides guidance for planning and designing age-appropriate living areas[30]. Karandinou et al. (2017) utilized a portable electroencephalogram (EEG) device to record neurophysiological data from subjects. They then correlated changes in the built environment with fluctuations in specific brain waves to investigate how the brain responds to different built environments[31]. Tilley et al. (2017) conducted an EEG study to investigate emotional changes in the elderly across various urban environments. The study found that urban green spaces play a crucial role in creating a supportive urban environment for the elderly by regulating stress caused by the built environment[32]. Tang et al. (2017) used functional magnetic resonance imaging (fMRI) to study the difference in restoration benefits between urban and natural environments[33].

4. Significance of Studying the Effect of Residential Environment on Elderly Health from a Neuroscience Perspective

4.1 Scientific Research Methods are Presented.

Applying neuroscience theories and methods to environmental research can provide numerous benefits. By utilizing neuroscientific techniques to examine the brain's reaction to different factors in residential environments, planners can gain insight into the scientific basis for people's emotional perceptions. Neuroscientific methods can complement traditional environmental research methods to improve their reliability. Neuroscience technology encompasses a broad and varied field. One of the most crucial research techniques in neuroscience is psychophysiological measurement. This technique involves measuring signals from both the central and peripheral nervous systems to explain the related psychophysiological and behavioral activities of human beings[34]. Neuroscience technologies primarily consist of central nervous system measurement and neuroimaging techniques. Each technology has its own research scope and limitations.

Central nervous system measures include Electroencephalogram (EEG) and Event-related Potential (ERP). Neuroimaging techniques include Functional Magnetic Resonance Imaging (fMRI), Positron Emission Tomography (PET), Magnetoencephalography (MEG), and Functional Near-infrared Spectroscopy (fNIRS). Electroencephalogram (EEG) is characterized as safe and non-invasive, relatively inexpensive and portable, with high temporal resolution but poor spatial resolution. Event-related Potential (ERP) are safe, non-invasive, measure a continuous process from stimulus to response, and are relatively inexpensive. Functional Magnetic Resonance Imaging (fMRI) is non-invasive, has high spatial

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resolution, but is not portable. Positron Emission Tomography (PET) is invasive, requiring injection of tracers with specific radiation, but has good sensitivity and flexibility. Magnetoencephalography (MEG) is non-invasive and has high spatial and temporal resolution, but the device is not portable and is more expensive.Functional Near-infrared Spectroscopy (fNIRS) is non-invasive, relatively inexpensive and portable, with good temporal resolution but insufficient spatial resolution.

4.2 Environmental Science and Neuroscience are Integrated.

Neuroscience research shows that the human brain is dynamic and plastic. This research helps designers accurately understand human experience and cognition in different built environments, as well as the scientific reasons behind emotional perception. It also provides a new perspective for interdisciplinary cooperation between neuroscience, environmental science, and other related disciplines. The field of built environment has greatly benefited from the development of neuroscience instruments, particularly wearable physiological feedback instruments. These instruments have increased the feasibility of research and opened up new possibilities for the future due to their portability. In 2015, the Neurourbanism Research Forum was established in Berlin, Germany. The forum covers neuroscience, urban planning, architecture, and sociology, and advocates for cross-disciplinary approaches worldwide [35]. Neurourbanism connects public mental health with urban planning. It investigates the impact of a city's architectural and social environment on mental health and ultimately on the brain[36]. This field emphasizes interdisciplinary cooperation between neuroscience, public health, and urban planning to create a healthier urban environment[37].

The combination of neuroscience and environmental design has become an emerging trend, utilizing relevant knowledge of neuroscience to promote cross-disciplinary research and innovation. This contributes to the formation of new subject areas and research directions.

5. Conclusions

This paper examines the theories of residential environment and health of the elderly in the context of population aging, urbanization, and frequent health problems. It emphasizes the importance of residential environment to the health of the elderly and their health needs. The relevant research on residential environment and health of the elderly is summarized from the perspective of neuroscience. Finally, the technology and methods of neuroscience are discussed, and summarizes the significance of studying the influence of residential environment on the health of the elderly from the perspective of neuroscience. The combination of neuroscience and environmental science is an innovative approach. Neuroscience has revealed the brain reactions of individuals in various environments, which can either promote or inhibit their mental and physical health. Applying neuroscience theory and methods to investigate the impact of residential environments on the health of the elderly is crucial in guiding the design of suitable living spaces for this population.

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