



Study on the Influencing Factors and Evaluation Methods of Cognitive Ability

Zeyu Zhang^(✉)

Guangxi University of Science and Technology, Liuzhou 545006, Guangxi, China
z.zhang.54@student.scu.edu.au

Abstract. Nowadays, the world population is aging seriously, and the decline of the elderly's cognitive ability has become a severe problem. Cognitive ability refers to the human brain's ability to process, store and extract information. Cognitive decline refers to a significant and measurable decrease or abnormality in various aspects of an individual's cognitive function, which might affect people's daily lives. Many factors affect mental ability, such as subjective cognitive ability decline and objective elements. It is essential to clarify the factors affecting cognitive ability and find proper ways to accurately evaluate a human's cognitive ability. Judging the reasons for the decline in cognition by analysing four factors, Using the three scales of Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA) and Boston Naming Test (BNT) for subjective evaluation, Objective evaluations were performed using Electroencephalography (EEG) and Quantitative Electroencephalogram (QEEG). Evaluate from a variety of perspectives. This paper summarises some influencing factors and contrasts typical evaluation methods of cognitive ability, which might reference future studies in alleviating the decline or accurate evaluation of cognitive ability.

Keywords: cognitive ability · influencing factors · evaluation methods

1 Introduction

Cognitive ability refers to functions generally considered a person's mental abilities. Most people's cognitive abilities decline with age. The decline of cognition in real life appears to be forgetting things such as buying vegetables while failing to pay, wanting to buy five dishes only buying three words, not reckoning, making decision errors, easy to get lost, learning to use a specific tool or daily household electrical appliances, microwave ovens, remote control, can't remember the current month, forget about good party and family, often can't find their place on it, repeated words many times and so on. These phenomena would bring obstacles to people's daily lives and act as a heavy burden on society. Research showed that many factors might have influenced the decline of cognitive ability. Besides, proper evaluation methods of cognitive ability are becoming a promising way to detect early human cognitive ability. Therefore, it is essential to clarify the factors affecting cognitive ability and develop appropriate evaluation methods of cognitive ability.

© The Author(s) 2023

Y. Chen et al. (Eds.): ICMETSS 2022, ASSEHR 693, pp. 1021–1030, 2023.

https://doi.org/10.2991/978-2-494069-45-9_123

Studies have shown that unhealthy diets, unsafe environments, poor sleep and drug use can be detrimental to cognitive performance. In addition, effective cognitive ability evaluation methods are of great significance. At present, the standard evaluation methods include Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA), Boston Naming Test (BNT), Electroencephalography (EEG), etc.

In this paper, we research the Factors affecting cognitive ability from diet, environment, sleep and drug. Especially for the elderly, Yi-Chun Chou's [2] team suggests that high diet quality and diverse vegetable intake are associated with a lower risk of cognitive decline in older adults. The change of environment will lead to a series of pollution and cause various diseases in people, and cognitive ability may be affected eventually. Older people are at greater risk of having sleep apnea, significantly affecting cognitive ability. Even sleep duration was linked to cognitive decline in older adults. However, the current technology is not good enough to make a good miracle drug to treat cognitive decline. But natural antioxidants are an effective medicine against dementia. At the same time, it is essential to develop appropriate cognitive assessment methods. In this paper, mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA) and Boston Naming Test (BNT) are introduced. These assessment methods can effectively measure and evaluate patients. Electroencephalography (EEG) and Quantitative Electroencephalogram (QEEG) are two objective evaluation methods to remove the subjective influence. This paper introduces and integrates factors affecting cognitive ability and the appropriate evaluation method scale.

2 Influence Factors

2.1 Diet

Diet has a significant effect on cognitive competence. It mainly affects older people. Dietary quality is represented by the variety of vegetables and diversity of food. Vegetable variety indicates that the number of vegetables is constant and that different vegetables are added. The same is true of food diversity. Old adults eat a variety of vegetables and have a high-quality diet. They have a lower risk of cognitive decline. On the contrary, senior adults do have not enough variety of vegetables. Aging adults have a higher risk of cognitive decline.

Yi-Chun Chou's [2] team suggests that high diet quality and diverse vegetable intake are associated with a lower risk of cognitive decline in older adults. Further studies with more extended follow-up periods, different geographical areas and larger sample sizes are needed.

2.2 Environment

Environmental impacts lead to degraded air quality and ubiquitous chemical pollution. It is increasingly recognised that a life course perspective is likely relevant to identifying essential determinants of cognitive decline that accompany aging. Thus, the evidence that environmental exposures play a role will be substantially strengthened by studies that measure exposures to environmental factors in early life and midlife and record

cognitive decline in a standardised and repeated fashion [3]. However, there is no clear evidence that environmental pollution is the main factor affecting mental performance. Reducing the total pollution of the environment will be a long-term thing. There is an excellent potential for the prevention of the severity of pollution. Kimberly C. Paul's team [3] study is underway linking ambient air pollution and noise to cognitive decline and dementias. However, there is still insufficient evidence, especially for long-term exposure to high noise.

2.3 Sleep

Older people are at greater risk of having sleep apnea, significantly affecting cognitive ability. REM sleep behaviour disorder may accelerate cognitive decline. In addition, Sleep also has a lot to do with mood. Cognitive decline was found to be associated with depression in recent years. Even depression is a significant factor in Alzheimer's disease. It was reported that as many as 24 to 58% of individuals with sleep-disordered breathing (e.g., obstructive sleep apnea) meet the criteria for depression [4]. 90% of people with depression have trouble sleeping. Compared to those without sleep problems, people with sleep problems have the highest relative odds (7.6 times) of having a new major depressive episode next year [5]. So, sleep plays a vital role in everyday cognition. Poor sleep affects perception, mobility and even brain thinking. A pattern of long and increased sleep is associated with the development of slight cognitive decline, and a relatively short sleep duration pattern decreases the odds of being on a rapid cognitive decline trajectory [6].

2.4 Drug

Due to their effects in multiple pathways through which oxidative stress leads to neurodegeneration and triggers neuroinflammation, natural antioxidants could prove valuable weapons in our fight against dementia [7]. Although natural oxidants are helpful in some ways, they have many drawbacks in clinical trials. But until these drugs are proven to be effective, we need to take a healthy attitude towards living and diet. Many foods contain antioxidants, which can help improve our health and even reduce cognitive decline. There are no drugs that directly and significantly improve mental performance.

3 Evaluation Methods

3.1 Subjective Evaluation

Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA) and Boston naming test (BNT) are commonly used scales to assess cognitive ability.

Folstein (1975) formulated mini-mental State Examination; this method is simple and easy to use and has been widely used abroad. It is called mental condition examination, which is a screening tool for the cognitive and intellectual functions of the elderly. The Montreal Cognitive Assessment (MoCA) was developed by Nasreddine in 2004 to quickly screen for Mild Cognitive Impairment (MCI). The cognitive areas assessed included attention and concentration, executive function, memory, language, visual-structural skills, abstract thinking, and calculation and orientation. The total score on the scale was 30, and the test results showed an average score of more than 26. Harcourt Assessment Resources LTD created the Boston Naming Test (BNT). This test has been widely used in aphasia research, and large scales constant modulus data of BNT can now be queried.

3.2 Objective Evaluate

Electroencephalography (EEG) is a neurophysiological assessment using arrays of electrodes placed across the scalp to record cortical activities in real-time; EEG has a better spatial resolution ability in detecting neuronal cellular function than structural neuroimaging. This allows for a non-subjective assessment of cognitive ability. Thus, it has a unique contribution to assessing the occurrence and progression of the non-motor symptoms of Parkinson's disease, such as cognitive impairment. EEG includes frequency-domain feature evaluation, nonlinear feature evaluation, brain network feature evaluation, event-related potential evaluation, etc.

Quantitative electroencephalogram (QEEG) measures are determinants of awake neurobehavioral function in healthy subjects [8]. Using spectral analysis to predict cognitive decline in OSA patients. Two-Way ANOVA was used to examine the effect of gender and OSA on EEG spectra. The power reduction is higher (more significant than alpha), indicating cognitive decline through data display [8]. As a non-invasive and inexpensive test, QEEG can provide quantitative parameters for assessing cognitive dysfunction in PD and help guide the clinical treatment of PD and predict the degree of dementia in PD. Quantitative Susceptibility Mapping (QSM) is an MRI technology developed in recent years based on Magnetic sensitivity weighted imaging (SWI) to quantify the magnetic susceptibility distribution in biological tissues (Table 1).

Table 1. Comparison of different assessment methods.

Evaluation method		Basic principle	Advantage	Disadvantage
Subjective evaluation	Mini-Mental State Examination (MMSE)	The Mini-Mental State Examination (MMSE), compiled by Folstein et al. (1975), is one of the most effective standardised intelligence State Examination tools. It can be used to screen for Alzheimer's disease; simple and easy.	This scale is a good choice for doctors because of its practical design, wide application and simplicity.	Easy to be affected by education level, mild cognitive impairment is not sensitive, sensitivity is poor—lack of view space and execution functions.
	Montreal Cognitive Assessment (MoCA)	Professor Nasreddine developed the Montreal Cognitive Assessment Scale (MoCA) in 2004. An assessment tool used to quickly screen for Mild Cognitive Impairment (MCI). The Cognitive areas assessed include attention and concentration, executive function, memory, language, visual structural skills, abstract thinking, computation and orientation.	It was more sensitive to the screening of mild cognitive impairment, covering a more comprehensive range of cognition, and comprehensively improving the scores of visual space and executive function. It's more reflective of the patient's memory.	More extended time consumption is associated with a decline in the completion of low education and a limited role in the diagnosis of dementia.

(continued)

Table 1. (continued)

Evaluation method	Basic principle	Advantage	Disadvantage
	<p>Boston naming test (BNT)</p> <p>The naming disorder is a common symptom of dementia patients and aphasia patients. BostonNamingTest (BNT) is one of the most commonly used to detect naming disorders. The Boston naming test (BST) consists of 60 line-drawn graphics, graded according to familiarity, ranging from familiar objects with high frequencies (such as beds, trees and pencils) to low-frequency things (such as shelves, colour palettes and abacuses). This test has been widely used in aphasia research, and large scales constant modulus data of BNT can now be queried.</p>	<p>This scale does not require a high level of education but a simple understanding of the object. This test helps name obstacles.</p>	<p>BNT's program selection may have something to do with favouring men [9]. The measurement range is not wide enough in the graph recognition naming ability test.</p>
Objective methods	<p>EEG frequency domain feature evaluation</p> <p>Frequency domain analysis applies to a broader range of data, which can be used to analyse ERPs data (mainly before and after stimulation) and RESTING EEG data.</p>	<p>A more comprehensive range of data is needed to analyse the spectrum energy of each band of EEG signals.</p>	<p>Compared with time-domain analysis, it has no higher time precision and accuracy; only the distribution of frequency band energy cannot reflect the change of specific frequency band energy over time [10].</p>

(continued)

Table 1. (continued)

Evaluation method	Basic principle	Advantage	Disadvantage
EEG nonlinear feature evaluation	The brain is a nonlinear system, and the EEG signal is a typical nonlinear signal. Entropy and complexity have the advantages of short data requirements and high speed and have become the first choice of characteristic parameters for diagnosing various brain diseases and studying brain function [11]	Computing data requires short and fast speed, which can easily visualise the brain; for patients with severe disorders of consciousness, the approximate entropy nonlinear feature is feasible to evaluate the process of consciousness rehabilitation in patients with severe diseases of consciousness.	For patients with mild disturbance of consciousness, the apparent increase in entropy may not be significant and cannot be intuitively assessed.
EEG event-related potential evaluation	Event-related potential (ERP) is a recognised objective, a sensitive and specific indicator that can reflect changes in the cognitive process of the brain and is an objective electrophysiological indicator for the detection of cognitive dysfunction [12]	The sensitivity and specificity are strong and can reflect changes in the brain during the cognitive process. Eeg results are associated with changes in event-related potentials to a certain extent; the sensitivity and specificity are strong and can reflect changes in the brain during the cognitive process. Eeg results are associated with changes in event-related potentials to a certain extent. Both event-related potential and electroencephalogram results can effectively assess cognitive impairment in patients with epilepsy [13]	Abnormal event-related potentials are associated with abnormal EEG, which can only be used to assist in judging abnormal EEG results. The relatively high incubation period

4 Discussion

This paper summarised the main factors that affect human cognitive ability, including food, environment, sleep, and medicine. These influencing factors are objective, focusing on the human body's external environment elements and ignoring subjective factors, such as people's emotions or endocrine factors. Future research should start from the human body itself; more attention has been paid to whether emotions, such as depression, are factors affecting cognitive ability from a subjective perspective.

The subjective scale is mainly used to judge cognitive decline in clinical practice. Such as Mini-Mental State Examination (MMSE). Although This scale is a good choice for doctors because of its practical design, wide application and simplicity. It can be used as a basis for the judgment key. These judgments are just preliminary judgments with subjective awareness attached. This is where objective evaluation comes in. Such as Electroencephalography (EEG). Raw EEG data is a finite discrete time series consisting of many sample points. The data from each sample point represents the size of the brainwave amplitude. The two perspectives of the signal are the time domain signal and the frequency domain signal. They have their advantages but are usually combined with looking at the time-frequency chart. The brain is a multi-dimensional dynamic system; traditional signal processing methods, including time domain, frequency domain and time-frequency analysis, are based on linear system theory. They can't collect all the data. There are many methods to study nonlinear dynamics, such as correlation dimension, entropy, complexity and Lyapunov index, which commonly use EEG nonlinear dynamics characteristic parameters. Current evaluation methods are varied. The brain is the most critical and complex part of the human body. The information needed to hit the brain requires sophisticated equipment. More precise and effective instruments are expected to evaluate.

For the clinical manifestation of cognitive decline, the prevention and evaluation of the present stage still need to be significantly improved. More accurate assessments are required to identify and distinguish mild cognitive impairment from other brain disorders accurately. By summarising the evaluation trend, it is possible to carry out in-depth brain signal capture and analyse the feedback made by the human brain to judge and evaluate. In terms of treatment, a treatment program for cognitive impairment and other cognitive disorders is still being pursued. Take Alzheimer's disease as an example; greengu-971 is a representative original new drug in China, which has reportedly passed phase iii clinical trials, which may be a breakthrough in drug treatment. In terms of the most significant pathogenesis research, domestic and international scholars have not been able to put forward revolutionary new hypotheses better to explain cognitive disorders, especially Alzheimer's disease. What are the core targets for the treatment of cognitive impairment? What are the internal relationships and mechanisms suggested by similar clinical symptoms among different diseases? These questions still need to be clarified by future researchers.

5 Conclusion

This paper summarises four influencing factors based on cognitive decline. The factors of cognitive decline were analysed from food, environment, sleep and medicine. Some feasible methods to prevent cognitive decline are summarised. In terms of evaluation, three subjective scales were used for assessment. Mini-Mental State Examination (MMSE), Montreal Cognitive Assessment (MoCA) and Boston naming test (BNT) are commonly used scales to assess cognitive ability. But they are subjective. Electroencephalography (EEG) and Quantitative Electroencephalogram (QEEG) are two objective evaluation methods to remove personal influence. The above is summarised. This paper summarises some factors affecting cognitive ability, including diet, Environment, Sleep and drugs. At the same time, the evaluation methods and some scales are summarised. Some ideas about factors and evaluation of cognitive ability in the future are put forward.

References

1. Xianwen S et al. "Associations of Dietary Pattern and Sleep Duration with Cognitive Decline in Community-Dwelling Older Adults: A Seven-Year Follow-Up Cohort Study". 1 Jan, 1559–1571 (2021).
2. Chou, Y.-C.; Lee, M.-S.; Chiou, J.-M.; Chen, T.-F.; Chen, Y.-C.; Chen, J.-H. "Association of Diet Quality and Vegetable Variety with the Risk of Cognitive Decline in Chinese Older Adults." *Nutrients*, 11, 1666(2019).
3. Paul KC, Haan M, Mayeda ER, Ritz BR. "Ambient air pollution, noise and the risk of late-life cognitive decline and dementia." *Yearbook of Public Health*, 40(2019).
4. Rauchs G, Carrier J, Peigneux P. "Sleep and cognition in older adults" 4,71(2013)
5. Xuxia L, Feng H, Qiu H, Lei H, Xu S, Gang Z, Jun Y, Bin D. "The mediating role of sleep quality in the relationship between cognitive decline and depression," *BMC Geriatr*, 3:22 (1): 178(2022).
6. Zhu, Q., You, Y., Fan, L. *et al.* "Associations between sleep duration patterns and cognitive decline trajectories in older Chinese adults." *Aging Clin Exp Res* 33, 3057–3063(2021).
7. Jurcau A. "The Role of Natural Antioxidants in the Prevention of Dementia-Where Do We Stand and Future Perspectives." *Nutrients*, 20;13(2):282(2021).
8. Chen YB. "Quantitative eeg assessment of cognitive ability in patients with Parkinson's disease", (2012).
9. Qi hao G, Zhen H, Wei xiong S, Yi-min S, Fafa L. "The role of Boston naming Test in the identification of mild cognitive impairment and alzheimer's disease". *Chinese Journal of Mental Health*, (02):81–84(2006).
10. Ruimin P, Jun J, Guangtao K, Hao D, Dongrui W, Jianbo S. "Epilepsy automatic detection based on EEG: review and prospect." *Journal of automation*, (02) 13:335-350 (2022).
11. Xueliang H, Wenwei Y, Jingqi L, Xiaoping L, Yi L, Weijie Z, Yong Y, "Correlation analysis and visualization of EEG nonlinear characteristics and CRS-R score during rehabilitation in patients with severe impairment of consciousness." *Chinese Journal of Biomedical Engineering*, 34(2015).
12. Yang LL, Yang T. "Pulmonary rehabilitation for patients with Coro - Navirus disease 2019 (COVID-19)." *Chronic Dis Transl Med*,6 (2): 79-86(2020).
13. Wanqiong C, "Evaluation of cognitive function in patients with epilepsy by event-related potential and ELECTROencephalogram." *Medical Theory and Practice*, 35(2022).

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

