

The Influence of Video Game Intervention on the Memory of the Elderly

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Abstract. The cognitive decline of the elderly has received more and more attention with the increase of the elderly population. Many researchers are seeking for efficient way to train the elderly and to slow down the aging. Several training methods, such as cognitive training, music training, physical activity, diet control, and video games training, have been proved to be useful. As a new method, video games training is more interesting, attractive and have the potential for transfer of the training effect. In this article, we focus on the video game intervention on memory for the elderly, and reviewed some methods and results of video games training.

Keywords: video game training, elderly, intervention, memory.

1. Aging and Intervention for the Elderly

The obvious decline in fertility and the increase in life expectancy in today's world are leading to a rapid aging of the world's population (World Health Organization, 2015). According to UN data, the proportion of the elderly population in the world's total population increased from 5.1 % in 1950 to 8.3 % in 2015, from 130 million to 610 million. Since the 1980s, the growth rate of the world population has been slower and slower than the growth rate of the elderly population. In 2015, the growth rate of the elderly population will reach 3.2 %, higher than the world population growth rate of 1.1 %. By the end of the 22nd century, the aging population will exceed 20 % of the world population. With the acceleration of the world's aging process and the increase of the elderly population, researchers pay more and more attention to the elderly. As individuals grow older, age-related cognitive decline occurs extremely common of the elderly, and if it is not interfered with, it has a high likelihood of developing mild cognitive impairment (MCI). Studies have shown that patients with MCI have a greater risk of developing Alzheimer's disease (AD), the most common neurodegenerative disease, within a few years (Ferris & Kluger, 1996). Alzheimer is the most common cause of dementia in the world and has a serious impact on the mental health and daily life of individuals. However, the current clinical drugs cannot reverse the course of Alzheimer's disease. Only two drugs, Acetylcholinesterase Inhibitors and Mem Antione, can improve some symptoms. And the expensive treatment costs impose emotional and economic burdens on patients and their families and communities (Anand, Gill & Mahdi, 2014). Since the time from healthy old people to MCI patients to AD patients usually exceeds 10 years, researchers try to use non-drug interventions at this stage to improve the cognitive health of the elderly, delay aging and contribute to the improvement of the aging society.

At present, there are many kinds of non-drug interventions, including physical activity, cognitive training, music training, diet control, etc. In recent years, long-term investigation and research on large samples showed that physical activity can reduce the risk of AD and improve the symptoms and living ability of AD patients. Teri et al. (2003) confirmed that the health status and memory ability of AD patients have improved significantly after professional nursing staff instructed AD patients to exercise at home for 3 months. In addition to AD patients, the study also found that aerobic exercise can also improve cognitive function of healthy elderly people. Erickson et al. (2011) conducted an aerobic exercise intervention study on healthy elderly subjects for up to one year. The results showed that the memory performance of the elderly in the aerobic exercise group was significantly improved compared with the elderly in the control group only performing stretching exercise.

In addition to physical exercise, cognitive training is also a very common method in elderly intervention. The pattern is generally that individuals take part in cognitive task training for a period

of time and then examine whether it can improve their target cognitive ability and other cognitive abilities. Liu et al. (2016) divided 45 subjects with MCI into an experimental group and a control group. The researchers conducted cognitive training for 30 subjects in the experimental group for two months and two hours a day, including attention, memory, cognition, language and task performance. The results showed that cognitive training can significantly help MCI patients' attention, language, orientation, visual perception, organization of visual movement and logical questioning ability. Cognitive training can also improve the cognitive ability of healthy elderly people. For example, in 2011, Irigaray et al. conducted an experiment using 12 sessions of cognitive training on healthy the elderly, they found that the elderly from experimental group presented better cognitive performance, better perception of quality of life and better scores of psychological well-being. Researchers concluded that cognitive interventions can contribute to the improvement of life and psychological well-being of the elderly.

Music training, including instrumental music training and vocal music training, is a multi-system and long-term learning process. During this process, various systems such as hearing, emotion, cognition and so on have joint activities around music signals, causing plasticity changes in the auditory system and promoting auditory processing of sound signals (Herholz & Za Torre, 2012; Kraus & Chandrasekaran 2010; Strait & Kraus, 2014). Parbrey - Clark et al. (2012) measured the scores of the experimental group (lifelong music training) and the control group (no music training) in the three language recognition tests and the threshold of language recognition. The results showed that the speech recognition ability of the elderly in the experimental group was significantly higher than that of the control group, and the auditory threshold of the experimental group was also significantly lower than that of the control group (Part - Clark, Anderson, Hittner, & Kraus, 2012).

With the improvement of living standards and the change of life style, people's eating patterns have changed. Dietary factors play an important role in the cognitive health of the elderly. Lack of various vitamins and trace elements, too high carbohydrate and fat intake will increase the harm of cognitive impairment, so increasing appropriate nutrient intake, such as polyunsaturated acids (PUFA) in plant chemicals and deep-sea fish, and reducing inappropriate ingredients in food will help improve cognitive function. Studies have shown that the lack of nuts, vegetables and fruits in the diet of MCI patients may be related to the impairment of cognitive function. At present, the cognitive intervention of the elderly tends to change from single intervention to multiple comprehensive intervention, such as using cognitive training and diet control at the same time. Multiple means work together and interact with each other to help the elderly improve their cognitive function.

In recent years, non-drug intervention methods have become more and more diversified. For better consideration of cognitive function intervention for the elderly, researchers considered that in addition to effectiveness, more attention should be paid to the interest of intervention and its appeal to the elderly. The new and different cognitive stimulation is of great significance to the improvement of the cognitive ability of the elderly. In the field of cognitive aging research, video games have been noticed as a treatment for age-related cognitive defects. Although cognitive training is the earliest and most widely used intervention method, many researchers believe that the transfer effect of cognitive training is small. Game training based on computers, TV and mobile platforms has shown many positive effects (Ming - Hsin Lu, Wei Jane Lin, 2017).

2. Introduction and Classification of Video Games

The video game that people usually say is a narrow concept, which refers to the man-machine interactive entertainment mode that depends on a certain game software control and is implemented by the player through the computer in the form of instructions (Liang, 2007). There are many kinds of electronic games, involving a wide range of fields, so far there is no standard classification method. Herz classification is the most frequently used in modern times, and games are mainly divided into adventure games, combat games, action games, simulation games, sports games, strategy games, guessing games and role-playing games. At present, the electronic games usually used in the intervention research can be divided into two categories, one is action video game, which requires

players to move quickly during the game to monitor the visual periphery and most of the time need to track multiple targets, including the rise of the country, Mario 64 and so on. Another type of game is non - action video game, which includes Russian diamonds, angry birds and so on. According to the picture of the video game, the video game can be divided into 2D game and 3D game. In this review, we divide the video game according to the picture characteristics of the game, that is, 2D / 3D type.

3. Characteristics of Memory Decline in the Elderly

With the increase of age, many cognitive abilities of the elderly have declined, and memory is no exception. Many elderly people are very worried about their memory problems and think that the most obvious thing they feel in the process of aging is the decline of memory. Many studies have also shown that almost all the elderly people's memory ability has been impaired, regardless of natural aging or pathological aging, but the decline in memory ability is not all - round.

Now researchers generally believe that human memory is not a single unit. Memory is composed of many different systems, which follow different rules. Tulving proposed five different memory systems: sensory memory, working memory, e episodic memory, semantic memory and procedural memory. The current study of memory aging found that if the sensory system of the elderly is functioning well, the age difference in sensory memory is very small. Similarly, for the elderly, the differences between procedural memory and semantic memory and those of the young are not significant. With the increase of age, the decline of memory ability is mainly reflected in working memory and episodic memory system. Episodic memory can be further divided into item memory and associative memory. Item memory refers to the memory of individual items, usually words and pictures of objects. The associative memory is the memory of the relationship between the project and the project or between the project and the background. Such as memorizing word pairs (items and items) or memorizing objects (items) on pictures and background scenes (backgrounds) corresponding to them. Associative memory tasks that need to encode and judge items and their background information are also referred as source memory tasks. In the further study of episodic memory, the researchers found that if the episodic memory is further divided, the aging of item memory is not significant, but the age damage of associative memory is very prominent. Naveh - Benjamin believes that the important reason for the memory loss of the elderly is that it is difficult for them to encode and extract the association between the two basic units. The basic unit can be two items, items and their backgrounds, two background features, or even two psychological codes. In other words, the elderly has no way to integrate the various parts of the episodic events into a unified whole. Although each part can be preserved in memory to some extent, the connection between them is very weak. The degree to which a memory test needs to create or use connections is the key to the memory performance of the elderly.

The computational model of the hippocampus is derived from animal studies on the hippocampus. The computational model of the hippocampus proposes two important functions of the hippocampus, one is pattern completion and the other is pattern separation. Pattern completion refers to the integration of incomplete and decomposed representations into previously stored complete representations, which enables us to extract complete memories from some clues. Another important function is pattern separation, which enhances the distinctiveness of representations and enables individuals to distinguish very similar representations. Animal researchers found that the model separation ability of the aged mice was impaired, and the memory impairment caused by the same aging was also found in human aging. Compared with young people, the elderly is more dependent on the processing of subject information, and their ability to encode and extract fine details has been impaired, leading to a decline in the performance of the elderly in identifying very similar items. Therefore, if the intervention study hopes to improve the memory function of the elderly, then the improvement is usually manifested in the ability of working memory, episodic memory or pattern separation.

4. Training Effect of Video Game Intervention on Memory of the Elderly

Based on the training effect of video games on the memory of the elderly, this paper collates the research on the intervention of video games training on the memory ability of the elderly since 2015. By comparing the specific effects of 2 - D games and 3 - D games on the elderly's memory function intervention, this paper discusses whether different kinds of games have improved the elderly's cognitive function, especially memory. Finally, the future research direction is summarized and prospected.

Pilar et al. (2016) designed a 2×3 mixed factor design to study the effect of 2 - D video game intervention on maintaining or improving visual spatial working memory, long-term memory and short-term memory. Pilar used six games (speed match, memory matrix, rotation matrix, face memory, money combo, lost in migration). we will not describe these six games in detail here. Specific information about the games can be found in the original (Video game training enhancements visuospatial working memory and episodic memory in older adults). This experiment used these six games to train the subjects in the experimental group for seven to eight weeks, with a total of 15 training sessions lasting one hour each time. In each training session, the participants played all six games twice. The measurement task is aimed at the following three aspects: visual space working memory, short-term memory and episodic memory. The measurement of visuospatial working memory (WM) used Corsi Block Task and Jigsaw - Puzzle Task. The results showed that the scores of subjects in the experimental group in Corsi Block Task were significantly higher than those in pre-test, while the control group showed a downward trend. The experimental group also scored significantly higher than the control group in the post test of the Jigsaw - puzzle task, thus the training improved the visuospatial WM of the subjects. The researchers used digit span test (WAIS III scale) to measure the short-term memory of the subjects. In digit forward test, there was no significant difference between the experimental group and the control group before and after training, while in digit backward test, there was no significant difference between the three tests of the experimental group and the control group, while the score of the control group decreased significantly. The researchers explained that the performance of digit forward test remained stable during the aging process, while the performance of digit backward test decreased with age. At the same time, the researchers measured the scores of immediate and delayed episodic memory test using the Faces and Family Pictures subtest of the WMS-III. The immediate recognition and recall were tested by Faces I and Family Pictures I, and delayed recognition and recall were assessed 25 min later using Faces II and Family Pictures II. The results showed that in Faces I and Faces II, the score of participants increased significantly. It indicates that the ability of recognition improved after training sessions. However, the results in Family Pictures were not significant, neither immediate recall nor delayed recall improved. This result might be explained that free recall requires greater resources than recognition and this effect increase with age. The results obtained in the Faces suggest that the task was easy for both groups. Pilar concluded that game training can effectively improve the visuospatial WM and episodic memory of the elderly. The brain of the elderly still has plasticity, but it needs some periodic boost to keep it.

In another study, Aniket et al. (2015) trained the participants for three weeks using spatial n - back games. The n - back paradigm requires the participants to compare the stimulus that has just occurred with the previous nth stimulus and control the load by manipulating the number of stimulus between the current stimulus and the target stimulus. In this study, in order to increase the fun of the game, the researchers improved the normal n - back training to spatial n - back training, and set up four main scenes to develop real events and scenes. On the screen, different stimuli are combined with different locations. The researchers tested the working memory of one of the subjects' transfer effects by using Digit Forward and Backward. The results showed that neither the training group nor the control group improved the memory span after training, and there was no significant difference between the results, indicating that using spatial n - back game training could not achieve the effect of improving memory span. Researchers believe that although the performance of the participants in the game improved obviously after training, it may be due to the exercise effect caused by the improvement of their

familiarity with the game, rather than the improvement of the working memory span of the participants.

In addition to 2D games, some researchers have chosen 3D action games to train the elderly. For example, Gregory et al. (2015) divided the subjects into three groups, and the 3D game training group (SM) used Super Mario 3D World games. Super Mario 3D World is a Wii U family video game published by Nintendo and developed by the Super Mario series, in which players control Mario to reach the destination to save others by breaking through the barriers. The 2D game control group (AB) used the Angry Birds game, which players used the mouse to control the slingshot on the screen to launch birds to attack pigs invading their homes. No game control group (NG) had no contact with researchers during the study. The whole experiment process includes game training for half an hour every day for the first two weeks and no training for the second two weeks, with a total of three tests of pretest, post test1 and post test2. The mnemonical similarity task is a recognition memory task originally designed to tax the process of pattern separation. It provides two measures: a lure discrimination index (LDI) and a recognition memory score. The researchers tested the subjects with MST and found that the score of LDI in SM group showed training effect, while the other two groups AB and NG did not. This shows that the 3D game Super Mario 3D World can promote Mnemonic Discrimination in the elderly.

In another study, Greg L and others trained subjects using Super Mario 64 games in 2017. Super Mario 64 is similar to Super Mario 3D World in the previous study, except that some parts have different tasks. Greg used the short term memory test to compare the short term memory of the game training group, the music training group and the unconnected control group after six months of a minimum of 30 minutes at least five days a week. The results of paired sample T test showed that the short-term memory of the game training group was significantly improved, but no such improvement was observed in the other two groups. In this study, the study also observed the changes of gray matter in the brain of the subjects and found that the gray matter of the elderly in the game training group increased significantly. Therefore, the researchers believe that the enhancement of short-term memory is related to the increase of gray matter in the brain.

Walter et al. (2013) conducted a study using 3D games in 2013, using the 3D game Mario Kart DS as an intervention to train subjects. In Mario Kart DS games, participants compete with computer-controlled characters and avoid danger during the race. The 2D game control group used Brain Fitness 2, a brain training game for the elderly, to complete different characters for memory, reaction time, language and mathematical abilities. Memory is measured by various means: Corsi Block Task, Everyday Recognition, Meaningful Memory, Memory Self - Efficiency Questionnaire. In the analysis of the test results, the test differences before and after training did not reach a significant level. The researchers believe that the subjects have low tolerance and negative emotions for the games in this study, which is consistent with the subjects' tendency to choose low-challenge tasks, and the subjects report that Mario Kart DS has poor game experience and do not believe it will improve cognitive function, so the training effect is weakened.

5. Summary

From the researches above, we can conclude that video games training increases older adults' memory in different aspects. For example, visuospatial WM, episodic memory, short-term memory and mnemonic discrimination. However, some researches did not find significant improvement in participant's memory, and they attribute this to the flaws in game designs. In future studies, we can focus more on the different effects between 2D and 3D games. It is likely that the mechanisms of the two kinds of games are different. Some researchers pay attention to the changes in the neuro-connection, which is the physiological basis of the mnemonically improvement.

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