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# Training Effects of Eye Movement on Improving Basic Cognitive Ability of Mild Cognitive Impairment (MCI) Patients and Normal Aging (NA) People

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**Abstract**: **Object:** To explore training effects of eye movement on improving basic cognitive ability of mild cognitive impairment (MCI) patients and normal aging (NA) people. **Methods:** In this study, patients with light degree of MCI and NA people of 60 - 75 years old were recruited as subjects; a test scale technique of basic recognition ability was applied; matching groups were designed with transverse and longitudinal comparisons; before and after experiments, the groups of the sensory integration training and control were respectively tested with the basic recognition ability; then all measured data were statistically processed. **Result:** Eye movement training can effectively improve the basic recognition ability of MCI patients and NA people. **Conclusion:** The sensory integration training plays an important role in improving the cognitive ability of MCI patients and NA people.

**Keywords:** Sensory Integration Training, Transverse, Longitudinal Comparison, Elderly, Senior, Control Group

## 1. Introduction

The term of mild cognitive impairment (MCI) was first introduced by Reisberg B in 1988 [1]. In 2018, the prevalence of MCI was 6.7% for ages 60–64, 8.4% for 65–69, 10.1% for 70–74, 14.8% for 75–79, and 25.2% for 80–84 in USA [2]; and the pooled prevalence of MCI in the older (>= 60 years old) population was 14.71% in China [3].

MCI can be considered as a prodromal condition for Alzheimer's disease (AD) that is not curable today [4].

We have not found any high-quality report to support effective pharmacologic treatments for MCI. On the other hand, in patients with MCI, exercise training (6 months) is likely to improve cognitive measures and cognitive training may improve cognitive measures [2].

Exercise training of eye movement is the cognitive process that transmits visual stimulation to the brain through the optic nerve conduction path and makes integration. Human Cognitive ability is closely related to brain function, and brain function has great plasticity. The effective training of the cognitive function of the brain can help develop brain potential and delay the process of brain decline [5, 6].

Though some of sensory integration (eye movement) trainings were used for young people's potential development [7], our previous studies focused on event-related potentials [6] and effects of fast reading, remembering and mental potential development on cognitive ability for elderly people with MCI [5].

In this study, we continued and expanded our previous investigations of eye movement and MCI of senior people [5, 6]; and characterized the elderly with MCI and the normal aging (NA), by observing effects of the visual integration training on improving the elderly MCI and delaying the decline of cognitive function of NA people.

## 2. Research Subjects and Methods

### 2.1 Subjects (Entrants) of Study

#### 2.1.1 MCI

The subjects of MCI mainly came from Huayu Elderly Apartment. They were prepared by screening from 500 elderly respectively in March 2016 and April 2018, Weifang city, Shandong province. Referring to Perton Standard [8] and making corresponding amendments, we selected a total of 97 senior people (60 ~75 years old) with MCI and high education, to participate in the visual eye movement training.

All subjects were right hand, had normal blood


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pressure or mild hypertension and did not have any habit of fitness exercise. Their visions (naked eye or correction) and hearings were normal; their cardiopulmonary function and blood sugar level were basically normal.

All subjects knew the object of the study and agreed to participate in this investigation, they filled out the health questionnaire form that mainly includes age, gender, education level, diseases and health status.

MCI selection criteria are: (1) age 60 - 75 years old; (2) subjective and objective examinations have cognitive impairments; (3) Minimum Mental State Examination (MMSE) score ≤ 26 points, Global Deterioration Scale (GDS) was rated 2 - 3 level; (4) life and social function decreased: Activity of Daily Living Scale (ADL) score ≤ 18 points; (5) Hachinski Ischemic Scale (HIS) score ≤ 4 points; (6) cognitive impairment course > 3 months; (7) elimination of cognitive function impairment caused by depression and special causes; (8) does not fulfill the diagnostic criteria for dementia; (9) excludes serious somatic diseases, long-term bedridden and other persons who were unable to complete their trainings.

**2.1.2 Normal Aging (NA)**
32 NA subjects were selected from 200 old people (60 – 70 years old) in Weifang city, from November 2016 to October 2018. A random digital table was applied to equally divide them into the intervention and control groups: 16 people in each group. The determination of subjects' handedness was performed with China's standard E91 evaluation, the both groups were right hand; their binocular vision (naked eye or correction) were normal (1.0) and their hearing were normal (24 dB) too. By comparing the two groups, the subjects were basically matched in age, sex, education time and MMSE score, and there were no statistically significant differences (P > 0.05). Additionally, all subjects understood and agreed to participate in the study.

Recruitment criteria: (1) their ages were 60 - 70 years old; (2) they often complain memory loss, but no pathological damages were found based on objective examination of evidences; (3) MMSE scores ≥ 28 points; (4) ADL scores ≤ 16; (5) they do not fit the diagnostic criteria for dementia.

Exclusion criteria: they had depression, brain trauma, heart, brain, or kidney disease that could cause severe brain dysfunction; they used special drugs such as a history of using a pharmaceutical to improve memory.

**2.2 Research Methods**
A single blind design was used in this investigation and the experimental period was 3 months. Before the intervention, according to the basic matches of sex, age, number of years of education, and the achievement of MMSE score and Raven Standard Reasoning test, the subjects were divided into training and control groups. There were no statistically significant differences in the matching comparisons between the two groups (P > 0.05).

The training group conducted visual eye movement training (3 months) and auditory integration training (6 months), and the control group did not intervene to maintain the original living habits.

Before and after training, the basic cognitive abilities of the subjects were evaluated with the test software, and evaluations were carried out on computers in the way of man-machine dialogues (the subjects needed only to press the corresponding keys on the keyboards).

The quiz was conducted in a quiet room and no third party was allowed to be present. Application of SPSS statistical software was used for T test.

The test includes 7 parts: (1) digital copy; (2) Chinese character comparison; (3) mental arithmetic/calculation; (4) positive and negative word recognition; (5) answer recollection mental calculation/recall; (6) double word re-recognition; (7) meaningless graphic re-recognition.

**3. Results**
Table 1 shows results of the basic cognitive ability test of MCI subjects before and after eye movement training. There were no significant differences in the basic cognitive abilities between the two groups before the training.

After 1 month of training, for the training group, the 2nd time results significantly improved (P < 0.05) longitudinally compared with that of the 1st time in the word re-recognition test; and are significantly better (P < 0.05) than that of the control group in the same time tests (transverse comparisons) of digital copy, Chinese character comparison and word re-recognition.

| Project | MCI control group | | | MCI training group | | |
|---|---|---|---|---|---|---|
| | The 1st time | The 2nd time | The 3rd time | The 1st time | The 2nd time | The 3rd time |
| Digit copy | 1.84 ±0.69 | 1.84 ±0.70 | 1.79 ±0.68 | 1.87 ±0.49 | 1.60 ±0.45[b] | 1.33±0.41[ab] |
| Comparison of Chinese characters | 2.33 ±0.98 | 2.34 ±1.06 | 2.25 ±1.15 | 2.40 ±0.70 | 2.06 ±0.73[b] | 1.46±0.53[ab] |
| Mental arithmetic | 0.34 ±0.1l | 0.33 ±0.12 | 0.33 ±0.12 | 0.30 ±0.12 | 0.30 ±0.11 | 0.40 ±0.10[a] |
| Chinese character rotation | 0.47 ±0.17 | 0.43 ±0.13 | 0.44 ±0.18 | 0.49 ±0.18 | 0.50 ±0.19 | 0.73 ±0.23[a] |
| Memory span | 2.94 ±0.80 | 2.81 ±0.83 | 2.82 ±0.64 | 2.57 ±0.77 | 3.33 ±0. 84 | 5.16±1.29[ab] |
| word recognition | 11.00 ±2.89 | 10.88 ±2.90 | 10.29±3.20 | 11.00±2.29 | 13.39±1.88ab | 16.83±1.82[ab] |
| Graph recognition | 12.33 ±3.16 | 12.38 ±3.28 | 12.00±2.92 | 12.31±2.92 | 13.06 ±3.33 | 15.11 ±2.84[a] |

Table 1. Comparison of basic cognitive ability test scores between eye movement training group and control group before and after training. (average±STD).
a : $P < 0.05$ (Longitudinal) Comparisons within groups in the different time tests;
b : $P < 0.05$ (Transverse) Comparisons between groups in the same time test.

After 3 months of training, for the training group, the 3rd time results are significantly better than that of the 1st time ($P < 0.05$) in the tests of basic cognitive abilities of 7 aspects; and are significantly better ($P < 0.05$) than that of the control group in the same time tests of digital copy, Chinese character comparison, memory breadth and word re-recognition.

Before and after eye movement training, the basic cognitive ability tests were carried out on the training and control groups of NA, the results are shown in table 2. The difference was not statistically significant ($T = 0.384$, $P > 0.05$) in the test of the basic cognitive abilities of the two groups before the intervention.

After the intervention of the two groups, the inter-group comparison was carried out, and the results showed the differences were significant in tests of the digital fast copy ($T = 2.425$, $P < 0.05$), rapid comparison of Chinese characters ($T = 2.479$, $P < 0.05$), mental answer memories ($T = 2.876$, $P < 0.05$).

For the comparison within the auditory integration training group before and after the intervention, statistical results show there are significant differences in tests of the digital fast copy ($T = 2.990$, $P < 0.05$), rapid comparison of Chinese characters ($T = 2.693$, $P < 0.05$), mental answer memories ($T = 3.513$, $P < 0.05$).

| Project | NA control group | | NA training group | |
|---|---|---|---|---|
| | Before training | After training | Before training | After training |
| Digit copy | 2.72±1.81 | 2.98±1.46 | 3.65±1.96 | 2.13±0.48 |
| Comparison of Chinese characters | 4.43±0.81 | 4.59±0.44 | 4.83±2.87 | 3.02±1.05 |
| Mental arithmetic | 9.55±3.27 | 10.35±2.96 | 12.13±6.32 | 15.32±4.56 |
| Chinese character rotation | 13.24±2.16 | 14.33±2.35 | 15.05±3.37 | 16.97±2.68 |
| Memory span | 1.50±1.25 | 1.67±1.88 | 1.02±0.53 | 2.24±1.22 |
| word recognition | 4.33±5.29 | 4.02±6.19 | 9.02±4.90 | 10.85±5.68 |
| Graph recognition | 3.84±3.09 | 4.61±2.68 | 4.04±3.77 | 5.72±4.05 |

Table 2. Comparison of the results of basic cognitive ability test before and after intervention between the two groups (average±STD).

**4. Discussion**

A large number of studies have shown that human cognitive abilities similarly develop following parabolic lines in a lifelong process. Before and after adulthood, cognitive abilities respectively increase and decrease with the aging [5 - 7].

In a previous study, Li D and colleagues found there were significant individual differences in the lifelong development of cognitive abilities [9] that are consistent with Wu W three concepts of aging: the successful, normal and morbid (MCI and even AD) [10]. The morbid aging cognitive abilities decreased obviously in response attention, recent memory, learning ability, reasoning ability, information processing and processing speed, visual space and structure ability, and executive function, compared with that of the other two aging; the above decreases are the declines of fluid intelligence in the elderly. Brain plasticity studies have shown that the brain is highly malleable under the influence of the outside environment (input), regardless of health or mild injury; children, adults or elderly

In 1982, scientists [5, 11] conducted fairly short cognitive training for the elderly in 60~80 years old, and found that as the number of training increased, fluid intelligence increased significantly.

Scientist Xu S [5] also concluded that the trained older people's average scores slightly exceed those of untrained youth. This conclusion is mainly related to the morphological and functional plasticity of the dendrites and synapses of the brain, and the plasticity can lead to more association of dendrites. The formation of new, considerable neural loops exceeds the location of the lost original neurons. The loops allow this part of the central nervous system to form a new network of dendrites, and effectively compensate neurological defects caused by brain aging and neurodegenerative changes.

Sensory integration training is an aerobic reading method, which can directly improve the cognitive ability of the elderly. After gradual training, the brain potential of the elderly is gradually developed.

In this study, we found that after a long period of sensory integration training, MCI older people significantly improved in the perceptual identification, similar comparison and memory breadth. Using the test, we also found that MCI seniors and NA people significantly improved their basic cognitive abilities after training.

The above results show that sensory integration training improves the memory efficiency of the elderly while significantly improving the brain function of the elderly in the both MCI and NA. Our results are consistent with two previous results of the behavior intervention studies: A long-term physical fitness exercise improves the intelligence level of the elderly and an eight-section of fitness method effectively raises the intelligent physiological age of the elderly [5 – 7].

In a related study of our previous theoretic modeling [12], we proposed a concept of health oriented lifelong learning (HOLL) to prevent, delay and/or treat aging or aged dementias caused by less mentally stimulating activities. In that study, we emphasized $O_2$ plays a role to learn new knowledge and to improve MCI. Generally, learning is a mental exercise training mostly. However, learning involves reading usually. Therefore, learning actually includes (physical) exercise training of eye movement too; and the results of our current and previous studies are (almost) consistent each other.

## Conclusion

In short, sensory integration training can effectively improve the cognitive function of MCI patients and NA people, and delay the decline of cognitive ability.

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