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# Impact of Piano Training on Physical, Cognitive Health, and Quality of Life of Older Adults at Changzhou Senior University Piano Teaching and Research Center: Intervention Program

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## ABSTRACT

Piano training stimulates different cognitive functions, which is not only beneficial to brain plasticity and used by the elderly to compensate for age-related declines in executive function, but also beneficial to improving their quality of life in old age. This study analyzes the impact of piano training on the behavioral performance of the elderly through three indicators: processing speed, working memory, and cognitive flexibility. Through interviews, it also analyzes the promotion of piano training on the quality of life of the elderly and its impact on their physical function and cognitive health. The study finds that piano training can effectively improve the inhibitory control, working memory, and cognitive flexibility of the elderly, thereby promoting executive function plasticity and delaying age-related declines in executive function. At the same time, piano training can enrich the retirement life of the elderly and enhance their quality of life.

## KEYWORDS

Elderly; Executive Function; Quality of Life.

## 1. INTRODUCTION

For the elderly, many bodily functions decline with age. Examples include physical function, cognitive health, and quality of life. These functions are crucial for regulating other cognitive processes and have a significant impact on the daily lives of the elderly. Fortunately, the decline of these functions can be delayed through targeted training interventions, including cognitive training[11], physical exercise[5], rhythmic movement activities[7], dance interventions, and other leisure activities for the elderly[4]. Among them, instrumental music training, as a multi-sensory integrated intervention, has received extensive attention from researchers in the field of geriatric cognitive health[1].

Instrumental music training is a form of cognitive training that requires the involvement of multiple sensory systems (vision, hearing, touch) and motor functions, as well as complex coordination and communication among these systems. Instrumental music training can stimulate different cognitive functions. During instrumental music training, selective attention, working memory, inhibition, task switching, updating, and monitoring are all involved, which are components of executive function[2]. Therefore, numerous studies have shown that instrumental music training can improve physical skills, cognitive health, and quality of life[8]. Long-term instrumental music practice not only enhances the level of behavioral performance of executive function but may also affect the brain structure and function related to executive function. This article will analyze the impact of short-term and long-term piano training on the behavioral performance and neural mechanisms of executive function in older adults from the perspective of three sub-dimensions of executive function: physical function,

cognitive health, and quality of life, using piano training as an example. For the dimensions of physical function and cognitive health, this article analyzes the impact of piano training on the behavioral performance of older adults from three indicators: processing speed, working memory, and cognitive flexibility. Through interviews, it also analyzes the promotion of piano training on the quality of life of older adults.

# 2. SUBJECTS AND METHODS

## 2.1. Target Audience

The piano program at Changzhou Senior University enrolled 37 selected students, all carefully chosen by instructors for their positive academic attitudes and demonstrated proficiency in daily studies. These participants began systematic piano training exclusively after enrolling in the senior university program, having previously received no professional piano instruction and with most having no prior piano experience. The study also included 24 non-piano program participants as controls, all of whom had never engaged in piano training and exhibited normal physical and cognitive functions without significant medical conditions. The experiment collected 47 valid data points, comprising 30 females and 17 males, divided into three groups: Group 1 (never piano learners), Group 2 (1-2 year piano learners), and Group 3 (over 2 year piano learners). Detailed characteristics are presented in Table 1:

**Table 1.** Age and piano learning duration of participants in each group

| | | N | least value | crest value | average value | standard error |
|---|---|---|---|---|---|---|
| age | first group | 18 | 56 | 75 | 65.83 | 6.06 |
| | second heat | 10 | 55 | 74 | 65.8 | 7.27 |
| | Group 3 | 19 | 56 | 75 | 66.21 | 4.71 |
| | amount to | 47 | 55 | 75 | 65.98 | 5.71 |
| Piano practice time (months) | second heat | 10 | 6 | 18 | 16.2 | 4.05 |
| | Group 3 | 19 | 30 | 54 | 41.68 | 10.29 |
| | amount to | 29 | 6 | 54 | 32.9 | 15.01 |

## 2.2. Experiment on Processing Speed and Working Memory Capacity

### 2.2.1. Processing Speed Experiment

Functional neuroimaging and repetitive transcranial magnetic stimulation studies have demonstrated that processing speed depends on the prefrontal cortex and parietal regions, particularly the ventral prefrontal cortex and medial/lateral prefrontal cortex, which include the supplementary motor area (SMA) and pre-supplementary area (pre-SMA)[3]. Zuk et al.27 employed functional magnetic resonance imaging (fMRI) to examine neural correlations of executive function in children with over two years of instrumental training versus those without musical training. Whole-brain analyses of pattern representation in fMRI revealed greater pre-SMA activation in children with instrumental training compared to those without training. Whole-brain analyses of task switching demonstrated enhanced activation in bilateral pre-SMA regions among children with instrumental training. These findings suggest that instrumental training facilitates activation of pre-SMA regions associated with cognitive flexibility. Although this conclusion was derived from child participants, we hypothesize that instrumental training may similarly enhance SMA region activation in older adults, thereby improving their processing speed, which is consistent with the findings of relevant randomized controlled trials on piano training in the elderly[6].

Visual Stimulus Materials: Five easily identifiable geometric shapes (e.g., circles, squares, triangles) from Microsoft Office Word drawing tools were selected and resized to 192×192 pixel images for visual processing speed experiments. Auditory Stimulus Materials: Music professionals recorded 15 1500-millisecond copper pipe sound segments (each consisting of three notes). Non-music learners then screened out five easily distinguishable audio clips for sound processing speed experiments.

### 2.2.2. Working Memory Capacity Experiment

Working memory, as a crucial component of executive functions, interacts with inhibitory control mechanisms. Specifically defined as a limited-capacity mental workspace capable of short-term information storage, processing, and retrieval, it serves as a key factor in completing various cognitive tasks. Common assessment methods include numerical memory span tests and N-back tasks. Research indicates that instrumental training can delay memory decline in older adults and enhance memory retention. For instance, Gooding et al. investigated the impact of early and middle-age instrumental training on memory performance in seniors. A study involving 237 cognitively normal elderly participants aged 60+ collected self-reported data on instrument types, training duration, and objective musical assessments. Participants were categorized into low-, medium-, and high-music knowledge groups based on self-reported training information. Semantic and situational working memory tasks were then administered to compare group performance. Results demonstrated that high-music knowledge participants achieved significantly higher working memory scores in situational contexts compared to low-music knowledge groups, suggesting that older adults with musical training experience exhibit superior working memory capabilities. At the same time, related studies have also found that music-based combined interventions can also have a positive effect on the working memory of the elderly[11].

The material selection for this experiment followed the setup of the processing speed experiment: 30 basic shapes and 30 sound materials were selected respectively, and matched through a random program into identical or different stimulus pairs, resulting in a total of 190 pairs for the formal experiment.

Visual stimulus presentation method: Stimuli were presented simultaneously in left-right parallel arrangement, with a presentation duration of 5000 milliseconds.

Presentation method of auditory stimuli: Stimuli were presented sequentially, with the duration of individual sound stimuli controlled within 4000 milliseconds.

### 2.2.3. Measurement of Fluid Intelligence

Extensive research has demonstrated that instrumental training exhibits strong neuroplasticity in the brain of older adults[1]. However, does instrumental training influence structural and functional alterations in brain regions associated with inhibitory control? A study by Moussard et al. investigated the underlying neural mechanisms by which instrumental training affects cognitive performance in the elderly. The study enrolled elderly musicians (mean age 69 years) with long-term instrumental training experience and non-musicians, who completed an inhibitory control task (Go/No-Go) with event-related potential (ERP) recording. Behavioral results showed comparable reaction speeds and accuracy rates between groups, but elderly musicians exhibited fewer errors during the No-Go test, indicating that instrumental training positively enhances inhibitory control in older adults[2]. ERP recordings revealed increased N2 and P3 wave amplitudes in elderly musicians, where N2 amplitude correlated with correct No-Go performance rates and P3 amplitude correlated with musical experience. These findings suggest that long-term instrumental training may confer inhibitory control advantages in elderly musicians, delaying the decline of inhibitory control-related neural mechanisms in older populations. In addition, related studies have shown that both active music production and receptive music therapy have positive effects on the cognitive function of the elderly, including fluid intelligence related indicators[9].

To this end, this study referenced Li Dan's CRT experiment to assess relevant indicators. The test comprised 60 items, with final results expressed as CRT-IQ.

# 3. EXPERIMENTAL RESULTS

## 3.1. Research Findings on Processing Speed and Working Memory

### 3.1.1. Relationship between Processing Speed and Working Memory Capacity in Elderly Participants

Given the critical role of age in cognitive aging, we controlled for age variables and conducted partial correlation analyses on visual material processing speed (VPS), auditory material processing speed (APS), visual working memory capacity (VWMC), and auditory working memory capacity (AWMC) across all participants. Results are presented in Table 2.

**Table 2.** Partial correlation matrix between processing speed and working memory capacity

| | APS | VWMC | AWMC |
|---|---|---|---|
| VPS | 0.511** | -0.325* | -0.366* |
| APS | | -0.229 | -0.357* |
| VWMC | | | 0.557** |

### 3.1.2. Analysis of Differences in Processing Speed

Table 3 data reveal significant differences in processing speed between the two materials. Further multiple comparisons (LSD) indicate that the APS scores showed statistically significant differences between the group with no piano training experience and those with over two years of piano study (P=0.019), while no significant difference was observed with the group having less than two years of training. Meanwhile, the VPS scores of the no-training group exhibited significant differences compared to both piano-training groups (P=0.041; P<0.023), whereas no significant differences were found between the two piano-training groups in terms of VPS and APS. These findings demonstrate that long-term piano training can effectively enhance processing speed in elderly individuals, which is consistent with the results of existing randomized controlled trials on piano training in the elderly[2].

**Table 3.** Results of multivariate covariance analysis of processing speed

| | | M (ms) | SD(ms) | F | DF | P |
|---|---|---|---|---|---|---|
| Processing speed of visual materials | first group | 638.94 | 123.79 | 4.214 | 2 | 0.021 |
| | second heat | 562.33 | 59.56 | | | |
| | Group 3 | 567.74 | 63.06 | | | |
| Processing speed of auditory materials | first group | 1580.52 | 198.53 | 3.511 | 2 | 0.039 |
| | second heat | 1480.19 | 94.69 | | | |
| | Group 3 | 1434.71 | 126.99 | | | |

### 3.1.3. Analysis of Differences in Working Memory Capacity

**Table 4.** Results of the Multivariate Covariance Analysis of Working Memory Capacity

| | | M (ms) | SD(ms) | F | DF | P |
|---|---|---|---|---|---|---|
| Processing speed of visual materials | first group | 5.78 | 1.31 | 1.697 | 2 | 0.195 |
| | second heat | 6.5 | 2.27 | | | |
| | Group 3 | 6.79 | 2.07 | | | |
| Processing speed of auditory materials | first group | 5.17 | 2.12 | 7.159 | 2 | 0.002 |
| | second heat | 7.6 | 1.78 | | | |
| | Group 3 | 7.47 | 2.39 | | | |

A multivariate covariance analysis of working memory capacity under two materials revealed significant differences in auditory material working memory capacity among participants, while visual material working memory capacity showed no significant variation. See Table 4. Further multiple comparisons (LSD) indicated that the AWMC (Auditory Working Memory Capacity) of the non-piano learners group differed significantly from both piano learning groups (P=0.005; P2=0.001), whereas no significant difference was observed between the two piano learning groups in AWMC.

### 3.2. Findings on Fluid Intelligence Research

This experiment revealed that fluid intelligence showed lower correlations with age, auditory material processing speed, and working memory, with coefficients of 0.094, -0.213, and 0.201, respectively. In contrast, higher correlations were observed between visual material processing speed and working memory content, with coefficients of-0.294 and 0.289, respectively.

## 4. INTERVIEW RESULTS

Through interviews with elderly residents at Changzhou University, most seniors expressed feeling lifeless and aimless, often describing their daily routines as tedious and empty. However, after enrolling in piano classes, they found music not only enriched their lives but also helped them connect with like-minded peers. During breaks or leisure time, they shared musical insights, significantly enhancing their retirement experiences. Interviews revealed that many seniors discovered their passion for music through piano lessons, sparking a desire to deepen their understanding and master this skill. Most participants found piano learning immensely enjoyable, as it combined professional music theory knowledge with stress-relief benefits. As aging progresses, seniors experience declining memory retention and reduced finger dexterity, yet piano practice effectively addresses these challenges by improving hand-brain coordination and physical function. The repetitive memorization required for piano playing also strengthens memory retention. Most importantly, these holistic benefits significantly boost mental and physical health, effectively reducing the risk of dementia-related conditions, which has been confirmed by a number of studies on music interventions for the elderly[3].

## 5. DISCUSSION

In conclusion, instrumental training exerts extensive and profound impacts on behavioral performance and neural mechanisms in elderly individuals (physical function, cognitive health, and quality of life). This demonstrates that piano instruction serves as an effective approach to enhance

executive function in the elderly, delay its decline, and improve quality of life. Future research can be conducted from the following three aspects.

Firstly, whether different types of instrumental training exhibit varying impacts on executive function in elderly individuals requires further investigation. Existing research on instrumental training predominantly focuses on piano training, followed by orchestral training. Currently, the differential effects of different instrument types on executive function in older adults have not been specifically examined. Regarding instrumental training, the motivational effects and underlying mechanisms of various instruments may influence training outcomes differently. Future studies should therefore explore the impacts and mechanisms of diverse instrumental training approaches on other aspects of elderly life from multiple instrument perspectives, and further compare the intervention effects of instrumental training with other music-based activities such as rhythmic exercise and dance[12].

Secondly, whether different music training modalities share identical effects and mechanisms on executive function in older adults warrants deeper exploration. Instrumental training represents one form of music training, which also includes singing exercises and receptive music listening. Existing research indicates that singing training and music listening positively mitigate age-related cognitive decline in seniors. In addition, a large number of studies have confirmed that music combined with physical exercise[10], or music-based multi-component combined interventions also have significant positive effects on the physical health and cognitive function of the elderly. However, whether different music training types exert similar effects on executive function mechanisms, and which intervention modality has the best cost-effectiveness for community-dwelling older adults, remains to be further investigated.

Finally, studies examining how instrumental training enhances quality of life through improved executive function in elderly populations require further refinement.

## 6. CONCLUSION

In conclusion, this study provides compelling evidence that piano training serves as an effective multidimensional intervention for promoting cognitive health and enhancing quality of life among older adults. By examining processing speed, working memory, and cognitive flexibility, the findings demonstrate that sustained piano practice-particularly over longer durations-significantly improves key components of executive function. Notably, elderly participants with more than two years of training exhibited superior performance in both visual and auditory processing speed, as well as in auditory working memory capacity, compared to non-learners. These improvements suggest that piano training contributes to maintaining and even enhancing neural efficiency associated with executive functioning.

Furthermore, the correlation analyses indicate meaningful relationships between processing speed and working memory, highlighting the integrated nature of cognitive processes influenced by musical training. Although fluid intelligence showed relatively weaker associations, the observed trends still support the broader cognitive benefits of engaging in structured, cognitively demanding activities such as piano learning. These results align with existing neuroscientific evidence suggesting that musical training stimulates brain regions related to attention, memory, and cognitive control, thereby supporting neuroplasticity in aging populations.

Equally important are the qualitative findings, which reveal that piano training enriches the psychosocial experiences of the elderly. Participants reported increased life satisfaction, reduced feelings of loneliness, and improved emotional well-being. The social interaction, sense of achievement, and enjoyment derived from music learning contribute significantly to a more meaningful and active retirement life. Additionally, improvements in hand–brain coordination and memory retention indicate that piano practice also supports physical function.

Overall, piano training emerges as a holistic intervention that not only delays age-related cognitive decline but also fosters emotional, social, and functional well-being. These findings underscore the value of integrating music-based programs into elderly education and community health initiatives to promote successful and active aging.

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