

# The effect of Chinese calligraphy therapy on cognitive functions of older adults with cognitive impairment: a systematic review

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## Abstract

*Chinese calligraphy is a task with visuospatial and semantic features. As a non-pharmacological therapy, it has been shown to be beneficial for the cognitive functions of both healthy older adults and older adults with Alzheimer's disease. The present review examined the effect of Chinese calligraphy therapy on the cognitive functions of older adults with cognitive impairment, with the aim of providing valid information about this type of therapy to the Western world. Following PRISMA guidelines, articles published between 2010 and 2020 were systematically searched using Google Scholar and Scopus. Ultimately, the included studies were five randomized controlled trials. They studied Chinese calligraphy as a treatment, they examined samples of Chinese older adults with cognitive impairment, and they were published in English. According to the present review Chinese calligraphy therapy is beneficial for older adults' attentional control, working memory, verbal episodic memory and picture memory, as well as their general cognitive status. Future intervention studies should use a uniform and comprehensive neuropsychological assessment protocol to define cognitive impairment. In addition, samples from other countries and calligraphy in other languages should be studied.*

**Keywords:** Chinese calligraphy, cognitive impairment, cognitive functions, older adults

**JEL classifications:** I00, I30, I31

## Introduction

As cognitive decline in ageing is an important issue in modern society, many researchers attempt to find ways to address it. On the spectrum of cognitive impairment, between the cognitive decline of normal aging and the pathological decline that characterizes dementia, there is a condition named mild cognitive impairment (MCI. Petersen, 2004). People with MCI have an increased likelihood of developing various types of dementia (Petersen, 2004; Petersen et al., 2018). However, as the pathology of dementia is not fully formed at this stage, and because functional decline has not yet occurred, MCI is perhaps the most appropriate stage for intervention (Tangalos & Petersen, 2018).

The interventions for MCI can be either pharmacological or non-pharmacological. Pharmacological interventions so far do not stop the progression of MCI to dementia (Cooper et al., 2013; Petersen et al., 2018), they treat symptoms only transiently, and they are not effective for all (Theodorou et al., 2010). Furthermore, they place a substantial financial burden on both patients and national health systems. On the other hand, non-pharmacological interventions for MCI and early stages of dementia, especially cognitive and physical exercise, appear to reduce the risk of further cognitive decline (Langa & Levine, 2014) and partially improve performance in several domains of cognitive functioning (Petersen et al., 2018; Reijnders et al., 2013; Rodakowski et al., 2015).

One form of non-pharmacological interventions is "mind-body activities". Their basic principle is that mental processes can influence one's physiological-physical, psychological and mental functioning (Stan et al., 2012). Some of them require mild physical exercise (Stan et al., 2012), while they all require concentration and formation of mental images (Stoney et al., 2009). Typical examples are hypnosis, yoga and Tai Chi.

### **Chinese calligraphy**

Another "mind-body activity" is Chinese calligraphy. For this activity, a soft-tipped brush is manoeuvred in order to write Chinese characters (Kao, 2006). Each character consists of strokes (lines) and is formed within an imaginary square with subdivisions (Kao, 2006; Kao & Ding-Guo, 2004). Thus, Chinese calligraphy is considered a visuospatial process during which the individual visually perceives and mentally forms the image of the character, organizes its visuospatial elements, and then controls his/her movement while handling the brush to finally write the character. Importantly, Chinese characters are logograms, meaning that a character represents a word (S. C. C. Chan et al., 2017). Therefore, Chinese calligraphy is a "mind-body activity" with visuospatial features and a rich semantic load.

### **Types of Chinese calligraphy**

Besides the calligrapher's personal style, nowadays there are five main script types in Chinese culture that determine the appearance of characters (Khan Academy, 2021). In chronological order, from the oldest type to the most modern one, there is seal script, clerical script, cursive script, running script/semi-cursive script/Hang script, and regular script/standard script/Kai script.

In *seal script*, the characters are organized in columns and each one is written within the limits of an imaginary square (Khan Academy, 2021). The strokes are of similar thickness and a constant and slow writing speed is required. In *clerical script*, there are curves and other elements that require adjustments in the application of pressure on the brush. The clerical script is not as time-consuming as seal script, while its characters appear wider than those of seal script.

*Cursive script* allows the calligrapher to express himself artistically more than the two previous script types while giving shape to the characters (Khan Academy, 2021). The components of the characters are fused together, and as the characters are drawn very quickly, it is a kind of shorthand. *Running script* is characterized

by the legibility of regular script and the expressiveness of personal style that cursive script allows, as well as by a wide range of writing speed.

Finally, in non-cursive *regular script*, the most legible type of writing, increased importance is placed on the harmonious formation of the character around a central axis, combining strokes from a defined set of strokes, which usually form a right angle (Khan Academy, 2021).

### **Chinese calligraphy and cognitive functions of older adults**

The positive effects of Chinese calligraphy have been studied in samples of older adults. For instance, according to reviews by Kao (2006, 2010), calligraphy therapy in elderly Alzheimer's patients improves concentration, short-term memory performance, spatiotemporal orientation, and motor coordination. In addition, mentally healthy older adults display benefits in terms of visuospatial ability and image memory after calligraphy therapy (Kao, 2006, 2010), while mental activities, among which Chinese calligraphy, appear to slow general cognitive decline (Leung et al., 2011).

### **Objective of the present review**

From the above, it can be concluded that Chinese calligraphy therapy can enhance certain cognitive functions of both healthy older adults and those with Alzheimer's dementia. However, Chinese calligraphy is an area of research unknown in the Western world. Thus, the aim of this review is to compile the findings regarding the effects of Chinese calligraphy therapy on the cognitive functions of older adults with cognitive impairment, in order to provide a source of valid information and a potential starting point for further research into calligraphy as a cognitive intervention in MCI and dementia.

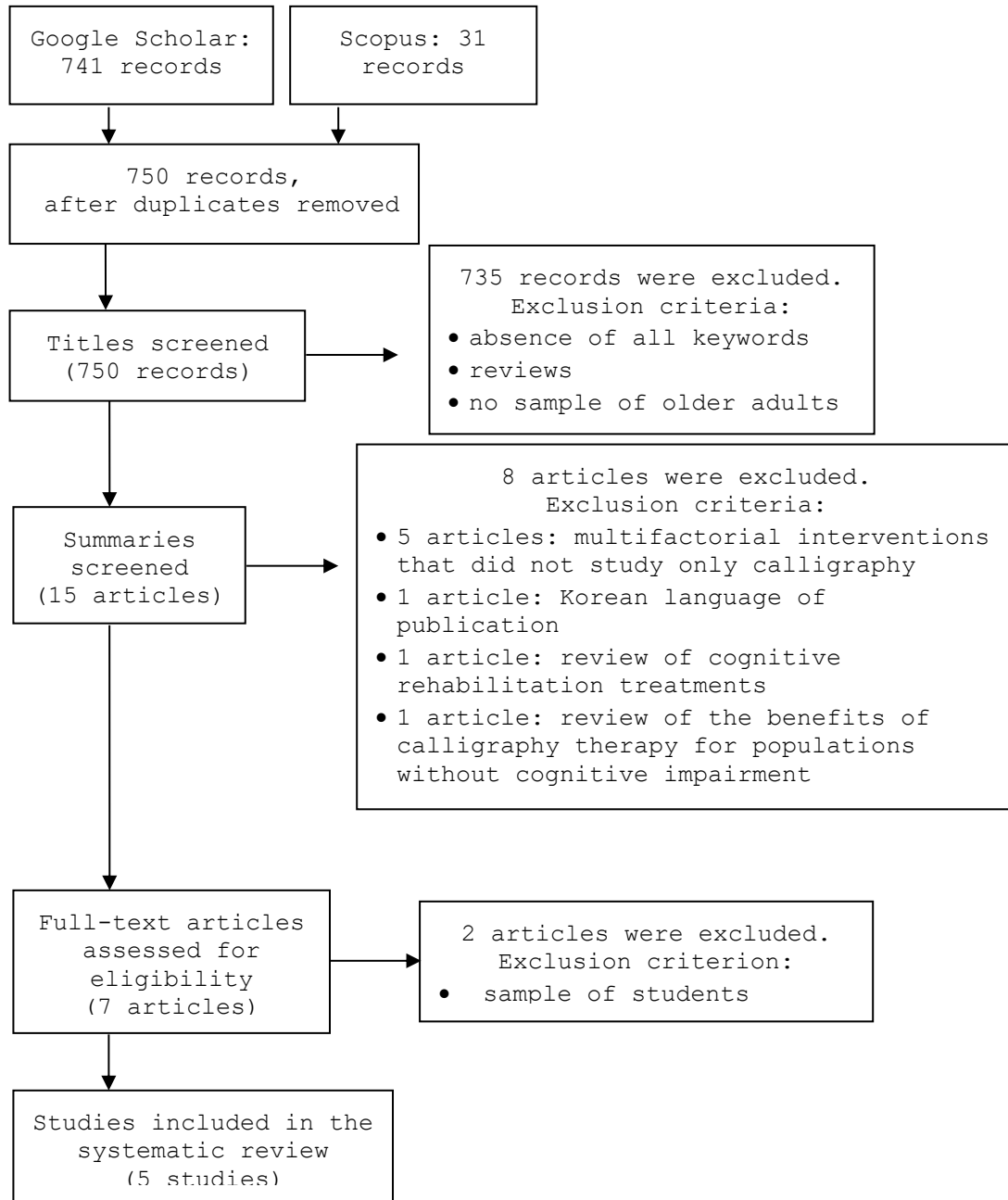
Based on the above, the hypothesis of the present study was that Chinese calligraphy has a positive effect on cognitive functions of older adults with cognitive impairment.

## **Methods**

### **Search strategy**

This systematic review is in accordance with the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA; Liberati et al., 2009). According to Figure 1, a systematic search was conducted on Google Scholar and Scopus. The keywords used were "calligraphy therapy AND cognition AND aging". The publication period was defined to be between 2010 and 2020 and the publication language was defined to be English. No citations and patents were included.

### **Figure 1: Flowchart of the included studies in this review**



**Study selection and eligibility criteria**

At first, the titles of the search results were screened, then the abstracts of the articles, and finally the whole articles with emphasis on the methodology of the studies. Studies were included in the review if they were only studying Chinese calligraphy as a treatment, if they examined samples of older adults with cognitive impairment, and if they were published in English. In addition, studies excluded from the review were reviews, and studies that were multifactorial interventions which did not study only calligraphy and did not separate the effects of calligraphy from those of the other intervention factors.

**Data extraction**

The information extracted from each study included in the review was its general data, that is the year and country of publication, its

aim, its methodology, including the type of research design, the characteristics of its sample, the form of the intervention, the duration of each session, the frequency and the total duration of the intervention, and the cognitive assessment tools used. Finally, the most important results of each study were extracted.

## **Results**

### **General study characteristics**

Five studies were included in this review. Their characteristics are presented in Table 1. All studies were published in English and conducted in Hong Kong or in China. Also, all were randomised controlled trials - experimental designs with a randomised sample, and one (Kwok et al., 2011) was a pilot study. The sample size ranged from 17 to 99 participants and the mean age ranged from 65.9 to 85.8 years. In the majority of the studies, women constituted more than 70% of the total sample. Furthermore, each study defined cognitive impairment differently and measured it with different instruments. Thus, samples were thought to have MCI and in one case (Kao et al., 2019) dementia. In all studies, measurements were taken before and after the intervention, and two studies also conducted a follow-up measurement after six months (C. C. H. Chan et al., 2018; S. C. C. Chan et al., 2017).

The aim of the studies was to investigate the effects of Chinese calligraphy therapy on the general cognitive status of older adults with cognitive impairment, as well as on specific cognitive functions, namely attentional control, working memory, verbal episodic memory and picture memory. An additional aim of S. C. C. Chan et al. (2016) was to investigate the neural processes associated with the generalization of the benefits of Chinese calligraphy on working memory from a task with Chinese calligraphy stimuli to a task with digits as stimuli. Also, Kao et al. (2019) compared the effect of Chinese calligraphy therapy on general cognitive status and on memory with that of acupuncture.

### **Cognitive assessment tools**

The tools used provide information on both general cognitive status and specific cognitive functions. C. C. H. Chan et al. (2018) and S. C. C. Chan et al. (2017, 2016) assessed attentional control with the Color Trails Test (CTT), namely the CTT1 subscale that evaluates visual tracking and attention, and the CTT2 subscale that assesses divided attention. C. C. H. Chan et al. (2018) and S. C. C. Chan et al. (2017) used the Symbol-Digit Modalities Test (SDMT) to evaluate visual scan ability and attentional control.

Additionally, the Digit Span Test-Backward (DST-B) was used to assess working memory and auditory attention (C. C. H. Chan et al., 2018; S. C. C. Chan et al., 2017, 2016). An additional measure of working memory was two two-back tasks, one with Chinese calligraphy strokes images and one with digits, that is stimuli unrelated to Chinese calligraphy, and simultaneous recording of event-related potentials on electroencephalogram (C. C. H. Chan et al., 2018. S. C. C. C. Chan et al., 2016).

**Table 1: Characteristics and results of the studies included in the review**

| Study                       | Sample size/<br>Average age<br>(S.D.)/Gender<br>(% women)        | Definition of<br>cognitive<br>impairment | Form of<br>intervention,<br>Duration of each<br>session,<br>Frequency,<br>Total duration   | Control<br>Condition   | Results   |
|-----------------------------|--|--|--|--|---|
| Kwok et al.<br>(2011)       | I.G.: 14/85.8<br>(4.9)/93.8%<br><br>C.G.: 17/85.8<br>(6.9)/64.3% | CMMSE<br>20-25                           | Copying characters in a variety of Chinese calligraphy styles,<br>30 minutes,<br>5 times a week,<br>8 weeks  | No intervention  | - E.G.: improvement in general cognitive status and in orientation, as well as in attention and calculation (CMMSE).<br>- C.G.: impairment in general cognitive status and in orientation (CMMSE).  |
| S. C. Chan et al.<br>(2016) | I.G.: 14/65.9<br>(5.0)/64.3%<br><br>C.G.: 16/66.4<br>(3.7)/93.8% | CDR 0.5                                  | Learning how to draw strokes in running script at first in a specially designed application and then with a brush, and converting characters from regular to running script with a brush,<br>90 minutes,<br>2 times a week,<br>8 weeks | Learning how to use an Apple iPad and writing Chinese characters in running script in a specially designed application | - E.G. compared to C.G.: shorter reaction time and shorter latency in the evaluation of visual representation (P300) in both the calligraphy stroke two-back task and the digit two-back task, longer latency in working memory updating (N200) in the calligraphy two-back task. |

| Study                                | Sample size/<br>Average age<br>(S.D.)/Gender<br>(% women)        | Definition of<br>cognitive<br>impairment   | Form of<br>intervention,<br>Duration of each<br>session,<br>Frequency,<br>Total duration   | Control<br>Condition   | Results  |
|--------------------------------------|--|--|--|--|--|
| S. C.<br>C. Chan<br>et al.<br>(2017) | I.G.: 48/69.4<br>(5.9)/66.7%<br><br>C.G.: 51/68.1<br>(5.7)/74.5% | 1)MoCA 19-26<br>2)CDR $\leq$ 0.5,<br>3)self-report<br>of cognitive<br>decline,<br>4)independence<br>in daily<br>activities | Brief practice in<br>writing strokes in<br>running script in<br>a specially<br>designed<br>application and<br>then converting<br>strokes and<br>characters from<br>regular script to<br>running script<br>with a brush,<br>90 minutes,<br>2 times a week,<br>8 weeks | Learning how<br>to use an<br>Apple iPad<br>and copying<br>characters<br>in regular<br>script on<br>paper with a<br>pen | - E.G.: Improvement in auditory<br>attention-working memory (DST-B)<br>and in divided attention (CTT2)<br>maintained at follow-up, and<br>improvement in attentional<br>control<br>(CTT2-CTT1).<br>- E.G. and C.G.: improvement in<br>immediate (J4) and delayed word<br>recall (J6 of CERAD-NAB)<br>maintained at follow-up.  |
| C. C.<br>H. Chan<br>et al.<br>(2018) | I.G.: 48/69.4<br>(5.9)/66.7%<br><br>C.G.: 51/68.1<br>(5.7)/74.5% | MoCA:<br><br>I.G.:<br>24.5(S.D. 2.9)<br><br>C.G.:<br>24.4(S.D. 3.0)  | Converting strokes<br>and characters<br>from regular<br>script to running<br>script both with a<br>brush and in a<br>specially designed<br>application,<br>90 minutes,<br>2 times a week,<br>8 weeks   | Learning how<br>to use an<br>Apple iPad<br>and copying<br>characters<br>in regular<br>script on<br>paper with a<br>pen | - E.G.: improvement in auditory<br>attention-working memory (DST-B)<br>and visual scan ability-<br>attentional control (SDMT)<br>maintained at follow-up, and<br>improvement in attentional<br>control (CTT2-CTT1)<br>- E.G. compared to C.G.: shorter<br>reaction time in both the<br>calligraphy stroke two-back task<br>and the digit two-back task.<br>- E.G. and C.G.: improvement in<br>delayed word recall (J6 of CERAD-<br>NAB) maintained at follow-up. |

| Study                | Sample size/<br>Average age<br>(S.D.)/Gender<br>(% women) | Definition of<br>cognitive<br>impairment | Form of<br>intervention,<br>Duration of each<br>session,<br>Frequency,<br>Total duration   | Control<br>Condition | Results   |
|----------------------|---|--|--|----------------------|---|
| Kao et al.<br>(2019) | I.G.:<br>9/77.29/77.8%<br><br>C.G.:<br>8/77.29/12.5%      | CMMSE $\leq 20$                          | Tracing and then copying characters in regular script and sometimes in seal or cursive script,<br>45 minutes,<br>2 times a day,<br>7 days Chinese calligraphy and<br>3 days rest,<br>1 month | Acupuncture          | - E.G.: improvement in attention and calculation (CMMSE) and in picture and verbal memory (Picture Free-Recall Test).<br>- C.G.: improvement in general cognitive status, in orientation and in behavioural subtests of the CMMSE |

Note. S.D., Standard Deviation; E.G., Experimental Group; C.G., Control Group; CMMSE, Chinese version of the Mini-Mental State Examination; CDR, Clinical Dementia Rating Scale; MoCA, Montreal Cognitive Assessment; DST-B, Digit Span Test (Backward); CTT, Color Trails Test; SDMT, Symbol-Digit Modalities Test; CERAD-NAB, Consortium to Establish a Registry for Alzheimer's Disease-Neuropsychological Assessment Battery.



C. C. H. Chan et al. (2018) and S. C. C. Chan et al. (2017) evaluated verbal episodic memory with subscales J4 (immediate recall), J6 (delayed recall), and J7 (word recognition) of the Consortium to Establish a Registry for Alzheimer's Disease-Neuropsychological Assessment Battery (CERAD-NAB). Kao et al. (2019) assessed verbal and picture memory with Sampson's (1970) Picture Free-Recall Test. Finally, Kao et al. (2019) and Kwok et al. (2011) assessed general cognitive status with the Chinese version of the Mini-Mental State Examination (CMMSE).

### **Effects of Chinese calligraphy therapy on each cognitive domain**

#### **Attentional Control**

According to S. C. C. Chan et al. (2017) and C. C. H. Chan et al. (2018), there was an improvement in divided attention and generally in attentional control as measured by the CTT and SDMT after Chinese calligraphy intervention, compared to before intervention. Moreover, the benefits were also observed at the follow-up measurement after six months (S. C. C. Chan et al., 2017).

#### **Working memory**

Regarding working memory, C. C. H. Chan et al. (2018) and S. C. C. Chan et al. (2017) observed that Chinese calligraphy had a positive effect on auditory attention and working memory as assessed by the DST-B. In fact, this positive effect was also observed six months later.

As for the two-back tasks, according to C. C. H. Chan et al. (2018) and S. C. C. Chan et al. (2016), the experimental group, compared to the control group, responded faster to both the calligraphy stroke two-back task and the digit two-back task. In addition, S. C. C. Chan et al. (2016) found that the experimental group, compared to the control group, showed a shorter P300 latency during both the calligraphy stroke two-back task and the digit two-back task, which is interpreted as a benefit for the evaluation of visual representation in the working memory buffer. The two previous findings imply that the benefits of Chinese calligraphy generalized to the two-back task that had no Chinese calligraphy stimuli but digits. Finally, in the experimental group, a longer N200 latency was observed only in the calligraphy stroke two-back task, a finding that is interpreted as a benefit for working memory updating.

#### **Memory**

S. C. C. Chan et al. (2017) and C. C. H. Chan et al. (2018) found improvement in immediate word recall and in delayed word recall in the experimental group, as measured by CERAD-NAB. At follow-up six months later, S. C. C. C. Chan et al. (2017) observed that these benefits in verbal episodic memory were maintained, whereas according to C. C. H. Chan et al. (2018) only the benefits in immediate word recall were maintained. In addition, Kao et al. (2019) found improvement in verbal and picture memory as assessed by the Picture Free-Recall Test.

#### **General cognitive status**

Chinese calligraphy therapy was associated with improvement in general cognitive status, as reflected by global CMMSE score (Kwok et al., 2011). Improvement was also observed in orientation (Kwok et

al., 2011) and attention and calculation (Kwok et al., 2011; Kao et al., 2019).

## **Discussion**

The present review studied the effect of Chinese calligraphy therapy on cognitive functions of older adults with cognitive impairment. Benefits in attentional control, in working memory, in verbal memory and picture memory, and in general cognitive status were found, thus confirming the hypothesis of the study.

The cognitive functions that were improved after the intervention are the cognitive functions practiced when converting Chinese characters from regular script to running script (S. C. C. Chan et al., 2017). In particular, at first, when encoding the character written in regular script and when mentally deconstructing the character into the strokes of which it is composed, attentional control is required. Then, when converting the character into running script form, divided attention is necessary.

Of course, central to the whole process is the role of working memory (see S. C. C. Chan et al., 2017). Initially, the character written in regular script and its strokes are mentally represented in working memory. Then, working memory retrieves from long-term memory the mental representations of the strokes in running script form and combines them appropriately to create the mental representation of the character now in running script form. Finally, again, working memory retains this mental representation until the individual puts it on paper.

Moreover, an important finding according to S. C. C. Chan et al. (2016) is that the benefits for working memory generalized to a task that had no calligraphy stimuli, but digit stimuli. Repeated exposure to the same stimuli has been shown to prevent generalization of the effects of cognitive interventions. Thus, it is likely that generalization was achieved because at each session participants practiced new material, and because the sessions were spread out over time, that is there were two sessions per week for eight weeks.

Finally, mnemonic benefits were not observed in acupuncture therapy, but only in Chinese calligraphy therapy (Kao et al., 2019). Probably, as Chinese characters are semantically loaded, whereas acupuncture has no verbal content, verbal memory and picture memory were practiced only during calligraphy therapy.

## **Limitations and suggestions for future research**

Regarding the quality of the present review, an important strength of its findings is that they came only from experimental studies. Its main limitations are that only two search databases were used to identify studies and only those studies published in English were selected, so that some studies were probably excluded.

Future intervention studies of the topic of this review should avoid the limitations of the previously analyzed studies. In particular, these studies had small samples consisting mainly of women, thus limiting the potential for generalisability of their results. In addition, the participants were only Chinese and only Chinese calligraphy was examined. At this point, it is worth noting that an English calligraphy intervention study showed benefits for the visuospatial ability of young adults (Kao et al., 2012). This finding

may suggest the importance of studying alphabetic calligraphy as a cognitive exercise for older adults with cognitive impairment in the future. Perhaps, because of the differences between alphabetic languages and Chinese, cognitive functions that are practiced and thus improved during calligraphy in an alphabetic language are different than those practiced during Chinese calligraphy.

Furthermore, cognitive impairment in each study was defined differently, using different instruments and without conducting a full neuropsychological assessment. Therefore, it is difficult to compare their results. Finally, only two studies performed a follow-up measurement after six months, leaving room for exploring the long-term cognitive benefits of this therapy.

### Conclusion

In summary, this review presents the findings of studies about Chinese calligraphy therapy as a means of improving cognitive functions in older adults with cognitive impairment. Chinese calligraphy appears to benefit attentional control, working memory, verbal episodic memory, and image memory, as well as the general cognitive status of older adults. Future studies should use a complete neuropsychological assessment protocol to define cognitive impairment. In addition, they could focus on calligraphy in other languages as a non-pharmacological therapy for cognitive impairment in elderly populations of other countries.

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