Chinese calligraphy writing for augmenting attentional control of older adults at risk of mild cognitive impairment: A randomized controlled trial

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Abstract

Background: Non-pharmacological intervention for individuals with mild cognitive impairment needs further investigation.

Objective: Test efficacy of eight-week Chinese calligraphy writing improving attentional control.

Design: Randomized, controlled trial.

Setting: Community centres.

Method: Ninety-nine participants with MCI.

Intervention: Participants randomized to receive eight-week Chinese calligraphy writing (n=48) or Apple IPad training (n=51).

Outcome: Participants' attentional control, working memory, visual scan and processing speed, and emotional calmness at baseline, post-training, and six-month follow-up.

Results:

The treatment effects were strong on improving attentional control (25.3%, P=0.010) and working memory (21.8%, P=0.002) at the post-training, and attentional control (31.3%, P=0.008) and visual scan and processing speed (P=0.016) at the follow up, but not emotional calmness.

Conclusion:

The findings support our hypothesis that cognitive approach to Chinese calligraphy writing training in eight-week would improve the attentional control and working memory functions of patients with early MCI. They also demonstrate the usefulness of using mnemonic strategy for improving cognitive functions.

Keywords: Mild cognitive impairment, attentional control, working memory, randomized controlled trial, Chinese calligraphy

Introduction

Aging population is a global challenge. Mild cognitive impairment (MCI) is a clinical diagnosis used to describe a spectrum of progressive cognitive impairments into dementia [1, 2]. It is further sub-divided into sub-types according to the type and extent of the dysfunctions, and the cause [3]. Much effort has been placed on devising effective interventions for slowing down the progressively neurodegenerative process among the individuals with MCI. Pharmacological interventions have recently been reported as without strong evidence of significant treatment effect [4, 5]. Non-pharmacological interventions are aimed at restoring or compensating the cognitive dysfunctions. The most common ones can be classified into cognitive training and physical exercise [6-9]. Evidence shows that, among the variety of interventional designs, only aerobic exercise and mental activity were found to reduce the risk of further cognitive decline [5]. More importantly, such positive effect was on global cognitive function rather than the specific dysfunctions. This may not be desirable for patients with neurodegeneration of whom the cognitive decline are more focal [3]. For instance, decline in attentional control is affected more often and earlier than memory and executive function [10]. As a result, effective interventions deemed beneficial to patients with MCI should be specific to these dysfunctions [11, 12]. A review of the studies on cognitive training for patients with MCI indicated that majority of the intervention designs served multi-purposes. This perhaps explains why these interventions resulted in non-specific effect on improving cognitive function [13, 14]. This study aimed to test the efficacy of eight-week Chinese calligraphy writing as a medium for training attentional control – a specific impairment in early stage, of older adults with MCI.

Chinese calligraphy writing involves using a brush to write Chinese characters. It is a mind-and-body activity which is culturally relevant to older adults [9, 15]. Chinese characters, characterized by its logographic outlook [16] can be written in different styles, e.g. *Kai* and *Hang* styles (see below). Specific style character requires learning of "curve of the stroke" which composes "shape of the character" unique to the style. For instance, characters written in *Kai* style have more discrete strokes than those in *Hang* style. The shape of a *Kai* styled character is less square than a *Hang* styled character (Figure 1). Previous clinical studies commonly classified calligraphy writing as a means of guided imagery or coordinated motor activity. When writing the characters, the participants were guided to produce the characters mimicking a particularly style and/or thinking about the semantic meaning of the written characters. Findings of these studies indicated that calligraphy writing was effective for improving global cognitive functions [17-19] as well as spatial working memory [4, 8]. Positive effects were also revealed on enhancing emotional stability [20] and psychological maladjustments [20, 21]. At the theoretical level, Werner et al. [22] suggested that the kinematic features (temporal and spatial) of the characters produced were useful for differentiating individuals with MCI from Alzheimer's disease.

Classic model of memory process suggests that information processing begins with encoding which requires orienting the attention for capturing the relevant information. Once effectively captured, the information can be maintained and transformed in the working memory. This study adopted a cognitive approach to using calligraphy writing for enhancing cognitive function among individuals with MCI in two ways. First, the rate limiting step of the writing practice focused on encoding and attentional control in transforming characters from *Kai* to *Hang* style at the stroke level. The treatment effect was expected to yield improvements in specific rather than global cognitive functions, which is deemed more beneficial to individuals with MCI. Second, mnemonic strategy (rehearsal, association and imagery) [23] was reinforced in the *Kai*-to-*Hang* character transformation. Learning began at the stroke level that participant was to associate *Hang* with *Kai* styled stroke by rehearsal (Figure 1). The steps involved in the *Kai*-to-*Hang* character transformation were: 1) encoding a *Kai* styled character; 2) decomposing the character into *Kai* styled strokes; 3) retrieving the rehearsed *Hang* styled strokes; 4) visualizing (imagery) the *Hang* styled strokes; and 5) composing the *Kai* styled strokes to form the *Hang* styled character to guide the writing. The *Kai*-to-*Hang* stroke and character transformations were consistently reinforced in the 8-week training program.

We hypothesized that when compared with the control, individuals participating in the 8-week Chinese calligraphy writing training would show improvements in attentional control and perhaps working memory. The improvements in the attentional control and working memory would sustain for six months after the training program. It is hypothesized that improvements in the abilities would correlate with the quality of the calligraphy writing produced during the sessions. It is also hypothesized that the training would exert positive effects on emotional calmness.

Insert Figure 1 Around Here

Methods

Design

It was a randomized controlled trial with participants randomly assigned to an experimental group (Chinese calligraphy writing) or a control group (learning use of Apple IPad). The assessment schedule was at the baseline, end of the intervention, and six months after the intervention.

Participants

The screening of the potential participants with MCI symptoms was conducted in four local community centres. A total of 453 community dwelling older adults were screened between June 2012 and March 2014. Among them, 102 met the selection criteria who were entered into the randomization process. The selection criteria were: 1) aged between 60 and 85 years old; 2) score on the Montreal Cognitive Assessment (MoCA) [24] was between 19 and 26 [25] score on the Dementia Rating Scale was 0.5 or below [26, 4] self-report of cognitive decline; 5) independent in daily living activities; 6) education level three years or more and able to read simple Chinese characters; and 7) willing to write with a soft brush and computer tablet. Individuals who had history of neurological or mental disorders were excluded from the study. The randomization was conducted by a research team member who was not involved in the screening process, or implementing the training programs and conducting the assessments. The participants were grouped to form cohort of 20 to 24 who were assigned to the experimental or control group by drawing lots. The numbers of participants assigned to the two groups were 48 and 51 respectively. Ethics approval of this study was granted by the institution in which the study was carried out. All participants gave their informed consent before they entered into the randomization.

Interventions

Both the calligraphy writing and learning use of Apple IPad were in group format, with at most 10 persons in one group, and of eight weeks in duration with two 1 hour and 30 minute sessions each week. The total time of the training was 24 hours.

Chinese calligraphy writing training (experimental)

For the calligraphy writing training, participants learnt and practiced writing of Chinese calligraphy using a soft brush pen. Each session was led by a professional calligraphy master and a research assistant. The 16 sessions were divided into two parts. The first eight sessions were for participants to learn writing basic strokes while the second eight sessions were to learn writing characters. Learning of the strokes and characters involved *Kai*-to-*Hang* script transformation. In other words, the participant was to read a stroke/character presented in *Kai* script (or *Kaishu*) but to write the stroke/character in *Hang* script (or *Xingshu*). At the beginning of each session (sessions 1 to 8), the participant practised writing the basic strokes in *Hang* script for 15 minutes with a tablet computer given to them individually. An App was custom-designed with which the participants practised writing 12 *Hang* styled strokes with the right index finger tracing images appearing on the screen. Visual feedbacks were given to the participant if the tracing of the stroke was not performed properly. There were two purposes for using a tablet computer for learning. First, the participants would be motivated by this method as most of the older people were fond of using technology for assisting learning. Second, the training received by the control group was learning the use of Apple IPad. The use of the tablet computer by the participants would reduce the between-group effect brought by the contact with tablet computer in the control group. The rest of the session required the participants to repeat the writing of the strokes using soft brush pen on paper. The calligraphy master demonstrated writing the strokes covered by the tablet computer-based writing. She also gave verbal feedbacks to the participants for improving the quality of the writing. On average, each participant wrote around 60 *Hang* styled strokes in one session. The second eight sessions focused on the *Kai*-to-*Hang* script transformation at the character level. In each session, the practice with the tablet computer on the strokes continued during the beginning 15 minutes. The participant then was shown a *Kai* styled character and without referring to the *Hang* styled strokes wrote the same character but in *Hang* script. On average, the participants wrote four to eight *Kai*-to-*Hang* styled characters in one session. Similarly, the master demonstrated the writing and provided verbal feedback to the participants with the assistance from the research assistant. Participants received handouts from the master by end of the 16 sessions who were encouraged to maintain a weekly practice after their discharge from the training program.

Apple IPad training (control)

For the Apple IPad training, the participants learnt in 16 sessions the functionality of Apple IPad. The training was conducted by the research assistant and a part-time helper. At the beginning of each class, the participants spent 15 minutes on using a pen to copy the characters printed in *Kai* script of a poem on a piece of paper. On average, the participants copied 20 to 28 characters in each session. To minimize potential biases, the copying exercise covered all the characters practised in the calligraphy writing group. The sequence of the Apple IPad functionality covered throughout the 16 sessions was: general functions such as usage of buttons, photo taking, and video recording (1^{st} and 2^{nd} sessions); surfing the web with Safari (3^{rd} to 10^{th} sessions); creating email account, and use email for communication (11th to 15th sessions); and general revision (16th session). The learning method included demonstration by the research assistant using a projector followed by practice by the participants on the tablet computer. Individual assistance was offered to participants who could not follow the pace of the group.

Procedure of Data Collection

Screening of the potential participants was conducted by research assistant (A) who was trained to administer all the clinical instruments. Demographic information on age and gender, and medical history was obtained and recorded. The names of the participants who selected to join the study were submitted to the researcher who was responsible for conducting the randomization process. Research assistant (B) contacted the participants on the logistics of commencing the calligraphy writing or the Apple IPad training group. Research assistant (A) in return contacted the participants to schedule the time for the first assessment. Each participant should complete three assessments: baseline (within two weeks before the intervention commenced), post-training (within two weeks after completion of the intervention) and six-month follow-up (within two weeks after six months from the intervention). All the assessments were conducted by research assistant (A) who were blinded to membership of the participants. Five clinical measures were used to capture the between-group treatment effects. They were Digit Span Test (Backward) (DST –Backward), Color Trails Test (CTT), Symbol-Digit Modalities Test (SDMT), Geriatric Depression Scale – Short Form (GDS-SF), and Consortium to Establish a Registry for Alzheimer's Disease – Neuropsychological Assessment Battery (CERAD-NAB). The clinical measures were administered according to random sequence. The performance of the participants in writing the scripts in the last session (16th) was evaluated by the calligraphy master according to the quality and quantity of writing basic strokes, applying the strokes to writing the character, and appearance of the script. The score on the overall performance ranged from 1 to 5 by aggregating the scores on each of the five criteria. Heart rate, heart rate variability, and blood pressure were measured after the participants completed the five clinical measures.

Measures

Cognitive measures

The DST–Backward [27] assessed the participants' auditory attention and to a lesser extent working memory. The participant was read a series of digits and was required to recall and say the digits heard in a reversed order. The CTT [28] evaluated visual tracking and attention in CTT1 and divided attention in CTT2. Participant was required to draw paths among digital circles in a consecutive order or among digital circles (in a consecutive order) and alternating colors. The CTT was reported good test-retest reliability between r=0.64 and 0.79. The test construct was found to be relatively culture free for use among Chinese subjects [29]. The SDMT [30] was used to evaluate progressing speed and switching attention in which the participant was to substitute digits from 1 to 9 with geometric symbols within 90 seconds. The verbal form was employed. The SDMT was previously applied to Chinese population and found to have good psychometric properties [31]. The GDS-SF assessed symptoms of depressive mood among older adults [32]. It was used in other studies on efficacy of cognitive rehabilitation for individuals with MCI [33]. The Chinese version of the GDS-SF was reported to have good psychometric properties for use among Chinese older individuals [34]. The CERAD-NAB assessed the participant's verbal episodic memory [35]. The three subtests included immediate recall (J4), delayed recall (J6), word recognition (J7) in which the participant was requested to recall or identify the list of words learnt after a five-minute delay. The Chinese version of the CERAD-NAB was validated by Liu et al. [36] and its reliability and validity were reported to be satisfactory.

Psychophysiological measures

Emotional calmness was measured with physiological arousal parameters including heart rate and heart rate variability (Polar RS800C, Polar Electro, Oulu, Finland), and blood pressure

(Portapres, Finapres Medical Systems, Amsterdam, Netherlands). Heart rate variability, a parameter reflecting overall balance between sympathetic and parasympathetic system, was analysed using Nevrokard computer software (Nevrokard Advanced Heart Rate Variability software 12.0, Izola, Slovenia). The ratio of heart rate low frequency/high frequency (LF/HF) was calculated, with higher values indicating domination of the sympathetic system, and lower values indicating domination of the parasympathetic system. These parameters were measured at the baseline, post-training, and six-month follow-up assessment occasions.

Data Analysis

Independent t-tests or Chi-square was used to test the between-group differences in the demographic characteristics and scores on the clinical measures taken at the baseline assessment. Two-way repeated measures ANOVAs were used to test the Group (calligraphy writing versus learning use of Apple IPad) and Occasion (before versus after the training) effects on the scores of each outcome measure. Significant interaction effects were followed with multiple comparisons using paired t-tests on the differences between baseline and post-training scores. Effect sizes were computed with Cohen's *d* statistics ($0.21 \leq$ small effects < 0.5; $0.51 \leq$ medium < 0.8). The long-lasting effects of the interventions were also tested with two-way repeated measure ANOVA with a different Occasion effect (before training and six-month follow-up). Pearson's correlation coefficient was computed to express the relationships between the participants' score on the calligraphy writing performance and the changes in scores on the cognitive measures (post-training minus baseline). Intention-to-treat analysis was conducted and the Last Observation Carried Over method was used for replacing missing data. The IBM SPSS v.20 was used for conducting the analyses and the significance for post-hoc comparisons were set at $p \leq 0.025$ (DST-Backward and SDMT (verbal)) or $p \leq 0.017$ (CTT and CERAD-NAB) after Bonferroni adjustments.

Results

Three participants withdrew due to medical reasons before commencing the training program (two in experimental and one in control). This resulted in 48 and 51 participants who began the experimental and control program respectively (Figure 2). No significant between-group differences were revealed in the age and gender composition of the participants (Table 1). There were relatively more female than male participants in both groups (experimental: 66.7% to 33.3%; control: 74.5% to 25.5%). The mean ages of the participants were 69.4 (SD=5.9) and 68.1 (SD=5.7) years for the experimental and control groups respectively. The mean scores on MoCA were 24.5 (SD=2.9) and 24.4 (SD=3.0), respectively. A total of five cohorts were conducted in both the experimental and control programs. Two participants dropped out from each of the two programs, due to personal (n=1) and medical reasons (n=3). As a result, 46 and 49 participants completed the training. The number of participants completed both pre- and post-training assessments were 45 and 48 for the experimental and control groups; and follow-up assessments were 41 and 47 respectively.

Insert Figure 2 and Table 1 Around Here

Treatment Effects

Statistically significant Group × Occasion effects were revealed on the sequence and span scores of DST-Backward (Sequence: $F(1,97)=4.578$, $p=0.035$); Span: $F(1,97)=6.892$, $p=0.010$), CTT2-CTT1 score of CTT ($F(1,97)=4.372$, $p=0.039$) (Table 2(A) and 2(B)). Other comparisons for scores on SDMT, GDS-SF, systolic and diastolic blood pressures, and heart rate variability (low/high frequency) were not statistically significant. Multiple comparisons indicated that the mean sequence score on the DST-Backward was significantly increased from the baseline (Mean=3.2, SD=1.3) to post-training (Mean=3.9, SD=1.3) ($t(47)=3.367$, $p=0.002$, $d=0.498$) for participants in the experimental group. In contrast, participants in the control group did not show significant differences between the two assessment occasions (t(50)=0.428, p=0.671, d=0.063). Similarly, the mean span score was significantly increased among participants in the experimental group (from 4.5 to 5.5) (t(47)=2.744, p=0.009, d=0.499). For the CTT2-CTT1, there were significant improvements in the scores from the baseline (Mean= 81.2, SD=57.1) to post-test occasion (Mean= 63.2, SD=32.8) (t=-2.697, p=0.010, d=-0.432) for the experimental group, which was not the case for the control group (t(50)=-0.708, p=0.483, d=0.116). It is noteworthy that both the experimental (p=0.018, d=0.341) and control groups (p=0.021, d=0.317) showed significant increases in the scores on the CERAD Memory test word encoding (J4) after completing the training programs. Similarly, increases in scores on the word delay recall (J6) were observed in both groups (p<0.001, d=4.841 and p<0.001, d=6.321, respectively).

Insert Table 2(A) and 2(B) Around Here

Long-lasting Effects

Statistical significant Group × Occasion (baseline versus six-month follow-up) effect was revealed on the sequence score of DST-Backward (F(1,97)=4.273, p=0.041), CTT2-CTT1 of the CTT (F(1,97)=4.057, p=0.047), and accuracy rate score on the verbal SDMT (F(1,97)=5.074, p=0.027). Other comparisons for scores on GDS-SF, systolic and diastolic blood pressures, and heart rate variability (low/high frequency) were not statistically significant. Multiple comparisons suggested that participants in the experimental group showed significant increase in the sequence score of DST-Backward from the baseline (Mean=3.2, SD= 1.3) to follow-up occasions (Mean=4.2, SD= 1.4) (t(47)=4.650, p<0.001, d=0.665), which was not observed for the control group (t(50)=1.656, p=0.104, d=0.263). No significant changes were revealed in the CTT2-CTT1 scores for both the experimental and control groups, however. For the verbal SDMT, the accurate rates were improved from baseline (Mean=96%, SD=6%) to follow-up occasion (Mean=98%, SD=3%) for the experimental group (t(47)=2.499, p=0.016, d=0.392), but not for the control group (t(50)=-0.339, p=0.736, d=-0.047). Similar to the treatment effect, there were significant improvements in participants' performances on the three CERAD subtests between the baseline and the follow-up assessment occasions regardless of the memberships. For the experimental group, the increases in the scores on J4 (from 8.0 to 8.7) (t(47)=3.028, p=0.004, d=0.466) and J6 (from 6.6 to 7.8) (t(47)=5.130, p<0.001, d=0.580) were in general higher than the J4 (from 8.1 to 8.8) (t(50)=2.765, p=0.008, d=0.437) and J6 (from 6.8 to 7.7) (t(50)=4.730, p<0.001, d=0.613) for the control group.

Discussion

The results indicated that the eight-week Chinese calligraphy writing training was effective for improving cognitive functions of the participants with MCI. The most significant finding was that the treatment effects were strong on augmenting attentional control as well as working memory. Besides, the training was found to improve visual scan and processing speed. The findings support our hypothesis that *Kai*-to-*Hang* styled stroke and character transformation involved in the eight-week training would improve the attentional control and working memory functions of patients with MCI. They also demonstrate the usefulness of using mnemonic strategy for intervening decline of cognitive functions among patients with early MCI. However, it did not support the notion that the training had an effect on promoting emotional calmness.

The rate limiting step of the *Kai*-to-*Hang* styled calligraphy writing embedded in the eight-week training was to encode and decompose the *Kai* styled strokes within its character; transform the decomposed *Kai* strokes into *Hang* style; and rehearse the *Hang* styled stroke in working memory before hand-written the script with a soft brush, which involved motor execution. The encoding process would tap intensively on the participants' visual scan and attentional control functions. The *Kai*-to-*Hang* styled transformation process at the stroke level would require retrieval and attentional control (switching) functions. Finally, the rehearsal of the *Hang* styled stroke before motor execution would tap demand on attentional control and working memory. The improvements in the attentional control due to the Chinese calligraphy writing training was reflected from the significant increases in the CTT2-CTT1 score of the CTT from post-training to baseline, which yielded a moderate effect size. The gains in the attentional control function were found to moderately correlate with the quality of the *Hang* styled stroke produced by the participants during the training. Our results are consistent with those reported by Kwok et al. [9] that a piloted calligraphy writing protocol was found to be beneficial for improving attention function of patients with MCI. Improvements in working memory of our participants were revealed by the significant increases in the sequence score of the DST-Backward between post-training and baseline. Despite the gains in the working memory function did not significantly correlate with the participants writing performance, such effect was supported by the visualization and rehearsal processes embedded in the calligraphy writing process. The plausible reason for the non-significant results is likely to be the difference in the modalities employed in the training and assessment. The scripts used in the training were visual-based whilst the items used in the DST-Backward were verbal-based digit. The difference in the modalities could have weakened the power of the correlational analyses between the participants' sequence score of DST-Backward and writing performance. Our results are somewhat different from Kwok et al. [9] which reported non-significant effect of the calligraphy writing training on improving memory function. This perhaps is because of their use of Mini-Mental State Examination which measures global cognitive function instead of specific memory function. Rapp et al. [37] used memory strategy training and revealed non-significant effect on improving memory function among MCI participants. On the contrary, Rozzini et al. [33] demonstrated computer-based memory training resulted in significant improvements in memory, attention and visuospatial functions among the MCI participants. Cheng et al. [38] employed multi-target cognitive training which was found to enhance memory function. Other studies employed multi-component cognitive training resulting in improvements in global cognitive function [39, 40]. The results of our study suggested that calligraphy writing – a modality-specific activity, can produce outcomes comparable to multi-component activities. Last but not least is the improvement in visual scan ability coupling with attentional control as reflected from the significant increases in scores on the verbal SDMT between the six-month follow-up and the baseline. The verbal SDMT score at the six-month follow-up assessment was found to significantly correlate with the participants' writing performances. It is noteworthy that the gains in the sequence score of DST-Backward and verbal SDMT were statistically significant in the six-month follow-up assessment, suggesting long-lasting treatment effect of the Chinese calligraphy writing training. Our findings suggest that Chinese calligraphy writing may yield better treatment effects in terms of visual scan and attentional control than generic cognitive training of which the effects were equivocal [4, 41].

The results did not support the notion that Chinese calligraphy writing training exerted better treatment effects on improving memory function than the Apple IPad training (serving as control). It is important to note that this was due to the non-significant between-group differences in the scores of the CERAD-NAB. In fact, both interventions showed significant treatment effects on improving encoding (in J4) and delay recall (in J6) functions. Nevertheless, the findings tended to suggest that calligraphy writing training was still effective for augmenting memory functions of the MCI participants. On the same token, Apple IPad training may also be beneficial for the participants in terms of improving memory function.

Last but not least, the study did not reveal significant effect of calligraphy writing training on influencing emotional calmness of the participants. This is counter-intuitive as calligraphy has been revealed to benefit emotional state such as relaxation and emotional calmness [41]. Other studies explained that calligraphy writing exerted slow-down effects on heart rate and respiration [20]. A number of reasons may account for the non-significant results. First, the calligraphy training protocol used in this study focused on the *Kai*-to-*Hang* styled transformation. Emphasis was placed on encoding and decomposing of characters into strokes, and association between the two types of strokes, and writing of the composed *Hang* styled character. Second, participants were reminded not to discuss their feelings associated with the characters and phrases written during the sessions. These were rather different from the protocols used in previous studies which emphasized more free-flow practices and expression of emotions during the classes [21]. The relatively fewer number of sessions and the duration of the training might have weakened the effects for leading to changes in the emotional state of the participants.

Limitations

This study has several limitations which would lower the power of its analyses and generalization of its results. First, the participants recruited for this study had slightly higher cognitive ability that that stipulated in Gill et al. [25]. The mean MoCA score was around 24.5 ± 3 so the majority of the participants would fall within 21 to 27. This would be higher than the referent 19 to 26 range. The results could have been different if the participants belonged to a group with lower cognitive ability. Second, the outcome measures used in this study might have biased the results as DST-Backward and CERAD-NAB did not require visual processing which was heavily involved in the calligraphy writing. Use of outcome measures involving visual processing would yield results specific to the intervention. Third, the cognitive approach adopted in this study to strengthening the *Kai*-to-*Hang* styled transformation is not common to that of previous studies. This perhaps accounted for the missing effects on the participants' emotional calmness. Besides, the results should be interpreted with caution and cannot be generalized to interventions which target at relaxation and emotional calmness by using Chinese calligraphy writing.

Conclusions

Findings of this randomized controlled trial indicated that the eight-week Chinese calligraphy writing training was effective for improving attentional control and working memory of participants with early MCI. The possible treatment effects were likely to be attributable to the

Kai-to-*Hang* styled transformation of the strokes of the Chinese characters and the mnemonic strategy involved for hand-written the *Hang* styled characters with brush. These findings are new to the field which further support the benefit brought by the Chinese calligraphy writing training to participants with MCI as these processes would be hampered during the early phase of MCI. The improved working memory and processing speed obtained at the six-month assessment occasion indicated that the eight-week training has the potential for generating long-lasting effects for alleviating and perhaps preventing progression of MCI. Future research is to test the treatment effect of Chinese calligraphy training beyond eight-week duration. More importantly, study should be extended to home-based and self-paced training, which is a feasible and sustainable model for service provision. Outcome measures can involve biochemical and brain imaging parameters.

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References

[1]. Gauthier S, Reisberg B, Zaudig M, Petersen R, Ritchie K, Broich K et al. Mild cognitive impairment. The Lancet. 2006;367:1262-1270.

[2]. Petersen R, Parisi J, Dickson D, Johnson K, Knopman D, Boeve B et al. Neuropathologic Features of Amnestic Mild Cognitive Impairment. Arch Neurol. 2006; 63:665.

[3]. Roberts R, Knopman D. Classification and Epidemiology of MCI. Clinics in Geriatric Medicine. 2013;29:753-772.

[4]. Kurz A, Pohl C, Ramsenthaler M, Sorg C. Cognitive rehabilitation in patients with mild cognitive impairment. International Journal of Geriatric Psychiatry. 2009;24:163-8.

[5]. Langa KM, Levine DA. The diagnosis and management of mild cognitive impairment: a clinical review. JAMA. 2014;312:2551-61.

[6]. Baker LD, Frank LL, Foster-Schubert K, Green PS, Wilkinson CW, McTiernan A, Plymate SR, Fishel MA, Watson GS, Cholerton BA, Duncan GE. Effects of aerobic exercise on mild cognitive impairment: a controlled trial. Archives of neurology. 2010;67:71-9.

[7]. Burns A, Guthrie E, Marino-Francis F, Busby C, Morris J, Russell E, Margison F, Lennon S, Byrne J. Brief psychotherapy in Alzheimer's disease. The British Journal of Psychiatry. 2005;187:143-147.

[8]. Kao HS. Calligraphy therapy: A complementary approach to psychotherapy. Asia Pacific Journal of Counselling and Psychotherapy. 2010;1:55-66.

[9]. Kwok TC, Bai X, Kao HS, Li JC, Ho FK. Cognitive effects of calligraphy therapy for older people: a randomized controlled trial in Hong Kong. Clinical interventions in aging. 2011;6:269.

[10]. Twamley EW, Ropacki SA, Bondi MW. Neuropsychological and neuroimaging changes in preclinical Alzheimer's disease. Journal of the International Neuropsychological Society. 2006;12:707-35.

[11]. Behl P, Edwards JD, Kiss A, Lanctot KL, Streiner DL, Black SE, Stuss DT. Treatment effects in multiple cognitive domains in Alzheimer’s disease: a two-year cohort study. Alzheimer's research & therapy. 2014;6:48.

[12]. Londos E, Boschian K, Lindén A, Persson C, Minthon L, Lexell J. Effects of a goal-oriented rehabilitation program in mild cognitive impairment: a pilot study. American journal of Alzheimer's disease and other dementias. 2008;23:177-83.

[13]. Jean L, Bergeron MÈ, Thivierge S, Simard M. Cognitive intervention programs for individuals with mild cognitive impairment: systematic review of the literature. The American Journal of Geriatric Psychiatry. 2010;18:281-96.

[14]. Vaughan L, Leng I, Dagenbach D, Resnick SM, Rapp SR, Jennings JM, Brunner RL, Simpson SL, Beavers DP, Coker LH, Gaussoin SA. Intraindividual variability in domain-specific cognition and risk of mild cognitive impairment and dementia. Current gerontology and geriatrics research. 2013; 2013.

[15]. Kao HS. Shufa: Chinese calligraphic handwriting (CCH) for health and behavioural therapy. International journal of psychology. 2006;41:282-6.

[16]. Chan CC, Leung AW, Luo YJ, Lee TM. How do figure-like orthographs modulate visual processing of Chinese words?. Neuroreport. 2007;18:757-61.

[17]. Clare L, Woods RT. Cognitive training and cognitive rehabilitation for people with early-stage Alzheimer's disease: A review. Neuropsychological Rehabilitation. 2004;14:385-401.

[18]. Belleville S. Cognitive training for persons with mild cognitive impairment. International Psychogeriatrics. 2008;20:57-66.

[19]. Yang XL, Li HH, Hong MH, Kao HS. The effects of Chinese calligraphy handwriting and relaxation training in Chinese Nasopharyngeal Carcinoma patients: a randomized controlled trial. International journal of nursing studies. 2010;47:550-9.
[20]. Kao HS, Zhu L, Chao AA, Chen HY, Liu IC, Zhang M. Calligraphy and meditation for stress reduction: an experimental comparison. Psychology research and behavior management. 2014;7:47.
[21]. Zhu Z, Wang R, Kao HS, Zong Y, Liu Z, Tang S, Xu M, Liu IC, Lam SP. Effect of calligraphy training on hyperarousal symptoms for childhood survivors of the 2008 China earthquakes. Neuropsychiatric disease and treatment. 2014;10:977.
[22]. Werner P, Rosenblum S, Bar-On G, Heinik J, Korczyn A. Handwriting process variables discriminating mild Alzheimer's disease and mild cognitive impairment. The Journals of Gerontology Series B: Psychological Sciences and Social Sciences. 2006;61:P228-36.
[23]. Gross AL, Parisi JM, Spira AP, Kueider AM, Ko JY, Saczynski JS, Samus QM, Rebok GW. Memory training interventions for older adults: a meta-analysis. Aging & mental health. 2012;16:722-34.
[24]. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, Cummings JL, Chertkow H. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. Journal of the American Geriatrics Society. 2005;53:695-9.
[25]. Gill DJ, Freshman A, Blender JA, Ravina B. The Montreal cognitive assessment as a screening tool for cognitive impairment in Parkinson's disease. Movement disorders. 2008;23:1043-6.
[26]. Morris JC. The Clinical Dementia Rating (CDR): current version and scoring rules. Neurology. 1993 Nov.
[27]. Wechsler D. Wechsler memory scale (WMS-III). Psychological Corporation; 1997.
[28]. D'Elia LF, Satz P, Uchiyama CL, White T. Color Trails Test: Professional Manual. Odessa (Florida): Psychological Assessment Resources.
[29]. Lee TM, Chan CC. Stroop interference in Chinese and English. Journal of Clinical and Experimental Neuropsychology. 2000;22:465-71.
[30]. Smith, A. Symbol Digits Modalities Test. Western Psychological Services (Los Angeles): 1982.
[31]. Chan CC, Wong R, Wang K, Lee TM. Emotion recognition in Chinese people with schizophrenia. Psychiatry Research. 2008;157:67-76.
[32]. Yesavage JA, Sheikh JI. 9/Geriatric Depression Scale (GDS) recent evidence and development of a shorter violence. Clinical gerontologist. 1986;5:165-73.
[33]. Rozzini L, Costardi D, Chilovi BV, Franzoni S, Trabucchi M, Padovani A. Efficacy of cognitive rehabilitation in patients with mild cognitive impairment treated with cholinesterase inhibitors. International journal of geriatric psychiatry. 2007;22:356-60.
[34]. Lee HC, Chiu HF, Kowk WY, Leung CM. Chinese elderly and the GDS short form: A preliminary study. Clinical Gerontologist: The Journal of Aging and Mental Health. 1993.
[35]. Morris JC, Mohs RC, Rogers H, Fillenbaum G, Heyman A. CERAD clinical and neuropsychological assessment of Alzheimer's disease. Psychopharmacology Bulletin. 1988;24:641-51.
[36]. Liu KP, Kuo MC, Tang KC, Chau AW, Ho IH, Kwok MP, Chan WC, Choi RH, Lam NC, Chu MM, Chu LW. Effects of age, education and gender in the Consortium to Establish a Registry for the Alzheimer's Disease (CERAD)-Neuropsychological

Assessment Battery for Cantonese-speaking Chinese elders. International Psychogeriatrics. 2011;23:1575-81.
[37]. Rapp S, Brenes GM, Marsh AP. Memory enhancement training for older adults with mild cognitive impairment: a preliminary study. Aging & Mental Health. 2002; 6: 5–11
[38]. Cheng Y, Wu W, Feng W, Wang J, Chen Y, Shen Y, Li Q, Zhang X, Li C. The effects of multi-domain versus single-domain cognitive training in non-demented older people: a randomized controlled trial. BMC medicine. 2012;10:30.
[39]. Buschert VC, Friese U, Teipel SJ, Schneider P, Merensky W, Rujescu D, Möller HJ, Hampel H, Buerger K. Effects of a newly developed cognitive intervention in amnestic mild cognitive impairment and mild Alzheimer's disease: a pilot study. Journal of Alzheimer's disease. 2011;25:679.
[40]. Tsolaki M, Kounti F, Agogiatou C, Poptsi E, Bakoglidou E, Zafeiropoulou M, Soumbourou A, Nikolaidou E, Batsila G, Siambani A, Nakou S. Effectiveness of nonpharmacological approaches in patients with mild cognitive impairment. Neurodegenerative Diseases. 2011;8:138-45.
[41]. Kao HS, Guo NF, Liu X. Effects of calligraphy practice on EEG and blood pressure in hypertensive patients. Annals of Behavioral Medicine. 2001;23:S085.

Table 2 (A) Mean scores and their standard deviations (in bracket) on the different clinical outcome measures of participants in the Chinese calligraphy writing (experimental) and use of Apple IPad training groups (control) for the baseline, post-training and six-month follow-up assessment occasions

Tests	Experimental (n=48)			Control (n=51)		
	Baseline Mean (SD)	Post-training Mean (SD)	Six-month follow-up Mean (SD)	Baseline Mean (SD)	Post-training Mean (SD)	Six-month follow-up Mean (SD)
DST-Backward						
Sequence	3.2 (1.3)	3.9 (1.3)	4.2 (1.4)	3.4 (1.3)	3.5 (1.2)	3.8 (1.2)
Span	4.5 (1.7)	5.0 (1.0)	5.1 (1.1)	4.8 (1.1)	4.7 (0.9)	5.0 (1.0)
CTT (Time (s))						
CTT1	70.1 (31.7)	60.1 (28.0)	61.2 (25.0)	69.5 (38.1)	59.8 (28.3)	59.0 (29.6)
CTT2	151.3 (79.1)	119.6 (36.2)	132.5 (46.3)	135.7 (51.5)	132.8 (79.4)	132.1 (58.2)
CTT2-CTT1	81.2 (57.1)	63.2 (32.8)	71.3 (35.7)	66.2 (43.3)	73.1 (71.5)	73.1 (46.4)
SDMT (Verbal)						
Acc. (%)	96.4 (6)	97.0 (4)	98.3 (3)	97.2 (3)	97.3 (4)	97.0 (5)
Correct	42.2 (10.6)	43.3 (10.5)	43.1 (10.1)	43.1 (12.6)	44.6 (11.4)	45.8 (11.6)
Total	43.5 (10.1)	44.5 (10.3)	43.7 (9.8)	44.3 (12.6)	45.8 (11.2)	47.1 (11.2)
CERAD-NAB						
J4	8.0 (1.6)	8.5 (1.4)	8.7 (1.3)	8.1 (1.7)	8.6 (1.4)	8.8 (1.3)
J6	6.6 (2.0)	7.5 (2.0)	7.8 (2.0)	6.6 (1.8)	7.5 (1.7)	7.6 (1.5)
J7	19.6 (1.1)	19.7 (0.9)	19.9 (0.4)	19.4 (1.6)	19.6 (1.0)	19.6 (1.2)
GDS	3.4 (2.8)	3.7 (3.3)	3.8 (3.3)	3.0 (2.9)	3.2 (3.3)	2.6 (2.9)

Note: DST-Backward=Digit Span Test (Backward); CTT = Color Trail Test; SDMT=Symbol-digit Modalities Test (Acc.=Accuracy Rate; Correct=Correct Attempts; Total=Total Attempts); GDS=Geriatric Depression Scale

Table 2 (B) Mean scores and their standard deviations (in bracket) on the different clinical outcome measures of participants in the Chinese calligraphy writing (experimental) and use of Apple IPad training groups (control) for the baseline, post-training and six-month follow-up assessment occasions (Cont'd)

Tests	**2*2 repeated measure (Baseline x Post)**		**2*2 repeated measure (Baseline x 6 month)**		**Within group comparison (Baseline x post)**		**Within group comparison (Baseline x 6 month)**	
					Experimental	Control	Experimental	Control
	$F_{(1,97)}$	*p*-value	$F_{(1,97)}$	*p*-value	*p*-value(effect size -d)		*p*-value(effect size -d)	
DST-Backward								
Sequence	4.578	0.035*	4.273	0.041*	0.002**(0.498)	0.671(0.063)	<0.001***(0.665)	0.104(0.263)
Span	6.892	0.010**	2.657	0.106	0.009**(0.499)	0.506(-0.091)	0.008**(0.505)	0.298(0.153)
CTT (Time (s))								
CTT1	0.003	0.956	0.096	0.757	0.006**(-0.335)	0.014*(-0.290)	0.019(-0.314)	0.003**(-0.308)
CTT2	4.722	0.032*	2.888	0.092	<0.001***(-0.439)	0.753(-0.043)	0.014*(-0.291)	0.484(-0.066)
CTT2-CTT1	4.372	0.039*	4.057	0.047*	0.010**(-0.432)	0.483(0.116)	0.147(-0.207)	0.179(0.153)
SDMT (Verbal)								
Acc. (%)	0.336	0.564	5.074	0.027*	0.451(0.121)	0.851(0.027)	0.016*(0.392)	0.736(-0.047)
Correct	0.104	0.748	2.361	0.128	0.213(0.102)	0.136(0.126)	0.202(0.088)	0.005**(0.224)
CERAD-NAB								
J4	0.011	0.918	0.015	0.902	0.018(0.341)	0.021(0.317)	0.004**(0.466)	0.008**(0.437)
J6	0.002	0.966	0.289	0.592	<0.001***(0.429)	<0.001***(0.497)	<0.001***(0.580)	<0.001***(0.613)
J7	0.329	0.567	0.221	0.639	0.224(0.132)	0.078(0.168)	0.025(0.355)	0.040(0.156)
GDS	0.018	0.893	1.908	0.170	0.464(0.112)	0.635(0.065)	0.440(0.115)	0.212(-0.142)

Note*:* DST-Backward=Digit Span Test (Backward); CTT = Color Trail Test; SDMT=Symbol-digit Modalities Test (Acc.=Accuracy Rate; Correct=Correct Attempts; Total=Total Attempts); GDS=Geriatric Depression Scale; statistical significance levels for post-hoc comparisons for DST-Backward and SDMT (Verbal) is *$p \leq 0.025$ and CTT and CERAD-NAB is *$p \leq 0.017$; **$p \leq 0.01$;***$p \leq 0.001$.