Chinese calligraphic writing to enhance cognitive performance and emotional calmness in older adults with mild cognitive impairment

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KEY MESSAGES

1. An 8-week Chinese calligraphy writing course improved working memory and delayed recall memory in older adults with mild cognitive impairment.
2. To a lesser extent, the training also improved attention control, visual scan, and processing speed functions.
3. Further research is needed to confirm the efficacy of the intervention, particularly beyond 8 weeks. The training has potential to be adopted by service providers for day-to-day use in Hong Kong.

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Introduction

Much effort has been placed on devising effective interventions to slow down the progressively neurodegenerative process among individuals with mild cognitive impairment (MCI). Non-pharmacological interventions aim to restore or compensate the cognitive dysfunctions. This study aimed to test the efficacy of an 8-week Chinese calligraphy writing course for attention control—a specific impairment in early stage—in older adults with MCI.

Chinese calligraphy writing is a mind-and-body activity culturally relevant to older adults.[1] It has been used as a cognitive approach to enhance cognitive function among individuals with MCI. Characters written in the *Kai* style have more discrete strokes than those in the *Hang* style. The shape of a *Kai*-style character is less square than that of a *Hang*-style character (Fig). The rate-limiting step of the writing practice focused on encoding and attention control in transforming characters from *Kai* to *Hang* style at the stroke level. A mnemonic strategy (rehearsal, association, and imagery)[2] was reinforced in the *Kai*-to-*Hang* character transformation. In this study, learning began at the stroke level such that participants were to associate *Hang* with *Kai*-style strokes by rehearsal before writing the *Hang*-style character with a brush.

We hypothesised that compared with controls, the experimental participants would show improvements in working memory and perhaps in attention control. The gain in these functions was tested with electroencephalogram (EEG). The two targeted event-related potential components were N200 and P300, which would reflect the underlying neural processes associated with the functions. We also hypothesised that the training would exert positive effects on emotional calmness.

FIG. Hypothetical processes of transforming *Kai*-to-*Hang*-style character of 們 involved in the Chinese calligraphy writing* (reprinted with permission from IOS Press)

* The steps involve in the *Kai*-to-*Hang*-style character transformation are: (1) encoding a *Kai*-style character, (2) decomposing the character into *Kai*-style strokes, (3) retrieving the rehearsed *Hang*-style strokes, (4) visualising (imagery) the *Hang*-style strokes, and (5) composing the *Kai*-style strokes to form the *Hang*-style character to guide writing.

Methods

This study was conducted from July 2012 to June 2015. A total of 99 older adults were randomly assigned to an experimental group (Chinese calligraphy writing, n=48) or a control group (learning to use an Apple iPad, n=51) [Table 1]. Respectively for the two groups, the mean ages were 69.4 (standard deviation [SD], 5.9) and 68.1 (SD, 5.7) years, and the mean Montreal Cognitive Assessment scores were 24.5 (SD, 2.9) and 24.4 (SD, 3.0). A total of 46 and 49 participants completed the training and 14 and 16 participants completed post-training EEG assessment, respectively.

Both interventions lasted 8 weeks, with two 1.5-hour sessions each week. The total duration of training was 24 hours. The calligraphy writing training was led by a professional calligraphy master and a research assistant. Participants learned to write basic strokes and characters involving *Kai*-to-*Hang* script transformation. Participants were to read a stroke/character presented in *Kai* script but to write the stroke/character in *Hang* script. The calligraphy master demonstrated the task on both a tablet computer and paper. The Apple iPad training involved learning its general functions such as usage of buttons, photo taking, and video recording (sessions 1 and 2); surfing the web with Safari (sessions 3 to 10); creating an email account and using email for communication (sessions 11 to 15); and general revision (session 16).

Each participant completed assessments at baseline, post-training, and 6-month follow-up conducted by a research assistant who was blinded to the randomisation. Between-group treatment effects were determined by five clinical measures: Digit Span Test (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). Heart rate, heart rate variability, and blood pressure were measured after completion of the five clinical measures.

In a post-training session to record an EEG while performing two 2-back tasks (contextual and non-contextual), the contextual stimuli were composed of strokes of *Kai*-style characters to which both groups were exposed. The non-contextual stimuli were 10 single-digit Arabic numbers from 0 to 9 that appeared in Arial font. The EEG signals elicited by the participants during task performances were captured with a 64-channel 90 mm Ag/AgCl sintered electrode CURRY Scan 7 Neuroimaging Suite (NeuroScan Labs, Sterling [VA], USA).

TABLE 1. Characteristics of the participants* (reproduced from Chan CS et al. J Alzheimers Dis 2017;58:735-46, with permission from IOS Press)

Characteristic	Experimental (n=48)	Control (n=51)	P value
Gender			0.391
Female	32 (66.7)	38 (74.5)	
Male	16 (33.3)	13 (25.5)	
Marital status			0.301
Single	4 (8.3)	1 (2.0)	
Married	28 (58.3)	29 (56.9)	
Separated/widow/bereft	16 (33.3)	21 (41.2)	
Age (years)	69.4±5.9	68.1±5.7	0.720
No. of sessions attended	14.5±2.6	14.4±3.0	0.864
Montreal Cognitive Assessment score	24.5±2.9	24.4±3.0	0.533
Educational level			0.143
Uneducated	1 (2.1)	0 (0)	
Below primary school	8 (16.7)	17 (33.3)	
Primary school	15 (31.3)	7 (13.7)	
Secondary school	11 (22.9)	16 (31.4)	
Secondary graduated	9 (18.8)	7 (13.7)	
Tertiary education or above	4 (8.3)	4 (7.8)	

* Data are presented as mean±SD or No. (%) of participants

Results

Treatment effects

Two-way repeated measure ANOVA revealed significant group × occasion effects 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=0.01) [Table 2]. The interaction effects on the CTT2-CTT1 score of CTT were also significant ($F(1,97)=4.37$, P=0.039). Other comparisons for scores on SDMT and GDS-SF, as well as systolic and diastolic blood pressure and heart rate variability (low/high frequency) revealed no significant differences. The mean sequence and span scores on the DST-Backward significantly increased from baseline to post-training (sequence: P=0.002, d=0.498, power=0.67; span: P=0.009, d=0.499, power=0.66) for those in the experimental group (Table 2). In contrast, controls showed no such differences. For the CTT2-CTT1, scores significantly decreased from baseline to the post-test occasion (P=0.010, d= −0.432) for the experimental group, but not the control group (P=0.483, d= −0.116). Both the experimental (P<0.001, d=0.429) and control (P<0.001, d=0.497) groups showed a significant increase in scores on the CERAD Memory word delay recall (J6) from baseline to post-test occasions.

For the experimental group, the participants had a significantly shorter latency elicited from the non-contextual than contextual condition in terms of N200 ($t(12)=4.70$, P=0.004) and P300 ($t(12)=5.15$, P=0.001). The control group showed no such change. Behaviourally, participants in the experimental group performed significantly faster, ie shorter response time, for both contextual (792.8±187.8 ms vs 1033.3±281.1 ms) and non-contextual stimuli tasks (734.7±185.6 ms vs 875.0±173.2 ms) than the control group ($t(28)=2.71$, P<0.01 and $t(28)=2.14$, P<0.05, respectively). No significant between-group

TABLE 2. Outcome measures at baseline, post-training, and 6-month follow-up assessment (reproduced from Chan CS et al. J Alzheimers Dis 2017;58:735-46, with permission from IOS Press)

Tests	2x2 repeated measure (baseline x post-training)		2x2 repeated measure (baseline x 6-month)		Within-group comparison (baseline x post-training)		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*)	
Digit Span Test (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)
Color Trails Test (CTT) [sec]								
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)
Symbol-digit Modalities Test (Verbal)								
Accuracy (%)	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 attempts	0.104	0.748	2.361	0.128	0.213 (0.102)	0.136 (0.126)	0.202 (0.088)	0.005 (0.224)
Consortium to Establish a Registry for Alzheimer's Disease – Neuropsychological Assessment Battery								
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)
Geriatric Depression Scale	0.018	0.893	1.908	0.170	0.464 (0.112)	0.635 (0.065)	0.440 (0.115)	0.212 (-0.142)

differences were revealed in the accuracy rates.

Long-lasting effects

Two-way repeated measure ANOVA revealed significant group × occasion (baseline vs 6-month follow-up) change for the sequence score of DST-Backward ($F(1,97)=4.27$, P=0.041), CTT2-CTT1 of the CTT ($F(1,97)=4.06$, P=0.047), and accuracy rate on the verbal SDMT ($F(1,97)=5.07$, P=0.027). Other comparisons for scores on GDS-SF, systolic and diastolic blood pressure, and heart rate variability (low/high frequency) were not significant. Participants in the experimental group but not the control group showed a significant increase in the DST-Backward sequence score from baseline to follow-up occasions (P<0.001, d=0.665, power=0.68). For verbal SDMT, the accuracy rate improved significantly from baseline to follow-up for the experimental group (P=0.016, d=0.392), but not for the control group. There were sustained increases in scores on the CERAD-NAB J4 in both experimental (P<0.004, d=0.466 to 0.580) and control (P<0.008, d=0.437 to d=0.613) groups.

Discussion

The 8-week Chinese calligraphy writing course effectively improved cognitive function in adults with MCI. The treatment effects on augmenting working memory and verbal delayed memory were strong. To a lesser extent, attention control, and visual scan and processing speed were also improved. These behavioural changes were supported by the electrophysiological results and suggested modulation of the encoding and manipulation (reflected from longer N200 latency) and updating processes of the working memory content (reflected from shorter P300 latency). The findings support our hypothesis that *Kai*-to-*Hang*-style stroke and character transformation can improve working memory and attention control functions in patients with MCI. It also sheds light on the usefulness of using a mnemonic strategy to halt the decline in cognitive functions among patients with early MCI. Nonetheless, our findings did not support the notion that the training promoted emotional calmness. This was perhaps due to the cognitive approach taken.

The rate-limiting step of the *Kai*-to-*Hang*-style calligraphy writing was to encode and decompose the *Kai*-style strokes within its character; transform the decomposed *Kai* strokes into *Hang* style; and rehearse the *Hang*-style stroke in working memory before writing the script with a soft brush that involved motor execution. The encoding process challenged intensively the participants' visual scan and attention control functions. The *Kai*-to-*Hang*-

style transformation process at the stroke level required retrieval and attention control (switching) functions. These were reflected by the increased CTT scores. The rehearsal of the *Hang*-style stroke before motor execution would challenge working memory and was evidenced by the increased DST-Backward sequence score. Our results for improvement of working memory are consistent with those reported by Kwok et al[3] who piloted a calligraphy writing protocol. Our results on working memory are consistent with those of Rozzini et al[4] who demonstrated that computer-based memory training resulted in significant improvements in memory, attention, and visuospatial functions among MCI participants. Improvement in visual scan ability coupled with attention control was demonstrated by the significant increases in scores on the verbal SDMT from baseline to 6-month follow-up. Our findings suggest that Chinese calligraphy writing may yield better treatment effects in terms of memory, visual scan, and attention control than computer-based cognitive training for which the effects were equivocal.[5]

This study has limitations that would lower the power and generalisation of its analyses and results. Readers should interpret the results with caution.

Conclusion

The 8-week Chinese calligraphy writing course improved working memory and delayed recall memory functions of participants with early MCI. The improved working memory, attention control, and processing speed at the 6-month assessment indicated that the training has potential long-lasting effects for alleviating and perhaps preventing progression of MCI. Future research is needed to confirm the benefits of Chinese calligraphy training beyond 8 weeks. The study should be extended to home-based and self-paced training, which is a feasible and sustainable model for service provision.

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