Auditory-based cognitive training programme for attention and memory in older people at risk of progressive cognitive decline: a randomised controlled trial

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KEY MESSAGES

1. A computerised cognitive training programme may help slow cognitive decline in the elderly.
2. Participants who underwent a computerised cognitive training programme demonstrated significant improvement in sustained attention and working memory at both individual and group levels.
3. All participants benefited from the cognitive training programme regardless of their pre-morbid general cognitive status or general intelligence.

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Introduction

Medical advances have drastically reduced the mortality rate worldwide. Coupled with a trend for a low fertility rate—particularly in developed countries—the world is ageing rapidly. By 2039 in Hong Kong, the elderly population (age >65 years) will constitute 28% of the total population. There will be more elderly people suffering degenerative changes in cognitive functioning. It is necessary to understand how ageing, whether normal or pathological, affects elderly people's cognitive functioning (eg processing speed, working memory, sustained attention, cognitive inhibition, and task switching ability).

Cognitive ageing may place a burden on the community, particularly on the health care system. Early identification and management of mild cognitive impairment may help prevent further deterioration. According to the frontal ageing/lobe hypothesis,[1] the frontal lobe of the brain is presumed to be most susceptible to deterioration with increasing age, whereas other regions are comparatively spared. Cognitive training based on the concept of neuro-plasticity (experience-induced neuroplastic changes) has been reported to slow cognitive deterioration and enhance cognitive functioning.[2] Cognitive training programmes have positive effects on processing speed, attention, memory, and reasoning in the elderly population.[3] Cognitive functioning improves as a consequence of positive brain changes through repetitive practice.

Attention and working memory are the building blocks for higher order cognitive functioning, such as executive planning and problem solving. In this study, we examined the efficacy of a computerised cognitive training programme for the elderly. A training paradigm was modelled after the Brain Fitness Programme.[3] Based on the concept of neuroplasticity, it was hypothesised that participants who received cognitive training would demonstrate improved attention and working memory.

Methods

Ethics approval was granted by the Institutional Review Board of The University of Hong Kong/Hospital Authority—Hong Kong West Cluster. Informed consent was obtained from each participant during screening.

Of 1159 community-dwelling Chinese adults aged ≥60 years, 533 met the inclusion criteria and were invited to participate of whom 150 declined. The 383 participants were considered at risk of cognitive decline (with a score of 20 to 26 on Montreal Cognitive Assessment) but were of normal general intelligence. They were randomised to one of three groups for 13 weeks: (1) cognitive training, (2) active control, and (3) no-contact control. Of participants, 97 dropped out because of time constraints; 286 who completed a cognitive assessment at time point 2 were analysed (Fig 1).

Results

The participants were comparable in terms of age

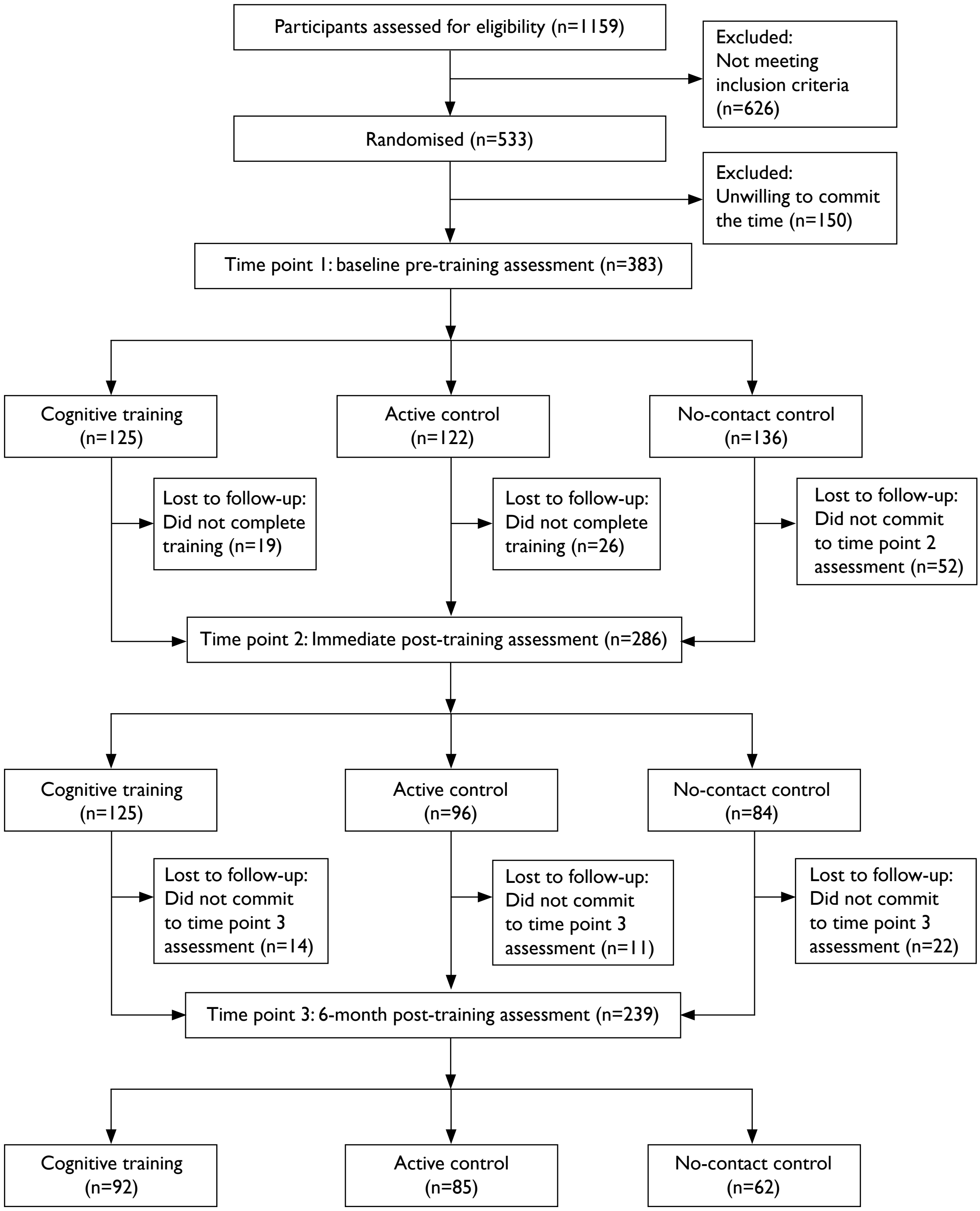

FIG 1. Flowchart of the study design

(mean±standard deviation [SD], 69.72±6.42 years; F=0.45, df=2-283, P=0.64), general cognitive status (mean±SD, 23.75±1.82; F=1.08, df=2-283, P=0.34), general intelligence (mean±SD, 90±9.78; F=1.36, df=2-283, P=0.26), cognitive processing speed status (mean±SD, 71.81±21.65; F=0.44, df=2-283, P=0.64), depression status (mean±SD, 3.98±2.65; F=1.91, df=2-283, P=0.15), and anxiety status (mean±SD, 4.44±2.87; F=2.02, df=2-283, P=0.14). The training groups were matched for gender composition (X^2 (2, n=286)=0.53, P=0.77).

Auditory sustained attention was measured using the Seashore Rhythm Test. There was a significant main effect in the cognitive training group (t[106]= -3.63, P<0.001). Repeated measures ANOVA indicated a trend for significant interaction

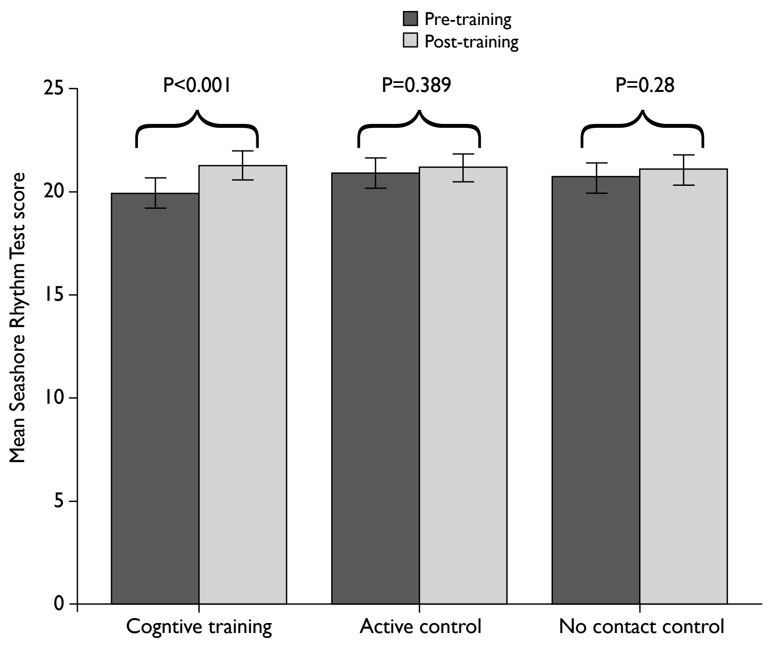

FIG 2. Training-associated changes in auditory sustained attention.

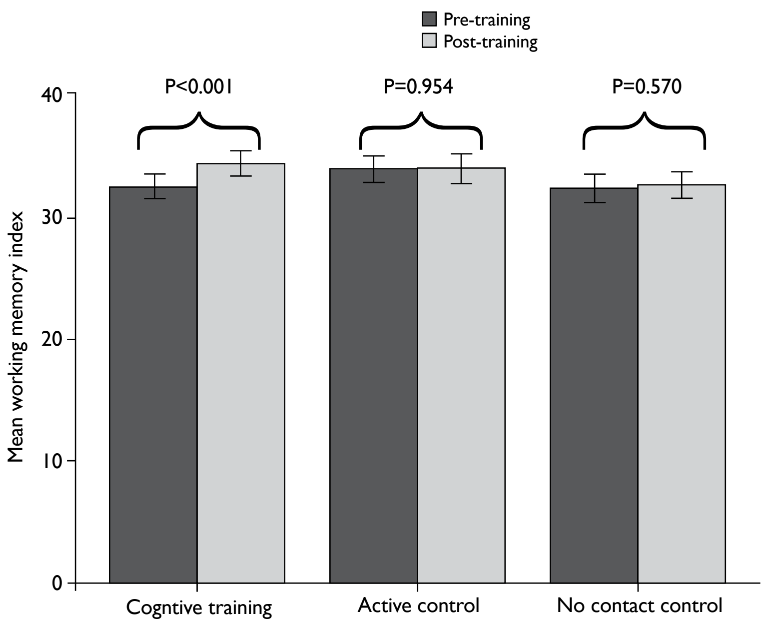

FIG 3. Training-associated changes in working memory index.

effect between the three groups (F=2.82, df=2-283, P=0.06). A post-hoc comparison showed that only the cognitive training group significantly improved after training, not the active control group (t[96]= -0.87, P=0.39) or no-contact control group (t[84]= -1.07, P=0.29) [Fig 2]. The training effect in the cognitive training group was presumed to be sustained at 6 months, as there was no significant difference at time points 2 and 3 (t[93]=0.24, P=0.81).

Visual sustained attention was measured using the Digit Vigilance Test. There was a significant main effect in all three groups although the post-training interaction effect was not significant among groups in terms of reaction time (F=0.03, df=2-280, P=0.97) or error (F=1.10, df=2-280, P=0.34).

Auditory and visual-spatial working memory was measured using the Digit Span Test and Spatial Span Test. There was a significant main effect in the cognitive training group (t[106]= -5.61, P<0.001). Repeated measures ANOVA indicated significant interaction effects (F=8.10, df=2-283, P<0.001). A post-hoc comparison showed that only the cognitive training group significantly improved working memory, not the active control group (t[96]= -0.06, P=0.95) or no-contact control group (t[84]= -0.57, P=0.57) [Fig 3]. The training effect in the cognitive training group was presumed to be sustained at 6 months, as there was no significant difference at time points 2 and 3 (t[93]=1.97, P=0.052).

None of the training effects in the cognitive training group correlated with either the baseline general cognitive status or general intelligence (all P>0.05). In addition, there was no interaction effect between gender and training effects for auditory sustained attention (F=0.36, df=1-104, P=0.55) or working memory (F=0.11, df=1-104, P=0.74).

Discussion

The findings of this study confirm that cognitive training improves the cognitive domains as indicated by improved working memory and auditory sustained attention. This concurs with the concept of neuroplasticity in which behavioural changes can be induced through manipulation of external experiences, such as structured cognitive training.

Working memory capacity can be expanded through targeted training.[4] The observed improvement was a near-transfer effect in which training of visual working memory improved both visual and auditory working memory, as reflected by the improved working memory index. A far-transfer effect will be confirmed in future studies.

The significant training effects for auditory sustained attention were only observed in the cognitive training group. No significant across-group difference was detected in visual sustained attention. The present training protocol failed to demonstrate a cross-modality training effect on sustained attention. This may be related to the use of different age cohorts, as the ageing brain is associated with neuronal and synaptic atrophy as well as physiological degeneration,[5] which may affect the neuroplastic effect in the elderly.

Baseline general intelligence and general cognitive status were not correlated with training effect. Regardless of pre-morbid cognitive functioning, elderly participants achieved significantly improved sustained attention and working memory. Participants with different levels of pre-morbid functioning may benefit from cognitive training.

Conclusions and implications

The findings of our study support the efficacy of the training programme based on the model of experience-induced neuroplastic change. The computerised cognitive training programme can be used for training elderly people at risk of degenerative cognitive decline. In elderly individuals with higher computer competency, adoption of a web-based training programme would allow self-administration at home at any time. Further studies with longer follow-up of the training effect in preventing Alzheimer's disease or mild cognitive impairment are warranted.

Acknowledgement

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