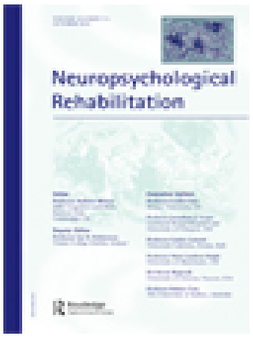

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Neuropsychological Rehabilitation

An International Journal

ISSN: 0960-2011 (Print) 1464-0694 (Online) Journal homepage: http://www.tandfonline.com/loi/pnrh20

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To cite this article: Amanda L. Gooding, Jimmy Choi, Joanna M. Fiszdon, Kirsten Wilkins, Paul D. Kirwin, Christopher H. van Dyck, Davangere Devanand, Morris D. Bell & Monica Rivera Mindt (2015): Comparing three methods of computerised cognitive training for older adults with subclinical cognitive decline, Neuropsychological Rehabilitation, DOI: 10.1080/09602011.2015.1118389

To link to this article: http://dx.doi.org/10.1080/09602011.2015.1118389

NEUROPSYCHOLOGICAL REHABILITATION, 2015
http://dx.doi.org/10.1080/09602011.2015.1118389

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Comparing three methods of computerised cognitive training for older adults with subclinical cognitive decline

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ABSTRACT

Cognitive rehabilitation for mild cognitive impairment (MCI) and early Alzheimer's disease is readily available to the geriatric population. Initial evidence suggests that techniques incorporating motivational strategies to enhance treatment engagement may provide more benefit than computerised training alone. Seventy four adults with subclinical cognitive decline were randomly assigned to computerised cognitive training (CCT), Cognitive Vitality Training (CVT), or an Active Control Group (ACG), and underwent neuropsychological evaluations at baseline and four-month follow-up. Significant differences were found in changes in performance on the Modified Mini Mental State Examination (mMMSE) and measures of verbal learning and memory across treatment groups. Experimental groups showed greater preservation of functioning on the mMMSE than the ACG group, the CVT group performed better than the ACG group on one measure of verbal learning and both measures of verbal memory, and the CCT group performed better than the ACG group on one measure of verbal learning and one measure of verbal memory. There were no significant group differences between the CVT and CCT groups on measures of verbal learning or memory. It was concluded that computerised cognitive training may offer the most benefit when incorporated into a therapeutic milieu rather than administered alone, although both appear superior to more generic forms of cognitive stimulation.

ARTICLE HISTORY Received 6 May 2015; Accepted 5 November 2015

KEYWORDS Mild cognitive impairment; Computerised cognitive training; Cognitive rehabilitation; Alzheimer's disease

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No potential conflict of interest was reported by the authors.
Funded by a grant from the Alzheimer's Association [IIRG-09–131861] and a Department of Veterans Affairs RR&D Career Development Award [RRD-B4146V] to JC.

Introduction

The development of effective treatments that delay the onset of debilitating cognitive symptoms in dementia is imperative to prepare the global health system to accommodate the growing influx of persons with dementia. Recent scientific evidence suggests that concurrent pharmacological and cognitive rehabilitation (CR) methods may have more benefit than medication alone in preserving function in patients suffering from the early stages of dementia due to Alzheimer's disease (AD; Petersen, 2004; Van Dyck, 2004). Cognitive rehabilitation for mild cognitive impairment (MCI) and early AD is a promising intervention for the geriatric population to help curb the insidious decline in cognitive and functional performance (Cipriani, Bianchetti, & Trabucchi, 2006; Loewenstein, Aceveda, Czaja, & Duara, 2004; Rozzini et al., 2007; Talassi et al., 2007). Although specific remediation protocols vary across models, most include computer-based, hierarchical repeated drill and practice exercises that target memory, attention, and executive functions, aimed at enhancing cognitive function in MCI and early AD.

Cognitive rehabilitation for patients with early AD may have a modest effect on patients with neurodegenerative pathology but presents challenges for individuals trying to adhere to these cognitive treatments (Choi & Twamley, 2013). Problems with intervention adherence may be due to components of the primary cognitive illness or secondary to geriatric depression, such as early memory deficits or apathy that may contribute to difficulties adhering to the treatment protocols (Clare et al., 2011; Devanand et al., 2004). Rehabilitation techniques that incorporate motivational strategies to enhance treatment engagement and cognitive outcome may benefit people with MCI. Indeed, increasing a patient's motivation to adhere to cognitive rehabilitation has been associated with better outcome in schizophrenia (Choi & Medalia, 2005) and pain management (Kerns & Habib, 2004). Patients motivated to participate consistently in order to achieve adequate treatment intensity is necessary for successful rehabilitation efforts. Moreover, patients who are intrinsically motivated seem to obtain greater cognitive and functional benefits from the training itself (Choi & Medalia, 2005).

One study to date has investigated the potential impact of including motivational instructional techniques in a CR programme for older adults with AD. Choi and Twamley (2013) randomly assigned 69 patients with mild to moderate AD on any cholinesterase (ChEI) regimen (e.g., galantamine, donepezil, rivastigmine) to receive either cognitive rehabilitation coupled with motivational variables (i.e., Cognitive Vitality Training; CVT) or computerised cognitive training alone (Posit Science's BrainFitness 1.0). Patients in the CVT group showed more preserved memory functioning compared to the group receiving memory training alone at 6 months ($p < .05$). Patients and caregivers in CVT reported better quality of life ($p < .05$) and less overall depressive symptoms ($p < .05$). A stepwise regression model showed that perceptions of self-efficacy and autonomy predicted memory outcome at 6-month follow-up, even after accounting for variance from baseline memory ability, overall dementia symptoms, and motivation ($R^2 = .53$, $p = .04$).

The mechanisms leading to better outcome in this study are still not entirely clear, but one can surmise that patients recently diagnosed with AD (and their caregivers) experience a tremendous loss of control in their lives, and motivation therapies like CVT can promote self-efficacy, control, and psychological well-being in individuals who begin to lose these qualities as part of their cognitive loss. This is consistent

with empirical evidence that medical treatments that incorporate patient-directed goals and offer patients more control over treatment planning provide greater therapeutic advantages over the traditional doctor-prescribed regimen (Brodie, Inoue, & Shaw, 2008; Kerns & Habib, 2004). Giving patients the ability to contextualise interventions as related to personal life goals while retaining some element of self-efficacy in medical procedures may enhance treatment adherence and patient motivation.

Few well-controlled studies exist that address the efficacy of computerised cognitive rehabilitation methods in MCI and AD (Cipriani et al., 2006; Loewenstein et al., 2004; Rozzini et al., 2007; Talassi et al., 2007). Meta-analyses of such studies reveal mixed results, with some showing little evidence that such interventions make a difference in cognition, while others document modest improvements in specific neuropsychological domains and functional abilities (Clare & Woods, 2008; Sitzer, Twamley, & Jeste, 2006). Maintenance of treatment gains in the context of a progressive neurodegenerative disease like AD is warranted. Treatment response, in relation to stage of disease, is also in question. Cognitive interventions for individuals in the earliest stages of neuropsychological decline may help elucidate the initial efficacy of treatment and the stability of those improvements over time. This rationale emphasises the importance of identifying effective cognitive and motivational interventions for MCI that can be implemented *before* individuals enter the more advanced stages of decline and receive an AD diagnosis.

This study follows up on the results of a pilot study (Choi & Twamley, 2013), which showed the efficacy of CR embedded in a motivational therapeutic milieu (i.e., CVT) compared to treatment as usual for patients with mild to moderate AD. The current study sought to compare directly this CVT method with more rigorous comparison conditions that will delineate the value of incorporating such a motivational milieu into cognitive training programmes for older adults with subclinical cognitive decline.

We hypothesised that individuals with subclinical cognitive decline who were enrolled in CVT would demonstrate greater preservation in performance on measures of learning and memory after completion of treatment than individuals enrolled in a generic CR condition (i.e., CCT), who would demonstrate greater preservation of functioning than individuals enrolled in an active control condition.

Methods

Participants

A total of 96 participants were recruited for this study, and completed the baseline neuropsychological evaluation. Of those, 74 participants completed the full treatment, 7 completed a partial portion of the treatment, and 15 did not complete any portion of the assigned treatment. The overall study attrition rate was 23%. Among those who did not complete treatment, 6 participants dropped out after the baseline neuropsychological evaluation, 4 participants dropped out after completing a portion of the 2-month follow-up evaluation, and 12 participants dropped out after completing the full 2-month follow-up evaluation. Demographic, clinical, and baseline neuropsychological variables were compared using one-way ANOVAs and chi-square analyses, and there were no significant differences on any of the demographic or clinical variables between those who dropped out and those who completed the full treatment (all $ps > .05$). Table 1

Table 1. Demographic, clinical, and neuropsychological data for all participants ($N = 74$).

	Percentage	Mean	*SD*
Demographic variables			
Age (years)		75.59	8.75
Education (years)		15.14	2.58
Gender—% Male	58.1		
Ethnicity			
Non-Hispanic white	59.5		
African American	17.6		
Hispanic/Latino	17.6		
Asian	5.4		
Clinical variables			
Estimated pre-morbid IQ		109.41	7.23
BDI-II Total Score		6.39	4.13
Living situation			
Community	82.4		
Residential	17.6		
Medication status			
ACHEI—% Yes	5.4		
Benzo—% Yes	4.1		
No of days to complete Training		102.89	34.83
Baseline neuropsychological variables			
mMMSE Total Raw Score		50.58	2.72
BSRT Total Raw Score		43.08	6.27
BSRT Total T- Score[a,b,c]		47.47	9.45
BSRT Delay Raw Score		4.81	2.56
BSRT Delay T- Score[a,b,c]		40.52	12.48
VR-I Raw Score		24.08	5.95
VR-I Percentile[a]		46.58	24.24
VR-II Raw Score		13.65	8.34
VR-II Percentile[a]		34.23	26.08
LM-I Raw Score		19.81	5.31
LM-I Percentile[a]		47.61	26.15
LM-II Raw Score		32.50	24.79
LM-II Percentile[a]		32.50	24.79

*All *ps* > .05; When possible, scores listed are demographically adjusted for [a]age, [b]education, and [c]ethnicity; Estimated pre-morbid IQ based on Wide Range Achievement Test–3rd Edition (WRAT-3) Reading Subtest Score; BDI-II = Beck Depression Inventory–2nd Edition; ACHEI = Acetylcholinesterase Inhibitors; Benzo = Benzodiazepines; mMMSE = Modified Mini Mental State Examination; BSRT = Buschke Selective Reminding Test; VR = Visual Reproductions Subtests; LM = Logical Memory Subtests.

summarises the demographic and clinical data of the participants who completed the full treatment.

Among those participants who completed treatment, approximately 58% were male. The mean age of the sample was approximately 76 years ($SD = 8.75$), and the mean education was approximately 15 years ($SD = 2.58$). Approximately 58% of the sample were non-Hispanic white, 19% African American, 18% Hispanic/Latino, and 5% Asian. The mean Wide Range Achievement Test–Third edition (WRAT-3) Reading subtest score, the premorbid IQ estimate, was 109.41 ($SD = 7.23$), suggesting that the estimated premorbid intellectual functioning of this sample was in the average range. The majority of participants (82%) were independent community dwellers. Very few participants were currently prescribed acetylcholinesterase inhibitors or benzodiazepines (approximately 5% and 4%, respectively), and the severity of depression symptomatology on a self-report measure, i.e., Beck Depression Inventory–Second edition (BDI-II Total Score), was low ($M = 6.39$, $SD = 4.13$). The average length of time to complete treatment was approximately 103 days ($SD = 34.83$), which is on par with the suggested 4-month time frame.

Study procedures

The study sample was recruited through the Memory Disorders Center (MDC) at Columbia University, which includes the Alzheimer's Disease Research Center (ADRC), Doctors Private Offices at the Neurological Institute, and the Memory Disorders Clinic at the New York State Psychiatric Institute (NYSPI) as well as through the Department of Geriatric Psychiatry at the VA Connecticut Healthcare System.

Diagnosis of subclinical cognitive decline was established by (1) subjective or informant memory complaints; (2) verbal memory impairment, as measured by > 0.5 *SD* decline on Wechsler Memory Scale-Revised (WMS-R) Logical Memory (LM) II or Buschke Selective Reminding Test (BSRT); (3) normal general cognitive function, as determined using the Mini Mental State Examination (MMSE) score > 24; and (4) normal independent functioning as determined by physician report and > 75 percentile score on Independent Living Scales (ILS).

All participants were assessed on baseline neuropsychological measures following inclusion into protocol, but, prior to randomisation, all participants were re-assessed on all outcome measures at 4 months. The following domains were assessed:

1. Premorbid intellectual functioning was assessed using the WRAT-3 (Gladsjo, Heaton, Palmer, Taylor, & Jeste, 1999; Wilkinson, 1993).
2. Global cognition was assessed using the Modified Mini Mental State Examination (mMMSE; Stern, Mayeux, Sano, Hauser, & Bush, 1987). This instrument included all items from the standard Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), plus the Wechsler Adult Intelligence Scale–Revised Digit Span subtest and additional attention/calculation and general knowledge, language, and construction items.
3. Explicit verbal learning and memory were assessed using the BSRT (Buschke, 1973; Strauss, Sherman, & Spreen, 2006) and the WMS-R LM I and II subtests (Wechsler, 1997).
4. Explicit visual learning and memory were assessed using the WMS-R Visual Reproductions (VR) I and II subtests (Wechsler, 1997).
5. Self-reported mood symptoms were assessed using the BDI-II (Beck, Steer, & Brown, 1996).

Treatment phase

This randomised clinical trial used a test–re-test treatment controlled design with recruited patients randomly assigned to one of three research arms—Computerised Cognitive Training (CCT), Cognitive Vitality Training (CVT), or an Active Control Group (ACG). The treatment phase sessions were provided in individual or group format, twice per week, with each session lasting approximately 60 minutes. Total exposure was the same for all treatment groups, and required approximately 30 hours of training within a 16-week period.

Computerised Cognitive Training (CTT)

Participants assigned to the CCT group participated in Posit Science's BrainFitness (Mahncke, Bronstone, & Merzenich, 2006). This neuroscience cortical plasticity-based

training programme is specifically designed for use with older adults, and incorporates repeated drill-and-practice exercises involving memory, attention, and executive functions within domain-specific training modules that allow for adaptive training with titrated difficulty levels. BrainFitness version 2.0.1, which incorporates specific modules for geriatric treatment, was used for this study, and has demonstrated success in various large-scale multi-centre trials to improve neuropsychological functioning in older populations (Mahncke et al., 2006; Smith et al., 2009; Zelinski et al., 2011).

Cognitive Vitality Training (CVT)

Participants assigned to the CVT group participated in a programme that incorporates empirically-validated motivational teaching and rehabilitation techniques into a highly engaging programme that emphasises enjoyment, intrinsic motivation, and active participation, while also engaging in a more traditional computer-based memory training programme. Pilot data collected by the principal investigator of this study (J.C.) suggested that optimal treatment intensity and dosage to obtain measurable improvements on outcome measures requires approximately 30 hours of training within a 16-week period. CVT consists of a traditional computerised cognitive rehabilitation programme (CCT) that is embedded within the Neuropsychological and Educational Approach to Remediation (NEAR) model of treatment (Medalia, Revheim, & Herlands, 2009).

Participants in the CVT group completed the same exercises as the CCT group using the BrainFitness programme described above, but within an incorporated motivational therapeutic milieu based on the principles put forth by NEAR. In short, studies of NEAR have demonstrated that individuals perform better on cognitive rehabilitation tasks if they are (1) allowed to personalise the incidental features in the training programme (i.e., can set personal goals rather than follow clinician-set goals), (2) provided choice over the aspects of the training activity (i.e., can select module of choosing and set personal time constraints), and (3) allowed to contextualise the training into a meaningful, real-world situation (i.e., training programme embedded into the context of high-interest or real-world themes, such as sport games or simulating a business transaction; Choi & Medalia, 2005). In addition to improved task performance, individuals enrolled in CR programmes that are specifically designed to increase motivation, such as NEAR, obtain greater neuropsychological and functional benefits from the training itself (Medalia & Richardson, 2005). The computer software described above (i.e., BrainFitness 2.0.1) allows for the manipulation of these three components of NEAR (i.e., personalisation, autonomy, and contextualisation), with the goal of promoting independence, treatment engagement, intrinsic motivation, and self-efficacy. Individuals in the CVT group were also encouraged to include a caregiver to be actively involved in the programme by participating in the feedback and information sessions.

Active Control Group (ACG)

Participants assigned to the ACG worked on various commercially available computer games and puzzles (i.e., BrainAge, Sudoku, crossword puzzles). Participants in this group worked on the computerised games in a similar format to individuals in the CCT and CVT groups (either at the hospital or remotely from home), and treatment dosage and intensity were identical to the CCT and CVT groups (i.e., a total of two hours per week). Including this group allowed for control of the effects of clinician

contact, and the potential nonspecific effects of cognitive exercise. This paradigm helped determine whether neuroscience-based cognitive rehabilitation treatments are more effective at improving memory ability than the mentally stimulating puzzles and games readily available to the public.

Data analysis

Treatment response (i.e., preservation of neuropsychological functioning) was defined using change scores from baseline to four-month follow-up on all neuropsychological measures utilising data for the 74 participants who completed treatment. While the reliable change index and standardised regression-based models are typically used in clinical settings to evaluate the clinical significance of changes in neuropsychological test scores over time (Barr, 2002), the goal of this study was to evaluate absolute changes in performance from baseline to four-month follow-up. Thus, change scores for this study were calculated by subtracting the baseline standard scores from the four-month follow-up standard scores on these same measures. When possible, standard scores (adjusting for age and/or education and gender) were used for analyses of all dependent variables, to allow for more clinically meaningful interpretation of the results. For neuropsychological variables, better treatment response is indicated by higher (at or above zero) change scores, which indicates either stable performance or improvement after treatment, and worse treatment response is indicated by lower (below zero) change scores, which indicates declines after treatment. For the BDI-II change score, better treatment response is indicated by lower (at or below zero) change scores, which indicates either stable mood symptoms or improvement after treatment, and worse treatment response is indicated by higher (above zero) changes scores, which indicate worsening mood symptoms after treatment. All change scores were operationalised as continuous variables that may be either positive or negative.

Results

Tables 2 and 3 summarise the neuropsychological functioning for the participants who completed treatment at baseline and at four-month follow-up. Results of one-way ANOVAs revealed that the three groups did not differ with respect to baseline performance on any of the demographic, clinical, or dependent variables (all $ps > .05$). In terms of the change scores (also reported in Table 3), the mean change scores on measures of verbal learning (i.e., BSRT Total *T*-score and LM-I Percentile), verbal memory (i.e., BSRT Delay *T*-Score and LM-II Percentile), and visual memory (i.e., VR-II Percentile), were all positive, suggesting that participants demonstrated improvement after completion of treatment. Similarly, a mean increase of 1.27 points was seen on the mMMSE from baseline to four-month follow-up. However, the same trend was not observed for the measure of visual learning (i.e., VR-I), which suggests a decline from baseline to four-month follow-up.

Table 4 summarises the results of a series of one-way ANOVAs comparing the dependent variables across the three treatment groups (i.e., ACG, CCT, and CVT). Consistent with the study's hypotheses, the three treatment groups were significantly different on changes in performance on a measure of global cognition, i.e., mMMSE, $F(2, 71) = 11.56$, $p < .001$, $\eta_\rho^2 = .25$; one measure of verbal learning, i.e., BSRT Total *T*-score, $F(2,$

Table 2. Baseline neuropsychological test performance by treatment group ($N = 74$).

	ACG ($N = 20$)		CCT ($N = 31$)		CVT ($N = 23$)	
	Mean	*SD*	Mean	*SD*	Mean	*SD*
mMMSE Total Raw Score	51.25	2.79	50.29	7.78	50.39	2.59
BSRT Total Raw Score	42.40	6.42	43.94	6.41	42.52	6.09
BSRT Total T- Score[a,b,c]	46.29	9.89	49.10	9.71	46.31	8.74
BSRT Delay Raw Score	4.95	2.80	5.13	2.38	4.26	2.60
BSRT Delay T- Score[a,b,c]	40.92	13.36	42.25	11.48	37.83	13.07
VR-I Raw Score	23.75	6.29	24.13	6.25	24.30	5.48
VR-I Percentile[a]	44.90	26.28	47.00	25.70	47.48	21.19
VR-II Raw Score	13.05	8.37	13.06	8.49	14.96	8.24
VR-II Percentile[a]	32.70	26.31	31.81	27.40	38.83	24.56
LM-I Raw Score	20.20	5.98	18.90	4.98	20.70	5.17
LM-I Percentile[a]	50.40	28.32	43.84	26.46	50.26	24.15
LM-II Raw Score	11.35	7.55	9.35	6.11	10.61	6.85
LM-II Percentile[a]	39.30	30.86	30.77	23.00	28.91	20.85
BDI-II Total Score	6.45	5.35	6.65	2.56	6.00	4.78

Where possible, scores listed are demographically adjusted for [a]age, [b]education, and [c]ethnicity; mMMSE = Modified Mini Mental State Examination; BSRT = Buschke Selective Reminding Test; VR = Visual Reproductions Subtests; LM = Logical Memory Subtests; BDI-II = Beck Depression Inventory–2nd Edition.

71) = 5.00, $p < .01$, $\eta_\rho^2 = .12$; and two measures of verbal memory, i.e., BSRT Delay *T*-score, $F(2, 71) = 8.55$, $p < .001$, $\eta_\rho^2 = .19$, LM-II, $F(2, 71) = 5.78$, $p = 01$, $\eta_\rho^2 = .14$. Tukey's HSD tests showed that both experimental groups showed greater preservation of functioning on a measure of global cognition than the ACG group; the CVT group performed better than the ACG group on one measure of verbal learning and both measures of verbal memory; and the CCT group performed better than the ACG group on one measure of verbal learning and one measure of verbal memory. There were no significant group differences between the CVT and CCT groups on measures of verbal learning or memory.

Table 3. Changes in neuropsychological test performance from baseline to 4-month follow-up for all participants ($N = 74$).

Test	Baseline Mean (*SD*)	Range	4-Month Mean (*SD*)	Range	Change score Mean (*SD*)
mMMSE Total Score	50.58 (2.72)	(43–56)	51.85 (2.31)	(46–56)	1.27 (2.75)
BSRT Total T-score[a,b,c]	47.47 (9.45)	(22.29–73.28)	50.52 (9.62)	(24.97–73.37)	3.05 (8.88)
BSRT Delay T-score[a,b,c]	40.52 (12.48)	(17.86–69.55)	47.36 (11.85)	(26.61–71.47)	6.84 (12.49)
VR-I Percentile[a]	46.58 (24.24)	(8.00–99.00)	45.91 (25.54)	(8.00–99.00)	−.68 (11.03)
VR-II Percentile[a]	34.23 (26.08)	(4.00–99.99)	36.09 (26.05)	(4.00–99.00)	1.86 (9.95)
LM-I Percentile[a]	47.61 (26.15)	(5–92)	52.66 (27.01)	(6–98)	5.05 (14.29)
LM-II Percentile[a]	32.50 (24.79)	(4–89)	42.31 (24.42)	(8–98)	9.81 (16.18)
BDI-II Total Score	6.39 (4.13)	(1–27)	7.38 (3.69)	(1–23)	.99 (3.65)

Where possible, scores listed are demographically adjusted for [a]age, [b]education, and [c]ethnicity; mMMSE = Modified Mini Mental State Examination; BSRT = Buschke Selective Reminding Test; VR = Visual Reproductions Subtests; LM = Logical Memory Subtests; BDI-II = Beck Depression Inventory–2nd Edition.

Table 4. Results of one-way ANOVAs comparing dependent variables across treatment groups.

	Mean	*SD*	*F*(2, 71)	*p*	η_p^2	Tukey's HSD
mMMSE Change Score			11.56	< .001	.25	CVT > ACG CCT > ACG
CVT	2.78	2.59				
CCT	1.45	2.45				
ACG	−0.75	2.15				
BSRT Total Change Score			5.00	< .01	.12	CVT > ACG
CVT	6.47	9.58				
CCT	3.52	7.37				
ACG	−1.61	8.56				
BSRT Delay Change Score			8.55	< .001	.19	CVT > ACG CCT > ACG
CVT	13.20	12.94				
CCT	7.28	10.80				
ACG	−1.14	10.25				
VR-I Change Score			.66	.52	.02	–
CVT	3.13	12.51				
CCT	3.61	8.69				
ACG	−2.30	7.41				
VR-II Change Score			2.52	.09	.07	–
CVT	0.43	12.17				
CCT	0.06	13.21				
ACG	−3.10	3.49				
LM-I Change Score			2.83	.07	.07	CCT > ACG
CVT	5.61	12.59				
CCT	8.52	17.09				
ACG	−0.95	9.06				
LM-II Change Score			5.78	.01	.14	CVT > ACG
CVT	17.87	12.48				
CCT	8.71	17.67				
ACG	2.25	13.85				
BDI-II Change Score			3.50	.04	.09	CVT < ACG
CVT	−0.43	3.86				
CCT	1.23	3.33				
ACG	2.40	3.42				

CVT = Cognitive Vitality Training; CCT = Computerised Cognitive Training; ACG = Active Control Group; mMMSE = Modified Mini Mental State Examination; BSRT = Buschke Selective Reminding Test; WMS-R VR = Wechsler Memory Scale–Revised Visual Reproductions Subtests; WMS-R LM = Wechsler Memory Scale–Revised Logical Memory Subtests; BDI-II = Beck Depression Inventory–2nd Edition.

In contrast to the study's hypotheses, the results revealed that the groups did not differ on changes in performance on a measure of visual learning (*ps* > .10). However, there was a trend towards significance on changes in performance on measures of visual memory, $F(2, 71) = 2.52$, $p = .09$, $\eta_p^2 = .07$. Moreover, trends towards significance were observed on changes in performance on another measure of verbal learning, i.e., WMS-R LM-I; $F(2, 71) = 2.83$, $p = .07$, $\eta_p^2 = .07$.

In terms of emotional functioning, the results revealed that the three treatment groups were significantly different on changes in overall depressive symptomatology, i.e., BDI-II, $F(2, 71) = 3.50$, $p = .04$, $\eta_p^2 = .09$. Tukey's HSD tests showed that the participants receiving CVT showed a relative decrease in mood symptoms after treatment compared to the ACG group, who showed a relative increase in mood symptoms. There were no significant differences between the CVT and CCT groups, or between the CCT and ACG groups.

Discussion

This study revealed significant differences in changes in performance on the mMMSE and measures of verbal learning and memory across the three treatment groups (i.e., CVT, CCT, ACG). Although between-group comparisons did not reveal significant differences between the CVT and CCT groups, the participants enrolled in CVT did demonstrate the largest treatment gains, and these treatment gains were significantly greater than those that were observed in the ACG group, who demonstrated subtle declines in performance following completion of treatment. Effect sizes generally suggest moderate to high practical significance, and on average participants in CVT improved by approximately 6.5 *T*-score points on a measure of verbal learning (i.e., BSRT Total Recall), and by approximately 13.2 *T*-score points on a measure of verbal memory (i.e., BSRT Delay Recall). The ACG group, meanwhile, demonstrated subtle declines on most measures. Additionally, the mMMSE score for the participants in the CVT group increased by an average of 2.78 points, compared to only 1.45 points in the CCT group; again, the ACG group declined by approximately 0.75 points in only four months. These findings are particularly meaningful in light of the fact that none of the treatment groups had significantly differed with respect to their performances on these measures at baseline. Furthermore, these results are consistent with the aims of this study, which hypothesised that participants in the CVT and CCT conditions would have greater cognitive gains than the ACG group; however, the hypothesis that CVT would be specifically superior to CCT was not supported.

In addition to the changes in neuropsychological status, the individuals in the CVT group showed the greatest benefit in terms of mood symptoms. On average, participants enrolled in the CVT group showed subtle reductions in their total depressive symptomatology (i.e., BDI-II), while those enrolled in either the CCT or ACG conditions showed relative increases in their total depressive symptomatology, with statistical differences again noted between CVT and ACG but not between CVT and CCT.

Several limitations to this study should be noted, however, including the restricted demographics of this sample (i.e., high levels of education and low representation of racial/ethnic minorities) and a higher than expected rate of attrition (23%), which may have resulted in a biased sample that may contain individuals with a significantly different clinical course than those individuals who discontinued study participation prior to the four-month follow-up evaluation. However, the nature of how they differ remains ambiguous, since participants who dropped out did not differ with respect to any of the demographic, clinical, or neuropsychological variables compared to those who completed treatment. Also, this study did not include measures to assess everyday functioning (i.e., managing finances or medications), and thus the generalisability of these cognitive gains to real-word performance is unknown.

Nonetheless, these findings are particularly significant as the global healthcare system prepares to accommodate an influx of older adults with dementing illnesses. It is imperative to develop effective treatments to delay the onset of the cognitive decline associated with AD. Even a temporary delay in cognitive decline will have a significant impact on the high treatment costs associated with the disease. Some estimates suggest that preventing a 2-point decline on the MMSE could save a family thousands of United States dollars annually, while a 2-point increase in MMSE score would save even more (Ernst, Hay, Fenn, Tinklenberg, & Yesavage, 1997).

These findings are somewhat convergent from the existing literature, which suggest the superiority of CVT compared to CCT in the preservation of memory functioning for individuals with AD (Choi & Twamley, 2013). However, the participants recruited for this study were notably much less impaired on the clinical spectrum than those in the former study, which had more stringent cutoffs for defining impairment and identifying individuals with mild-to-moderate AD. Nonetheless, considerable evidence suggests that cognitive rehabilitation treatments, especially the more comprehensive models that incorporate motivational techniques, are effective at improving both cognitive skills and real-world functioning in individuals with psychiatric illness, and studies have demonstrated that patients who are intrinsically motivated obtain even greater cognitive and functional benefits from the training itself (Choi & Medalia, 2005). Although we did not find significant differences between CVT and CCT, our results do support the notion that comprehensive models that incorporate motivational techniques may be superior to other cognitively stimulating activities, such as word puzzles, Sudoku, and other commercially available games. What remains to be seen, however, is whether these treatment gains are sustained over time. For this reason, future research from our laboratory aims to re-examine outcomes at one year following completion of treatment.

These findings are of practical clinical significance, because patients with subclinical cognitive decline and early stages of dementia may have difficulty adhering to cognitive rehabilitation techniques due to overlapping depressive symptoms such as poor motivation and poor concentration (Clare et al., 2011; Devanand et al., 2004). Although our results are mixed, rehabilitation techniques like Cognitive Vitality Training (CVT), which stress motivational strategies to enhance treatment engagement, may still benefit the cognitive function of people with subclinical cognitive decline. Given the multitude of cognitive rehabilitation methods available, and particularly given the advent of commercial software readily available for purchase (e.g., Lumosity, Posit Science, etc.), clarifying the short-term and long-term benefits of various treatments will be important to ensure that clients are receiving maximal benefit from therapy.

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