J Head Trauma Rehabil

Compensatory Cognitive Training for Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn Veterans With Mild Traumatic Brain Injury

Daniel Storzbach, PhD; Elizabeth W. Twamley, PhD; Mai S. Roost, PhD; Shahrokh Golshan, PhD; Rhonda M. Williams, PhD; Maya O'Neil, PhD; Amy J. Jak, PhD; Aaron P. Turner, PhD; Halina M. Kowalski, MA; Kathleen F. Pagulayan, PhD; Marilyn Huckans, PhD

Objective: The purpose of the study was to evaluate the efficacy of group-based compensatory cognitive training (CCT) for Operation Enduring Freedom (OEF)/Operation Iraqi Freedom(OIF)/Operation New Dawn (OND) Veterans with a history of mild traumatic brain injury. **Method:** One hundred nineteen OEF/OIF/OND Veterans with history of mild traumatic brain injury participated at 3 sites, and 50 of the Veterans were randomized to CCT group, while 69 Veterans were randomized to the usual care control group. The CCT group participated in 10 weeks of CCT. Both CCT and usual care groups were assessed at baseline, 5 weeks (midway through CCT), 10 weeks (immediately following CCT), and 15 weeks (5-week follow-up) on measures of subjective cognitive complaints, use of cognitive strategies, psychological functioning, and objective cognitive performance. **Results:** Veterans who participated in CCT reported significantly fewer cognitive and memory difficulties and greater use of cognitive strategies. They also demonstrated significant improvements on neurocognitive tests of attention, learning, and executive functioning, which were 3 of the cognitive domains targeted in CCT. **Conclusions:** Findings indicate that training in compensatory cognitive strategies facilitates behavioral change (ie, use of cognitive strategies) as well as both subjective and objective improvements in targeted cognitive domains. **Key words:** *cognitive training, mild traumatic brain injury, OEF/OIF/OND Veterans*

THE HEALTHCARE needs of military personnel and Veterans reporting deployment-related traumatic brain injury (TBI), cognitive difficulties, and

Author Affiliations: *VA Portland Healthcare System, Portland, Oregon (Drs Storzbach, Roost, O'Neil, and Huckans and Ms Kowalski); Departments of Psychiatry (Drs Storzbach, O'Neil, and Huckans) and Neurology (Dr Storzbach), Oregon Health & Science University, Portland, Oregon; Center of Excellence for Stress and Mental Health, VA San Diego Healthcare System, San Diego, California (Drs Twamley and Jak); Department of Psychiatry, University of California, San Diego, La Jolla (Drs Twamley, Golshan, and Jak); VA Puget Sound Health Care System, Seattle, Washington (Drs Williams, Turner, and Pagulayan); Departments of Rehabilitation Medicine (Drs Williams and Turner) and Psychiatry and Behavioral Sciences (Dr Pagulayan), University of Washington School of Medicine, Seattle.*

This work was supported by VA Merit Review Award #D7217-R to Daniel Storzbach and Elizabeth Twamley from the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Rehabilitation Research and Development. Author Maya O'Neil is currently receiving funding from a Veterans Affairs Health Services Research and Development Center of Innovation grant, Center to Improve Veteran Involvement in Care, Award #CIN 13-404, and an Agency for Healthcare Research and Quality–funded PCOR K12 award to MEO (#1 K12 HS019456 01). For the remaining authors, none were declared. This material is the result of work supported with resources and the use of facilities at the Veterans Affairs Medical Centers in Portland, Oregon, San Diego, California, and Seattle, Washington.

The contents do not represent the views of the U.S. Department of Veterans Affairs or the United States Government.

The corresponding author, Daniel Storzbach, declares that he had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. D. Storzbach and E. Twamley coequally shared first authorship and contributed equally to this work.

The authors declare no conflicts of interest.

Corresponding Author: *Daniel Storzbach, PhD, VA Portland Healthcare System, 3710 SW US Veterans Hospital Rd, Portland, OR 97239 (daniel.storzbach@va.gov).*

DOI: 10.1097/HTR.0000000000000228

related neuropsychiatric comorbidities are of major concern for the Veterans Affairs (VA) and Department of Defense, particularly following the recent conflicts in Afghanistan (Operation Enduring Freedom [OEF]) and Iraq (Operation Iraqi Freedom [OIF]; Operation New Dawn [OND]).[1] A national retrospective study of 164 438 OEF/OIF/OND Veterans who sought care at any VA facility over a 1 year period indicated that 91% of Veterans had been screened for TBI and 21% had screened positive.[2] This is consistent with previously reported rates of TBI in OEF/OIF/OND populations, with most cases reportedly being in the mild range.[3]

Although research from civilian populations suggests that postconcussive symptoms typically resolve within days or months of a single mild TBI (mTBI),[4–7] this literature does not necessarily generalize to OEF/OIF/OND Service members. In general, OEF/OIF/OND Veterans are at an increased likelihood of multiple mTBIs sustained over 1 or more deployments and a different set of preinjury and injury-associated risk factors, as well as postinjury comorbidities. Deployment itself may impact aspects of cognition, with 1 landmark study finding deployment-associated deficits in attention, verbal learning, and visual-spatial memory, even after controlling for the effects of brain injury, stress, and depression.[8] Among combat Veterans with a history of mTBI, rates of self-reported "slowed thinking, difficulty organizing and finishing things," forgetfulness, and concentration problems are common, with 64% to 83% of Veterans endorsing these problems at a moderate to very severe level.[9]

The etiology of these objective and subjective cognitive difficulties remains unclear but is often thought to be multifactorial. In particular, following combat-related mTBI, there is a high incidence of comorbid pain and psychiatric symptoms.[10] Among OEF/OIF/OND Veterans with mTBI who received care within the VA, 73% had comorbid posttraumatic stress disorder (PTSD), 45% had comorbid depression, and 70% had head/back/neck pain.[11] Among OEF/OIF/OND Veterans, history of mTBI (>6 months postinjury), with or without loss of consciousness, is not associated with poorer cognitive outcomes when psychiatric factors such as PTSD and depression are taken into account.[12–15]

Taken together, previous studies demonstrate the complexity of risk factors that may combine to produce subjective cognitive complaints and objective cognitive impairments in OEF/OIF/OND combat Veterans and military personnel. Such findings highlight the need for interventions that effectively address the cognitive symptoms of OEF/OIF/OND Veterans, regardless of the specific etiologies of these problems.[16]

Despite the obvious and growing need for postacute rehabilitation among OEF/OIF/OND Veterans, there are few studies to date that evaluate the efficacy of specific cognitive rehabilitation interventions for combat Veterans with history of mTBI.[17–19] Several systematic reviews on cognitive rehabilitation for mTBI[20–22] indicate that most trials are small or poorly designed. Cognitive rehabilitation research has primarily focused on moderate to severe TBI in civilian populations,[23] but there are no practice standards for treatment of mTBI.

To begin to address this clinical and research gap, we previously designed and piloted a group-based cognitive strategy training treatment for OEF/OIF/OND Veterans with mild severity neurocognitive disorder and a history of combat-related TBI,[17] and Cognitive Symptom Management and Rehabilitation Therapy (CogSMART).[18,19] On the basis of our experience with these pilot studies, we revised the treatment manual, now titled compensatory cognitive training (CCT) for TBI (E. W. Twamley, M. Huckans, S. Tun, et al, unpublished data, 2012). The purpose of the current study was to implement a large-scale, multisite, randomized controlled trial to evaluate the efficacy of CCT for OEF/OIF/OND Veterans with a history of mTBI. Compensatory cognitive training draws from the theoretical literature on compensatory strategy training for other cognitively impaired populations,[24–27] a rehabilitation model that aims to teach individuals strategies that allow them to work around cognitive deficits. Consistent with this model and the previously described expert recommendations for civilians and Service members with TBI,[23,28] manualized group-based CCT treatment provides training in compensatory attention and learning/memory skills, formal problem-solving strategies applied to daily problems, and the use of external aids, such as calendar systems and assistive devices to promote completion of daily tasks.

The present study reports outcomes for group-based CCT treatment. It was hypothesized that, following CCT, participants would report significantly fewer memory and general cognitive difficulties and significantly greater use of compensatory cognitive strategies relative to control participants receiving usual care (UC). In addition, it was hypothesized that, following CCT, participants would show improvement on objective cognitive and functional capacity measures.

METHODS

Participants and procedures

Data were collected from 3 VA medical centers (Portland, Puget Sound, and San Diego) between March 2010 and July 2013. Participants were recruited through clinic referrals at participating VAs, flyers, and medical record review, followed by recruitment letters sent to Veterans who met the requisite prescreening criteria. All participants received compensation for time and travel. Inclusion criteria were (1) OEF/OIF/OND Veterans enrolled at 1 of the participating VA sites who were able to provide informed consent and (2) as part of standard VA clinical care, had screened positive for history of mTBI by a clinician using a standardized interview and positively endorsed any difficulties with attention, memory, decision making, or processing speed (items 13-17 on the Neurobehavioral Symptom Inventory) (NSI)[29] and willingness to participate in audio-recorded sessions. Exclusion criteria included (1) meeting *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition)[30] criteria for primary psychotic disorder or a substance use disorder with less than 30 days of abstinence or (2) having auditory or visual impairments that would prevent meaningful participation in groups or benefit from targeted cognitive strategies.

Following enrollment and baseline assessment, participants were randomized to CCT (n = 50) or UC (n = 69) in cohort groups of 7. Assessors were blind to randomization status, which was revealed by the study statistician after baseline assessments were completed. During their study participation, all participants continued to receive their regular medical, psychiatric, and psychotherapeutic care.

Compensatory cognitive training

Compensatory cognitive training is a manualized, group-based, compensatory cognitive rehabilitation treatment designed to address the symptoms of OEF/OIF/OND Veterans reporting cognitive problems within the context of mTBI history. It is provided in weekly 120-minute group sessions for 10 weeks. All CCT treatment groups were facilitated by master's or doctoral level therapists, usually in pairs.

Each CCT treatment group session consisted of interactive didactic presentations, in-class discussions, and activities that introduced participants to a variety of cognitive strategies, and external aids (see Table 1).

All participants were given a copy of the treatment manual and a calendar or day planner. Participants received extensive graduated training in and practice with their day planners across sessions (ie, introduction to and practice with 1 or 2 elements per week), with a particular focus on how the day planners could facilitate their use of the other compensatory strategies taught in class that week.

Those interested in utilizing the CCT for TBI treatment manual for clinical purposes are encouraged to

TABLE 1 *Summary of compensatory cognitive training curriculum by session*

Session	Major concepts	Examples of strategies taught	Class activities	Home exercise
1	Course intro and TBI psychoeducation	Creating a "home" for important items	Day planner use	Finding a home for the day planner
2	Managing physical symptoms associated with mTBI	Strategies for dealing with sleep problems	Progressive muscle relaxation	Practice progressive muscle relaxation 2 times
3	Organization and prospective memory, part I	Time management	Scheduling	Practice using the calendar
4	Organization and prospective memory, part II	Weekly planning session	Enter it into the calendar	Follow through with planning session
5	Attention and concentration	Paying attention during conversations	Practicing paying attention during conversations	Active listening once a day
6	Learning and memory, part I	Internal memory strategies	Practice chunking	Practice using a strategy everyday
7	Learning and memory, part II	Overlearning	Scheduling strategies in planner	Practice using a strategy everyday
8	Planning and goal setting	Goal setting	Planning out an important goal	Practice planning out a goal
9	Problem-solving and cognitive flexibility	Self-monitoring	6-step problem-solving method	Practice problem-solving with 2 life goals
10	Skill integration and review	Review	How to maintain skills	Provided with additional TBI-related resources

Abbreviations: mTBI, mild traumatic brain injury; TBI, traumatic brain injury.

contact the authors and retrieve the manual at our Web site (www.cogsmart.com); contact the authors for permission to use the manual for research or other nonclinical purposes.

Treatment fidelity monitoring

To ensure treatment fidelity, facilitator training was conducted prior to intervention implementation at all sites. All CCT sessions were audio-recorded, and 20% of sessions were randomly selected throughout the course of the study for adherence to the manual using a CCT fidelity rating scale. The fidelity rating was completed by 1 of the coauthors (MSR), who is also a doctoral-level neuropsychologist. Before rating the study tapes, she underwent one-on-one training with 1 of the principal investigators (DS) and reviewed the treatment manual as well as rated several practice tapes. A minimum interrater reliability of 90% was achieved prior to rater-completing ratings independently. The mean fidelity across rated sessions was 97%, and no sessions were rated below 80%.

Measures

Assessments were administered at baseline, 5 weeks (midway through CCT), 10 weeks (immediately following CCT), and 15 weeks (5-week follow-up). All measures were administered at all time points, with 2 exceptions; the Reading subtest of the Wide-Range Achievement Test-IV was administered only at baseline, and the objective cognitive tests were administered only at baseline and 10 weeks.

1. Self-Reported Cognitive Symptom Severity:
   - *Prospective-Retrospective Memory Questionnaire* (PRMQ)[31–33]: A self-report severity measure of prospective and retrospective memory problems relevant to everyday life. Likert scale 1-5, with 1 = never and 5 = very often.
   - *Multiple Sclerosis Neuropsychological Screening Questionnaire–Patient Version* (MSNQ)[34]: A self-report severity measure of attention and organizational problems. Likert scale 0-4, with 0 = never and 4 = very often.
2. Compensatory Strategy Use:
   - *Memory Compensation Questionnaire* (MCQ).[35,36] The MCQ is a 44-item self-report questionnaire that rates the extent to which patients use various strategies to improve memory performance relevant to daily living. Likert scale 0-4, with 0 = never and 4 = always.
   - *Portland Cognitive Strategies Scale 2.0 (PCSS).* This scale was created specifically for use in this study. This measure includes items rating each of the following: usefulness of the class, internal strategies, external aids, and the frequency with which participants applied strategies/aids to their daily life. Additional items ask participants to rate specific compensatory strategies and aids in terms of the frequency with which they were used and their usefulness; these ratings are then combined into summary scores. Likert scale 0-3, with 0 = never and 3 = daily.
3. Self-Reported Postconcussive Symptom Severity:
   - *The Neurobehavioral Symptom Inventory*[29]: A 22-item postconcussive symptom rating scale widely used within the VA. Likert scale 0-4, with 0 = none and 4 = very severe.
4. Objective Cognitive Performance:
   - *The Wide Range Achievement Test-IV*[37]: Reading subtest that provides an estimate of premorbid general intellectual functioning. A higher score indicates greater premorbid intellectual functioning.
   - *Hopkins Verbal Memory Test–Revised* (HVLT-R)[38]: Verbal list learning (total recall trials 1-3) and delayed recall. A higher score indicates a higher level of performance.
   - *Wechsler Adult Intelligence Scale*–4th Edition, Digit Span Subtest and Digit Symbol Subtest (WAIS-IV)[39]: A measure of attention and working memory and a measure of processing speed, respectively. A higher score indicates a higher level of performance.
   - *Delis-Kaplan Executive Function System, Trails Subtest and Verbal Fluency Subtest*[40,41]: A visual-motor task used to measure flexibility in thinking (executive function) and processing speed, and a measure of verbal fluency, generativity, and processing speed, respectively. A higher score indicates a higher level of performance.
5. Self-Reported Psychiatric Symptom Severity:
   - *PTSD Checklist–Military Version* (PCL-M)[42,43]: A PTSD symptom severity measure based on *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition) diagnostic criteria. A higher score on the scale indicates more severe symptomatology.
   - *Beck Depression Inventory, Second Edition* (BDI-II)[44]: A depression symptom severity measure based on *Diagnostic and Statistical Manual of Mental Disorders* (Fourth Edition) diagnostic criteria. A higher score on the scale indicates more severe symptomatology.
6. Quality of Life:
   - *Satisfaction with Life Scale* (SLS)[45]: A brief measure of global life satisfaction. A higher score indicates greater satisfaction.
7. Adaptive Functioning:
   - *University of California San Diego (UCSD) Performance-Based Skills Assessment, Brief Version* (UPSA-Brief)[46] requires the examinee to

demonstrate financial and communication skills in a series of role-play exercises. Used to assess everyday functioning. A higher score indicates a higher level of performance.

Data analysis

Descriptive statistics were obtained for all variables, as were tests of normality and homogeneity of variance. Data were examined for missing values. Baseline data were analyzed using analysis of variance and χ^2 tests. Hierarchical linear modeling (HLM) with the maximum likelihood method was used to test primary hypotheses across study visits. Data were analyzed from all randomized subjects on whom we have a baseline assessment and at least 1 postbaseline evaluation. Hierarchical linear modeling utilizes all available data without casewise exclusion for a missing data point. The random effect of intercept for individuals was included in all models. Repeated-measures analyses of variance were used to evaluate group differences in objective cognitive performance and functional capacity change from 0 to 10 weeks.

RESULTS

All primary outcomes (PRMQ, MSNQ, NSI, PCSS, MCQ, PCL-M, BDI-II, and SLS) were normally distributed and no variables were transformed. There were no significant differences among sites for age, education, gender, marital status, or baseline measurement of outcomes. There was a significant difference among sites on ethnicity ($\chi^2 = 26.17$, $df = 8$, $P = .001$) where the Portland VA subjects were primarily Caucasian (87%), comparable to the local area ethnicity distribution. There were also no significant differences between treatment groups on age, education, gender, ethnicity, marital status, or any baseline outcome measurements. Table 2 presents demographic data for the CCT and UC groups, and Table 3 presents outcomes by measure for these groups over time. In addition, the CCT group reported the class to be moderately helpful to very helpful (mean satisfaction score = 35.91, SD = 13.42), and 93% of the respondents on CCT class satisfaction survey stated that they would recommend the class to another veteran, while 3% reported maybe and 3% reported "I don't know." Baseline missing data for each of the outcome variables ranged from 0% to 7.2%. Postbaseline missing data increased slightly over time, ranging from 12.1% to 18.2% for week 5, 14.8% to 24.4% for week 10, and 17.7% to 28.3% at week 15.

Hierarchical linear model was used to test hypotheses that, compared with those receiving UC, Veterans receiving CCT would report a significant decrease in self-reported symptoms (PRMQ, MSNQ, NSI, PCL-M, BDI-II, and SLS) and an increase in cognitive strategy usage (MCQ and PCSS) (see Table 4). There was a significant 2-way interaction of time by group for the PRMQ total score, where the CCT group reported significantly fewer memory difficulties relative to controls throughout the study. There was no significant change at week 5 ($t = -1.51$, $P = .135$); however, weeks 10 and 15 were significantly different from baseline ($t = -3.96$, $P < .001$; $t = -3.60$, $P = .001$, respectively), with the strongest effect at week 10. There was a significant 2-way interaction of time by group for MSNQ. Similar to the PRMQ, there was no significant change at week 5 ($t = -0.02$, $P =$ NS) but significantly different means from baseline for weeks 10 and 15 ($t = -2.36$, $P = .021$; $t = -2.67$, $P = .009$, respectively), with the strongest effect at week 10. There was not a significant 2-way interaction between time and group on the MCQ, but there was a significant group by time interaction on the PCSS (report 5-, 10-, 15-week change here). There was no significant group by time interactions on other measures, including the BDI-II, PCL-M, NSI, and SLS. Furthermore, there was no significant effect for cohort or its interaction with the outcomes.

All HLM analyses were repeated including study site as a factor in the model, and none of the 3-way interactions were significant. The 2-way interactions of time by group were significant for the PRMQ, MSNQ, and PCSS (similar to the models without site).

TABLE 2 *Demographic information for treatment groups*

	CCT group ($N = 50$)	UC group ($N = 69$)	F, or χ^{2a}	df^a	P^a
Age, mean years (SD)	35.4 (8.4)	34.8 (7.4)	0.213	1.117	.645
Education, mean years (SD)	13.8 (1.7)	13.7 (2.1)	0.086	1.113	.770
WRAT-4, mean standard score (SD)	97.0 (8.8)	99.7 (8.3)	2.838	1.115	.095
Gender, % men	94%	96%	0.165	1	.684
Ethnic background, % Caucasian	68%	64%	1.954	4	.744
Marital status, % married	48%	49%	0.189	2	.911

Abbreviations: CCT, compensatory cognitive training; UC, control; WRAT, Wide Range Achievement Test.
[a]Results reflect analysis of variance or χ^2 tests across the 2 groups.

TABLE 3 *Self-reported symptoms, cognitive strategies usage, and objective, cognitive, and functional capacity outcomes by treatment group over time, reported as mean (standard deviation)*

	CCT				UC			
	Baseline (*N* = 50)	**Week 5 (*N* = 37)**	**Week 10 (*N* = 36)**	**Week 15 (*N* = 35)**	**Baseline (*N* = 69)**	**Week 5 (*N* = 50)**	**Week 10 (*N* = 51)**	**Week 15 (*N* = 50)**
PRMQ Total	57.2 (8.0)	55.0 (7.5)	49.6 (10.0)	49.8 (8.5)	55.4 (10.5)	55.2 (11.03)	55.2 (11.98)	55.0 (12.3)
MSNQ Total	37.8 (9.1)	37.3 (8.1)	33.6 (9.5)	34.4 (9.7)	37.0 (10.2)	36.4 (9.0)	36.3 (10.2)	37.7 (10.5)
MCQ Total	119.8 (23.5)	115.9 (20.8)	123.1 (26.2)	124.9 (25.8)	118.5 (25.7)	121.7 (23.9)	119.5 (28.3)	120.4 (29.7)
NSI Total	45.0 (16.3)	45.6 (17.4)	40.9 (17.9)	39.6 (17.6)	44.8 (14.5)	44.0 (15.9)	43.5 (17.7)	43.2 (17.6)
PCSS Frequency Total	38.6 (11.8)	46.2 (8.6)	50.4 (6.1)	51.4 (6.4)	40.1 (11.2)	42.3 (10.3)	43.0 (10.3)	44.6 (8.5)
PCL-M Total	57.5 (14.5)	55.7 (16.3)	53.2 (16.4)	53.1 (17.3)	58.9 (14.5)	57.5 (16.1)	57.2 (17.0)	58.7 (16.4)
BDI-II Total	24.9 (12.2)	22.1 (12.7)	20.5 (14.0)	21.1 (15.4)	25.3 (12.6)	25.1 (12.4)	23.7 (14.8)	25.3 (13.4)
SLS Total	16.3 (7.5)	15.8 (7.2)	17.4 (8.5)	16.6 (7.7)	16.7 (7.1)	14.5 (6.4)	17.7 (7.8)	15.6 (7.1)

Abbreviations: BDI-II, Beck Depression Inventory-II; CCT, Compensatory Cognitive Training; MCQ, Memory Compensation Questionnaire; MSNQ, Multiple Sclerosis Neuropsychological Screening Questionnaire—Patient version; NSI, Neurobehavioral Symptom Inventory; PCL-M, PTSD Checklist-Military Version; PCSS, Portland Cognitive Strategies Scale 2.0; PRMQ, Prospective-Retrospective Memory Questionnaire; SLS, Satisfaction with Life Scale; UC, control.

However, the 2-way interaction for time by group was also significant for MCQ ($F_{3,89} = 3.38$, $P = .022$). The interactions for NSI, PCL-M, BDI-II, and SLS were not significant.

Repeated-measures analyses of variance were used to test the hypothesis that, compared with those receiving UC, Veterans receiving CCT would demonstrate improvement on objective measures of neuropsychological performance (WAIS-IV Digit Span, HVLT-R Learning, HVLT-R Memory, D-KEFS Letter Fluency, D-KEFS Trails 4 Switching, D-KEFS Category Fluency Switching, WAIS-IV Digit Symbol Coding) and functional capacity (UPSA-Brief) (see Table 4). There were significant 2-way interactions of time by group on WAIS-IV Digit Span, the HVLT Learning, and D-KEFS Letter Fluency, with Veterans in the CCT group demonstrating a significant increase in scores (ie, improved performance) compared with those in the control condition. There were trends for group by time interaction on the HVLT-R Memory and UPSA-Brief, indicating improvement in the CCT group relative to the UC group that did not reach statistical significance. Interactions were not significant on the D-KEFS Trails 4 Switching, D-KEFS Category Fluency, or WAIS-IV Digit Symbol Coding.

DISCUSSION

The present randomized controlled trial supports the efficacy of group-based CCT treatment for OEF/OIF/OND Veterans with persistent self-reported cognitive complaints associated with a history of mTBI. Compared with those assigned to usual care, Veterans who participated in CCT reported significantly fewer cognitive and memory difficulties and greater use of cognitive strategies. In addition, Veterans who participated in CCT demonstrated significant improvements on neurocognitive tests of attention, learning, and executive functioning, 3 of the cognitive domains targeted in CCT. Overall, these findings indicate that multimodal training in compensatory cognitive strategies facilitates behavioral change (ie, use of cognitive strategies) as well as both subjective and objective improvements in targeted cognitive domains (see Table 5).

In contrast, CCT for TBI was not associated with improvements on processing speed measures or executive tasks that involved switching. This may be because we did not include strategies in the CCT intervention that were specifically designed to improve processing speed or switching. Moreover, we encouraged participants to avoid multitasking as a way to improve attention and task completion in daily life, which is perhaps inconsistent with the requirements of a switching task. There was a nonsignificant trend toward CCT being associated with improvements on the UPSA-Brief, a performance-based measure of everyday functioning that uses

TABLE 4 *Hierarchical linear modeling and RM ANOVA results of compensatory cognitive training for traumatic brain injury compared with control (N = 119)*[a]

HLM results for self-report measures administered at baseline, 5, 10, and 15 wk: group by time interactions	**Test statistic**	***df***	***P***	**Partial η^2, week 10**	**Partial η^2, week 15**
Cognitive symptom severity					
PRMQ Total	$F = 5.71$	3.89	.001	0.142	0.122
MSNQ Total	$F = 4.56$	3.86	.005	0.067	0.091
Self-reported postconcussive symptom severity					
NSI Total	$F = 2.35$	3.90	.078	0.018	0.025
Compensatory strategy use					
MCQ	$F = 2.46$	3.89	.068	0.003	0.001
PCSS	$F = 6.59$	3.91	<.001	0.163	0.134
Psychiatric symptom severity					
BDI-II	$F = 2.03$	3.93	.115	0.035	0.049
PCL-M	$F = 1.84$	3.89	.146	0.021	0.049
Quality of life					
SLS	$F = 1.78$	3.89	.157	0.011	0.059
RM ANOVA results for objective measures administered at baseline and 10 wk				**Partial η^2**	
Neuropsychological performance and functional capacity					
WAIS-IV Digit Span (attention)	$F = 4.31$	1.86	.041	0.048	
Hopkins Verbal Learning Test-R learning (learning)	$F = 4.96$	1.86	.029	0.054	
Hopkins Verbal Learning Test-R delayed recall retention (memory)	$F = 2.85$	1.82	.095	0.034	
D-KEFS Letter Fluency (executive functioning)	$F = 7.07$	1.86	.009	0.076	
D-KEFS Trails 4 Switching (executive functioning)	$F = 0.07$	1.86	.789	0.001	
D-KEFS Category Fluency Switching (executive functioning)	$F = 0.07$	1.80	.795	0.001	
WAIS-IV Digit Symbol Coding (processing speed)	$F = 0.01$	1.86	.946	0.000	
UCSD Performance-based Skills Assessment—Brief	$F = 3.67$	1.93	.059	0.038	

Abbreviations: BDI-II, Beck Depression Inventory-II; D-KEFS, Delis-Kaplan Executive Function System; MCQ, Memory Compensation Questionnaire; MSNQ, Multiple Sclerosis Neuropsychological Screening Questionnaire—Patient version; NSI, Neurobehavioral Symptom Inventory; PCL-M, PTSD Checklist-Military Version; PCSS, Portland Cognitive Strategies Scale 2.0; PRMQ, Prospective-Retrospective Memory Questionnaire; RM ANOVA, Repeated Measures Analysis of Variance; SLS, Satisfaction with Life Scale; UCSD, University of California San Diego; WAIS-IV, Wechsler Adult Intelligence Scale—4th Edition.
[a]Partial η^2 effect sizes: Small >0.01, medium >0.06, large >0.15.

TABLE 5 *Mean objective cognitive outcomes by treatment group over time*

	CCT			**Control**		
	N	**Baseline**	**Week 10**	***N***	**Baseline**	**Week 10**
HVLT-R Total Recall T Score	37	43.0 ± 10	50.6 ± 13	51	42.6 ± 12	44.7 ± 12
HVLT-R Retention T Score	33	42.6 ± 14	48.5 ± 12	51	46.6 ± 13	47.2 ± 12
Digital Span Total Standard Score	37	8.7 ± 3	10.16 ± 3	51	9.96 ± 3	10.3 ± 3
DKEFS Letter Fluency Scaled Score	37	9.96 ± 3	11.46 ± 3	51	10.47 ± 4	10.65 ± 3
Digit Symbol Coding Standard Score	37	8.5 ± 3	9.89 ± 2	51	8.49 ± 3	9.96 ± 8
DKEFS Trails-Condition 4 Scaled Score	37	9.3 ± 3	9.95 ± 3	51	9.84 ± 2	10.35 ± 2
UPSA-Brief Total Score	41	79.71 ± 1	86.83 ± 8	54	83.44 ± 10	86.47 ± 9
DKEFS Category Fluency Total Switching Accuracy Scaled Score	35	11.20 ± 4	11.83 ± 3	47	10.11 ± 4	10.53 ± 3

role-plays to evaluate financial and communication skills; future studies should, therefore, evaluate whether a CCT intervention that is modified to include targeted training in everyday tasks could yield more robust effects in this area. Likewise, although in session 2 the CCT for TBI intervention included brief training in stress reduction techniques to manage physical and psychiatric symptoms common in a TBI population (eg, progressive muscle relaxation), the CCT for TBI intervention was not associated with reduced symptoms on measures of PTSD, depression, or physical symptoms. Future studies should, therefore, evaluate whether a CCT intervention that is modified to include more intensive and targeted treatment of specific comorbidities could provide additional benefit. For example, our group is currently conducting a randomized controlled trial to evaluate the efficacy of "Cognitively Augmented Behavioral Activation for Comorbid TBI and PTSD," a manualized treatment that targets cognitive impairments using CCT techniques, as well as PTSD symptoms using behavioral activation techniques.

These results are consistent with previous literature demonstrating that cognitive strategy training is effective with civilians following single events, such as stroke or moderate to severe TBI,[47,48] Veterans with a history of mild to moderate TBI,[18,19] as well as patients with schizophrenia.[27,49] Similar to previous studies showing that Veterans return from combat with a variety of medical and psychiatric comorbidities, particularly PTSD, that may cause, exacerbate, or otherwise contribute to cognitive impairments,[12,13,15] our sample of OEF/OIF/OND Veterans reported high rates of PTSD. Thus, the present study indicates that CCT is efficacious with a diverse population of Veterans with a history of mTBI and a range of other risk factors that may be contributing to their current cognitive difficulties.

As with all studies, this trial has several important limitations to consider. Because our sample was limited to OEF/OIF/OND Veterans with mTBI, it is unclear whether the CCT for TBI intervention would be more or less efficacious with Veterans with moderate to severe TBI, noncombat Veterans, or non-Veterans. Similar to the OEF/OIF/OND population seeking care at the participating VA sites, our sample was predominantly male, Caucasian, and relatively young; thus, we are unable to evaluate whether results are generalizable to other more diverse populations. Lack of participant blinding, particularly when paired with patient self-reported outcomes, has the potential to bias results. Also, although assessors were blind to the randomization status at baseline, they were unblinded for the follow-up assessments. Future research could address this limitation through comparative effectiveness research utilizing an active treatment control condition and through research designs that allow for preservation of participant and provider blinding to treatment condition.

In summary, our study demonstrates the efficacy of CCT for TBI, a manualized, group-based rehabilitation intervention for OEF/OIF/OND combat Veterans with a history of mTBI and other cognitive risk factors. Group-based rehabilitation interventions are highly attractive options for VA medical centers as they capitalize on limited staff resources and can easily be integrated into the menu of mental health, primary care, or rehabilitation classes that a typical VA medical center already provides. Although additional comparative effectiveness research is warranted to further examine the utility of cognitive rehabilitation for this population, data from this study offer VA Medical Centers a practical, low-cost outpatient treatment option for OEF/OIF/OND Veterans with cognitive impairments.

REFERENCES

1. O'Neil M, Carlson KF, Storzbach D, et al. Factors associated with mild traumatic brain injury in Veterans and military personnel: a systematic review. *J Int Neuropsychol Soc*. 2014;20:249–261.
2. Stroupe KT, Smith BM, Hogan TP, St Andre JR. Healthcare utilization and costs of Veterans screened and assessed for traumatic brain injury. *J Rehabil Res Dev*. 2013;50:1047–1068.
3. Tanielian T, Jaycox LH, eds. *Invisible Wounds of War: Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery*. Santa Monica, CA: RAND Corporation; 2008.
4. Belanger HG, Vanderploeg RD. The neuropsychological impact of sports-related concussion: a meta-analysis. *J Int Neuropsychol Soc*. 2005;11:345–357.
5. Iverson GL. Outcome from mild traumatic brain injury. *Curr Opin Psychiatry*. 2005;18:301–317.
6. Karr JE, Areshenkoff CN, Garcia-Barrera, MA. The neuropsychological outcomes of concussion: a systematic review of meta-analyses on the cognitive sequelae of mild traumatic brain injury [published online ahead of print November 11, 2013]. *Neuropsychology*. 2014;28(3):321–336. doi:10.1037/neu0000037.
7. Schretlen DJ, Shapiro AM. A quantitative review of the effects of traumatic brain injury on cognitive functioning. *Int Rev Psychiatry*. 2003;15:341–349.
8. Vasterling JJ, Proctor SP, Amoroso P, Kane R, Heeren T, White RF. Neuropsychological outcomes of army personnel following deployment to the Iraq war. *JAMA*. 2006;296:519–529.
9. Scholten JD, Sayer NA, Vanderploeg RD, Bidelspach DE, Cifu DX. Analysis of US Veterans Health Administration comprehensive evaluations for traumatic brain injury in Operation Enduring Freedom and Operation Iraqi Freedom Veterans. *Brain Inj*. 2012;26:1177–1184.
10. Lew HL, Otis JD, Tun C, Kerns RD, Clark ME, Cifu DX. Prevalence of chronic pain, posttraumatic stress disorder, and persistent postconcussive symptoms in OIF/OEF Veterans: polytrauma clinical triad. *J Rehabil Res Dev*. 2009;46:697–702.
11. Taylor BC, Hagel EM, Carlson KF, et al. Prevalence and costs of co-occurring traumatic brain injury with and without psychiatric disturbance and pain among Afghanistan and Iraq War Veteran V.A. users. *Med Care*. 2012;50:342–346.

12. Nelson NW, Hoelzle JB, Doane BM, et al. Neuropsychological outcomes of U.S. Veterans with report of remote blast-related concussion and current psychopathology. *J Int Neuropsychol Soc.* 2012;18:845–855.
13. Shandera-Ochsner AL, Berry DT, Harp JP, et al. Neuropsychological effects of self-reported deployment-related mild TBI and current PTSD in OIF/OEF Veterans. *Clin Neuropsychol.* 2013;27:881–907.
14. Verfaellie M, Lafleche G, Spiro A, Bousquet K. Neuropsychological outcomes in OEF/OIF/OND Veterans with self-report of blast exposure: associations with mental health, but not mTBI [published online ahead of print November 18, 2013]. *Neuropsychology.* 2014;28():337–346. doi:10.1037/neu0000027.
15. Hoge CW, McGurk D, Thomas JL, Cox AL, Engel CC, Castro CA. Mild traumatic brain injury in U.S. Soldiers returning from Iraq. *N Engl J Med.* 2008;358:453–463.
16. Brenner LA, Vanderploeg RD, Terrio H. Assessment and diagnosis of mild traumatic brain injury, posttraumatic stress, and other polytrauma conditions: burden of adversity hypothesis. *Rehabil Psychol.* 2009;54:239–246.
17. Huckans M, Pavawalla S, Demadura T, et al. A pilot study examining effects of group-based Cognitive Strategy Training treatment on self-reported cognitive problems, psychiatric symptoms, functioning, and compensatory strategy use in OIF/OEF combat Veterans with persistent mild cognitive disorder and history of traumatic brain injury. *J Rehabil Res Dev.* 2010;47:43–60.
18. Twamley EW, Jak AJ, Delis DC, Bondi MW, Lohr JB. Cognitive Symptom Management and Rehabilitation Therapy (CogSMART) for Veterans with traumatic brain injury: pilot randomized controlled trial. *J Rehabil Res Dev.* 2014;51:59–70.
19. Twamley EW, Thomas KR, Gregory AM, et al. CogSMART compensatory cognitive training for traumatic brain injury: effects over 1 year. *J Head Trauma Rehabil.* 2015;30(6):391-401. doi:10.1097/HTR.0000000000000076.
20. Borg J, Holm L, Peloso PM, et al. Nonsurgical intervention and cost for mild traumatic brain injury: results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. *J Rehabil Med.* 2004;43(suppl):76–83.
21. Comper P, Bisschop SM, Carnide N, Tricco A. A systematic review of treatments for mild traumatic brain injury. *Brain Inj.* 2005;19:863–880.
22. Snell DL, Surgenor LJ, Hay-Smith EJ, Siegert RJ. A systematic review of psychological treatments for mild traumatic brain injury: an update on the evidence. *J Clin Exp Neuropsychol.* 2009;31(1):20–38.
23. Cicerone KD, Langenbahn DM, Braden C, et al. Evidence-based cognitive rehabilitation: updated review of the literature from 2003 through 2008. *Arch Phys Med Rehabil.* 2011;92:519–530.
24. Huckans M, Hutson L, Twamley E, Jak A, Kaye J, Storzbach D. Efficacy of cognitive rehabilitation therapies for mild cognitive impairment (MCI) in older adults: working toward a theoretical model and evidence-based interventions. *Neuropsychol Rev.* 2013;23:63–80.
25. McGurk SR, Twamley EW, Sitzer DI, McHugo GJ, Mueser KT. A meta-analysis of cognitive remediation in schizophrenia. *Am J Psychiatry.* 2007;164:1791–1802.
26. Sohlberg MM, Ehlhardt L, Kennedy M. Instructional techniques in cognitive rehabilitation: a preliminary report. *Semin Speech Lang.* 2005;26;268–279.
27. Twamley EW, Vella L, Burton CZ, Heaton RK, Jeste DV. Compensatory cognitive training for psychosis: effects in a randomized controlled trial. *J Clin Psychiatry.* 2012;73:1212–1219.
28. Helmick K, Members of Consensus C. Cognitive rehabilitation for military personnel with mild traumatic brain injury and chronic postconcussional disorder: results of April 2009 consensus conference. *NeuroRehabilitation.* 2010;26:239–255.
29. Cicerone KD, Kalmar K. Persistent postconcussion syndrome: the structure of subjective complaints after mild traumatic brain injury. *J Head Trauma Rehabil.* 1995;10:1–17.
30. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 4th rev ed. Washington, DC: American Psychiatric Association; 2000.
31. Crawford JR, Henry JD, Ward AL, Blake J. The Prospective and Retrospective Memory Questionnaire (PRMQ): latent structure, normative data and discrepancy analysis for proxy-rating. *Br J Clin Psychol.* 2006;45:83–104.
32. Crawford JR, Smith G, Maylor EA, Della Sala S, Logie RH. The Prospective and Retrospective Memory Questionnaire (PRMQ): normative data and latent structure in a large nonclinical sample. *Memory.* 2003;11:261–275.
33. Smith G, Della Sala S, Logia RH. Prospective and retrospective memory in normal aging and dementia. *Memory.* 2000;8:311–321.
34. Benedict RH, Munschauer F, Linn R, et al. Screening for multiple sclerosis cognitive impairment using a self-administered 15-item questionnaire. *Multiple Sclerosis (Houndmills, Basingstoke, England).* 2003;9:95–101.
35. de Frias CM, Dixon RA. Confirmatory factor structure and measurement invariance of the memory compensation questionnaire. *Psychol Assess.* 2005;17:168–178.
36. Dixon RA, de Frias CM, Bäckman L. Characteristics of self-reported memory compensation in older adults. *J Clin Exp Neuropsychol.* 2001;23:650–661.
37. Wilkinson GS, Robertson GJ. *WRAT-4: Wide Range Achievement Test Professional Manual*. Lutz, FL: Psychological Assessment Resources, Inc.; 2006.
38. Shapiro AM, Benedict RH, Schretlen D, Brandt J. Construct and concurrent validity of the Hopkins Verbal Learning Test-revised. *Clin Neuropsychol.* 1999;13:348–358.
39. Wechsler D. *Wechsler Adult Intelligence Scale–Fourth Edition*. San Antonio, TX: Pearson; 2008.
40. Delis DC, Kaplan E, Kramer JH. *Delis-Kaplan Executive Function System Manual*. San Antonio, TX: The Psychological Corporation, a Harcourt Assessment Company; 2001.
41. Delis DC, Kramer JH, Kaplan E, Holdnack J. Reliability and validity of the Delis-Kaplan executive function system: an update. *J Int Neuropsychol Soc.* 2004;10:301–303.
42. Blanchard EB, Jones-Alexander J, Buckley TC, Forneris CA. Psychometric properties of the PTSD checklist. *Behav Res Ther.* 1996;34:669–673.
43. Weathers FW, Litz BT, Herman DS, Huska JA, Keane TM. The PTSD checklist: reliability, validity, and diagnostic utility. Paper presented at: 9th Annual Meeting of the International Society for Traumatic Stress Studies; 1994; San Antonio, TX.
44. Beck AT, Steer RA, Brown GK. *Manual for the BDI-II*. San Antonio, TX: The Psychological Corporation; 1996.
45. Diener E, Emmons RA, Larsen RJ, Griffin S. The satisfaction with life scale. *J Pers Assess.* 1985;49:71–75.
46. Mausbach BT, Harvey PD, Goldman SR, Jeste DV, Patterson TL. Development of a brief scale of everyday functioning in persons with serious mental illness. *Schizophrenia Bull.* 2007;33:1364–1372.
47. Cappa SF, Benke T, Clarke S, Rossi B, Stemmer B, van Heugten CM. EFNS guidelines on cognitive rehabilitation: report of an EFNS task force. *Eur J Neurol.* 2005;12:665–680.
48. Cicerone KD, Dahlberg C, Malec JF, et al. Evidence-based cognitive rehabilitation: updated review of the literature from 1998 through 2002. *Arch Phys Med Rehabil.* 2005;86:1681–1692.
49. Wykes T, Spaulding WD. Thinking about the future cognitive remediation therapy–what works and could we do better? *Schizophr Bull.* 2011;37(suppl 2):S80–S90.