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Authors
Twamley, EW
Thomas, KR
Gregory, AM
et al.

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CogSMART Compensatory Cognitive Training for Traumatic Brain Injury: Effects Over 1 Year

Elizabeth W. Twamley, PhD; Kelsey R. Thomas, MS; Amber M. Gregory, BA; Amy J. Jak, PhD; Mark W. Bondi, PhD; Dean C. Delis, PhD; James B. Lohr, MD

Objective: There are very few evidence-based treatments for individuals with mild to moderate traumatic brain injuries. We developed and tested a 12-week, manualized, compensatory cognitive training intervention, Cognitive Symptom Management and Rehabilitation Therapy (CogSMART), which targeted postconcussive symptom management, prospective memory, attention, learning/memory, and executive functioning. The intervention focused on psychoeducation and compensatory strategies such as calendar use, self-talk, note taking, and a 6-step problem-solving method. **Setting:** VA Healthcare System. **Participants:** A total of 50 Veterans with mild to moderate traumatic brain injuries receiving supported employment. **Design:** Twelve-month randomized controlled trial with participants assigned to receive CogSMART or additional supported employment sessions for the first 12 weeks. Outcome assessments were administered at baseline and 3, 6, and 12 months. **Main Measures:** Assessments measured postconcussive symptoms, neuropsychological performance, functional capacity, psychiatric symptom severity, quality of life, and weeks worked during the 12-month trial. **Results:** Hierarchical linear modeling analyses using all 4 time points demonstrated significant CogSMART-associated reductions in postconcussive symptoms ($r = -0.28$, $P = .026$, $d = 0.64$) and improvements in prospective memory ($r = 0.35$, $P = .031$, $d = 0.55$) and quality of life ($r = 0.34$, $P = .009$, $d = 1.0$). The groups did not differ on weeks worked during the trial. **Conclusion:** CogSMART has the potential to improve postconcussive symptoms, cognitive performance, and self-rated quality of life in individuals with mild to moderate traumatic brain injuries. **Key words:** *brain injury*, *cognitive rehabilitation*, *depression*, *employment*, *posttraumatic stress disorder*, *rehabilitation*, *unemployment*

TRAUMATIC BRAIN INJURY (TBI) is the hallmark injury among Veterans of Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn (OEF/OIF/OND),[1] with mild TBI occurring in approximately 20% of OEF/OIF/OND Veterans.[2,3] About 7% of this cohort of returning Veterans report persistent postconcussive symptoms.[4] Among civilians, too, TBIs are common and most TBIs are mild,[5] with about 10% of those with mild TBI report persistent postconcussive symptoms.[6,7] Although controversial, mild TBI has long been thought to have only a short-term effect on neuropsychological functioning,[8–11] and studies of individuals sustaining sports-related concussions show that most cognitive and postconcussive symptoms resolve within days to 3 months.[12] However, those with traumatic injuries take longer to return to their preinjury functioning,[13] and comorbid psychiatric disorders can contribute to both neuropsychological and functional impairment in those with mild TBI.[14] A relatively large number of both civilians and Veterans report persistent postconcussive symptoms, and many additionally demonstrate neuropsychological impairments in the context of valid assessment,[15] sometimes beyond several months.[8,16] These impairments can hinder functional recovery, including cognitive readiness for work, school, and independent living.[17,18] Thus, treatments for

***Author Affiliations:** Center of Excellence for Stress and Mental Health, VA San Diego Healthcare System, San Diego, California (Drs Twamley, Jak, Delis, and Lohr); Department of Psychiatry, University of California, San Diego, La Jolla, California (Drs Twamley, Jak, Bondi, and Lohr); Department of Clinical and Health Psychology, University of Florida, Gainesville (Ms Thomas); Department of Psychology, The University of Alabama at Birmingham, Birmingham (Ms Gregory); Psychology Service, VA San Diego Healthcare System, San Diego, California (Drs Jak and Bondi).*

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***Corresponding Author:** Elizabeth W. Twamley, PhD, Neuropsychology Unit, Center of Excellence for Stress and Mental Health (CESAMH), VA San Diego Healthcare System, 3350 La Jolla Village Dr (116A), San Diego, CA 92161 (etwamley@ucsd.edu).*

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individuals with mild to moderate TBI and persistent cognitive and postconcussive symptoms are urgently needed. Although there have been numerous studies of cognitive rehabilitation in severe TBI,[19,20] there has been scant research on rehabilitation for those with mild to moderate TBI.[21]

Individuals with mild to moderate TBI may exhibit impairments in multiple neuropsychological domains, including concentration, learning and memory, prospective memory (remembering to do things in the future), and problem-solving.[7,16,22–24] Any of these cognitive impairments can limit functional recovery, including return to work and school.[25,26] Furthermore, comorbidities such as posttraumatic stress disorder (PTSD; comorbid in 73% of Veterans with TBI), depression (comorbid in 47%), and chronic pain (comorbid in 72%)[4] can contribute to neuropsychological impairments.[7,27,28] The evidence base in cognitive rehabilitation for individuals with mild to moderate TBIs is limited[29]; the Department of Veterans Affairs (VA) and Department of Defense guidelines for treating mild TBI make no recommendations regarding compensatory cognitive training or compensatory aids, focusing instead on psychoeducation and vocational rehabilitation.[30]

We developed and evaluated a 12-week, compensatory cognitive training intervention focusing on habit learning and compensatory strategies in prospective memory, attention, learning/memory, and executive functioning. Our manualized treatment, Cognitive Symptom Management and Rehabilitation Therapy (CogSMART), was based on our reviews of prior cognitive training studies in schizophrenia and Alzheimer disease[31–33] and consultation with the Acquired Brain Injury program at Mesa College in San Diego and other experts in cognitive training. Consistent with the VA/Department of Defense (DoD) Clinical Practice Guideline,[30] we emphasized psychoeducation regarding TBI and included postconcussive symptom management strategies targeting sleep disturbance, fatigue, headaches, and tension. The CogSMART intervention was designed to be portable, practical, and deliverable without extensive training. We previously tested the compensatory cognitive strategies in participants with severe mental illness and found positive effects on cognition, psychiatric symptoms, functional capacity, and quality of life.[34] Table 1 provides a listing of the CogSMART modules and sample strategies taught. The manual is available to the public free of charge at www.cogsmart.com. We tailored the CogSMART manual to those with mild to moderate TBI because they represent the vast majority of OEF/OIF/OND Veterans with TBI (82% mild, 8% moderate, only 2.5% severe, and remaining 7% unclassifiable). Furthermore, those with mild to moderate brain injury are more likely to return to competitive work, which was the focus of our combined treatment.

Meta-analytic results from the psychiatric literature suggest that cognitive rehabilitation yields better outcomes when it is provided in the context of a broader psychosocial rehabilitation program,[32,35] and the VA/DoD Clinical Practice Guideline explicitly encourages interventions to promote community integration.[30] Furthermore, because cognitive abilities among clients with TBI predict functional skills and ability to work,[17,36,37] supported employment programs for individuals with TBI have successfully implemented compensatory cognitive strategies.[38] For these reasons, we evaluated CogSMART within the context of a supported employment program for Veterans with TBI. In this pilot randomized controlled trial, all participants received supported employment for 1 year. Participants were randomized to receive CogSMART, provided by their supported employment specialist (SE-Cog), or additional supported employment sessions (enhanced supported employment; ESE) for the first 3 months of the year-long study. We hypothesized that, compared with ESE participants, those who received supported employment plus CogSMART would report reduced postconcussive symptom severity (primary outcome) and would exhibit improvements in cognitive performance and functional capacity.

METHODS

Participants

Fifty Veterans at the VA San Diego Healthcare System participated in the study after providing written informed consent. All participants were OEF/OIF Veterans with a history of mild to moderate TBI (loss of consciousness for <24 hours; posttraumatic amnesia for <7 days)[30] documented in a prior clinical neuropsychological evaluation and confirmed by a structured interview. They were required to have documented impairment (>1 SD below normative reference means) in at least 1 neuropsychological domain (ie, attention, processing speed, working memory, learning, memory, executive functioning) in the context of valid clinical neuropsychological testing by a VA or DoD neuropsychologist using at least 1 performance validity measure (eg, Test of Memory Malingering, California Verbal Learning Test-II Forced Choice). Finally, all participants were unemployed but wanted to return to work. Those who were currently abusing alcohol or substances or who were participating in other intervention studies were excluded.

On average, the 50 participants were 32 years of age, had 13 years of education, 96% were men, 64% were members of a racial or ethnic minority group, and 74% met criteria for threshold PTSD.[15] The median length of loss of consciousness for the worst TBI was 1.25 minutes;

TABLE 1 *CogSMART modules and sample strategies*

Module	Compensatory strategies and habits taught in CogSMART
Postconcussive Symptoms	1. Psychoeducation regarding the natural course of postconcussive symptoms 2. Appropriate pacing, use of routines, lifestyle strategies 3. Stress reduction (eg, progressive muscle relaxation, abdominal breathing, mindfulness, visualization, grounding) 4. Sleep hygiene education, headache management, and education regarding depression, anxiety, and PTSD
Prospective Memory	1. Daily calendar use 2. To-do lists and prioritizing tasks 3. Linking tasks; using "can't miss reminders" to cue tasks
Attention and Vigilance	1. Conversational vigilance skills (reduce distractions, eye contact, paraphrasing, and asking questions) 2. Task vigilance skills (paraphrase instructions, use self-talk during tasks to maintain focus)
Learning and Memory	1. Encoding strategies (write things down, paraphrasing/ repetition, association, chunking, categorizing, acronyms, rhymes, visual imagery, name-learning strategies) 2. Retrieval strategies (systematic searching) and organizational strategies for general learning and memory
Executive Functioning	1. Six-step problem-solving method (define problem, brainstorm solutions, evaluate solutions, select a solution, try it, evaluate how it worked) 2. Self-talk while solving problems 3. Hypothesis testing and self-monitoring

Abbreviations: CogSMART, Cognitive Symptom Management and Rehabilitation Therapy; PTSD, posttraumatic stress disorder.

the median length of total losses of consciousness summed across up to 4 TBIs was 2 minutes. On average, the time since the most recent TBI was more than 4 years. Sample characteristics by group are presented in Table 2. The SE-Cog and ESE groups differed in age ($P = .042$) and education ($P = .014$) but did not differ on race, ethnicity, gender, postconcussive symptom severity, or psychiatric symptom severity, nor did they differ on any TBI-related variables or neuropsychological variables (see Table 2). Four participants from each group dropped out of the study; 2 participants decided not to pursue work, 1 moved, and 5 were lost to follow up. The 8 participants who dropped out did not differ significantly from participants who were retained ($n = 42$) in age, years of education, minority status, neuropsychological functioning, postconcussive symptom severity, or psychiatric symptom severity (all Ps > .05). See Figure 1 for the CONSORT diagram of participant flow.

Procedure

Participants were referred by the VA San Diego Healthcare System Wellness and Vocational Enrichment Clinic, TBI Cognitive Rehabilitation Clinic, Polytrauma Clinic, and Neuropsychological Assessment Unit. Participants were compensated $20 per assessment session but were not paid to participate in treatment. Following baseline assessment, participants were randomized to receive SE-Cog or ESE for 1 year; therefore, all worked toward a goal of competitive employment during the 1-year study. One employment specialist delivered CogSMART for 1 hour per week in addition to the standard 1-hour supported employment visit, for a total of 2 visits per week, and another employment specialist delivered ESE (2 visits per week) to control for the nonspecific therapeutic factors provided in CogSMART. CogSMART and ESE were provided during the first 12 weeks of supported employment so that time and contact with the employment specialist were equivalent across groups (for further details, see reference Twamley et al).[39]

Measures

Measures were administered at baseline, 3 months (ie, following completion of the CogSMART or ESE portion of the study), 6 months, and 12 months. All tests were administered according to standardized procedures by a research assistant trained to a high level of interrater reliability (ie, rs > 0.90). The research assistant was not aware of participant randomization status at the baseline assessment but was aware of treatment group for subsequent assessments.

TABLE 2 *Sample characteristics and differences between study groups at baseline assessment*

Characteristic	Supported employment plus CogSMART (*n* = 25) Mean (SD), median, or %	Enhanced supported employment (*n* = 25) Mean (SD), median, or %	*t*, Mann-Whitney *U*, or χ^2	*df*	*P*
Age, y	29.68 (6.05)	33.84 (7.89)	2.09	48	.042
Education, y	12.88 (1.27)	14.00 (1.80)	2.54	48	.014
Gender, % male	96	96	0.00	1	1.00
Race, % White	24	48	3.13	1	.077
Ethnicity, % Hispanic/Latino	36	36	0.00	1	1.00
Length of LOC, worst TBI, minutes	3 (0-420)	1 (0-1440)	268.50	. . .	.386
Length of total LOC across ≤4 TBIs	6 (0-420)	1 (0-1440)	257.00	. . .	.274
Time since worst TBI, y	4.68 (3.04)	6.00 (4.89)	1.15	48	.257
Time since most recent TBI, years	4.08 (2.78)	5.04 (4.61)	0.89	48	.377
Length of unemployment, days	332.92 (330.00)	346.76 (381.05)	0.14	48	.891
Neurobehavioral Symptom Inventory	43.00 (16.08)	38.68 (13.88)	1.02	48	.314
Clinician-Administered PTSD Scale	65.88 (25.31)	58.50 (27.52)	0.99	48	.329
Hamilton Depression Rating Scale	16.44 (5.90)	14.48 (7.05)	1.07	48	.292
Quality of Life Interview mean satisfaction rating	4.68 (1.41)	4.12 (1.42)	1.40	48	.168
Premorbid IQ estimate (WRAT-III Reading)	96.28 (8.06)	98.24 (10.78)	0.73	48	.470
MIST summary score	32.16 (9.93)	33.68 (9.59)	0.55	48	.585
MIST 24-h probe	0.28 (0.61)	0.64 (0.91)	1.64	42.16[a]	.108
CVLT-II Trials 1-5 learning T-score	43.08 (12.93)	41.96 (9.85)	0.35	48	.732
CVLT-II Long-Delay Free Recall *Z*-score	− 1.10 (1.25)	− 0.90 (1.16)	0.59	48	.561
WAIS-III Digit Span scaled score	8.60 (1.96)	9.52 (3.53)	1.114	37.52[a]	.261
D-KEFS letter fluency scaled score	9.36 (2.81)	9.04 (3.22)	0.37	48	.710
D-KEFS category fluency scaled score	8.76 (2.96)	8.12 (3.98)	0.65	48	.522
D-KEFS category switching scaled score	8.36 (3.07)	7.68 (3.02)	0.79	48	.434
WCST-64 perseverative errors T-score	45.88 (6.44)	42.64 (10.44)	1.32	39.94[a]	.194
UPSA total score	83.00 (10.57)	78.57 (10.13)	1.15	48	.137

Abbreviations: CogSMART indicates Cognitive Symptom Management and Rehabilitation Therapy; CVLT-II, California Verbal Learning Test-2nd Edition; D-KEFS, Delis-Kaplan Executive Function System; LOC, loss of consciousness; MIST, Memory for Intentions Screening Test; PTSD, posttraumatic stress disorder; TBI, traumatic brain injury; UPSA, UCSD Performance-Based Skills Assessment; WAIS-III, Wechsler Adult Intelligence Scale—3rd Edition; WCST-64, Wisconsin Card Sorting Test-64 card version; WRAT-III, Wide Range Achievement Test—3rd Edition.

[a]Degree of freedom adjusted because of unequal variances between groups.

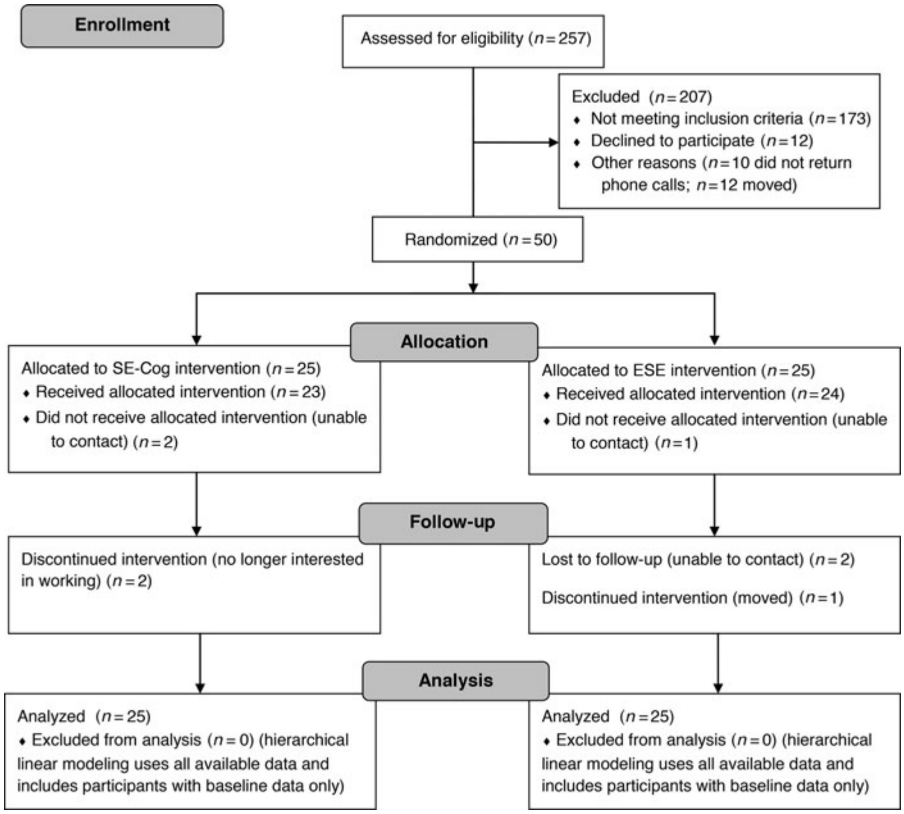

Figure 1. CONSORT diagram. ESE indicates enhanced supported employment; SE-Cog, Supported Employment + CogSMART.

Measures of cognitive functioning were selected to thoroughly characterize the sample and assess change in the 4 targeted CogSMART cognitive domains (prospective memory, attention, learning and memory, and executive functioning), as follows:

1. Premorbid IQ: Wide Range Achievement Test–3rd Edition (WRAT-3) Reading test (administered at baseline only; the age-corrected standard score is reported).[40]
2. Prospective memory: Memory for Intentions Screening Test (MIST).[41] This 30-minute test requires examinees to perform directed actions at certain times or in response to specific event cues. The MIST summary score measures short-term prospective memory ability during the 30-minute test, and the 24-hour probe score reflects long-term prospective memory ability over a 24-hour period (examinees are asked to call the examiner 24 hours following the test to report how they slept).
3. Attention and working memory: Wechsler Adult Intelligence Scale–3rd Edition (WAIS-III) Digit Span age-corrected scaled score.[42] This test requires the examinee to repeat strings of digits in both forward and backward order.
4. Verbal learning and memory: California Verbal Learning Test-II (CVLT-II).[43] The trials 1-5 T-score was used as an index of verbal learning (acquisition of words over 5 learning trials). The long-delay free recall Z-score was used to measure memory following a 20-minute delay. Both scores are corrected for age and gender.
5. Executive functioning: Delis-Kaplan Executive Function System (D-KEFS) Verbal Fluency test age-corrected scaled scores.[44] This task requires examinees to generate words beginning with a given letter (letter fluency), belonging to a given category (category fluency), and to switch between words from 2 different categories (category switching). The 64-card Wisconsin Card Sorting Test (WCST) perseverative errors T-score was used as a measure of cognitive flexibility.[45]

Postconcussive symptom severity was measured with the Neurobehavioral Symptom Inventory,[28] which measures severity of self-reported postconcussive symptoms on a 0 to 4 scale ranging from "none" to "very severe." There are 12 physical symptoms (eg, dizziness, headaches, nausea, light and sound sensitivity), 4 cognitive symptoms (eg, problems with concentration, memory, decision-making, slowed thinking), and 6 emotional symptoms (eg, fatigue, sleep disturbance, anxiety, depression, irritability). The total score was used as the primary outcome. Posttraumatic stress disorder symptom severity was measured with the Clinician-Administered PTSD Scale[46] to determine PTSD diagnosis and measure symptom severity. Depressive symptom severity was measured with the 17-item Hamilton Depression Rating Scale.[47] The Quality of Life Interview-Brief Version[48] assessed subjective judgment of global quality of life, rated by the participants on a 1 to 7 scale ranging from "terrible" to "delighted." Data regarding job attainment, hours worked, and wages earned were collected weekly.

Data analyses

Previous analyses of our 3-month outcomes have been published.[39] This is the first report to include the 6-month or 12-month outcomes. The hierarchical linear modeling (HLM) method used in this report uses all available data points, so this report includes some individuals who were missing 3-month data but had 6- or 12-month data and were, therefore, not included in the previously published analyses. The focus of the current report is on outcomes over the entire year of the study and also includes work outcomes such as weeks worked and wages earned, which were not included in the previously published study. Given the new data points and new outcomes in these analyses, along with the small sample size and pilot nature of the study, we elected not to use an α correction.

Prior to the analyses, data were examined for normality. The loss of consciousness variables were not normally distributed, so medians were used to characterize the sample. Group differences in work outcomes were analyzed using χ^2 analyses and analyses of variance controlling for age and education.

Hierarchical linear modeling was used to answer the study questions related to cognitive and self-reported outcomes. Hierarchical linear modeling allowed for all available data (ie, full information maximum likelihood with available cases) to be utilized without casewise exclusion for a missing data point.[49,50] These models were estimated using the maximum likelihood method under the simplest assumptions of diagonal random error structure and repeated error structure over time.

For the HLMs, prior to analyses, the raw scores were transformed into a standardized metric, so the resulting effect estimates are comparable. The random effect of intercept for individuals was included in all models. At baseline, the age and education of the 2 groups were statistically different. Therefore, age and education were included as covariates in the HLM analyses. Visit, which included 4 time points, was modeled as a continuous parameter. The level 1 parameters were group (ESE and SE-Cog, with SE-Cog as the reference category), age, education, and visit; the level 2 parameter was individuals. For all significant parameters and outcomes, effect sizes are reported as r values (small = 0.10; medium = 0.30; large = 0.50).[51]

Cohen d effect sizes of the group differences (SE-Cog vs ESE) in change scores from baseline to each of the follow-up visits (3-, 6-, and 12-month) were also calculated, separately from the HLMs, to show the magnitude of the group differences in each measure at each visit (small = 0.20; medium = 0.50; large = 0.80).[51] Because these effect sizes were determined using change scores, missing follow-up data and not controlling for age and education may account for the occasional differences between this method (to calculate Cohen ds) and the results found using HLM. Results from both methods are presented later.

RESULTS

Table 3 presents all model parameter estimates, test statistics, and effect sizes for the HLM outcome measures. Figure 2 provides graphs of the outcomes that had significant group by visit interactions. Table 4 shows the Cohen d effect size for the group differences in change scores from baseline to 3-, 6-, and 12-month follow-ups. The significant findings related to our hypotheses are discussed below, but all data are included in the tables.

Treatment effects on subjective outcomes

The Neurobehavioral Symptom Inventory total score had a significant visit by group interaction in which the SE-Cog group had reduced postconcussive symptoms relative to the ESE group ($r = -0.28$, $t[1, 62.08] = -2.29$, $P = .026$). This effect was strongest at 3 months ($d = 0.98$) but remained strong at 6 ($d = 0.69$) and 12 months ($d = 0.64$). We then examined the visit by group interactions on the Neurobehavioral Symptom Inventory Affective, Cognitive, and Somatic subscales identified by Caplan et al.[52] There was a significant visit by group interaction on the Affective subscale ($r = -0.21$, $t[1, 55.70] = -3.00$, $P = .005$) and a trend toward significance on the Cognitive subscale ($r = -0.12$, $t[1, 66.26] = -1.67$, $P = .099$) but no effect on the Somatic subscale ($r = -0.06$, $t[1, 60.96] = -0.86$, $P = .392$). There was a significant visit by group interaction for Quality of Life Interview-Brief Mean Satisfaction Scale ($r = 0.34$, $t[1, 56.47] = 2.69$, $P = .009$) such that the SE-Cog participants' quality of life improved significantly more than the ESE participants following the intervention. This effect was strongest at 3 months ($d = 0.48$) and 12 months ($d = 1.0$).

Treatment effects on cognitive outcomes

For the MIST Summary score outcome, there was a significant visit by group interaction ($r = 0.35$, $t[1, 35.49] = 2.25$, $P = .031$) such that the SE-Cog group improved

TABLE 3 *Hierarchical linear models*[a]

	MIST summary score						MIST 24-h probe					
	β	SE	*df*	*t*	*P*	*r*	*β*	SE	*df*	*t*	*P*	*r*
Intercept	.09	0.11	32.44	0.90	.376	0.16	–.03	0.08	133.75	–0.40	.691	–0.03
Age	–.26	0.11	31.52	–2.32	**.027**	–0.38	.14	0.08	114.66	1.75	.083[b]	0.16
Education	.11	0.11	29.91	0.96	.343	0.17	.11	0.08	116.35	1.41	.161	0.13
Group (SE-Cog)	–.01	0.12	34.09	–0.13	.899	–0.02	.13	0.09	133.81	1.49	.138	0.13
Visit	–.00	0.06	35.43	–0.05	.960	–0.01	–.11	0.07	63.46	–1.58	.118	–0.19
Group × Visit	.14	0.06	35.49	2.25	**.031**	0.35	.12	0.07	63.55	1.71	.093[b]	0.21
	CVLT-II trials 1-5 immediate						**CVLT-II long-delay free recall**					
	β	SE	*df*	*t*	*P*	*r*	*β*	SE	*df*	*t*	*P*	*r*
Intercept	.07	0.12	49.05	0.54	.589	0.08	.05	0.12	49.17	0.38	.709	0.05
Age	–.31	0.13	45.70	–2.34	**.024**	–0.33	–.32	0.13	46.49	–2.45	**.018**	–0.34
Education	.12	0.13	45.53	0.88	.382	0.13	.06	0.13	46.39	0.46	.649	0.07
Group (SE-Cog)	–.02	0.14	48.81	–0.16	.877	–0.02	–.04	0.13	49.06	–0.33	.746	–0.05
Visit	.22	0.06	40.20	3.73	**.001**	0.51	.27	0.06	45.44	4.86	**<.001**	0.58
Group × Visit	–.08	0.06	40.30	–1.34	.189	–0.21	.03	0.06	45.55	0.62	.542	0.09
	WAIS-III digit span						**D-KEFS letter fluency**					
	β	SE	*df*	*t*	*P*	*r*	*β*	SE	*df*	*t*	*P*	*r*
Intercept	.03	0.13	52.44	0.23	.819	0.03	.02	0.13	48.45	0.18	.861	0.03
Age	–.14	0.14	51.02	–1.02	.311	–0.14	.05	0.14	47.58	0.35	.731	0.05
Education	.00	0.14	50.86	0.02	.983	0.00	.01	0.14	47.15	0.08	.934	0.01
Group (SE-Cog)	–.19	0.14	52.79	–1.33	.190	–0.18	.13	0.14	49.19	0.92	.363	0.13
Visit	.07	0.05	48.60	1.47	.149	0.21	.05	0.06	44.08	0.80	.427	0.12
Group × Visit	.03	0.05	48.66	0.72	.473	0.10	–.02	0.06	44.19	–0.37	.712	–0.06
	D-KEFS category fluency						**D-KEFS category switching**					
	β	SE	*df*	*t*	*P*	*r*	*β*	SE	*df*	*t*	*P*	*r*
Intercept	.03	0.12	46.40	0.27	.790	0.04	.06	0.11	44.74	0.56	.577	0.08
Age	–.10	0.13	45.48	–0.75	.456	–0.11	–.20	0.12	42.93	–1.68	.101	–0.25
Education	–.16	0.13	45.41	–1.17	.248	–0.17	–.16	0.12	42.55	–1.32	.194	–0.20
Group (SE-Cog)	.01	0.14	46.85	0.07	.947	0.01	–.10	0.12	45.03	–0.82	.417	–0.12
Visit	–.06	0.06	36.69	–1.04	.307	–0.17	.06	0.06	38.97	0.95	.346	0.15
Group × Visit	–.02	0.06	36.81	–0.42	.679	–0.07	–.09	0.06	39.04	–1.48	.147	–0.23
	WCST-64 perseverative errors						**UPSA-Brief: total score**					
	β	SE	*df*	*t*	*P*	*r*	*β*	SE	*df*	*t*	*P*	*r*
Intercept	–.08	0.10	36.95	–0.78	.440	–0.13	.01	0.10	49.64	0.06	.782	0.01
Age	.27	0.11	32.26	2.50	**.018**	0.40	.22	0.11	47.74	1.92	.067[b]	0.27
Education	–.01	0.11	32.58	–0.07	.943	–0.01	.08	0.11	47.17	0.74	.490	0.11
Group (SE-Cog)	–.07	0.11	36.50	–0.66	.511	–0.11	.16	0.12	49.86	1.39	.351	0.19
Visit	–.14	0.06	41.91	–2.36	**.023**	–0.34	.09	0.07	44.06	1.32	.116	0.20
Group × Visit	.04	0.06	42.13	0.62	.541	0.10	–.02	0.07	44.20	–0.24	.812	–0.04
	Neurobehavioral Symptom Inventory						**QOLI-Brief: mean satisfaction**					
	β	S.E.	*df*	*t*	*P*	*r*	*β*	SE	*df*	*t*	*P*	*r*
Intercept	.02	0.13	50.45	0.12	.904	0.02	.04	0.13	50.48	0.32	.747	0.04
Age	–.06	0.14	48.09	–0.39	.698	–0.06	–.03	0.14	50.52	–0.21	.838	–0.03
Education	–.16	0.14	47.85	–1.12	.268	–0.16	.10	0.14	50.22	0.70	.491	0.10
Group (SE-Cog)	–.80	0.15	50.55	–0.56	.576	–0.08	.14	0.14	51.10	0.98	.332	0.14
Visit	–.09	0.50	61.92	–1.83	.072[b]	–0.23	.08	0.05	56.35	1.74	.087[b]	0.23
Group × Visit	–.12	0.05	62.08	–2.29	**.026**	–0.28	.13	0.05	56.47	2.69	**.009**	0.34

Abbreviations: CVLT, California Verbal Learning Test; D-KEFS, Delis-Kaplan Executive Function System; MIST, Memory for Intentions Screening Test; QOLI-Brief, Quality of Life Interview-Brief; SE-Cog, Supported Employment + CogSMART; UPSA, UCSD Performance-Based Skills Assessment; WAIS-III, Wechsler Adult Intelligence Scale-3rd Edition; WCST-64, Wisconsin Card Sorting Test-64 card version.

[a]Values in boldface indicate significant findings ($P < .05$).

[b]Trends ($P < .10$).

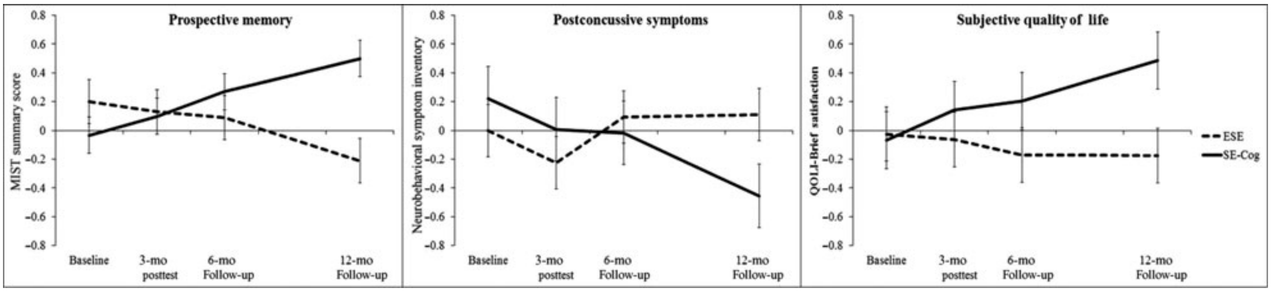

Figure 2. Predicted mean values of significant outcomes by group. Note. Error bars represent 95% confidence intervals. Outcomes are in *z*-score metric. The means are based on the predicted values from the HLMs, which controlled for age and education. ESE indicates enhanced supported employment; MIST, Memory for Intentions Screening test; QOLI-Brief, Quality of Life Interview-Brief; SE-Cog, Supported Employment + CogSMART.

TABLE 4 *Effect sizes for group differences in change scores from baseline to 3-, 6-, and 12-month follow-ups*[a]

	3-mo minus baseline change score Cohen *d*	6-mo minus baseline change score Cohen *d*	12-mo minus baseline change score Cohen *d*
MIST Summary Score	− 0.08	0.17	0.55
MIST 24-h Probe	0.74[b]	0.75[c]	0.41
CVLT Trials 1-5 Learning	− 0.07	0.02	− 0.71[c]
CVLT Long-Delay Free Recall	0.08	0.80[b]	0.02
WAIS-III Digit Span	− 0.46	0.25	0.11
D-KEFS Letter Fluency	0.29	0.30	0.10
D-KEFS Category Fluency	0.33	0.17	0.06
D-KEFS Category Switching	0.17	− 0.14	− 0.46
WCST-64 Perseverative Errors	− 0.50	− 0.08	− 0.59
UPSA-Brief: Total Score	− 0.34	− 0.11	− 0.02
Neurobehavioral Symptom Inventory	0.98[b]	0.69[c]	0.64[c]
QOLI-Brief: Mean Satisfaction Scale	0.48	− 0.19	1.00[b]

Abbreviations: CVLT indicates California Verbal Learning Test; D-KEFS, Delis-Kaplan Executive Function System; MIST, Memory for Intentions Screening Test; QOLI-Brief, Quality of Life Interview-Brief; UPSA, UCSD Performance-Based Skills Assessment; WAIS-III, Wechsler Adult Intelligence Scale—3rd Edition; WCST-64, Wisconsin Card Sorting Test-64 card version.

[a]Positive effect sizes denote differential improvement in the supported employment plus CogSMART group compared with the enhanced supported employment group.

[b]$P < .05$.

[c]$P < .1$.

in prospective memory significantly more than the ESE group. This effect was strongest at 12 months ($d = 0.55$). There was also a trend for the visit by group interaction for the MIST 24-hour probe ($r = 0.21$, $t[1, 63.55] = 1.71$, $P = .093$), with the SE-Cog group improving more than the ESE group. This effect was strongest at 3 ($d = 0.74$) and 6 months ($d = 0.75$).

Treatment effects on work outcomes

There were no group differences in competitive work attainment (13/25 obtained competitive jobs in each group; $\chi^2 = 0$, $df = 1$, $P = 1.000$). Controlling for age and education, analyses of variance revealed no group differences in competitive work outcomes, including weeks worked, hours worked, and wages earned (all *F* values <0.73, all *P*s > .397).

DISCUSSION

We found that CogSMART, in the context of supported employment for Veterans with mild to moderate TBI, was associated with improvements in both subjective and objective functioning. Compared with those receiving ESE (a robust control group), those who received supported employment plus CogSMART reported significant reductions in postconcussive symptoms and improvements in quality of life. The effects on postconcussive symptoms appeared to be driven mainly by significant CogSMART-associated reductions in affective symptoms and possibly by trend-level reductions in cognitive symptoms. Compared with control participants, those who received CogSMART improved in their prospective memory performance (ie, their ability to remember to do things at specified times or in response to specific event cues). These improvements have obvious implications for treatment adherence, as prospective memory ability is required to remember to attend appointments and take medications.[53] Prospective memory ability is also important for everyday functioning at home, school, work, and in social relationships (eg, remembering to pay bills, study for a test, complete job assignments, and recognize important events such as birthdays and anniversaries).[54] The significant CogSMART-associated improvements were in the medium to large range of effect sizes, and the effect sizes frequently increased over the course of the 12-month follow-up period, even after the CogSMART intervention was over, suggesting that participants continued to use their strategies over time. However, work outcomes did not differ between groups, with about half the participants in each group attaining competitive work within the year. This result is extremely consistent with work attainment rates in VA-supported employment programs for Veterans with TBI or mental health conditions nationally[55] and suggests that the individualized nature of supported employment may help compensate for cognitive impairments by appropriately matching clients to the cognitive demands of potential jobs.

This study has a number of strengths as well as limitations. In terms of strengths, it included a randomized design that used both objective outcome measures (eg, neuropsychological measures, competitive work outcomes such as hours worked and wages earned) and subjective, patient-centered outcome measures (eg, self-reported postconcussive symptoms, psychiatric symptoms, and quality of life). The inclusion of a robust control group (ESE) is also a strength because the 2 treatment groups received equal therapist time. Another strength was the 12-month treatment outcome interval, which allowed observation of CogSMART-associated effects over a relatively long time frame. Our study also had some limitations that often accompany pilot intervention research. First, our sample was small, limiting our ability to detect small effect size changes, and there was a 16% dropout rate over the 12-month follow-up interval. Second, the examiners administering the follow-up assessments were not blind to the treatment condition of the participants, raising the possibility of experimenter bias (see reference Hrobjartsson et al).[56] Furthermore, this study included a sample of unemployed veterans with a history of mild to moderate TBI who expressed interest in returning to work; therefore, our results may not generalize to individuals with more severe TBI, nonveterans, or those who are not interested in obtaining work.

Future studies will be needed to determine whether the effects of CogSMART persist after 1 year and whether the intervention can be efficacious for individuals with more severe brain injuries, as well as non-Veterans. In addition, given the high number of recent Veterans returning to school using post 9/11 GI Bill benefits, the effects of CogSMART within a supported education context should also be investigated. Given our nonsignificant results on neuropsychological tests of attention, learning/memory, and executive functioning, these modules of the intervention may be less helpful, or less effective for certain individuals, and these are questions for a future dismantling study. Future research with larger samples will be needed to examine whether the presence and severity of psychiatric comorbidities affect CogSMART outcomes, in addition to the mechanisms of effect (eg, prospective memory strategy use affecting prospective memory performance outcomes). It is possible that compensatory cognitive training interventions such as CogSMART may be modifiable and useful for other populations with cognitive impairment (eg, from PTSD, depression, or chronic pain) in the absence of TBI.

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