Long-Term Effect of Cognitive Rehabilitation Regardless of Prerehabilitation Cognitive Status for Veterans with TBI

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To link to this article: https://doi.org/10.1080/23279095.2019.1652174

Published online: 28 Aug 2019.
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ABSTRACT
Persisting difficulties in executive functioning (EF) are common after traumatic brain injury (TBI). Cognitive rehabilitation can be effective, but the impact of pretreatment neurocognitive functioning on long term effects of rehabilitation is unknown. Because this information can impact treatment planning, we examined the relationship between prerehabilitation neurocognitive status and long-term effects of EF training. Archival data were drawn from a trial of Goal-Oriented Attentional Self-Regulation group-format EF training for Veterans with TBI [mild-severe; 11 years postinjury; 96% male, 32% nonwhite, 14.21 years education (SD 1.72), 41.13 years old (SD 11.39)]. Using prerehabilitation neurocognitive performance, participants were clustered into cognitive difficulty (CD) and cognitively normal (CN) groups. Six-plus months after EF rehabilitation training, participants completed a structured telephone interview and/or in-person cognitive/functional/emotional assessment using standardized measures of cognitive, daily, and emotional functioning frequently employed in TBI research. At 6+ months post-EF training compared to prerehabilitation, CD and CN improved in multiple cognitive (Overall Attention/EF: \( F(1,18) = 26.17, \) partial \( \eta^2 = .59 \); Total Memory: \( F(1,18) = 6.82, \) partial \( \eta^2 = .28 \)) and functional domains (Goal Processing Scale [GPS] total score: \( F(1,15) = 6.71, \) partial \( \eta^2 = .31 \)). CD improved more than CN on Learning and Memory functional domain [\( F(1,15) = 6.10, \) partial \( \eta^2 = .29 \)]. Results of our small archival analysis raise the possibility that Veterans with chronic TBI may demonstrate long-term effects of EF training.

KEYWORDS
Cognitive rehabilitation; traumatic brain injury; Veterans

Introduction
Traumatic brain injury (TBI) is a common problem among Veterans of all eras (Helmick et al., 2015; Ivins, Schwab, Baker, & Warden, 2006; Reiber et al., 2010). TBI may lead to deficits in executive control and attention regulation and associated problems with daily functioning and community integration, which can persist for years (Dillahunt-Aspillaga et al., 2018; Hoge, Goldberg, & Castro, 2009; Schneiderman, Braver, & Kang, 2008; Seal et al., 2009; Tanielian & Jaycox, 2008; Vanderploeg, Curtiss, & Belanger, 2005; Vasterling, 2007). Although there are potentially effective treatments available, even for patients with relatively remote history of brain injury, the impact of pretreatment cognitive status on long-term effect of rehabilitation is unknown (Cicerone et al., 2019; Cicerone et al., 2011).

One such promising treatment for difficulties with executive control after brain injury is Goal-Oriented Attentional Self-Regulation (GOALS), a cognitive rehabilitation training that targets executive control functions by training participants in applied mindfulness-based attention regulation and goal management strategies and linking them to participant-defined real-life goals (Novakovic-Agopian et al., 2011). This training has been shown to be effective in improving objective cognitive performance for Veterans with mild-severe TBI (Novakovic-Agopian et al., 2011;
Novakovic-Agopian et al., 2018) and healthy older adults with cognitive complaints (Turner et al., 2019) compared to a matched psychoeducational control training and has even been shown to improve goal-directed control over neural processing on fMRI (Arnemann et al., 2015; Chen et al., 2011).

The literature on cognitive rehabilitation after TBI points to a lack of knowledge around long-term effects on daily functioning (Cicerone et al., 2011), and controversy exists regarding the utility of objective cognitive measures to predict response to treatment immediately and over time. The extent to which performance on objective neuropsychological measures is correlated with functional problems in daily life is limited (Chaytor & Schmitter-Edgecombe, 2003), and Veterans with history of TBI may experience problems with daily functioning while receiving scores within normal limits on objective neuropsychological measures. Furthermore, it is unclear whether or not cognitive status at prerehabilitation baseline is important in moderating long term effects.

In a previous study with Veterans with chronic mild-severe TBI (Kornblith et al., 2018), we analyzed archival data from a published randomized controlled trial (RCT) (Novakovic-Agopian et al., 2018) in order to investigate the impact of pretreatment cognitive status on immediate post-treatment response to the GOALS intervention. We identified neuropsychological profiles among Veterans with history of TBI and examined the differing impact of GOALS training based on participants’ baseline (i.e., prerehabilitation) cognitive status. Results showed two distinct profiles of neuropsychological functioning in a sample of veterans with history of chronic mild to severe TBI: a cognitively normal group (CN), and a second group with cognitive difficulty (CD), particularly in attention, executive function (EF), and learning and memory, that also experienced more difficulty with emotional regulation and daily functioning. Of interest, and contrary to expectations, these groups did not differ based on age, education, gender, or initial injury severity. Furthermore, Veterans with chronic TBI who demonstrated residual cognitive difficulties (CD group) showed significant improvement on neuropsychological and functional performance measures after GOALS, and both CD and CN groups of Veterans showed improvement after GOALS on measures of emotional functioning. These results suggest there is a benefit to training of EF skills for emotional regulation outcomes, even for participants who do not show deficits on objective neuropsychological measures, and indicate that most Veterans with chronic TBI can derive benefit from cognitive rehabilitation training with a focus on executive control. Furthermore, these results provide support for movement away from a traditional deficit-based approach and towards a strengths-based approach emphasizing training in abilities with high generalization value, such as attentional control, problem solving, and goal attainment for Veterans with chronic TBI and cognitive complaints. However, the impact of prerehabilitation cognitive status on long-term effect of GOALS training is unknown. The available literature suggests that outcomes after cognitive rehabilitation are affected by demographic factors including age, injury severity and education level (Hammond, Hart, Bushnik, Corrigan, & Sasser, 2004; Rohling, Faust, Beverly, & Demakis, 2009), as well as prerehabilitation cognitive status (Bajo & Fleminger, 2002; Hanks et al., 2008; Hanks, Rapport, Millis, & Deshpande, 1999; Ownsworth & McKenna, 2004; Sigurdardottir, Andelic, Roe, & Schanke, 2009), but a minimal amount is known about how prerehabilitation cognitive status impacts long-term response to training and follow-up outcomes.

Here, we report results of an analysis of archival data examining the impact of the same prerehabilitation cognitive profiles identified above on cognitive and functional task performance and daily and emotional functioning at long-term follow-up at least six months after completing GOALS training for Veterans with chronic TBI. The current study represents a rare opportunity to examine the impact of a cognitive rehabilitation intervention on neurocognitive and functional performance and generalization of cognitive gains to emotion regulation and daily functioning at long-term follow-up. In addition, we are uniquely able to examine long-term rehabilitation outcomes for TBI-exposed Veterans both with and without objective cognitive difficulty, and whether those difficulties impact ability to retain benefits or encode strategies for long-term use.

**Methods**

The study from which these archival data are drawn was approved by IRBs at participating institutions including University of California, San Francisco, and the Veterans Affairs (VA) Medical Centers in San Francisco and Martinez. All participants provided informed consent prior to any of the study procedures taking place. Behavioral assessments and interventions
took place at VA Medical Centers in San Francisco and Martinez.

**Study design**

This study reports the results of a secondary analysis of archival data from a randomized controlled trial (RCT) comparing GOALS to a psychoeducational control intervention for Veterans with chronic TBI.

Of 106 potential participants assessed for eligibility in the original RCT, 61 did not meet inclusion criteria or declined to participate after the initial phone screen. Of 45 consented, 10 left the study prior to intervention allocation due to scheduling difficulties, changes in medication, or family circumstances; two were lost to follow-up after allocation. At prerehabilitation baseline, (Novakovic-Agopian et al., 2018) a total of 33 Veterans with history of chronic TBI and subjective complaints of executive difficulties in their daily lives underwent a comprehensive multilevel evaluation of neuropsychological, emotional, and functional status. Some participants demonstrated objective difficulty on neuropsychological measures, and some did not. After completing the baseline evaluation, consecutively recruited participants were placed in small groups (average group size: three participants), and the entire group was then randomized to receive either GOALS EF training or Brain Health Education (BHE) control training (carefully matched to GOALS for therapist time and intensity) (Novakovic-Agopian et al., 2018). Please see the CONSORT diagram in the published paper (Novakovic-Agopian et al., 2018) for details on recruitment, screening, and allocation procedures. Most participants who started with BHE then completed GOALS immediately after completing BHE in a crossover study design. At about six months after completing GOALS training, participants were again evaluated with the same multilevel battery consisting of neuropsychological and complex functional performance assessment, and self-report measures of daily and emotional functioning. They also completed a structured telephone interview. The assessments were administered by the same evaluator at all time points, and every attempt was made to administer them at the same time of the day. The results of the original RCT, previously described, from which our archival data are drawn have been previously published and presented (Novakovic-Agopian et al., 2016; Novakovic-Agopian et al., 2018; Novakovic-Agopian et al., 2019).

In a previous secondary archival analysis, scores on neuropsychological measures completed pretreatment were used to categorize Veterans into clusters based on baseline cognitive functioning (neuropsychological performance only), which were used to examine the impact of baseline cognitive status on response to GOALS EF treatment compared to a matched control immediately post-treatment (Kornblith et al., 2018).

Our current secondary analysis of archival data from the trial described above includes only participants with data for baseline neurocognitive status who also completed the long-term follow-up about six months after completing GOALS training. Of these, a total of 24 Veterans completed at least one aspect of the follow-up evaluation ($n = 13$ CD, $11$ CN): 23 participants completed a structured telephone follow-up interview ($n = 12$ CD, $11$ CN); 20 participants completed the neuropsychological assessment ($n = 10$ CD, $10$ CN); 17 completed the functional evaluation ($n = 9$ CD, $8$ CN), and 14 completed the questionnaires ($n = 7$ CD, $7$ CN).

**Participants**

Among the 24 participants with baseline neurocognitive data completing one or more aspects of the follow-up assessment and included in the current secondary archival analysis, average age was 41.13 years (range 25–66; SD 11.39); Participants were 96% male, 68% white, and had an average of 14.21 years of education (range 12–18; SD 1.72). The majority of participants ($n = 13$) sustained a mild TBI, with the reminder experiencing moderate ($n = 5$) or severe ($n = 6$) injury. The injuries occurred at least two years prior to study participation (average time since injury: 11.5 years). These demographic and injury characteristics did not differ by prerehabilitation cognitive status group (CD vs. CN). Veterans in this sample who completed in-person follow-up did not differ from those who did not complete follow-up ($n = 9$) on age, ethnicity, years of education, injury severity, time since injury, or prerehabilitation cognitive status group. Female Veterans were over-represented in the group that did not complete follow-up ($chi square = 5.23$, $p = .02$).

**Intervention**

All participants in this study were Veterans with a history of chronic mild to severe TBI and subjective cognitive complaints and who completed GOALS. Some also completed a control psychoeducational
control training carefully matched for therapist time and intensity prior to participating in GOALS (n = 8; see Novakovic-Agopian et al. (2018). Participants who also completed this control intervention did not differ from participants who completed GOALS only on any demographic factors (age, p = .22, time since injury, p = .67; years of education, p = .14, injury severity, p = .57; gender, p = .43; and ethnicity, p = .29) or most outcomes of interest. However, participants who also completed control training did differ from participants who completed GOALS only on Goal Processing Scale [GPS] Planning at follow-up, such that participants who also completed control training had higher scores, p = .02).

**Goal-Oriented Attentional Self-regulation (GOALS) Training** emphasizes two key components. First, regulation of distractibility (i.e., redirection of attention to goal-relevant processes and the filtering of nonrelevant “noise,” especially in the context of distractions) is addressed with attention regulation training. This aspect of the training emphasizes principles of applied mindfulness-based attention regulation to redirect cognitive processes toward task-relevant activities even when distracted. This requires identifying the current primary task, separating information into relevant and nonrelevant categories, and working to selectively maintain relevant information while letting go of nonrelevant information. Participants are trained in applying a metacognitive strategy (“STOP-RELAX-REFOCUS”, SRR) to stop activity when distracted, anxious, and/or overwhelmed; relax; and then re-focus attention on the current primary goal. They are taught to actively apply goal-directed attention regulation skills to a range of situations, from simple information processing tasks to complex multistep problems and challenging low-structure situations occurring in their own lives. Training via in-class exercises and homework is applied to progressively more challenging situations, including holding increasing amounts of information in mind, culminating with maintaining information while exposed to distractors. Homework includes practice in maintaining goal-direction during challenging real-life situations identified by participants. At the beginning of each session, participants discuss their experiences completing the homework examples with the rest of the group.

The second major component of GOALS training involves the active application of these goal-oriented attentional self-regulation skills to the identification, selection, and execution of self-generated complex goals. Participants are asked to identify personally relevant and feasible functional goals (e.g., finding an apartment, looking for a job, writing a school term paper, planning a vacation) as individual and group projects. They are then trained in applying the goal management strategies on the functional task(s) of their choice. The main objective is to allow extensive practice and application of skills, thereby linking the attentional regulation directly to goal attainment efforts.

**Measures**

**Neuropsychological assessments**

The current study used a neuropsychological battery specifically designed to assess performance in cognitive domains of complex attention and EF that are commonly affected by TBI and targeted by GOALS training. Cognitive domains assessed include Working memory (Auditory Consonant Trigrams (Stuss, Stethem, & Poirier, 1987), Letter Number Sequencing subtest from the Wechsler Adult Intelligence Scale, Third Edition (WAIS III; Wechsler, 1997); Inhibition of automatic responding (Stroop Inhibition task time and errors from the Delis-Kaplan Executive Function System [DKEFS]; Delis, Kaplan, & Kramer, 2001); Mental flexibility (Trail Making Test-Part B, Heaton, Miller, Michael, & Grant, 2004), Design Fluency-Switching (DKEFS; Delis et al., 2001), Verbal Fluency Switching (DKEFS; Delis et al., 2001), Stroop Inhibition-Switching (time and errors [DKEFS]; Delis et al., 2001); and Sustained Attention (Digit Vigilance Test; Heaton et al., 2004) time and error scores. A composite Overall Attention and Executive Function variable (AVXE) was constructed using Z scores on measures from the Inhibition, Working Memory, Mental Flexibility, and Sustained Attention domains.

Participants’ performance in cognitive domains commonly affected by TBI, but not targeted by the intervention, was also assessed as a marker of potential nonspecific changes: Total recall (Hopkins Verbal Learning Test–Revised [HVLT-R]; Brief Visual Memory Test–Revised [BVMT-R] Benedict, 1997); and Delayed Recall (HVLT-R and BVMT-R Delayed Recall trials). A Total Memory composite score was created using the Total Recall and Delayed Recall scores.

To minimize practice effects, alternative test forms (DKEFS, HVLT-R, BVMT-R) and/or norms for repeated testing (Auditory Consonant Trigrams) were used for repeated administrations whenever feasible.
Functional assessment

The GPS (Novakovic-Agopian et al., 2014) involves the observation and rating of a participant completing a challenging task that engages executive control using a scoring system to quantify observations. Participants are instructed to plan and execute a task requiring them to gather and compare information about three different activities of their choice, using the available means while following specified rules in a limited time (30 minutes). Participants work in an office equipped with a computer with Internet access, a telephone, yellow pages telephone book, blank paper, pen, calculator, and clock. They are given the task instructions page, which contains the key requirements of the task and the task rules.

Participants’ performance on this measure is rated, by trained and experienced administrators with the assistance of a scoring manual, in the following subdomains of EF: Planning, Initiation, Maintenance of Attention, Self-monitoring, Sequencing and Switching, Flexibility, and Execution. An Overall Performance score is also produced. Functional performance in these domains is rated on a scale ranging from 0 (not able) to 10 (absolutely not a problem). The GPS Overall Performance Score is the average of the seven subdomain scores. Please see our previous work (Novakovic-Agopian et al., 2014; Novakovic-Agopian et al., 2018) for more information regarding this measure.

Measures of daily and emotional functioning

Participants also completed self-report measures of daily and emotional functioning. Participants completed the Mayo-Portland Adaptability Inventory (MPAI-4; Malec, Moessner, Kragness, & Lezak, 2000), a measure of common sequelae of TBI including impact on activities of daily living, emotional adjustment, and community integration. Depressive symptoms were assessed using the Beck Depression Inventory-II (BDI-II; Beck, 1996). Symptoms of post-traumatic stress disorder (PTSD) were evaluated with the PTSD Checklist - Military Version (PCL-M; Weathers, Huska, & Keane, 1991). Level of psychological distress was assessed using the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1992).

Structured telephone interview

Participants completed a structured telephone interview which included questions about: 1) change in daily activities including: work, school, caregiving, managing daily IADLS; 2) continued use of trained strategies; 3) the impact of training on emotional and daily functioning; and 4) the degree of change in performance of daily activities requiring attentional control and EF. Questions regarding new or increased involvement in daily activities and use of trained strategies are answered in a yes/no format; yes items are queried for frequency (daily vs. weekly vs. monthly). Questions about impact of training and degree of change are answered based on an ordinal scale on which 5 designates the same as before the start of training, 0 designates much worse, and 10 designates much better.

Prerehabilitation cognitive status

In a previous secondary analysis of data from the original RCT (Kornblith et al., 2018), baseline neuropsychological composite domain scores of Overall Attention/Executive Function (OA/EF), Auditory Working Memory (AWM), Sustained Attention (SA), Mental Flexibility (MF), Inhibition (I), Composite Memory (TM), Total Recall (TR), and Delayed Recall (DR) were used to place participants into homogenous clusters using two-step cluster analysis. Two distinct clusters were identified: “Cognitive Difficulty” (CD) and “Cognitively Normal” (CN). Clusters did not differ on demographic variables or injury severity (Table 1). Bayes Information Criterion (BIC) was 141.56, BIC change was −8.109, ratio of BIC changes was 1.00, and ratio of distance measures was 1.24. Cluster quality measures of cohesion and separation fell in the Good range. The largest identified group (CD) contained 60% of the sample and was characterized by weak scores (mean z scores ≤.75 or below) on Overall Attention/Executive Function, Auditory Working Memory, Total Memory, Total Recall, and Delayed Recall. The second-largest group (CN) contained 40% of the sample and consisted of average scores (all mean z scores greater than −.2) on the neuropsychological variables. Please see Kornblith et al. (2018) for more details. The CD and CN groups in the current study did not differ based on TBI severity (mild, n = 13, vs. moderate-severe, n = 11; chi square = .73, p = .392).

Statistical analysis

Scores on neuropsychological variables were transformed to z scores before analysis. Scores on BDI-II, GPQ, and PCL-IV-M were analyzed in their original
scales; POMS raw scores were converted to z scores, and MPAI raw scores were converted to T scores. All analyses were conducted using SPSS Version 24 (IMBCorp, 2016). Descriptive statistics were calculated for the neuropsychological (individual tests and domain scores), functional, and self-report variables for the whole sample and both baseline cognitive status groups at both baseline and long-term follow-up. The assumptions for all statistical tests were met.

A repeated-measures multivariate analysis of variance (MANOVA) was used to compare performances on neurocognitive domain scores at baseline and follow-up for both cognitive status groups (CD and CN). Similarly, a MANOVA was used to compare cognitive status group performance on GPS functional task domain scores baseline and follow-up. In addition, separate repeated measures MANOVAs were conducted to compare baseline scores to long-term follow-up performance on measures of everyday and emotional functioning (raw-score measures for BDI-II and PCL; z score measures for POMS; T score measures for MPAI) for CD and CN. Finally, descriptive statistics were obtained for results of the follow-up telephone interview and compared between prerehabilitation cognitive status groups.

We present results of analyses without adjustment for multiple comparisons because such adjustments aim to prevent results of \( p < .05 \) in the case where all differences are truly zero (Perneger, 1998; Rothman, 1990; Savitz & Olshan, 1995), which is not a realistic assumption about the presence or absence of true differences in this context. In addition, because there are clear relationships between outcomes examined here, the results do not detract from each other, and lack of adjustment allows for these related findings to corroborate each other and reduce the risk of spurious conclusions.

## Results

### Missing data

At long-term follow-up, complex functional assessment (GPS) data were missing for three Veterans, questionnaire data were missing for six Veterans, and structured telephone interview data were missing for one Veteran. Veterans with missing data for a measure were removed from that analysis, resulting in slightly different sample sizes (see Tables 1–3). Veterans with missing data \((n = 13)\) on one or more measures did not differ from the rest of the sample on age \((p = .93)\), gender \((p = .53)\), education \((p = .45)\), ethnicity \((p = .23)\), injury severity \((p = .27)\), time since

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### Table 1. Effects of prerehabilitation cognitive status (CD vs. CN) and GOALS training on long-term neurocognitive outcomes.

<table>
<thead>
<tr>
<th>CD ((n = 10))</th>
<th>CN ((n = 10))</th>
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<tbody>
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<td>Baseline</td>
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<td>M</td>
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<td>Overall Attention/Executive Function</td>
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<tr>
<td>Auditory Working Memory</td>
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</tr>
<tr>
<td>Attention, Memory, Inhibition</td>
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</tr>
<tr>
<td>Total Memory</td>
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<tr>
<td>Delayed Recall</td>
<td>0.05</td>
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<tr>
<td>Total Recall</td>
<td>0.04</td>
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</tbody>
</table>
| Note: CD = cognitive difficulty; CN = cognitively normal; GOALS = Goal-Oriented Attentional Self-Regulation. No significant interaction effects of baseline cognitive status and treatment; data not shown. Significant omnibus effect of baseline cognitive status (CD vs. CN): F(7,12) = 23.41, \( p < .001 \), partial eta squared = .93.

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### Table 2. Effects of prerehabilitation cognitive status (CD vs. CN) and GOALS training on long-term functional outcomes.

<table>
<thead>
<tr>
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### Table 3. Effects of prerehabilitation cognitive status (CD vs. CN) and GOALS training on long-term emotion outcomes.

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injury ($p = .37$), prerehabilitation cognitive status (CD vs. CN; $p = .84$), or study group (GOALS vs. BHE; $p = .12$).

**Neurocognitive outcomes**

Results of a repeated measures MANOVA comparing baseline and long-term follow-up performance on cognitive domains for the CD vs. CN groups revealed that overall, Veterans with TBI who completed GOALS EF training demonstrated improved performance at follow-up compared to baseline, regardless of prerehabilitation cognitive status, in multiple cognitive domains: Total Memory, Delayed Recall, Overall Attention/Executive Function, Mental Flexibility, Sustained Attention, and Auditory Working Memory. Participants did not show improved performance compared to baseline on Inhibition or Total Recall at long-term follow-up (see Table 1). Results of between group comparison of CD vs. CN on cognitive domain scores show that CD demonstrated weaker performance compared to CN in most cognitive domains at both baseline and follow-up (Table 1). There were no interaction effects detected between group (CD vs. CN) and treatment (data not shown).

**Functional task performance**

Results of a repeated measures MANOVA comparing baseline and long-term follow-up performance on domains of GPS functional task performance for the CD vs. CN groups revealed that overall, Veterans with TBI who completed GOALS EF training demonstrated improved, compared to baseline, performance regardless of prerehabilitation cognitive status in multiple domains of functional task performance, including Planning, Self-monitoring, Sequencing/switching, Execution, Learning, and Memory, and GPS Total Score (Table 2). There was a statistically significant interaction effect detected between prerehabilitation cognitive status (CD vs. CN) and treatment on Learning and Memory domain performance such that members of the CD group improved more following treatment compared to members of the CN group (Table 2). There was no main effect of baseline cognitive status alone on GPS functional task performance (data not shown).

**Daily and emotional functioning**

A repeated measures MANOVA revealed no significant differences in improvement on scores on multiple
scales from measures of emotional functioning at six months after completing GOALS treatment between CD and CN groups (Table 3). Participants with and without baseline cognitive difficulty showed improvement at follow-up on PCL-M Total Score, POMS Depression, Confusion, and Total Mood Disturbance (Table 3). There were no significant interaction effects of baseline cognitive status and treatment detected on any outcome variables, and no effects on any MPAI scales (data not shown).

**Structured telephone interview**

**Use of strategies**

Ninety-one percent \((n = 21; 11\; CD\; and\; 10\; CN)\) of our sample reported continued use of trained strategies, especially the stop-relax-refocus metacognitive strategy and applied mindfulness. Continued use of strategies did not differ based on prerehabilitation cognitive status (CD vs. CN; \(p = .95\)).

**Daily activities**

When asked about changes in daily activity participation compared to prerehabilitation, significantly more members of the CD group reported a positive change in participation in social (chi square = 4.10, \(p = .04,\) phi = .42) and volunteer (chi square = 4.10, \(p = .04,\) phi = .42) activities (i.e., they reported not taking part in these activities before training, but after training reported that they are taking part in these activities), compared to members of the CN group. There were no group differences observed for competitive employment (\(p = .92\)), involvement in an academic program (\(p = .92\)), caregiving (\(p = .75\)), household chores (\(p = .86\)), paying bills (\(p = .48\)), driving or using public transportation (\(p = .95\)), or engaging in medical or mental health treatment (\(p = .88\)).

**Daily tasks requiring attentional control/EF**

Participants were also asked to rate their degree of post-training change on a number of daily tasks requiring attentional control and EF relative to prerehabilitation on a scale of 0 (much worse) to 5 (the same) to 10 (much better). Participants in both CD and CN overall reported improvement in ability to complete each of the tasks queried (see Novakovic-Agopian et al., 2019, for more details). No statistically significant differences between groups (CD vs. CN) were observed in the tasks queried: planning (\(p = .73\)), self-monitoring (\(p = .50\)), attention/working memory (\(p = .62\)), divergent thinking (\(p = .95\)), execution (\(p = .75\)), learning (\(p = .92\)), awareness (\(p = .48\)), and sequencing (\(p = .64\)).

**Emotional and daily functioning**

When asked to rate how much certain aspects of emotional and daily functioning were impacted in response to training relative to prerehabilitation on a scale of 0 (much worse) to 5 (the same) to 10 (much better), participants in both CD and CN on average reported positive change in each of the items queried. There were no statistically significant differences

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**Table 3. Effects of prerehabilitation cognitive status and GOALS training on long-term self-reported emotional functioning outcomes.**

<table>
<thead>
<tr>
<th></th>
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<th>CN (n = 7)</th>
<th>CD (n = 7)</th>
<th>CN (n = 7)</th>
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<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Follow-up</td>
<td>Baseline</td>
<td>Follow-up</td>
<td>Prehabilitation cognitive status</td>
<td>Treatment</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>F (1,10)</td>
<td>Partial (\eta^2)</td>
<td>F (1,10)</td>
<td>Partial (\eta^2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BDI-II Raw</td>
<td>24.00</td>
<td>11.92</td>
<td>24.17</td>
<td>8.23</td>
<td>2.60</td>
<td>.21</td>
<td>.25</td>
<td>.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCL-M Raw</td>
<td>55.17</td>
<td>17.68</td>
<td>47.00</td>
<td>14.38</td>
<td>5.21*</td>
<td>.34</td>
<td>.51</td>
<td>.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17.00</td>
<td>6.81</td>
<td>11.67</td>
<td>6.62</td>
<td>.06</td>
<td>.01</td>
<td>.08</td>
<td>.01</td>
<td></td>
<td></td>
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<tr>
<td>Avoidance</td>
<td>21.17</td>
<td>7.68</td>
<td>17.83</td>
<td>6.82</td>
<td>.10</td>
<td>.01</td>
<td>.00</td>
<td>.00</td>
<td></td>
<td></td>
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<tr>
<td>Arousal</td>
<td>15.50</td>
<td>5.58</td>
<td>15.50</td>
<td>3.21</td>
<td>2.38</td>
<td>.19</td>
<td>.05</td>
<td>.01</td>
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<tr>
<td>POMS Z score</td>
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<td></td>
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<tr>
<td>Total Mood</td>
<td>-1.51</td>
<td>1.28</td>
<td>-1.50</td>
<td>1.13</td>
<td>5.28*</td>
<td>.32</td>
<td>.10</td>
<td>.01</td>
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<tr>
<td>Disturbance</td>
<td>-1.47</td>
<td>1.12</td>
<td>-1.77</td>
<td>8.22</td>
<td>4.67</td>
<td>.30</td>
<td>.14</td>
<td>.01</td>
<td></td>
<td></td>
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<tr>
<td>Tension</td>
<td>-1.82</td>
<td>1.79</td>
<td>-1.49</td>
<td>1.49</td>
<td>6.12*</td>
<td>.36</td>
<td>.17</td>
<td>.02</td>
<td></td>
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<tr>
<td>Depression</td>
<td>-0.87</td>
<td>1.68</td>
<td>-1.35</td>
<td>1.67</td>
<td>2.85</td>
<td>.21</td>
<td>.12</td>
<td>.01</td>
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<tr>
<td>Anger</td>
<td>-1.56</td>
<td>.90</td>
<td>-1.33</td>
<td>.72</td>
<td>11.05**</td>
<td>.50</td>
<td>.09</td>
<td>.01</td>
<td></td>
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<tr>
<td>Confusion</td>
<td>-1.20</td>
<td>.90</td>
<td>-1.86</td>
<td>1.31</td>
<td>.00</td>
<td>.00</td>
<td>1.89</td>
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<tr>
<td>Vigor</td>
<td>-1.20</td>
<td>1.12</td>
<td>-1.18</td>
<td>.85</td>
<td>2.55</td>
<td>.19</td>
<td>.04</td>
<td>.00</td>
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<tr>
<td>Fatigue</td>
<td>-1.20</td>
<td>1.12</td>
<td>-1.18</td>
<td>.85</td>
<td>2.55</td>
<td>.19</td>
<td>.04</td>
<td>.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. GOALS = Goal-Oriented Attentional Self-Regulation; BDI-II = Beck Depression Inventory-II; PCL-M = PTSD Checklist – Military Version; POMS = Profile of Mood States. No significant interaction effects of baseline cognitive status and treatment; data not shown.

\(\*p < .05.\)

\(\*\*p < .01.\)

\(\*\*\*p < .001.\)
observed on these measures between CD and CN participants in self-esteem \( p = .58 \), knowledge of strengths and weaknesses \( p = .66 \), self-confidence \( p = .68 \), relationships \( p = .39 \), mood \( p = .65 \), managing daily tasks at work, home, and school \( p = .93 \), and managing frustrations \( p = .87 \).

Of note, the absence of significant results on the above measures may be a result of a lack of statistical power rather than the true absence of difference.

**Discussion**

This study used archival data from a previous clinical trial (Novakovic-Agopian et al., 2018) to examine the impact of baseline cognitive status on long-term effect of rehabilitation for Veterans with chronic TBI six or more months after completing EF training. The results of that previous trial show that participants in GOALS training demonstrate greater improvements in aspects of cognitive, emotional, and daily functioning compared to participants in a matched psychoeducational control intervention (Novakovic-Agopian et al., 2018), and that most of these gains are maintained at long-term follow-up (Novakovic-Agopian et al., 2019). Results from our current, small archival study focused on the impact of prerehabilitation cognitive status suggest that Veterans with chronic TBI and subjective cognitive complaints, with and without objective prerehabilitation neurocognitive deficits, may benefit from EF training and maintain that benefit over time. Specifically, our results suggest that at six or more months after completing EF training, veterans with chronic TBI continue to demonstrate statistically significant gains in neurocognitive functioning and performance on a complex functional task relative to their baseline performance, and report improvements in daily functioning. Although these results are preliminary and inferences limited by small sample size, they support the long-term efficacy and generalizability of EF training for TBI patients and underscore the need for future research including larger studies in this area. Additionally, we found that veterans with more cognitive difficulty pretraining showed more improvement on a complex functional assessment post training at follow-up, specifically on a scale measuring learning and memory, compared to those without cognitive objective cognitive difficulty. Veterans with more cognitive difficulty pretraining also appear to be more likely to report improved involvement in social or volunteering activities after training at long-term follow-up compared to the baseline cognitively normal group, although a small sample size for this analysis makes interpretation of these results challenging. Of note, because of our small sample size, it is possible there are more differences related to prerehabilitation cognitive status on the outcomes studied then we were able to detect here (i.e., more improvement compared to baseline for one of the groups compared to the other). Therefore, further research on this topic using larger samples is indicated.

To our knowledge this is the first study to examine the impact of baseline neurocognitive status on long-term effect of rehabilitation. Of those extant studies that do examine follow-up outcomes for EF training interventions, samples, modality of training, and outcomes vary. Three studies of EF training including follow-up data collection have demonstrated long-term benefit of training the cognitive domains targeted by the trainings at follow-up: After 5 weeks of computer-based working memory training, healthy young and older adults showed improvement on a letter memory task, which was maintained at 18 months post-treatment, but limited generalization. Following in-person training focused on self-awareness, planning, goal-setting, and other aspects of EF, administered over three months, brain injured patients showed improvement on a self-report measure of “daily life executive functioning” maintained at 6 months post-training, but did not improve on standard neurocognitive measures of EF (Spikman, Boelen, Lamberts, Brouwer, & Fasotti, 2010). After eight two-hour sessions of in-person goal-management training with an additional emotional regulation component, brain injured patients showed gains in everyday EF, as measured by a self-report inventory, which were maintained at a six-month follow-up (Tornås et al., 2016). A cognitive rehabilitation training program emphasizing pragmatic communication skills, including an EF training component, also demonstrates long-term maintenance of training gains for patients with severe TBI (Gabbatore et al., 2015) and generalizability of improvement not just to trained skills but to daily functioning (Bosco et al., 2018), as well as changes in neural activity detected on fMRI (Sacco et al., 2016). Considering our results in the context of the limited available literature, these findings add to the growing body of evidence that EF training may be effective in both the short and long term. Our results are unique among the existing literature, however, because we show generalized gains (i.e., benefit not just in the cognitive skills that are the focus of the training, but on nontrained neurocognitive tasks, functional performance of complex tasks, and
measures of emotion regulation and daily function as well) and maintenance of gains over time, which appear to exist regardless of baseline cognitive status. Furthermore, our sample is unique because of the chronicity of the injuries experienced by our Veteran participants (average time since injury: 10 years). These results suggest that meaningful, long-term improvement in cognitive skills as well as emotion regulation and daily functioning is possible for Veterans with chronic TBI and cognitive complaints, even for those participants who do not demonstrate deficits on objective neuropsychological testing at pre-rehabilitation baseline. Our findings bolster the value of established, validated neurocognitive measures in predicting long-term response to rehabilitation and generalizability of rehabilitation gains, but we also show that Veterans without deficits on objective neuropsychological measures can derive long-term benefit from EF training. Furthermore, our results suggest that a strengths-based approach of training generalizable cognitive and self-regulation skills (vs. the traditional deficit-based approach) results in long-term benefit from rehabilitation for Veterans with chronic TBI. Overall, this study has implications for better understanding of the retention of gains from cognitive rehabilitation interventions as well as continued use of strategies trained in such interventions.

As in our previous report of archival analysis of immediately postrehabilitation outcomes for this sample (Kornblith et al., 2018), we did detect some differential results based on prerehabilitation cognitive status groups here at six-months plus after completing treatment, in spite of our small sample size. Most notably, participants who had more cognitive difficulty prior to starting treatment reported more improvement in daily activity participation and showed more improvement in performance on the learning and memory scale of a functional performance measure at long-term follow-up, perhaps demonstrating that these individuals had “room for improvement” in these domains. However, the majority of the results of this study suggest that participation in GOALS executive functioning training may contribute to improved functioning in cognitive, complex functional, mood, and daily functioning domains for Veterans with chronic TBI six months or longer after completing treatment, regardless of the presence or absence of objective cognitive difficulty pretreatment. These results suggest that participation in group-format executive functioning training is an effective intervention to address cognitive complaints associated with TBI, even very chronic injuries, and even for Veterans who may not demonstrate cognitive impairment on objective testing. However, we acknowledge that the lack of differences detected between groups here may represent failure to detect true differences due to small sample size and lack of power rather than true equivalency at follow-up on most outcomes between baseline cognitive status groups.

Our current results are interesting to consider in juxtaposition with the results of assessment immediately after training (Kornblith et al., 2018), which suggested that those participants with cognitive difficulty at baseline improved more after training on neurocognitive outcomes, whereas both groups improved on daily and emotional functioning outcomes. We suspect that both groups are now showing cognitive improvements because of the continued use of trained strategies, which 91% of our sample, regardless of baseline cognitive status, reported. In particular, participants reported continued use of the stop-relax-refocus metacognitive strategy as well as continued use of applied mindfulness. In addition, GOALS training may result in a meaningful increase in perceived self-efficacy through experiential demonstration of success in personal and group goals during training. Self-efficacy may be a moderator of outcomes following rehabilitation of TBI (Cicerone & Azulay, 2007; Cicerone, Mott, Azulay, & Friel, 2004), and reduced self-efficacy is a documented consequence of TBI (Moore & Stambrook, 1995). Although we did not measure self-efficacy in this study, we hypothesize that post-training increases in this dimension of self-concept could be driving the generalized improvement seen at follow-up, particularly in self-report of improvement in daily functioning. Another possible explanation for the absence of group (i.e., CD vs. CN) differences at follow-up is the fact that our sample at long-term follow-up is smaller compared to the sample size for the immediately postrehabilitation evaluation discussed above. Although we did detect some significant differences in the current study, the small N may have reduced our ability to detect all true differences in our data.

Strengths of this study include multilevel assessment and long-term post-treatment follow-up.

There are several important limitations of this study. The most important is small sample size, and replication of this research with larger samples is required. The small size of our sample significantly limits our ability to make confident assertions about the relationships between the variables studied, but our ability to detect some significant results (i.e., improvement at follow-up compared to baseline for
both groups) suggest that those are the strongest and most important relationships. However, our analysis and interpretation of the follow-up telephone interview data and difference between baseline cognitive status groups may be particularly vulnerable to low power and type II error because some of those interpretations rest on a lack of significant differences detected by our analyses. Another important limitation is the absence of a control group (i.e., all participants whose data were analyzed for the current study completed GOALS). Because we show greater improvement after GOALS versus the control intervention immediately post-treatment in the published results of the original clinical trial (Novakovic-Agopian et al., 2018) and because of the chronicity of the brain injuries studied, we hypothesize that the improvement seen at six months following completion of GOALS is likely related to treatment effects and not a result of simply being involved in the study or of natural improvement of TBI-related symptoms over time. The absence of correction for multiple comparisons is also a limitation; although we have provided a rationale for not doing so related to our expectations about the theoretically related nature of the outcomes, we recognize that future studies in this area may want to employ a correction for multiple comparisons to provide a more stringent criterion for judging statistically significant results.

The use of self-report data for some of the outcome measures is an additional limitation. Finally, more extensive evaluation, including neuroimaging, may be helpful in specifying injury-specific details and the potential neuroplastic effects of training.

Acknowledgments

We wish to thank participating Veterans and a number of individuals who made this study possible, in particular: Deborah Binder MS for helping with development of Brain Health Education training protocol; Gerald Carlin OTR/L, Fred Loya PhD, Michelle Madore PhD, Jim Muir PhD, Michelle Murphy PhD, Annemarie Rossi OTR/L, and Nick Rodriguez for their exceptional work with participant training and evaluations.

Disclosure statement

No conflict of interest exists.

Instrument availability

The long-term follow-up telephone interview questionnaire may be made available to interested researchers by contacting Tatjana.Novakovic-Agopian@va.gov.

Funding

This material is based upon work supported by the Department of Veterans Affairs Rehabilitation Research & Development Service Merit Review Awards [VANCHCS Project # B74671 and VA IIO1RX001111-01A1] and VA Office of Academic Affiliation Interprofessional TBI/Polytrauma Rehabilitation Research Fellowship.

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article has or will confer a benefit on the author(s) or on any organization with which the author(s) is/are associated. Archives of Physical Medicine and Rehabilitation, 85(6), 943–950. doi:10.1016/j.apmr.2003.07.019


