Rehabilitation of Executive Functioning With Training in Attention Regulation Applied to Individually Defined Goals: A Pilot Study Bridging Theory, Assessment, and Treatment

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Objective: To assess feasibility and effects of training in goal-oriented attentional self-regulation for patients with brain injury and chronic executive dysfunction. Participants: Sixteen individuals with chronic brain injury and mild to moderate executive dysfunction. Design: Participants were divided into 2 groups: one group completed goal-oriented attentional self-regulation training during the first 5 weeks, followed by a brief (2-hour) educational instruction session as a control midway through the second 5 weeks; the other group participated in reverse order. Measures: Neuropsychological and functional performance assessed at baseline and at weeks 5 and 10. Results: Participants found training in goal-oriented attentional self-regulation engaging, incorporated some trained strategies into daily life, and reported subjective improvements in personal functioning. At week 5, participants who completed training significantly improved on tests of attention and executive function and had fewer functional task failures, while performance did not change after educational instruction. At week 10, participants who crossed over from educational instruction to goals training also significantly improved on attention and executive function tests. Participants who crossed from goals training to educational instruction maintained their week 5 gains. Conclusions: Training in goal-oriented attentional self-regulation is theoretically driven and feasible in a research setting. Pilot results suggest improvements in cognitive and functional domains targeted by the intervention. Keywords: attention regulation training, brain injury, cognitive rehabilitation, executive control, functional performance, metacognitive training

The inability to pay attention, organize, and develop efficient strategies for completing daily activities is one of the most common and persistent sequelae of brain injury. These deficits represent failures of “executive control,” a collection of processes that are necessary for the regulation of goal-directed behavior, such as selective attention, working memory, task switching, sequencing, and planning.1,2 Deficits in executive control may directly contribute to poor outcomes and impede rehabilitation of dysfunction in other cognitive domains. If goal-directed control functions such as attention are not in place, other rehabilitation treatments are hampered.3–8

The material is based upon the work supported by the Office of Research and Development Rehabilitation R&D Service Department of Veterans Affairs, and the California Pacific Medical Center Foundation.

We thank participating patients and a number of individuals who made this study possible, in particular: Gary Ibarra, PhD, for helping with the development of the Goal Processing Questionnaire and advice; John Garfinkle, MS, CCC-SLP, for conducting functional evaluations; Sarah Ramsdale, OTR/L, for conducting therapy sessions; Cathy Kennedy, PT, and Byron Morganroth, MS, for their invaluable help with organizing and managing the study at California Pacific Medical Center, and Deborah Binder for helping with editing portions of this manuscript. We are grateful to Brian Levine, PhD, Ian Robertsson, PhD, and Tom Manly, PhD, for providing us with the Goal Management Training material and consultation during the research protocol development process, and to Kevin Barrows, MD, for use of his CD for mindfulness home practice.

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Increasing clinical evidence supports the proposition that training-based therapies targeting executive control processes, such as attention, problem solving, and the use of metacognitive strategies, may improve functioning in the individuals with brain injury.9–17 Our particular interest was in examining changes with an intervention that targets attentional control as a “gateway” function that could influence the efficiency and effectiveness of other executive functions.

Two conceptual lines converge to delineate target processes for intervention. First, pathways from perception to action require mechanisms for the selection of information for in-depth processing as well as the maintenance and protection of this information from disruption during working memory and subsequent learning, decision making, and/or problem solving. At the more basic level, deficits in selective information processing manifest as problems with distractibility, poor concentration, and poor ability to retain information. Second, at higher levels, many patients with brain injuries show an overall “life disorganization” with poor ability to manage and attain goals even when they may be able to describe their intentions at the outset. Duncan and others18,19 have described this phenomenon as “goal neglect.”

Maintenance of goal-related information is important for guiding sequences of steps (sub goals) required to accomplish the goal. At a more basic level, goal information provides an “attentional template” for guiding selective attention from the early stages of perception through working memory and beyond. Functions of attention and working memory are thought to play a central role in these selection and maintenance processes and appear to involve regions of prefrontal cortex as well as interconnected networks.20–22 Deficits in attention and working memory are common with acquired brain injuries, whether lesions are localized to prefrontal cortex, along white matter and interconnecting networks, or poorly localized, as is often the case with traumatic brain injury (TBI).2 We hypothesize that processes of selective information processing influence the efficiency and effectiveness of goal management. Therefore, intervening on these processes may help to ameliorate symptoms of goal neglect.

Goal Management Training (GMT) is an intervention designed to treat goal neglect by improving participants’ organization and ability to achieve goals (Robertson, Levine, & Manly, unpublished training material, 2005). It was originally conceptualized by Robertson23 and then elaborated and expanded by Levine and colleagues.24–26 It emphasizes the cessation of ongoing activity “STOP” and a metacognitive strategy for breaking down goals into manageable substeps, showing that learning of these strategies in a brief intervention improved goal management on tasks. Additional techniques, including a meditation technique, goal definition, task splitting, and monitoring, were also incorporated into their intervention. The training intervention implemented in the current study comprises modifications of GMT as well as attention, mindfulness, and problem-solving interventions described by Kabat-Zinn,27 Cicerone,16 d’Zurilla and Goldfried,28 Nezu, Nezu and D’Zurilla,29 Von Cramon et al,30 and Rath et al31. The resulting training protocol takes into account the links between attention and working memory through goal-based direction of behavior in daily life.

To maximize the potential for improving attention-regulation skills, and the goal-directed functions they support, the intervention implemented in this study emphasizes 2 key components. First, regulation of distractibility (redirection of attention to goal-relevant processes and the filtering of nonrelevant “noise” especially in the context of distractions) is addressed with mindfulness-based attention-regulation training. Second, these goal-oriented attentional self-regulation skills are practiced in daily life and actively applied to self-generated complex goals. Participants are asked to identify personally relevant and feasible functional goals as individual and group projects and are then trained in 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.

The goals of this pilot study were to determine the feasibility of administering this training protocol to the individuals with chronic brain injury and mild to moderate difficulties in executive functioning, and to assess the effects of the intervention at multiple levels of functioning. As a preliminary test of the theory, we evaluated the effects of training on the hypothesized target-cognitive processes of complex attention and executive function. Given the particular importance of functions of goal-directed processing in complex contexts, where distractions may disrupt pathways to goal attainment, we further examined effects in complex “real-life” settings. Hypothesized neural effects were tested with functional magnetic resonance imaging measures of goal-directed neural processing. This report focuses on the behavioral effects of training.

METHODS

Participants

This study was approved by institutional review boards at participating institutions, including California Pacific Medical Center, University of California, San Francisco and Berkeley; and the VA Medical Center in San Francisco. All participants provided informed consent prior to any of the study procedures taking place.
Behavioral assessments and interventions took place at California Pacific Medical Center.

Sixteen participants with chronic (more than 6 months) acquired brain injury were included in the study. Three additional participants completed partial baseline assessments but did not participate in the rest of the study because of change in health, family situation, and job demands. Participants were referred to the investigators from their physicians and treatment providers at several San Francisco Bay Area Hospitals.

The majority (11) of the participants had a history of TBI, 3 had a history of stroke or cerebral hemorrhage, 1 had brain tumor, and 1 had leukoencephalopathy (Table 1). All participants were on stable medication regimens during the study duration and had no active illicit drug use, severe depression, aphasia, or other conditions that would impede participation in the intervention or measurements. All participants were independent in basic activities of daily living but reported mild to moderate difficulties on daily tasks involving organization, problem solving, multitasking, and distractibility. At baseline assessment, only 1 of the 16 participants was working full-time (in a less-demanding job than prior to TBI). Prior to the injury, all were either working or studying full-time.

### Interventions

The goal-oriented attentional self-regulation training (goals training) involves ten 2-hour sessions of group-based training, 3 individual 1-hour training sessions, and approximately 20 hours of home practice over 5 weeks. It is conducted in a small group format with 2 to 5 patients and 2 instructors per group.

The group session outline is illustrated in Table 2. The main components include mindfulness-based attention-regulation training emphasized in the first half of the intervention and goal-management strategies applied to participant-defined goals emphasized in the second half of the intervention. The initial group sessions focus on attention-regulation training and incorporating strategies for reducing distractibility via in-class exercises and homework exercises with increasingly complex levels of application. As implemented in GMT, concepts of mindfulness and absentmindedness are introduced to raise awareness including the use of an absentmindedness homework log. In addition, the goals training emphasizes principles of applied mindfulness-based attention regulation to redirect cognitive processes toward goal-relevant activities even when distracted. This requires identifying the primary goal, dividing the information into relevant and nonrelevant, and working to selectively maintain relevant information while letting go of non-relevant information. Training via in-class exercises and homework is applied to progressively more challenging situations, including maintaining increasing amounts of information in mind and maintaining information during distractions.

Each group session begins with a brief applied mindfulness exercise as a first step in refocusing on tasks at hand. These exercises are supported by homework including daily practice with mindfulness in a quiet setting assisted by an audio CD from a traditional mindfulness-based stress-reduction course (provided by Kevin Barrows, MD, University of California, San Francisco). To assist application in daily-life situations, participants are trained in applying a single-phrase metacognitive strategy (which we called “STOP—RELAX—REFOCUS” [SRR]) to stop activity when distracted and/or overwhelmed, relax and then refocus attention on the current, primary goal. This is similar to the strategy called “Stop and Think” in Problem Solving Therapy and to “Stop and State” in GMT but with a greater emphasis on the importance of selective information processing to focus on goal-relevant information despite distractions. Participants are taught to actively apply goal-directed attention-regulation skills to a range of situations from simple information-processing tasks to complex multistep tasks to challenging situations in their life.

Homework includes practice in maintaining goal direction during challenging real-life situations identified by participants. At the beginning of each session, participants discuss the homework examples with the rest of the group. Homework includes logging successes and failures in applying SRR to anxiety-provoking situations in their daily life.

The second phase of training extends the application of goal-directed attentional self-regulation strategies to individually salient, self-generated complex goals. The stepwise goal management and execution strategies we chose to use were modified from the GMT and Problem Solving Therapy protocols. Several in-class exercises for introducing goal management concepts and strategies were modified from the Goal Management Training Manual materials, including a multi-tasking exercise derived from the Complex Task in GMT and a card-naming task derived from the Clapping task in GMT. As an initial step in practicing planning and execution of simple tasks, participants are assigned a homework task of bringing refreshments of their choice (eg, cookies, cheese, and crackers) for the rest of the group members for an assigned group session, while following a budget. To further emphasize active application of these strategies, participants are asked to identify feasible and realistic functional goals as individual projects (eg, planning a meal, learning to use an organizer, and follow a schedule) and group projects (eg, planning a group outing or presentation) and are then trained in goal-management strategies on the functional task(s) of their choice.

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### TABLE 1  Participant characteristics

<table>
<thead>
<tr>
<th>Part. #</th>
<th>Age</th>
<th>Gend.</th>
<th>Edu.</th>
<th>Brain Injury Information (time since injury)</th>
<th>Work/school at baseline (prior to intervention)</th>
<th>Primary functional complaints at baseline (prior to intervention)</th>
<th>Neuroimaging findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>F</td>
<td>19</td>
<td>TBI s/p MVA (23 y)</td>
<td>Working full-time, less demanding position than prior to injury</td>
<td>Difficulties at work with: easily overwhelmed by multiple tasks, difficulty prioritizing, very anxious when communicating with boss; lost several jobs since the injury</td>
<td>No detectable lesions or atrophy on MRI</td>
</tr>
<tr>
<td>2</td>
<td>56</td>
<td>F</td>
<td>16</td>
<td>Left thalamic stroke (1 y)</td>
<td>Not working, not going to school</td>
<td>Difficulties concentrating, structuring, prioritizing, and deciding on daily schedule/tasks, easily fatigued</td>
<td>Linear lesion in left thalamus, hypointense on T2-weighted MRI</td>
</tr>
<tr>
<td>3</td>
<td>58</td>
<td>M</td>
<td>16</td>
<td>Right frontal hemorrhage secondary to arteriovenous malfunction (1 y)</td>
<td>Not working, community college classes</td>
<td>Difficulties in concentration, planning, organizing, and remembering daily tasks; easily overwhelmed</td>
<td>Right frontal cystic lesion consistent with prior resection</td>
</tr>
<tr>
<td>4</td>
<td>31</td>
<td>M</td>
<td>16</td>
<td>TBI s/p fall left frontal contusion (1.5 y)</td>
<td>Not working, community college classes</td>
<td>Difficulties in sustaining attention and following through on daily tasks and activities; being more distractible and forgetful</td>
<td>Residual of left frontal hemorrhage, and multifocal T2 white matter hyperintensities</td>
</tr>
<tr>
<td>5</td>
<td>47</td>
<td>M</td>
<td>18</td>
<td>TBI s/p fall (1.5 y)</td>
<td>Not working, community college classes</td>
<td>Difficulties with concentration, organization, and multitasking</td>
<td>No detectable lesions or atrophy on MRI</td>
</tr>
<tr>
<td>6</td>
<td>34</td>
<td>F</td>
<td>16</td>
<td>TBI s/p MVA (1.5 y)</td>
<td>Not working, part time classes for BA degree</td>
<td>Difficulties at school with planning, multitasking, managing multiple assignments; fatigability; lost previous job</td>
<td>Small L frontal and inferior parietal white matter T2 hyperintensities on MRI</td>
</tr>
<tr>
<td>7</td>
<td>45</td>
<td>M</td>
<td>18</td>
<td>Leukoencephalopathy secondary to chemotherapy; (1 y)</td>
<td>Not working, community college classes</td>
<td>Difficulties with having hard time remembering new information, organizing and planning daily schedule</td>
<td>Generalized atrophy, small foci of subfrontal white matter T2 hyperintensity, linear right frontal track c/w prior catheter placement on MRI</td>
</tr>
<tr>
<td>8</td>
<td>62</td>
<td>M</td>
<td>18</td>
<td>TBI s/p assault, bi-frontal subdural hematoma (6 mo)</td>
<td>Working part-time; Same position as prior to injury</td>
<td>Difficulties at work and at home with multitasking, fatigue, planning, and sustaining attention on tasks</td>
<td>Generalized atrophy, split septum pellucidum on MRI</td>
</tr>
<tr>
<td>9</td>
<td>60</td>
<td>F</td>
<td>18</td>
<td>TBI s/p MVA (2.5 y)</td>
<td>Not working; Not going to school</td>
<td>Difficulties with multitasking, organization, planning, sustaining attention on tasks, being more easily fatigued</td>
<td>No gross structural findings. Small T2 hyperintensity adjacent to anterior horn and posterior horn of R lateral ventricle</td>
</tr>
</tbody>
</table>

(continues)
<table>
<thead>
<tr>
<th>Part. #</th>
<th>Age</th>
<th>Gend.</th>
<th>Edu.</th>
<th>Brain Injury Information (time since injury)</th>
<th>Work/school at baseline (prior to intervention)</th>
<th>Primary functional complaints at baseline (prior to intervention)</th>
<th>Neuroimaging findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>63</td>
<td>F</td>
<td>16</td>
<td>Right temporoparietal tumor resection (1.5 y)</td>
<td>Not working; Not going to school</td>
<td>Difficulties with concentration, fatigue, planning daily schedule on daily tasks, and caring for husband</td>
<td>Confluent white matter T2 hyperintensities throughout both hemispheres. Right temporoparietal lesion c/w tumor resection. Left inferior frontal lesion with surrounding T2 hyperintensity</td>
</tr>
<tr>
<td>11</td>
<td>51</td>
<td>F</td>
<td>17</td>
<td>TBI s/p MVA (1.5 y)</td>
<td>Not working; Not going to school</td>
<td>Difficulties with daily tasks at home: initiation, sustaining attention on tasks, organization, following through</td>
<td>Right frontal encephalomalacia with lesser left medial and orbitofrontal encephalomalacia, ventriculomegaly and enlarged sulci</td>
</tr>
<tr>
<td>12</td>
<td>55</td>
<td>F</td>
<td>16</td>
<td>TBI s/p fall, left-frontal contusion (1 y)</td>
<td>Not working; Not going to school</td>
<td>Difficulties with organization and planning of daily activities</td>
<td>Left orbitofrontal encephalomalacia and T2 hyperintensity c/w gliosis</td>
</tr>
<tr>
<td>13</td>
<td>24</td>
<td>M</td>
<td>15</td>
<td>TBI s/p fall + multiple blast exposures (4 y)</td>
<td>Not working; Full-time classes for BA degree</td>
<td>Difficulties with concentration, multitasking, keeping up with schoolwork; easily overwhelmed</td>
<td>No detectable lesions or atrophy on MRI</td>
</tr>
<tr>
<td>14</td>
<td>41</td>
<td>M</td>
<td>15</td>
<td>TBI s/p fall + multiple blast exposures (5 y)</td>
<td>Not working; Part time classes for BA degree</td>
<td>Difficulties with school assignments: organization, concentration, multitasking, easily overwhelmed</td>
<td>No detectable lesions or atrophy on MRI</td>
</tr>
<tr>
<td>15</td>
<td>62</td>
<td>F</td>
<td>16</td>
<td>Left basal ganglia stroke (2 y)</td>
<td>Not working; Community college classes</td>
<td>Difficulties with initiation, organization, planning, and following through with daily tasks</td>
<td>Multiple T2 hyperintensities in frontal-subcortical, periventricular and occipital white matter, with enlarged sulci</td>
</tr>
<tr>
<td>16</td>
<td>57</td>
<td>F</td>
<td>16</td>
<td>TBI s/p fall (6 y)</td>
<td>Not working; Not going to school</td>
<td>Difficulty with initiation, planning and follow through with more challenging activities, easily overwhelmed</td>
<td>No detectable lesions or atrophy; Incidental finding of small pineal cyst</td>
</tr>
</tbody>
</table>

Abbreviations: MRI, magnetic resonance imaging; s/p, status post; TBI, traumatic brain injury; MVA, motor vehicle accident.
TABLE 2  Goal-oriented attentional self-regulation training session outline

<table>
<thead>
<tr>
<th>Session</th>
<th>Applied attention regulation</th>
<th>Applied problem solving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 1</td>
<td>Introduction and overview</td>
<td>Absentmindedness and mindfulness</td>
</tr>
<tr>
<td>Session 2</td>
<td>Progressive information maintenance: Mindfulness exercises</td>
<td>Goal selection: Options for group and individual projects</td>
</tr>
<tr>
<td>Session 3</td>
<td>Breaking down projects into subtasks, creating timeline. Apply to group and individual projects</td>
<td>Execution and dealing with procrastination</td>
</tr>
<tr>
<td>Session 4</td>
<td>Staying on tasks, error correction, and adjustments</td>
<td>Project progress review and adjustments</td>
</tr>
<tr>
<td>Session 5</td>
<td>Individual project presentation</td>
<td>Group project presentation and graduation celebration</td>
</tr>
</tbody>
</table>

The 3 individual sessions are distributed at the beginning, middle, and toward the end of the training. Sessions focus on the following goals.

Session 1: Orientation to the training program, including orientation to and clarification of the Participant Handbook, discussion of (a) common internal and external distractions encountered and potential solutions, (b) homework implementation (eg, listening to mindfulness tape, noticing absentminded slips in daily life), and (c) feasible individual goals.

Session 2: Review of implementation of the following program strategies: (a) discussion of plans for individual and group projects, (b) identification of challenges to project completion (eg, anxiety-provoking situations, procrastination), and (c) discussion of successes and failures in homework implementation (eg, use of SRR in daily life).

Session 3: Review of implementation of SRR and other strategies in daily life. Review of implementation and adjustments for individual and group projects.

To ensure consistency of administration, an intervention manual was written for both the instructors and the participants. Clinicians experienced in working with individuals with brain injury (occupational therapists, neuropsychologist) were trained in administering the research intervention and were supervised by one of the authors of the instruction manual (Novakovic-Agopian).

The brief comparison intervention involved didactic instruction regarding brain injury and resources in a 2-hour session during the other 5-week period and was administered by the same trainers.

**Design**

A pseudo-random crossover design was employed. The goals-edu group started with goal-oriented attentional self-regulation—goals training, and crossed over to brain health educational instruction after 5 weeks. The edu-goals group started with the education instruction and crossed over to the goals training after 5 weeks. Sixteen participants (described in Table 1) completed the 10-week pilot study protocol. Participants were placed in small groups (average group size was 3 participants) based on common factors (eg, interests, age). Eight participants started with goals training, and 8 started with educational instruction. There was no significant difference between the 2 groups in age (goals-edu mean = 49.0 years, standard deviation = 12.1; edu-goals mean = 51.6 years, standard deviation = 13.2), education (goals-edu mean = 17.3 years, standard deviation = 1.25; edu-goals mean = 16.1 years, standard deviation = 0.99), and cognitive performance in executive function and memory domains (Attention and Executive Function Domain z score goals-edu mean = −0.42, standard deviation = 0.63, edu-goals mean = −0.40, standard deviation = 0.48; and Memory Domain z score goals-edu mean = −0.50, standard deviation = 1.05; edu-goals mean = −0.16, standard deviation = 0.78). As shown in Table 1, the majority of participants in both groups had a history of TBI (6 of 8 in the goals-edu group and 5 of 8 in the edu-goals group).

**Measures**

Participants were evaluated with a multilevel battery consisting of neuropsychological and functional (“real-life”) measures at baseline, week 5, and week 10, after either goals training or educational instruction. Functional magnetic resonance imaging data were acquired in an adjunct study but are not presented in this report.

**Neuropsychological assessment**

The neuropsychological battery used in this study was developed to assess performance in cognitive domains of complex attention and in executive function that are commonly affected by TBI and targeted by goals training. Working memory with distractions was assessed with (1) Auditory Consonant Trigrams requiring recall of 3 consonants after counting backward by 3 from a specified number for a variable amount of time, and...
(2) Letter Number Sequencing Wechsler Adult Intelligence Scale Third Edition (WAIS III), requiring mental reordering of scrambled letter-number series of increasing lengths. Sustained attention was assessed with the timed Digit Vigilance test, requiring detection and crossing out of a specified number intermixed with other numbers on 2 pages. Inhibition of automatic responding was assessed with Stroop Inhibition Delis-Kaplan Executive Function System (DKEFS) in which words are printed in dissonant ink color and participants are instructed to name the color of the ink instead of the more automatic response of reading the word. Mental flexibility was assessed with (1) Trails B, requiring rapid alternation between letters and numbers to connect them in order; (2) Design Fluency-Switching DKEFS, requiring alternating between empty and filled dots while generating different designs with 4 lines; (3) Verbal Fluency Switching DKEFS, requiring generating words that belong to 2 specified categories and alternating between them; and (4) Stroop Inhibition-Switching DKEFS, during which the participant is presented with words printed in dissonant ink color, some of which are contained in boxes, and the participant is instructed to name the color of the ink unless the word is inside the box, in which case they are to read the word.

Performance on verbal and visual memory tests was assessed with Hopkins Verbal Learning Test–Revised (HVLT-R), requiring participants to learn 12 words after 3 learning trials and to recall them after 25 minutes, and with Brief Visual Memory Test–Revised, requiring participants to learn and reproduce 6 abstract designs over 3 learning trials and to reproduce them after 25 minutes. Verbal and visual memory may be indirectly affected by changes in attention and executive functioning.

Participants’ performance in cognitive domains commonly affected by TBI, but not targeted by the intervention, was also assessed as a marker of potential non-specific changes. Psychomotor speed and reaction time were assessed with Trails A, requiring rapidly connecting in order numbers on a page and with Visual Attention Task Overall RT, requiring responding rapidly to a target stimulus presented on a computer screen.

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

Functional assessments

It may be argued that the accurate measurement of executive control functioning requires observation and quantification of performance with real-life, functional tasks that demand planning, multitasking, and goal management in a low structure environment. To address the functional and ecological limitations of conventional clinical neuropsychological tests in characterizing executive dysfunction, we included functional assessments in the neurobehavioral test battery (for further discussion, see Burgess et al and Wilson).

Participants completed a functional assessment task, the modified Multiple Errands Task (MET). MET is an unstructured functional task that allows clinicians to directly assess a patient’s ability to follow outlined rules and complete multiple “real-world” tasks in a limited time period. While keeping the main subcomponents of the task outlined in Alderman and Knight et al, we adapted MET to be used in local hospital settings and developed 3 alternate forms to allow for longitudinal assessments. Participants were presented with written instructions and a hospital map and asked to complete 12 subtasks in 40 minutes, while following 9 specified task rules. The 12 subtasks involved performing different activities (eg, buying specified items, collecting an envelope with instructions from a specific location, using a hospital phone system to reach a specific person); obtaining information (eg, determining the opening time of the hospital shop on a Saturday or the name of the US city predicted to reach the highest temperature tomorrow); and stopping ongoing activity to meet the evaluator at a specified place and time. To minimize practice effects, 3 alternate forms specifying 12 subtasks were used at baseline and at weeks 5 and 10. For example, one of the subtasks at baseline involved buying a bottle of water, at week 5 a can of coke, and at week 10 an apple juice. Task performances are rated as follows: 0 = successful completion, 1 = partial completion, and 2 = failure, so that a maximum number of task failures is 24. The 9 task rules included the following: not leaving the hospital grounds, spending a maximum of $5.00 (they are given a $10.00 bill), not entering a building or room without completing part of the task inside, not going back to the same hospital area more than once; buying no more than 2 items from 1 location, not talking about things unrelated to the task, and completing a task in the allotted time.

Repeated neuropsychological and functional measures were administered by the same evaluator and every attempt was made to administer them at the same time of the day. Although evaluators were not unaware of the treatment condition, evaluators and therapists were separate individuals.

Participants also completed a questionnaire designed to assess changes in specific functional domains related to goal processing (eg, planning, attention maintenance, self-monitoring) after training (Goal Processing Questionnaire).

Statistical considerations

All neuropsychological test data were scored on the basis of standardized age and, when available, www.headtraumarehab.com
educational and repeated administration norms, and transformed into z scores for consistency. To assess the impact of training on targeted cognitive domains and reduce the variability and number of multiple comparisons, z scores of individual neuropsychological tests were averaged into the overall Attention and Executive Function Domain Score as well as the other Cognitive Sub-Domain Scores.

**Attention and Executive Function domain score (average of z scores):** Letter Number Sequencing; Auditory Consonant Tri- grams 9, 18, 36 seconds; Digit Vigilance Test -Time and Errors; Design Fluency Switching; Verbal Fluency Switching; Trails B; Stroop Inhibition/Switching-Time and Errors; Stroop Inhibition-Time and Errors.

**Mental Flexibility subdomain score (average of z scores):** Design Fluency Switching; Visual Attention Test Overall RT.

**Sustained Attention subdomain score (average of z scores)** Digit Vigilance Test -Time and Errors

**Inhibition subdomain score (average of z scores)** Stroop Inhibition-Time and Stroop Inhibition Errors

**Memory domain score (average of z scores):** HVLT-R Total Recall; BVMT-R Total Recall; HVLT-R Delayed Recall; and BVMT-R Delayed Recall.

**Learning subdomain score (average of z scores):** HVLT-R Total Recall; and BVMT-R Total Recall.

**Delayed Recall subdomain score (average of z scores):** HVLT-R Delayed Recall; and BVMT-R Delayed Recall.

**Motor Speed of Processing domain score (average of z scores)** Trails A; and Visual Attention Test Overall RT.

All statistical analyses were conducted using SAS v9.2. Comparisons between groups were made using t tests, comparisons within groups (pre- to postintervention) used paired t tests.

**RESULTS**

Of 19 participants who were consented for the study, 16 (84%) completed the 10-week protocol. The 3 participants who withdrew did so during baseline assessments because of circumstances unrelated to the study (change in health, job demands, or death in the family). Fifteen of 16 participants who completed the 10-week study completed all 3 neuropsychological and functional assessments (baseline, week 5, and week 10), and 1 completed the functional evaluation but not the neuropsychological assessment at week 10 because of a family emergency. In addition, more than half of the participants who completed the 10-week protocol desired to continue with the training even after the study completion.

This study employed a crossover design, with each of 2 groups exposed to both the intervention (goals training) and the control (educational instruction) activities for a period of 5 weeks each. The primary analysis assessed differences in change between the 2 groups at week 5. Second, an analysis for the corroboration of the goals training intervention effects using a within-subject comparison was afforded by the crossover from educational instruction to goals training. Third, maintenance effects of goals training were evaluated by Assessment 3 in the goals-edu groups.

**Primary analysis—study period 1: Changes from baseline to week 5**

During the first 5 weeks, the goals-edu group received goals training, while the edu-goals group received brief educational instruction. Assessments made at the end of the first 5-week period were compared with the assessments made at baseline for each group, and changes were compared between the 2 groups. As shown in Figure 1, the 8 participants who had goals training during this period showed improvement of close to 1 SD relative to baseline (P < .0001) on the overall Attention and Executive Function summary domain while the 8 participants who had the brief educational instruction showed minimal or no change.

Changes in neuropsychological domain scores for the 2 groups are presented in Figure 2. In addition to the Attention and Executive Function domain, significant differences in change from baseline to week 5 were detected between the 2 groups in the Memory Domain (P = .006). No significant differences in change were seen between the two groups for Speed of Processing.

Changes in individual neuropsychological tests are listed in Table 3, organized by domains. Within the Attention and Executive Function summary domain, significant group differences in change over the first 5-week period were detected in the following subdomains: Working Memory (P < .0001), Mental Flexibility (P = .009), Inhibition (P = .005), and Sustained Attention (P = .01). Within the Memory Domain, significant differences in change were detected for the Learning (P = .02) and Delayed Recall (P = .01) subdomains. For each of these subdomain scores, the pre- to postintervention changes were greater for the goals training group. No significant differences in change from baseline to week 5 were seen between the two groups for Speed of Processing.

When the change in the number of task failures on the Multiple Errands Test was assessed separately for each group, the goals-edu group had significantly fewer Task Failures after goals training (P < .01), while the difference for edu-goals group was not significant after the brief
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Goals training

**Figure 1.** Changes in attention and executive function domain z scores for individual participants in the goals-edu and edu-goals groups.

Educational instruction. Although there was a greater decrease in the number of task failures in the goals-edu group than in the edu-goals group over the first 5-week period, this difference was not significant. These results suggest a trend toward improvement on a complex functional task after goals training, but the small sample size did not give enough power to detect the between-group difference.

**Study period 2: Changes from week 5 to week 10**

After completing the first 5 weeks of training, the participants in the 2 groups crossed over to different interventions. The relevant data were analyzed separately and are presented in Table 3 and Figures 1 and 2.

**Goals-training intervention effect after “multiple baselines”**

Relative to their performance at week 5, after completing goals training, the participants in edu-goals group significantly improved by week 10 in the overall Attention and Executive Function Domain (P < .0001) and the following subdomains: Working Memory (P = .0008), Mental Flexibility (P = .0008), Inhibition (P = .01), and Sustained Attention (P = .01). Their performance also improved in the Memory Domain (P = .02), Learning (P = .05), and Delayed Recall subdomains (P = .02) but not on the Speed of Processing. This group showed a trend toward fewer task failures on the Multiple Errands Test.

**Crossover from goals training to educational instruction—Maintenance effects**

Relative to their performance at week 5, participants in goals-edu group who completed educational instruction during the second 5 weeks maintained their gains from week 5 and did not significantly change in most cognitive domains or in the number of task failures on the Multiple Errands Test. The exceptions to this were improved performance in the overall Attention and Executive Function domain (P < .04) and Working Memory subdomain (P < .02).

**Self-report measures**

At completion of week 10 of training, participants rated the relative changes in their abilities from pre- to posttraining on a scale 0 to 10 (0, much worse; 5, no change; and 10, much better; Goal Processing Questionnaire). Their responses are summarized in Table 4.
Individual and group projects

Examples of individual projects completed by participants during goals training include the following: Implementing a calendar/organizational system to increase follow-through with school assignments and daily tasks; inventorying, cleaning up and making a spread sheet of all family medications so they could be monitored and refilled as appropriate; cooking a family meal, including purchasing ingredients and following a recipe; taking recertification classes to regain driver’s license; and getting a personal trainer and creating and following through on a physical workout regimen for the first time in his life.

The group projects included Brain Injury Information and Resources Handbooks and pamphlets, videotape on living with brain injury with examples from participants’ daily lives, and presentation on accessible recreational outings participants took as a group.

DISCUSSION

The first aim of this pilot study was to assess the feasibility of administering the research intervention and multilevel assessment to the individuals with brain injury and chronic mild to moderate difficulties in executive functioning. Participant feedback and a high rate of successful completion of the protocol suggest that this protocol for training in goal-oriented attentional self-regulation is feasible and practically applicable in a clinical research setting.

The second aim was to assess and characterize training-related changes in participant functioning on functional (“real-life”) measures as well as domain-specific neuropsychological measures. It may be argued that the ecologically valid measurement of executive control functioning requires observation and quantification of performance with real-life, functional tasks in a low structure environment. Following goals training, the participants showed a decrease in task failures on a complex functional task confirming generalization of training effects to functional performance in complex, real-life settings. Furthermore, participants improved on neuropsychological measures of complex attention and executive functions, including working memory, mental flexibility, inhibition, and sustained attention. These findings were consistent with the hypothesized cognitive targets of the training.

There may have been a particularly strong effect on the tests most related to the protection of working memory from distractions. The robustness and specificity of this finding was unexpected, though consistent with the theoretical targets of the intervention. We theorized that the essential ingredients of this intervention included mindfulness-based attention-regulation techniques that were introduced during the initial training sessions and...
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43 Further attention-regulation techniques, although further psychological testing provide preliminary support for these strategy. The findings from domain-specific neuropsychological daily lives involved the applied mindfulness-based at-

TABLE 3 Individual Neuropsychological Tests and Domain Scores Change for the 2 Groups

<table>
<thead>
<tr>
<th>Neuropsychological tests and domains</th>
<th>Study period 1 Mean change in z score from week 0 to week 5</th>
<th>Study period 2 Mean change in z score from week 5 to week 10</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>goals-edu (Group 1)</td>
<td>goals-edu (Group 2)</td>
</tr>
<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>Attention and Executive Function</td>
<td>0.84 0.17</td>
<td>0.03 0.11</td>
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<tr>
<td>Summary Domain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Working Memory Subdomain</td>
<td>1.12 0.93</td>
<td>−0.12 0.22</td>
</tr>
<tr>
<td>Letter Number Seq.</td>
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<td>−0.11 0.66</td>
</tr>
<tr>
<td>Auditory Cons. Trig. 9 s.</td>
<td>0.99 0.58</td>
<td>0.03 0.42</td>
</tr>
<tr>
<td>Auditory Cons. Trig. 18 s.</td>
<td>1.33 0.96</td>
<td>−0.30 0.59</td>
</tr>
<tr>
<td>Auditory Cons. Trig. 36 s.</td>
<td>1.35 0.76</td>
<td>−0.09 0.43</td>
</tr>
<tr>
<td>Mental Flexibility Subdomain</td>
<td>0.64 0.48</td>
<td>0.04 0.08</td>
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<tr>
<td>Design Fluency Switching</td>
<td>0.78 0.92</td>
<td>0.18 0.39</td>
</tr>
<tr>
<td>Verbal Fluency Switching</td>
<td>1.54 1.63</td>
<td>0.07 0.44</td>
</tr>
<tr>
<td>Trails B</td>
<td>0.39 0.31</td>
<td>−0.03 0.24</td>
</tr>
<tr>
<td>Stroop Inhib./Switch.- Time.</td>
<td>0.83 0.38</td>
<td>0.01 0.24</td>
</tr>
<tr>
<td>Stroop Inhib./Switch.- Error</td>
<td>0.12 0.59</td>
<td>−0.03 0.56</td>
</tr>
<tr>
<td>Sustained Attent. Subdomain</td>
<td>0.96 0.56</td>
<td>0.27 0.23</td>
</tr>
<tr>
<td>Digit Vigilance Test: Time</td>
<td>0.83 0.93</td>
<td>0.05 0.40</td>
</tr>
<tr>
<td>Digit Vigilance Test: Error</td>
<td>1.10 0.76</td>
<td>0.49 0.52</td>
</tr>
<tr>
<td>Inhibition Subdomain</td>
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<td>0.04 0.25</td>
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<tr>
<td>Stroop Inhibition: Time</td>
<td>0.83 0.48</td>
<td>0.17 0.18</td>
</tr>
<tr>
<td>Stroop Inhibition: Error</td>
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<td>−0.08 0.41</td>
</tr>
<tr>
<td>Learning Subdomain</td>
<td>0.45 0.38</td>
<td>−0.10 0.28</td>
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<tr>
<td>HVLТ-R Total Recall</td>
<td>0.51 0.38</td>
<td>0.08 0.26</td>
</tr>
<tr>
<td>BVMT-R Total Recall</td>
<td>0.39 0.42</td>
<td>−0.09 0.33</td>
</tr>
<tr>
<td>Delayed Recall Subdomain</td>
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<td>0.25 0.40</td>
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<tr>
<td>HVLT-R Delayed Recall</td>
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<tr>
<td>BVMT-R Delayed Recall</td>
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<td>−0.37 0.62</td>
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<td>Motor Speed of Processing</td>
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<td>−0.18 0.46</td>
</tr>
<tr>
<td>Summary Domain Score</td>
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<td>−0.03 0.29</td>
</tr>
<tr>
<td>Trails A</td>
<td>0.48 0.78</td>
<td>−0.06 0.35</td>
</tr>
<tr>
<td>Visual Atten. Test RT</td>
<td>0.31 0.57</td>
<td>0.06 0.46</td>
</tr>
</tbody>
</table>

*aP < .05.

applied throughout classroom and home practice, including complex goal management in their daily lives. In post-participation interviews, participants reported that the aspects of the intervention most helpful in their daily lives involved the applied mindfulness-based attention-regulation technique. The findings from domain-specific neuropsychological testing provide preliminary support for these attention-regulation techniques, although further investigation will be needed to more fully determine essential aspects of the training intervention.43 Further supporting the hypothesized targets of training, no changes were found on measures of basic psychomotor speed. Direct comparisons between the magnitudes of changes on different tests or domains were not pursued because of low statistical power.

Relevant to questions of transfer, participants’ improvements on memory measures occurred despite the use of alternative test forms to minimize practice effects, and absence of direct memory training. This suggests that improvements in memory domain were most likely related to improvements in attention and executive functions. In particular, decreased distractibility and improved ability to select and hold goal-relevant information in mind are likely to optimize one’s ability to learn new information and be more efficient in retrieving it later. In contrast, participants’ performance did not change in any of the domains mentioned earlier after the brief control educational instruction.

One goal of the current approach was to provide strategies applicable to everyday life even after the cessation of formal training. To assess the subjective changes.

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in strategy use, participant self-reports were collected. Responses suggested improvements in abilities to stop and relax during stressful times, refocus on a goal, hold goal-relevant information in mind, and break complex tasks into manageable components. Participants also reported applying some of the trained strategies to challenging situations in their lives, such as studying for and taking examinations and talking to their boss.

Participants appeared able to maintain training gains at short-term follow-up based on examination of week 10 assessments in the goal-edu group. Furthermore, results suggest continuing improvement on measures of attention and executive function and working memory. One explanation for this may be continued practice of skills and strategies learned even after completion of training as reported anecdotally by several participants. In particular, participants reported continued use of the applied mindfulness exercises and “Stop–Relax–Refocus” strategy several months after completion of the study. However, additional follow-up is needed to assess the longer-term effects of the intervention.

The findings from this study support the use of problem solving and metacognitive strategies also included in a number of other interventions, including problem-solving and goal-management protocols developed by d’Zurilla and Goldfried, Von Cramon et al, Rath et al, and Levine et al. For example, in GMT, patients are trained in clearly defining a goal, learning the steps required to achieve it, and then regularly checking their progress. Schweizer et al described successful strategy application and improvements in performance with this approach in a case study as well as in a controlled study of healthy older adults. The current intervention extends this by placing greater emphasis on attention regulation, with the idea that improving goal-directed attention regulation would benefit all subsequent stages of goal management. In contrast with more basic attention training protocols, we felt it important to connect the attention training with actual goal-management activities in which attention regulation plays an important functional role.

Another intervention that combines attention and problem solving as targets of therapy is an attention and problem solving group-based training protocol recently described by Evans et al. Initial group sessions address attentional difficulties and later ones introduce and allow practice of problem-solving strategies. During group sessions, participants are encouraged to adopt a systematic approach to solving problems and to manage and monitor goal achievement through periodic mental checking. In a recent study by Miotto et al, participants with chronic frontal lesions showed improvement on a functional measure (Multiple Errands Test) and on caregiver ratings of executive functioning (DEX Questionnaire) but not on neuropsychological tests after the implementation of the attention and problem-solving training relative to control conditions.

This study has several limitations. The sample size was relatively small, limiting the power to detect between-group differences for the functional measurements that have higher variability. Sample size also limited analyses of the relations between measurements. The control intervention (educational instruction) allowed assessment of test-retest effects but did not control for therapist interactions, time, and attention. An additional limitation was that although evaluators and therapists were separate individuals and repeated assessments were administered by the same evaluator, evaluators were aware of the participant’s treatment condition.

The development of novel treatments may benefit from an improved understanding of the neural bases of training therapies such as this. Two recent reviews of interventions for executive dysfunction have noted a gap between theories about subsystems of executive functions and intervention design and practice. Understanding the neural bases of these subsystems of executive control, including the mechanisms by which improvements occur, may provide a foundation for guiding the development of treatments to enhance executive control functioning. We would
hypothesize that training effects may be mediated by modulation of prefrontal cortex functioning, including altering network interactions involved in selective information processing. These hypotheses may be testable using functional neuroimaging techniques.

In sum, this protocol for training in goal-oriented attentional self-regulation is theoretically driven and feasible to apply in a clinical research setting. Cognitive and functional performance assessments as well as participant self-report measures appear to support improvements in cognitive and functional domains emphasized by training, including selecting and holding goal-relevant information in mind in the face of distractions during the course of goal attainment.

REFERENCES


