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Rehabilitation of executive functioning: An experimental–clinical validation of Goal Management Training

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Abstract

Two studies assessed the effects of a training procedure (Goal Management Training, GMT), derived from Duncan's theory of goal neglect, on disorganized behavior following TBI. In Study 1, patients with traumatic brain injury (TBI) were randomly assigned to brief trials of GMT or motor skills training. GMT, but not motor skills training, was associated with significant gains on everyday paper-and-pencil tasks designed to mimic tasks that are problematic for patients with goal neglect. In Study 2, GMT was applied in a postencephalitic patient seeking to improve her meal-preparation abilities. Both naturalistic observation and self-report measures revealed improved meal preparation performance following GMT. These studies provide both experimental and clinical support for the efficacy of GMT toward the treatment of executive functioning deficits that compromise independence in patients with brain damage. (*JINS*, 2000, *6*, 299–312.)

Keywords: Traumatic brain injury, Frontal lobes, Strategy application, Goal neglect

INTRODUCTION

> *Before going to work, Robert quickly made a sandwich with all his favourite ingredients. He wrapped it up, then picked up his bag and went to work. Feeling hungry at lunch time, he reached for his sandwich, only to realize that he left it sitting on his kitchen counter at home.*
>
> *Peggy decided to tidy up her messy apartment for some visitors. On the bureau, she noticed a letter from her friend that she had never answered. An hour later, she had written a reply to her friend, but her apartment never got tidied, and the visitors were about to arrive.*

Maintaining intentions in goal-directed behavior (hereafter referred to as goal management) depends on higher-level control over more basic cognitive and motor processes. As such, it is considered an executive function associated with the frontal lobes (Duncan, 1986; Norman & Shallice, 1986). For most people, goal management deficits (i.e., "goal neglect"; Duncan et al., 1996) like the ones illustrated above are an occasional nuisance. For many people with injuries and diseases of the brain, however, disorganized behavior associated with goal neglect is an everyday occurrence that compromises functional independence.

Traumatic brain injury (TBI), which affects ventral frontal and anterior temporal cortices and ascending systems involved in arousal and regulation, is among the most common causes of executive dysfunction (Mattson & Levin, 1990; Stuss & Gow, 1992). In particular, TBI-related goal management deficits have been documented in laboratory studies of strategic self-regulation (Levine et al., 1998; Robertson et al., 1997; Whyte et al., 1996). The real-life everyday disorganization caused by such deficits is often the chief cognitive complaint in patients with TBI (Mateer et al., 1987), and is associated with negative occupational outcomes (Crépeau & Scherzer, 1993).

In spite of the impact of goal neglect on patients' day-to-day lives, there are few theoretically grounded, experimentally validated rehabilitation protocols for this problem. This is attributable to a focus on behavioral deficits that are quan-

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tified in the laboratory (e.g., performance on tests of memory and attention), whereas goal neglect occurs in naturalistic situations in which behavior is not constrained by environmental structure or overlearned habits.

To address this need, Robertson (1996) developed Goal Management Training (GMT), a structured, interactive, manual-based rehabilitation protocol based on Duncan's (1986) theory of disorganization of behavior following frontal lobe lesions. As many authors have pointed out (e.g., Miller et al., 1960; Newell & Simon, 1963) much of human behavior is controlled by goal lists, or lists of goals and subgoals constructed in response to environmental or internal demands (e.g., get ready for guests to arrive). When the current state of affairs does not match the goal state, a store of actions is consulted, and actions are then activated to resolve the discrepancy in an iterative process. However, actions can also be activated in response to competing and sometimes irrelevant input (e.g., the letter on the bureau; see also Norman & Shallice, 1986). A function of the goal list is to impose coherence on behavior by controlling the activation or inhibition of actions that promote or oppose task completion. An important aspect of goal-directed behavior is the selection of new actions when previously selected actions fail to achieve the goal. According to Duncan (1986), much of the disorganized behavior seen in patients with frontal systems dysfunction (i.e., dysfunction in the frontal cortex or its interconnections) can be attributed to impaired construction and use of such goal lists.

Each of the five GMT stages corresponds to an important aspect of goal-directed behavior (see Figure 1). In Stage 1, orienting, participants are trained to assess the current state of affairs and direct awareness towards relevant goals. Goals are selected in Stage 2, and these are partitioned into subgoals in Stage 3. Stage 4 concerns encoding and retention of goals and subgoals. In Stage 5, the outcome of action is compared with the goal state (monitoring). In the event of a mismatch, the entire process is repeated.

This paper describes two applications of GMT. In Study 1, we implemented a brief version of GMT to patients with traumatic brain injury (TBI) and impaired self-regulation in a randomized group trial. The group trial demonstrated the potential efficacy of GMT in real-life situations using paper-and-pencil tasks similar to many everyday activities. Study 2 is a single-case study in which GMT was expanded and used to improve disorganized meal preparation behavior in a postencephalitic patient.

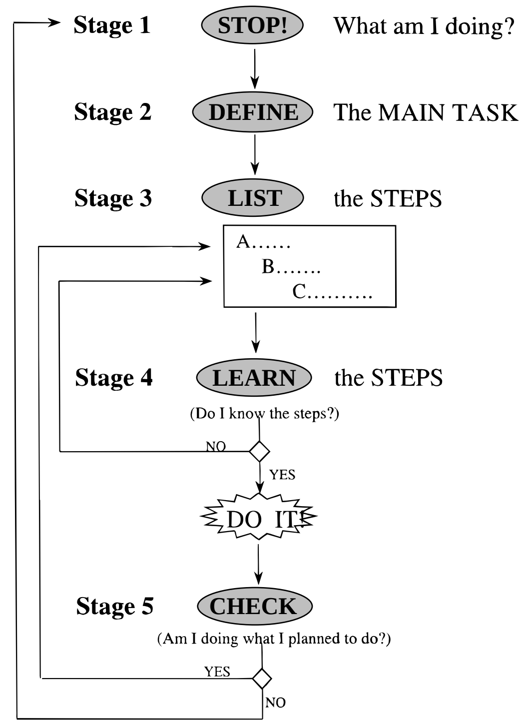

Fig. 1. Flowchart used to illustrate the five steps in goal management training.

STUDY 1

Because of the prevalence of goal management deficits in patients with TBI (Levine et al., 1998; Mateer et al., 1987; Robertson et al., 1997; Whyte et al., 1996), we elected to validate GMT using TBI patients. Thirty participants were randomly assigned to receive brief trials of GMT or motor skills training (MST). Before and after training, both groups completed an investigation of everyday paper-and-pencil tasks designed to mimic unstructured situations that give rise to goal management deficits. We hypothesized that the participants receiving GMT would show greater improvement on the posttraining tasks (relative to the pretraining tasks) than the participants receiving MST.

Methods

Research participants

Training was administered along with a battery of cognitive and psychosocial outcome measures 3 to 4 years post-TBI. Initial contact took place in-hospital (at the time of injury) within a series of 94 consecutive admissions to a major medical trauma center. Injury and acute recovery characteristics were meticulously documented in the context of a research project on posttraumatic amnesia (Schwartz et al., 1998; Stuss et al., 1999). After exclusions due to serious medical illness or death, psychiatric illness, substance abuse, refusals to participate, and loss of contact over the 3 to 4 years, 30 were available for participation. These patients represented the full range of TBI severity, from mild to severe (with the constraint that all patients were hospitalized). Severity indicators (the Glasgow Coma Scale, GCS, and posttraumatic amnesia, PTA) indicated an overall moderate level of severity. All participants were living independently, classified as *good recovery* (N = 24) or *moderate disability* (N = 6) according to the Glasgow Outcome Scale (Jennett & Bond, 1975). None had focal neurological syndromes or linguistic or mnestic disorders that would prevent them from participating in the training or completing the assessment

Table 1. Participant characteristics

	Sex		Age		Education (yrs)		GCS[1]			PTA (days)[2]			Time since injury[3]	
Training	Male	Female	*M*	*SD*	*M*	*SD*	*M*	*Mdn*	*SD*	*M*	*Mdn*	*SD*	*M*	*SD*
GMT	5	10	29.0	13.0	12.6	2.5	10.7	12.0	4.2	17.9	16.0	14.7	3.7	0.63
MST	9	6	30.8	9.2	13.0	2.3	10.8	11.0	4.2	14.6	11.0	11.4	3.8	0.80

[1]Glasgow Coma Scale score at 6 hr postinjury.
[2]Post Traumatic Amnesia, defined as number of days until scores on the Galveston Orientation and Amnesia Test (GOAT) were greater than or equal to 75 on 2 consecutive days (Levin et al., 1979).
[3]Years from the date of injury to the date of training.

measures. The participants were randomly assigned to GMT and MST groups.

Thirteen of the 30 participants had lesions on acute CT, 9 of whom had lesions involving the frontal lobes (or, in the case of 1 individual, basal ganglia). These were roughly evenly distributed across groups: the GMT group contained 5 participants with frontal lesions and 1 with a posterior lesion, the MST group contained 4 participants with frontal lesions and 3 with posterior lesions. As seen in Table 1, the groups were matched for injury severity, age, and education; there were no significant group differences for these variables. The GMT group contained a greater proportion of women than the MST group, but this difference was not statistically significant.

As part of a separate study, the participants in this study also completed a strategy application test designed to be sensitive to deficits in self-regulation and goal attainment encountered by patients with ventral frontal brain damage and TBI (Levine et al., 1998, 1999). In this paper-and-pencil test, initial items (e.g., sentences to copy) can be completed briefly, but lengthier items are encountered as one progresses through the test. Given limited time constraints and a goal to complete as many items as possible, efficient performance depends on the inhibition of the environmentally driven habit to complete all items and a shift in strategy to selective completion of brief items. The dependent variable is the proportion of items completed that are brief. This task was modeled on Norman and Shallice's (1986; Shallice & Burgess, 1991) theory of supervisory attention, also drawn upon by Duncan (1986). The participants in this study were significantly impaired, with a proportional score of .78 (.79 for the GMT group and .77 for the MST group), compared to .90 for an age-, education-, and socioeconomic status-matched control group [$N = 11$; $t(37) = 2.03$, $p < .05$; data were unavailable for 2 participants]. As a group, therefore, the subjects in this study were demonstrably impaired on a task reminiscent of the unstructured, real-life situations targeted by GMT.

Measures

Everyday paper-and-pencil tasks. Three tasks designed for this study were used to assess the effects of training. Each task involves holding goals in mind, subgoal analysis, and monitoring. Two sets of the three tasks were constructed for administration in pretraining (Everyday Tasks 1) and posttraining (Everyday Tasks 2). The tasks and instructions were identical across the two sets, but the stimuli were different to minimize practice effects. The GMT and MST groups received the same tasks and forms in the same order. Two of the tasks (proofreading and room layout) were also incorporated into training as examples of application of GMT principles. To equate exposure to the tasks across training groups, these two tasks were also administered to participants in the MST group.

Proofreading. Participants were given a paragraph of text and a list of three simple proofreading instructions (see Figure 2 for example). The instructions involved underlining, circling, and crossing out words that met certain criteria (e.g., circle all numbers). Instructions were limited to three in number to ensure that they would be within participants' encoding and retention capacities. A maximum of 60 s

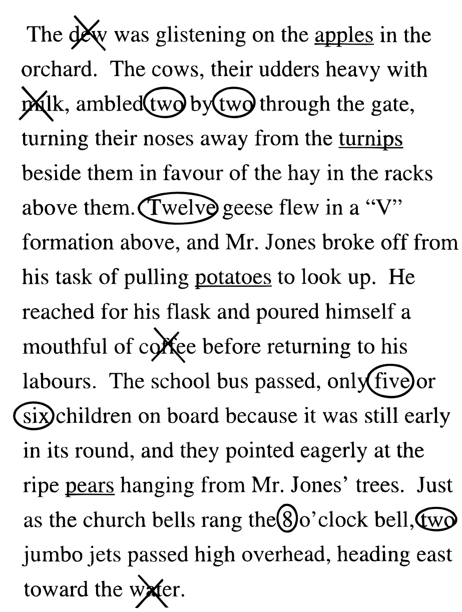

Fig. 2. Sample proofreading task as it would appear if correctly completed. For this task, the instructions were to circle the numbers, underline fruits and vegetables, and put an 'X' through liquids.

was allowed for study of the instructions, then the instructions were removed from view and the participants were told to follow them as quickly and as accurately as possible. Dependent variables were the time spent reading the instructions, the time to complete the task, and number of errors. For both the pre- and posttraining assessments, scores on two separate proofreading tasks were averaged together.

Grouping. Participants were given a sheet with two columns, each listing 23 individuals' age and sex (e.g., "25 M"). Instructions for grouping these individuals based on age and sex were listed on a separate sheet. For example, participants were instructed to classify individuals according to age by numbering those age 30 or below as '1' and those above age 30 as '2', place check mark next to the females, and circle individuals age 65 and up. A maximum of 60 s was allowed for study of the instructions, then the instructions were removed from view and the participants were told to follow them as quickly and as accurately as possible. Dependent variables were the time spent reading the instructions, the time to complete the task, and number of errors.

Room layout. A 5×5 grid represented columns and rows of a seating scheme for a meeting. The rows and columns were numbered from 1 to 5. In each of the 25 cells, a letter ('A' to 'E') indicated an employee from one of five companies (company *A* to company *E*). This grid could be used to answer a series of questions of varying complexity about the relative positions of company employees, such as, "What company is just above the 'B' in Row 2?" or, "Start in the upper right-hand corner and follow the companies around the outside of the pattern in a counter-clockwise (to the left) direction. What is the second company following the company between the third 'B' and the third 'C' you come to?" Five questions of ascending difficulty were devised for each room layout task. Dependent variables were the time to answer the questions and the number correctly answered.

Neuropsychological tests. Three clinical measures considered to be sensitive to TBI were administered: the Stroop interference procedure, Trail Making A and B, and the Digit Symbol subtest from the WAIS–R. These tests are described in Lezak (1995). Data from these tasks were used to compare the two groups on complex attentional processes potentially related to treatment outcome. These data were unavailable for 1 participant in each of the two groups.

Procedure

This study was part of a larger study of cognitive and psychosocial outcome after TBI consisting of two 4-to-6-hr sessions. Training (including administration of the everyday tasks) took place in the second session. All neuropsychological tests were administered prior to training. Fifty dollars per session (paid at the conclusion of the second session) was provided to compensate for time and expenses.

As described above, the everyday tasks used in pre- and posttraining assessments were identical for both groups. Both GMT and MST sessions lasted approximately 1 hr and were conducted individually by a research assistant trainer.

Goal Management Training (GMT). The five stages of GMT were illustrated with a flow chart (see Figure 1). Training stages comprised verbal definitions of goal management processes, concrete examples of breakdown in these processes, and illustrative activities, as depicted in Table 2. Prior to the first stage, an example of goal management failure was given (going into a room and forgetting what you

Table 2. Goal Management Training (Robertson, 1996)

Stage in model (Figure 1)	Goal management process	Activities
1. STOP!	Orienting and alerting to task	*Trainer*: Provide orienting "catchphrases" (e.g., "Wait a minute!").
		Patient: Select a catchphrase, or generate own catchphrase.
2. Define main task	Goal setting	*Trainer*: Explain concepts of goal-setting and prioritizing.
3. List steps	Partitioning goals into subgoals	*Patient*: Write main task and subgoals for situations from own life.
		Trainer: Give additional examples of subgoal definition.
		Patient: List main task and subgoals for trainer-provided situations (e.g., power outage). Perform room layout task, focusing on listing subgoals.
		Trainer: Give feedback on room-layout performance.
4. Learn steps	Encoding and retention of subgoals	*Patient*: Perform proofreading task and evaluate own performance.
		Trainer: Give feedback on proofreading performance. If there were errors, readminister the task up to two times.
		Introduce encoding enhancement techniques (e.g., visualization), and their application to proofreading task.
		Patient: Perform a second proofreading task.
		Trainer: Give feedback and readminister once if necessary.
5. Check	Monitoring	*Patient*: Provide example from own life of going off-task.
		Examiner: Provide an additional example of going off-task.
		Illustrate feedback loop from monitoring to orienting–alerting (Stage 1).

wanted to do once you reached the room), followed by similar example that was elicited from the participant. Training administration followed a script contained in a trainer's manual. This script governed both the speech and the actions of the trainer. The trainer memorized the script (although it was always present for the trainer to consult). While the script was closely adhered to, the trainer incorporated the participant's own examples of goal management failures into the script as frequently as possible. Participants were provided with a workbook that contained an outline of the trainer's script and the paper-and-pencil exercises. The training session concluded with a real-life activity (setting up an answering machine), which the participant partitioned into subgoals and performed. The entire training session lasted approximately 1 hr.

Motor skills training (MST). MST trained procedural processes unrelated to goal management: reading and tracing mirror-reversed text and designs (see Table 3). The trainer was present throughout MST, providing instructions and encouragement in a similar manner to GMT. Paragraphs, word lists (containing one-, two-, or three-word stimuli), and letters were used for the mirror-reversed reading tasks (although only the paragraphs were administered repeatedly). The mirror-tracing task consisted of 20 trials (10 per hand) of tracing a star. Paragraph reverse reading and mirror tracing were the only tasks that were repeated and thus the only ones analyzed for procedural learning effects. Dependent variables were time to completion and errors (incorrect words for paragraph reverse reading and going outside of the boundaries for mirror tracing). For each of the three paragraph reverse reading trials, scores for the two paragraphs were averaged.

Statistical analyses

Pre- and posttraining data were analyzed in 2×2 mixed-design ANOVAs, with training group (GMT and MST) and testing session (pre- and posttraining) as factors. The effects of GMT were reflected in the interactions between group (GMT *vs*. MST) and test session (pre *vs*. post). Both accuracy (error rates) and speed (time spent reading the rules and time to completion) were analyzed. Main effects of test session (due to nonequivalence of pre- and posttest forms, fatigue, or practice effects) and group (due to group differences in speed and accuracy that inadvertently emerged from random assignment of participants to groups) were not directly relevant to training effects, but did affect interpretation of group means. For example, if a posttraining task was easier than its pretraining counterpart, a greater degree of improvement for the GMT group over the MST group would signify a positive effect of GMT. If a posttraining task was harder than its pretraining counterpart, a positive GMT effect would be signified by less decline in performance for the GMT group than the MST group. In the case of significant interactions, analyses of the simple effects of test session for each group were conducted as planned comparisons, with the *a priori* hypothesis that GMT would be associated with either greater improvement or less decline on the tasks. For ease of interpretation, the pre- and posttraining data are displayed as normalized difference scores.

To assess the effects of procedural learning tasks in MST, paired t tests were conducted comparing performance on the first and last trials of procedural learning tasks.

Table 3. Motor skills training

Task	Activity
Mirror reading	Read two paragraphs (Time 1) Study reversed letters. Read lists of words. Read two paragraphs (Time 2).
Proofreading[1]	
Room layout[1]	
Mirror tracing	Trace a star figure, 10 trials with each hand.
Mirror reading	Read two paragraphs (Time 3).
Proofreading[1]	

[1]Tasks were administered as in GMT to equate exposure to the tasks across groups.

Results

Neuropsychological tests

The GMT group was generally slower on the timed neuropsychological tests, with group differences on the interference condition of the Stroop interference procedure and on Trail Making, Part B being significant or nearly significant [$t(26) = 2.94$, $p < .05$; and $t(26) = 1.97$, $p < .06$, respectively]. Although this finding suggests a minor degree of nonequivalence of groups, this nonequivalence works against the significant findings for speed reported below.

Everyday tasks pre- and posttraining

Accuracy. The accuracy of the GMT group either improved more or declined less across test sessions than did the accuracy for the MST group (see Figure 3). Significant Group $\times$ Test session interactions were noted for proofreading [$F(1,28) = 6.43$, $p < .05$] and grouping [$F(1,28) = 5.56$, $p < .05$]. For proofreading, planned comparisons indicated that the MST group committed significantly more errors in post- than in pretraining [$t(14) = 3.86$, p $< .01$], while the GMT participants' performance did not significantly differ across sessions [$t(14) = 0.15$]. For grouping, the MST group showed a nonsignificant increase in errors from pre- to posttraining [$t(14) = .83$], whereas the GMT group substantially reduced their errors in posttraining, [$t(14) = -3.06$, $p < .01$]. The proofreading and grouping results could not be accounted for by ceiling or floor effects. Neither group was near ceiling on the proofreading pretest (i.e., both groups were capable of increasing errors) or near floor on the grouping test (i.e., both groups were capable of decreasing errors). For room layout, both groups showed similar reductions in errors.

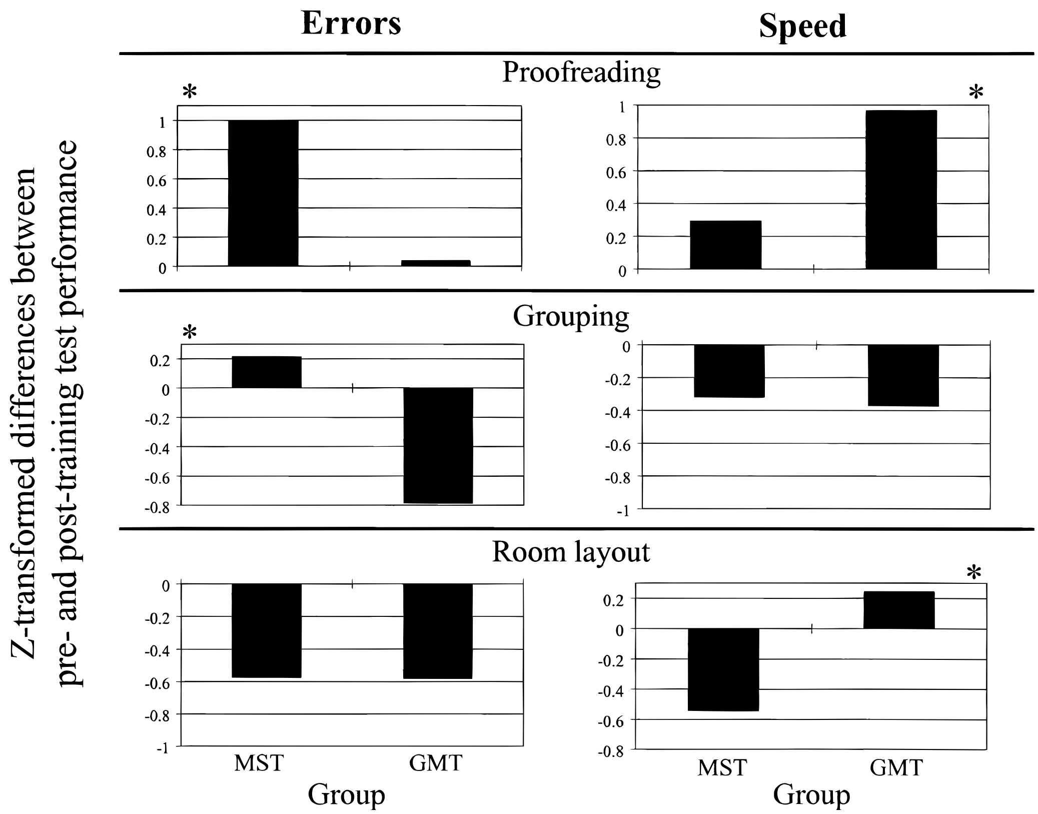

Fig. 3. Pre- to posttraining changes in errors and speed for the three tasks. For the purposes of presentation, posttraining data were subtracted from pre-test data and the difference was transformed to a standard (z) score. For errors, negative scores indicate a reduction in errors from pre- to posttraining. For speed, positive scores indicate increased time (and presumably increased care and attention) from pre- to posttraining. Significant Group × Test session interactions are indicated with asterisk.

Speed. Participants in the GMT group devoted more time to task completion from pretraining to posttraining, reflecting increased care and attention, whereas those in the MST group slowed to a lesser degree, or showed the reverse pattern of decreased time on posttraining tasks (see Figure 3). The reliability of these effects was supported by significant interactions for proofreading [$F(1,28) = 5.20, p < .05$] and room layout [$F(1,28) = 4.57, p < .05$]. In the case of proofreading, the GMT group slowed significantly from pre- to posttraining [$t(14) = 3.74$, $p < .05$], whereas the pre-/posttraining time difference for the MST group was not significant [$t(14) = 1.14$]. For room layout, the GMT group slowed slightly in posttraining [$t(14) = .95$], whereas the MST group devoted *less* time to the tasks than they did in the pretraining session [$t(14) = -2.10, p < .06$]. Both groups similarly reduced their time on the posttraining grouping task.

The significant findings could not be accounted for by overall slowing in the GMT (as suggested by the minor group differences in speed on the neuropsychological tests), because the GMT group performed faster than the MST group on both proofreading and room layout pre-training tests. While it is possible that this baseline difference contributed to the larger difference score in the GMT group, it is noted that the mean times for GMT group surpassed those of the MST group for both posttraining tasks, indicating slower performance both relative to their own baseline and relative to the MST group.

The differences in time devoted to reading proofreading and grouping instructions between the pre- and posttraining tasks did not yield significant group effects. These data were limited to ceiling effects as participants were allowed no more than 60 s to read the instructions.

Effects of motor skills training. MST participants improved significantly on procedural learning measures. Both time to reverse-read the paragraphs and errors were reduced substantially in the third trial as compared the first trial [$t(14) = -4.40$, $p < .01$; and $t(14) = -3.27$, $p < .01$, respectively]. Mirror tracing was accomplished significantly faster in the 10th trial as compared the first trial [$t(14) = -7.46$, $p < .01$; and $t(14) = -5.79$, $p < .01$] for dominant and nondominant hands, respectively. Mirror tracing errors did not change significantly across trials.

Discussion

Goal Management Training (GMT) was associated with improved performance on paper-and-pencil tasks that correspond to everyday situations known to be problematic for people who have sustained a TBI. These effects were significant in spite of the relatively brief intervention. The specificity of GMT to executive functioning (as opposed to nonspecific training effects) was supported by our use of a randomized group trial. Participants in the MST group received similar amounts of trainer contact to those in the GMT group. Moreover, the MST training was effective for the procedural learning tasks at which it was targeted.

The GMT group's slower performance on the post-training tasks suggested that GMT increased participants' care and attention to the tasks, in turn reducing errors. Explicit instructions to slow down were not part of the GMT protocol. Indeed, clinical experience indicates that simply telling patients to slow down is not an effective rehabilitation technique. It is unlikely that slowing *per se* could explain the GMT effects, as many dysexecutive, error-prone patients are abnormally slow. It is rather more likely that the GMT group's slowing was a byproduct of the application of GMT principles.

The patients in this study were selected from consecutive admissions, providing a representative sample of TBI patients with initial injury severity equated across groups. Consistent with the documented relationship between TBI, frontal systems deficits, and self-regulation (Mattson & Levin, 1990; Stuss & Gow, 1992), they were impaired on a test of strategic self-regulation derived from theories of supervisory attention and goal management (Levine et al., 1998, 1999). These participants were not, however, selected for real-life disorganized behavior. Future studies should focus on such individuals, as they would be most likely to benefit from GMT.

One of the pitfalls of randomized design is lack of control over assignment of participants to groups. Our TBI group were typical in their high variability of outcome (although care was taken to match participants according to initial injury severity, age, and education). Random assignment inadvertently resulted in some group differences, as reflected by the GMT group's significant slowing in the Stroop interference condition and some significant main effects of group on the everyday tasks. Furthermore, there were significant main effects of test session due to the nonequivalence of pre- and posttraining test forms. That is, some of the everyday tasks used in the posttraining assessment were more difficult than their pretraining counterparts. The interaction analyses, however, revealed differential effects of GMT on posttraining test performance relative to the pretraining baseline. That is, GMT participants either improved more or declined less than the MST group on the posttraining measures. These results could not be accounted for by ceiling or floor effects or baseline group differences.

A major concern for any rehabilitation study is generalization to activities not specifically addressed by the intervention. As room layout and proofreading were incorporated into the training module, they do not provide any information on generalization. However, the significant effect of GMT on errors on the grouping task, which was not included in training, suggests that the training effects associated with GMT were generalizable, at least within the constraints of behavior assessed in the laboratory. It was not expected that the brief training would produce significant lasting effects on participants' day-to-day functioning. Given the significant effects on the everyday tasks, however, it is reasonable to predict that an expanded version of training would produce lasting effects outside of the laboratory. Evidence in favor of this hypothesis is presented in Study 2, where an expanded version of GMT was applied in a dysexecutive patient.

STUDY 2

Meal preparation, involving management of multiple subgoals, foresight, working memory, and prospective memory, is a classic example of a task reliant on executive functions (e.g., Penfield & Evans, 1935). In this case study, we describe an application of GMT towards the rehabilitation of meal preparation in a postencephalitic patient. Like TBI, the pathology of encephalitis is multifocal and affects frontal and temporal structures, causing deficits in executive functioning and memory. Patient K.F., a 35-year-old postencephalitic woman, had attentional and executive deficits with complaints of inability to manage the demands of meal preparation, demands that she had expertly negotiated prior to her illness. To address this problem, we used the GMT described in Study 1 and supplemented it with additional training based on GMT principles. This training consisted of paper tasks based on goal management principles while also being tailored to the patient's request for assistance with meal preparation. Once she was able to apply the goal management strategies effectively in the paper-and-pencil everyday tasks, further graded tasks enabled the transfer of this skill to practical, real-life situations.

Methods

Research participant

K.F., a 35-year-old, right-handed university graduate, was referred to the Medical Research Council's Cognition and Brain Sciences Unit at Addenbrooke's Hospital, Cambridge, U.K. for memory assessment and therapy 5 months after an episode of meningo-encephalitis. Complaints at that time included retrograde amnesia, an inability to take in new information, and impaired concentration. K.F. had shown great determination in trying to tackle her difficulties; for example, she had been unable to return to her previous job as a teacher's aide, but had obtained a new job as a sales assistant. Nevertheless she was frustrated by the impact of her memory and concentration problems on her daily life, especially meal preparation. Developmental and medical history were normal. Her educational and occupational attainments were in the superior range, as evidenced by obtaining a degree from a prestigious U.K. university and previous employment in management training.

History of illness. In June 1996 K.F. was admitted to hospital with severe headache, stiff neck, back pain, vomiting, and photophobia. She became extremely confused and disorientated (but did not lose consciousness) and had two generalized seizures. CSF tested positive for enterovirus and negative for herpes simplex virus and varicella. Head CT and MRI were normal. Her initial EEG showed features consistent with encephalopathy, without features specific for herpes simplex virus, and additional activity thought to be postictal in origin. A second EEG taken 11 days later showed minimal residual slow activity without epileptiform abnormalities.

K.F. was discharged after 15 days of treatment with Cefotaxime, Acyclovir, and Phenytoin and improvement in her orientation and memory. Following discharge she reported experiencing frequent visual hallucinations, sometimes associated with a strange smell. A third EEG in September 1996 showed no epileptiform abnormalities. However, a sleep-deprived EEG carried out in November 1996 revealed left medial temporal irregular midfrequency complexes in drowsiness. The findings were interpreted as confirming left medial temporal pathology, although they were not specific for focal seizures. Carbamazepine was prescribed, and when seen for the present study in January 1997, K.F. was stabilized on Tegretol Retard 400 mg b.d. She remained seizure-free from this point forward.

Neuropsychological assessment. Overall, K.F.'s neuropsychological functioning was impaired relative to her estimated superior premorbid level of intellectual functioning (estimated IQ = 120; Nelson & Willison, 1991). Her most significant deficits were on tests of everyday attention (Robertson et al., 1994) and memory (Wilson et al., 1985) where scores ranged from borderline to impaired. In contrast, performance on standard laboratory assessment of memory (Baddeley et al., 1994) was normal. Autobiographical memory (both events and personal semantic information, Kopelman et al., 1990) was borderline. Although executive deficits were clearly apparent on the everyday attention and memory tests and in day-to-day life, K.F.'s overall score on a battery of executive functioning tests (Wilson et al., 1996) was low average. Performance on tests of linguistic (Baddeley et al., 1992) and perceptual skills (Warrington & James, 1991) was intact.

Measures

Dependent variables consisted of everyday paper-and-pencil tasks and two real-life measures: meal preparation performance (as observed by the trainer) and K.F.'s own reports of her meal preparation behavior, documented in a self-report diary. There were five assessment periods: baseline, posttraining, and 1-, 3- and 6-month follow-ups (see Table 4).

Everyday paper-and-pencil tasks. The everyday paper-and-pencil tasks from Study 1 were also used in this study. Everyday Tasks 1 and 2 were administered in the baseline and posttraining periods, respectively. They were repeated in the follow-up periods, with Everyday Tasks 1 administered at 1 and 6 months and Everyday Tasks 2 administered at 3 months. Only error data (and not speed) are reported for these tasks.

Table 4. Summary of K.F's assessment and training

Assessment–training period	Session number	Session content
Baseline	1	Everyday Tasks 1
	2, 3	Meal preparation Observation 1 (Self-Report Diary 1)
GMT	4	GMT Stages 1–3 (see Figure 2 and Table 2)
	5	GMT Stages 4–5 (see Figure 2 and Table 2)
	6, 7, 8	Meal preparation training with checklist
Posttraining	7	Everyday Tasks 2
	9, 10	Meal preparation Observation 2 (Self-Report Diary 2)
Follow-up	11 (1 month)	Meal preparation Observation 3 Everyday Tasks 1
	12 (3 months)	Meal preparation Observation 4 Everyday Tasks 2 (Self-Report Diary 3)
	13 (6 months)	Meal preparation Observation 5 Everyday Tasks 1

Meal preparation. Meal preparation performance was assessed using a continuous observation schedule. Based on early observations and K.F.'s reports, four categories of problematic behaviors were defined. These included failure to assemble the necessary ingredients, misinterpretation of written instructions (e.g., focusing on irrelevant details), repeated checking of instructions, and sequencing–omission errors (e.g., omitting key steps or carrying out steps in the wrong order). These behaviors were classified using a strict criterion whereby any deviation from the specific requirements of the recipe was tabulated. The total number of problematic behaviors in each category was taken as a measure of meal preparation performance. In assessment periods where meal preparation was observed in more than one session, scores were averaged across sessions.

Self-report diary. K.F. recorded her own meal preparation behavior in a self-report diary for baseline, posttraining, and 3-month follow-up assessment periods of 2 weeks in length (see Table 4). For each meal attempted in the assessment period, she recorded the recipe and a brief description of the problems she encountered, if any. For the posttraining and follow-up assessments, K.F. indicated what strategies she used.

Procedure

The entire assessment and intervention process took place over 13 sessions (see Table 4). The first three of these were devoted to collection of pretraining baseline data on the everyday paper-and-pencil measures and meal preparation observation. After Session 3, prior to GMT, K.F. completed her self-report diary.

GMT was carried out as described in Study 1 (see Figure 1 and Table 2), but was expanded over two sessions (Sessions 4 and 5; see Table 4). The GMT materials were supplemented by exercises involving recipes that required K.F. to implement the GMT stages, some of which were left with K.F. as homework assignments. The recipes used were graded in difficulty, beginning with a group consisting of simple snacks (e.g., a ham and pickle sandwich), progressing to a group of real recipes from K.F.'s own favorite cookbook, and finally to recipes selected by K.F. herself. The stages were taught using an errorless method based on prompting and fading (Wilson et al., 1994), with the first three stages ("Stop," "Define the main task," and "List the steps") covered in Session 4 and the last two stages ("Learn the steps; do it!"; "Check; am I doing what I planned to do?") in Session 5. Within each level of difficulty, prompts were included in the first recipe, then faded out in subsequent recipes to the point where just the stage numbers were given and K.F. supplied the details.

GMT was further applied to meal preparation in Sessions 6 through 8. Recipes (including collecting and assembling ingredients, setting the oven temperature, and cooking instructions) were transcribed to a checklist that was used to structure meal preparation using the five GMT stages (modified somewhat to apply to meal preparation; see Figure 4). This checklist was inserted into a washable clear plastic wallet, so that each step could be checked off using a water-soluble pen as it was completed, and both the checklist and the wallet could be reused. Posttraining assessment on the everyday measures occurred in Session 7.

Meal preparation performance was again assessed in Sessions 9 and 10, followed by a 2-week period of self-rating with the diary. Follow-up assessments at 1, 3, and 6 months were conducted in Sessions 11 through 13. These involved additional meal preparation performance observation and testing with the everyday task batteries. K.F. completed a self-report diary prior to Sessions 10 and 12 (i.e., posttraining and 3-month follow-up).

Statistical analysis

Nonparametric statistical tests for related samples were used to analyze changes in performance across the various assessment sessions. Problem behaviors were analyzed with Friedman two-way nonparametric analysis of variance (Siegel, 1956) with problem behaviors as items and three assessment phases (*baseline*, *posttraining*, and *follow-up*) as conditions. (Observational data for the three follow-up sessions, which were nearly identical, were collapsed for the purposes of statistical analysis.) The trend in improvement across sessions was assessed with Page's L trend test (Greene & D'Olivera, 1982).

Results

Everyday tasks

As documented in Study 1, GMT was associated with improved performance on the everyday paper-and-pencil tasks. Scores on these tasks are presented in Table 5. As noted above, the pre- and posttraining batteries (Everyday Tasks 1 and 2) were not equated for difficulty. For the sake of comparison, error scores on the same tasks from the Study 1 GMT group are included in Table 5.

As seen in Table 5, K.F.'s improvement from baseline to postintervention was most apparent on proofreading, although room layout error scores decreased as well. Training was not associated with change in performance on the grouping task. The proofreading and room layout gains were maintained across the three follow-up sessions, although it is noted that these sessions involved repeat administrations of the batteries. In the 3-month administration of the Grouping task, K.F.'s large number of errors was attributable to failure to apply one of the grouping rules. Similar behavior on this task was observed in some of the Study 1 TBI participants.

Meal preparation performance observation

Baseline observation of K.F.'s cooking indicated that, although she eventually completed the chosen recipes, the problematic behaviors compromised her efficiency and were a considerable source of frustration. An average of 19 of these behaviors occurred in the baseline sessions, with repeated checking accounting for nearly half of these. As seen in Figure 5, these behaviors were significantly reduced relative to baseline in the posttraining and follow-up assessments [$\chi^2(2) = 6.125$, $p < .05$]. The trend in reduction was significant [$L_{k3n4} = 54.5$, $p < .05$].

Self-report diary

K.F.'s self-reported difficulties in meal preparation declined after training (see Table 6). In the baseline sessions, she reported difficulties with 8 of 10 (80%) attempted recipes, including difficulty in finding the desired recipe, assembling the required ingredients, interpreting instructions, preparing the dish, and relying entirely on memory rather than consulting a recipe. Repeated checking was also reported, although not recorded in the diary. Posttraining, she reported problems on 3 of 10 (30%) attempted recipes in the self-report diary, with gains maintained at 3 months, where she reported problems on only 1 of 10 (10%) attempted recipes.

K.F.'s self-reported improvement in meal preparation was related to the use of two strategies: using her checklist and cueing herself with "stop and think." Of 20 recipes attempted across the posttraining and 3-month follow-up di-

Recipe: ....

PREPARATION TIME: TOTAL TIME:

COOKING TIME:

SET OVEN TEMPERATURE :

COLLECT THE INGREDIENTS: TIME NEEDED......................

CHECK Have I got everything I need?

PREPARE THE INGREDIENTS: TIME NEEDED:.....................

CHECK Is everything ready to start?

COMPLETE THE STEPS ONE AT A TIME: TIME NEEDED:...................

CHECK Have I followed all the steps?

COOKING INSTRUCTIONS: TIME NEEDED:..................

CHECK Have I written the cooking times on the blackboard?

Fig. 4. K.F.'s recipe checklist.

aries, K.F. employed a strategy on 14. Within these 14, problems were encountered on only one (7%; see Table 6). In contrast, of the six recipes without a reported strategy, three (50%) were associated with difficulties.

Discussion

This case study illustrates an application of GMT to a real-life situation. In the chronic phase of her recovery from meningo-encephalitis, K.F. demonstrated neuropsychological deficits on tasks of attention, executive functioning, and everyday memory, deficits which corresponded to her impaired self-regulation in managing demands of certain everyday situations. In particular, K.F. was frustrated by her inefficiency in negotiating meal preparation. GMT is specifically designed for patients with K.F.'s profile of executive dysfunction. Its flexibility allows it to be targeted at a variety of everyday situations. Therefore, it was readily

Table 5. Number of errors on everyday tasks for K.F. and Study 1 GMT participants

Assessment period		Everyday Task: Proofreading	Room Layout	Grouping
Baseline				
Everyday Tasks 1	K.F.	6	4	5
	Study 1 GMT group[1]	4.4	3.1	6
Posttraining				
Everyday Tasks 2	K.F.	0	2.5	6
	Study 1 GMT group[1]	4.5	2	0
Follow-up[2]				
Everyday Tasks 1	1 month	1	2	3
Everyday Tasks 2	3 month	2	2.5	36
Everyday Tasks 1	6 month	1	3	6

[1]Data from the GMT group are means, except for the Grouping task, where medians are presented due to high skewness.
[2]Follow-up tasks administered to K.F. only.

adapted to accommodate K.F.'s desire to improve her meal preparation behavior.

The effect of GMT on everyday paper-and-pencil tasks documented in Study 1 was demonstrated in K.F. More importantly, there were lasting gains in the efficiency of K.F.'s real-life meal preparation behavior, as indicated by naturalistic observation and her own self-report diary. While ratings by an independent observer on tasks both related and unrelated to the training would have been optimal, the convergent results from three different assessment techniques (i.e., everyday paper-and-pencil tasks, observation, and diary) are nevertheless encouraging.

The results also converge with those of Study 1 and extend them to behavior outside of the laboratory. This effect was promoted by incorporating real-life cooking exercises into the training, which took place in K.F.'s own home. Although we did not directly measure the generalization of GMT principles to noncooking situations, K.F. did report that she was applying them in a variety of situations at home and at work, ranging from pricing a new consignment of stock to completing a mountaineering expedition.

In larger-scale group interventions, one-on-one therapy such as that provided to K.F. is not always available. However, interventions can be individualized in the clinic, and generalization to real-life can be fostered with homework assignments and involving family members.

K.F.'s reported strategy use increased after GMT. She reported fewest difficulties for those recipes where she used a strategy: either the checklist or cuing herself with "stop and think." As the checklist provided maximal environmental support and structure to K.F., it is not surprising that her performance improved with checklist use. Such an external aide is most appropriate for patients with difficulty internalizing newly acquired strategies, or for less severely impaired patients in highly demanding and complex situations. In contrast, K.F.'s success with self-cuing suggests an internalization of a key aspect of GMT. Although K.F. reported no strategy for six posttraining and follow-up recipes, it is likely that GMT still influenced her behavior at these times, as suggested by a reduction in the number of problems encountered on these six meals relative to baseline.

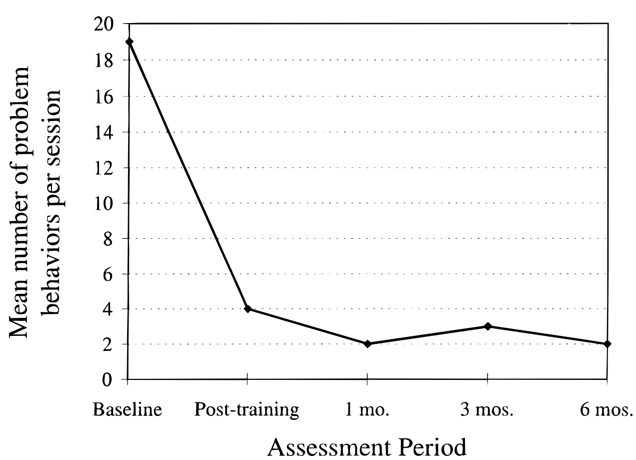

Fig. 5. Mean number of problem behaviors per session observed during meal preparation in different assessment periods.

Table 6. Number of meals in which K.F. encountered difficulty (according to self-report diary) across three assessment periods

Assessment period	Strategy: No strategy	Recipe checklist	"Stop and think"	Total
Baseline	8 (of 10)	n/a	n/a	8 (of 10)
Posttraining	2 (of 4)	1 (of 5)	0 (of 1)	3 (of 10)
3-month follow-up	1 (of 2)	0 (of 5)	0 (of 3)	1 (of 10)

GENERAL DISCUSSION

Goal Management Training (GMT) is designed for rehabilitation of patients with impaired self-regulation affecting organization of everyday behavior, as frequently observed with TBI. As it was only 1 hr in duration, the GMT protocol used in Study 1 is considered a training probe rather than a full-fledged intervention protocol. In spite of the brevity of the intervention and the heterogeneity inherent in TBI patients, the findings supported the efficacy of GMT under the rigorous constraints of a randomized control trial. Study 2 demonstrated application of a more clinically relevant, expanded GMT to real-life functioning. Taken together, the results suggest that GMT is a viable method for rehabilitating executive functioning.

Theoretical Approaches to Executive Dysfunction: Practical Implications for Rehabilitation

Many neuropsychological rehabilitation techniques in current use have little theoretical grounding. In this respect, GMT is unique in that it is based directly on a theory of goal management deficits following frontal systems dysfunction (Duncan, 1986). From a practical standpoint, the advantages of this theory are its emphasis on everyday behavior and its delineation of components that are easily transferred to a staged rehabilitation protocol. Most importantly, however, this theory pertains directly to the dysexecutive, self-regulatory deficits caused by TBI and other brain diseases affecting frontal systems.

The design of this study did not permit direct assessment of relationship between response to GMT and frontal systems damage. Both TBI and encephalitis cause frontal cortical damage as well as focal cortical and diffuse damage in other brain regions. In our sample, there was evidence of frontal systems dysfunction from both acute CT and test performance (i.e., the strategy application test in TBI patients and tests of everyday attention and memory in patient K.F.). Our findings are therefore supportive of GMT's efficacy in patients with frontal systems dysfunction, but confirmation of this relationship would require administration of GMT to patients with focal lesions (documented in the chronic stage of recovery, preferably with MRI) with and without accompanying diffuse injury. In the present context, we emphasize the psychological construct of executive dysfunction as opposed to specific lesions. That this construct emerged from studies of patients with frontal brain damage should not constrain application of GMT, which can be applied to patients irrespective of type or location of brain damage.

GMT, while theoretically derived, is broad in scope, encompassing the multiple factors in goal management, including attention, problem definition, problem-solving, encoding and retrieval strategies, and monitoring. This multifaceted approach was selected to address the full range of cognitive systems affected by TBI and other brain injuries. As we were not able to analyze the effects of individual GMT stages, we do not know the relative effects of specific aspects of GMT, although there were qualitative reports that orienting ("stop and think") was particularly important in Study 2. Assessment probes after each stage of the expanded GMT would help in understanding the mechanisms of the training effects. It is likely that these mechanisms will vary according to the patient's pattern of executive strengths and weaknesses. For example, training effects in a patient whose primary problem is poor organization in memory will most likely be related to Stage 4 (learning the steps), which emphasizes encoding and retention of subgoals. Alternatively, patients with sustained attention deficits may benefit most from Stage 1 (orienting).

GMT is an interactive protocol that depends to some extent on patients' insight into their own goal management deficits. Patients with high awareness and motivation (such as K.F.) are most likely to benefit, whereas patients with severely compromised awareness and denial of their problems are least likely to benefit. Those patients falling in between these two extremes will require varying amounts of trainer guidance to appreciate GMT's applicability to their own lives. Patients with severe amnesia are unlikely to internalize GMT stages, although those without severely compromised executive functions may benefit from a modification of GMT in which the stages are prompted externally (e.g., DeLuca & Locker, 1996; Kirsch et al., 1987; Sohlberg & Mateer, 1989).

Top-Down *versus* Bottom-Up Approaches and Generalization

A dilemma frequently faced by rehabilitation workers is whether to treat behavior in one domain (a bottom-up approach), or to focus on training processes that can be applied across domains (a top-down approach). The former approach is likely to affect a targeted behavior, but the latter approach, if it is within the abilities of the patient, is more likely to promote generalization. As an example of the former approach, Burgess and Alderman (1990) elected to modify lower-level routines (e.g., yelling) that were being inappropriately triggered. This was seen as preferable to attempting to train supervisory control in severely brain injured patients. Von Cramon and von Cramon (1994) embedded problem-solving training in a work trial for a severely brain-injured pathologist. Training was associated with improved diagnostic accuracy in the pathologist, but did not generalize to other situations. In both of these studies, action selection was modified within a single domain. In contrast, Cicerone and Wood (1987) used modified self-instructional training (Meichenbaum, 1977) and a staged protocol similar to GMT in a top-down approach to their patient with severe TBI and executive dysfunction. While transfer of training was demonstrated with pre–post assessment on laboratory tasks, generalization to real-life situations did not occur until training was explicitly applied to these situations, a finding in accord with the principle that generalization must be built into the intervention.

GMT emphasizes a top-down approach by training broadly applicable stages of goal management and applying them to a variety of situations. In future research, generalization should be achieved by extending GMT over several sessions and incorporating more real-life situations into the protocol. However, it can also be applied to behavior in a single domain, as in patient K.F., who specifically requested assistance with meal preparation. In her case, repeated application of GMT to meal preparation may have routinized strategic behavior in a bottom-up fashion, as suggested by her improved performance on recipes where no explicit strategy was reported. Although it was not the goal of the intervention, improvement in top-down supervisory skills and broader generalization was suggested by K.F.'s anecdotal reports of application of GMT principles on other aspects of her life.

Alternative Paradigms

Von Cramon et al.'s (1991) problem-solving training (PST), which contains five stages very similar to GMT stages, was validated in an intensive, 6-week, 25-session randomized trial in patients with mixed etiologies and documented problem-solving deficits. PST participants made significant gains on both laboratory tasks and real-life behavioral ratings in comparison to a control group receiving memory training. The protocol was theoretically derived (from D'Zurilla and Goldfried's, 1971, model of problem-solving), but the clinical setting where it was applied required methodological flexibility. For example, some participants were treated individually, whereas others were supervised in small interactive groups.

To our knowledge, there are no other validated protocols for this type of executive functioning rehabilitation, although there have been some case studies (Burke et al., 1991; Lawson & Rice, 1989). As goal management is reliant on multiple cognitive processes, rehabilitation efforts directed towards these specific processes are also relevant. In particular, Sohlberg and her colleagues (Sohlberg et al., 1992a, 1992b) have trained prospective memory by successively increasing the interval between encoding and execution of intentions. Such training could supplement GMT by buttressing patients' ability to maintain intentions in mind over a delay. Application of strategies to improve retrospective memory (e.g., Wilson, 1987) are included to facilitate encoding and retention of subgoals (GMT Stage 4).

Although attention and executive functions are intimately related (Stuss et al., 1995), rehabilitation of each has developed separately. Attention rehabilitation employs time-constrained, simple tasks in a highly structured format, whereas executive functioning rehabilitation involves complex, unstructured tasks that are not time-limited (Robertson, 1999). In their current forms, therefore, attention training protocols are not comparable to GMT, although training of specific attentional processes relevant to GMT would be expected to improve goal management behavior.

Conclusions

Executive functions comprise a wide range of abilities that are sensitive to brain disease. While the structure and neuroanatomical correlates of executive functions are a matter of debate, there is broad agreement that executive functioning deficits have debilitating effects on patients' lives and pose special challenges to rehabilitation workers. This is especially true for TBI, one of the most common causes of executive dysfunction.

Goal Management Training (GMT; Robertson, 1996) is a theoretically derived protocol that addresses that subset of executive functions serving the maintenance of intentions in the self-regulation of behavior. Disruption of these functions causes goal neglect, or failure to execute intentions, which in turn results in everyday dysfunction, especially in patients with brain disease affecting the frontal lobes or their connections.

The validity of GMT was assessed in a randomized group trial of TBI patients and a case study of a postencephalitic patient. We showed that GMT improved performance on both paper-and-pencil everyday tasks as well as meal preparation, a real-life task heavily reliant on strategic self-regulation. A remaining question for future studies concerns the generalization of expanded GMT to a broader range of real-life situations in patients with brain disease.

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