

Self-Regulation after Traumatic Brain Injury: A Framework for Intervention of Memory and Problem Solving

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ABSTRACT

Self-regulation of behavior is mediated by the frontal lobes and commonly disrupted after a traumatic brain injury. The rehabilitation field is only now beginning to understand self-regulation as a set of dynamic relationships between metacognitive beliefs and knowledge, ongoing self-monitoring or self-assessment during activities, and self-control (i.e., strategy decisions). This article provides a framework for understanding self-regulated learning and problem solving, along with a summary of the existing intervention literature. We conclude by providing clinicians with principles that emphasize accurate self-monitoring and explicit instruction to connect self-monitoring to strategy decisions.

KEYWORDS: Metacognition, executive functions, self-monitoring, self-control, learning, generalization, strategy instruction

Learning Outcomes: Upon completion of this article, the reader will be able to (1) define the component parts of self-regulation and describe the relationships among the components; (2) identify ways to obtain information about metacognitive beliefs and knowledge, self-monitoring ability, and strategy decisions (i.e., self-control); (3) summarize intervention used to improve self-regulated learning and problem solving; and (4) list the key principles that should guide intervention aimed at improving self-regulation.

Difficulty self-regulating cognitive and linguistic processes is common in individuals with traumatic brain injury (TBI), particularly those with focal injury to the frontal lobes.¹⁻³ Impairments in self-regulation are likely to

reflect damage to the frontal lobes, as even patients with diffuse axonal injury are likely to have frontal and temporal lobe damage.⁴ Extensive research has documented the relationship between self-regulation and injury to the

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frontal lobes and their networks in clinical populations.^{5,6} Functional imaging studies have confirmed the activation of specific areas of the frontal lobes during activities that require self-monitoring,⁷ working memory,⁸ and strategic decision making.⁹ The clinical experience of speech-language pathologists and other rehabilitation professionals validates these research findings, as adults and children with TBI appear to have difficulty regulating their own thoughts and actions. The purpose of this article is to provide an updated framework that describes impaired self-regulation after TBI and presents the results of intervention studies aimed at improving self-regulation. Specifically, we focus on self-regulated learning and problem solving. Other aspects of self-regulation are discussed in the accompanying papers on behavioral regulation and direct instruction techniques.

AN UPDATE OF CONCEPTS: EXECUTIVE FUNCTIONS, METACOGNITION, AND SELF-REGULATION

The higher level processes listed before are referred to by several different terms that reflect different orientations; among these, the terms “self-regulation,” “metacognition,” and “executive functions” are the most common. Clear definitions of these terms are elusive, and their boundaries are blurred. Traditionally, rehabilitation professionals such as speech-language pathologists and neuropsychologists used the term “executive functions” to mean the following:

integrative cognitive processes that determine goal-directed and purposeful behavior and are superordinate in the orderly execution of daily life functions, which includes the ability to formulate goals; to initiate behavior; to anticipate the consequences of actions; to plan and organize behavior according to the spatial, temporal, topical or logical sequences; and to monitor and adapt behavior to fit a particular task or context.^{10(p. 1605)}

Stuss¹¹ provided a hierarchic but interrelated framework in which executive functions

are the middle level or component; they receive input from both lower level basic processes that may be domain specific (e.g., memory for geography, comprehension of jokes), and they receive input from higher level metacognitive processes that include values, motivations, and beliefs about the “self.” From this perspective, the self includes metacognition, the highest level within the cognitive system, and is influenced by not only personal values but also ongoing self-monitoring or self-assessment during activities. The products of executive functions provide feedback upward to the self and downward to more basic processes, modifying both over time. According to this framework, the ultimate goal of therapy is an adjustment in metacognitive beliefs to reflect a “new” self through ongoing successful or unsuccessful experiences using alternative strategies.^{12,13}

By contrast, developmental, educational, and cognitive psychologists conceptualize executive functions as *part of* the metacognitive system, a view that is supported by decades of research.^{14–17} “Meta” refers to one’s ability to view, observe, and assess more basic cognitive processes, and the prefix meta can be applied to several subsystems, such as metamemory, metalinguistics, and metacomprehension. Thus, metacognition is cognition about cognition or thinking about thinking. It includes self-awareness or *metacognitive beliefs or knowledge* (beliefs about our cognition) as well as *self-monitoring* and *self-control* of cognition while performing an activity.

In this perspective, metacognitive beliefs are partially shaped by cultural, familial, and personal values stored as autobiographical knowledge. They are created and updated by new daily experiences and situations and, to a lesser extent, by tasks that are repetitive routines.¹⁸ In this way, there is a dynamic relationship between metacognitive beliefs and ongoing, daily routines and new experiences. Everyday routines are automatic and, once habitual, do not require input from one’s beliefs or from conscious and explicit self-monitoring. However, whenever a person is required to perform a task that is slightly different from the routine, success is dependent on that person’s ability to detect what is different, monitor

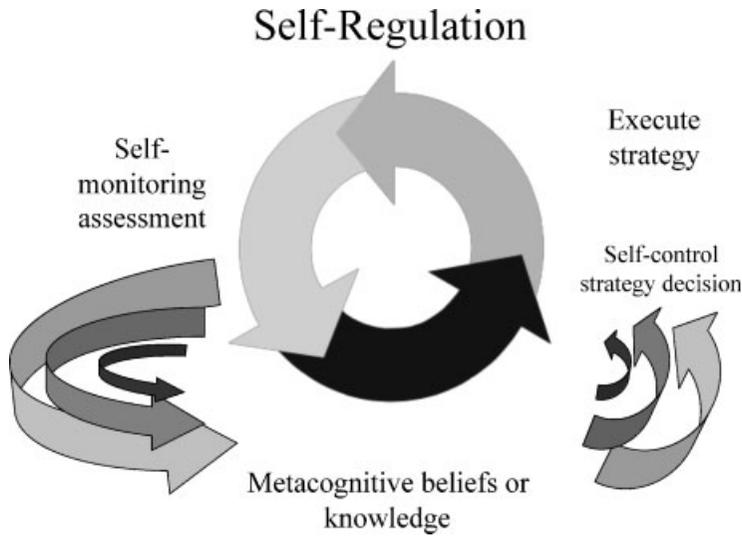


Figure 1 Self-regulation depicted as ongoing relationships between metacognitive beliefs/knowledge, self-monitoring, self-control, and strategy execution that occur during activities.

his or her performance given this change, make a strategy decision, and execute the strategy. Beliefs about the person's own cognitive abilities influence his or her willingness to accept and eventually to use an alternative strategy. Figure 1 depicts self-regulation as the dynamic relationships among metacognitive beliefs and knowledge, self-monitoring, self-control, and strategy execution.

Self-monitoring is the ongoing self-assessment that occurs internally *during* cognitive-communication activities. Self-monitoring occurs when an individual compares actual performance with an expected performance goal. There are numerous ways to operationalize self-monitoring, including ease of learning judgments, predictions of recall (also called "judgments of learning"), feelings of knowing, and retrospective judgments about performance.¹⁹ The results (i.e., the products) of self-monitoring are not only useful for updating beliefs but also important for making decisions about the use of strategies, called self-control. From this perspective, the products of self-monitoring are synonymous with internal feedback.²⁰ As depicted in Figure 1, self-monitoring creates internal feedback, which is used to make a decision about a strategy. For example, while reading a journal article you continuously monitor whether or not you understand what you read. If you determine that you did not

understand a section through monitoring, you use this self-generated internal feedback to decide to do one of the following (i.e., you use self-control): (1) ignore this feedback, do nothing different, and continue to read; (2) reread the section more slowly while allocating more attention; or (3) continue to read, hoping that you will figure it out as you go, and, if not, return to the section to reread it later. Here, the decision to use a strategy referred to as self-control is equivalent to "executive functions." Butterfield and Belmont²¹ explained that "executive function is exhibited when the subject spontaneously changes a control process or sequence of control processes as a reasonable response to an objective change in an information processing task" (p. 284). Here, executive functions are part of the metacognitive system rather than superordinate to it.

This perspective stresses the relationships between internal feedback created by self-monitoring and decisions about strategies in self-control when the situation or task has changed, forcing the individual to rely on the slow, thoughtful, and conscious processing depicted in Figure 1. When one has many experiences, the feedback created from these experiences can be used to revise the autobiographical beliefs one holds about oneself. For example, an adult who is 60 years old had always thought that she was particularly good

at remembering not just colleagues' names but also details about them, such as where they grew up and went to school. In recent years, however, she has found that she cannot always recall names although she can still recall personal details. She has used these recent experiences to revise her metacognitive belief about her own recall—she is still good at recalling details but no longer good at recalling names.

Research over the past 30 years involving individuals across the life span has updated our understanding of the relationships between the parts of self-regulation (beliefs, self-monitoring, and self-control), helping to direct rehabilitation of self-regulation after TBI²¹ (see reference 14 for review). First, metacognitive beliefs and knowledge are typically assessed out of context by using questionnaires and structured interviews, and the results on a questionnaire differ from the ability to self-monitor “on line” or during activities. These divergent aspects of metacognition are based on different processes and can vary independently from each other.²² Second, performance ratings in individuals with or without brain injury are susceptible to a paradoxical phenomenon called “discounting,” in which individuals who remember less end up rating their confidence higher instead of lower.²³ Discounting has been used to explain why adults without brain injury or memory impairment typically underestimate their memory²³ and why individuals with memory impairment typically overestimate their memory.²⁴ Thus, correlations between performance ratings and performance are more valid because they allow for individual variation when using a rating scale. Third, individuals should use strategies to enhance performance that are based on accurate on-line self-monitoring in new situations or tasks and to a lesser extent on their metacognitive beliefs.^{25,26} In routine activities, strategy use reflects the strategies that have become a part of the individual's implicit memory, their automatic routine.^{13,16} Finally, when presented with a new situation or a situation that requires strategic decision making, the internal feedback created by continuous self-monitoring during and after the activity is critically important to self-regulation and to the updating of the self.²⁷

SELF-REGULATION AFTER TRAUMATIC BRAIN INJURY

The manifestations of impaired self-regulation and executive functions in individuals with TBI include difficulty starting or initiating, stopping or inhibiting, shifting, and adjusting; overconfidence or underconfidence in beliefs about their skills; and impaired self-monitoring or self-control during activities.^{28–30} Given the heterogeneity among persons who are injured, the injuries themselves, and the resulting behavioral disorders, it is not surprising that there are numerous approaches to intervention, although the common goal is to provide each individual with internal or external strategies that will be used *spontaneously* in everyday situations outside the therapy room. In this review, we consider intervention approaches that focus on self-awareness and self-regulation of memory, learning, and problem solving. More general discussions of executive function disorders and approaches to intervention after TBI can be found elsewhere.^{31,32} For additional information about metacognitive approaches in teaching and remediation, the reader is referred to publications by Pressley and Ghatala,¹⁵ Borkowski,³³ Hacker, Dunlosky, and Graesser,¹⁴ and Swanson¹⁷ who describe applied research across the life span.

As a part of the Academy of Neurologic Communication Disorders and Sciences (ANCDS) Evidence-based Practice Project, we conducted an extensive review of the research literature on intervention for disorders of executive function and metacognition after TBI. Both general and specific terms were used to search Medline, CINAHL, PsychInfo, and ERIC databases through 2004. This review yielded over 30 intervention studies. For inclusion and exclusion criteria, the reader is directed to the technical report by Kennedy et al³⁴ located at www.ancds.org/PracticeGuidelines. The intervention studies that are summarized in the following section are based on this review. We are currently critiquing this evidence so that we can make clinical recommendations

*For a comprehensive review of the conditions that facilitate accurate self-monitoring, the reader is referred to Kennedy (2004).²⁴

in the form of practice standards, guidelines, and options.

METACOGNITIVE BELIEFS

It is common for clinicians, families, and friends to report a discrepancy between their assessment of a survivor's abilities and the survivor's beliefs concerning his or her own abilities after injury. Most empirical accounts of self-awareness after TBI have compared the injured individuals' self-ratings on questionnaires with the ratings of family, friends, or rehabilitation staff. Historically, it was thought that most adults with TBI were unaware of their limitations. Today, we know that this does not apply to all individuals, nor does it apply to all skills. First, we now know that individuals in the acute recovery phase tend to be less accurate at assessment of their abilities than their therapists.³⁵ Second, the longer individuals with TBI live with disability, the more likely they are to be realistic in their awareness or beliefs about their disability.³⁶ Third, individuals with TBI are more realistic about physical skills and activities of daily living than they are about their cognitive, memory, and communication abilities.³⁷ Fourth, not all individuals with TBI are overconfident; for example, Prigatano and Altman³⁸ identified adults who were overconfident, underconfident, or realistic. Further, judgments made in retrospect about confidence in one's answer are typically more accurate than predictions of future performance.^{39,40} Finally, general beliefs about disability measured on questionnaires are related to personal goal setting but not related to activities,⁴¹ whereas questionnaires such as the Behavior Rating Inventory of Executive Function⁴² that ask about performance on specific activities have been found to be a valid predictor of performance.⁴³

Advances in the ways in which we obtain information about beliefs can help us obtain more accurate and domain-specific information. For example, we modified the Structured Awareness Interview described by Giacino and Cicerone³⁰ to include the use of a Likert rating scale in which clients rated their certainty (1) about having a particular problem, (2) that other people are aware of the problem, (3)

about the extent to which they use strategies to mitigate the problem, and (4) that they would consider using a particular strategy.⁴⁴ In addition, psychometrically strong and valid questionnaires such as the Awareness Questionnaire⁴⁵ are providing us with confidence in the accuracy of the information we obtain.

There is limited evidence in support of educational, or "top-down," intervention approaches that attempt to improve survivors' general awareness or appraisal of their disabilities after injury. Beardmore, Tate, and Liddle⁴⁶ randomly assigned injured children living with their families to one of two intervention groups. Children assigned to the experimental group received a single 30-minute session of educational instruction about their injury and its cognitive consequences, whereas children assigned to the control group received instruction on how to organize school materials and homework. Neither group demonstrated gains in their knowledge or awareness of disability, perhaps because of the brevity of the treatment.

Owensworth, McFarland, and Young⁴⁷ documented the effects of a 16-week treatment program in a group of adults with chronic cognitive and psychosocial difficulties after TBI who had failed traditional rehabilitation programs. Intervention included education about brain injury, its cognitive consequences, and psychosocial problems, as well as instruction on the use of strategies that were individually recommended by clinicians. Months after the end of intervention, interviews with survivors, reports of relatives, and scores from the Sickness Impact Profile revealed that participants had more realistic beliefs about their cognition and behavior as well as positive changes in behavior. Although there was no comparison or control group, the fact that participants were in the chronic stage after injury suggests that the results were not due to spontaneous recovery.

METACOGNITIVE SELF-MONITORING AND SELF-CONTROL

Research from educational and cognitive psychology indicates that across the life span, individuals use feedback (externally provided

or internally generated) to guide their strategy decisions in novel tasks and situations when trying to learn or remember explicit information and solve problems. Impaired learning and impaired problem solving after TBI are well documented, but it is only within the past 15 years that rehabilitation researchers have studied how self-regulation plays a role in these processes. That is, we are only beginning to understand how individuals with TBI self-monitor and use feedback and metacognitive beliefs to guide strategy decisions during the learning and problem-solving process. A similar literature is emerging in the area of self-regulation of social skills, and readers are encouraged to read the article on this topic by Ylvisaker, Turkstra, and Coelho in the current issue of this journal.

Self-Monitoring and Self-Control of Memory and Learning

Individuals can be accurate at self-monitoring in two ways. First, they can be relatively accurate at making judgments, meaning that they judged recall to be poor when they performed relatively more poorly on a recall test and judged recall to be good when they performed relatively better on a recall test. In other words, judgments of recall were higher when recall was better and vice versa. Inaccurate self-monitoring is documented when the correlation between judgments of recall and actual recall performance is low or no better than chance (i.e., close to 0). This can occur when an individual's judgments of recall do not reflect recall performance. Second, they can be accurate in their confidence versus overconfident or underconfident. Kennedy²⁴ gave this example: "when determining how confident you are at correctly recalling the items at the grocery store, you may decide that you are 40% confident you will recall ketchup, eggs, and milk; but 80% confident you will recall bananas and bread. Averaged across items, you are 56% confident you will recall these; however at the grocery store, you recall only 40% of the items. Thus, you were over-confident by 16%" (p. 143). These two outcome measures vary independently; that is, individuals can be accurate at monitoring their recall but over-confident.

The accuracy of self-monitoring depends on many factors. One factor is brain injury, particularly injury to the frontal lobes, which are thought to be a core neural substrate for self-regulation of behavior.⁴⁸ Other factors that affect self-monitoring ability include the type of information being learned (e.g., a list of words, unrelated pairs of words, narrative text, or expository text),^{24,49} the types of judgments made (e.g., global estimates of amount recalled, predictions made immediately after studying or after a delay from studying, judgments about one's confidence in an answer),^{39,40,50} and whether the measures are relative (correlations) or absolute (confidence scores).⁵¹ Further, self-monitoring accuracy does not generalize across tasks and stimuli; one may be accurate at judging one's ability to remember names but inaccurate at judging one's memory for details in stories.^{24,52}

Intervention aimed at improving self-regulation takes two general approaches.³⁴ One approach focuses on the underlying process (e.g., attention or working memory). Evidence in favor of this approach is still emerging.⁵³ A second approach explicitly instructs the individual to rely on external or internal feedback in a step-by-step manner, to provide the individual with some aspect of control by using strategies. External feedback might include the therapist's feedback (e.g., the therapist informs the client of his or her performance and compares this with the client's recall prediction), and internal feedback might include self-monitoring or self-checking (e.g., the client compares his or her performance with what the client predicted).

The second approach is based on the assumption that individuals with TBI use internally generated feedback when making study strategy decisions. Kennedy et al²⁸ investigated this assumption. Participants studied word pairs, made predictions of recall either immediately after studying each pair or after an intervening period of time, and then were given the opportunity to select items they wanted to study again. Adults with or without brain injury were more accurate at predicting recall when predictions were slightly delayed after studying than when predictions were made immediately after studying (i.e., while

rehearsing). Regardless of brain injury status, participants selected items to restudy that they had judged they were less likely to remember on a recall test. Participants then took a recall test, restudied selected items, and took another recall test. Recall improved most for adults with brain injury when they restudied items that they had accurately identified as unlikely to be recalled (those selected after delayed predictions, not immediate predictions), whereas the recall of adults without brain injury improved after restudy regardless of whether they had accurately identified the items as unlikely to be recalled or not. This finding implies that self-monitoring accuracy is critical for adults with brain injury to make sound strategy decisions.

Few studies have sought to improve the accuracy of monitoring memory in individuals with TBI. Rebann and Hannon⁵⁴ attempted to improve prediction accuracy on an impairment-level memory task in three adults with brain injury who were attending a community college program. Prior to and after intervention, predictions of recall were compared with actual scores on the Brief Multiparametric Memory Test.⁵⁵ The intervention consisted of verbal and visual performance feedback as well as praise and lottery tickets, which were provided twice weekly for 5 to 6 weeks. Although participants lowered their recall predictions somewhat, memory improved as well; thus, improved memory performance accounted for some of the calibration between predictions and performance. In a second study, Schlund⁴⁰ documented the effects of systematic feedback and review on the prediction accuracy of an adult with a severe brain injury who chronically overestimated his everyday memory abilities. The authors developed a questionnaire that included personalized details about the participant's therapy regime. The participant completed 4 or 5 treatment sessions each week, for a total of 38 sessions. During each session, the researcher provided feedback and review of performance after the participant predicted his or her recall (for the same day and the next day), answered questions, and the participant made postdiction estimates of the accuracy of his or her answers. Realistic postdiction estimates emerged first, followed by realistic same-day predictions.

Overestimations for next-day performance remained unchanged. Neither study reported maintenance or generalization effects.

The second general intervention approach, which uses explicit instruction, is borrowed from education psychology and is referred to by several names such as self-instruction or reciprocal teaching. Rather than focusing on the part of the self-regulation system that is impaired, this approach instructs the individual to engage in step-by-step procedures with the goal of successful strategy use and improved self-regulation. That is, the ultimate goal is the spontaneous generalization of skills from trained tasks to untrained tasks. This approach encompasses current principles in cognitive rehabilitation: errorless learning, shading and fading of the behavior and the use of strategies, distributed practice and repetition to reach criteria, and the use of what is called "metacognitive strategy training," in which the dynamic relationship between self-monitoring and self-control is explicitly taught (see the article by Sohlberg, Ehrlhardt, and Kennedy in this issue for an in-depth discussion of these principles). Webster and Scott⁵⁶ presented an early example of this approach in a case report of an individual with severe attention and memory deficits who was 2 years after injury. In 11 intervention sessions, overt self-talk was shaped and faded to covert self-talk when the participant was attempting to pay attention while listening to stories. Memory for verbally presented paragraph information improved, and the client reported that he used these strategies to help him concentrate while reading. Thus, these covert strategies may have generalized to reading. When reading was later tested, it had indeed improved.

Two other studies have described the use of step-by-step self-instruction to improve memory after TBI. In a group study, Freeman, Mittenberg, Dicowden, and Bat-Ami⁵⁷ compared the performance of a group of adults with TBI who received 2 weeks of memory intervention with that of a control group that received no intervention. The memory intervention group received instruction on a range of compensatory memory strategies that could be used when studying expository text, then were given step-by-step instruction on the

use of these strategies. These instructions made the relationship between self-monitoring and strategy decisions explicit: stop and think about strategy to use, use the strategy, and check and compare what you remembered with the text. The intervention group recalled more expository text than the group that did not receive intervention, although the authors did not report on maintenance or generalization.

In a case study, Lawson and Rice⁵⁸ documented improvement in recall in a 15-year-old student whose injury was 3 years prior to the study. In 38 therapy sessions, the researchers provided a five-phase intervention program that included strategy training for word lists, paired words, and imagery; executive training, in which the participant was instructed in understanding the steps and acknowledging what needed to be done, selecting a strategy to use, trying the strategy, and checking his own performance; and a final phase in which the strategies were applied to reading and mathematics activities. The amount remembered increased in each phase; however, the participant initiated the use of strategies only after the executive or self-instruction phases. The authors reported anecdotal evidence that the self-initiated use of strategies continued for 6 months, but there was no generalization of strategy use to standardized reading or mathematics tests.

The finding just described is consistent with the notion that self-regulated learning does not generalize across tasks and domains. The ability to predict one's future recall for lists of words differs from the ability to predict memory for stories or textbook material. Further, the strategies we use for one type of learning activity generalize to different learning activities only to the extent that the activities are similar; this includes features such as the material to be learned, the conditions under which the material was initially learned, and the way in which the material will eventually be accessed (e.g., recalled with or without cues, recognized with or without cues).^{24,52}

In a recent study, those with severe anterograde amnesia and executive function disorders from brain injury were able to learn to use email after participating in a systematic inter-

vention program that used the principles of direction instruction using TEACH-M.⁵⁹ In a single-subject, multiple baseline intervention design, four adults with acquired brain injury participated in an intervention program that was designed to teach a specific task—a seven-step email task. Intervention consisted of (1) errorless learning and prompts while initially learning the steps (computer- and therapist-assisted), (2) metacognitive strategy training (reflection and prediction of difficulty of next steps), (3) cumulative review of performance and retrieval opportunities of the steps using spaced retrieval, and (4) additional metacognitive strategy training (comparing actual with predicted performance). All four participants demonstrated the ability to learn the email task as the result of direct instruction; that is, the number of correct email steps increased for all participants and for three participants this was maintained at 1 month. Generalization effects to an untrained interface set up within 3 days after the intervention ended, were found and maintained at 1 month for three of the four participants. In the context of a whole treatment program, these results hold promise for teaching individuals with severe memory impairments specific yet complicated skills using instruction that included self-regulation throughout the protocol.

Self-Regulated Planning and Problem Solving

Disorders of planning and problem solving are commonly associated with TBI and can have a major impact on long-term community living. By contrast to the literature on self-regulation of learning, just discussed, the literature on self-regulation of planning and problem solving provides ample evidence that intervention using a step-by-step instructional approach is both efficacious and effective.

Effective planning and problem solving requires the individual to perform a series of complex steps in a particular sequence. As noted by Marlowe,⁶⁰ the initial step in thinking strategically requires that the individual “be able to label or identify the task demands accurately” (p. 450). Once this is accomplished, the individual must:

- Identify the goal
- Identify all the potential strategies that could be used
- Compare and contrast the strategies to decide which would be the optimal one for this particular problem
- Prioritize strategies in order of preference and likelihood of success; include alternative strategies as a backup
- Create steps of action that are necessary, including identifying and gathering the necessary materials
- Initiate the action steps
- Self-monitor/check the action steps as they are performed
- Modify the steps as necessary, implementing alternative strategies if needed
- Continue with action steps, modifying as needed until goal is achieved
- Retrospectively review what worked and what did not and why

Not all of these steps are required in every situation that involves solving a problem. Thus, it is difficult to make direct comparisons and draw general conclusions about an intervention's efficacy or effectiveness across studies because the studies differed in their intervention in the following ways: (1) the specific aspect of problem solving that was impaired and addressed as a goal (e.g., creating goals, identifying solutions, self-monitoring performance after solutions are implemented), (2) the number of intervention steps, (3) the strategies taught as one of the steps to compensate or facilitate strategic thinking, (4) the type of feedback provided, (5) how the feedback was shaped and faded, (6) whether or not intervention included a phase designed to facilitate generalization of outcomes, and, particularly pertinent to this discussion, (7) the degree to which intervention included explicit steps toward self-regulation (i.e., metacognitive strategies such as self-prediction, -monitoring, -checking or decisions about strategies). In addition, studies also differed in their design (randomized clinical trials, within-subject studies, single-subject designs, and case reports), participants, and outcome measures.

That said, in our review of the research through 2004, we found 18 intervention studies

that addressed disorders of planning or problem solving.³⁴ Of these, 10 studies attempted to improve strategic problem-solving behavior by including aspects of self-regulation in step-by-step instruction as a major part of the intervention. In most of these studies, the term "metacognitive strategy training" was used to describe the aspects of the treatment program that focused on self-monitoring or self-control related to problem solving. Two studies documented intervention for problem solving by specifically targeting aspects of self-regulation. Cicerone and Giacino⁶¹ reported on eight adults with TBI who participated in an intervention that aimed at (1) improving self-prediction accuracy (participants predicted the number of moves to complete the Tower of London task and were given feedback on their prediction accuracy), (2) reducing errors and off-task behaviors through self-instruction (fading from overt to covert self-talk), or (3) providing self-monitoring therapy to those who did not respond to self-instruction (i.e., the clinician pointed out errors to the participant, who recorded the errors and compared this with prior errors). The amount of generalization to untrained tasks depended on the intervention. Those who received self-prediction intervention (i.e., feedback after predictions) showed some improvement in self-monitoring during other tasks, whereas those who received self-monitoring intervention generalized the error-reporting strategy to other tasks. Self-instruction intervention through fading overt to covert self-talk did not generalize to other problem-solving tasks without explicit instruction.

Burke, Zencius, Wesolowski, and Doubleday⁶² treated problem solving in five adults with chronic cognitive impairments after TBI who were making a transition back to work. They identified needs for remediation in areas such as solving vocationally relevant behavior problems, improving initiation, and improving self-monitoring and self-regulation of behavior. A single-subject, multiple-baseline design was implemented, and intervention occurred in the context in which the behaviors occurred. Depending on the target behavior, checklists, cue cards, and verbal feedback were faded, whereas inhibition was facilitated by explicitly teaching self-monitoring and having the

participants keep a written journal. All behaviors improved during the intervention phases and were maintained for several months, although generalization was not reported.

The majority of recently published interventions for disorders of problem solving include self-regulation through the use of metacognitive strategies within a larger therapy program, although how and where self-regulation is incorporated into the treatment program vary across studies. Therefore, the discussion that follows provides readers with examples of interventions in which self-regulation was explicitly identified.

In the first randomized clinical trial aimed at problem solving in adults with TBI, stroke, or other neurological disease, von Cramen, Matthes-von Cramon, and Mai⁶³ compared the efficacy of teaching internal memory strategies (MST) to therapy aimed at improving problem solving (PST). The PST consisted of having participants identify and formulate problems and solutions, identify the pros and cons of solutions, and self-check and monitor implemented solutions. The PST group demonstrated improvement on a planning task as well as standardized tests of impairment (e.g., the Tower of Hanoi and intelligence tests), whereas the MST group improved in their recall of paired words and face-name associations. The rehabilitation staff validated improved planning skills to everyday problem situations in the PST group using a rating scale; thus, the results indicated that some generalization to naturally occurring problems occurred.

In a study by Fassotti, Kovacs, Eling, and Brouwer,⁶⁴ a group of 22 adults with severe and chronic cognitive impairment from TBI were randomly assigned to one of two intervention groups: time pressure management (TPM) or concentration therapy (CT). The goal of the study was to determine TPM's effectiveness. In both groups the main tasks were to watch short video stories that varied from concrete to abstract. The TPM intervention consisted of awareness and acceptance training and self-instruction to use a three-step approach when faced with problem solving, and this was practiced with increasing distractions. The CT intervention group was instructed to focus on

the main theme, avoid being distracted, and rehearse these instructions. Both groups received therapy two or three times weekly for 2 to 4 weeks. After intervention, the TPM group used more steps when determining solutions to problem scenarios than the CT group, and this was maintained at 6 months after intervention. Regardless of intervention, accuracy improved in both groups; however, the authors noted that accuracy in solving problems was relative to the extent that the individual anticipated or predicted difficulty. The TPM group demonstrated greater improvement on several standardized tests of attention and memory than the CT group. Thus, a step-by-step approach to problem solving was efficacious in that the steps were learned and maintained.

Rath, Simon, Langenbahn, Sherr, and Diller⁶⁵ compared an innovative group therapy approach that focused on emotional self-regulation and strategic thinking for problem solving with conventional cognitive rehabilitation in adults with mild to severe TBI. Participants had made a good recovery but had mild residual problems with social and vocational skills. They were able to take notes and give and receive feedback and had intellectual awareness of their cognitive abilities. Group therapy was divided into two modules: problem orientation and problem-solving skills. In the problem orientation module, participants learned to identify real-life problem situations and their reactions to these through feedback using lists of personal pitfalls and the contexts in which problems resulted in overreaction. Important to this module was instruction on inhibiting impulsive responses that can flood the cognitive system, using a self-regulation worksheet. Participants analyzed their emotional responses by documenting their reactions and the precursors that triggered the reaction, then "reframing" by mentally rewinding the situation to observe how it could be avoided. In the problem-solving skills module, participants applied the emotional self-regulation strategies learned in the prior module by proceeding through a step-by-step program that included "stop and think", asking "clear-thinking questions", "defining the problem", "generating options", and "follow-up". Role playing and giving and receiving feedback were key elements in this

module as well. The self-regulation treatment group made gains over those made by the conventional group on several measures of impairment and everyday activities associated with problem solving and self-appraisal of problem solving. These treatment effects were maintained at 6 months after intervention. The authors emphasized that because this intervention included only those with mild residual cognitive deficits, its effectiveness cannot be assumed for those with more severe attention impairments and anterograde amnesia. For these individuals, step-by-step instructions and shaping and fading of desired behavior would probably be necessary.

CONCLUDING REMARKS

Individuals with TBI often demonstrate difficulty regulating their behavior, particularly when the injury includes the frontal lobes. Converging evidence from educational, cognitive, and neuropsychological rehabilitation indicates that self-regulation is represented as the dynamic relationships among metacognitive beliefs and knowledge, self-monitoring and self-control during activities, and strategy use. The perspective described in this article emphasized the importance of accurate self-monitoring as a guide for decisions about strategy use (i.e., self-control).

Advances in assessing metacognitive beliefs and knowledge through questionnaires and structured interviews now provide rehabilitation professionals with a better understanding of the relationships among responses on questionnaires, activities, and personal goals. In addition, we know that there are conditions in which individuals without brain injury are accurate or inaccurate at monitoring their learning and problem solving. Only recently have we begun to test these conditions with individuals with TBI in investigations in which the self-assessment and task conditions vary. There is emerging evidence that for this clinical population, basing strategy decisions on accurate self-monitoring is at least as important as, if not more so than, for individuals without brain injury.

Intervention studies that have targeted self-regulated learning are limited in number

and scope. Although it appears that accurate self-monitoring is a critical step in regulating one's own learning, there are relatively few intervention studies that have applied this principle to the rehabilitation of individuals with impaired learning after TBI. In contrast, several studies have documented the efficacy and effectiveness of intervention aimed at improving problem solving through sequences of steps, including self-monitoring or self-checking.

The use of direct, step-by-step self-instruction holds promise for training individuals with TBI to regulate their own learning spontaneously after strategies have been learned. In conclusion, we recommend the following principles to guide rehabilitation professionals' perspective when treating disorders of self-regulated learning and problem solving.

- During conscious and intentional learning and problem solving, individuals with TBI as well as those without brain injury will be successful at regulating their own behavior, but only to the extent that their internal feedback (i.e., self-monitoring) is accurate.⁶⁶ The first step in this self-monitoring approach is to identify conditions, situations, tasks, and activities in which self-monitoring is likely to be accurate or inaccurate.
- If feedback is provided by clinicians, a necessary step would be to identify situations, conditions, and tasks in which the client's own feedback (e.g., self-predictions) is accurate and educate the client about these conditions before training the use of this feedback to make strategy decisions.
- The connection between self-monitoring and strategy decisions should be made explicit for the client through instruction. For example, the use of strategies could be represented visually in a decision-making rubric for the individual client. The rubric should include tasks and situations in which that client is accurate at self-monitoring and inaccurate at self-monitoring and identify the strategies that should be used in either situation. For example, a client with moderately impaired memory may be accurate at assessing his prospective memory for appointments but inaccurate when predicting his memory for lengthy conversations that tax his attention

span. Using a daily planner may be a good strategy for prospective memory impairment, and training him to take notes during important conversations at work would probably compensate for any metamemory and memory deficits.

- The current evidence suggests that we should not expect individuals with TBI to spontaneously generalize the use of strategies to untrained situations²⁴; rather, we should facilitate generalization by providing multiple opportunities to practice the strategies in various contexts and under constrained and unconstrained conditions.⁶⁷ During this application phase, individuals should actively self-monitor their performance and compare what they predicted with their actual performance. This active self-monitoring may facilitate a revision or updating of the individual's metacognitive beliefs.

In closing, the reader is reminded that in an ongoing review of the research evidence, we are critiquing intervention studies whose aim was to improve executive functions, metacognition, and self-regulation. The project is organized around three clinical questions: Who benefits from this intervention? What does the intervention include and how much is needed to obtain the benefits? What are the benefits or outcomes of this intervention and do the benefits include generalization of skills? The reader is encouraged to visit the ANCDs Web site for updates on this project (www.ancds.org/PracticeGuidelines).

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