Rehabilitation of Executive Function: To Err is Human, To Be Aware—Divine

Michael Studer, PT, MHS, NCS

Abstract: Regaining independence after a neurologic insult requires more than improved motor control. To assume roles and responsibilities and individual must have the executive functions of planning, organizing and self-monitoring. Physical therapists are evolving their role as movement specialists by appreciating the executive function skills required to fully integrate and participate in society. Tasks trained in physical therapy provide and ideal opportunity to incorporate executive function as patients practice mobility skills and experience errors in safety and efficiency. This article will begin to bridge the gap between cognitive and motor rehabilitation by providing practical applications to integrate executive function rehabilitation into current physical therapist practice.

Key Words: executive function, problem solving, rehabilitation, awareness, physical therapy (JNPT 2007;31: 128–134)

INTRODUCTION

Physical therapists are becoming more aware of the importance of cognition which is highlighted in an enablement model of rehabilitation. This emphasis on cognition can be seen in research\(^1\)–\(^4\) teaching, and in clinical practice. At the III STEP (Symposium on Translating Evidence to Practice) conference in Salt Lake City Utah in 2005, Dr. James Gordon urged physical therapists to recognize the role of cognition in teaching patients to monitor their environment and acquire high levels of skill.\(^5\) The highest levels of skill often depend on cognition. As Gordon and Quinn wrote, about task efficiency, which involves both physical and mental efficiency required to perform tasks with the least amount of energy necessary and in a reasonable time frame.\(^6\) As a profession, physical therapy is coming to understand the importance of cognition on balance, motor learning and generalization of skill.\(^1\)–\(^5\)

One aspect of cognition is executive function. There is no consensus on the definitions and skills that comprise executive function. Levin and Hanten\(^7\) described executive function as basic and complex processes. Basic processes include working memory and inhibition and more complex processes involve decision making. They mention as well other domains of executive function such as motivation, self-regulation, and social cognition. Hart et al.\(^8\) characterized executive functions as metacognitive skills required for self-monitoring and self-regulation as well as the ability to adjust one’s behavior to meet everyday social and practical goals. The authors feel that executive functions are as a set of cognitive control functions used to organize and maintain goal-directed behavior by deploying and distributing attention, and monitoring and adjusting behavior, in real time based on continually updated representations in working memory.

Hart\(^8\) and colleagues were referring to social skills when they wrote about “behavior” in these excerpts. This author suggests that this description can be applied to the dynamic process that patients experience while relearning motor control. The ongoing monitoring and adjusting of behavior according to continually updated representations\(^8\) is an aspect of executive function this author recommends become a focus of physical therapy interventions for patients relearning independence and community integration.

Another model of executive function has been proposed by Mateer.\(^9\) In this model, executive function includes higher frontal lobe skills of initiation and persistence, and generative thinking, as well as awareness and organization. Mateer’s model of executive function will serve as the basis for this paper, with specific emphasis on awareness, generative thinking and organization.

The definitions of executive function are relevant to physical therapist practice. Helping patients overcome impairments in executive function factored into our interventions may maximize patients’ ability to acquire the necessary skills and achieve functional independence. Physical therapists are in a good position to help patients with ongoing awareness and their ability to self-monitor.\(^8\) A good time to work on awareness is presented as patients practice mobility skills to improve safety and efficiency. Physical therapists can contribute to the development of patients’ abilities to problem solve. Consider the patient who parks the wheelchair too far from a bed for a safe transfer. That patient must learn how to recognize the potential problem and correct it without cues from a therapist. This paper will review the executive functions of awareness and problem solving, as well as offer ideas for incorporating these executive skills into practical rehabilitation management.
AWARENESS AS KEY

Self-awareness is one of the most critical elements of executive function for patients rehabilitating from brain injury. Higher levels of awareness can contribute to improved attention, memory and problem solving. Individuals who comprehend their limitations have established a relevant framework for comparing their current ability with the level of function they want. This awareness allows rehabilitation to have meaning for the individual. When therapy is meaningful and relevant, the person’s ability and desire to learn may be enhanced. Increased awareness has been correlated with positive outcomes in Activities of Daily Living (ADL),14–18 increased employment improved Instrumental Activities of Daily Living (IADL),23 and reduction in falls. It is important to note that awareness in not the same as orientation. In fact, orientation to person, place, time and date has not shown to be significantly correlated with outcome.25,26 Patient who are oriented—yet are unaware of their own impairments—may not be successful in therapy.24–29

One aspect of awareness is the ability to analyze one’s own performance. This ability may be a key to successful interventions. “Optimally patients should be cognitively and physically engaged in the tasks at hand and demonstrate the ability to analyze their performance. Analyzing performance requires not only the ability to differentiate between successful and unsuccessful outcomes, but also to identify, at least in general terms, the successful and unsuccessful elements of performance.” The ability to analyze performance is a skill that physical therapists should develop in all patients.

There are potential psychological and emotional consequences of increasing awareness. Some studies have revealed a correlation between increased self-awareness and levels of depression or anxiety in patients recovering from brain injury. Bach and David wrote that acknowledging deficits was not a guarantee of a good outcome because this awareness increased emotional distress. The entire rehabilitation team, with a patient’s family, can provide appropriate emotional support as patients become increasingly aware of their impairments.

Assessment of patient awareness can begin with the interview. Therapists can learn about a patient’s insight by listening to them talk and express their goals. More information can be obtained about the level of the patient’s awareness through observation. Observation affords an opportunity to assess the level of awareness, which will guide treatment. Within the constraints of maintaining the patient’s safety, therapists should allow their clients to make choices and learn from the consequences of these choices. Treatment can then be directed at helping patients move up the hierarchy of awareness from a level at which people recognize their own problems to the ability to prevent errors. In rehabilitation, the ability to recognize errors is critical. The most successful patients will recognize when they have placed the “wrong foot up first”, the “wrong arm in first” or were not able to stand up because their hands were in the wrong place. Physical therapists can help people self-monitor to look for these errors and prevent them in the next attempt.

Another treatment idea that can be used to improve all levels of awareness is a game known as “Safety Says.” It’s great for groups of patients, or it can be played with individual patients. It is played just like Simon Says, yet the “contestants” only do what is instructed if their own rules of safety tell them that it would be safe to do. Case H.W. explains how this game works (see Box 1).

SAFETY SAYS

Case: H.W. H.W. is a 61-year-old male who sustained a right parietal stroke. He has left neglect and is in the associative phase of learning, but often forgets the left brake on his wheelchair prior to standing. I am playing “Safety Says” with H.W. and I offer the following. With brakes unlocked, I stand 8–10 feet in front of him with my arms crossed so as to limit visual/gestural cues. I say, “H, please stand up.” He promptly says, “I need you on my left before I can stand.” I walk over to him and stand on his left—he then promptly attempts to stand, brakes unlocked. As the wheelchair begins to roll when he attempts to push-up, I let him continue (as safety allows). Soon, he comes to a point where he cannot achieve standing unless he is pushing from a stable surface. Fortunately, he realizes this before I intervene with an indirect cue and realizes that “I win” that round of safety says.

The progression of interventions can be guided by the patient’s level of awareness. Patients are given more responsibility for recognizing, detecting and preventing problems as they increase their awareness. The levels of awareness, as developed by Crossen and colleagues are the most widely accepted model in clinical practice and research. The lowest level of awareness is intellectual, followed by emergent and anticipatory. Therapists must recognize, however, that some patients start at a level lower than the intellectual level (ie, with no awareness at all). This level is known as anosagnosia. Patients with anosognosia need to be given opportunities to experience their problems and see the consequences of their imbalance, weakness or environmental neglect. They need to see their problems—repeatedly. At this level patients can be resistant to verbal cues and reasoning that show that they have a problem. There is some evidence that group therapy can be beneficial as patients can be much more receptive to advice from a cohort than a therapist. If group therapy is not available, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosognosic patient view themselves on videotape. Though not yet empirically tested, it may be helpful to have the anosagn...
existence of a problem. Obviously most patients post traumatic brain injury (TBI) do not possess intellectual awareness as they emerge from a coma, and this appears to be a primary cause of agitation. Patients who do not know that they have a problem can be combative, resistant to staying in a hospital and unwilling to work with nurses and therapists. Behavioral management at this level is, beyond the scope of this article. Of note, patients can be in more than one level of awareness at a time. For example, they may be aware of their arm or leg weakness, but be unaware of their dysphagia.

The next level, emergent awareness, describes the ability to recognize a problem that is occurring. Realizing that you are losing your balance, have lost your way back to a room, or are putting your shirt on backward are all examples of emergent awareness. This skill requires the ability to self monitor, consistent with the definition from Hart et al. cited earlier, “monitoring and adjusting behavior online . . .”6 Certainly this could be a valuable skill for patients relearning functional skills after brain damage.

Anticipatory awareness is the highest level of awareness. Patients who can recall past efforts and attempt to avoid a problem are demonstrating anticipatory awareness. Even if a solution is inappropriate, the attempt to prevent a problem is an excellent sign that the patient has advanced to this level of awareness. Examples of anticipatory awareness include: calling for assistance before getting up from bed, using compensatory swallowing techniques without cues, or making entries in a memory notebook for future recall.

**Acquiring Higher Levels of Awareness: Suggestions for Practice**

Patients who lack intellectual awareness will be disoriented may not know that they have problems and therefore do not know why they are working with therapists and nurses. How can the therapist help patients gain intellectual awareness? First, it is helpful to bring familiar tasks and settings to the patient. The familiar can come in the form of family, pictures, music, avocational interests and pets. Second, patients need to repeatedly see significant problems resulting directly from their actions. It is important that the patient be allowed to make an error without endangering him/herself or becoming agitated. As Merzenich and Kleim suggested at III STEP, neuroplasticity is driven by challenge—“The task must also be difficult enough to introduce a threat of failure in order to maintain focused attention on the task.” Patients should be provided the opportunity to experience some measure of failure, such as allowing them to lose their balance (but not fall), take protracted amounts of time for bed mobility, hit their wheelchair against walls, or attempt to propel themselves in a wheelchair with the brakes locked. It has been argued that the most effective way to help a patient’s awareness evolve is to allow a problem to occur in a safe, meaningful and relevant environment.

Therapists can intervene with physical or verbal assistance if the patient’s efforts to problem solve will lead to unsafe or agitated behavior. Monitoring patient frustration with themselves or therapists is important in a learning strategy where errors are allowed. Patients can be advised that they are being challenged to help them improve more quickly. When warned ahead, patients may be more tolerant of errors and interpret them as opportunities—not failures. Failures can lead to agitation. Recall that people with impaired awareness frequently have impaired impulse control and a higher incidence of agitation.

Finally in an effort to solidify or move beyond intellectual awareness, patients can routinely be asked to report on their performance prior to receiving augmented feedback from the therapist. This allows patients to monitor their performance and adjust future efforts. Patients will then begin to develop an internal self-reference which is integral to the rehabilitation process.

Patients can be assisted through the higher levels of awareness by modifying some of techniques performed at lower levels of awareness (eg, reminding patients that they will be asked to evaluate their performance post-task). As patients come to expect that they will be “called on” after the task is complete, they become more attentive, watching for errors and successes that they can report. In emergent awareness, patients are given the opportunity to predict performance. A patient is more likely to demonstrate emergent “during-task” awareness if they were asked to track this before the task started. This may be as simple as asking, “How many times do you think that you might lose your balance as we walk back to your room?” (see The Power of Prediction).

After the patient has provided an assessment their task performance, it may be helpful to ask them for “advice” about modifications for next time. Three simple questions can facilitate self-analysis, forcing the patient to become more actively involved in the learning process. How did you do? What are you going to do next time? What can you do to make this easier? As patients become accustomed to answering these questions at the end of a task, they understand the need analyze their performance during a task. Patients can build awareness as they plan and monitor each attempt, becoming more actively involved in the strategy employed, and rely less on therapist’s feedback. This helps them begin the progression toward planning, known as anticipatory awareness.

Promoting anticipatory awareness involves the techniques that were described for the lower levels of awareness with a gradual reduction in reminders. For patients to develop anticipatory awareness, they must be able to independently recognize the potential for a problem and plan accordingly. As patients begin to demonstrate more proficient anticipatory awareness (ie, consistently and accurately plan behavior), therapists can reduce the frequency of the indirect cues used to remind the patient about their responsibility for post-task feedback. Patients who have consistent anticipatory awareness will have developed their attention to monitor themselves and memory to recall past errors. They can be expected to utilize their own advice from previous efforts, to improve their safety and independence. Note that rehabilitation techniques for promoting awareness are built on the same principles that guide other rehabilitation techniques—promoting
independence by withdrawing therapist assistance as skill improves.

It is important to remember the value of awareness and integrate appropriate techniques and cues into daily interactions with clients. Impaired awareness is positively correlated with impaired attention. Patients with improving or preserved awareness can be more actively involved in learning as they attend to improving themselves. This level of attention and intensity bring relevance to learning—a critical element driving neuroplasticity.

Using the “power of prediction” (often referred to as “error estimation” in the literature) can be very effective for improving awareness as well as attention. As a patient attempts to meet or beat their predicted time, decrease effort, reduce incidences of loss of balance, or diminish the level of assistance needed, they are attending to the task. This gives them the best opportunity to learn about their impairments as well, promoting an intellectual and potentially emergent awareness (See Box 2).

THE POWER OF PREDICTION

Scenario #1: A patient who overestimates his abilities in ADLs. The patient has not been experiencing repeated losses of balance while sitting at the edge of bed putting on a shirt.

Therapist: “Before we begin our work to put this shirt on, I would like you to tell me how many times you think you will lose your balance before the shirt is completely on?”

Patient: “Why would I lose my balance? I am just sitting here pulling a shirt over my head. I don’t think that I will lose my balance even once.”

Therapist: “In our work together, I have found that it has been difficult for you to concentrate on balance and another task at the same time. Why don’t we count the number of times that you need my help along the way, that way, we will both find out some information. If I heard you correctly, your prediction would be zero, though, right?”

Patient: “Right.” In this scenario, the patient might lose his balance 2–3 times, and recognize or admit to 1–2 of them. Both the therapist and the patient can benefit as they walk away with more information about the patient’s abilities. The therapist has reassessed the patient’s awareness and helped to build emergent awareness. The patient has attended to the task (to see if the prediction came true), begins to recognize the need for assistance (building awareness), and is motivated to be correct in the prediction on the next effort.

GENERATIVE THINKING/ORGANIZATION: THE FOUNDATIONS FOR PROBLEM SOLVING

When the central executive system is operating normally, we have the ability to solve a problem, learn from it, and prevent that problem from occurring again. Among other things, problem solving requires attention to the problem, awareness of your own abilities, and a memory for previous attempts. We see then that the skill of problem solving is dependent upon those three—attention, awareness and problem solving—again reinforces the importance of physical therapists including the development of a patient’s awareness in a rehabilitation program.

Patients can become very dependent on therapists who provide solutions or cues to solutions whenever a problem arises. Patients need to experience some struggle and be challenged, so that they can problem solve and learn to become more efficient. Patients may continue to use the “wrong” solution to the same problem if explicitly told that the solution is unsafe or wrong. Challenging tasks that require problem solving may help to reduce one of the most common barriers to rehabilitation, impaired attention. Again, as Merzenich and Kleim suggested at III STEP, a threat of failure can be therapeutic and will promote increased attention—a critical element for neuroplasticity.

If therapists allow errors, how and when should the therapist intervene with a cue or physical assistance? The Systematic Cueing Strategy provides guidance for therapists to manage patient problem solving attempts. Regardless of the problem at hand, therapists should let patients continue to see problems, generate their own solutions and monitor themselves unless there are concerns of safety or agitation.

Using Figure 1 as a guide, the reader is asked to envision a common problem that your patient experiences in function. Example may be the loss of sitting or standing balance, wheelchair setup for safe transfer, dressing, wheelchair mobility, or self-feeding.

Step One: Problem Recognition

The first step is to allow the patient sufficient time to recognize the problem. In some cases, more time is not enough. The problem must be significant enough to be recognized, such as a near fall. In many cases, the patient who is severely involved will not recognize the problem independently. It is tempting to solve problems for patients when it is obvious that they do not recognize that a problem exists. Recognizing and ultimately solving the problem for a patient will cause them to continue to need augmented feedback to recognize and solve problems. If the patient is repeatedly unable to recognize a problem, this is represented as an “error” on Figure 1. Therapists should intervene at this time with an indirect cue. Indirect cues can come in any form of augmented feedback—beginning with the most subtle for that circumstance (often visual, followed by tactile, then verbal). The absence of any feedback can be a cue. For example, a therapist can pause and keep their distance when the patient is ready to stand from the wheelchair, thereby giving the patient a cue that a brake is unlocked, conveying that “You are not ready to stand”.

Step Two: Problem-Solving Attempts

The generation effect refers to patient’s enhanced ability to remember information that is self-generated compared with information provided by a therapist that is passively presented. Patients need to actively recognize that a problem
is occurring. Then they need time to generate possible solutions. Generating information enhances recall, leading to greater attention and interest, which can also improve memory performance. It is a very favorable indicator if the patient can generate multiple solutions to a problem, even if some are incorrect. Generating multiple solutions is an indicator of a high level of attention and comprehension of the problem parameters. Therapists must be patient, allowing the client time to generate solutions. People will remember a solution that they have generated better than one that the therapist has suggested, no matter how gently the solutions were given.

Patients should be allowed to implement their solution—even if it is incorrect—as long as they will not endanger themselves or others or become frustrated. This allows them another opportunity to problem-solve and a chance to see whether their first solution is viable. A patient who is cued and redirected prior to attempting an errant solution will be almost as likely to implement that very solution when faced with the same problem until they see that it does not work. Therapists should guide patients to the correct solution if they need help because their actions will lead to unsafe behavior or agitation. The sequence of error → indirect cue → error → alternative indirect cue → error → direct cue may be a helpful template for organizing feedback. In this framework, the second indirect cue (if needed) can be slightly more assistive or in a different modality. Verbal cues are usually the most assistive. If the patient fails to implement a correct solution after direct cuing, the therapist may then choose to demonstrate the solution.

Finally, therapists working with adults with brain injury must address confabulation and personality in problem solving. While it is important to generate solutions, it should be noted that confabulation is not an acceptable solution. Confabulation is a better sign than a patient who is unable to offer any solution, and awareness of confabulation is a positive sign. Confabulation without awareness indicates an intellectual level of awareness at best. Additionally, therapists must be cognizant of the influence of individual personality traits on the development of problem solving ability. Knowing when to help and when to allow someone to struggle, given their tolerance and personality, is important. Personality assessment is beyond the scope of this article, but the reader is directed to the following references.

**THE FUTURE OF EXECUTIVE FUNCTION REHABILITATION**

Rehabilitation of executive functions has traditionally been an effort of compensation. Articles on memory prosthetics, cues, mnemonics and other strategies to improve various aspects of executive function have dominated the literature for years. These memory aids have been found to require a significant amount of executive function and may overload the patient. In addition, people with impaired awareness and attention may not have the cognitive resources to notice when a mnemonic is needed nor the resources necessary to successfully implement such strategies. As such, there has been a recent shift toward remediation or true rehabilitation of executive functions. Developments in neuroplasticity have provided the foundations for this shift.

Researchers are now attempting to test concepts on recovery of cognition through neuroplasticity. Lillie and Mateer suggested in their article “Constraint-based therapies as a Proposed Model for Cognitive Rehabilitation” that the cognitive system has the same capacity and potential to improve as the motor system. The authors recommend an approach that involves memory training without compensatory strategies using intense and challenging practice. They argue that this technique should be referred to as forced use therapy, rather than constraint-induced.
Sullivan\textsuperscript{51} cited four critical elements that must be present to stimulate neuroplasticity, in the context of motor control. These elements are, task specificity, complexity, intensity and difficulty. It is important to keep these points in mind when challenging patients cognitively. As Gordon stated “We co-manage the process of neuroplasticity. Recovery is the process in which the patients’ tissues heal themselves. As physical therapists we share in this recovery process by challenging the system with the right amount of task difficulty at just the right time.” This is true for the cognitive, as it is the motor, as both involve neuroplasticity.\textsuperscript{5}

**SUMMARY**

The rehabilitation of executive functions is often overlooked in physical therapy as the domain of other rehabilitation professionals. Executive functions are integral to the learning process that is the foundation for functional improvement and independence. Physical therapists can assist their patients with impairment recognition, thereby improving awareness.\textsuperscript{52,54} Regaining skill requires cognition and motor control. We must enable patients to gain independence and skill through exposing them to a real-world approach including limited feedback, and opportunities to fail or succeed safely.

Three essential points summarize the physical therapists’ role in rehabilitation of executive functions:

1) Ask patients to predict their performance before they begin a task. This will maximize their attention to the task, thereby giving them the best opportunity to be an active learner. Patients should be allowed to compare their predicted to their actual performance. This provides an opportunity for patients to minimize future errors, increase their attention during future trials, and stay safe through better recognition of their potential problems. As the title of this article suggests . . . perhaps a new twist is appropriate, “To err is human, to be aware—divine.”

2) Ask patients to provide post-task feedback about their performance—including what they did do differently with the next trial. This will also help patients’ perception of their task performance.

3) Use the systematic cueing strategy to maximize patient recognition of errors and improve their ability to independently generate solutions. Rely on the generation effect; patients who are allowed to generate a solution to a problem are much more likely to apply this solution on the next exposure to the problem.

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