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## Metacognition as the ultimate executive: Techniques and tasks to facilitate executive functions

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### Abstract

It has been well-documented that executive function deficits are a common consequence of brain injury. Metacognitive processes, in close alliance with executive functions, are viewed as integral components of learning and awareness. Combining all of these areas may be necessary to achieve a beneficial treatment plan for improving executive functions. This article provides a definitional analysis of executive functions and metacognitive processes and it discusses the role of learning, internal mediation, and strategy development. A specific executive functions program is described and suggested as a framework for establishing a metacognitive-learning routine.

*Keywords:* Brain injury; Metacognition; Executive functions; Neurorehabilitation

### 1. Introduction

The prevalence of executive function disorders following traumatic brain injury has been well-documented in the rehabilitation literature [1-4]. Executive functions may be compromised as the direct result of damage to the higher level medial and orbitofrontal regions of the frontal lobes [2]. However, since the brain acts as an integrated whole in regulating executive functions, damage to other cortical areas may indirectly result in executive function deficits, secondary to disrup-

tion of the brain's informational flow at all levels [5]. Since the presence of brain injury, (primarily of the frontal lobes), may prohibit the effective interaction of various cognitive subskills [3], executive function deficits may be apparent at all levels of injury severity and in all spheres of daily living [6], including interpersonal, social, recreational, emotional, educational and vocational areas. The fullest extent of these deficits may become most evident during tasks and situations which require independent thinking and creative decision-making [5].

According to Lezak [2] individuals with executive function deficits may appear apathetic, disinterested and incapable of initiating and complet-

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ing a variety of daily activities. Initiation problems may deter performance of even 'primitive' behaviors such as getting out of bed or eating and may cause an individual to become virtually devoid of affect or emotional responsivity. In contrast, executive function deficits may also present in the form of impulsive or aggressive behaviors, (often referred to as behavioral dyscontrol), indicating an apparent loss of inhibition, social awareness and judgment. Although the manifestation of these behaviors is contingent upon the site of injury (i.e. medial, orbitofrontal frontal regions), any range or combination of resultant behaviors thereof, may prevent an individual from functioning independently.

Executive functions may be depicted as cognitive directors [7], since they assist in the interplay between other cognitive processes, such as memory, attention and perception [3]. In a similar vein, metacognitive functions may be viewed as awareness directors, since they oversee the thinking processes, allowing knowledge of 'thinking about thinking' [8]. Executive and metacognitive abilities incorporate the highest levels of cognition, reflecting the very essence of an individual's thoughts, behaviors and responses. These skills have been identified as critical components in the learning/rehabilitative process and because of their complex nature are frequently viewed as being difficult to remediate. However, it appears that many individuals may indeed benefit from approaches which provide a structured therapeutic regimen serving as a 'prosthetic' executive system [3]. These approaches emphasize the establishment of routines, the development of well-practiced strategies and the acquisition of compensatory techniques [5].

Executive functions are commonly defined as interrelated abilities in self-monitoring, initiation, planning, goal-setting and self-awareness [1,5,9,10,11]. Similarly, metacognitive skills are denoted to include the processes of awareness, evaluation, prediction, anticipation and self-control [8,13]. Metacognitive processes, which foster knowledge about one's own cognitive capacities and the ability to monitor one's own performance, are representative of the core of executive functioning. Executive function deficits may therefore be viewed as disturbances in the

metacognitive aspects of self-awareness and self-regulation.

Metacognitive impairments are manifested most evidently by poor self-monitoring and lack of awareness of behaviors, responses and attitudes. As is the case with executive function deficits, metacognitive impairments can negatively influence functioning within social, familial, educational and vocational settings. Decreased self-awareness may cause an individual to perceive tasks or situations as being less demanding and therefore he or she will be less likely to exert effort, monitor or verify performance outcome. Poor or inefficient self-monitoring will then likely lead to an inability to implement corrective life strategies, which in turn may cause increased anxiety, reduced motivation and further impede the learning process [14]. An absence of metacognitive understanding can ultimately interfere with rehabilitative treatment. Subsequently, therapeutic approaches which endeavor to provide explicit instruction of metacognitive and self-regulatory techniques appear to be the most efficacious avenue for executive function training with brain injured patients.

Analyzing the central definitional components of executive functions (i.e. self-monitoring, initiation, planning, goal-setting, and self-awareness) and metacognition (i.e. awareness, evaluation, prediction, anticipation and self-control) may be helpful in developing a more solid understanding of these complex functions, and in turn, formulating treatment strategies. Table 1 and Table 2 provide a summary of these definitional components.

However, it is important that these components be viewed as elements in a circular paradigm containing reciprocal, interchangeable processes, which are not necessarily hierarchical in nature (Fig. 1). An inclusive therapy program should attempt to address these executive and metacognitive components concurrently.

## 2. The assessment process

Formal neuropsychological measures attempt to assess and better define an individual's functional strengths and weaknesses, establishing a baseline of functions which can be used for future

Table 1  
Components of executive functions defined

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Executive:

Self-Awareness

- Forming goal-directed intentions
- Appreciating one's own strengths and weaknesses
- Recognizing oneself within a social context
- Knowing what factors affect one's actions and responses

Goal-Setting

- Identifying elements of a problem
- Identifying criteria for solutions
- Recognizing any potential constraints to solutions
- Comparing problems to previous situations
- Subdividing problems into more manageable parts
- Retrieving and acting upon relevant information
- Utilizing environmental cues
- Selecting salient points
- Generating and examining solutions and alternatives

Planning

- Organizing and ordering thoughts and actions
- Ability to control impulses
- Awareness of appropriate planning sequences
- Identifying goals
- Deciding about locations and time frames
- Choosing necessary materials to achieve goals
- Predicting outcomes
- Tracking progress
- Evaluating solutions

Initiation

- Ability to persevere
- Mental flexibility
- Behavioral flexibility
- Ability to complete planned actions within a time frame
- Speed of response
- Ability to avoid premature actions
- Ability to follow rules

Self-Monitoring

- Ability to make good judgments
  - Insight
  - Social sensitivity
  - Social-correction
  - Self-inhibition
  - Self-evaluation
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Table 2  
Components of metacognitive functions defined

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Awareness

- Gaining knowledge about one's own strengths and weaknesses
- Gaining knowledge about strategies
- Gaining knowledge about aspects of situations

Evaluation

- Appraising the difficulty of a task
- Assessing the complexity of a situation
- Estimating any problems in advance, as well as evaluating the final outcome process after completed

Prediction

- Formulating educated guesses about the potential consequences of an action or response
- Planning results based on decisions being made
- Foreseeing limitations

Anticipation

- Looking ahead to possible results of an action or response
- Recognizing possible results of utilizing particular strategies

Self-Control

- Regulating external behaviors/responses based on self-monitoring
  - Utilizing what has been learned from the process and modifying responses as necessary
  - Using feedback
- 

proaches have been developed over the past few decades [15]. Assessment techniques may include emphasis on the Luria-Nebraska Neuropsychological Battery, the Halstead-Reitan Neuropsychological Battery, or a 'mixed-measurement' approach utilizing various tests and measurements [16]. Additional testing may include those measuring academic achievement, personality and vocational interests.

In terms of specific assessment of executive/metacognitive functioning, structured tests may include the Trail Making Test, the Category Test, the Wisconsin Card Sorting Test, Tower of London Task, Porteus Maze Test and the Tinkertoy Test. Although these measures can provide useful information regarding some of the constituents of executive and metacognitive functioning, their contrived, highly instructive and well-controlled

comparisons at prescribed intervals. Within this framework, a number of applied assessment ap-

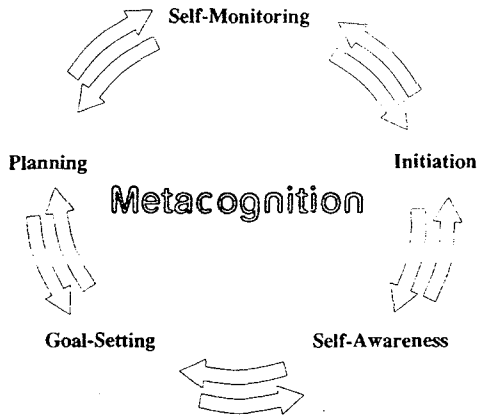


Fig. 1. A circular paradigm containing executive and metacognitive components

parameters may actually detract from a thorough investigation. The use of such highly structured tasks may make it difficult to adequately determine the integrity of the executive control system because the very process of formal testing may mask existing impairments [1]. Formal testing can thus reduce the ability to fully evaluate the demands an individual may encounter within daily functional activities.

As a result of these inherent limitations in structured assessment procedures, some researchers have proposed that executive functions should be evaluated through naturalistic observation [7] and/or by less restrictive assessment protocols [12,23]. Kay and Silver [7] suggest that observational data within real-life situations be organized via a series of guiding questions in areas of judgment, spontaneity, goal-setting, planning, initiation, self-assessment, efficiency, flexibility, organization, productivity and follow-through. A similar approach is recommended by Ben-Yishay and Diller [11] which considers the degree of preparation, methodicalness, and flexibility during naturalistic task completion.

It appears logical to conclude that the most comprehensive information regarding executive and metacognitive functioning may be gleaned from a combination of neuropsychological measures and observational assessments.

### 3. A metacognitive treatment approach

A review of relevant literature discussing therapeutic approaches for executive and metacognitive deficits indicates the following categories of treatment [3,4,17,18]: environmental, behavioral management, self-regulatory, self-instructional, compensatory and strategy training. These categories may be further subdivided into three fundamental classifications: (1) approaches which are only externally mediated (environmental-behavioral management), (2) those which attempt to promote internal mediation (self-regulatory, self-instructional), and (3) a combination of external and internal mediation (compensatory and strategy training). Environmental and behavioral approaches rely heavily on a substitution philosophy which de-emphasizes internal controls [4]. Conversely, the emphasis of the latter four methods is founded upon the common themes of structure, goal-direction, self-management, problem-solving and generalization, with the objective of fostering an adequate level of personal autonomy.

Several authors have observed a positive relationship between increased metacognitive and executive skills and general treatment outcomes [19,20]. Training programs have involved videotaped feedback, group discussion, behavioral reinforcement [21], self-prediction of performance, questionnaires [22], self-instruction, verbal self-regulation [17], role reversals [23], self-questionnaire and self-evaluations [24]. All of these approaches appear to enact varying levels of success in remediating metacognitive and executive skills.

Toglia [14] discusses a multicontext approach to training which appeared effective in establishing a pattern of learning for brain injured patients [25]. This approach promoted a conglomeration of metacognitive and executive principles to help patients achieve improved functioning in task-specific situations, along a continuum of generalization/transfer stages. Similarly, Cicerone and Giancino [4] describe a training program which utilized self-prediction, self-instruction and error monitoring in order to incur a transition from external to internal mediation, thereby enhancing higher order functioning.



Table 4  
Task-question list from executive functions module

\*After each exercise, discuss the following questions with the patient:

1. What skill was this exercise addressing?
2. What was the goal of this exercise?
3. How did you do on this exercise?
4. How might this exercise help you in everyday activities?

\*Chart the patient's performance on the Exercise Performance Summary Sheet which is included on the following page.

formance with actual achievements. Comparative rating scales serve to prompt task knowledge and self-appraisals with the intended by-products of strategy planning and self-monitoring. These scales and charts correspond with every task in the Executive Functions Module and are considered to be vital tools in maintaining the executive/metacognitive threads of the program.

Therapeutic exercises within the Executive Functions Module of BRAINWAVE-R have been devised to improve executive and metacognitive functioning by providing instruction, practice, and

generalization opportunities in the following areas:

- Self-organizing
- Planning
- Strategy development (ie. self-talk, writing lists, self-questioning, report writing)
- Problem analysis
- Cognitive flexibility
- Sequencing steps
- Time management
- Time estimation
- Selecting relevant information
- Prioritizing
- Self-awareness
- Goal-setting
- Self-regulation
- Initiation
- Developing a personal profile

The first two exercises, titled 'Self-Organizing', exemplify the nature of the entire Executive Functions Module. The instructive format of these exercises may prove beneficial to any treatment plan which attempts to combine cognitive,

Table 5  
Comparative self-rating scales from executive functions module

Exercise 2. Self-organizing

Do this now.

Rate how well you predict you will do this exercise by circling the number which applies:

- 5 = No problems in completing whole task correctly
- 4 = A few mild problems but I will complete over 3/4 of the task correctly
- 3 = I will not complete the whole task but will do over 1/2 of it correctly
- 2 = I will have some problems so that I can only complete a small part of the task
- 1 = I will have major problems with this task

Do this after you have completed exercise 2

Rate how well you actually did this exercise by circling the number which applies:

- 5 = No problems in completing whole task correctly
- 4 = A few mild problems but I completed over 3/4 of the task correctly
- 3 = I did not complete the whole task but did over 1/2 of it correctly
- 2 = I had some problems so that I could only complete a small part of the task
- 1 = I had major problems with this task

metacognitive, and executive training goals. The self-organizing exercises are arranged in the following manner:

1. The clinician explains the upcoming task(s) and provides directions to the patient.
2. The patient rates predicted performance on the upcoming task(s) (prediction/anticipation).
3. The patient reads clearly written expository information about four recommended methods of self-organization (awareness/strategy learning).
4. The patient answers a series of questions about the information learned from reading; in answering these questions, the patient reflects upon the steps involved in each of the four methods (knowledge/strategy learning).
5. The patient takes notes from the text information.
6. The patient creates visual representations in the form of posters/diagrams to 'personalize' the four methods (initiation/internal mediation).
7. The patient places the visual representations in an obvious location for easy reference (planning/external mediation).
8. The patient charts actual performance on the preceding task (self-awareness).
9. The therapist discusses relevant factual information with the patient, as well as emphasizing the value of self-perception in task performance (self-awareness).
10. Family members are encouraged to reinforce information and methods via discussion and practice (learning transfer).
11. The patient responds to the designated task-performance questions (self-evaluation), [Table 4].
12. The patient and clinician list (and discuss) scores from predictions, actual patient performance, and therapist rating scales on the exercise performance summary chart (self-evaluation/goal-setting) [Table 3].
13. The four self-organizational methods are practiced during structured and real-life sit-

uations in subsequent exercises of the module (learning transfer/self-monitoring).

This therapeutic sequence may easily be modified according to individual patient needs. The following adaptations could be made:

- For patients who have difficulty writing, text notes could be taped on a cassette recorder, or dictated notes transcribed on a word processor.
- For patients who have difficulty reading, an oral discussion about the four organizational methods could be included earlier on in the task sequence.

This suggested task progression contains vital elements of the executive, metacognitive and learning domains emphasized throughout this article. Although specific to the exercises in the Executive Functions Module of BRAINWAVE-R, the sequential format can be utilized to enhance/supplement a variety of commercially-available or self-made cognitive activities. The key concepts of self-awareness, internalization, patient responsibility, strategy development and task reinforcement are also maintained throughout the sequence. Establishing a therapeutic routine, similar to the one suggested here, may likely provide the tools necessary to improve executive function deficits of brain-injured patients.

#### 4. Case studies

##### 4.1. Case study 1

MN is a 34-year-old single male with a high school education. He had worked as a chef for 16 years. Previous job performance was described as favorable. MN was reported by his employer to be well-organized, thorough, dependable and well-liked, although shy and soft spoken. MN sustained a closed head injury in a motorcycle accident. The initial CAT scan indicated multiple hemorrhagic and bilateral frontal contusions. MN's documented length of coma was 2 months. He was admitted to a rehabilitation facility 8 months post-trauma.

Upon admission to the rehabilitation facility cognitive problems were identified via neuropsychological testing in visual perception, verbal memory, mental flexibility and planning abilities. These results were supported by functional and observational assessments which highlighted problems in the areas of organization, self-monitoring, initiation, self-awareness, goal-setting and problem-solving.

MN participated in a cognitive therapy plan which utilized the Executive Functions Module of BRAINWAVE-R, in conjunction with functional skills application training over a 12-week period. The goals of the program were to improve MN's self-awareness of his strengths and weaknesses and to implement compensatory strategies within functional situations.

At the end of the 12 week phase MN demonstrated adequate learning of strategies for self-organizing, planning, task breakdown, simplifying and organizing information, time management and mental flexibility within structured situations. Efforts were also made to apply taught strategies for activities of daily living, public transportation and community involvement. However, MN tended to remain reliant on external cuing and prompting for accurate self-ratings and appropriate goal setting. The emphasis at this point was placed on family education in terms of providing suitable prompts and external structure as compensatory mechanisms for areas which remained weak.

#### 4.2. Case study 2

TR is a 25-year-old single male, with a college education. He taught History for 5 months prior to joining the Army. TR successfully completed his officer training course. TR was described by his father as cheerful, outgoing, charismatic, funny, restless and well-liked.

TR sustained a traumatic brain injury secondary to falling from a fourth floor window. Initial MRI revealed right temporal lobe contusions, generalized edema, intracranial hemorrhage in the right parietal lobe and a left frontal lobe contusion. TR's documented length of coma was 2 months. He was admitted to a rehabilitation facility 5 months post-trauma.

Upon admission to the rehabilitation facility, cognitive problems were identified via neuropsychological testing in areas of left hemianopsia, visual-spatial skills, verbal memory, processing speed, concept formation and utilization of feedback. These findings were supported by functional and observational assessments which highlighted difficulties in the areas of sequencing, organizing, goal-setting, self-monitoring and self-awareness.

TR participated in a cognitive therapy plan which utilized the Executive Functions Module of BRAINWAVE-R, in conjunction with functional skills application training over a 4-week period. The goals of the program were to improve self-monitoring, goal-setting, self-awareness and planning skills.

TR was particularly responsive to the performance summary chart of the program which encouraged him to compare predicted and actual ratings. At the end of the 4-week phase TR demonstrated improved planning and goal-setting abilities as well as transfer to more structured simulated real-life tasks, although transfer to less structured situations remained problematic.

### 5. Conclusion

The inter-relationship between executive and metacognitive functions suggests the value of incorporating both of these cognitive processes when developing treatment methodology for brain-injured patients. Principles of learning, aimed at establishing awareness of knowledge, strategies, and generalization, can also be built into cognitive exercises to help maximize patient autonomy. An understanding of internal and external mediation mechanisms is important in developing workable treatment programs. The Executive Functions Module of The BRAINWAVE-R Rehabilitation Program, described in this article, attempts to provide a framework for realizing all of these aspects, with metacognition as the ultimate executive.

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