Tutorial: Cognition

See Tutorials on Attention, Memory, Retrieval, Organization, Problem Solving, Reasoning, Self-Regulation/Executive Functions

WHAT IS COGNITION?

In general, the word "cognition" refers to all of the mental activities involved in receiving information, comprehending it, storing it, retrieving it, and using it. Thus cognition includes:

1. The sensory and perceptual processes that enable us to receive information from the world (e.g., vision, hearing, smell, taste, and tactile sensation/perception);

2. All of the mental processes involved in attending to the information, recognizing it as something meaningful, making sense of the information, relating it to what is already known, organizing the information, deciding what is important and what is not important, storing the information for later retrieval, retrieving it when useful;

3. Using the information to make decisions about what to do, to solve problems, to communicate, and the like.

There are two importantly different ways to think about cognition. First, cognition may be considered a collection of processes and systems (see lists below) that are relatively independent of one another, independent of emotion and volition, and independent of the individual's contexts of action. Alternatively, cognition can be understood in a more functional and integrated way as an inter-related set of mental processes that guide action and problem solving in the real world (see below). In this sense, cognitive processes are not independent of one another, of emotion and volition, or of the individual's contexts of action.

The first view of cognition underlies many tests of cognitive functioning as well as cognitive training and retraining programs that isolate specific cognitive processes and target them with discrete cognitive "exercises". The second and more functional view of cognition underlies cognitive intervention programs that target cognitive processes within the context of meaningful academic and everyday activities. Both views of cognition serve their respective purposes. The functional view supports cognitive intervention plans that have been shown to be more effective in producing functional outcomes for a variety of disability populations. **(See Tutorial on Cognitive Intervention/ Rehabilitation)**

COGNITION AS A COLLECTION OF RELATIVELY INDEPENDENT PROCESSES AND SYSTEMS FOR ACQUISITION AND USE OF KNOWLEDGE ("Faculties of the Mind")

Information processing theories of cognition – developed out of complex and ever-changing analogies between human cognition and the operation of a computer – often offer operational definitions of cognition via lists of components of the cognitive "mechanism". Typically lists of this sort are accompanied by models of cognitive functioning depicted as flow diagrams: boxes and connecting arrows and feedback loops depicting information stores and processes acting on the flow of information. What follows is a **typical list of aspects of cognition:**

COMPONENT SYSTEMS OF COGNITION

Working Memory

- Structural Capacity (normal adults: 7 plus or minus 2 units of information held in consciousness at one time) and Functional Capacity (how much information can be held in WM when well organized; varies with type of information)

- Phonological Loop (auditory-verbal information) and Visual-Spatial "Holding Space" versus Supervisory Control System
- Processes that enable information to be held in consciousness and that act on that information discriminate between important and unimportant information, to organize the information, and the like

Knowledge Base (Long-term Memory)(For elaboration, See Tutorials on Memory; Retrieval; Word Retrieval)

- Episodic Memory (autobiographical information) versus Semantic Memory (depersonalized information)
- Declarative Memory (remembering that... such and such is the case) versus Procedural Memory (remembering how to ... do something)
- Explicit Memory (possessing a memory trace and also an awareness that one has the memory) versus Implicit Memory (possessing a memory trace, but no sense that one has the memory)
- Remote Memory (Retrograde Amnesia = difficulty remembering events stored before neurological damage) versus Recent Memory (Anterograde Amnesia = difficulty remembering events that have occurred more recently and after the neurological damage)

Executive System (See Tutorial on Self-Regulation/Executive Functions)

- *Metacognition:* Executive functions applied to cognition. Two aspects:
  - *Static:* knowing about cognitive processes; knowing about one's own cognitive strengths and weaknesses; knowing procedures (strategies) to improve cognitive functioning
  - *Dynamic:* deliberate strategic/executive control over cognitive processes like attending, learning, organizing, reasoning; using strategies to improve cognitive functioning
- *Executive Functions:* Those functions involved in deliberately pursuing any type of goal in the face of difficulty or stress (especially novel, non-routine tasks or complex, organizationally demanding tasks)
  - Self-awareness of strengths and limitations
  - Ability to set adequately reasonable goals
  - Ability to plan and organize goal-directed behavior
  - Ability to self-initiate goal-directed behavior
  - Ability to self-inhibit competing behaviors
  - Ability to self-monitor behavior
  - Ability to self-evaluate behavior in relation to goals
  - Ability to solve problems and think and act strategically in the face of obstacles
  - Ability to flexibly shift focus of attention, strategies, behaviors, and perspectives as required by context and goals, and as dictated by feedback from previously unsuccessful behavior and strategies

Response System

- *Output modalities* (e.g., verbal, manual)
- *Control/coordination* of output (e.g., coordinated execution of motor movements)

COMPONENT PROCESSES
Attention (For elaboration, see Tutorial on Attention)

- *Arousal and Alertness*
- *Preparing* attention
- *Maintaining/Sustaining* attention
- *Selecting* a focus of attention (concentrating)
- *Suppressing/Filtering* distractions
- *Shifting/Switching* focus of attention

- *Dividing/Sharing* attention

Perception

- *Recognizing and Identifying* objects received via sensory stimulation
- *Discriminating* among objects perceived

Memory and Learning (For elaboration, see Tutorials on Memory; Retrieval; Word Retrieval)

- *Encoding* (putting information into memory), *Storage* (holding information in storage over time), and *Retrieval* (bringing information from storage into consciousness)
- *Involuntary, incidental, implicit* memory (remembering when the goal of the activity was other than to remember) versus Deliberate, Effortful, Strategic memory (the goal of the activity was to learn or remember)
- *Retrospective* memory (memory for past events) versus *Prospective* memory (memory for appointments, remembering to do planned activities)
- *Verbal and Nonverbal* memory
- *Sensory Modality-Specific* memory

Organization (For elaboration, see Tutorial on Organization)

- *Identifying* features
- *Classifying/Categorizing* information
- *Sequencing* information
- *Analyzing* information
- *Integrating/Synthesizing* information into main ideas, themes, and scripts

Reasoning and Problem Solving (For elaboration, see Tutorial on Problem Solving)

- *Deductive* versus *Inductive* versus *Analogical* reasoning
- *Evaluative* reasoning
- *Convergent* versus *Divergent* thinking

Inter-relationships among components of cognition: Even if there are separable components of cognition, it is clear that they interact. For example, if a student does not attend effectively to an assignment, it is unlikely that the information will be remembered. Similarly, if the student fails to make connections as new information is presented (organize, elaborate), then memory for that information will be weak. Furthermore, if a student is not aware of memory problems or is a poor problem solver, then strategic learning and memory will be negatively affected. Many more examples of inter-relationships among cognitive components could be added to this list.

Cognition, context, and action: Typically information-processing theories of cognition (like 19th century faculty psychology theories) divorce in-the-head cognitive processing from the specifics of an individual's domains of action contexts and specific actions. Obviously cognitive processes exist in part to drive intelligent action. However, within this tradition cognitive processes and systems are not defined in relation to domains of action as they are in more functional theories of cognition. Therefore, it was commonly believed until recently that one can improve cognitive processes (with cognitive exercises) and these improvements will automatically improve performance across all contexts of action. This approach has been called a "bottom up" approach to addressing cognitive challenges. Studies of transfer of cognitive skill have called this view into question.

Cognition and emotion: Information processing theories differ in their handling of the emotional/affective aspects of experience and action. Some separate cognition and emotion sharply. Others offer integrated

theories of social-emotional cognition and nonsocial cognition. A few place affective processing at the heart of all human information processing. Neuro-imaging studies of the brains of people engaged in cognitive tasks suggest that emotional/affective processing is typically involved in activities that are considered cognitive.

Cognition and culture: Historically, information processing theorists have not recognized fundamental differences in thinking and cognitive processing based on cultural differences. Studies of individuals from diverse cultures tend to show some fundamental differences in cognitive processing.

COGNITION AS GOAL-DIRECTED PROBLEM SOLVING

In contrast to the theories outlined above, a variety of theories of cognition and cognitive development tie cognitive functioning tightly to practical problem-solving activity in the world. These theories include those associated with Lev Vygotsky, Alexander Luria, John Dewey, and others. These theories have more recently been grouped under the heading "Situated Cognition". The understanding of cognition as ultimately practical problem solving is the central theme. Problem solving includes all ordinary activities that have a cognitive aspect (e.g., playing a game, planning an activity, exploring an idea, conversing, remembering, etc.). According to situated cognition theorists, what most people consider relatively separate components of cognition (e.g., attending, remembering, organizing, etc) are really integrated aspects of problem solving. Cognition includes the processes of intelligent adaption to interpersonal and practical problems. This definition also blurs the distinctions among cognitive, emotional/affective, and social processes – problem solving involves emotion, social relations, and social structure.

Cognition and Context: Within these theories, mental processes exist to guide action in pursuit of goals in social and physical contexts. The context that is associated with cognitive processing includes at least:

(1) the goal of the activity;
(2) the domain of knowledge involved in the activity;
(3) specific features of the task;
(4) the interpersonal/social context, including social values, socially transmitted problem-solving tools and technologies.

Thus an individual's cognitive skill is predicted to vary with each of these four factors.

Cognition and Emotion: These theories also blur the distinction between cognitive, emotional, and social processes. Human problem solving involves emotion, social relations, and social structure. For example, at fundamental levels, people from markedly different cultural backgrounds think and organize their worlds differently.

WHY IS COGNITION IMPORTANT FOR MANY STUDENTS WITH TBI?

For many individuals, it is during the school years that the greatest demands are placed on cognitive functioning. Students need to pay attention effectively, organize information for thorough comprehension and effective expression (e.g., reading books, writing papers), remember the information and retrieve it for tests, reason effectively, and apply strategic thinking to the many academic problems that arise in school. Thus effective cognitive functioning is critical for all students to learn and profit from their educational experiences.

Unfortunately, cognitive impairment is one of the most common outcomes after TBI in children of all ages. Virtually any cognitive function or combination of cognitive functions can be damaged. However, because certain parts of the brain are more vulnerable than others, there are common profiles of cognitive

impairment. Vulnerable parts of the brain include the frontal lobes (especially prefrontal areas) and the limbic system.

Damage to the frontal lobes can impair control of attention, even in students who appear to be quite alert. Attention span may be short, distractibility may be severe, and shifting and dividing of attention may be difficult. **(See Tutorial on Attention.)** Controlled memory/learning and retrieval may also be difficult. Thus, studying (i.e., trying to put information into memory) may be inefficient and deliberate retrieval (e.g., searching memory during a test) may be weak. **(See Tutorials on Memory; Retrieval.)** Organizing information and events may also be weak. This includes relating pieces of information for purposes of deeper comprehension, paying attention to the most important parts of a story or text book, and effectively organizing information when reciting in class or writing themes and stories. **(See Tutorial on Organization)**

Damage to the frontal lobes also reduces the effectiveness of problem solving and strategic studying and learning. Thus students whose cognitive processes may be weak also have specific difficulty compensating effectively for that weakness. This deficit requires intensive efforts to teach compensatory strategies so that the student can succeed at school. **(See Tutorial on Cognitive and Learning Strategies.)** Students with frontal lobe injury may also be impulsive, so they do the first thing that comes to mind, which may not be strategic. They may also think and say or write the first thought that comes to mind and therefore make many errors in their school work. Impulsiveness may also block the student from checking her work (self-monitoring) and making necessary adjustments in response to errors. **(See Tutorial on Impulsiveness/Disinhibition.)**

Damage to parts of the limbic system – especially the hippocampus – impairs those processes involved in declarative memory (i.e., remembering that such and such is the case) and episodic memory (i.e., remembering events in one's life). In contrast, procedural memory (i.e., remembering/learning how to do something), routine learning (e.g., developing habits of thought or action), and implicit memory (i.e., certain memories "stick", but the student has no awareness of the memory) may be well preserved even if the hippocampus is damaged. **(See Tutorials on Memory; Retrieval; Explicit and Implicit Memory; Errorless Learning.)**

WHAT ARE THE MAIN THEMES IN INTERVENTION AND SUPPORT FOR STUDENTS WITH COGNITIVE IMPAIRMENT?

See Tutorials on Cognitive Intervention/Rehabilitation; Memory; Retrieval; Organization; Problem Solving; Instructional Routines.

Historically, three approaches to helping children and adults with cognitive impairments have been described in the rehabilitation and special education literatures.

- **Restoration/improvement of underlying cognitive processes:** For well over 100 years, educators and therapists have explored the possibility of improving cognitive functioning by engaging the student in cognitive exercises that target components of attention, memory, organization, reasoning, problem solving, and the like. From the 1970s through the 1990s, cognitive exercises of this sort were popular in TBI rehabilitation. Recent summaries of this large intervention literature indicate that it is possible to improve performance on the training tasks, but that transfer of those improvements to everyday academic and social tasks and activities is severely limited. **(See Tutorial on Cognitive Intervention/ Rehabilitation.)**
- **Student strategies used to compensate for ongoing cognitive impairments:** Some students with ongoing cognitive impairments are able to learn strategies that compensate to some degree for the impairments. For example, students with memory impairments may learn to use external aids (e.g., memory book, electronic storage system) or internal mental strategies (e.g., rehearsing information to be remembered, organizing or elaborating the information in special ways). **(See Tutorials on Cognitive Intervention/ Rehabilitation; Memory; Retrieval; Organization.)**
- **Environmental compensations, including modified teaching routines and adjustments in expectations for the student's performance:** For some students with ongoing cognitive

impairments, it is critical to modify teaching routines and other aspects of the student's environment. For example, students with memory problems may need teachers to organize, highlight, and repeat information in ways that go beyond standard teaching procedures. Similarly they may need posted reminders, the use of tape recorders, or buddy systems to compensate for memory problems. **(See Tutorials on Cognitive Intervention/ Rehabilitation; Memory; Retrieval; Organization; Instructional Routines.)**

There have also been differences of opinion with respect to the sequence of these categories of intervention. A traditional approach has been to first attempt to improve underlying cognitive functions with exercises or pharmacologic interventions (i.e, a bottom up approach). In the case of students with TBI, this was typically done in rehabilitation centers or other special training centers. In the event that students continued to have cognitive impairments, therapists or educators would next attempt to teach the student compensatory strategies, again often in special training settings. Finally, in the event that the student continued to have cognitive difficulties, environmental compensations would be explored in the student's community school and home.

An alternative to this traditional sequence reverses the sequence. In this case, the student is placed in as natural an educational environment as possible and environmental/instructional modifications and compensations are made that enable the student to participate in the curriculum in that setting (i.e., a top down approach). Within this participation, the student might then be taught strategies to compensate for ongoing cognitive impairments. Finally, with habituation and routinization of these strategic procedures, the procedures might be internalized, thereby reducing the underlying cognitive impairment.

The latter sequence is more consistent with the philosophy of inclusion implemented in most educational settings. It is also designed to avoid the common pitfall of failure of transfer from a training setting and activities to functional settings and activities.

All of these themes are elaborated in the **Tutorial on Cognitive Intervention/ Rehabilitation.**

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