Cognitive Function in Cerebrovascular Accident (CVA) & Traumatic Brain Injury (TBI) – MSHA Part One

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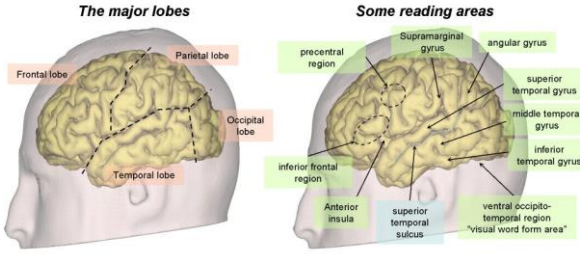
Overview of Cognitive Processes

- Attention
- Memory
- Executive Functions

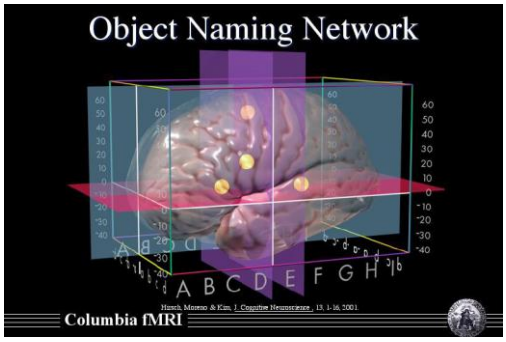
Sohlberg and Mateer (APT, 1989)) Model

- Sustained Attention
- Alternating Attention
- Selective Attention
- Divided Attention

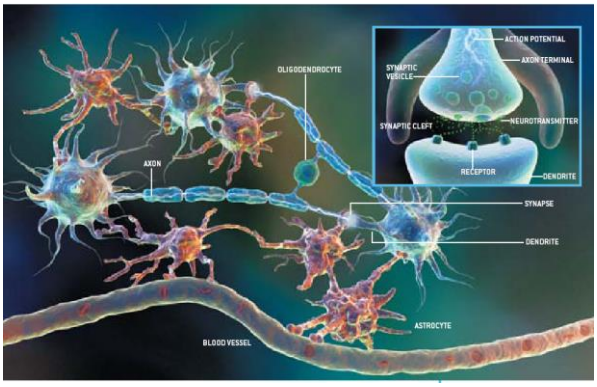


DeHaene, 2009

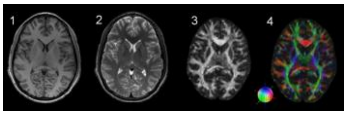
Neurons that fire together wire together in networks



Neuronal Communication System



Diffusion Tensor Imaging



- Measures diffusion (motion) of protons in water molecules.
- Direction of proton motion within a voxel can be described by a "tensor".
- Proton diffusion tends to be relatively isotropic in gray matter.
- The linear structure of fiber tracts constrains proton diffusion and produces **anisotropy**.

HUMAN BRAIN MATURATION is EXPERIENCE DEPENDENT

- Nodes in a network become mapped, first
  - To perceive world around us - LANGUAGE
  - To act on the world around us – talk, read, do math problems
- Later to plan, prioritize, solve novel problems

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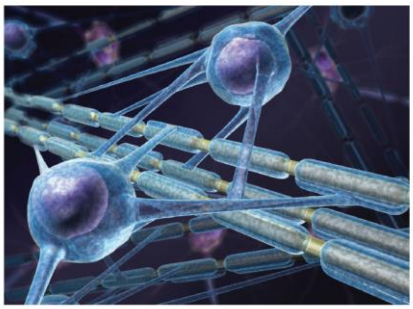
NEUROSCIENCE

Change in the Brain's White Matter

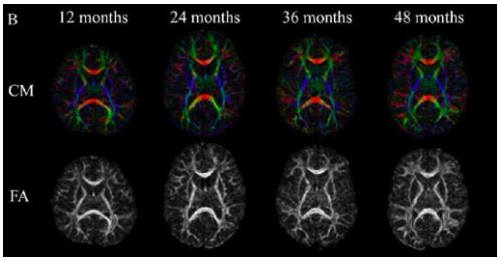
The role of the brain's white matter in active learning and memory may be underestimated.

R. Douglas Fields 5 NOVEMBER 2010 VOL 330 SCIENCE

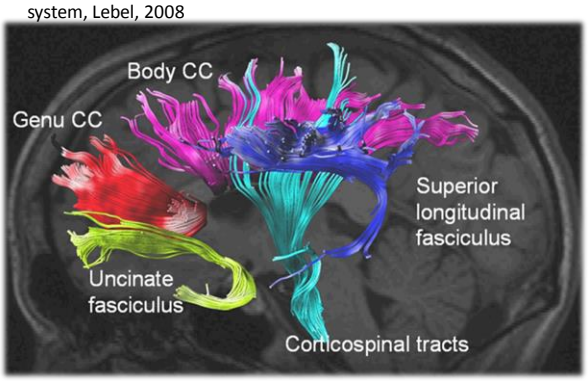


White matter. Myelin that coats and insulates neuronal axons may control the propagation of electrical impulses in a manner that affects information processing.

Fiber Tract Development
Observable with DTI
(from Hermoye et al., 2006)



Understanding the development of the Brain's Superhighway system, Lebel, 2008



Different dimensions of adult cortical plasticity are enabled by the behaviorally-context-dependent release of:

- acetylcholine (focused attention/reward) (Kilgard, Bao)
- dopamine (reward, novelty) (Bao)
- norepinephrine (novelty) (Bollinger)
- serotonin (Bollinger)
- et alia

In infants, exposure-based plasticity is relatively uniform. In older children, learning-induced changes are complexly "nuanced" by differences in behavioral context that result in the differential release of 6 or 7 modulatory neurotransmitters.

Attention Assessment – usually conducted by Psychologists

- Immediate span of attention
  - Forward and backward digit span
- Focused Attention
  - Cancellation Tasks
  - Trail Making Test
    - Part A – randomly distributed numbers that must be connected in ascending order (dot to dot)
    - Part B – set shifting and some degree of divided attention (performance closely related to tests of timed executive function)

Attention (2)

- Sustained Attention
  - Conners Continuous Performance Test (Conners & Multi-Health Systems Staff, 1995; Test of Variables of Attention, Greenberg, 1998).

Attention (3)

- Divided Attention
- Response Inhibition – Stroop Test

Inhibition (Davidson, et al., 2004)

- Cognitive Control (Executive Functions) – Inhibition
  - Inhibition – inhibiting distractions selective and sustained attention
  - Inhibiting a strong behavioral inclination makes a change possible as well as social politeness
  - External stimuli and engrained behavioral tendencies exert strong influences on our behavior – inhibition allows us to act otherwise

Response inhibition – Stroop-like test

RED	GREEN	BLUE	YELLOW	PINK
ORANGE	BLUE	GREEN	BLUE	WHITE
GREEN	YELLOW	ORANGE	BLUE	WHITE
BROWN	RED	BLUE	YELLOW	GREEN
PINK	YELLOW	GREEN	BLUE	RED

Response inhibition – Stroop-like Test

RED	GREEN	BLUE	YELLOW	PINK
ORANGE	BLUE	GREEN	BLUE	WHITE
GREEN	YELLOW	ORANGE	BLUE	WHITE
BROWN	RED	BLUE	YELLOW	GREEN
PINK	YELLOW	GREEN	BLUE	RED

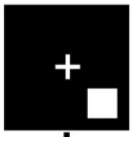
Are medications necessary?

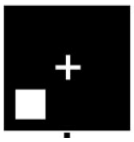
- Neuroscientists hope to eventually provide effective interventions that would decrease the necessity for medication to treat attentional disorders
- Evidence-based neuroscience approaches can enhance attentional skills in all children
  - Technological approaches:
    - Fast ForWord
    - CogMed
    - Brain HQ (adolescents)
    - TEVO
- Educators can help as well

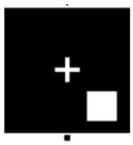
Improving fluid intelligence with training on working memory

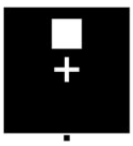
Susanne M. Jaeggi*†‡, Martin Buschkuehl*†‡, John Jonides*, and Walter J. Perrig†

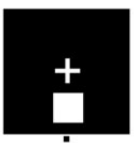
Proceedings of the National Academy of Sciences
May, 2008

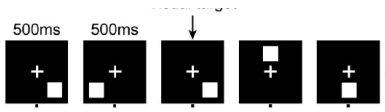












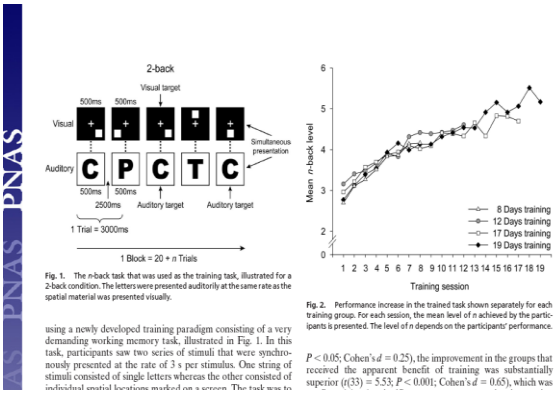


Fig. 1. The *n*-back task that was used as the training task, illustrated for a 2-back condition. The letters were presented auditorily at the same rate as the spatial material was presented visually.

Fig. 2. Performance increase in the trained task shown separately for each training group. For each session, the mean level of *n* achieved by the participants is presented. The level of *n* depends on the participants' performance.

using a newly developed training paradigm consisting of a very demanding working memory task, illustrated in Fig. 1. In this task, participants saw two series of stimuli that were synchronously presented at the rate of 3 s per stimulus. One string of stimuli consisted of single letters whereas the other consisted of

$P < 0.05$; Cohen's $d = 0.25$), the improvement in the groups that received the apparent benefit of training was substantially superior ($t(33) = 5.53$; $P < 0.001$; Cohen's $d = 0.65$), which was

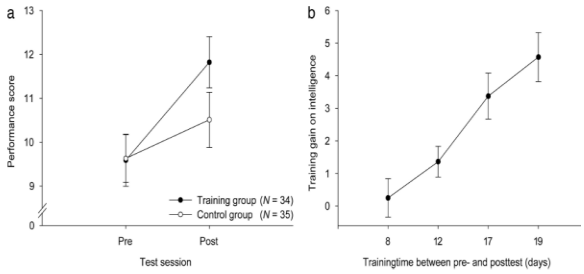


Fig. 3. Transfer effects. (*a*) Mean values and corresponding standard errors of the fluid intelligence test scores for the control and the trained groups, collap over training time. (*b*) The gain scores (posttest minus pretest scores) of the intelligence improvement plotted for training group as a function of training t Error bars represent standard errors.

session. However, the training-time-dependent gain in *Gf* remained intact after controlling for the gain in working memory

that the strong relationship between working memory and primarily results from the involvement of attentional con

Assessments

- Objective – isolate deficient processes and guide rehabilitation
- Most Frequently Used (usually by Educational Psychologists) Include:
  - Set-shifting – Wisconsin Sort Test (WCST)
  - Planning – Trail Making Test, Part B
  - Fluency tasks
- Shown to be related to focal DLPFC lesions

Task Switching

- Card sorting
- Go/no-go (Simon says)
  - Can increase complexity to increase task switching
- http://www.nytimes.com/interactive/2010/06/07/technology/20100607-task-switching-demo.html

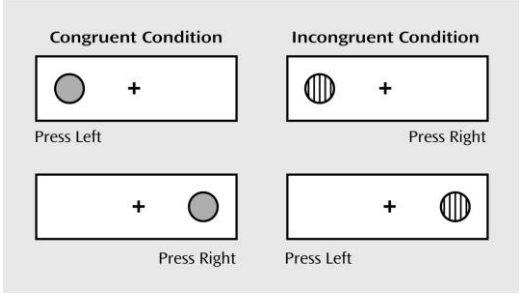
Activation Regulating Functions

- Damage to left or right medial frontal regions results in poor capacity to generate or maintain actions or mental processes
- Fluency tasks
- STROOP Test – problems maintaining a selected target
  - Sensitive to DLPFC and VMPFC lesions

Other Assessments used in research that can be applied for clinical use

- Dots incongruent vs. dots congruent
- Object or picture sorting where the sorting rule is switched

Dots mixed task



In the congruent condition, the correct response is to press the dot on the same side as the stimulus. In the incongruent condition, the response and stimulus are on opposite sides. In the mixed condition, equal numbers of congruent and incongruent trials are randomly intermixed.

Inhibition/distractibility

- Holding information in mind while inhibiting a prepotent response
  - Day-night
  - Tapping (When I tap once you tap twice)
  - Appearance-reality (clouds)
- http://www.nytimes.com/interactive/2010/06/07/technology/20100607-distraction-filtering-demo.html?th&emc=th

Assessment and Treatment of Cognitive Disorders in Adults

Etiologies of Cognitive Disorders in Adults

Focal Lesions

- RH CVA
  - CVA represents a disruption of the cerebral vascular system
  - Problems with attention
    - Hemispatial Neglect - Usually to the left side of space
    - Simultagnosia - Global attention (often viewed more as a perceptual impairment)
  - TOM

TBI and penetrating head injury mechanisms

- Coup and contrecoup injuries - contusions
- Hemorrhages – ruptured vessels
  - Epidural
  - Subdural
  - Intracerbral
- Infarction of vessels caused by swelling
- Shearing stains – diffuse axonal injury

Bigler, E. (2007) Anterior and Middle Cranial Fossa in Traumatic Brain Injury: Relevant Neuroanatomy and Neuropathology in the Study of Neuropsychological Outcome

MECHANISMS OF TRAUMATIC BRAIN INJURY

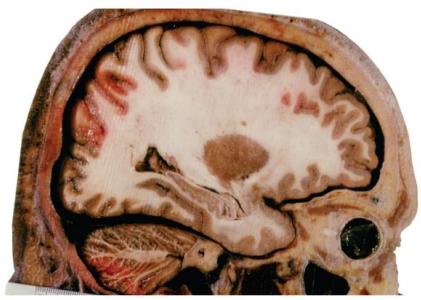


Figure 6. Parasagittal plane through the long axis of the hippocampus at post-mortem. Note how the temporal pole is "cradled" and "hugged" by the middle cranial fossa as well as the sharp edge of the sphenoid ridge, as it juts into the Sylvian fissure. The head of hippocampus is approximately 2 cm from the sphenoid ridge and, when brain compression occurs, can deform over the ridge. See Figures 11 and 12. From *Atlas of the Human Brain* (2nd ed., p. 83), by J. K. Mai, G. Paxinos, and J. K. Assheuer, 2004, Amsterdam: Elsevier. Copyright 2004 by Elsevier. Adapted with permission.

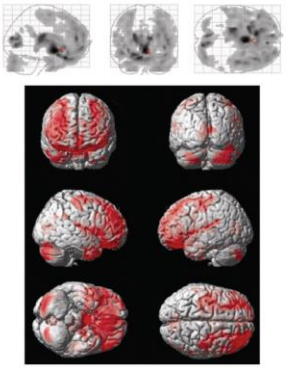
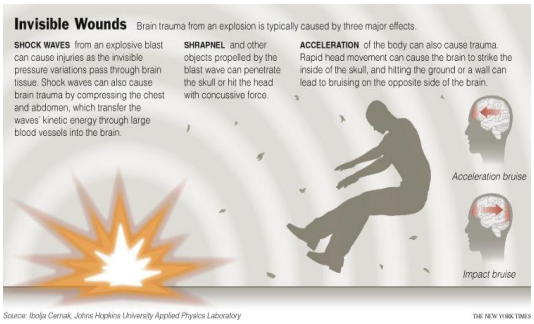
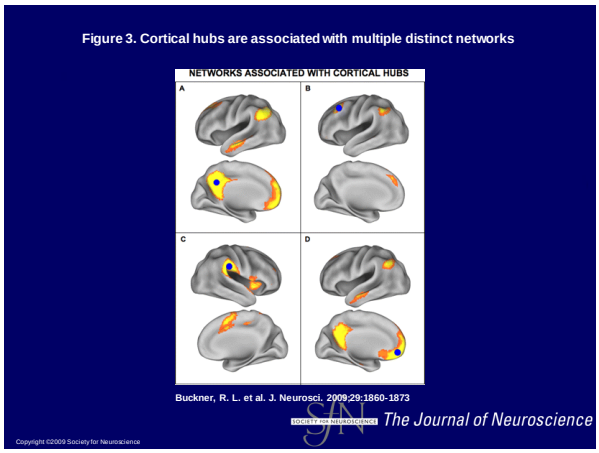


Figure 9. Voxel-based morphometry (VBM) of traumatic brain injury (TBI) showing the greater likelihood of gray matter pixel density reduction



Degenerative Neuropathies

- Dementias
  - Progressive
  - Degenerative
  - Disease processes



Chemotherapy Related Cognitive Impairments (CRCI) based on published research

Table 2. Weighted Average Effect Sizes By Cognitive Domain

Domain	k	No. of Comparisons	Effect Size (*g*)	95% CI	*P*
Attention	16	21	−0.02	−0.12 to 0.08	.743
Executive functioning	14	19	−0.12	−0.23 to 0.00	.052
Information processing	6	11	−0.11	−0.25 to 0.03	.122
Motor speed	8	11	0.06	−0.37 to 0.49	.785
Verbal ability	12	15	−0.19	−0.30 to −0.07	.002
Verbal memory	17	23	−0.06	−0.18 to 0.06	.313
Visual memory	15	21	0.02	−0.09 to 0.13	.730
Visuospatial ability	8	9	−0.27	−0.45 to −0.08	.006

Jim, H et al. (2012) Meta-Analysis of Cognitive Functioning in Breast Cancer Survivors Previously Treated With Standard-Dose Chemotherapy. *Journal of Clinical Oncology.* VOLUME 30 NUMBER 29

Other acquired neuropathies that cause Cognitive Impairment

- Toxic encephalopathy
- Anoxia/hypoxia
- Tumors
- Radiation necrosis of white matter tracts

Pre-frontal Lobes

- Ventromedial – includes anterior limbic system
  - Theory of mind (mentalizing) (with R TPJ)
  - Self-perception
  - Motor monitoring
  - Self-monitoring
  - Important in delayed gratification
  - Empathy
- Dorsolateral – Executive functions (cognitive control)
  - Organization, planning, flexibility
  - Task switching
  - Inhibitory control
  - Working memory
  - Processing speed

Product Summary Overview

Determine if an attention problem is one of the underlying factors contributing an individual's learning problems.
•Pass/Fail criterion scores indicate whether performance matches that of individuals with normal attention skills
• Listens to single words presented on the tape and raises a thumb when the target word is heard.
•Written by the author of SCAN-3: Tests for Auditory Processing Disorders

Auditory Continuous Performance Test (ACPT)
Author(s): Robert W. Keith, Ph.D.
Screen for auditory attention deficits
At a Glance:
Administration: 10 minutes
Scores: Pass/Fall criterion score
Audio Available: Yes
Qualification level: B-Level
Publication Date: 1994
Ages / Grades: 6:0 through 11:11

Commonly used Neuropsych Batteries and Assessments

Adults - Working memory
- *Wechsler Memory Scale*
- *Digits Forward Test*
- *Point Digit Span*
- *Letter Span*
- *Recurring Figures Test*
- *Picture Scanning of Behavioral*
- *Inattention Test*
- *Wechsler Memory Scale -III Family Pictures*
- *Weschler Memory Scale-III*
- *Hopkins Verbal Learning Test - Revised*
- *Four Unrelated Words*
- *Benson Bedside Memory Test*
- *Auditory-Verbal Learning Test*
- *Wechsler Memory Scale, Logical Memory*
- *Memory Assessment Scales*

Commonly used Neuropsych Batteries and Assessments

Adults - Executive Functions (cognitive control) (RT Processing speed) in adults on:

- Organization, planning, flexibility
- Task switching
  - Car Sort
  - Trailmaking Test
- Inhibitory control – *Stroop Test*

Adults - Critical thinking

- *Luria's Neuropsychological Investigation*
- *Wechsler Adult Intelligence Scale -*
- *III Digit Symbol-Coding*
- *Digit Symbol Substitution*
- *Symbol Digit Modalities Test*
- *Category Test (HCT)*
- *Object Sorting Test*

Acute Care v. Outpatient Tests for SLP's

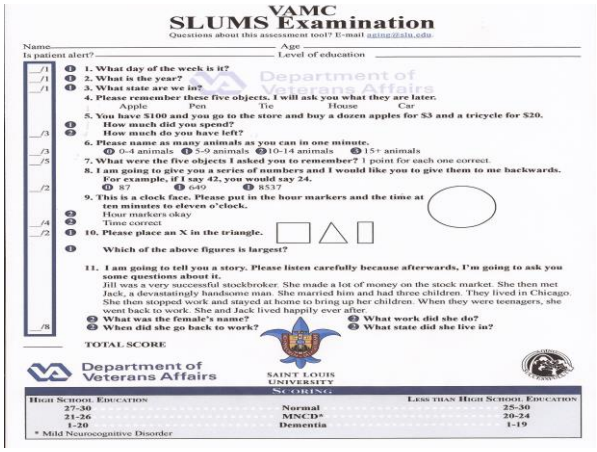
- Acute Care
  - Cognistat
  - HI-LAB (?)
  - if the patient does have a hx of dementia:
    - SLUMS or
    - MoCA.
- For the outpatient setting
  - RBANS
  - BURNS
  - CLQT
  - For RH patients – RICE-3
  - TrailMaking A&B
  - RIPA
  -

Cognistat

Rapidly assesses neurocognitive functioning in...
3 general areas:
Level of Consciousness
Orientation
Attention (Digit Span)
5 major ability areas:
Language (Comprehension, Repetition, Naming)
Constructional Ability (Drawing from Memory, Arranging Tiles)
Memory
Calculation Skills
Executive Skills (Reasoning, Judgment)
Normative Data:
Adolescents from 12 to 17 years of age and Adults 18 years of age and older
Time to Administer:
15-20 minutes for cognitively intact individuals and 20-30 minutes for those who are cognitively impaired

Administration Webinar

- http://www.cognistat.com/node/41



VAMC
SLUMS Examination
Questions about this assessment tool? E-mail aging@slu.edu

Name _____ Age _____
Is patient alert? _____ Level of education _____

1. What day of the week is it?
2. What is the year?
3. What state are we in?
4. Please remember these five objects. I will ask you what they are later.
Apple Pen Tie House Car
5. You have $100 and you go to the store and buy a dozen apples for $3 and a tricycle for $20.
How much did you spend?
How much do you have left?
6. Please name as many animals as you can in one minute.
0-4 animals 5-9 animals 10-14 animals 15+ animals
7. What were the five objects I asked you to remember? 1 point for each one correct.
8. I am going to give you a series of numbers and I would like you to give them to me backwards.
For example, if I say 42, you would say 24.
87 649 8537
9. This is a clock face. Please put in the hour markers and the time at ten minutes to eleven o'clock.
Hour markers okay
Time correct
10. Please place an X in the triangle.
Which of the above figures is largest?
11. I am going to tell you a story. Please listen carefully because afterwards, I'm going to ask you some questions about it.
Jill was a very successful stockbroker. She made a lot of money on the stock market. She then met Jack, a devastatingly handsome man. She married him and had three children. They lived in Chicago. She then stopped work and stayed at home to bring up her children. When they were teenagers, she went back to work. She and Jack lived happily ever after.
What was the female's name?
When did she go back to work?
What work did she do?
What state did she live in?

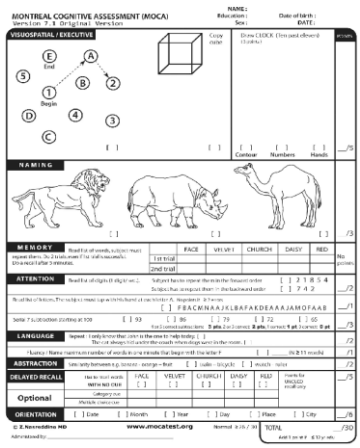
TOTAL SCORE

Department of Veterans Affairs
SAINT LOUIS UNIVERSITY

SCORING:

High School Education		Less than High School Education
27-30	Normal	25-30
21-26	MNCD*	20-24
1-20	Dementia	1-19

* Mild Neurocognitive Disorder



MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

NAME:
Education:
Sex:
Date of birth:
DATE:

VISUOSPATIAL / EXECUTIVE
Copy cube
Draw CLOCK (Ten past eleven)
/5

NAMING
/3

MEMORY
Read list of words, subject must repeat them. Do 2 learning trials even if 1st trial is successful. Do a recall after 5 minutes.
FACE VELVET CHURCH DAISY RED
1st trial
2nd trial
No points

ATTENTION
Read list of digits (1 digit/sec.)
Subject has to repeat them in the forward order [ ] 2 1 8 5 4
Subject has to repeat them in the backward order [ ] 7 4 2
/2

Read list of letters. The subject must tap with his hand at each letter A. No point if 2 or more errors.
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B
/1

Serial 7 subtraction starting at 100
[ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4 or 5 correct subtractions: 3 pts, 2 or 3 correct: 2 pts, 1 correct: 1 pt, 0 correct: 0 pt
/3

LANGUAGE
Repeat: I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ]
Fluency / Name maximum number of words in one minute that begin with the letter F [ ] (N ≥ 11 words)
/2 /1

ABSTRACTION
Similarity between e.g. banana – orange = fruit [ ] (ruler – watch) [ ] (train – bicycle)
/2

DELAYED RECALL
Optional
FACE VELVET CHURCH DAISY RED
Points for SPONTANEOUS recall only
/5

ORIENTATION
[ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City
/6

© Z. Nasreddine MD www.mocatest.org
Normal ≥ 26 / 30
TOTAL /30
Add 1 pt if ≤ 12 yr edu.
Administered by:

SLUMS Download

- http://medschool.slu.edu/agingsuccessfully/pdfsurveys/slumsexam_05.pdf

MoCA Download

- https://pdbp.ninds.nih.gov/assets/crfs/Montreal%20Cognitive%20Assessment%20(MoCA)7_1.pdf

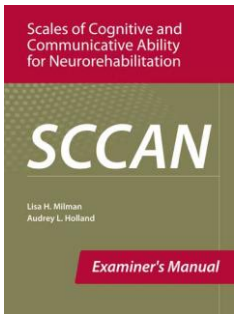
Repeatable Battery for the Assessment of Neuropsychological Status (RBANS™) Christopher Randolph

- 30 minutes adult assessment
- RBANS can be used a variety of ways including:
  - • As a stand-alone "core" battery for the detection and characterization of dementia in the elderly
  - • As a neuropsychological "screening battery
- RBANS has two parallel forms, ideal for measuring change in the client's neuropsychological status over time.

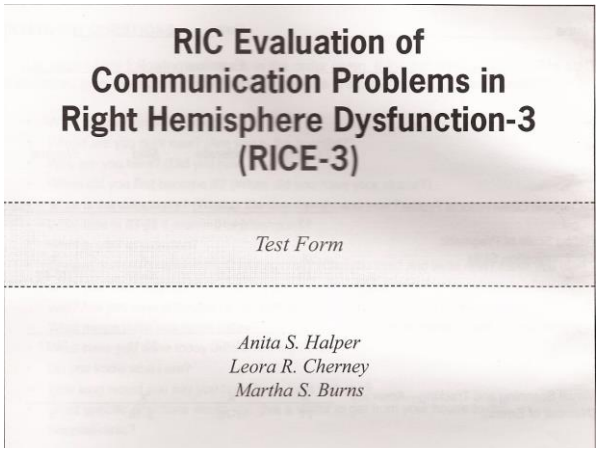
Burns Brief Inventory of Communication and Cognition (Burns Inventory)
Author(s): Martha S. Burns, Ph.D., CCC-SLP
Identify communication and cognitive deficits

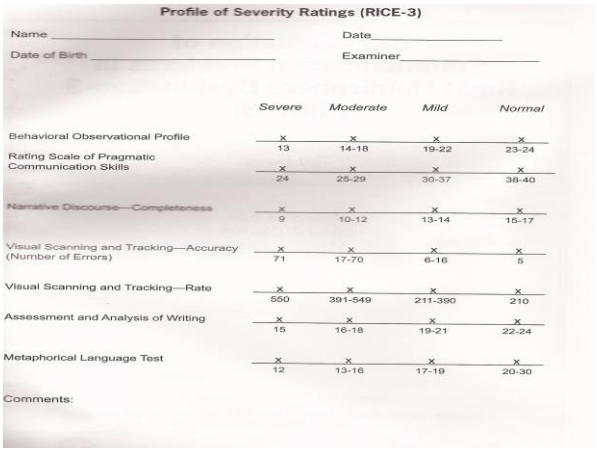
Administration: 30 minutes
Scores: Criterion-Referenced Scores
Audio Available: Yes
Qualification level: B,Q1,Q2-Level
Publication Date: 1997
Ages / Grades: 18 through 80 years
Norms: Criterion referenced to identify moderate level impairment

- The **Cognitive Linguistic Quick Test (CLQT)** assists you in quickly identifying strengths and weaknesses in five cognitive domains (attention, memory, executive functions, language, and visuospatial skills) of adults with neurological impairment due to strokes, head injury, or dementia.
- **Quick Screener**
- Administered in 15 to 30 minutes
- Scored in 10 to 15 minutes (cut scores, no normative data)
- Can be administered at a table or bedside (as long as patient can sit up and use a pen)
- Available in both English and Spanish
- Useful for screening a full range of cognitive processes with patients who may have decreased language skills



Test Purpose
Use the *SCCAN* to:
identify patients with neurocognitive and communicative impairment
determine the severity of the impairment
help plan treatment
measure changes in patient functioning over time
Subtests
The test contents relate to daily activities adults would be expected to perform for independent living. The *SCCAN* has eight scales:
Oral Expression
Orientation
Memory
Speech Comprehension
Reading Comprehension
Writing
Attention
Problem Solving





Profile of Severity Ratings (RICE-3)

Name _____ Date _____

Date of Birth _____ Examiner _____

	Severe	Moderate	Mild	Normal
Behavioral Observational Profile	x 13	x 14-18	x 19-22	x 23-24
Rating Scale of Pragmatic Communication Skills	x 24	x 25-29	x 30-37	x 38-40
Narrative Discourse—Completeness	x 9	x 10-12	x 13-14	x 15-17
Visual Scanning and Tracking—Accuracy (Number of Errors)	x 71	x 17-70	x 6-16	x 5
Visual Scanning and Tracking—Rate	x 550	x 391-549	x 211-390	x 210
Assessment and Analysis of Writing	x 15	x 16-18	x 19-21	x 22-24
Metaphorical Language Test	x 12	x 13-16	x 17-19	x 20-30

Comments:

TVTC
Thames Valley Test Company

Behavioural Assessment of the Dysexecutive Syndrome (BADS)
Wilson, Alderman, Burgess et al., 1996
Behavioural Assessment of the Dysexecutive Syndrome (BADS)C For children

Administration: 35 to 45 minutes
Qualification level: B-Level

Understanding RH problems with Attention including Neglect

Attention and Attentional disorders

- Functional attentional networks
  - Diffuse network – arousal and alterting
    - Awakens, surveys internal mileau and extrapersonal space for relevant novel or changing stimuli
    - Acetylcholine and norephinephrine
    - Disorder - delirium
  - Mixed cortical-subcortical – orientation to stimuli
    - Disorders – progressive supranuclear palsy – impaired visual orientation and visually guided behavior
    - Posterior parietal cortex lesions – hyperattention to ipsilateral cues
  - Cortical network – mediates selective attention
    - Disorders - neglect

Left Neglect Syndrome

- Reduction of neural resources that can be mobilized
  - By sensory events located on the left
  - By motor plans directed to the left
- Patient may behave as if one-half of the universe has abruptly ceased to exist
- Often multimodal
- May co-exist with but not caused by hemianopia, hemihypesthesia, or hemiparesis

Clinical characteristics - severe

- May shave, groom, dress only right side of body
- May fail to eat food on left side of plate or tray
- May omit left side of words on a page
- May fail to copy detail on left side of drawing
- May leave wide left margin when writing
- May display a tonic rotation to the right

Clinical characteristics - mild

- May not show obvious deficits except on testing
  - May fail to observe left side of road while driving
  - May tend to ignore objects in left pocket
  - May forget to scan desk for notes or items on the left side of desk or room

Assessment

- Bilateral simultaneous stimulation
- Cancellation tasks
- Drawing of a clock
- It is not a disorder of seeing, hearing, or moving but one of looking, detecting, listening, and exploring

Representational (perceptual) component

- More obvious when competing events are present on the right
  - Probed with tests of extinction,
    - Demonstration
    - Distinguish from hemianopia
  - line bisection
    - Mark midpoint of horizontal line
    - Hemianopics tend to be left of center (compensation)
  - covert attentional shifts

Patient Demo

- George – drawing of a clock

Motor exploratory aspects of neglect

- A pervasive reluctance to scan and explore left hemispace
  - Lack of interest in the left side
  - Rightward bias
- Seen in cancellation tasks where pt starts at the right and moves left
- Rightward bias seen in tasks where pt asked to erase targets (rather than cancel) as right targets decrease left sided attention increases

Neglect dyslexia

- Fail to read words on the left or letters on the left side of a word
  - May show confabulatory completions of left side of word or sentence

Exploratory deficit & hypokinesia

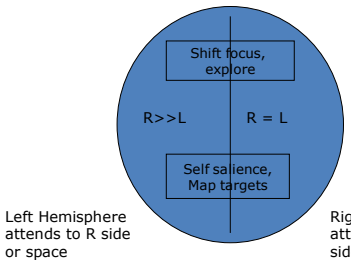
- Also see problems with manual exploration (tactile search)
  - Blindfolded searches of objects
- *Hypokinesia* – general impairment of leftward movements
- Intentional neglect – reluctance to direct movements to the left

Motivational aspects

- Patients with left neglect devalue the left and assume nothing of importance could be occurring on the left
  - May be related to motivation
  - Ie., very hungry patient may explore the left side of tray better than less hungry one

Mesulam's neglect model

- Damage to the RH results in the left hemisphere pushing toward the right (neglecting the left)



Anatomy of neglect

- Right inferior parietal lobe damage results in neglect
  - Once called a "parietal sign"
- However, frontal lobes, cingulate, thalamus, temporo-occipito-parietal area and striatum also contribute
- All these areas form an interconnected network
- Better term maybe "attentional network syndrome"

Comorbidity

- Unilateral neglect commonly occurs in conjunction with
  - Anosognosia – denial of illness (correlation = .46)
  - Constructional deficits (correlation = .4)
  - Dressing difficulty (apraxia) (Correlation = .64)

Causes

- Focal right hemisphere lesions
- During seizures
- Toxic-metabolic encephalopathy, subdural hematoma, or head injury may give rise to unilateral neglect
- Recovery after CVA varies from 9 to 43 weeks
- Persistent cases caused by large lesions that extend to subcortical structures

Saxe, 2006

- The developmental trajectory from attending to:
  - Human faces and bodies (infants),
  - to understanding goal-directed actions (toddlers),
  - to the uniquely human representational theory of mind (preschoolers),
- is reflected in the functional profiles of three regions in lateral occipitotemporo-parietal cortex

Right Parietal Junction

- Research of Rebecca Saxe on the importance of the Right Parietal Junction in thinking about another person's thoughts
  - We have been attributing theory of mind to pre-frontal lobe function but…….
  - Saxe's research points to the importance of the RPJ in Theory of Mind and Social Cognition in general
    - Since children develop social skills early – see new research on intention and affiliation as early as nine months old (Bloom, Wynn, etc.) – this may be the precursor to full TOM skills that later emerge with other areas

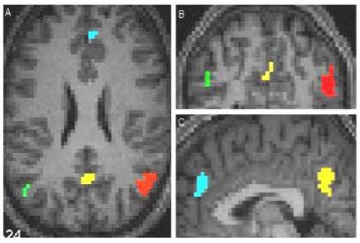
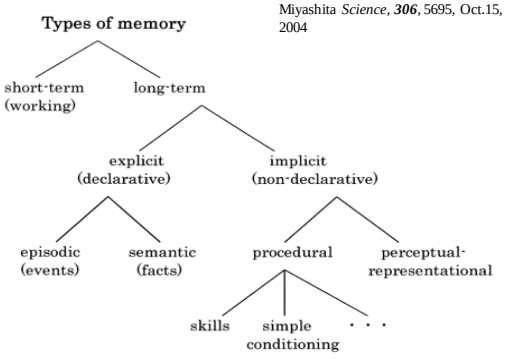


Fig. 1. Four 'Theory of Mind' regions of interest (ROIs) in a single representative subject. ROIs were defined as contiguous voxels in which the response was higher when subjects read stories about beliefs than when subjects read logically similar stories about photographs ($p < 0.0001$, uncorrected). Red = right temporo-parietal junction (RTPJ). Green = left TPJ. Cyan = medial prefrontal cortex (MPFC). Yellow = posterior cingulate (PC). (A) Axial slice, $z = 24$. (B) Coronal slice, $y = -60$. (C) Saggital slice, $x = 4$ (midline).

Disorders of memory in adults

- Brief review of Types of memory
- Memory disturbances associated with head injury and stroke
- Memory disturbances associated with oncological cancer treatments



Miyashita *Science*, ***306***, 5695, Oct.15, 2004

Organization of Memory (Mesulam, 2000)

- The memorization process - short term memory- depends on the limbic system
- The storing process -learned material that is reconstructed, reassembled and consolidated for permanent memory traces - explicit memory
- The remembering process

Organization of Memory

- Memorization – short term memory Impairments
  - Holding Attentional disorders
  - Working memory TBI
  - Acquiring – encoded Anterograde amnesia
- Storage – learning/explicit Amnesia
  - Semantic
  - Episodic
- Remembering – recognition Agnosia v. recall Aphasia
  - Implicit – procedural memory, priming, skills
  - Explicit – scanning and retrieval

Short term memory

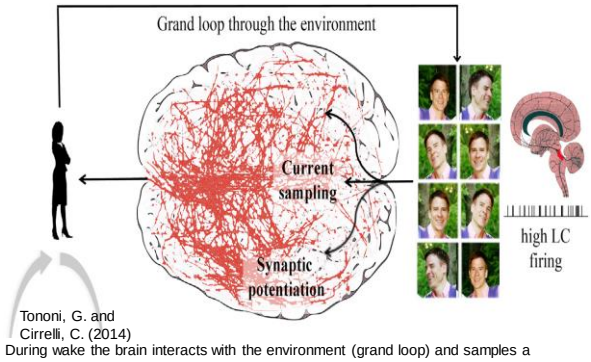
- Holding – encoding
- Working memory

Short-term memory span

- STM = 7 ± 2 items
  - Boutla, Spulla, Newport and Bavelier (2004) Short-term memory span: insights from sign language. *Nature Neuroscience* ***7***, 997-1002.
- But in American Sign Language it is 5±1
  - Authors demonstrate that this cannot be due to phonologic factors, item duration or reduced memory capacity in deaf individuals
  - 7± may be due to reliance of speakers on auditory-based rather than visually based representations

What is learning and memory?

- The job of the brain is to detect and change based on relevant events in the ***environment***
  - Neurons can only fire or not fire
  - So, neurons must fire preferentially for relevant events and experiences of value – Grand Loop
  - Ignore or fire less regularly for irrelevant events
  - Then "save" the relevant synapses and discard the irrelevant synapses
  - This is the *neural plasticity* of memory and learning



Tononi, G. and Cirrelli, C. (2014)
During wake the brain interacts with the environment (grand loop) and samples a limited
number of inputs dictated by current events (current sampling, here represented by a new acquaintance).High levels of neuromodulators, such as noradrenaline released by the locus coeruleus(LC), ensure that suspicious coincidences related to the current

The "fit" brain - Neuroplasticity

- Preferentially strengthens (hence prioritized for saving) synapses that are:
  - Sustained by repetition – statistically recurring or coinciding more frequently
  - Better integrated with older memories
    - Importance of functionality in treatment
    - Relationship to past in treatment
- Weaker synapses will be subject to decay and discarded

To understand how our patients learn from us we need to know

- The WHAT of Memory - What are the types of memories ? E.g..
  - Events – important for Orientation e.g.
  - Facts – SLP world – semantic knowledge
  - Motor skills – OT and PT world – ADL's, transfers, gait
- The HOW of Memory – All therapists have this in common
  - Value of repetition and practice
  - Value of past knowledge, interest
  - Factors that aid retention – fitness of the brain

Components of Memory and Learning– THE WHAT OF MEMORY (*Historical View)*

- Short Term Working Memory and Acquisition – Top down – pre-frontal
- Long Term
  - Declarative (explicit)
    - Episodic (events) – largely hippocampus
    - Semantic (facts) – widely dispersed through cortex
  - Procedural (implicit)
    - Skills and motor learning – largely striatal once overlearned
    - Conditioning – largely striatal

Components memory and learning – *The HOW of Memory part 1* (see especially Tononi and Cirelli, 2014)

- ***Short Term (Working) Memory***
  - ***Acquisition*** – relies on short term working memory – "OK, I think I've got it. Heel toe away we go"
  - ***Consolidation*** – during wake, probably highly related to selective attention and prioritization based on previous knowledge (Early Hippocampal)
    - Support and sustain synapses related to **relevant memories –** "That makes sense! If I don't hold on the hand rail I might fall"
    - Suppress weak synapses or those less integrated with previous memories "What's that man's name again?"

Components of Memory and Learning – *The How of Memory part 2*

- ***Long Term Memory - Learning***
  - ***Matching*** – High levels of neuromodulators in wake maintain the "grand loop" with the environment to enable learning "Oh yes, I remember now, we did that yesterday"
  - ***Gist Extraction*** – forming more enduring memories of high-level invariants, such as faces, places, or even maps, than low-level details and unique instances of a specific encounter – "So this is what I have to know to climb any steps!"
  - ***Integration*** (see Nere et al., 2013 for computer simulation)
    - new material is better learned if it fits with previously learned schemas "I play tennis – core and balance are important there also"
    - Incorporated with an organized body of old memories – "I remember from dance lessons – try to avoid looking down at your feet"

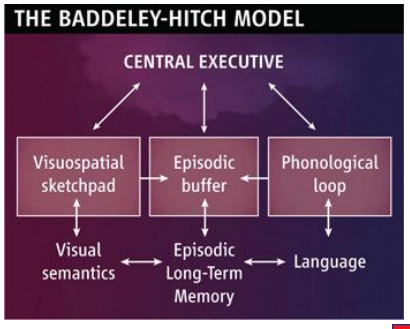
Components memory and learning – *The How Of memory - part 3* (after Tononi and Cirelli, 2014)

- ***Disregarding and Discarding –***
  - ***Protection from interference*** – likely dependent on neurotransmitters like Glutamate – Importance of a non-distracting environment and limiting emotional distractions
  - ***Forgetting*** – essential for dealing efficiently with inevitable accumulation of unimportant details – Essential role of ***SLOW WAVE SLEEP***

Short Term Memory
Acquisition (requires working memory)

Working memory, Cowan 2008

- Working memory defined in three different, slightly discrepant ways:
  - short-term memory applied to cognitive tasks
  - as a multi-component system that holds and manipulates information in short-term memory,
  - And, as the use of attention to manage short-term memory



M. Balter Science 328, 160-163 (2010)

Published by AAAS

Science AAAS

Studies with normal adults

- Jolles et al (2010) Practice effects in brains: changes in cerebral activation after working memory practice depend on task demands. *Neuroimage 52,* 658-668
- Kondo et al (2005) Changes in brain activation associated with use of a memory strategy: a functional MRI study. *Neuroimage 24,* 1154-1163

Short term memory

- Holding
- Working memory
- Acquiring - encoding

Short Term Memory

Consolidation - Early Hippocampal

- Support and sustain synapses related to relevant memories –
  - –repetition
  - – integration with past knowledge
- Suppress weak synapses or those less integrated with previous memories
  - –Inhibition of irrelevant or interfering information
    - »Maladaptive patterns or associations
    - »Recurrent utterances

Retrograde and Anterograde Amnesias

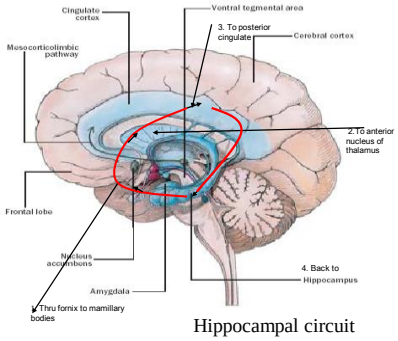
- Associated with traumatic head injuries
  - – Temporal gradient where
    - the time before the injury (retrograde) can be days, months, even years)
    - the time after the injury (anterograde) can last for years but may be less severe over time
- Contrast this to remote memory impairment seen in dementia where there is a loss of memory from the distant past

Medial temporal lobes

- Hippocampal formation
  - – Input is largely excitatory
  - – Inhibitory input arises from contralateral hippocampus
  - – Strong dopaminergic, noradrenergic and serotonergic inputs
  - – Exquisite sensitivity to hypoxia
- Parahippocampal gyrus
- Amygdala

Hippocampal formation

- Likely builds directories/address books to bind and find fragments of experience
  - Once learned, memory representations are distributed throughout the neocortex
    - Both episodic and semantic
  - They continue to consolidate over time
  - Establishes initially sparse and fragile linkages, nurturing them and inserting them into a matrix of existing knowledge



Hippocampal circuit

Pure Amnesia

- Inability to learn anything new
  - Due to bilateral hippocampal damage
  - Can hold information in attention
  - Working memory is ok as long as attention is not distracted
  - Cannot remember anything after being distracted

Amygdala

- Bilateral damage does not cause significant memory impairment in humans
  - Probably critical in forming long-term emotional memories
  - Bonds a stimulus with its emotional connotation
  - Mediates the influence of emotional valence on learning
  - Encodes the emotional valance of an experience

Amygdala

- Deep posterior cerebral arteries/ECT may affect this region specifically
- Emotionally based memory - past experiences that triggered emotional responses may fail to now - or emotions may not fit situation
- Disconnection lesions may result in emotion recorded in the autonomic NS with no conscious awareness

Long term memory

- Storage
- Remembering

The storing process

- Episodic memory - unique, personally experienced events (note: these are the hardest to recall and most easy to alter of change through suggestion)
- Semantic memory - general principles, facts, associations, - parietal lobe

Recent vs. remote memory (Frankland and Bontempi, *Nature Reviews Neuroscience,* ***6***, 119-130 (2005)

– Medial temporal lobe damage causes temporally graded retrograde amnesia with sparing of remote memory
  - Experience is initially encoded in parallel in hippocampal and cortical networks
  - Replay of hippocampal cortical networks strengthens the cortical-cortical connections
  - This eventually allows memories to become independent of the hippocampus

Long term memory

- Declarative(explicit)
  - Facts (semantic)
  - Events (episodic)

The remembering process

- Explicit retrieval and scanning to choose the correct traces are involved in accurate recall *Confabulation is a symptom of inability to correctly scan and retrieve*
- Implicit memories are not consciously remembered but traces can be demonstrated to exist. *Consist of procedural memory for motor skills and priming effects from previously learned but forgotten information*

Semantic Memory

- Input into the matrix of knowledge through limbic connections
  - after consolidation become independent of limbic connections
  - Episodic memories for personal experience remain tethered to limbic areas
- Pick's disease is an example of patients with good language and cognition in the face of poor performance on tasks requiring intact semantic knowledge

Everyday memory

- *Prospective memory* - the capacity to remember to do things
- it does rely on some of the same structures as episodic memory and is drastically impaired in amnesic syndrome
- Rivermead Behavioral Memory Test has proved to be sensitive to and correlate with lapses of everyday memory

Autobiograhical Memory

- Recollection of early life events
- Role of memory in the concept of self
- Confabulation
- How we evaluate the veracity of our memories
- Pattern across life-span
- Vivid and flashbulb memories

Long Term Memory

- The implicit-explicit distinction
- *Implicit learning* – demonstrated in amnesics who showed enhanced performance without being able to recollect the experience of learning (late 1970's)
- *Procedural/declarative* distinction (mid 1980's) – procedural=skills, declarative=facts

Short Term to Long Term Memory

- Is not always gradual
- There are different strength levels based on
  - How widely distributed the memory is
  - How strong the synapses are
- As clinicians – our job is to drive wide distribution and synapse strength as early in the process as possible

Long Term Memory – All Therapies

- Matching –
  - Grand loop – many varied but similar experiences with information
  - Potentiation over progressive wake/sleep cycles
- Gist Extraction – (main idea)
  - highly sleep dependent
  - Becomes widely dispersed [default mode network]
- Integration

Matching

- The "grand loop"
- This favors retention of statistical regularities in the environment (as opposed to imagined or trivial experiences)
- **This is the principal upon which most intensive computerized interventions depend**

Progressive matching over repeated sleep/wake cycles (Tononi & Cirelli, 2014)

- Leads to
  - Transfer
  - Transformation
  - Integration

Gist Extraction

- Forming more enduring memories of high-level invariants, such as faces, places, or even maps, "the big picture" than low-level details and unique instances of a specific encounter - essential for generalization and carry over
- Benefits of sleep (Stickgold and Walker, 2013) for
  - Gaining insight of a hidden rule
  - Enhancing the extraction of second-order interactions
  - Helping abstraction in language learning

Integration – What we know without effortful retrieval

- New material is better learned if it fits with previously learned schemas
  - –Importance of functionality
  - –ADL's
- Incorporated with an organized body of old memories

Procedural memory

- Skill learning
- Difficult to access consciously
- Basal ganglia and cerebellar functions
- Often a dramatic dissociation with episodic and/or semantic memory
- Common etiologies include – Parkinson's disease, Huntington's chorea, cerebellar lesions

Intervention

- Evidence-based interventions for memory and cognitive impairments in adults
  - Spaced retrieval and errorless learning
    - In patients with severe memory disturbances
    - for memory intervention as applications for perceptual impairments
  - Memory strategies for higher level patients
    - Developing memory strategies
    - Memory training

Memory enhancement in healthy older adults using a brain plasticity-based training program: A randomized, controlled study
Mahncke, H. et al.

PNAS **August 15, 2006** vol. 103 no. 33 **12523–12528**

Mahncke et al

Table 1. Training improves thresholds as measured in training tasks

	Exercise				
Improvement	Speed of processing	Spatial syllable match memory	Forward word recognition span	Working memory	Narrative memory
Participants showing improvement	93%	77%	91%	80%	91%
Average improvement	41%	10%	18%	13%	18%

Data for five of six training exercises are shown; data are not available for exercise 2 (syllable identification). The ET group was able to learn to perform the tasks and showed task-specific improvements after training.

Cognitive Training: The Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE)

- Community-dwelling seniors – recent study
  - 10 years after 5-6 weeks of cognitive training
  - experienced significantly improved reasoning and speed of processing skills,
  - as well as better activities of daily living
  - compared with those who didn't get such training.
- Main results after 5 years published in *JAMA* in 2006,
  - first large-scale randomized trial
  - showed that cognitive training improves cognitive function in noninstitutionalized persons
  - Training is transferable to daily function.

Subject and Cognitive Training Design

- 6 metropolitan centers - included 2802 participants
  - average age of 73.6 years
  - no significant cognitive dysfunction.
- randomly assigned to 1 of 3 interventions — a memory, a reasoning, **or** a speed-of-processing **or** no-contact control group.
- Training was conducted in small groups in ten 60- to 75-minute sessions over 5 to 6 weeks.

Tasks

- The speed-of-processing training is now available through PositScience – Brain HQ
- Although the other 2 training programs are not yet commercially available, Dr. Rebok and his colleagues have a grant from the National Institute on Aging (NIA) to develop a Web-based version of the ACTIVE memory training.

Conclusions on function

- Short period of training
  - enhanced all of the cognitive abilities
  - and functional skills — the primary outcome of the study
  - And lasted 10 years!
- "After 10 years of participation, 60% to 70% of the participants said they were as well as, or better off than, when they started the study in terms of their everyday activities," said Dr. Rebok.

But, this research is on normal aging adults

- The value of "Brain Fitness" is not limited to typical brains
  - The aging process has many similarities to specific neuropathologies whether MCI, early stage dementias, even Parkinson's Disease
  - Just as physical fitness enhances effects of physical training, research now indicates enhancing memory processes (and reasoning and processing speed) is beneficial to all individuals even with neurological injury
- The CogMed and much motor learning research has included stroke patients

Take away for Clinicians and Nursing

- Computerized cognitive training is available now
  - *Posit Science exercises* (those used in the ACTIVE trial) are available and inexpensive
  - Working memory exercises for children and adults are available and inexpensive
  - The training is highly evidence based for enhancing and maintaining memory and other cognitive skills
- **Computerized memory, reasoning, and processing speed exercises can be included as an *adjunct* to any and all treatment programs with memory impaired individuals**

Task-Specific Training (Naoyuki Takeuchi and Shin-Ichi Izumi, 2013)

- All training after stroke should be targeted to goals that are relevant to the functional needs of the patient
- Task-specific training to facilitate activities of daily living or other relevant motor tasks is a well-accepted principle of stroke rehabilitation
  - Task-specific training can effectively recover a wide array of motor behaviors involving the upper limbs, lower limbs, sit-to-stand movements, and gait after stroke
  - Compared to traditional stroke rehabilitation approaches such as simple motor exercises, task-specific training induces long-lasting motor learning and associated cortical reorganization

Enriched Environment (Naoyuki Takeuchi and Shin-Ichi Izumi, 2013)

- Enriched environments
  - Those that provide greater opportunity for physical activity and motivation
  - a well coordinated multidisciplinary team can provide an enriched environment
  - Patient involvement in patient-centered interdisciplinary goal setting has been shown to encourage their motivation and engagement in therapy
- Reported benefits of multidisciplinary care extend to patients of all ages and to patients with varying stroke severity

Preventing Maladaptive Plasticity
(Naoyuki Takeuchi and Shin-Ichi Izumi, 2013)

- From a PT and OT perspective maladaptive plasticity that weakens motor function and limits recovery
- From a speech perspective – maladaptive plasticity results in recurrent utterances and hyperfluent neologisms in aphasic patients
- From a nursing and family perspective – maladaptive plasticity results in repetitive habits that interfere with re-acclimation in the home, community or vocational setting

Evidence-Based Research for Cognitive Rehabilitation

Interventions in the manual

- The interventions described can be readily used by occupational therapists, speech and language therapists, psychologists, and other rehabilitation professionals.
- Guidelines adapted into step-by-step procedures that can be used by clinicians who treat individuals with brain injury.

Most effective for individuals with severe memory impairments

- Use of external compensations with direct application to functional activities is recommended for people with severe memory deficits after TBI or stroke.
- Practice Guideline

Memory Interventions discussed in the Cognitive Rehabilitation Manual and Reviewed by Cicerone et al. 2011

Intervention	Level of Recommendation
Memory strategy training is recommended for mild memory impairments from TBI, including the use of internalized strategies (eg, visual imagery) and external memory compensations (eg, notebooks).	Practice Standard
Use of external compensations with direct application to functional activities is recommended for people with severe memory deficits after TBI or stroke.	Practice Guideline

Memory Interventions discussed in the Cognitive Rehabilitation Manual and Reviewed by Cicerone et al. 2011

Intervention	Level of Recommendation
For people with severe memory impairments after TBI, errorless learning techniques may be effective for learning specific skills or knowledge, with limited transfer to novel tasks or reduction in overall functional memory problems.	Practice Option
Group-based interventions may be considered for remediation of memory deficits after TBI.	Practice Option

Compensatory Strategy Training (Cicerone, et al 2011 review)

- 4-week structured, group format memory training program
- Results indicated that frequency and intensity of memory training were critical in improving memory performance.
- Also demonstrated increased knowledge of memory strategies and use of memory aids:
  - reduced behaviors indicative of memory impairment, and
  - improved performance on neuropsychologic assessment of memory

Memory Interventions discussed in the Cognitive Rehabilitation Manual and Reviewed by Cicerone et al. 2005, 2001

- Errorless learning and Spaced Retrieval
  - **Ehlhardt**, L., Sohlberg, M.M. et al. (2008). Evidence-based Practice Guidelines for Instructing Individuals with Acquired Memory Impairments: What **Have We Learned** in the Past 20 Years? *Neuropsychological Rehabilitation, 18 (3),* 300-342
- Focus - minimizing errors during **delivery** of instruction:
  - **Errorless learning**
  - **Spaced retrieval**
  - Most helpful for individuals with more severe cognitive impairments.

Strategic Memory and Reasoning Training (SMART)

- **Sandra Bond Chapman**
  - Director of the Center for Brain Health at The University of Texas at Dallas
- SMART teaches how
  - to think strategically enabling deeper understanding
  - to imagine potential problems, identify multiple solutions, create novel directions, and view issues from diverse perspectives.