Goal-directed regulation of attention and problem solving:

Neural behavioral launchpads towards successful cognitive functioning after brain injury

Tatjana Novakovic-Agopian, PhD

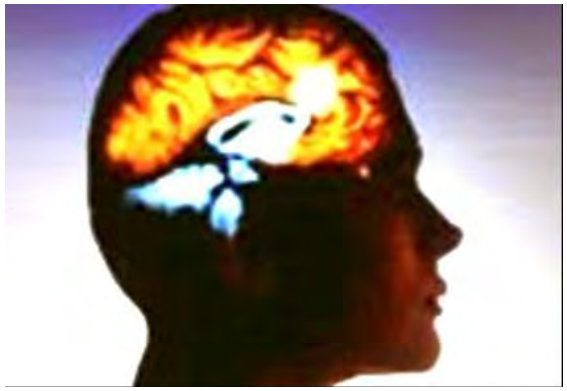
Rehabilitation Neuropsychologist SFVAMC

Assistant Professor, Dept of Neurology, UCSF

Anthony J.-W. Chen, MD

Cognitive and Rehabilitation Neurology, VA Northern California

Assistant Professor, Dept of Neurology, UCSF



Strengthening the Cognitive Control Functions

Attentional Regulation and Problem Solving Applied to Individual Goals

Tatjana Novakovic-Agopian, Ph.D
Rehabilitation Neuropsychologist, SFVAMC
Assistant Professor, UCSF
Co-Director Program In Rehabilitation Neuroscience

Veteran's Experience

I noticed that I had changed drastically when I returned home and tried to go back to work…

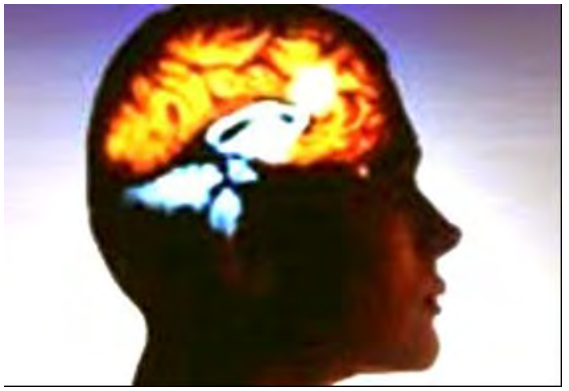
I would get distracted easily….

I had trouble starting tasks, deciding what to do,

and how to do it….

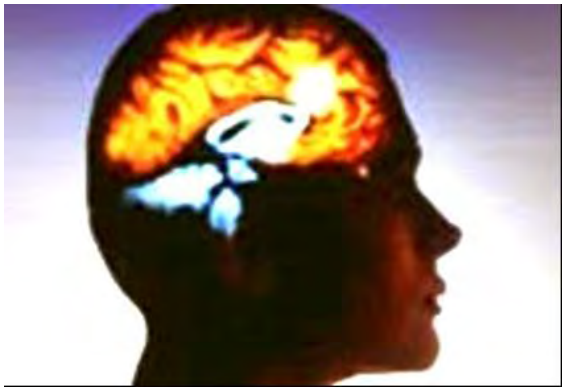
Statement form a veteran with TBI

Deficits in Executive Control Functions …



- **Some of the most persistent, and most disabling consequences of brain injury, including ability to:**
  - **Select goal-relevant information**
  - **Hold goal-relevant information in mind**
  - **Use it for decision-making and goal management in daily life**
- **Common Symptoms:**
  - **Difficulty concentrating, easily distracted**
  - **Difficulties with organization, prioritization and planning**
  - **Most apparent in complex, unstructured environments– *when we're not told what to do***

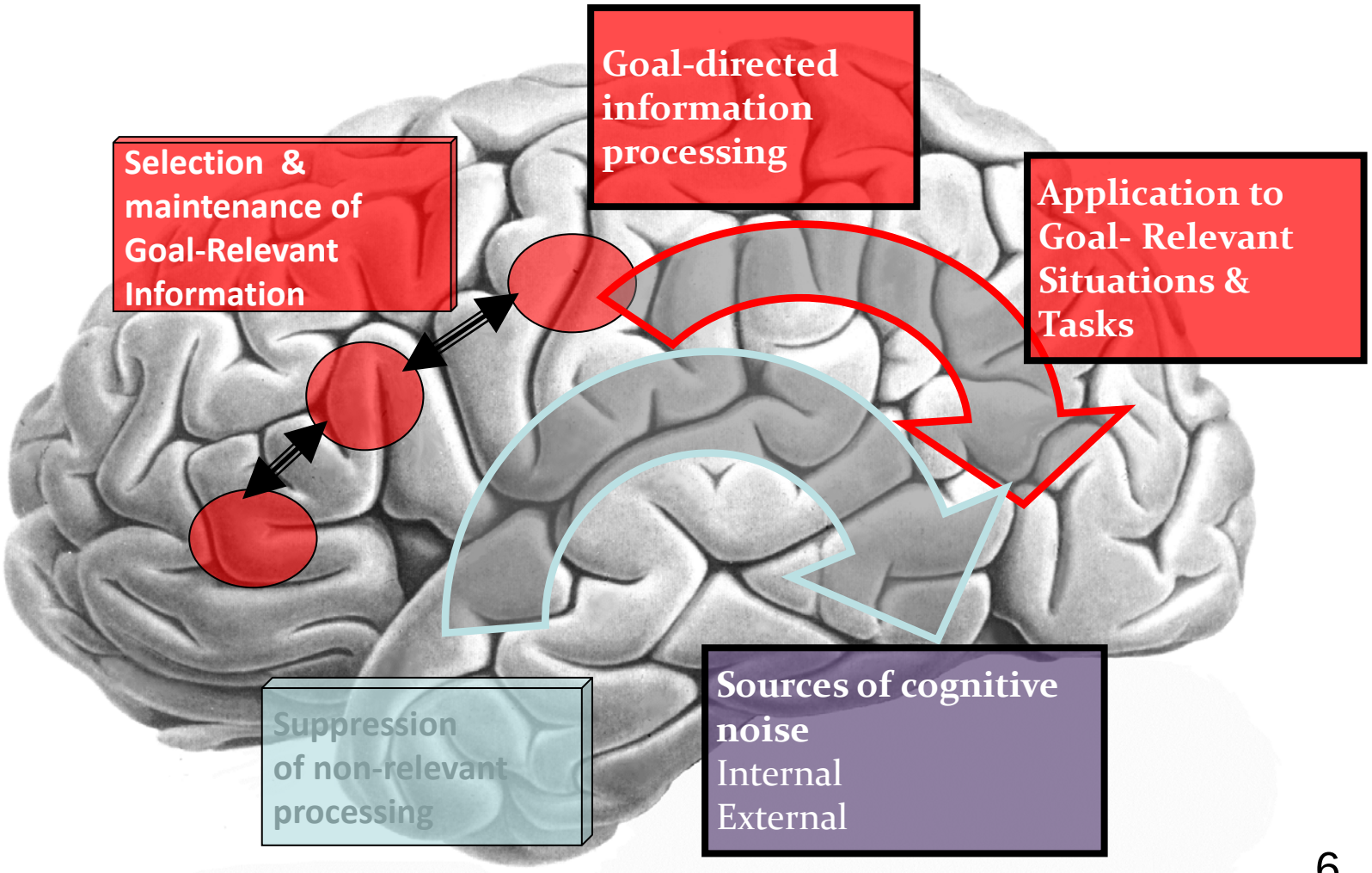
What are 'Executive Control Functions'?



- Neuro-behavioral processes facilitating goal achievement
  - Depend on frontal systems
  - Disrupted by both frontal injuries, and disconnection of networks

- Basic mechanisms for goal-directed control
  - Selection and maintenance
  - Manipulation and adjustment

Training in goal–oriented attentional regulation applied to personally relevant situations & goals



Intervention:
Goal-Oriented AttentionaL Self-regulation
GOALS

Novakovic-Agopian, Chen & Rome 2007

- Focus on:

  1. Attention regulation skill building

  2. Applying attention regulation and problem solving strategies to participant-defined goals and daily life

Influenced by:

MBSR (Kabat-Zinn)
GMT (Levine & Robertson)
Problem Solving Therapy (D'Zurilla & Nezu)

Attention Regulation Skill Building

Training in goal-directed selection and maintenance

- Practice *focusing on and holding goal relevant information in mind*
- Practice *letting go* of distractions (non-goal relevant)
- Apply to progressively more challenging tasks
- *Stop-Relax-Refocus*

Applied Attention Regulation and Problem Solving

Practice applying attention regulation and problem solving strategies on:

- Progressively more challenging situations in daily life
- Selection and execution of feasible individual and group projects

GOALS intervention: Process vs. Content Training

- **Individualization of treatment content:**
  - ***Focus on participants own goals and life situations***

- **Standardization of treatment process:**
  - ***Goal setting; Selection and maintenance of information based on goal-relevance; Self monitoring; Error correction***

GOALS Training Protocol

- 5 weeks: 10 two hour sessions of group training,
  3 hours of individual training,
  ~20 hours of homework.
- Small group format: 2-5 participants & 2 therapists
- Manualized training in applying goal-based attention regulation and problem-solving strategies on a functional task(s) of participants' choice.
- Participants identify feasible functional goals they are interested in working on as:
  - a group goal / project
  - an individual goal / project

GOALS Session Outline

Session 1	**Applied Mindfulness Based Self Regulation**	**Applied Problem Solving**	**Introduction and overview**
Session 2			**Absentmindedness and mindfulness**
Session 3			**Progressive information maintenance: Mindfulness exercises**
Session 4			**Goal selection: Discuss options for group and individual projects**
Session 5			**Breaking down projects into sub-tasks, creating timeline. Apply to group and individual projects**
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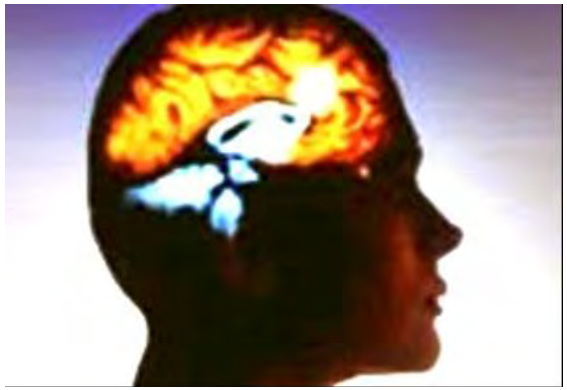
Session 7			**Staying on tasks, error correction and adjustments**
Session 8			**Project progress review and adjustments**
Session 9			**Individual project presentation**
Session 10			**Group project presentation and graduation celebration**



Pilot GOALS Study Results

Tatjana Novakovic-Agopian, Anthony Chen , Scott Rome , Gary Abrams, Holli Castelli, Annemarie Rossi, Ryan McKim, Nancy Hills & Mark D'Esposito.
Journal of Head Trauma Rehabilitation (2011).

Anthony Chen, Tatjana Novakovic-Agopian, Terry Nycum, Shawn Song, Gary Turner, Nancy Hills, Scott Rome, Gary Abrams, & Mark D'Esposito,
Brain ***(2011).***

Support:

VA Rehabilitation Research and Development & CPMC Foundation

Pilot Study Design

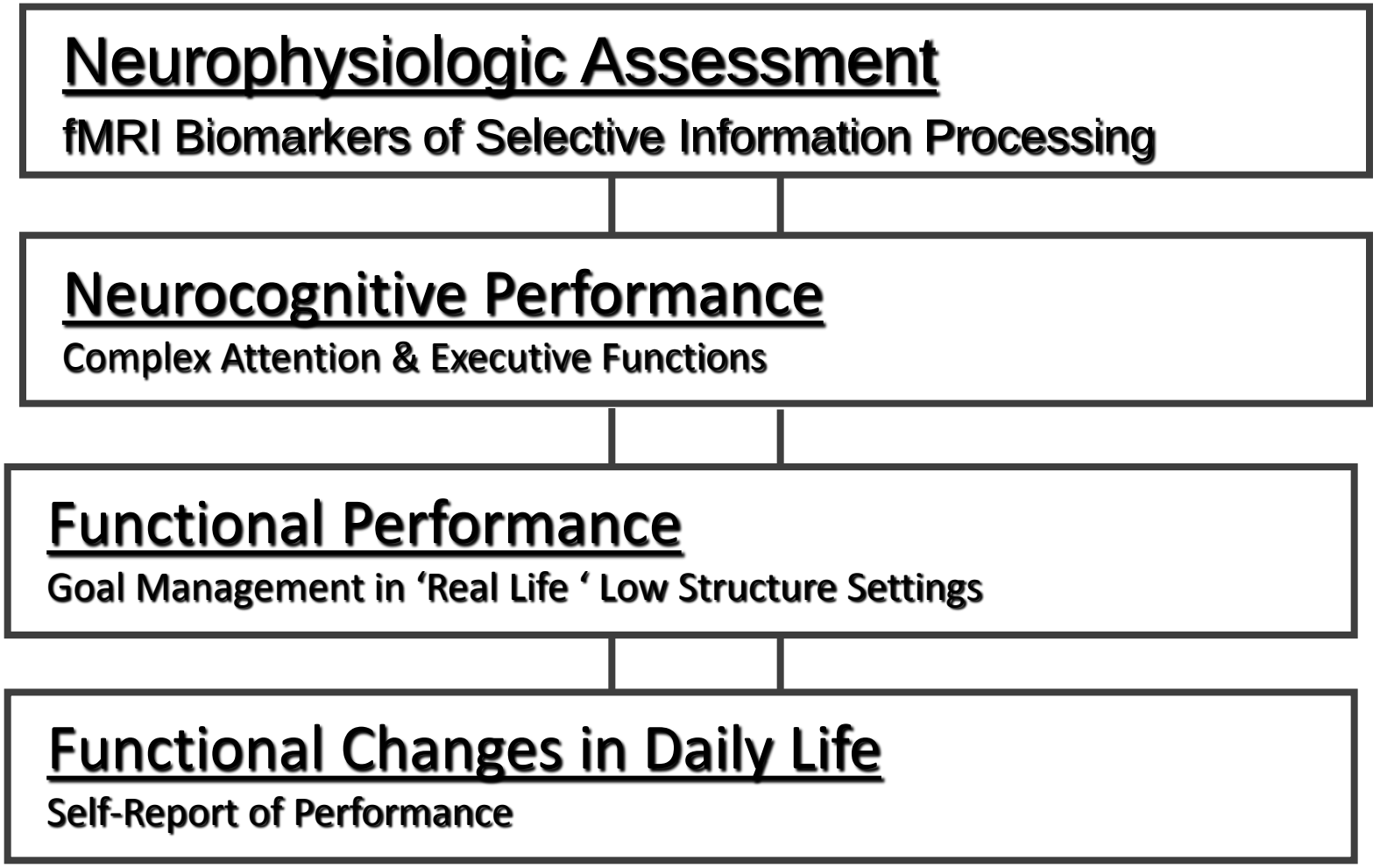
16 individuals with chronic (6+ months) acquired brain injury.

Residual mild-moderate functional deficits, including dysfunction in areas of planning, organization, prioritizing & multitasking.

- **8 participants started with the GOALS, followed by EDU**
- **8 started in the reverse order**

Baseline		Period 1: Weeks 1 - 5		Period 2: Weeks 5 - 10	
Group 1	Assessment 1	**GOALS** Training	Assessment 2	Brief **EDU** training	Assessment 3
Group 2		Brief **EDU** Training		**GOALS** Training	

Assessment Levels



Behavioral Study Measures

Neuropsychological Assessment

Complex Attention and Executive Function

Working Memory
- Letter Number Sequencing
- Auditory Consonant Trigrams

Sustained Attention
- Digit Vigilance–time & errors

Mental Flexibility
- Design & Verbal Fluency Switching
- Trails B
- Stroop Inhibition /Switching- time & errors

Inhibition
- Stroop Inhibition –time & errors

Learning and Memory

Hopkins Verbal Memory Test - Revised

Brief Visual Memory Test - Revised

Functional Performance

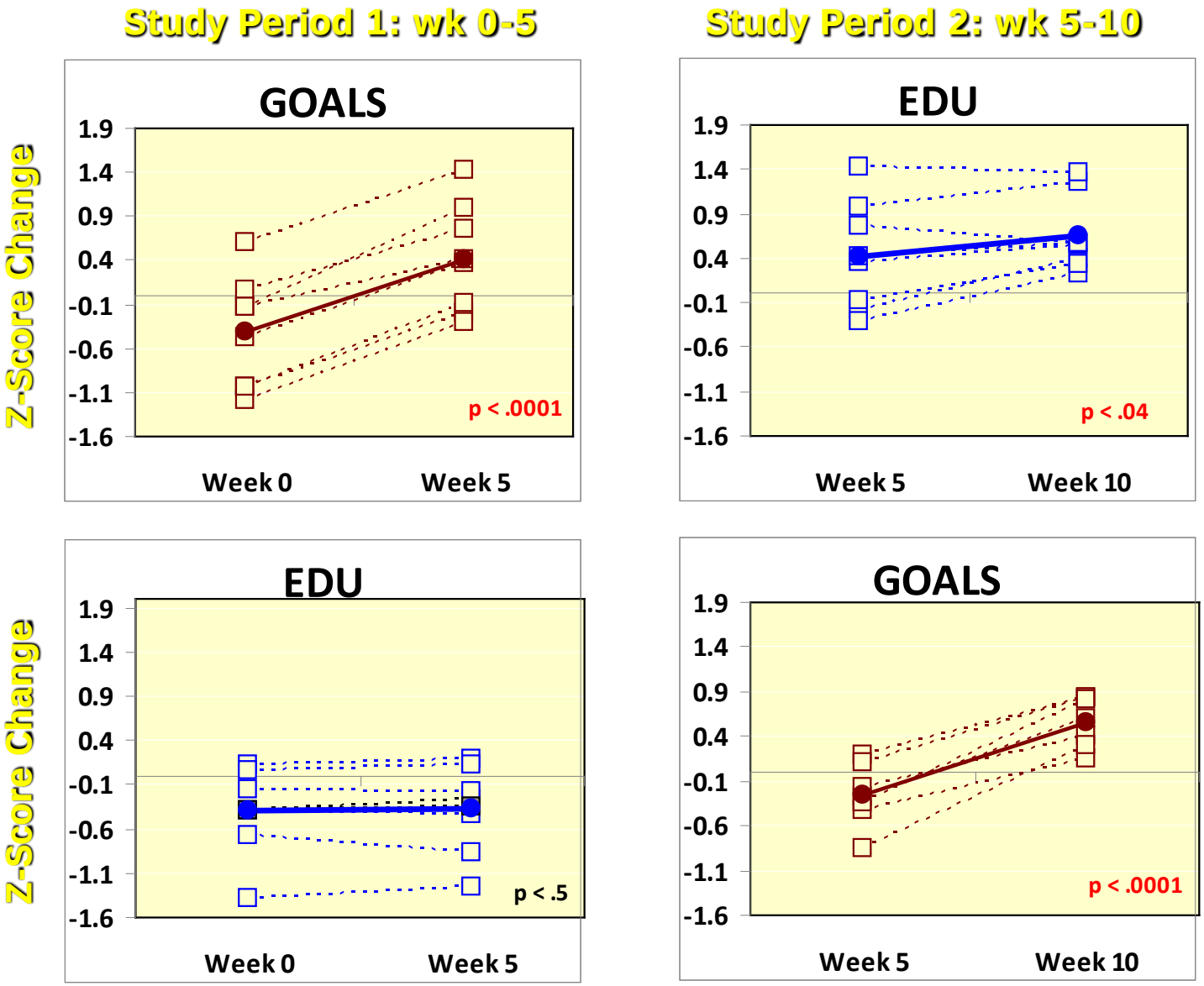
Complex Functional Task Performance

Multiple Errands Test (MET)

Self-Assessment of Functional Performance in Daily Life

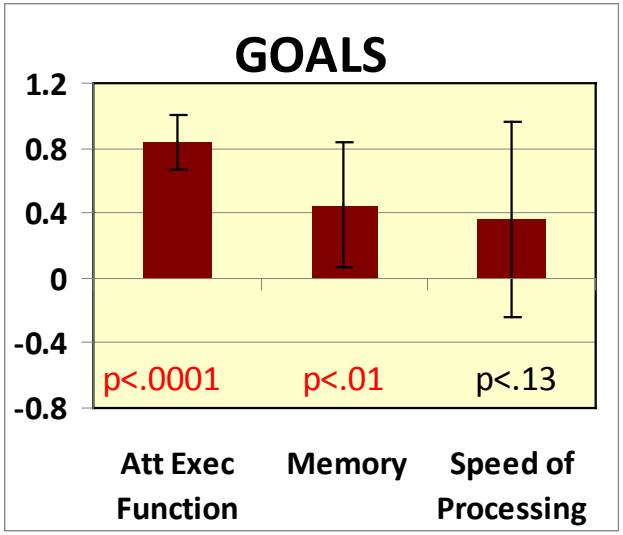
Goal Processing Questionnaire (GPQ)

Neurocognitve Performance
Attention and Executive Function

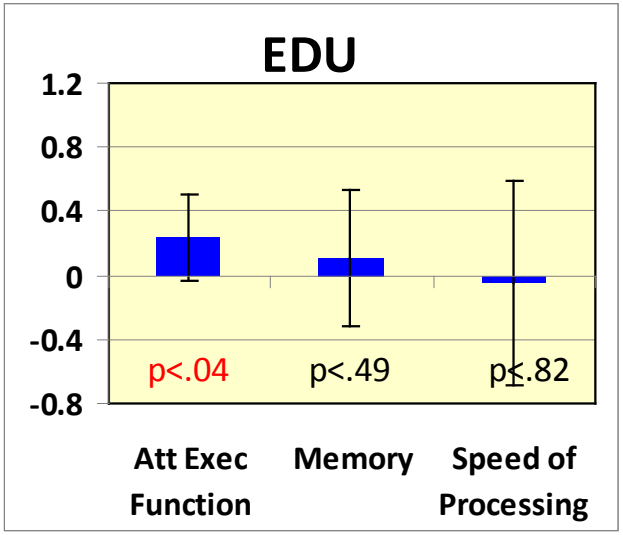


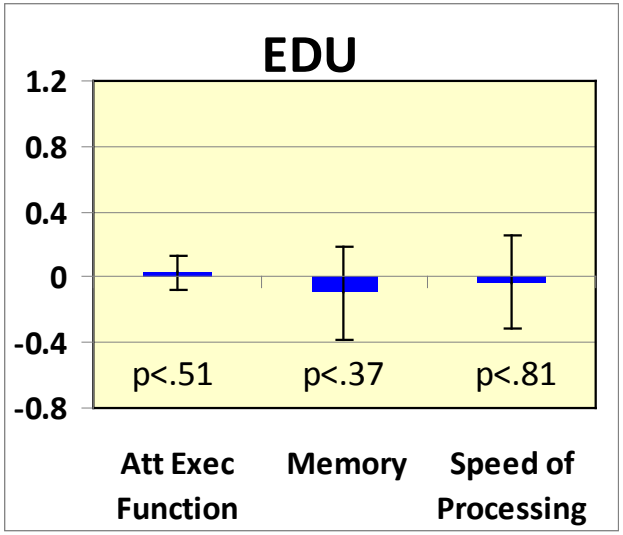
Attention / Exec., Memory, and Speed of Processing Changes

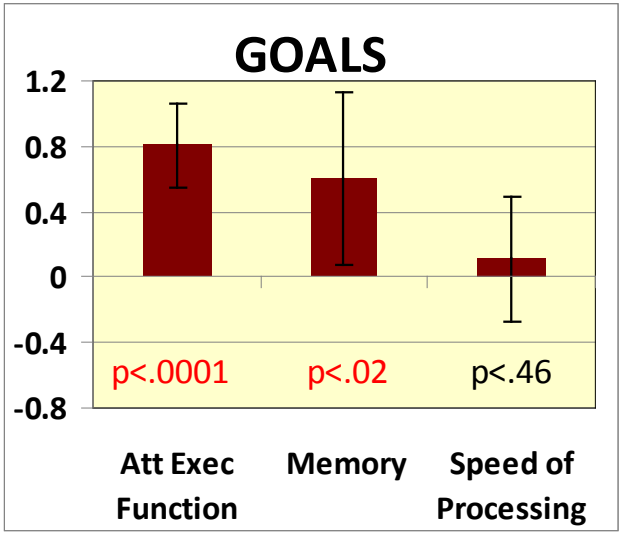
Study Period 1: wk 0-5



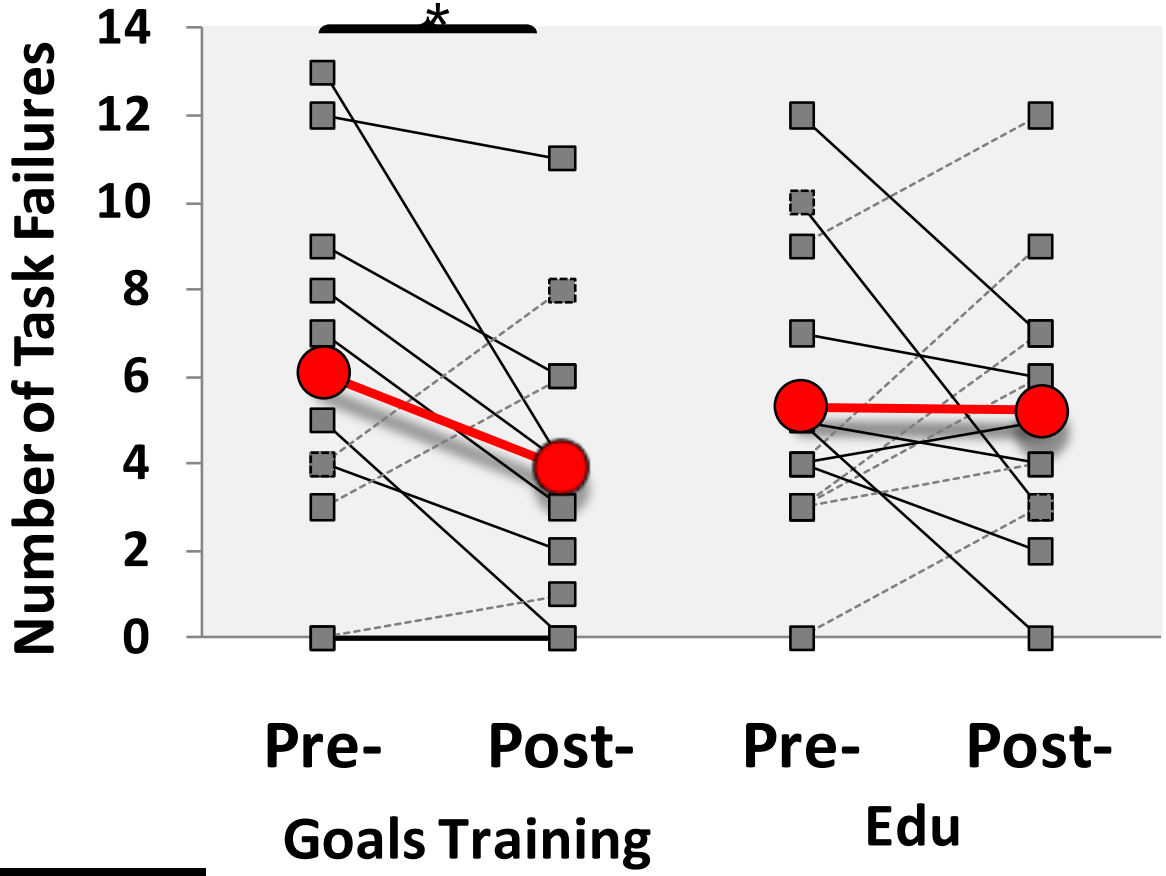
Study Period 2: wk 5-10





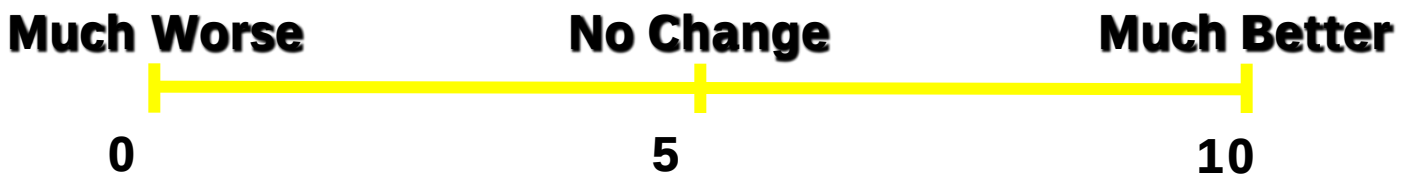


Complex "Real Life" Functional Task Performance
Multiple Errands Test
Change in Number of Task Failures



Self-Report of Functional Performance

Change Post GOALS training (Relative to Baseline)



Ability to stop and relax during stressful times	7.8
Ability to stop and refocus on the current goal.	7.6
Ability to break complex task into more manageable tasks.	7.6
Ability to hold and maintain information in mind.	7.2
Ability to choose feasible daily goals to accomplish.	7.1
Ability to prioritize multiple or complex tasks.	7.0

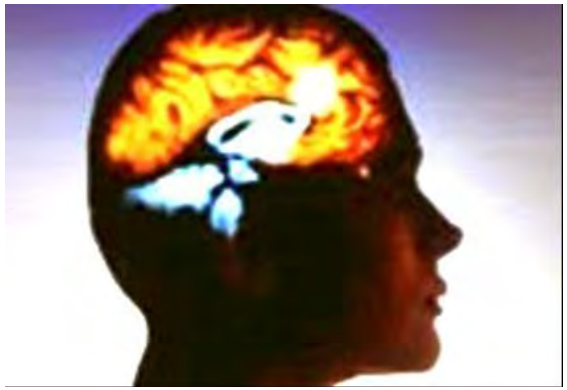
Long Term Follow-up:

11 months-2 years after completion of training:

- 100% (16/16) participated in a structured telephone interview
- 94 %(15/16) able to spontaneously describe training strategies found helpful
- 88% (14/16) reported continuing to use some of trained strategies in their daily lives:

  -Stop Relax Refocus
  -Stop and review one's work
  -Prioritize daily tasks
  -Break larger tasks into subtasks

- 69% **(11/16)** reported returning to work **(7 work for pay; 4 volunteer)**, as compared 13% **(2/16)** prior to training.



GOALS Veteran TBI Study

Tatjana Novakovic-Agopian, Anthony Chen , Gary Abrams, Jim Muir, Annemarie Rossi, Gerald Carlin, Michelle Murphy, Deb Binder, Fred Loya , Michelle Madore, Rich Fitzsimons, Ryan McKim, Nancy Hills, & Mark D'Esposito

Support: VA Rehabilitation Research and Development

GOALS Session Outline

Session 1	**Applied Mindfulness Based Self Regulation**	**Applied Problem Solving**	**Introduction and overview**
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Brain Health Workshop - EDU

Control intervention matching GOALS
in therapist time and intensity

Session 1	Introduction and Basic Brain Anatomy
Session 2	Neuroplasticity
Session 3	Movement, Vision and Language
Session 4	Memory
Session 5	Attention and Executive Functions
Session 6	Sleep and the Brain
Session 7	Diet and Physical Activity and the Brain
Session 8	Stress and the Brain
Session 9	Emotions and the Brain
Session 10	Social Bonds and the Brain/ Lessons Learned

Assessment of Sub-Components of Executive Functioning in Ecologically Valid Settings:

Goal Processing Scale

Novakovic-Agopian, Chen, Rome, Rossi, Abrams, D'Esposito, Turner, McKim, Muir, Hills, Kennedy, Garfinkle, Murphy, Binder, and Castelli. Journal of Head Trauma Rehabilitation (2014).

Goal Processing Scale

- Goal Processing Scale (GPS)- designed to assess functional performance in the context of achieving a goal in a ‘real-world’ setting
- Assessment involves two components:
  - Challenging tasks that engage executive control
  - Rating system to quantify observations.
- GPS task: Participants are asked to gather and compare information about 3 different activities (products/services-alternate forms) of their choice using available means while following specified rules in a limited time.

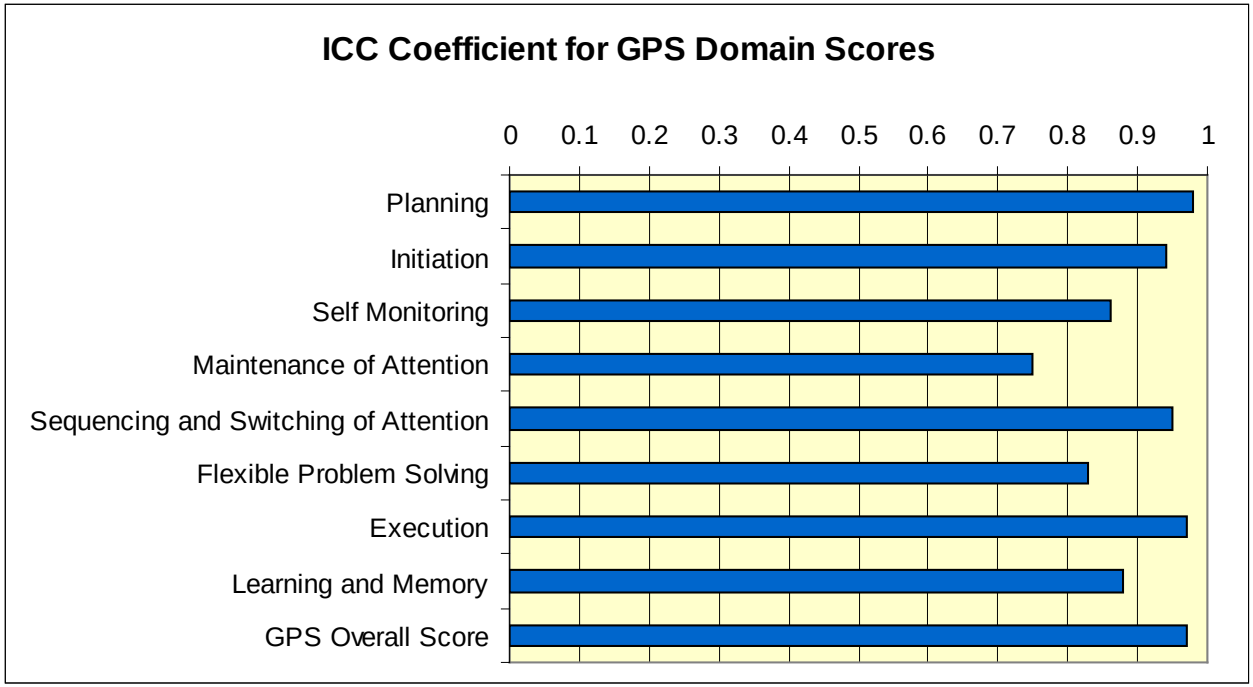
Complex Functional Task Performance:
Assessment of Sub-Components of Executive Functioning
Goal Processing Scale

1. Planning
2. Initiation
3. Self Monitoring
Periodically stopping ongoing activity
Re-assessing task performance
Noticing and correcting errors
4. Maintenance of Attention
Sustaining attention on a task in a non distracting environment
Sustaining attention on a task in a distracting environment
5. Sequencing and Switching of Attention
Switching attention between task subcomponents
6. Flexible Problem Solving
Flexibility in approaching alternate solutions
7. Task Execution
Effectiveness in executing steps relevant to identified plan and goals
Effective time management
Accurate task completion
8. Learning and Memory
Ability to recall strategies when needed
Ability to learn from mistakes
GPS Overall Score (Average of Domains 1- 8)

Performance rated on a scale: 0 (not able) to 10 (not a problem)

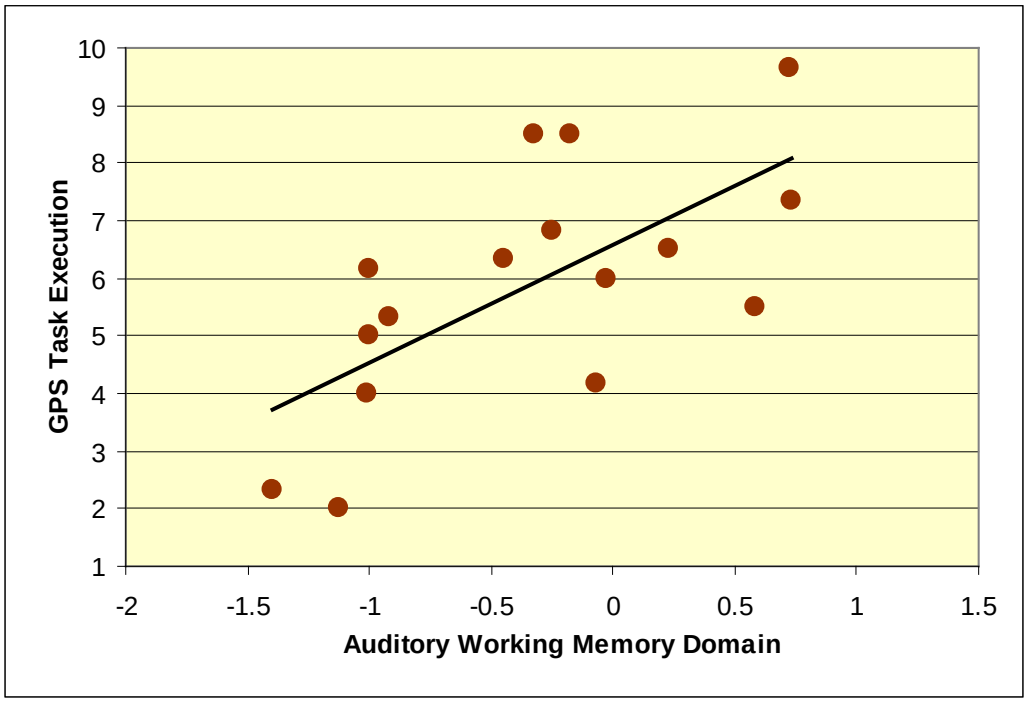
GPS – Validation Study

- 19 patients with chronic brain injury and executive dysfunction
- INTER-RATER AGREEMENT (ICC):
  0.97 for GPS Overall Performance
  0.75-0.98 for eight GPS performance sub-domain scores



GPS – Validation Study

- **CORRELATION WITH SECOND FUNCTIONAL TASK**: GPS Overall performance significantly correlated with MET performance
- **NEUROCOGNITIVE UNDERPINNINGS OF REAL WORLD PERFORMANCE?** Performance on working memory measures correlated with and was predictive of functional performance on GPS Overall summary, as well as with Task Execution, Attentional Sequencing/Switching, Self Monitoring, & Learning/Memory sub-domains.



GOALS TBI - Ongoing study

24 Veterans with chronic TBI

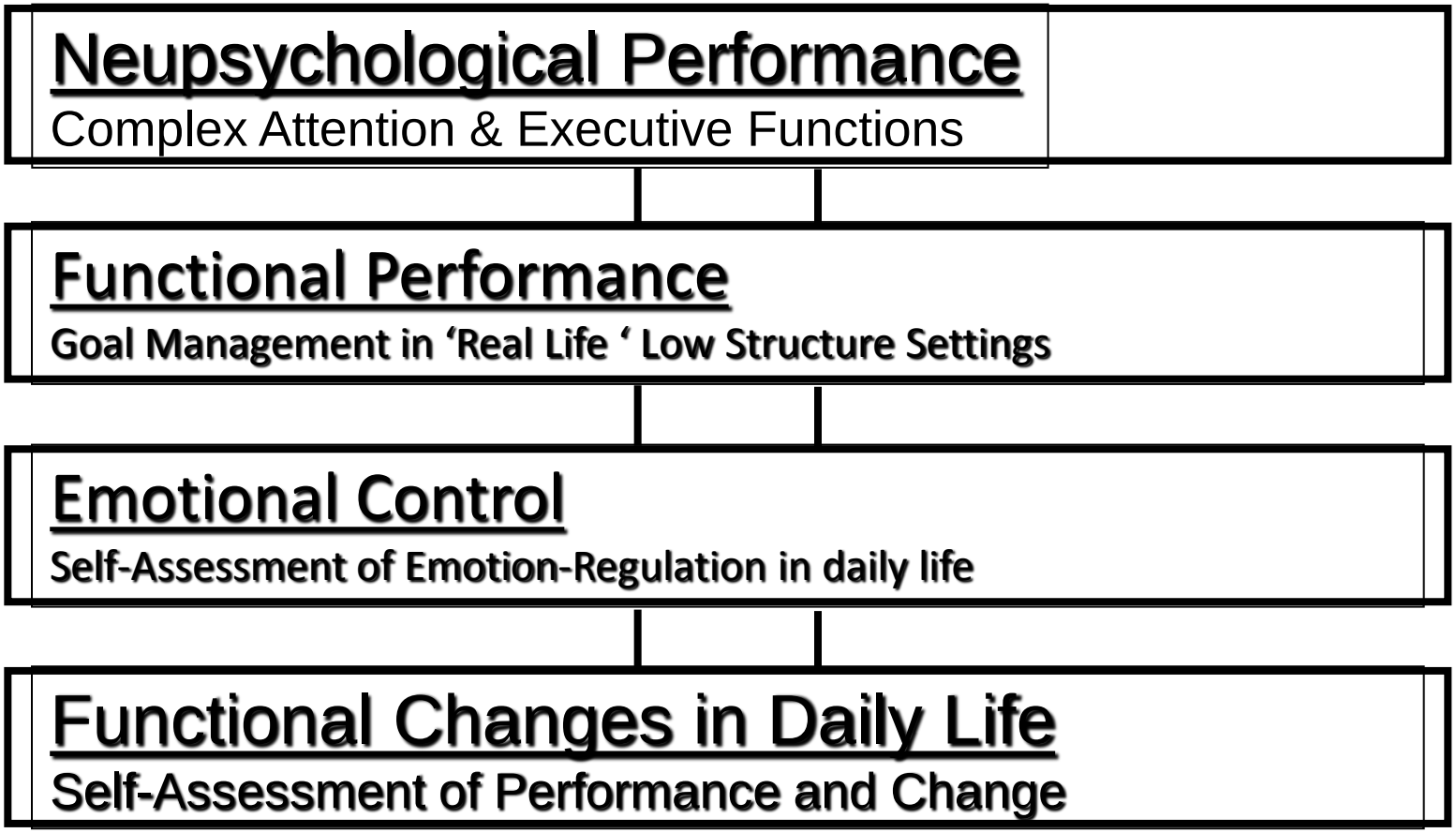
Mild-moderate functional deficits, in areas of planning, organization, prioritizing, multitasking. Stable medication regimen.

Randomized control design

Evaluators blinded to intervention

Baseline		5 Weeks		10 Weeks		6 Months Follow-up	
Group 1	Assessment 1	GOALS Training	Assessment 2		Assessment 3		Assessment 4
Group 2		**EDU** Training		GOALS Training			

Assessment Levels



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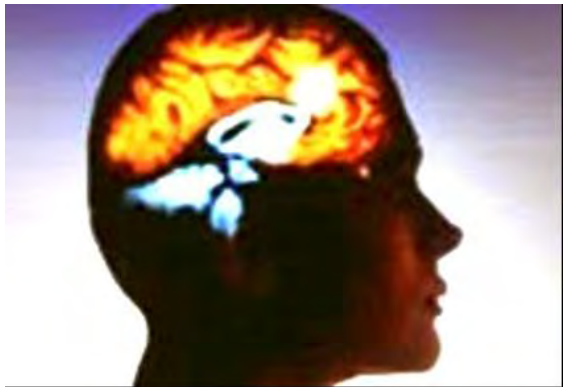
Self-Assessment of Functional Performance in Daily Life

Mayo Portland Adaptability Inventory (MPAI)
Goal Processing Questionnaire (GPQ)

Emotional Adjustment

Self-Assessment of Emotional Adjustment / Regulation

Profile of Moods States (POMS)
Beck Depression Inventory II (BDI II)
Post-Traumatic Checklist-Military (PCL-M)



GOALS PTSD -mTBI Veteran Study

Investigators: Tatjana Novakovic-Agopian, Gary Abrams, Anthony Chen, John McQuaid , Thomas Neylan

Support: VA Rehabilitation Research and Development

GOALS PTSD mTBI - Started

Veterans with current dx PTSD and mTBI

Mild-moderate functional deficits, in areas of planning, organization, prioritizing, multitasking. Stable medication regimen.

Randomized control design

Evaluators blinded to intervention

Baseline		5 Weeks		10 Weeks		6 Months Follow-up	
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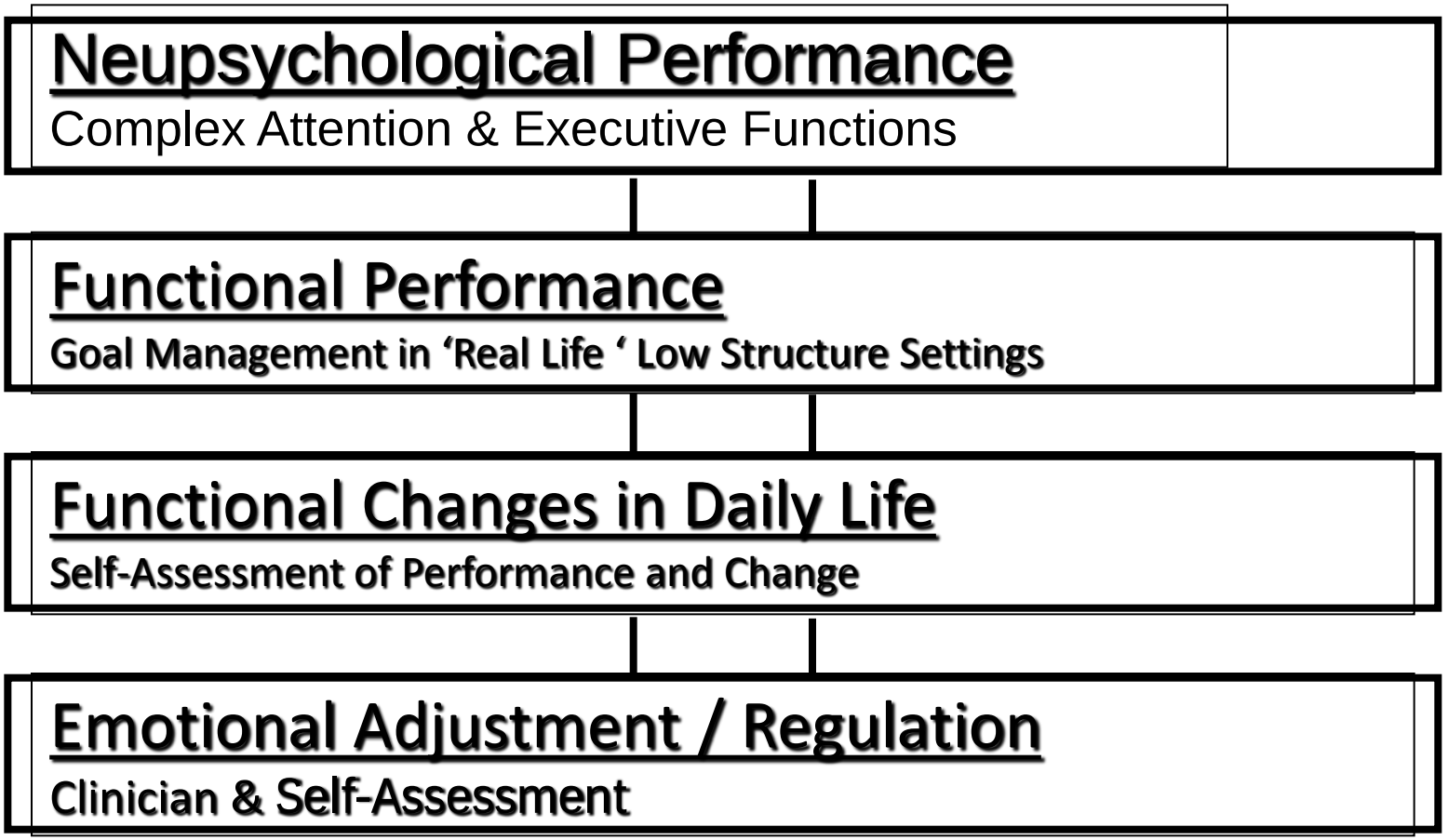
Group 2		**EDU** Training		**GOALS** Training			

Assessment Levels



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Goal Processing Questionnaire (GPQ)

Emotional Adjustment

Clinician Assessment

Clinician-Administered PTSD Scale (CAPS)

Mini International Neuropsychiatric Interview(MINI) (Depression Module)

Self-Assessment of Emotional Adjustment / Regulation

Profile of Moods States (POMS)

Beck Depression Inventory II (BDI II)

Post-Traumatic Checklist-Military (PCL-M)

Difficulties in Emotion Regulation Scale (DERS)

New Directions

- ***Does strengthening cognitive control mechanisms improve functioning in other domains such as emotional regulation in daily functioning?***

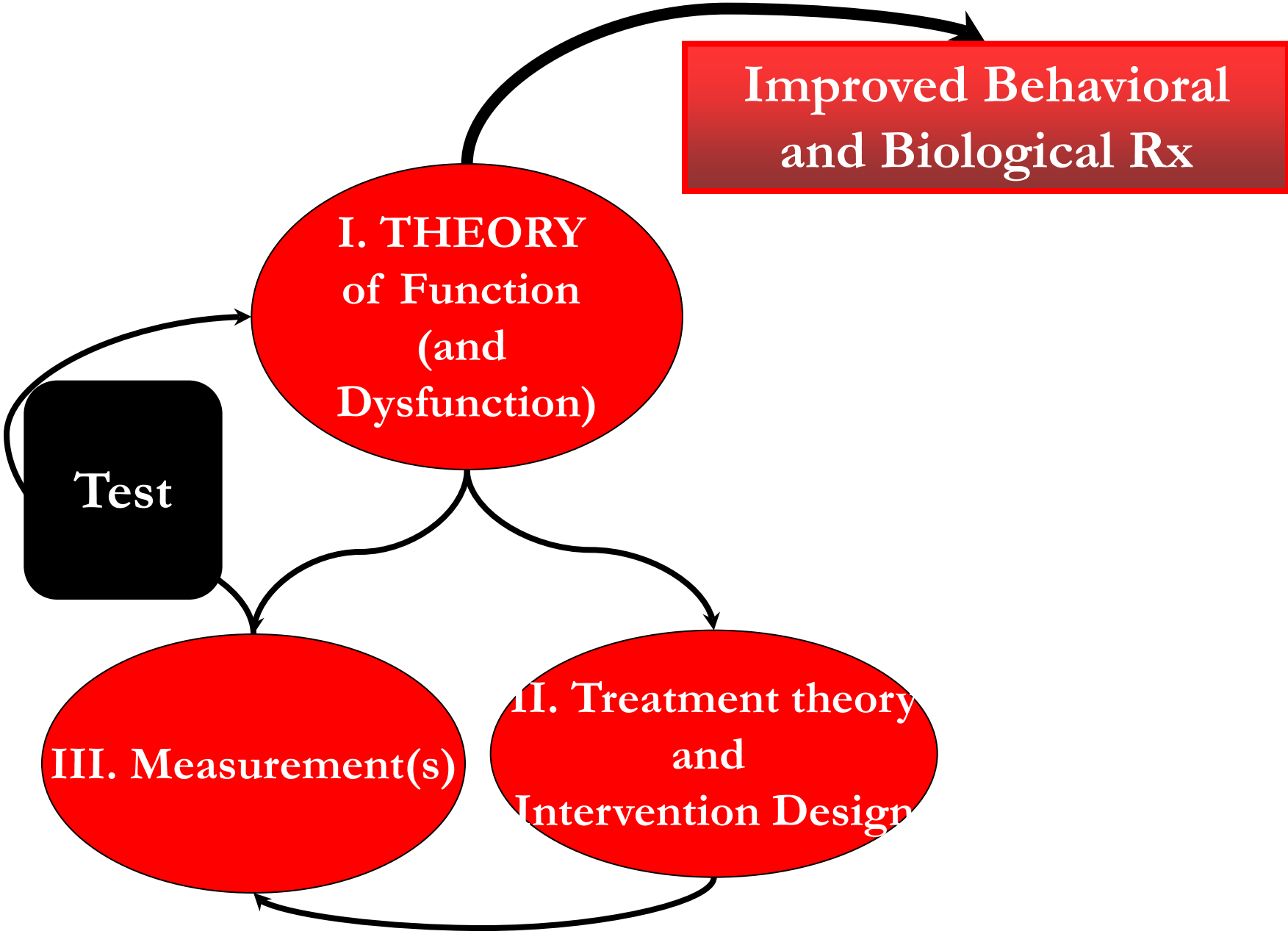
- ***Trial of GOALS training in Veterans with current dx of PTSD and history of mTBI***

- ***Enhancing community integration – work and school***

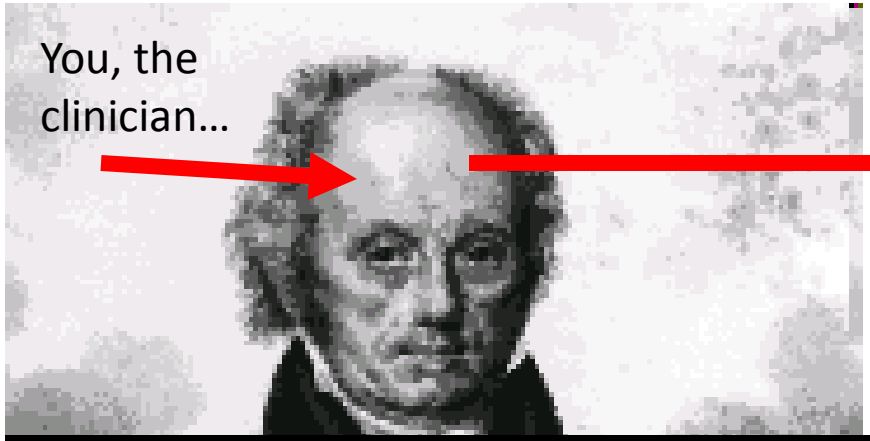
Determining neural-behavioral *launchpads* for successful cognitive functioning after brain injury

Anthony J.-W. Chen, MD
Program in Rehabilitation Neuroscience
VA Northern California, SF VA,
UC Berkeley, UCSF

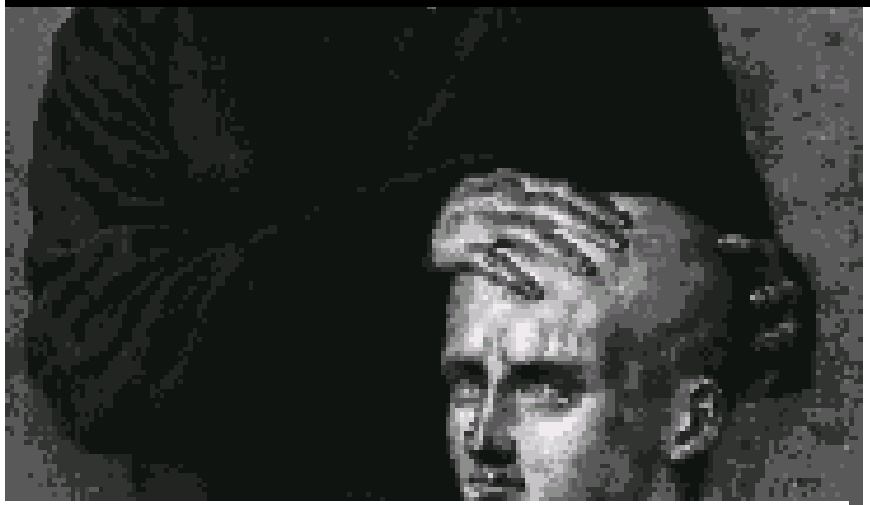
Rehabilitation Neuroscience

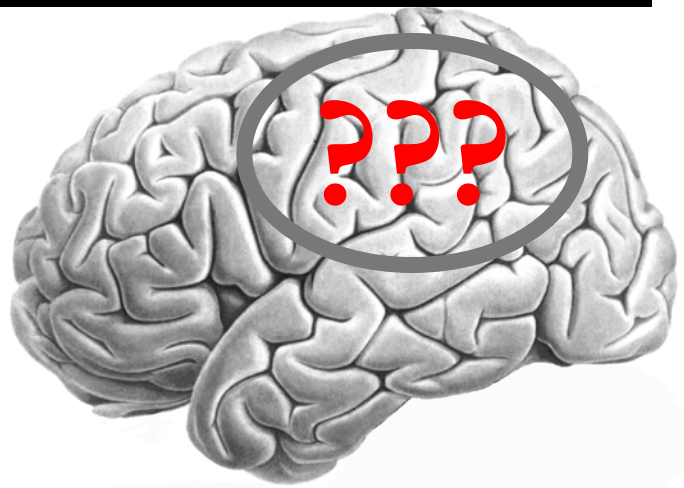


When improvements do occur, what's going on inside…?



Biomarkers to test intervention mechanisms





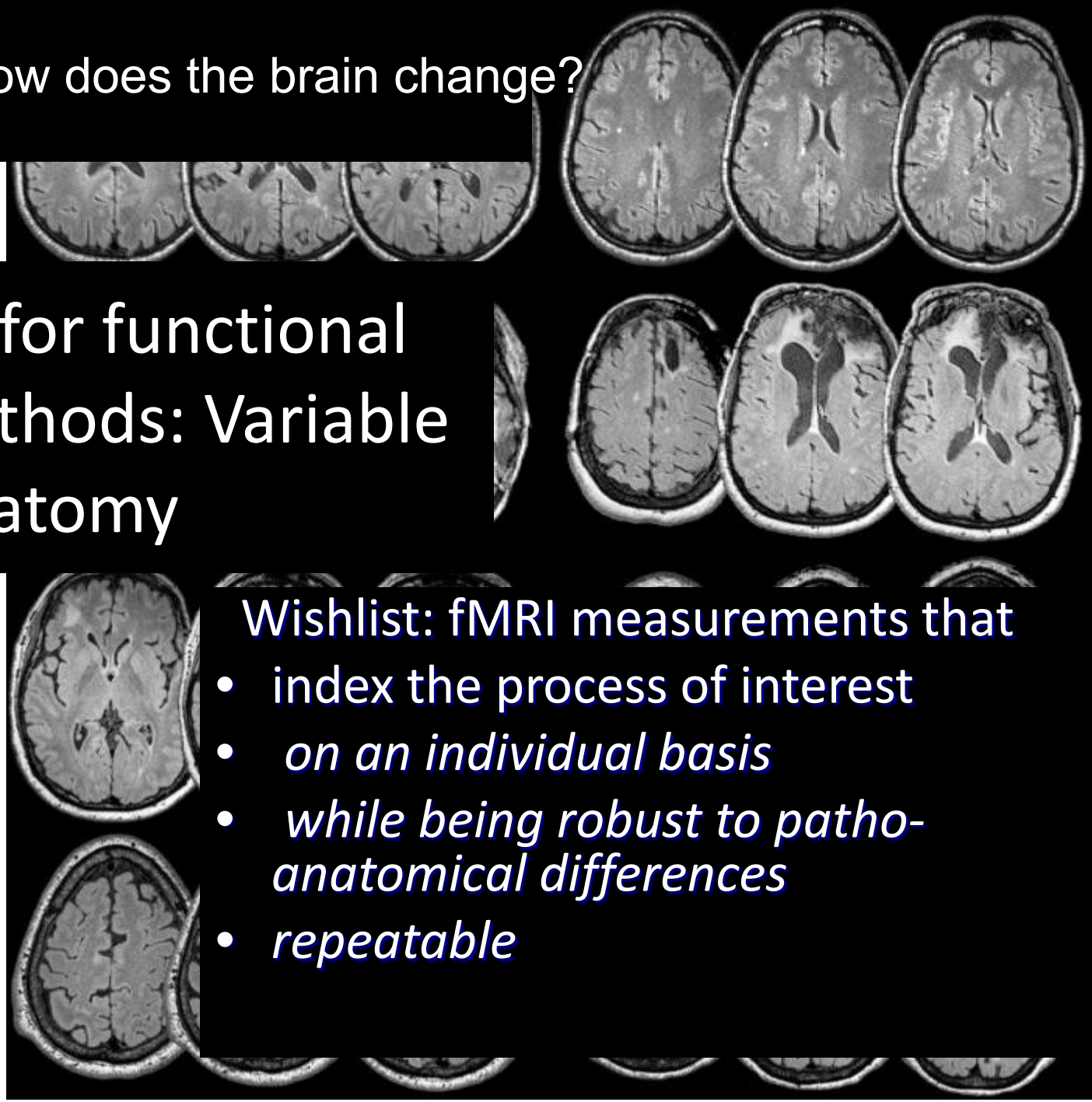
Intervention theory– key processes

neurologic functions important for
the *direction* of
neural-behavioral processes
based on *goals*

Biomarkers to test intervention mechanisms:
What neural changes support
sharpened goal-directed cognition?

- Sharpening of neural information processing based on goals?
  - Markers of 'Selective attention—working memory'
  - Brain state regulation
    - Optimal brain network state for goal-directed cognition?

Biomarkers: How does the brain change?



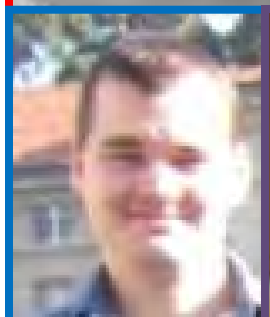
Challenge for functional imaging methods: Variable anatomy

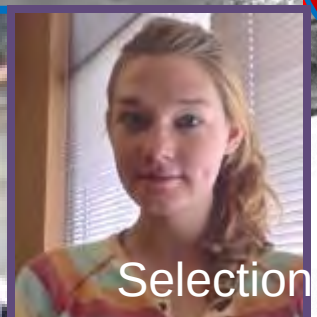
Wishlist: fMRI measurements that

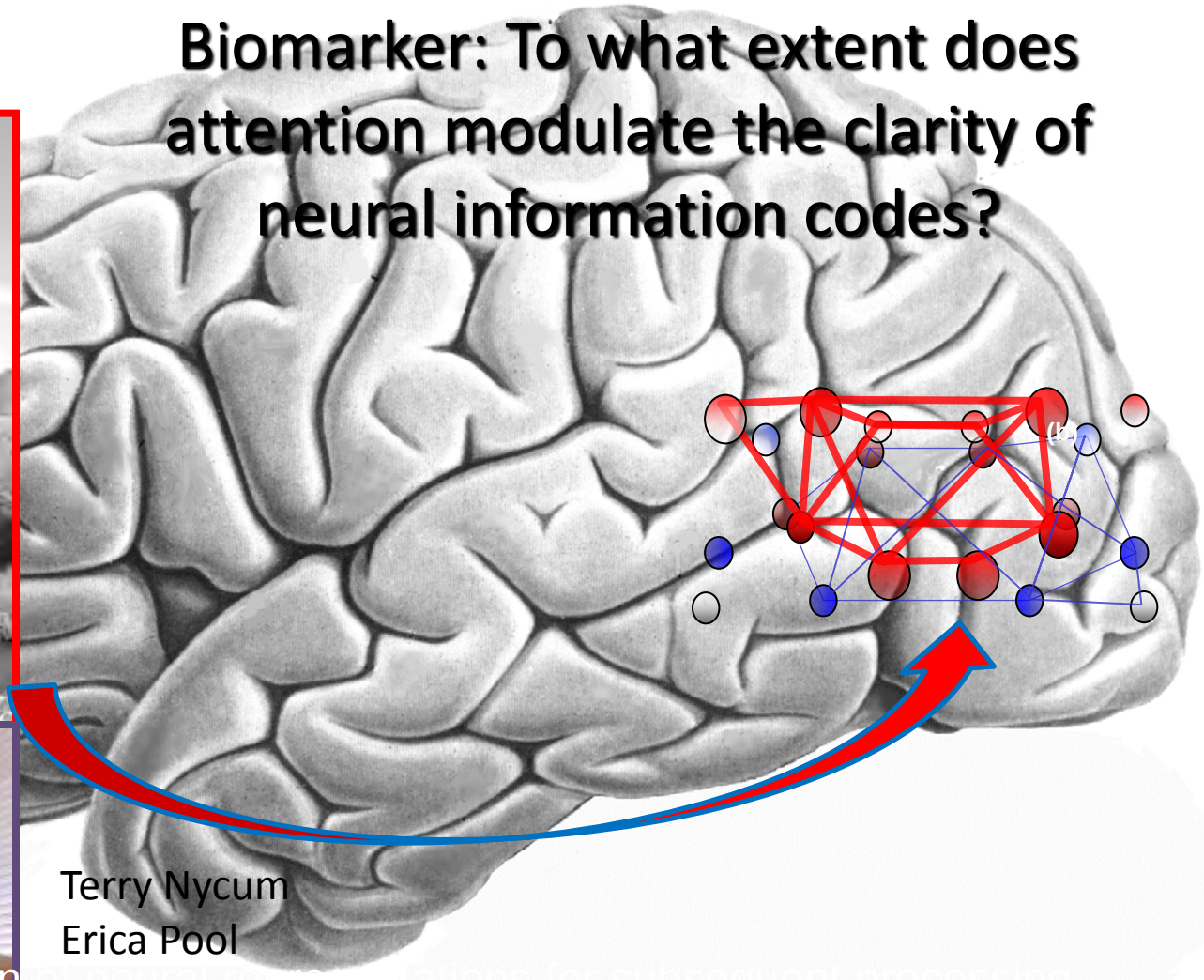
- index the process of interest
- *on an individual basis*
- *while being robust to patho-anatomical differences*
- *repeatable*

Concept: Information is coded in distributed, functionally integrated neural networks–

Biomarker: To what extent does attention modulate the clarity of neural information codes?







Terry Nycum
Erica Pool

Selection of neural representations for subsequent processing

Goal-direction: View all images, *but Select* and hold in mind SCENES (don't be distracted by Faces)

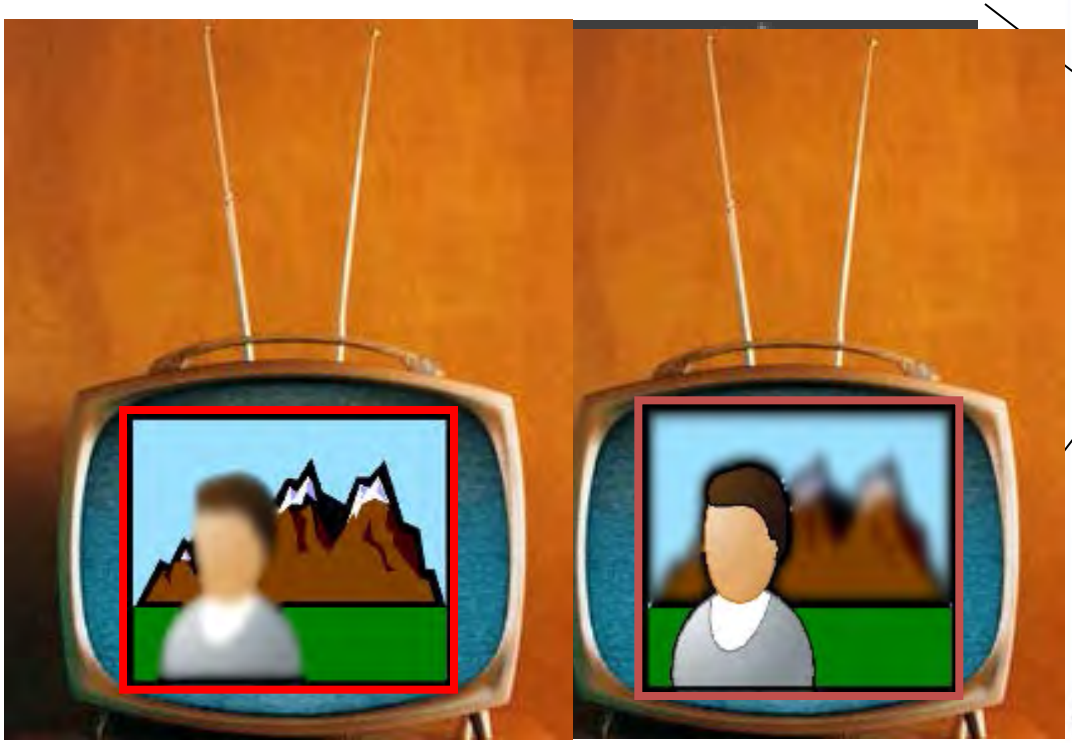
Do any scenes match?

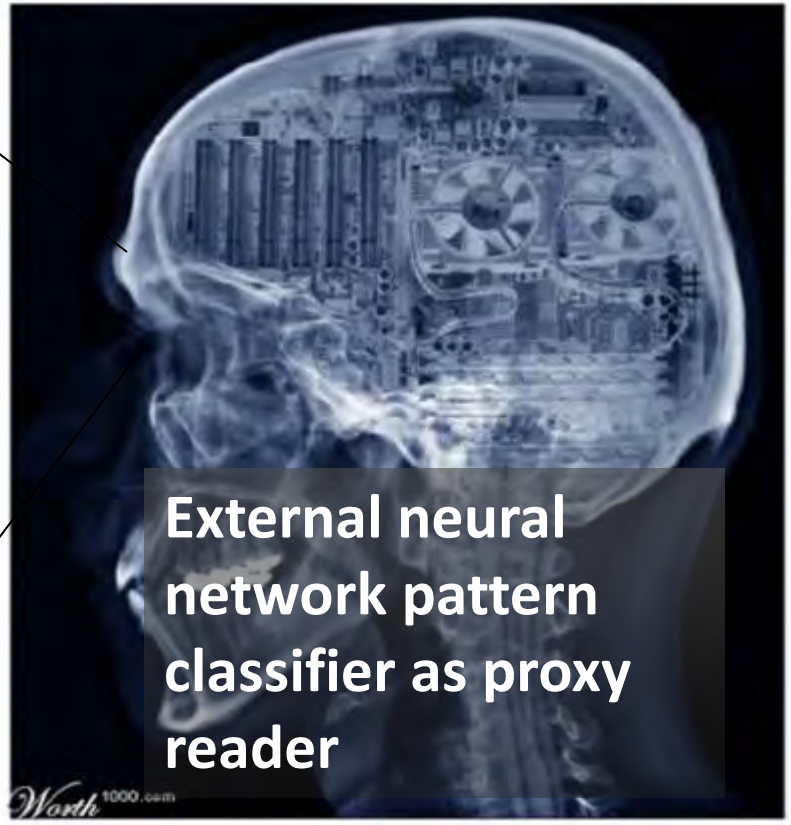
How would we measure how ***clearly*** external/perceptual information is represented brain networks?

Brain activity patterns from fMRI:

More clearly decoded→ sharper representations

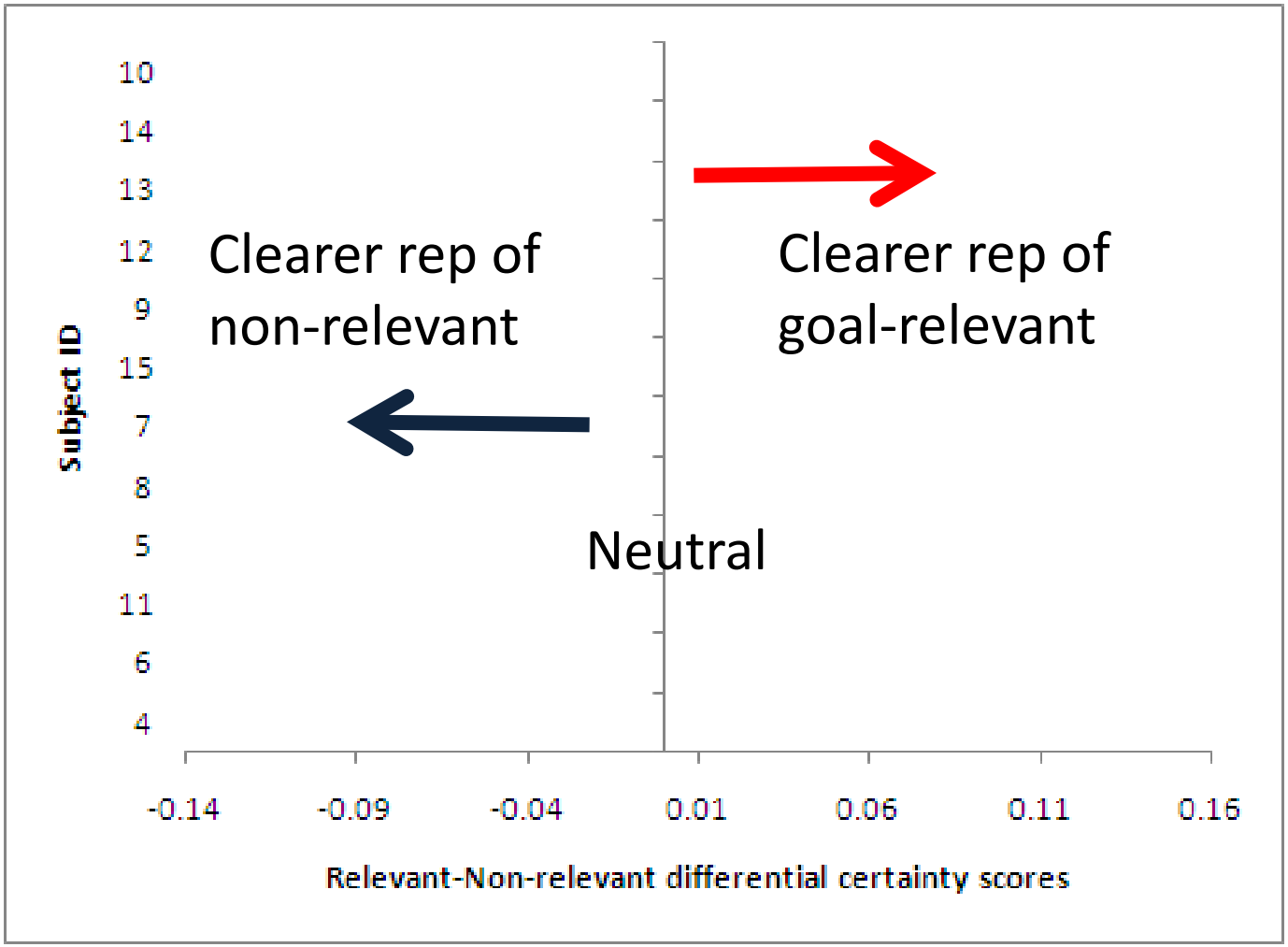
Does training preferentially sharpen neural representations of goal –relevant visual information?





Chen, Novakogic-Agopian, Nycum et al., Brain, 2011

An index of goal-directed regulation of neural representations: Balance of representation of goal-relevant vs. non-relevant



Training to improve goal-oriented attention regulation

Attention regulation

Applied, applied, applied in goal-directed activities across multiple cognitive contexts

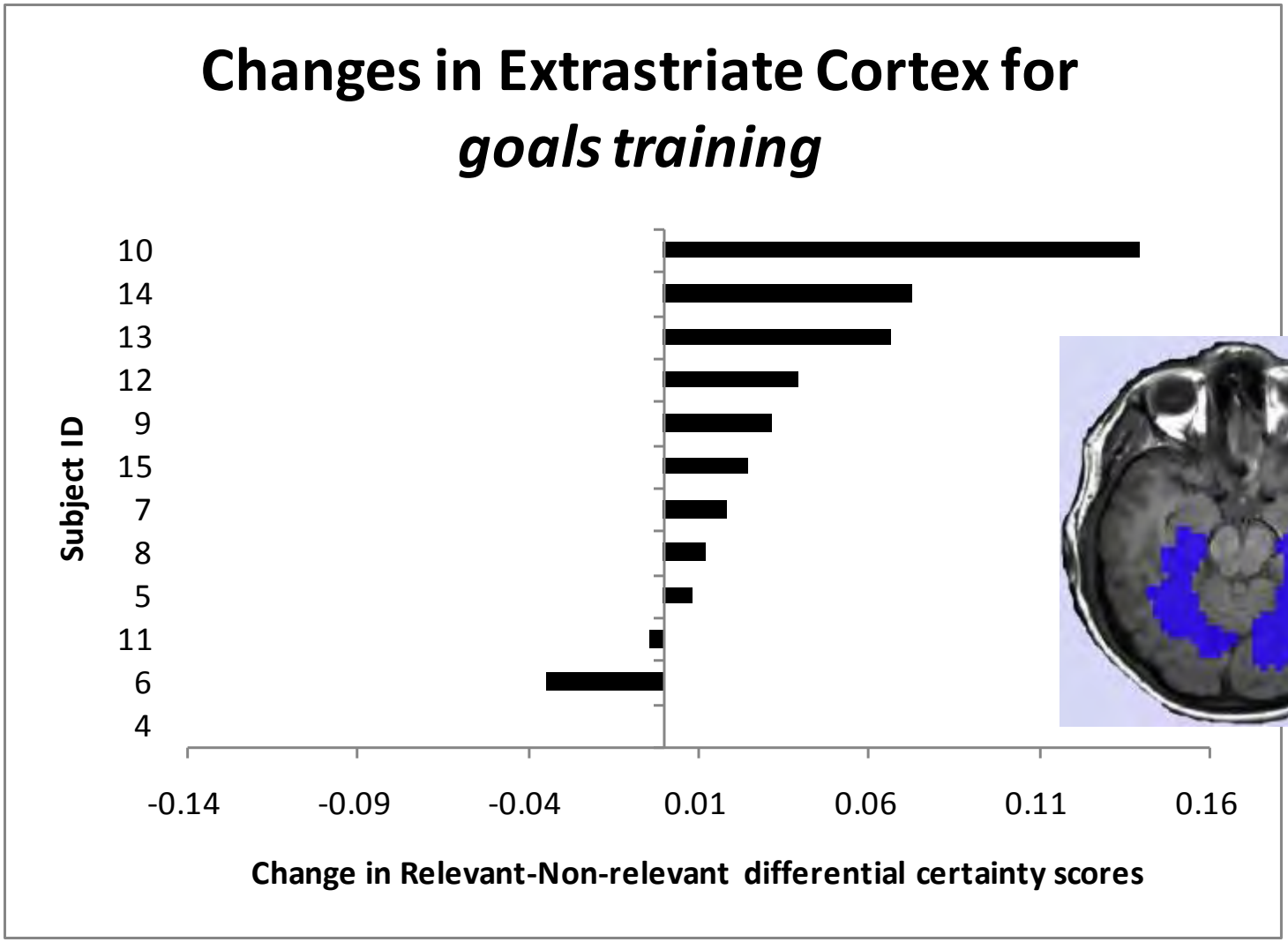
Supervised exercises → **Personal life situations**

Personally-relevant Individual and Group Projects

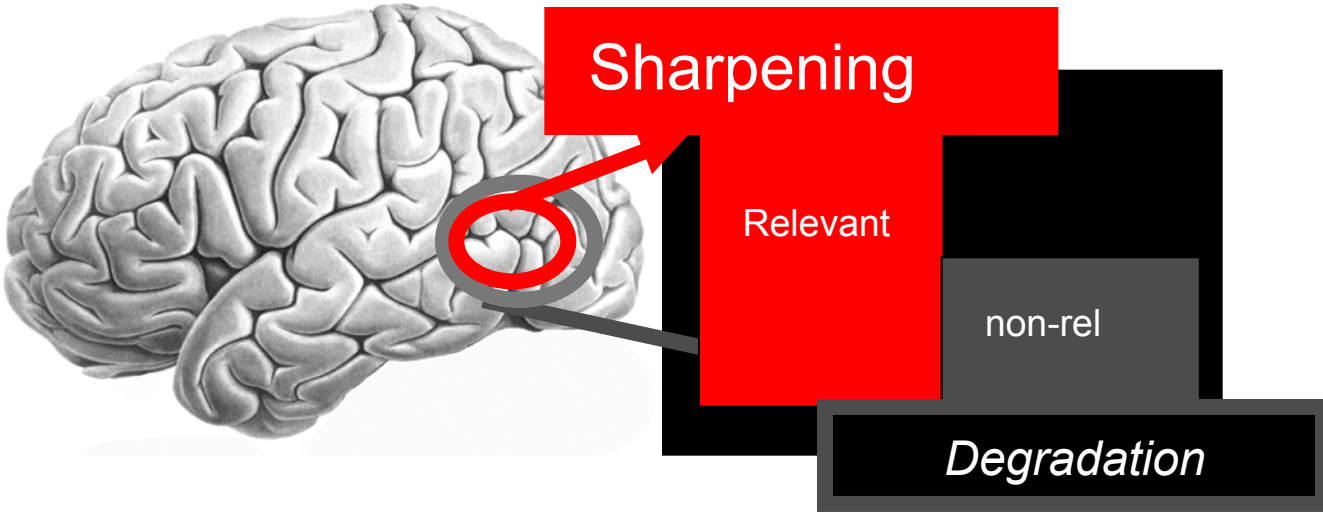
- Key training elements
  - Focus on goal-relevant information
    - Determine relevant or not relevant?
    - Re-direction if off goal
  - Optimal state– relaxed and ready

Novakovic-Agopian, Chen, et al., 2011, J head Trauma Rehab

How does attention regulation training alter the balance of representation in neural codes?



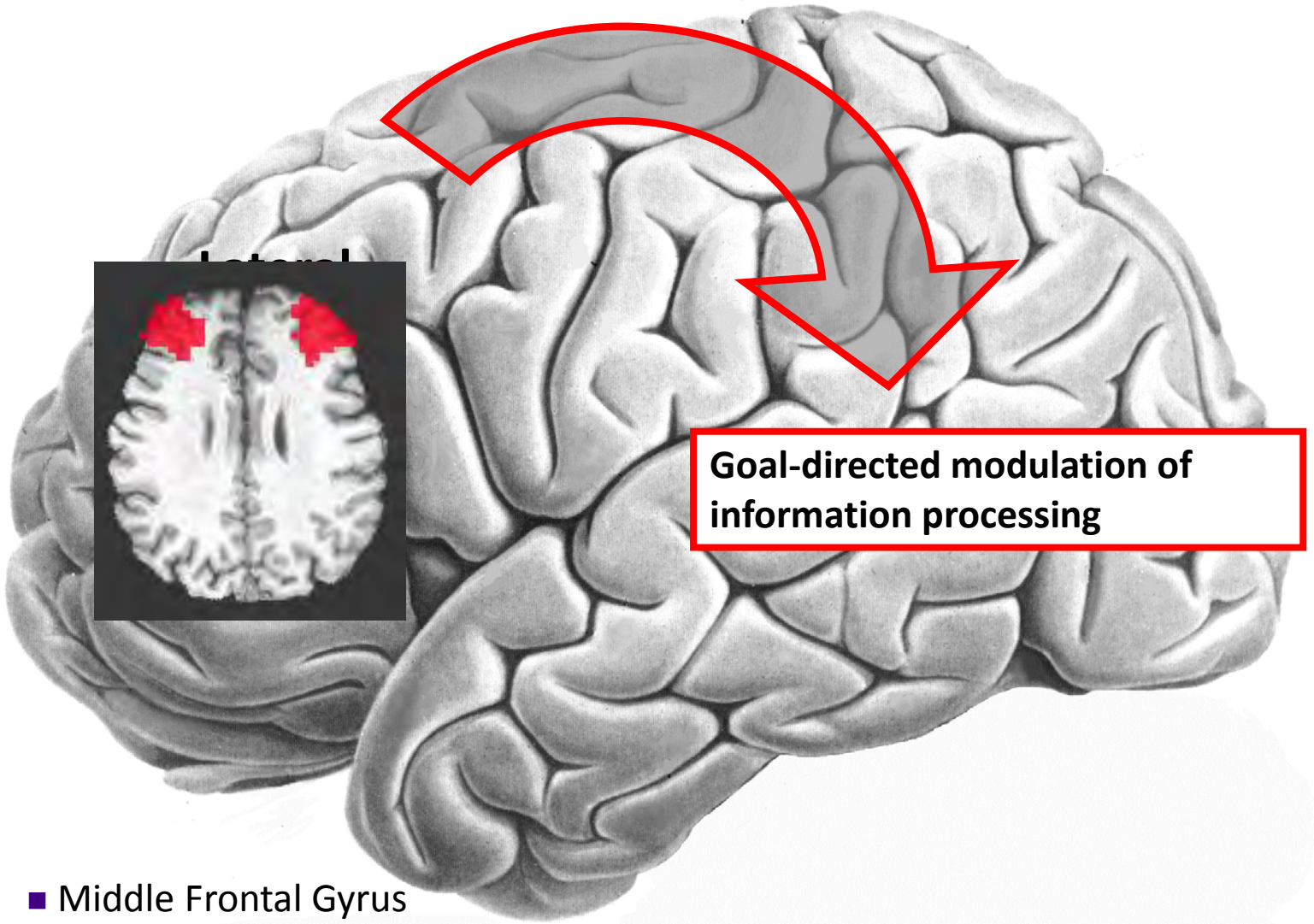
Implications for understanding a neural mechanism of improvement in cognition



Training **augments the goal-directed sharpening of neural representations** in visual processing

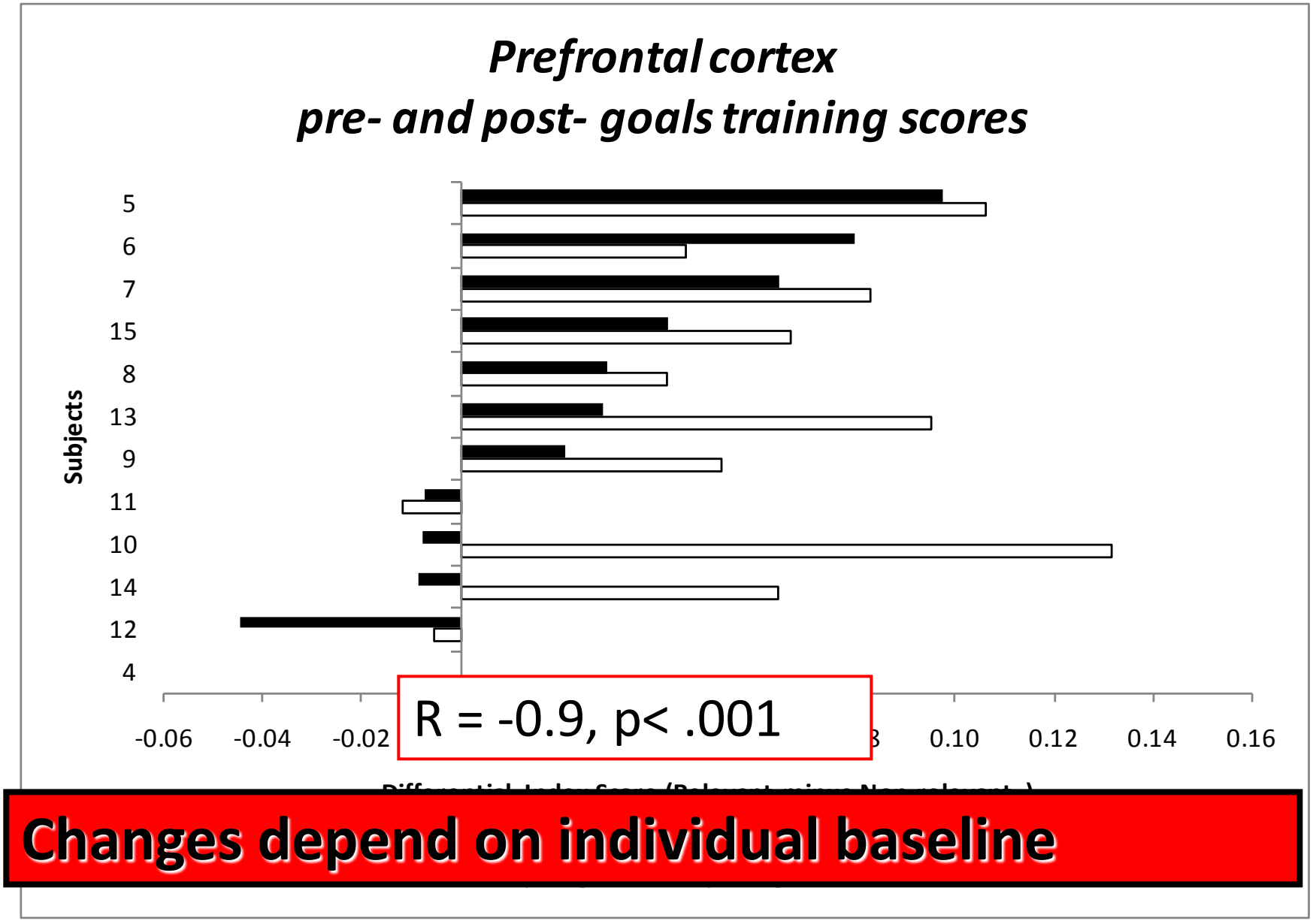
Chen, Novakovic-Agopian, et al., Brain, 2011

What happens to the balance of representation in a source of guidance– lateral prefrontal cortex



- Middle Frontal Gyrus

Changes in Lateral Prefrontal Cortex

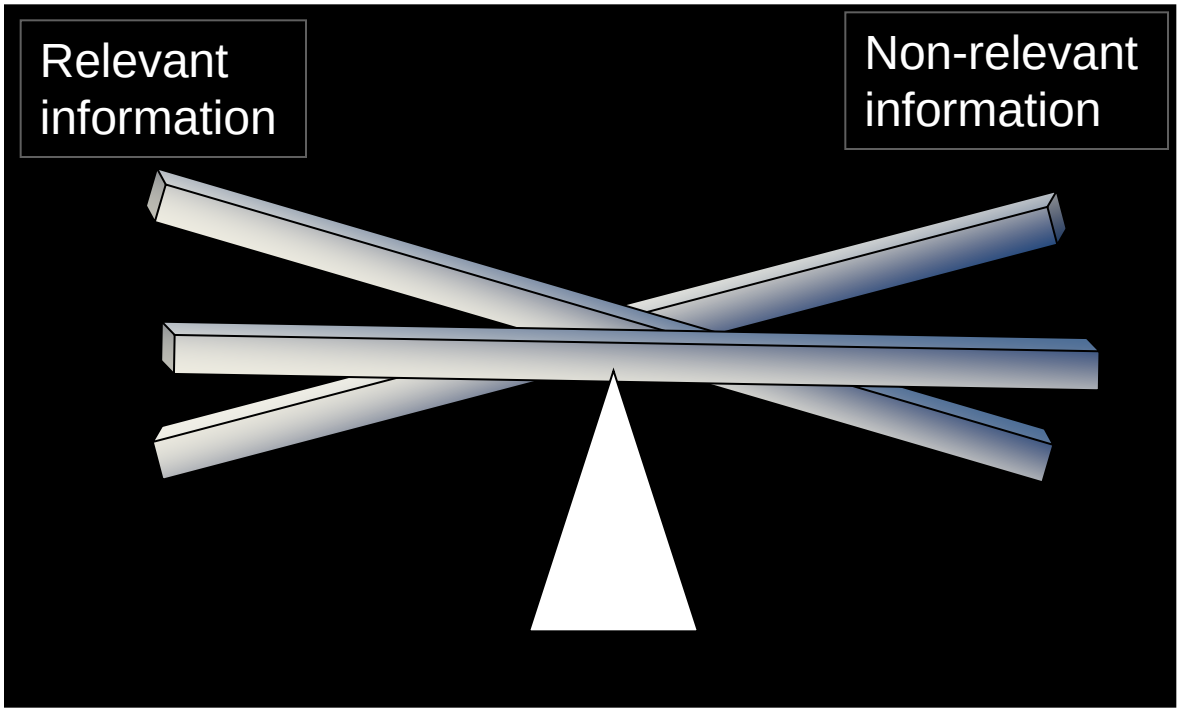


Changes depend on individual baseline

A mechanism of improved attentional self-*regulation(?)*

Neural strategy shifts of the

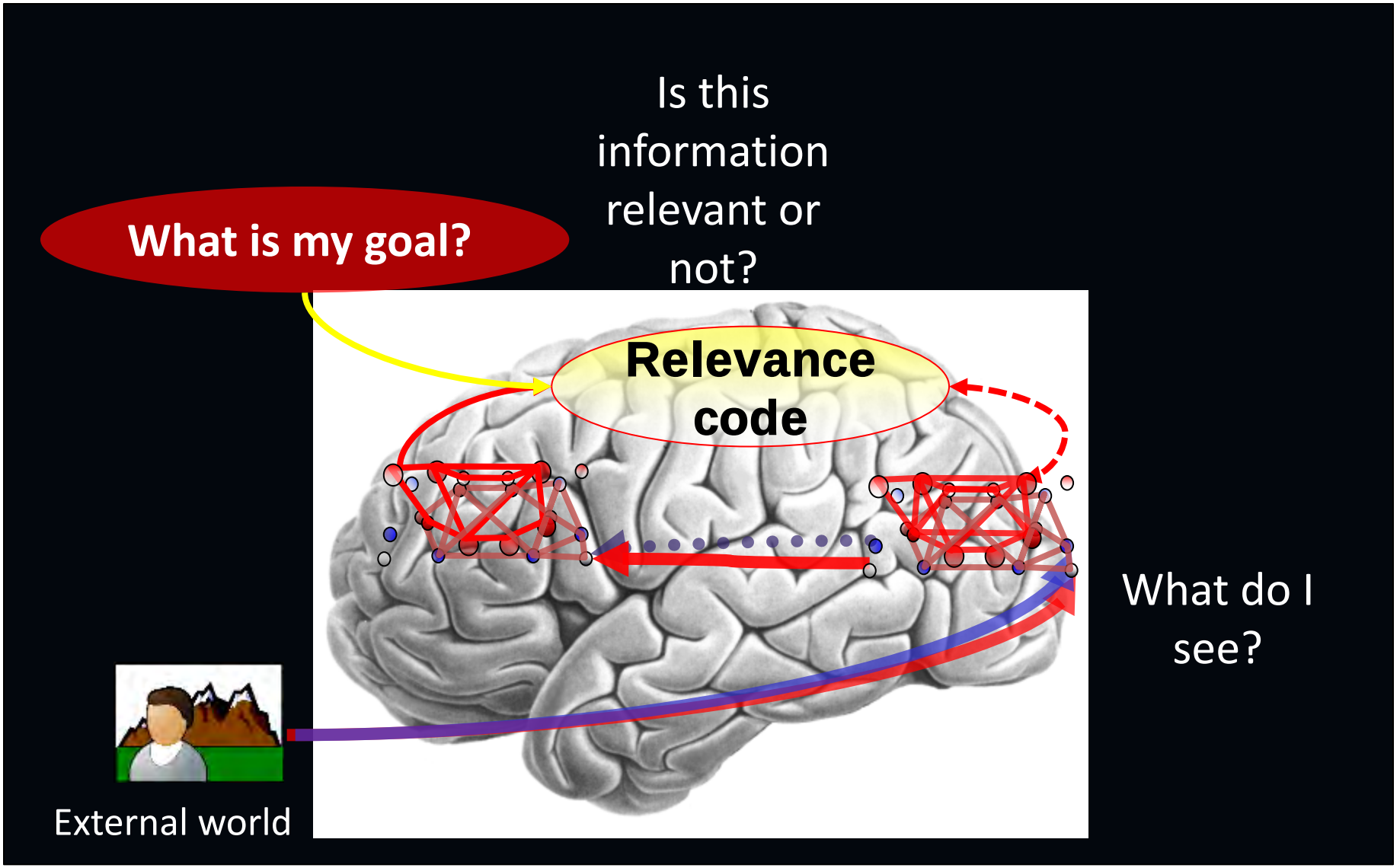
balance of neural representations to optimize performance _for each individual_



Finding paths towards improved Rx: **Unanswered questions and Frontiers**

- *Biomarkers* to test intervention target processes
  - Brain networks important for goal-directed information processing
  - Optimal *brain network states* for learning?
- Translational Rx: From brain to game? (And game to brain?)

What information codes are required for goal-direction of information processing?



Is the individual

Ready to Learn?

What general neural-behavioral factors provide a launch pad for an individual to be ready to learn from training?

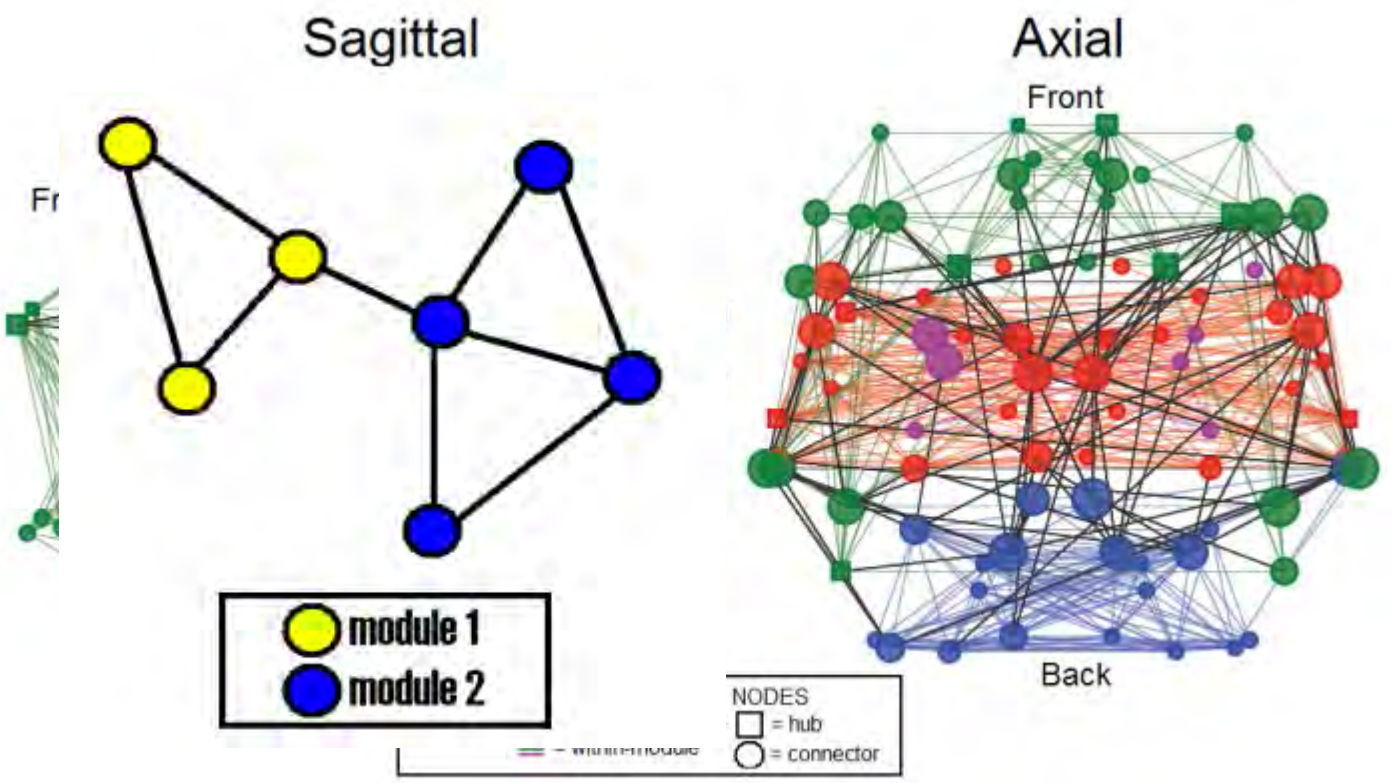
Regulation of
'brain state' to support goal-directed cognition:
The importance of brain network organization

- 'Baseline' brain state provides launch pad from which 'attention,' learning and other goal-based cognition is deployed

Noisy, disorganized, frazzled

Relaxed and ready

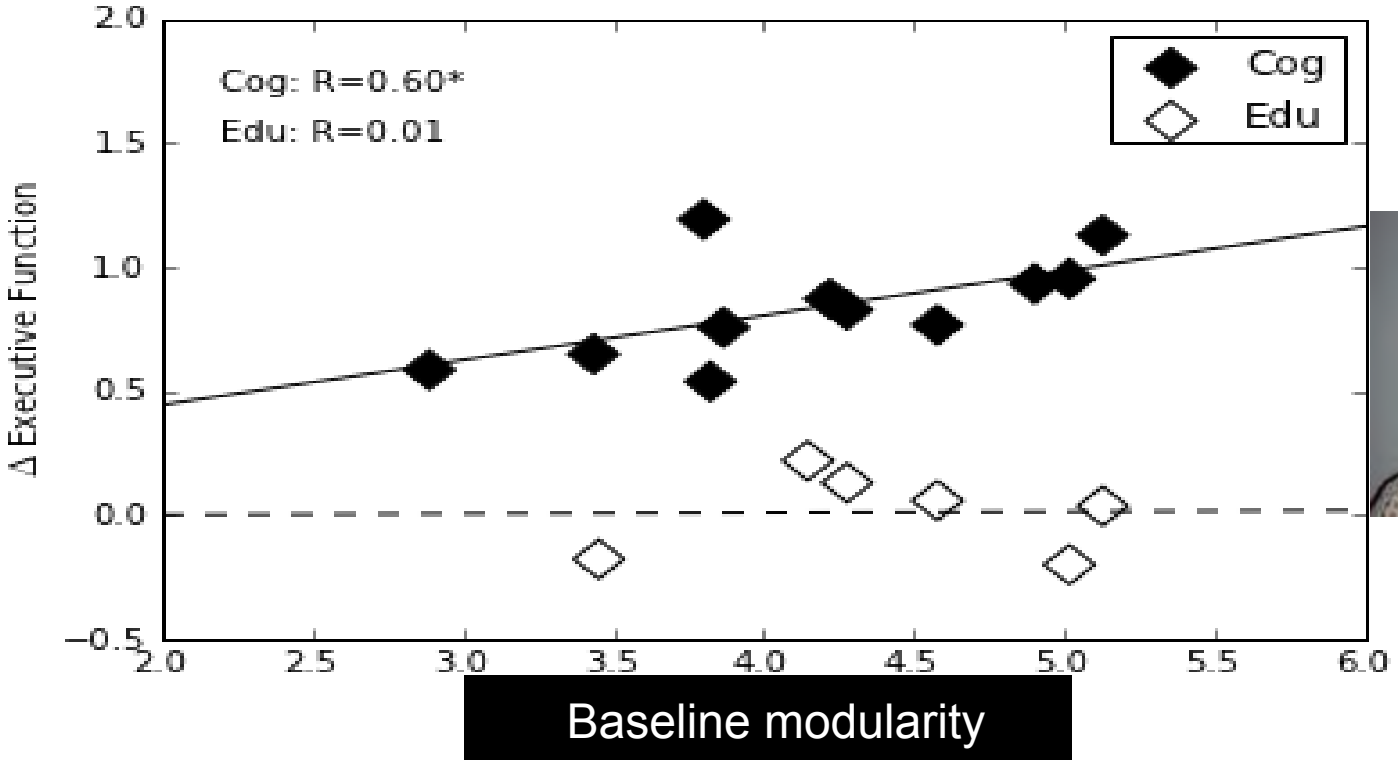
Indexing the regulation of brain state – *functional brain network organization*



Modular organization may support goal-oriented cognition and plasticity (attention, working memory, learning)

Does baseline brain network state predict response to training?

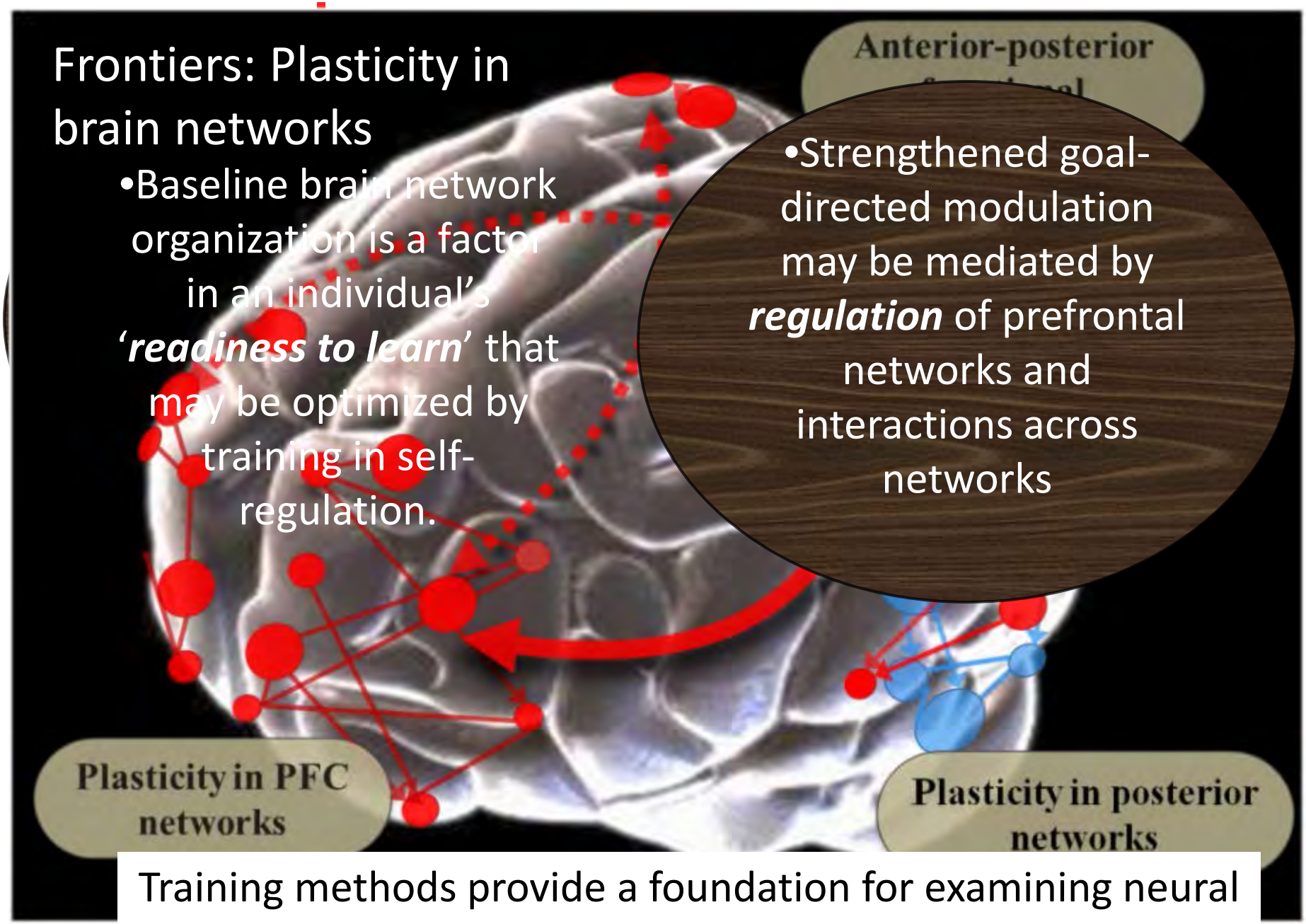
Patient fMRI scans during 5 minutes of 'active focus' resting state *before* goal-oriented attention training



Katelyn Begany, Anthony Chen, Tatjana Novakovic-Agopian, et al., in prep

Frontiers: Plasticity in brain networks

- Baseline brain network organization is a factor in an individual's '***readiness to learn***' that may be optimized by training in self-regulation.



Training methods provide a foundation for examining neural mechanisms

From Brain to Game? **Creating a '*digital sandbox*' for sharpening networks for goal-directed control after brain injury**

Leverage technology …

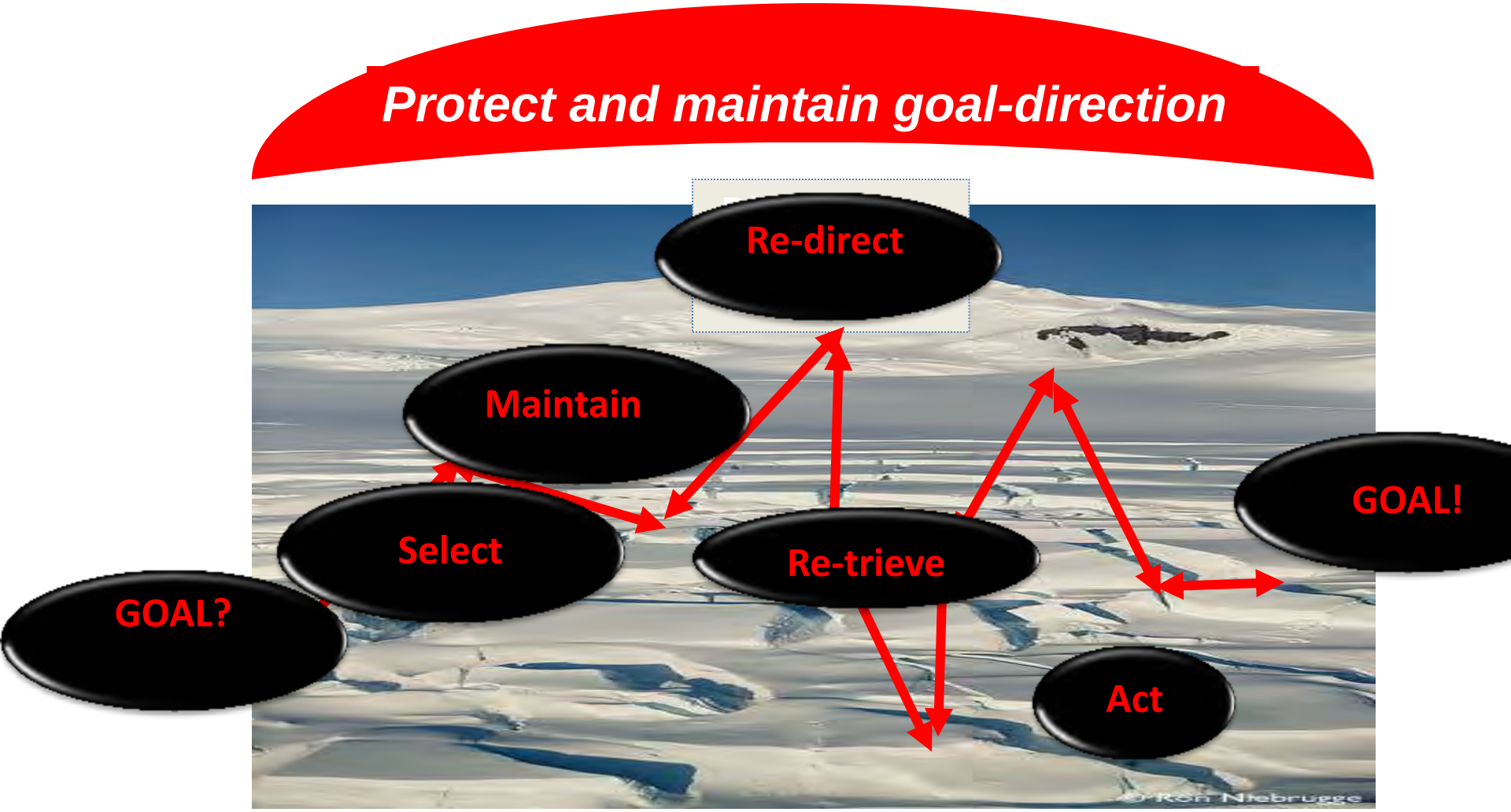
To enhance/support learning opportunities?

To intensify training (on key skills and strategies)?

To reach farther… provide better access to training?

Enhance transfer of skills to personal life contexts/goals?

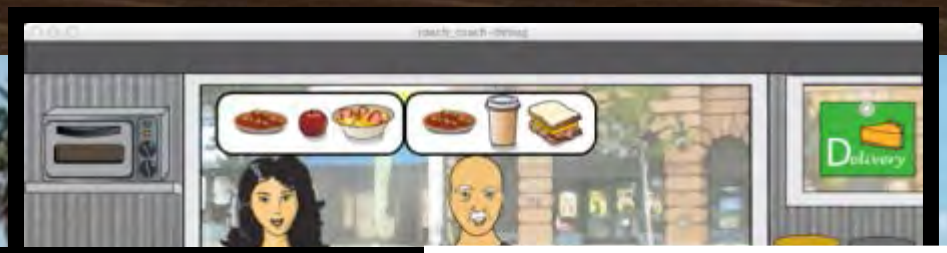
From real life problems to training approaches:



- Training of core processes, *functionally integrated and coordinated based on a goal*

Training opportunities
Apply, apply, apply
'*Apprentice*': Working up through cognitive challenges across multiple contexts

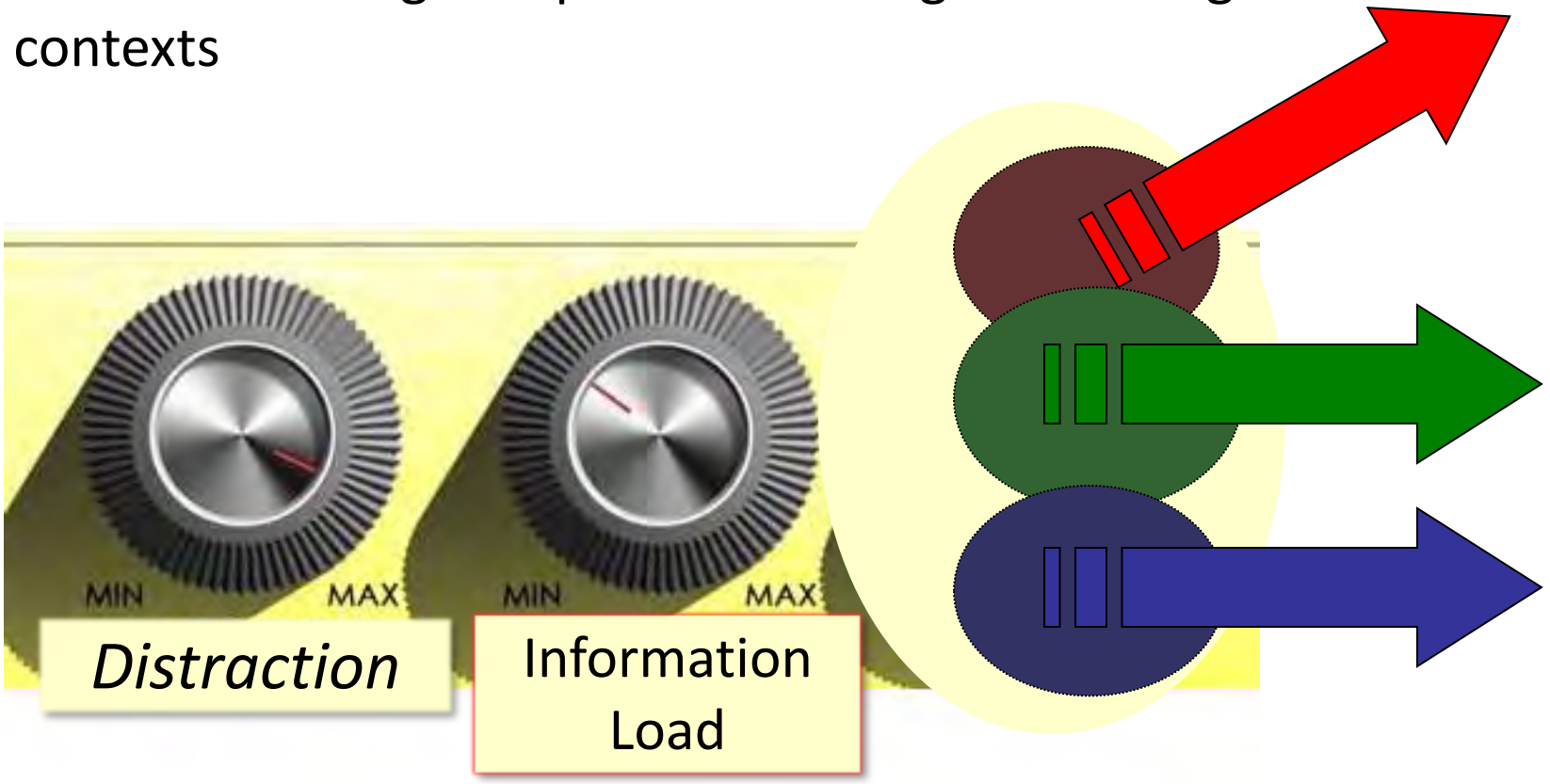
Working the brain ‘From Start-up to CEO’



Complex cognitive contexts in which goal-directed cognition can be challenged

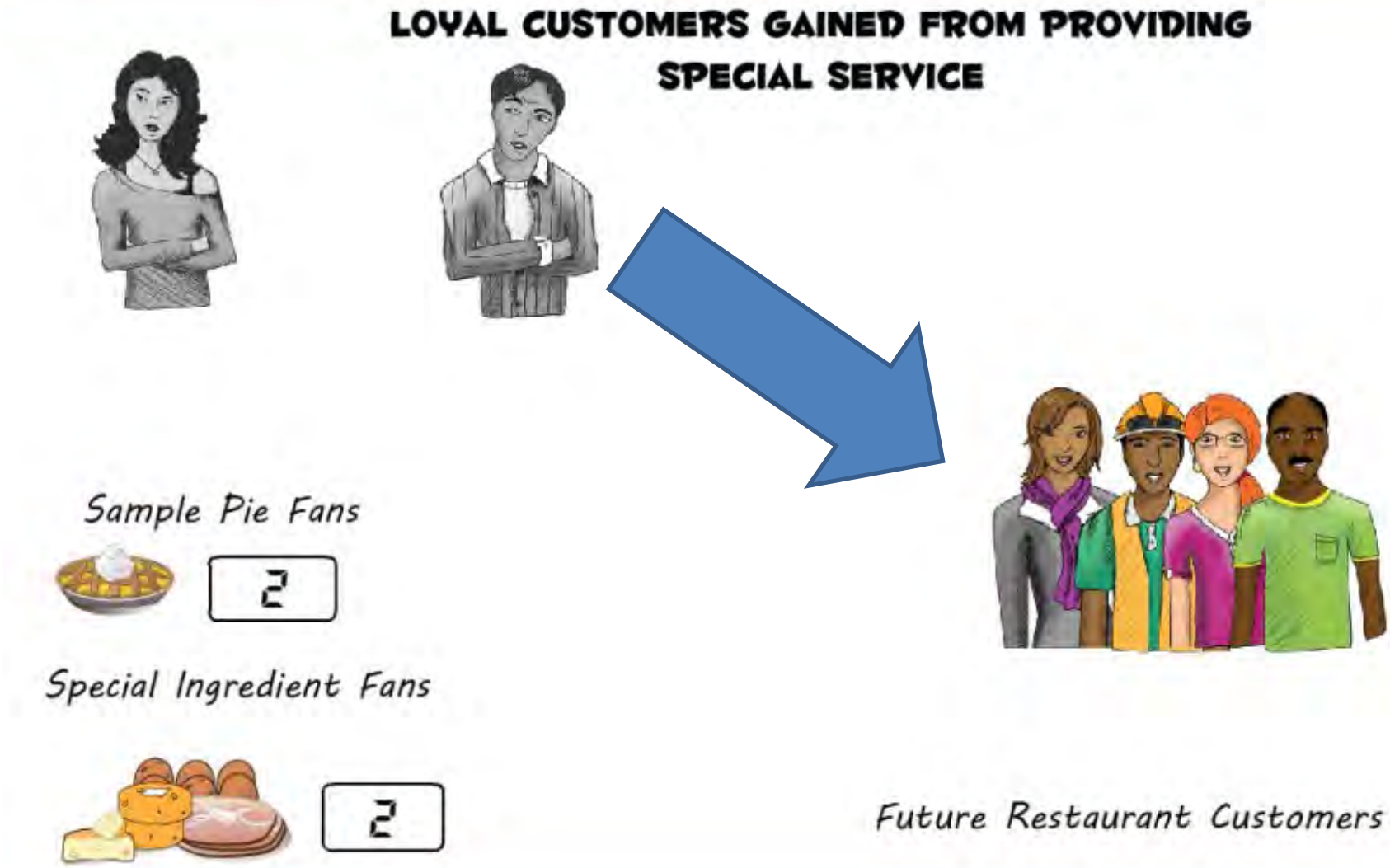
Games scenarios as training tool: Provides calibrated, progressive challenges in goal-directed processing

- Allows ‘Dialing ’ of specific demands selectively
- But not ‘isolating’ the processes–integrated in cognitive contexts



New measurement possibilities: Are you keeping the goal in mind?

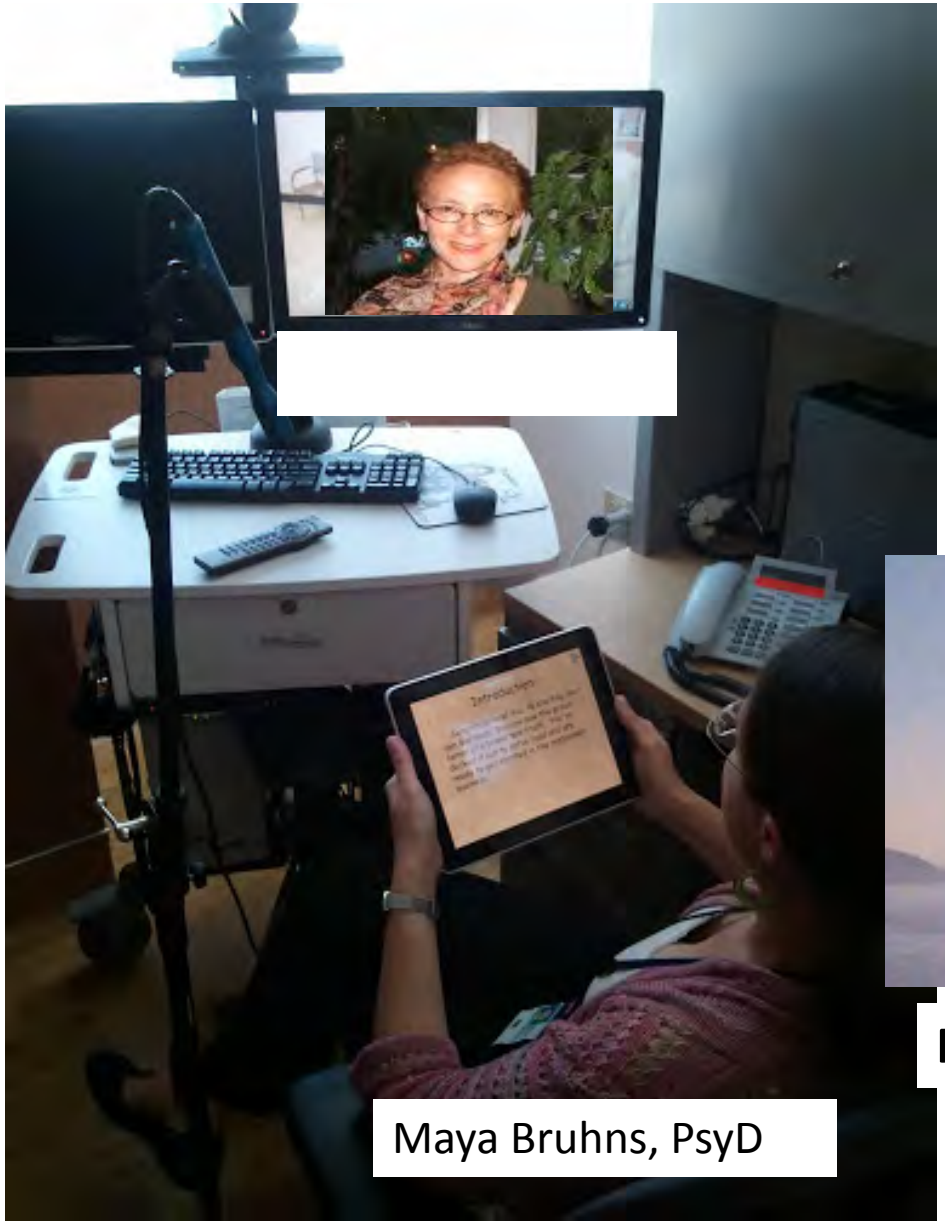
Goal maintenance→ Goal congruent decisions/ actions



From game to life

- help trainees draw the connections between game and outwardly different contexts in life -- same core situations, processes and applicable skills

Thus, can we improve Rx– *anywhere?*



Maya Bruhns, PsyD

Training

… in the ‘living room’

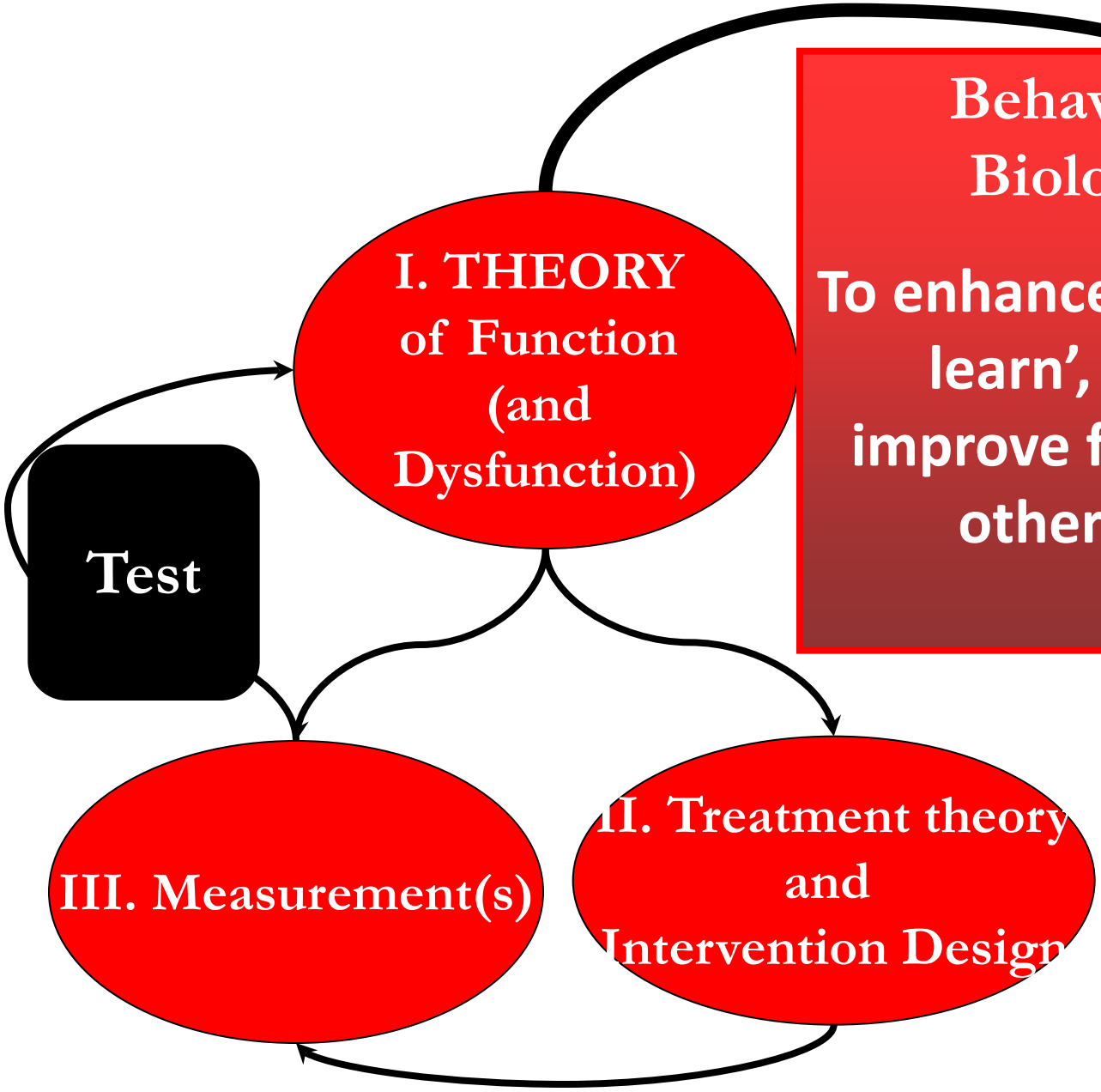
… over rivers, mountains

… with school, work

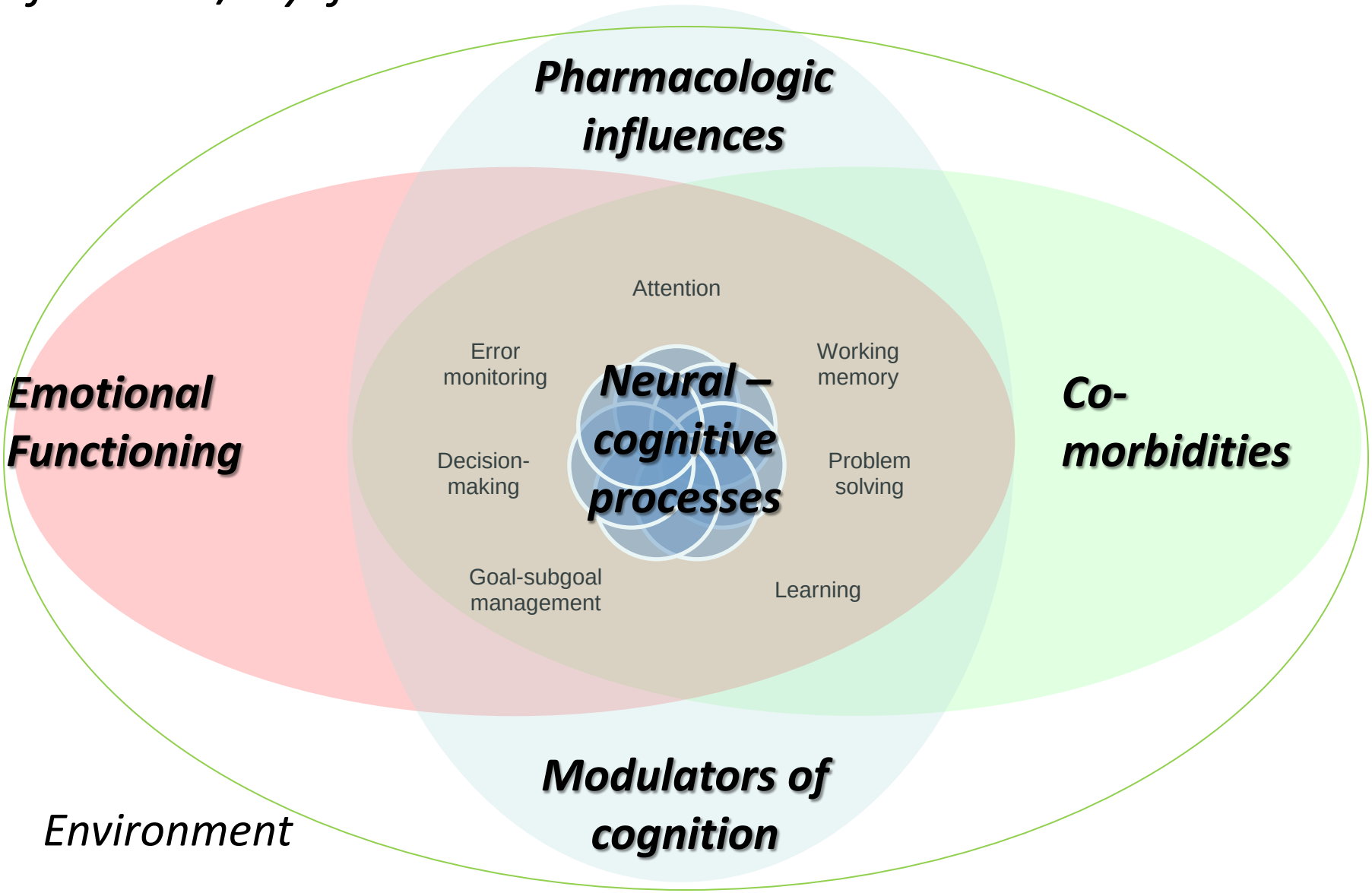
… where the individual is

Fred Loya, PhD

Nick Rodriguez


I. THEORY of Function (and Dysfunction)
Test
III. Measurement(s)
II. Treatment theory and Intervention Design
Behavioral and Biological Rx
To enhance 'Readiness to learn', adapt and improve functioning in other domains

Targets within a complexity of influences on individual function/ dysfunction



THANKS!

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