UNCLASSIFIED

Innovations in Treatment of Combat Related Traumatic Brain Injury and Co-Morbid Psychological Health Conditions

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- American Board of Psychiatry and Neurology
- Fellowship in Cerebrovascular Disease (University of Texas)
- Bachelor of Science in Biochemistry (Catholic University of America)

Disclosures

- Dr. Thomas DeGraba has no relevant financial or non-financial relationships to disclose relating to the content of this activity
- The views expressed in this presentation are those of the author and do not necessarily reflect the official policy or position of the Department of Defense, nor the U.S. Government.
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Learning Objectives

At the conclusion of this activity, participants will be able to:

1. Describe the principles of a holistic Interdisciplinary Intensive Outpatient Program combining neurological & behavioral health rehabilitation with integrative medicine techniques.
2. Identify pathological injuries from traumatic brain injury (TBI) and operational stressors that benefits from the use of an interdisciplinary care approach.
3. Recognize the effect of integrative medicine techniques on recovery in neurological and psychiatric conditions.
4. Discuss the principles for optimizing the use of multi-domain self-report outcome measures to assess response to treatment.

Background: NICoE and the Defense Intrepid Network

History

- **In the National Defense Authorization Act of 2008, Congress directed the Department of Defense (DoD)** to establish a comprehensive plan for programs to prevent, diagnose, treat, and rehabilitate service members with TBI, posttraumatic stress disorder (PTSD), and other mental health conditions.
- **Congress further instructed DoD to conduct research** to better understand TBI, develop new therapies, and mandated dissemination of these practices.
- DoD accepted the gift via the Intrepid Fallen Heroes Fund to **build the NICoE**.

National Intrepid Center of Excellence (NICoE) Overview

The **NICoE opened on June 24, 2010.** The NICoE, a Directorate of the Walter Reed National Military Medical Center, is **dedicated to improving the lives of patients and families affected by TBI** through collaborative efforts with patients, families, referring providers, and researchers. NICoE's interdisciplinary model of care includes traditional and complementary medicine, advanced imaging and diagnostic, research and education. The NICoE opening was followed by Intrepid Spirit Center Fort Belvoir in 2013.

The Intrepid Network

Since 2010, the **Intrepid Network** has grown to **13 partner sites,** with the interdisciplinary care model as the foundation of their care.

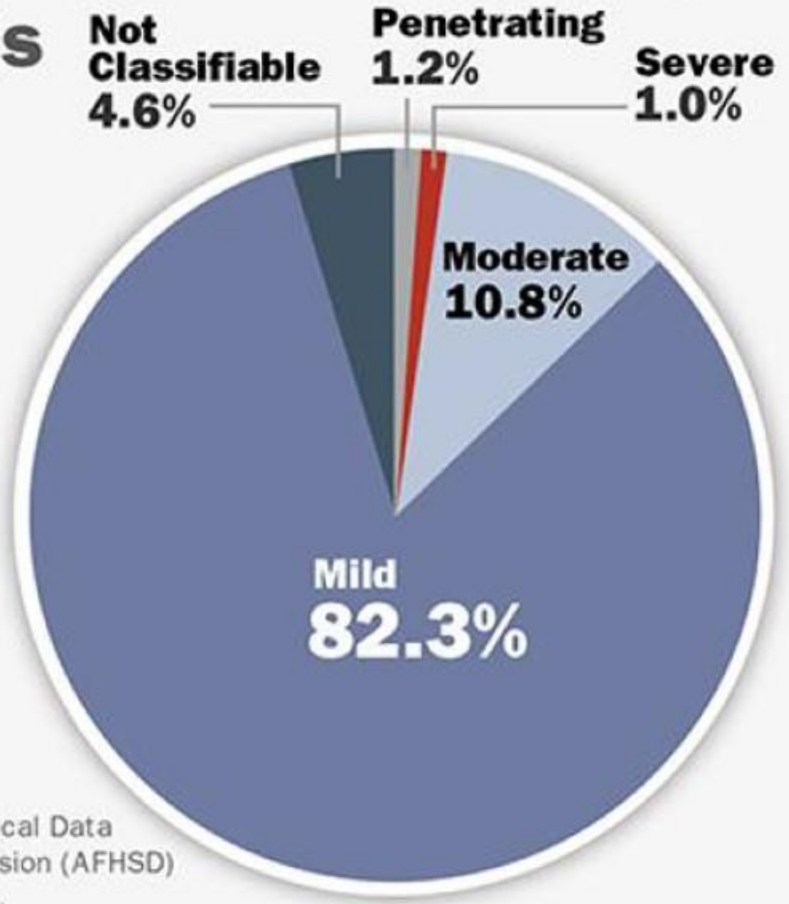
National Intrepid Center of Excellence

Defense Intrepid Network for TBI and Brain Health (Intrepid

DOD Numbers for Traumatic Brain Injury Worldwide — Totals

2000–2021 Q4

Penetrating	5,606
Severe	4,591
Moderate	49,055
Mild	373,710
Not Classifiable	20,957
Total - All Severities	**453,919**



Source: Defense Medical Surveillance System (DMSS), Theater Medical Data Store (TMDS) provided by the Armed Forces Health Surveillance Division (AFHSD)

Prepared by the Traumatic Brain Injury Center of Excellence (TBICoE)

**Percent may not add to 100% due to rounding*

2000–2021 Q4, as of February 11, 2022

2021 Q1-Q4

Total TBI =18,491

mTBI 84.5%

Moderate 14.8%

Severe/Penetrating=0.7%

https://health.mil/Military-Health-Topics/Centers-of-Excellence/Traumatic-Brain-Injury-Center-of-Excellence/DOD-TBI-Worldwide-Numbers

TBI and Psychological Health Conditions: Physiological Response to Repetitive TBI and Operational Stressors (OS)

Concussive & Subconcussive exposure

- Combat – IED, breaching, boats, RPG, danger close drops
- Training – Breachers, Carl Gustav, combatives, parachute jumps, fast boats

Complex clinical conditions with TBI and Psychological Health Injury (PHI)

Chronic Operational Stress:

- Decreased cognitive bandwidth
- Sympathetic/parasympathetic imbalance
- Cerebral autonomic dysfunction

Blast Exposure

Can we relate the stress response to a physiological disturbance?

Can we modulate the stress response in a socially adaptive manner?

Photo Courtesy Dept of Defense

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Long Term Effects
Reduction of Cognitive Bandwidth & Autonomic Function

Physical

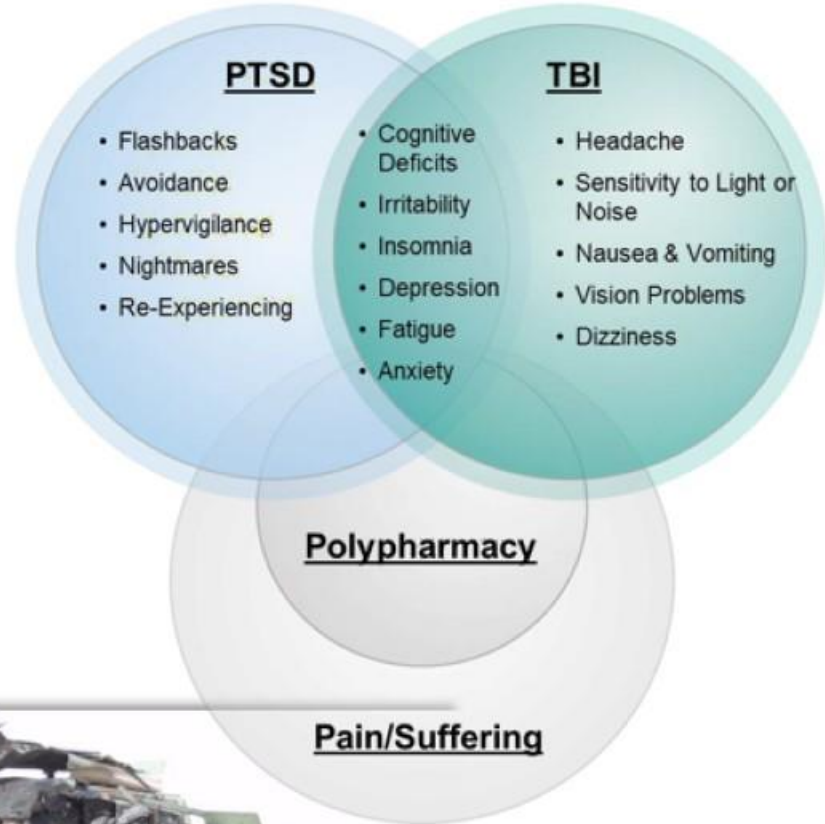
- Headache
- Nausea
- Fatigue
- Sleep Disturbance
- Dizziness
- Balance Problems
- Visual Disturbances
- Light Sensitivity
- Ringing in the Ears

Cognitive

- Poor Attention
- Difficulty Finding Words
- Poor Concentration
- Memory Problems
- Slowed Thinking- Easy stuff is hard
- Takes longer and more effort for tasks

Emotional

- Anxiety
- Depression
- Irritability
- Mood Swings



Sensory Integration – Target Acquisition

Auditory Processing – Hang on to signal

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Symptom Persistence Following TBI

- About 15–20 percent will experience persisting symptoms that require longer-term, interdisciplinary management. (Ontario Neurotrauma Foundation, 2017).
- Diffuse Axonal Injury
- Inflammation: mitigate inflammation
- Cerebral Autonomics (TBI & OS)
- Neural Network Disturbance (TBI & OS)
- Glial and Vascular Disturbance

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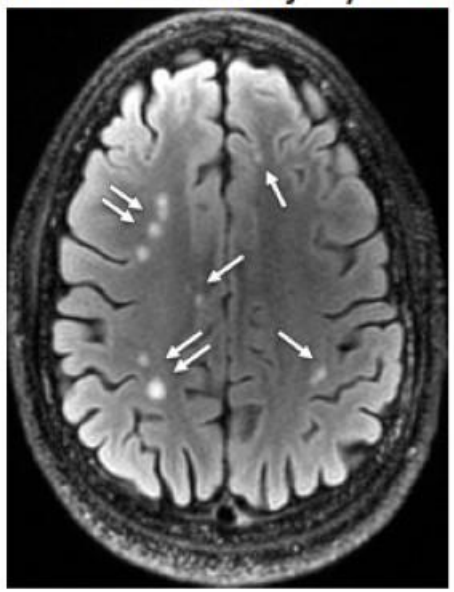
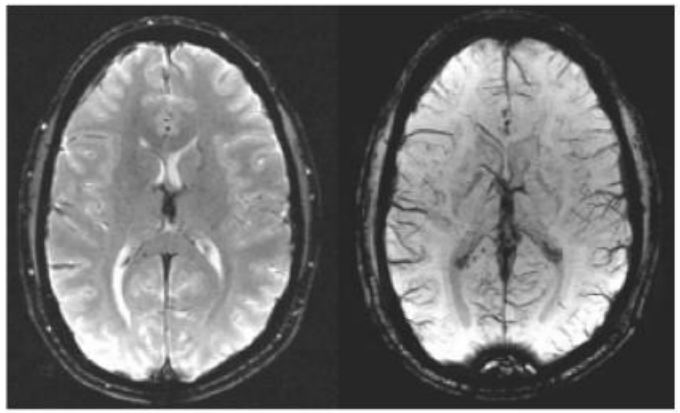
Evidence of Brain Injury

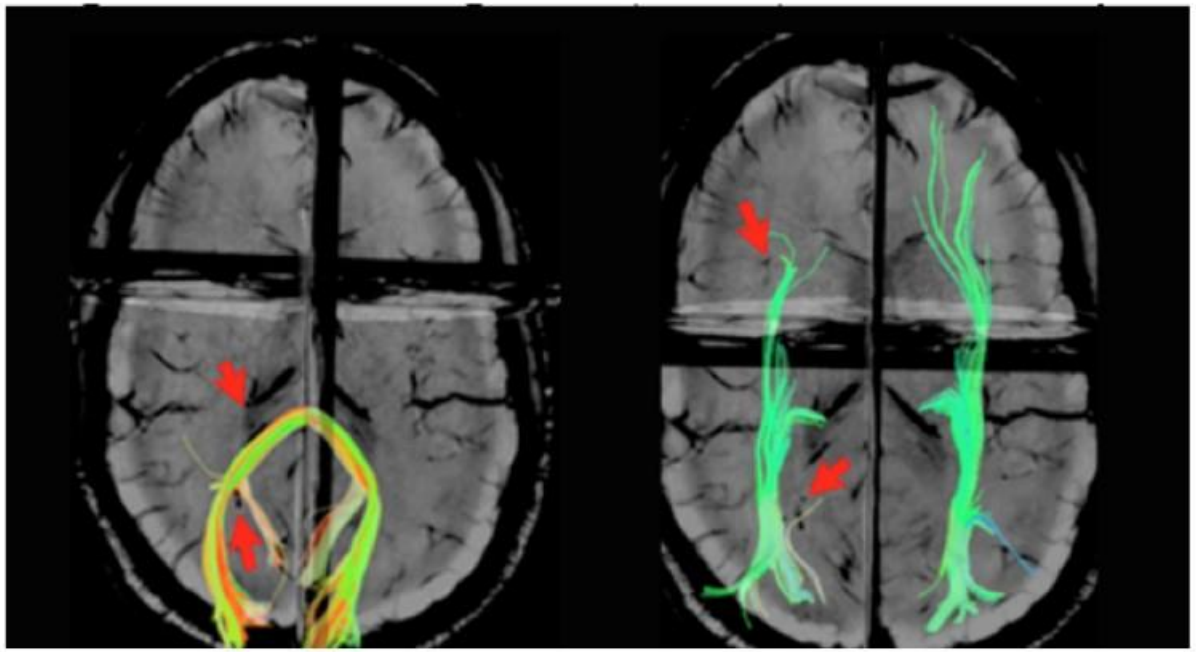
Diffuse axonal injury lesion





Routine MRI- GRE TBI Study- SWI

Riedy, etal. Radiology 2015



Yeh PH, etal. Open J Medical Imaging 2012,2,137-161

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Symptom Persistence Following TBI

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- Diffuse Axonal Injury
- **Inflammation: (Devoto et al. 2020), (Smith, D., et al. 2021)**
- Cerebral Autonomics (TBI & OS)
- Neural Network Disturbance (TBI & OS)
- Glial and Vascular Disturbance

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Symptom Persistence Following TBI

- About 15–20 percent will experience persisting symptoms that require longer-term, interdisciplinary management.
- Diffuse Axonal Injury
- Inflammation: Acute and Chronic TBI
- **Cerebral Autonomics** (Institute of Medicine report, Cernak) (TBI & OS)
- Neural Network Disturbance (TBI & OS)
- Glial and Vascular Disturbance

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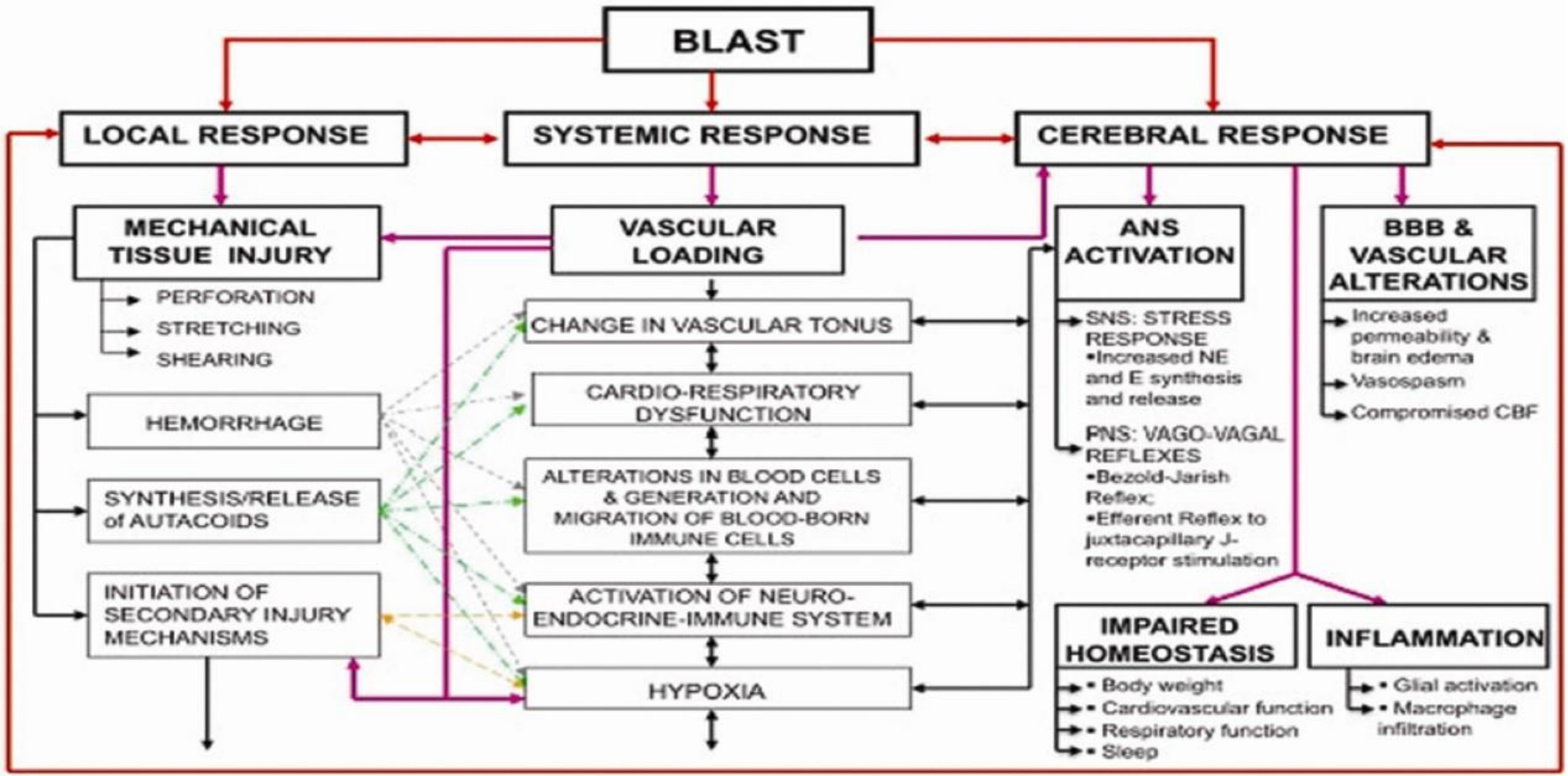
Physiological Response (IOM 2014 Report to Congress-long-term effects of blast)



Cernack 2010 Frontiers in Neurology

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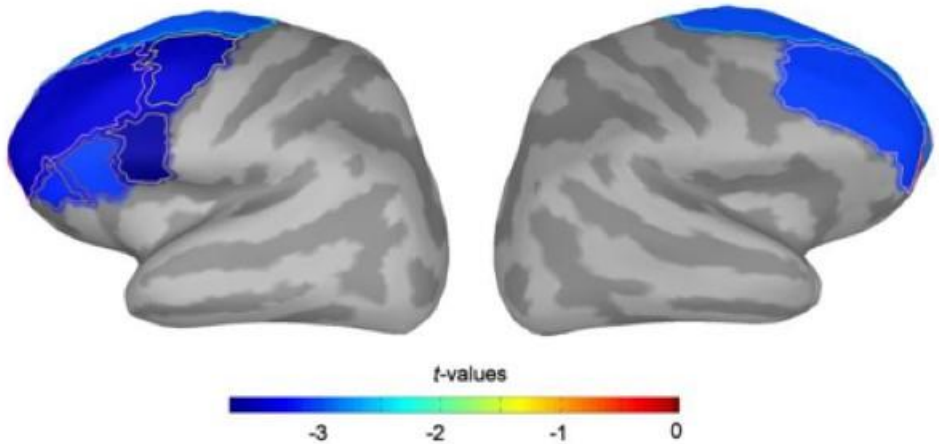
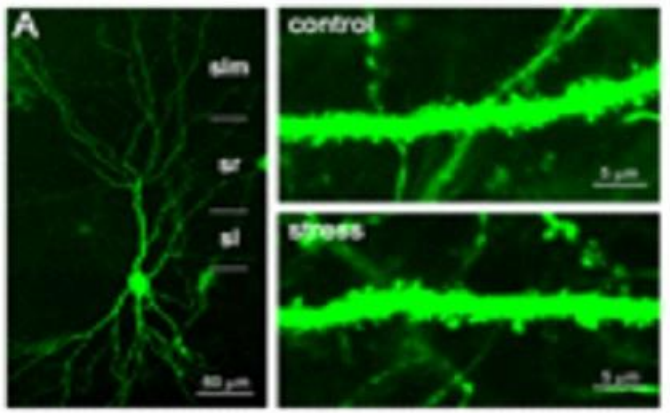
Magnetoencephalogram (MEG) Pattern of PTSD





Stress Induced dendritic spine loss. Chen et.al. PNAS Jul 2010.

Background:
Reduction in **resting-state** prefontal alpha-band power associated with severity of PTSD symptoms

Alpha Band (8-13 Hz) Activity at Resting State

(Popescu et al, 2016)

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- Neural Network Disturbance (TBI & OS)
- Glial and Vascular Disturbance
  - Long term dementia (Shiverly, et al. 2016)
  - Cerebral Vasomotor Reactivity

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Recovery

- Neurological & Psychological Rehabilitation
- Neuromodulation / Neuroplasticity
- Autonomic modulation
- Contributors of hormonal regulation of repair (Brain Derived Neurotrophic Factor)
    - Sleep
    - Aerobic exercise
    - Nutritional factors
    - Neurocognitive rehabilitation (Brain Training)
    - Mind Body Techniques

A Consensus Study Report of The National Academies of Science Engineering and Medicine 2022 Traumatic Brain Injury:

A Roadmap for Accelerating Progress Committee

Consensus Recommendations

- Create and implement an updated classification system for TBI. The current clinical classification scheme for TBI should be updated to be more accurate and informative for care and research
- Integrate acute and long-term person- and family-centered management of TBI. All people with TBI should have reliable and timely access to integrated, multidisciplinary, and specialized care to address physical, cognitive, and behavioral sequelae of TBI and comorbidities that influence quality of life

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Interdisciplinary Intensive Outpatient Program (IOP) [Proof of Concept] Goal: Return SMs to Full Duty and Enhance Interpersonal Relationship

Foundation of the Synchronized Network

- Four-week interdisciplinary, patient-centered, holistic IOP that uses traditional rehabilitation, neurological, and behavioral health (BH) treatments combined with integrative medicine interventions.
- Leverages the co-localization of a team comprising 18 disciplines to expedite diagnostic evaluation and to build on each other's expertise to achieve common goals and develop a collaborative care plan.
- The patient is at the center of the care team, enhancing patient-provider rapport, and enabling a more efficient identification of goals for recovery, and providing immediate feedback of response to treatment.
- The rehabilitative culture encourages skills-based training for self-efficacy and education modules for self-advocacy techniques to enhance sustainable recovery & resilience beyond program discharge.





Photo & Graphics courtesy NICoE PAO

NICoE Evaluation and Treatment Activities
Intensive Care Outpatient Model

Week 1

Individual
- Acupuncture
- Audiology Evaluation
- CPAP Titration
- Family Therapy Interview
- Fasting Labs
- Injury History Questionnaire
- Meet with Nurse
- Neurology/Sleep Evaluation
- Neuropsychology Interview 1
- Nursing Intake
- Optometry Evaluation
- Physical Therapy Evaluation: Orthopedics
- Psychiatry Evaluation
- Sleep Study
- Speech Language Pathology Evaluation
- Team Coordinator Evaluation
- Vitals
- Wellness Evaluation

Group
- Biofeedback Training
- Creative Arts Therapy: Mask Making Group
- Fisher House Brief
- Intake Questionnaires
- Introduction to Recreational Activities
- Introduction to TBI
- Introduction to the NICoE
- Introduction to Wellness Group
- Managing Triggers Part 1
- Movement, Music, and Meditation Group
- Research Participation Opportunities Part 1
- Sleep Enhancement Group

Week 2

Individual
- Art Therapy Evaluation
- Art Therapy Follow Up
- Audiology Follow Up
- Family Therapy Follow Up
- Meet with Nurse
- Music Therapy Evaluation
- Neurology/Sleep Follow Up
- Neuropsychology Testing
- NICoE-MRI TBI Protocol
- Optometry Evaluation
- Physical Therapy Follow Up
- Progress to Goals
- Psychiatry Follow Up
- Speech Language Pathology Follow Up
- Team Coordinator Follow Up
- Vestibular Evaluation
- Vitals

Group
- ANS Regulation Part 1
- Creative Arts Therapy: Writing Introduction to Nutrition Group
- Lunch or Introduction to Computer Based Brain Training (Optional)
- Lunch or Spirituality Group (Optional)
- Managing Triggers Part 2
- Movement Studio Group
- Music Therapy Group
- Open Yoga Studio (Optional)
- Psychological Health & Healthy Recovery Group
- Relationships & Intimacy Group
- Research Participation Opportunities Part 2
- Self-Management Skills for Chronic Pain Group
- Wind Down YOGA (optional)

Week 3

Individual
- Acupuncture
- Audiology Follow Up
- Family Therapy Follow Up
- Imaging Review
- Meet with Nurse
- Neurology/Sleep Follow Up
- Neuropsychology Follow Up
- Physical Therapy Follow Up
- Progress to Goals
- Psychiatry Follow Up
- Research (Optional)
- Speech Language Pathology Follow Up
- Team Coordinator Follow Up
- Vitals
- Wellness Follow Up/ HRV

Group
- ANS Regulation Part 2
- Cognitive Skills Group
- Creative Arts OPEN Studio: Music, Art, Writing, Mind Body
- Lunch or Spirituality Group (Optional)
- Lure Tying Group (Optional)
- Movement Group Part 1
- Movement Group Part 2
- Music Therapy: Jam Group/Songwriting
- Nutrition in the Kitchen
- Open Yoga Studio (Optional)
- Wellness Planning Group
- Wind Down YOGA (optional)

Week 4

Individual
- Acupuncture
- Art Therapy Follow Up
- Audiology Follow Up
- Discharge Meeting
- Family Therapy Follow Up
- Meet with Nurse
- Mind Body Skills
- Music Therapy Follow Up
- Neurology/Sleep Follow Up
- Neuropsychology Follow Up
- Physical Therapy Follow Up
- Psychiatry Follow Up
- Speech Language Pathology Follow Up
- Team Coordinator Follow Up
- Vitals

Group
- Creative Arts OPEN Studio: Music, Art, Writing, Mind Body
- Creative Arts Therapy: Collage Group
- Creativity & Closure Group
- Discharge Questionnaires
- Managing Triggers Part 3
- Mindful Eating Group
- Moving Through Transition
- Open Yoga Studio (Optional)
- Warrior Care Program Brief (Optional) / Lunch

- ***Four Weeks***
- ***Schedule is tailored to meet the needs of each service member***
- ***105- 135 Total clinical care hours***

(DeGraba, et al, 2021)

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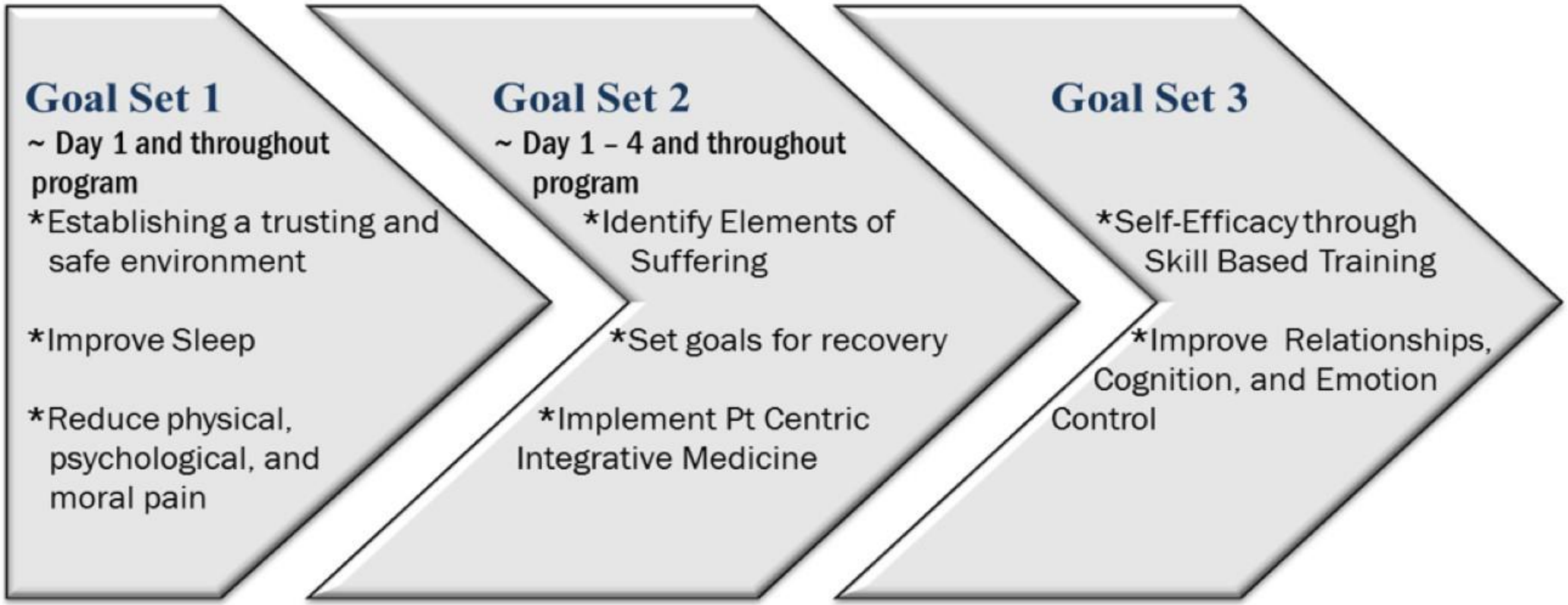
Sequenced Goal Sets



Overview of Goal Sets at NICoE During 4-Week Intensive Outpatient Program

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Service Member Survey of essential elements of the interdisciplinary IOP

- Interdisciplinary Intake with multiple key providers
- Non-judgmental environment for patient centric care
- Nurse coordinator – touchstone between them and the care team, rapid iterative feedback on treatment
- Sequenced care & Co-treatment sessions
- Skills based training supported by scientific demonstration / education
- Family based therapies

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Tracking Integrative Medicine Therapies in PTSD

- Time (minutes) spent engaged in group, individual and independent sessions in each therapy correlation to change in psychological health (PH) conditions.
- Creative Arts Therapies [Combined]
  - Art Therapy
  - Music Therapy Therapeutic Writing
- Wellness- Mind Body Techniques [Combined] Acupuncture, Animal-Assisted Therapy Biofeedback, Breathing, Heart Math,
  - Tai Chi, Labyrinth, Meditation, Yoga, Spirituality, Reiki Treatment

Courtesy NICoE PAO photography

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Observed Mask-making Themes

Patriotism

The Injury

Split Self

Death/Grief

(Courtesy National Intrepid Center of Excellence, Arts Therapy Studio, n.d.)

(Courtesy National Intrepid Center of Excellence, Arts Therapy Studio, n.d.)

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Preliminary Data on Art Therapy

- Genomics:
  - Down regulation of genes involved in inflammation
  - Up Regulation of genes involved in neurite outgrowth, radial longitudinal organization of axon growth, synaptic plasticity.
- Autonomics
  - Increased cerebral vasomotor reactivity
  - (Transcranial Doppler Breath Holding Index Elevation)

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- Creative Arts Therapies [Combined]
  - Art Therapy
  - Music Therapy
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- Wellness- Mind Body Techniques [Combined] Acupuncture, Animal-Assisted Therapy Biofeedback, Breathing, Heart Math, Tai Chi, Labyrinth, Meditation, Yoga, Spirituality, Reiki Treatment

Courtesy NICoE PAO photography

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Biofeedback

- Skin Temperature / thermal regulation
- Electromyography – measure of muscle tension
- Breath Rate
- Heart Rate
- Heart Rate Variability (HRV)

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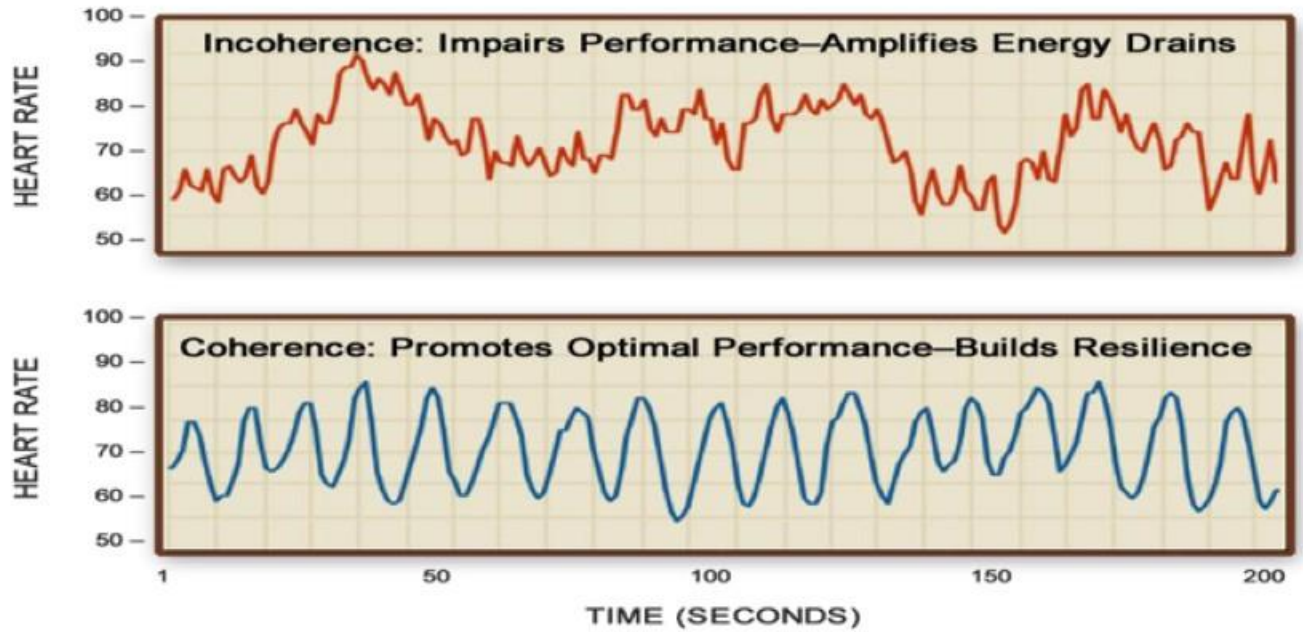
HRV Effects on Neurocognitive Function



Inhibits Brain Function (Incoherence)

Facilitates Brain Function (coherence)

- Improved self-regulation
- 40% improvement in long-term memory
- 24% improvement in short-term memory
- Improved mental focus
- Increased information processing ability
- Improved (faster) reaction time
- Higher test scores
- Improved learning ability

(McCraty, 2017; Bradley, 2010; Bedell, 2010; Lloyd, 2010; Ginsberg, 2017)

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Brain Fitness Center (BFC)

- The NICoE's BFC provides service members (SMs) and beneficiaries with computer game-based brain training programs for cognitive rehabilitation and to enhance mental performance.
- The BFC studies the effects of these products on patients while supporting their therapeutic goals and instilling healthy brain habits by providing cognitive-stimulating activities.
- The majority of BFC patients have been diagnosed with mild TBI most commonly due to a blast in a combat environment. However, other populations with cognitive complaints due to psychiatric diagnosis and acquired injuries to the brain are served.

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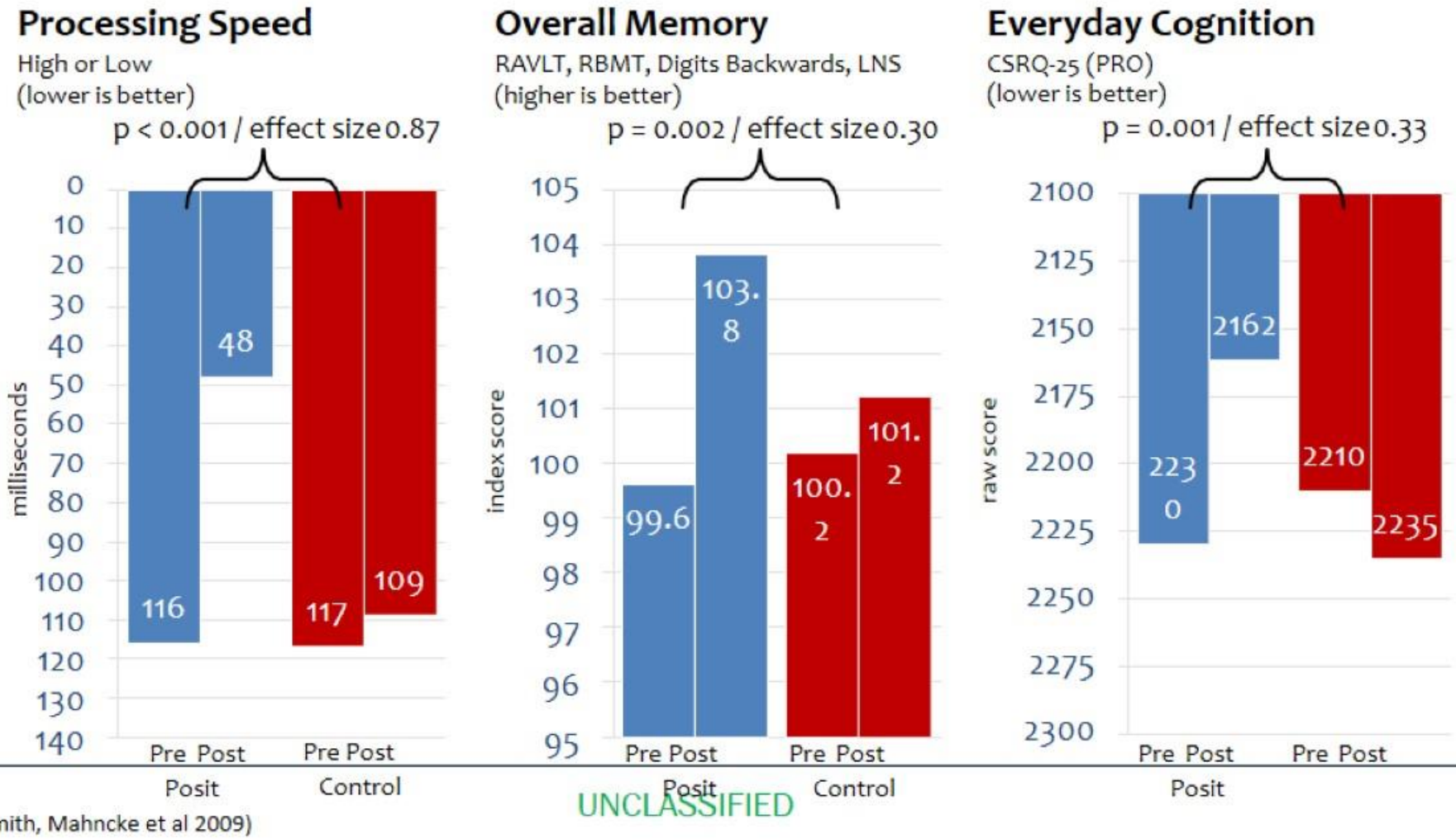
IMPACT Showed That Plasticity-Based Brain Training Improves Memory

IMPACT Study: 487 healthy older participants, multi-site RCT Compared BrainHQ exercise vs DVD-based adult education



(Smith, Mahncke et al 2009)

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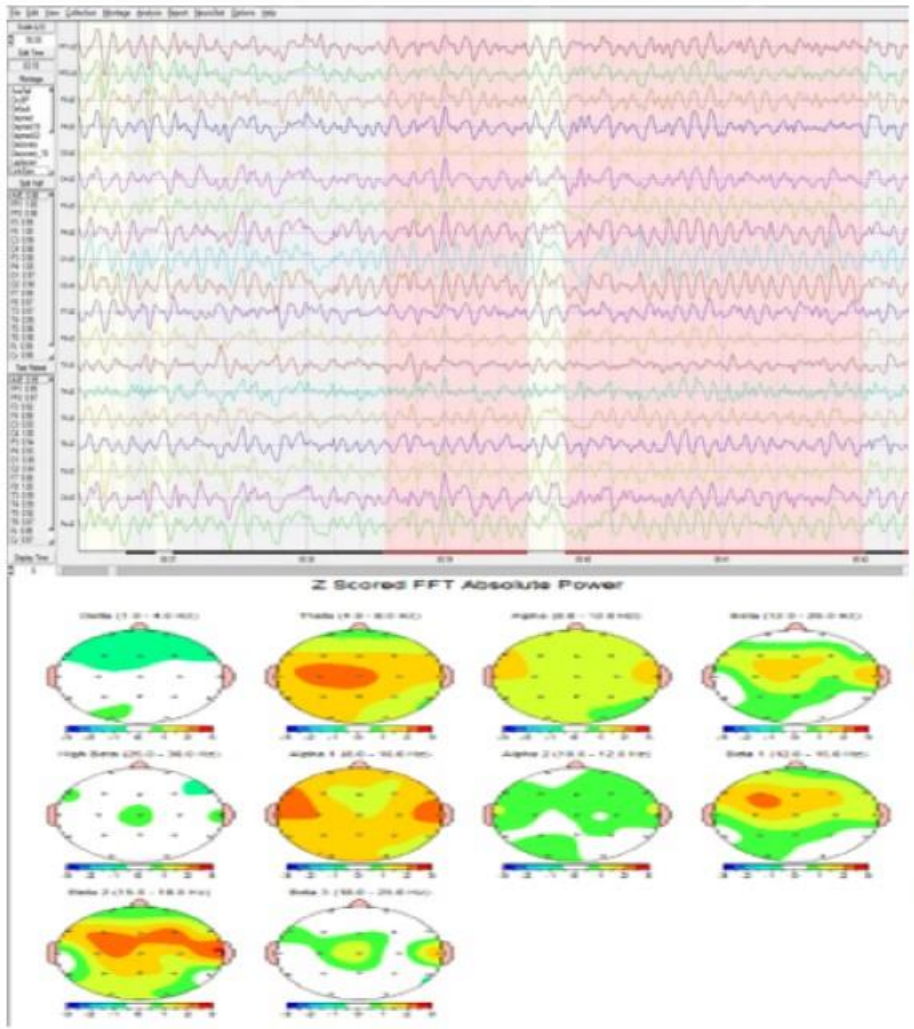
Quantitative Electroencephalogram (EEG)



(Courtesy Dr. Marc Zola; Fort Campbell, n.d.)

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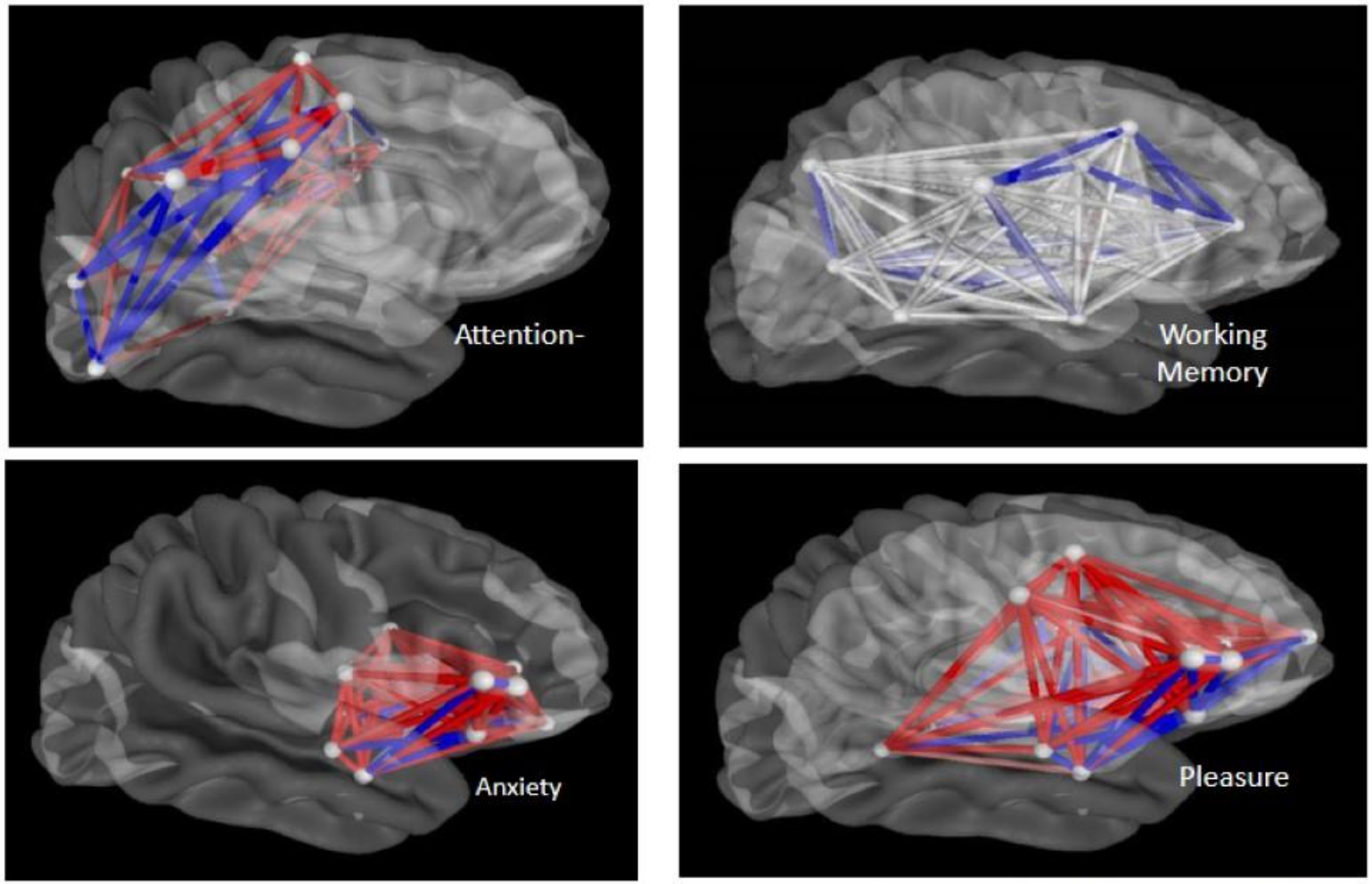
Neural Networks



(Courtesy Dr. Marc Zola; Fort Campbell, n.d.)

Intrepid Network Clinical Programs/Services/Specialties

Defense Intrepid Network for TBI and Brain Health (Intrepid Network)

Clinical Programs

- **TBI Outpatient Program –** A program that provides diagnostic evaluation, treatment, diagnoses, and follow-up care for TBI of all severities.
- **Intensive Outpatient Program (IOP)* –** A multi-week program for TBI patients with tailored treatment plans that focus on the mind, body, and spirit.
- **TBI Inpatient Consultation** –** Inpatient consultation for MEDEVAC and Acquired Brain Injury (ABI).
- **Other Programs Supporting the Military Treatment Facility (MTF)/Installation/Market****
  - **Acute Concussion Care (ACC) –** Acute concussion services for the MTF
  - **Sleep Clinic –** Comprehensive sleep medicine services for the Intrepid Network site clinical programs and the MTF
  - **Pain Clinic –** Comprehensive pain management services for the Intrepid Network site clinical programs and the MTF
  - **ANAM Support –** Support for the Automated Neuropsychological Assessment Metrics (ANAM) across the deployment cycle
  - **Arts in Health Program** – Arts in Health services, which may include support for clinical programs and community engagement, for the Intrepid Network site and the MTF
  - **Mind-Body Wellness Program** – Mind-Body Wellness services, which may include support for clinical programs and community engagement, for the Intrepid Network site and the MTF

Clinical Services and Specialties

Behavioral Health Services
- Psychiatry
- Psychology
- Social Work

Medical Services
- Neurology
- Neuro-optometry
- Physiatry
- Primary Care
- Sleep Medicine
- Sports Medicine

Rehabilitation Services
- Audiology
- Occupational Therapy
- Physical Therapy
- Pain Management
- Speech-Language Pathology

Integrative Health Services
- Animal Assisted Therapy
- Creative Arts Therapies
- Mind-Body Wellness
- Nutrition
- Spiritual Wellness

Clinical Support Services
- Advanced Diagnostics & Testing
- Brain Fitness Center
- Nursing
- Case Management
- Referral Management
- Medical Support
- TBI Portal for Clinical Care Management
- TBI Education and Training

*Intrepid Network sites residing in the same DHA market (i.e., ISC Fort Belvoir) may not offer an IOP

**All Intrepid Network sites may not offer these clinical programs

Last Updated: 18 April 2022

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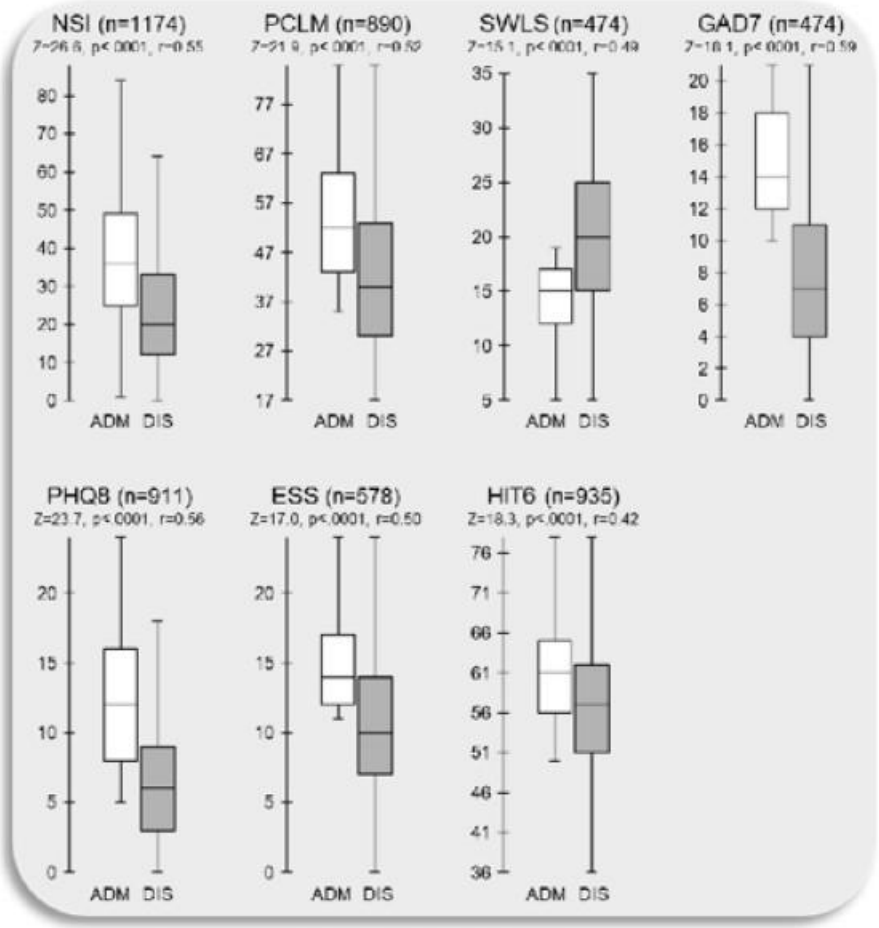
Clinical Health Outcomes Pre-Post Interdisciplinary IOP

- **NICoE Clinical Database Efficacy in Health Outcomes: BLUF**
  - 1,456 Service Members participating in 4 wk interdisciplinary intensive outpatient program (IOP) enrolled from Aug 2011 to Feb 2019.
  - Statistically significant and clinically meaningful improvement in 7 domains of assessment
  - Sustained improvement at 1, 3 and 6 months post-discharge

Efficacy of Interdisciplinary IOP Care: Admission to Discharge

Scores Statistically significantly & Clinically Meaningful improvement across all assessments



DeGraba, et al. Frontiers in Neurology 2021

7 validate symptom score

Assessment	Symptomatic Range	Improvement	p-value
NSI	No composite threshold	86%	<0.0001
PCL-M	≥35	85%	<0.0001
SWLS	≤19	81%	<0.0001
PHQ-8	≥5	87%	<0.0001
GAD-7	≥10	91%	<0.0001
ESS	>10	78%	<0.0001
HIT-6	≥50	71%	<0.0001

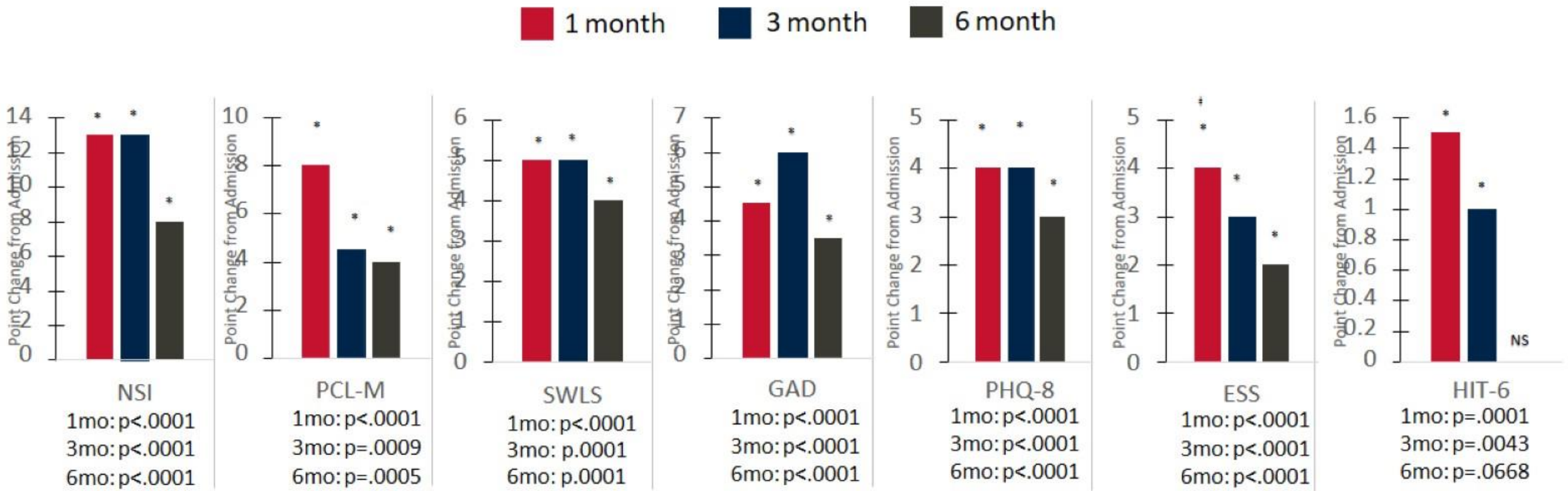
Improvement Criteria

NSI ≥5, PCLm ≥10, SWLS ≥5, PHQ-8 ≥5, GAD-7 ≥5, ESS ≥2, HIT-6 ≥5

1,456 AD Service Members IOP enrolled from Aug 2011 to Feb 2019, had sustained improvement 6 months

Durability of Recovery

Wilcoxon sign-rank test of assessment scores from Admission vs. 1-, 3-, & 6 month time points, show that patients continue to have a significant decrease of symptoms across all measures except HIT-6 at 6 months



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NICoE After Action Report: Attributes of Efficacy

The NICoE Patient Satisfaction Surveys, (n=558)

- 96.3% reported "Overall Satisfaction" as "strongly agree" response
- 96.8% reported that they felt comfortable and safe in the NICoE environment "strongly agreed"
- 98% of Service Members (SMs) "strongly agree" that they recommend the NICoE to others.
- 91% of SMs "strongly agreed" they had acquired the skills to actively engage in their
- recovery
- 87% of SMs "strongly agree" that they felt more confident in expressing their health needs with other health providers.

5= strongly agree, 4= agree, 3= Neither agree or disagree, 2= disagree, 1= strongly disagree

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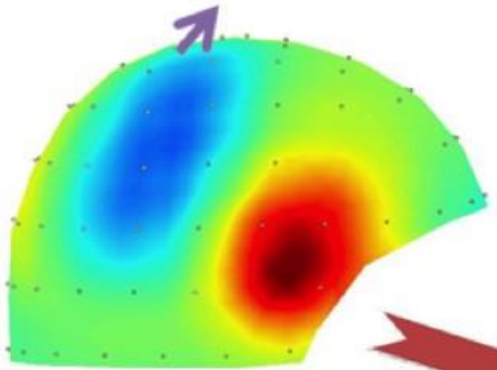
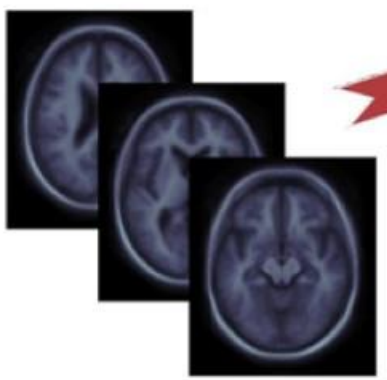
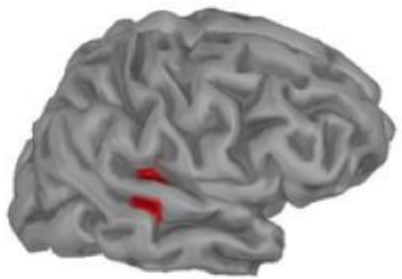
Magnetoencephalography: Network Signal



Magnetic field

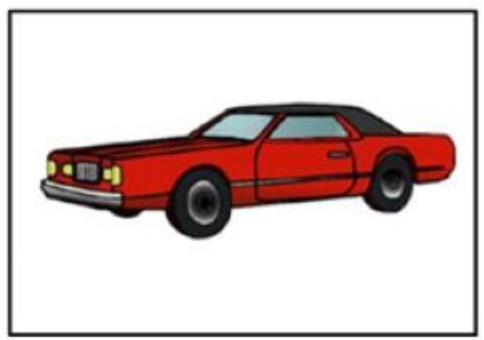


MRI



Reconstructed brain sources

(Photos courtesy NICoE PAO, n.d.)



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MEG

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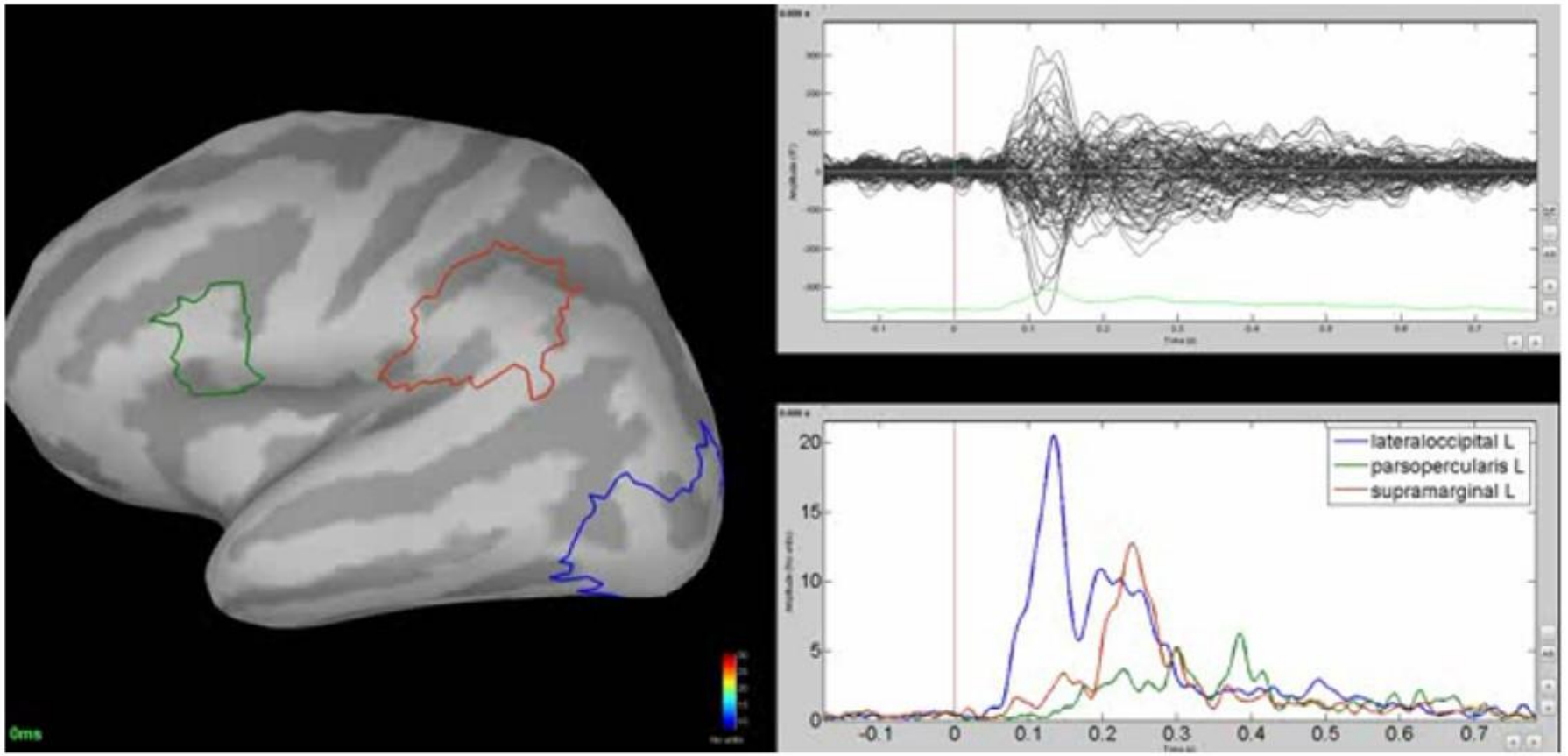

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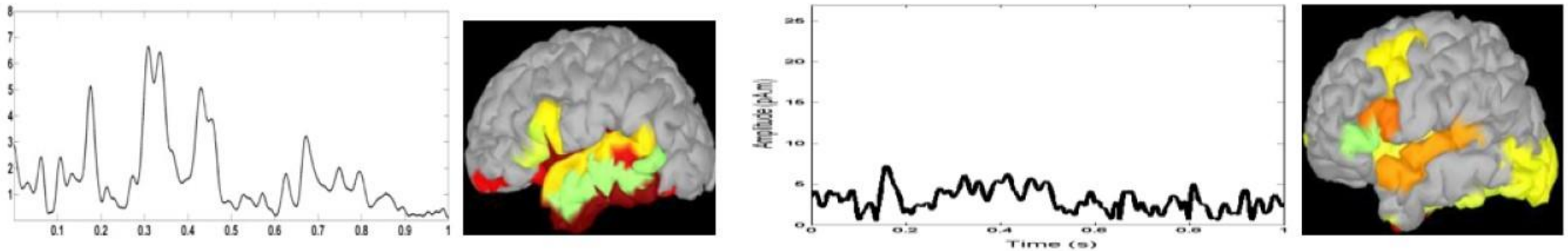
Continuum of Care
Case Study

- Service Member sustained combat related traumatic brain injury
- Cognitive deficits described as memory and executive function compromise



Activation curves in composite for occipital, temporal parietal and frontal during silent picture naming paradigm.

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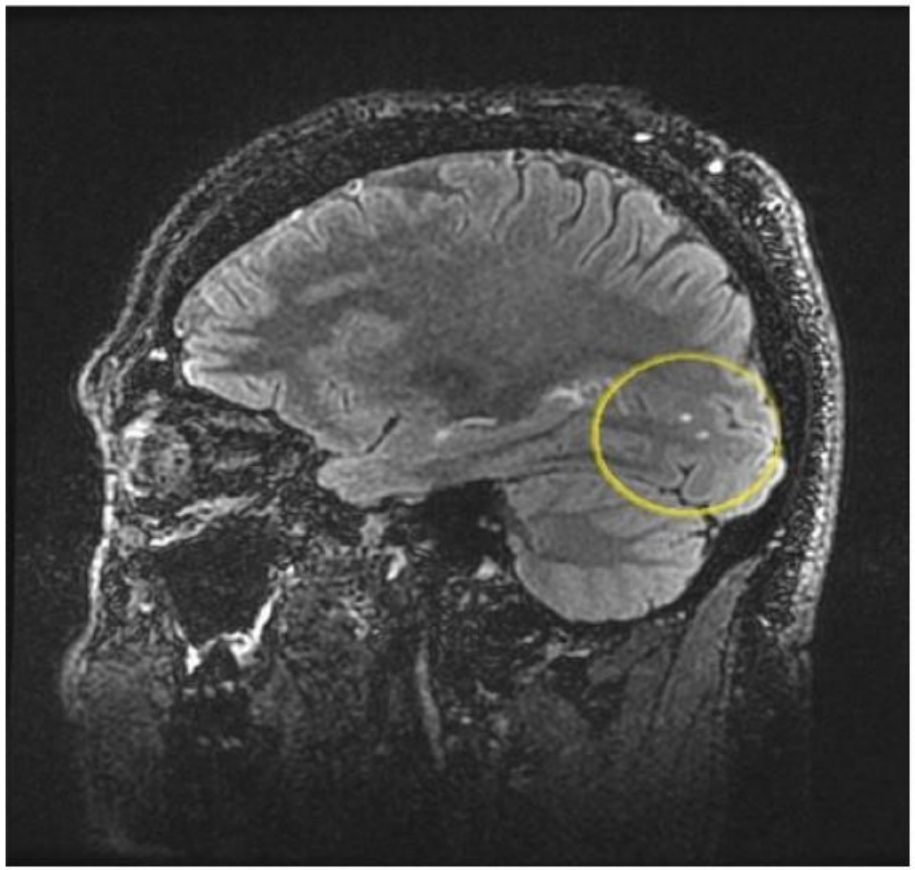
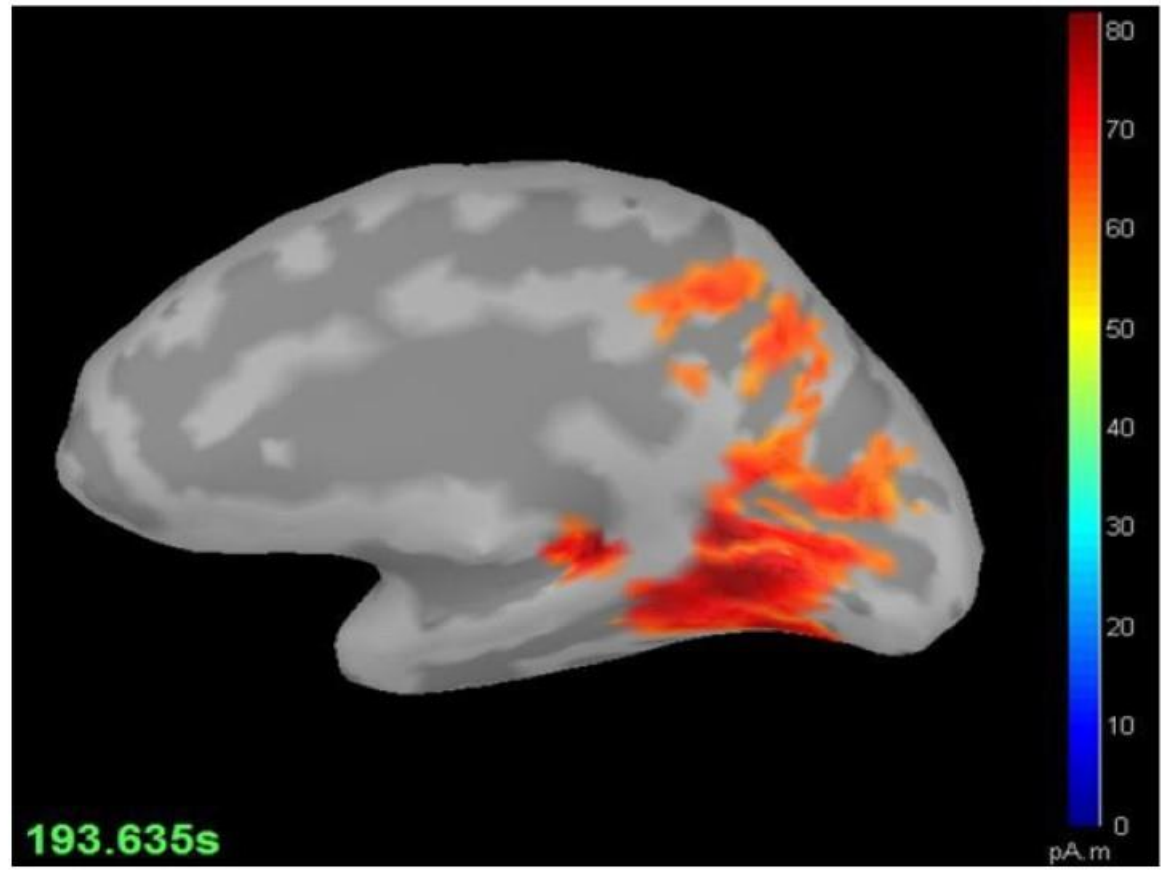
MRI T2 white matter lesions – Correlate with Delta activity





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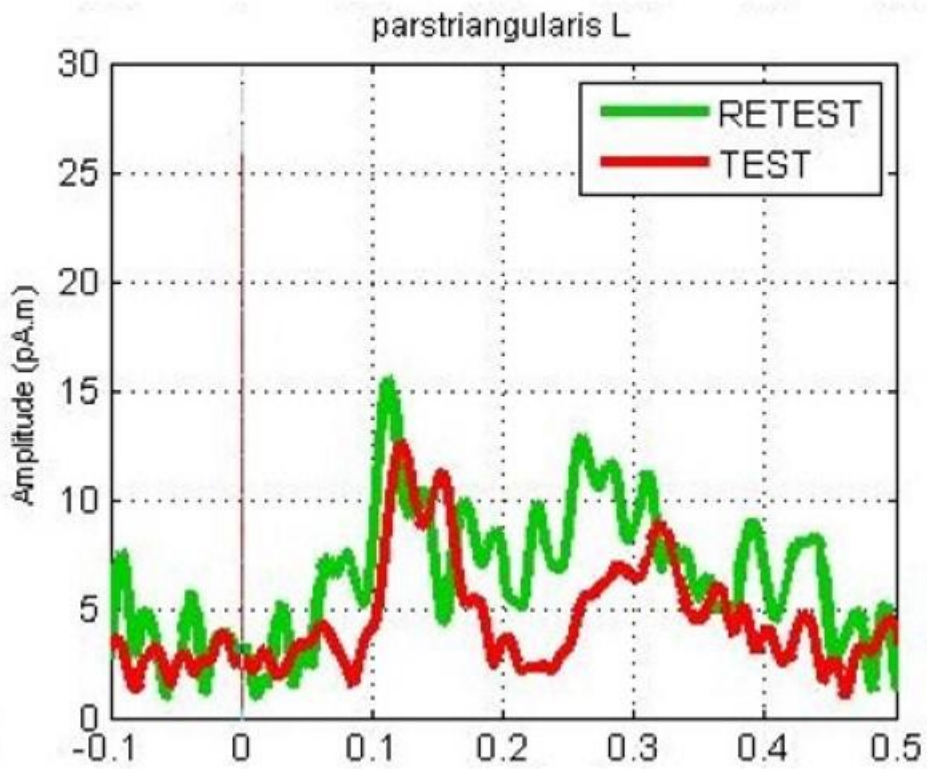
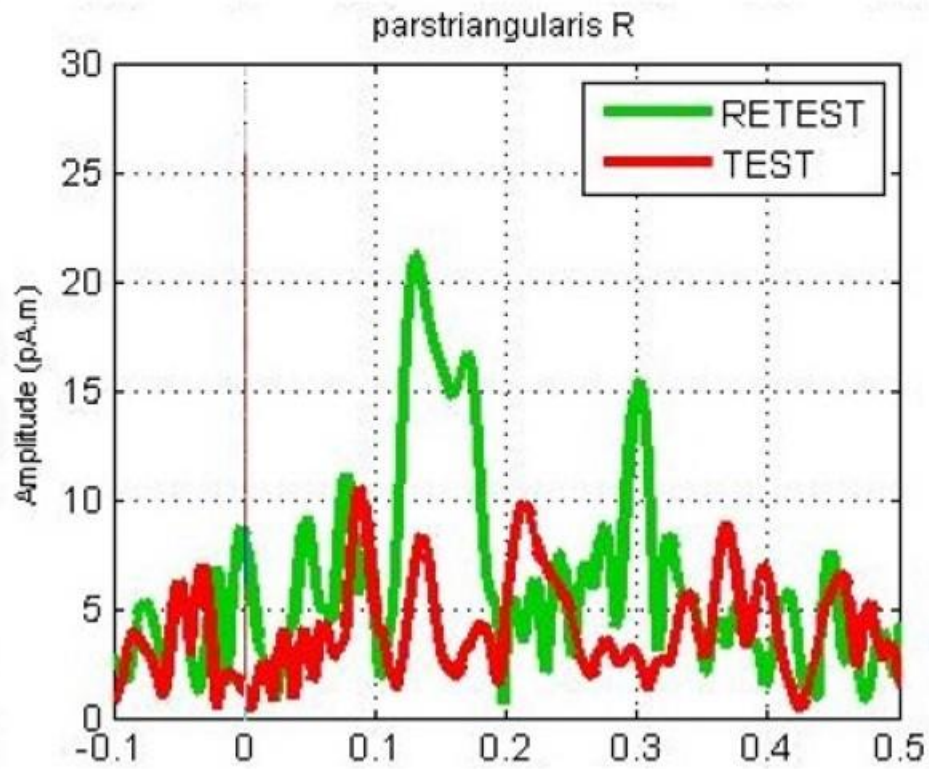
Neural Pattern:
Pre vs post neurocognitive training





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Key Takeaways

- Repetitive combat and mission related TBI and Operational stressors can result in pathophysiological conditions that leads to persistent neurological and operational symptoms
- The interdisciplinary intensive outpatient program (IOP) utilizes conventional neurological and behavioral health rehabilitation techniques with integrative medicine techniques significantly improves multiple domains in recovery.
- Interdisciplinary IOP demonstrated sustained benefit up to six months.
- Utilization of integrative medicine including creative arts therapy and mind body/wellness techniques have demonstrated association with reduction in behavioral health comorbidities.
- Recovery in behavioral health comorbidities are associated with biological changes measured in cerebral autonomic and cerebral electrophysiological parameters.

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