# Exploring the Effects of EEG Neurofeedback Training on Verbal Episodic Memory in a TBI Sample

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## Background

- Traumatic brain injuries (TBIs) are characterized by impairment in physical, behavioral, and cognitive functioning.
- Memory impairment is one of the most common complaints.
- Despite their prevalence, there are limited treatment options available for TBI-driven memory complaints.
- Neurofeedback training (NFT) is a recently investigated brain-based intervention, which uses brain activity as a method of self-regulation through operant conditioning.
- Recent research has explored the use of NFT to improve cognitive functioning in TBI patients.
- Investigations testing effects of NFT on cognition-based TBI symptoms have not produced consistent findings.
- This pilot study tested whether this novel intervention may be successful in improving these memory deficits.

## Objective

- To test the effect of a brain-based treatment on verbal episodic memory in a sample of veterans with TBI.
- To explore potential underlying mechanisms as measured by resting-state functional connectivity.

## Methods

- Twelve veterans (11 men, 1 woman) ranging from 26 to 58 years of age with a TBI diagnosis.
- Neurofeedback protocol used an "eego RT" brand 32-channel EEG amplifier.
- This pilot study was randomized, double-blind, and placebo-controlled with three treatment phases:

**Baseline Assessment**
- Informed consent
- Clinical interview with baseline measures
- fMRI scan lasting 4 hours
- Randomized to active or sham treatment (Active = 9, Sham = 3)

**Neurofeedback Treatment**
- 20 sessions of EEG NFT
- 30 minutes per session
- 2-3 per week
- Over 7-10 weeks

**Exit Assessment**
- Same clinical interview as baseline assessment
- Re-administration of clinical assessments
- Additional fMRI scan lasting 4 hours

- Clinical measure of focus was the California Verbal Learning Test-II (CVLT)
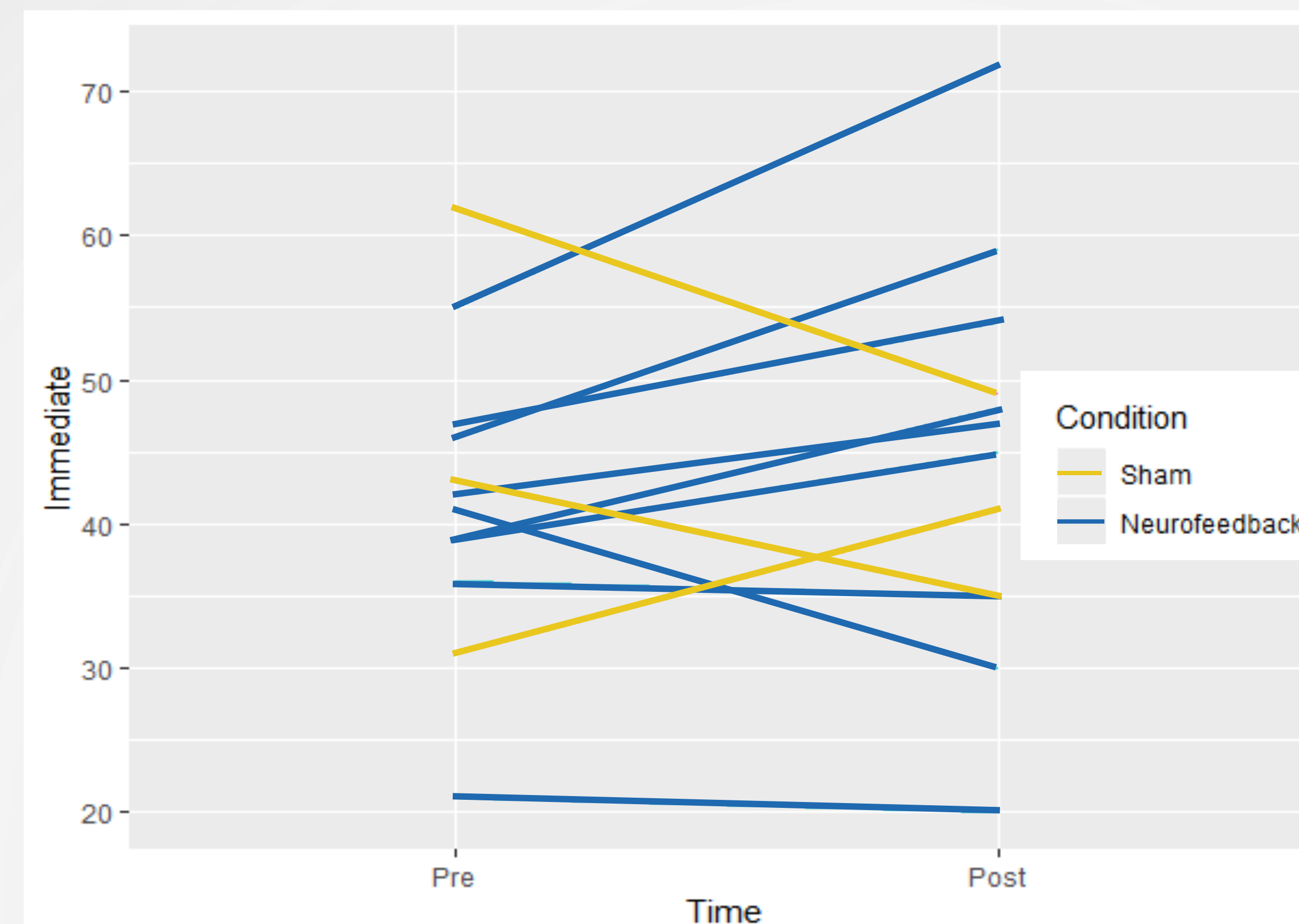
## Results



**Figure 1. Immediate Recall in NFT Pre vs. Post Treatment**

Although interaction of Condition by Time was not significant, visual exploration of the data for each participants' memory scores pre and post treatment showed improvement in memory performance for several participants in active NFT group post treatment, with a marginal main effect.
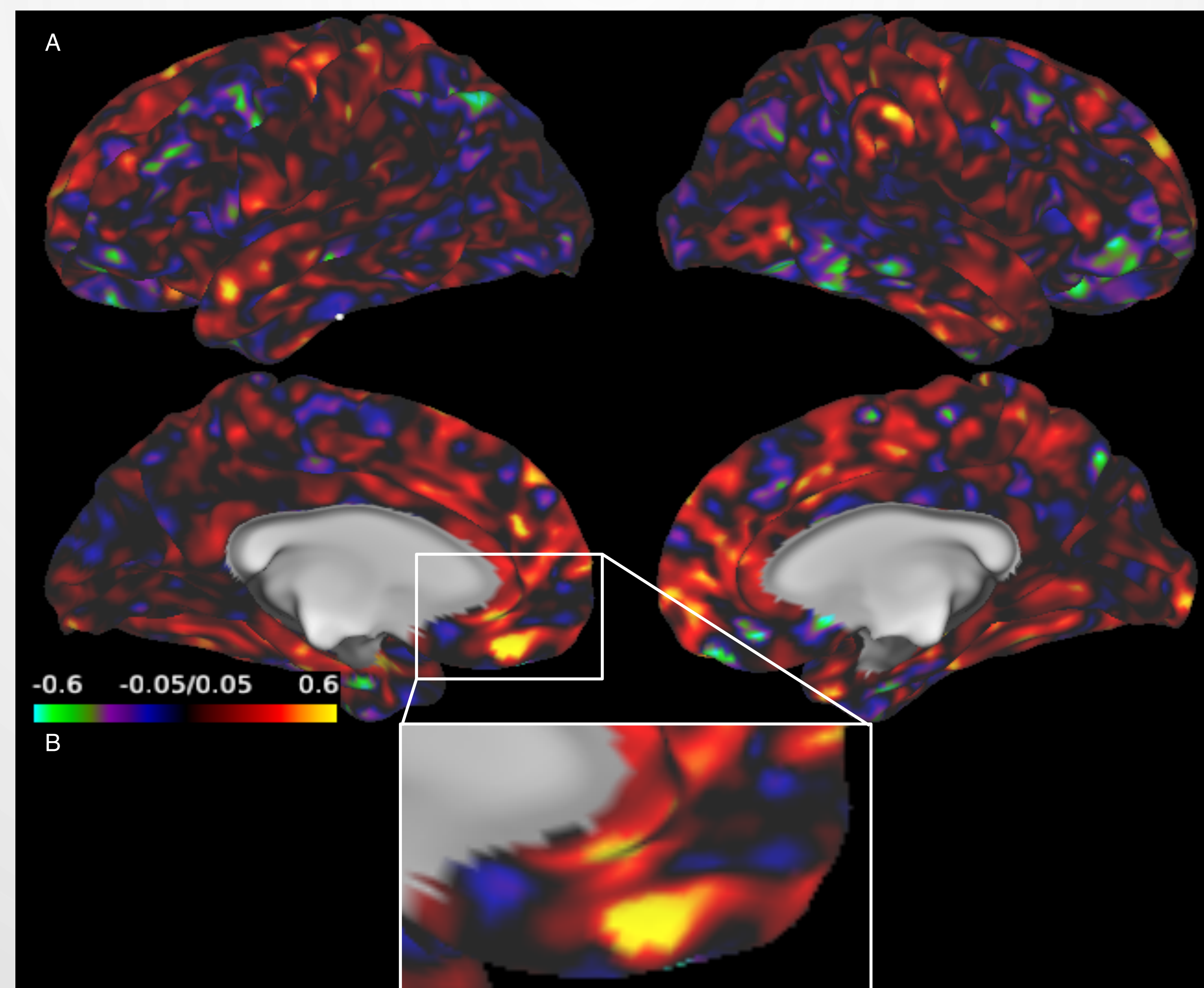


**Figure 2. Brain map of resting-state functional connectivity pre vs. post NFT**
- All participant data correlating functional connectivity changes with CVLT score changes (2A)
- Strong positive values represent increased connectivity associated with increased CVLT scores
- Displays an increase in functional connectivity in ventromedial prefrontal cortex (vmPFC) correlated with improvement in CVLT performance (2B)

## Discussion

- Marginal effect of NFT on immediate recall
  - Suggests improvement in memory scores following treatment
  - Provides valuable insight through its focus on veterans
  - Future studies would benefit from larger sample size and more balanced treatment groups
- An increase in false positive memory responses post treatment
  - May suggest non-adaptive memory or learning strategies
  - Future replication should utilize numerous different measure of memory
- Increases in connectivity between temporal lobe and vmPFC were correlated with improved CVLT scores post treatment
  - May indicate NFT as effective for improving network connectivity and subsequent cognitive changes
  - May suggest an important neural connection for memory function
  - Aligns with literature reporting connectivity changes following NFT
  - Future studies may benefit from completing fMRI recording during memory task
  - Using a multi-seed analysis approach may produce increased reliability of results

## Conclusion

- This pilot study provides initial exploration of NFT as a method of verbal episodic memory enhancement in veterans with TBI
- These exploratory findings may suggest a critical neural connection necessary for enhanced memory functioning
- These findings may hold promise for future research on the use of NFT for memory enhancement in various populations
- This study proposes ideas for future research designs and may hold promise for intervention techniques

## Acknowledgments

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