MRI, qEEG, and Neuropsychological Outcomes following Cognitive Rehabilitation Training for Severe Traumatic Brain Injury: A Clinical Case Study

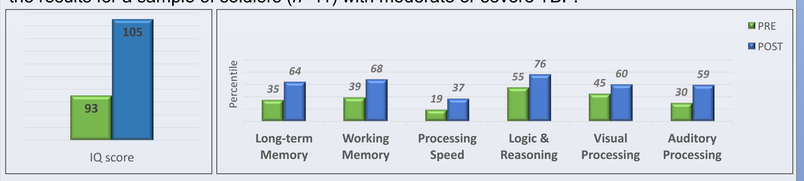
Amy Lawson Moore, PhD[1] & Christina Ledbetter, PhD[2]

[1]Gibson Institute of Cognitive Research, Colorado Springs, CO; [2]LSU Health Sciences Center, Shreveport, LA

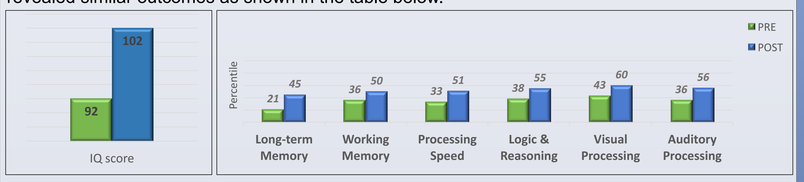
INTRODUCTION

Background and Prior Research. Cognitive struggles frequently persist beyond the recovery period following traumatic brain injury (TBI). Deficits are injury-dependent but typically involve memory, processing speed, and reasoning skills. LearningRx is a clinician-delivered cognitive rehabilitation training program that concurrently targets multiple cognitive skills through repeated engagement in game-like but rigorous mental tasks in 90 minute training sessions at least three days per week. The current study examined neuropsychological, functional, and neuroimaging outcomes following 60 hours of LearningRx training for a client with severe TBI.

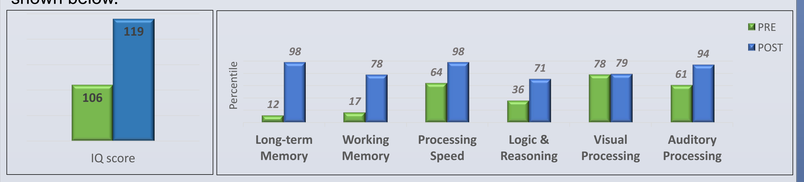
We have reported significant improvements in cognition and/or neural connectivity in multiple published studies on LearningRx cognitive training programs with diverse samples including soldiers with traumatic brain injury and children with learning disabilities. The table below shows the results for a sample of soldiers (n=11) with moderate or severe TBI[1].



Results from a large observational study[2] of LearningRx clients with mild or moderate TBI (n = 273) revealed similar outcomes as shown in the table below.



Results from a former professional football player with repetitive concussions included substantial gains in long-term memory, working memory, processing speed, and logic and reasoning, as shown below.



Finally, preliminary results from an ongoing TBI clinical trial showed increases in IQ score for the first 5 participants with a mean increase of 21 points. All cases achieved gains in long-term memory, processing speed, logic and reasoning, and auditory processing; and four of five cases gained on visual processing and working memory. Participants with mild TBI exhibited significant training-induced changes in neural connectivity. Analyses of clinical significance indicated 91% of post-test scores were classified as *recovered* or *improved*.[3]

The results presented in the current poster are from a participant in an ongoing clinical trial designed to examine neural correlates of cognitive change in TBI using MRI and qEEG following 60 hours of LearningRx cognitive training.

CASE HISTORY

- 58 year old male in high-level STEM career suffered severe TBI in bicycle accident 8 years prior
- 14-hour coma, 11-night hospital stay, and 18-day inpatient rehab
- Diffuse axonal injury with multiple petechial hemorrhages in both cerebral hemispheres, left thalamus, and basal ganglia along with small volume subarachnoid hemorrhage and mild mass effect in medial left temporal lobe
- Multiple facial fractures with dental trauma and pituitary shear
- Following discharge required 24-hour supervision due to gait impairment, cognitive impairment, and diplopia.
- After physical recovery, patient continued to suffer cognitive impairment with marked working memory and processing speed deficits.
- Patient was prescribed Aricept and had undergone 6 weeks of near-infrared therapy years prior to the time he entered the study.
- Patient was no longer able to perform in a STEM field and was employed in custodial work.

METHODS

- Using a case study design, we examined changes in IQ score, working memory, long-term memory, visual & auditory processing, processing speed, reasoning, and everyday functioning following 60 hours of cognitive training for a client with severe Traumatic Brain Injury.
- We also examined neural connectivity changes with fMRI and electrical activity with qEEG.
- Neuropsychological assessments included the Woodcock Johnson IV – Tests of Cognitive Abilities and the Patient Competency Rating Scale.

Example of a working memory training task

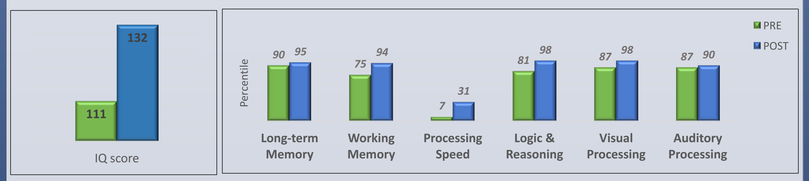
Example of a visual processing training task

- The intervention targeted working memory, long-term memory, processing speed, attention, visual processing, auditory processing, and reasoning skills.
- Training intensity was tightly controlled by the clinician using a metronome, timer, and deliberate distractions to "load" the client with several simultaneous tasks. A metronome added to the intensity and ensured that mental breaks were minimized.
- Client attended three 90-minute training sessions per week for 14 weeks.

Clinician delivering a training task

- MRI scanning was performed on a Siemen's 3T MR scanner and included acquisition of a T1 weighted, high resolution (512x512x192) anatomical image, and a 12-minute resting state EPI-BOLD functional acquisition (TR = 3 secs). Resting state connectivity was performed using the SPM CONN toolbox.
- qEEG was acquired on a Deymed TruScan24 and analyzed with NeuroGuide and LORETA.

NEUROPSYCHOLOGICAL TESTING RESULTS



- Greatest pretest deficit in processing speed followed by working memory
- Largest gains in processing speed and working memory
- 21 point increase in IQ score as measured by the Woodcock Johnson IV

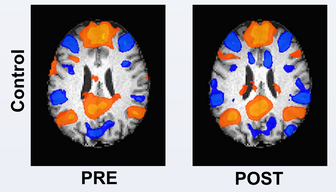
FUNCTIONAL RESULTS

- TBI Competency Rating Scale improved from pretest *Moderate* impairment to *None* post-training
- Improved problem-solving & focus
- Staying on task is easier
- Motivation for life is back
- No longer on Aricept for memory
- Improved mood and decreased depression

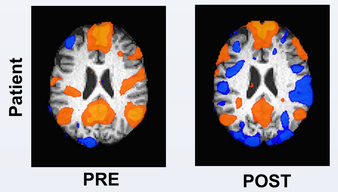
Returned to prior high-level STEM career position!

MRI RESULTS

DMN Connectivity: Default Mode Network Positive (orange) and Negative (blue) Correlations identified with the Medial Prefrontal Cortex (MPFC) Seed



Pre and Post Activity with the MPFC :
- Correlated with the posterior cingulate and bilateral parietal cortices.
- Anticorrelated with extrastriate visual areas (bilateral superior occipital gyrus).
- Anticorrelated with the attention networks (bilateral frontal poles and bilateral parietal operculum).

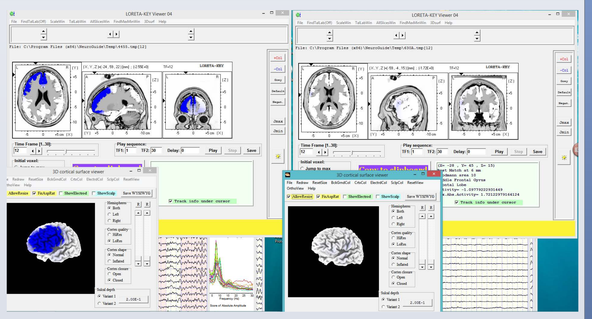


Pre Activity with the MPFC :
- Correlated with the posterior cingulate and bilateral parietal cortices.
- Abnormally correlated activity with the attention network bilateral parietal operculum regions.
- Anticorrelated with the left extrastriate visual area, but no correlation was seen with the right.

Post Activity with the MPFC :
- Anticorrelated with extrastriate visual areas (bilateral superior occipital gyrus).
- Anticorrelated with the attention networks (bilateral frontal poles and bilateral parietal operculum).

qEEG RESULTS

- Pretest LORETA showed low beta and high alpha in the left frontal region consistent with mood, depression, and memory deficits.
- Post-test LORETA showed normalization of left frontal activity consistent with improvements in mood, depression, and memory.



PRE POST

CONCLUSIONS

- On MRI severe TBI manifested as hyperconnectivity in the DMN and absence of anti-correlations. Post-training MRI showed normalization of connectivity in the DMN with restoration of anticorrelations in attention & visual areas.
- Remediation of both cognitive and life skills was achieved with LearningRx cognitive rehabilitation training.
- Cognitive training appears to be a promising intervention for TBI

REFERENCES

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[2]Moore, A.L., & Wainer, H. (2016). *LearningRx client outcomes and research results.* Colorado Springs, CO: Gibson Institute of Cognitive Research.

[3]Moore, A.L., Ledbetter, C., & Carpenter, D.M. (2017). *MRI and neuropsychological outcomes following cognitive rehabilitation training in traumatic brain injury: A multiple case study.* Presented at Society for Neuroscience, November 2017, Washington, DC.

ACKNOWLEDGEMENTS

- This study is registered at ClinicalTrials.gov (# NCT02918994). Funding for this study was provided by LearningRx & ethics approval was granted by the Institutional Review Board at Gibson Institute of Cognitive Research

CONTACT

Amy Moore, PhD amoore@gibsonresearch.org or Christina Ledbetter, PhD cledbe@lsuhsc.edu