Longitudinal changes in the EEG spectrum during recovery after severe brain injury

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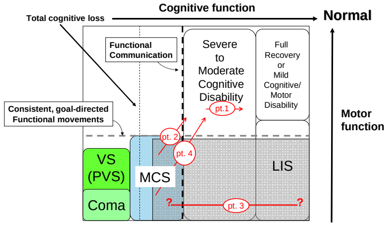
Introduction

Slow changes in brain structure and function can occur in the setting of severe brain injury. Finding out how and when these changes occur is essential to understanding recovery from severe brain injuries in general. This suggests longitudinal assessment of recovering patients.



Schiff, ND (2010) TINS, 33, 1-9.

EEG Methods

EEG methods allow us continuous sampling of brain states and network responses in order to characterize recovery over time

This method can be used to cross-validate imaging data as well as behavioral assessments i.e., CRS-R.

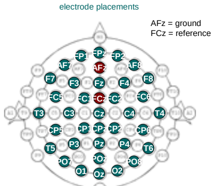
Recording

32+ hrs of recording with video augmented longitudinal bipolar recording montage (International 10/10 system)
200 or 256 Hz sampling rate
XLTEK data acquisition system (XLTEK, Ontario, CN LH65S1)

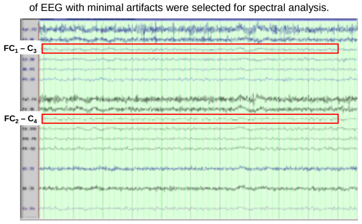
Analysis

Selection of artifact-free segments from both resting awake (eyes open) and sleep states based on visual review of the record and video.

Power spectra (bandwidth 1Hz, with confidence limits) estimated using multitaper method, implemented in matlab with Chronux toolbox.



Sample Awake segment: A minimum of 30 10-second segments of EEG with minimal artifacts were selected for spectral analysis.



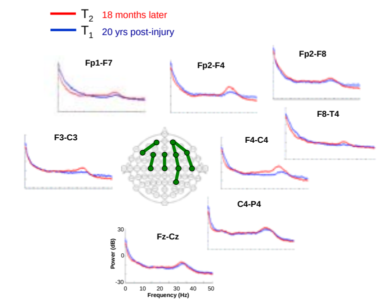
Results - Patients studied longitudinally

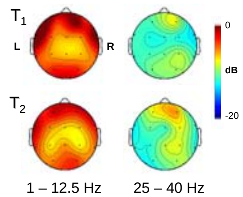
Patient 1 - 39 yr old man
1st visit - 20 yrs post-injury

TBI at age 19 due to a MVA in 1984
Coma for 6 weeks; followed by brief period in VS
19 yrs in MCS living in a nursing home
Spontaneous language in 2003
Poor short-term memory

Voss, H.U., et al., (2006) J Clinical Investigation 16: 2005-2011.

Changes noted at 2nd visit:
Neurological: Some functional recovery of left upper extremity
Behavioral: Increase in baseline arousal level
Improvement in attentional focus/response persistence
Speech is improved
more intelligible; no paraphasic or dysnomic errors
no errors in confrontation naming





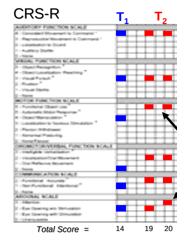
Summary of Spectra Changes

Significant *increases* in power spectra in the 25-40 Hz frequency range in 13/18 bipolar channel comparisons.

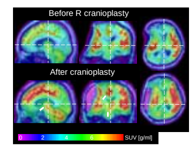
Significant *decreases* in power in the 1-12.5 Hz frequency range in 13/18 channels.

Largest differences in the R hemisphere channels (7/8), and both midline channels (Fz-Cz, Cz-Pz).

Patient 2 - 18 yr old woman
1st visit - 6 mos post-injury



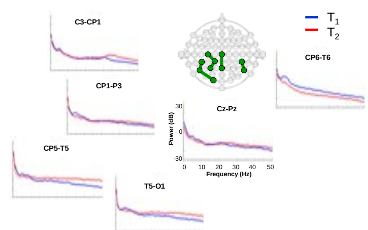
Improved motor function, vocalizations and attention following 2nd cranioplasty

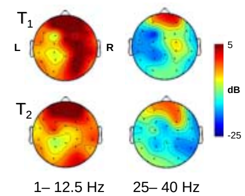


MVA in Aug 2008; bilateral craniectomies

L cranioplasty prior to T_1
R cranioplasty prior to T_2

$T_2 - T_1$ = 4 months





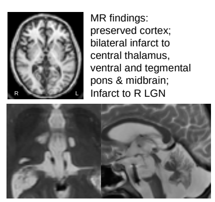
Summary of Spectral Changes

Decrease in power at frequencies below 10 Hz with an increase in power above 30 Hz.

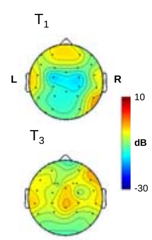
Largest differences evident in L centroparietal channels.

Patient 3 - 24 yr old woman
1st visit - 2 yrs post-injury

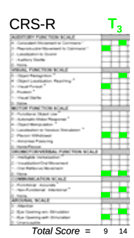
Stroke due to basilar artery occlusion with brainstem infarct in 2006
opens and moves L eye;
has preserved vertical gaze.
severely impaired motor function
demonstrates inconsistent communication with downward eye movements



MR findings: preserved cortex; bilateral infarct to central thalamus, ventral and tegmental pons & midbrain; Infarct to R LGN



20 – 35 Hz



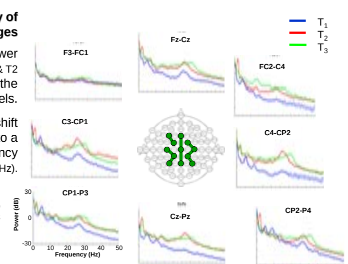
Median CRS-R scores obtained at T_1 & T_2 = 9.

Summary of Spectral Changes

Increase in power above 15 Hz (T_3 & T_2 vs T_1) primarily in the central channels.

Prominent peak shift (T_3 vs T_1 & T_2) to a higher frequency range (from 25 to 30 Hz).

Artifact seen in all channels (1-6 Hz) due to palatal myoclonus



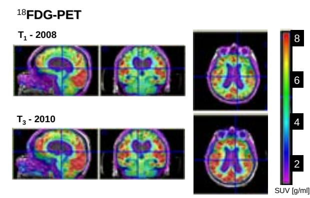
Patient 4 - 58 yr old woman
1st visit - 1 yr post-injury

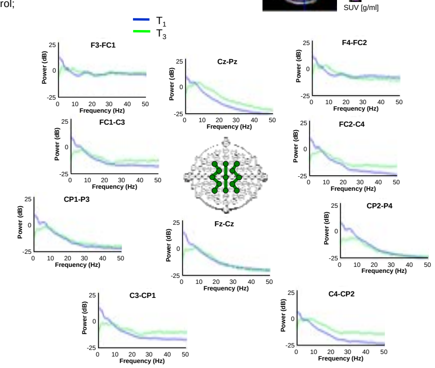
Diffuse encephalopathy following fat emboli in 2007

Baseline exam: eyes open, consistent visual tracking

Changes noted at 2nd Visit: emergence of inconsistent verbalization; increased arousal

Changes noted at 3rd Visit: consistent, fluent verbal communication; improved motor control; emotional reactivity; spontaneous humor





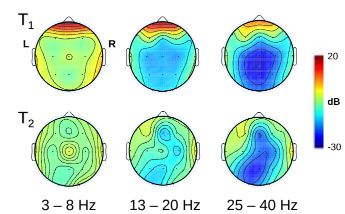
Conclusions

Each patient is different, and yet, all patients demonstrated significant longitudinal changes in power spectra associated with behavioral recovery and metabolic change.

Increases in EEG power were seen in the beta and gamma frequency ranges (pts. 1, 2, 3, 4).

Decreases in power were seen in the delta and theta frequency ranges (pts. 1, 2, 4).

Using qEEG, specifically the power spectrum, we see common patterns of recovery for all of these patients despite varying structural abnormalities, different ages and etiologies, underlying medical conditions, medications and changing metabolic patterns.



References

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Voss, H.U., et al., (2006) Possible axonal regrowth in late recovery from the minimally conscious state. *J Clinical Investigation*, 16, 2005-2011.

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