Assessment of Acute Mild Traumatic Brain Injury by Quantitative EEG Analysis

Mission Connect: Mild Traumatic Brain Injury Translational Research Consortium

The Integrated Clinical Protocol: Neurophysiology Core

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A part of The University of Texas Health Science Center at Houston

Background

There are four related clinical research projects in the Mission Connect Mild TBI Translational Research Consortium. The Neurophysiology Core will provide electroencephalographic (EEG) data for one of its projects which will investigate the early (<24 hr.) diagnosis of mild traumatic brain injury (MTBI) and early differentiation of MTBI from post-traumatic stress disorder (PTSD).

Study Objectives

Specific Aim #2.1.1 — To investigate differentiation of patients sustaining MTBI from a group of patients with orthopedic injury (OI) based on cognitive performance, diffusion tensor imaging (DTI), and EEG findings within 24hr after injury and at follow-up over a six month interval.

Specific Aim #2.1.2 — To investigate reporting of acute stress disorder (ASD) symptoms, acute post-concussion symptoms (PCS) in relation to DTI and EEG by groups of patients with MTBI or OI.

Methodology

A 30 to 60 minute EEG will be recorded within 24hr of injury and then 3 months later utilizing a standard clinical protocol.

Visual Analysis — The following parameters will be described: frequencies of the occipital dominant alpha rhythm and the background activity in the frontal, temporal, and central regions and the presence of any asymmetries of the background rhythms, focal slow wave activity or epileptiform activity.

Computer-Based Quantitative Analysis — Eight referential channels will be used for the quantitative analysis (Fp1, Fp2, C3, C4, O1, O2, T3, T4). Extensive EEG analysis software/hardware has been developed within the Section of Neurophysiology, Department of Neurology, Baylor College of Medicine, using the Matlab programming language, and will be available for this project. The background characteristics of each 30-second EEG sample will be determined through the application of a battery of procedures that will permit the the characterization of frequency components, amplitude distribution, rhythmicity, continuity and bilateral symmetry. Measured parameters for each EEG sample include: ***Power spectra*** will be based on the fast Fourier transform (FFT) to provide information concerning the average amplitude of specific frequency components in the 8 anatomical regions studied. ***Period/amplitude analysis*** will consider the EEG signal from each channel on a wave-by-wave basis and provide estimates of average frequency, average amplitude, and maximal amplitude for each of the 8 EEG channels. ***Coherence analysis*** will provide a frequency-specific measure of correlation, or similarity, between two channels as a measure of interhemisphere symmetry.

Data Analysis — Using multivariate statistical techniques, analyses will examine the patterns of recovery in behavioral, cognitive, and EEG function, beginning within 24hr of injury and progressing through the six month post injury period.

Results To Date

This initial phase of the project has been directed towards the establishment of protocols and logistics of EEG recordings, and the pilot testing of computer-based quantitative EEG analysis.

Conclusions

Visual and computer-based analysis of EEG are potentially useful tools in diagnosis of MTBI and its early differentiation from PTSD. The Integrated Clinical Protocol of Mission Connect is designed to define that role.

Potential Impact

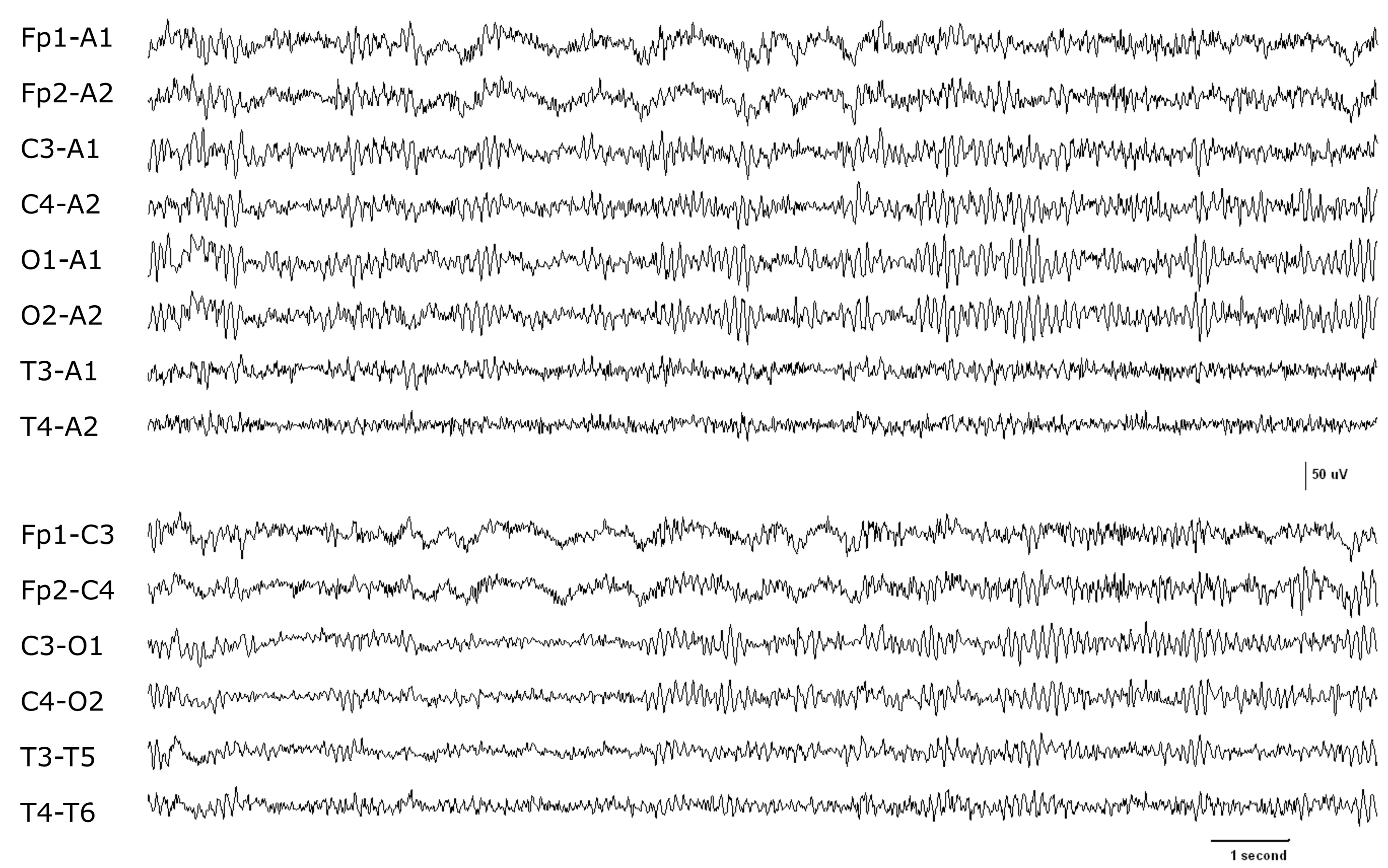
The contributions of the Neurophysiology Core to the Integrated Clinical Protocol of Mission Connect may establish the clinical utility of EEG in the early diagnosis of MTBI and its differentiation from other disorders.

Table 1. Period/Amplitude Analysis

	Delta Range (0.5-3.5 Hz)			Theta Range (3.51-7.5 Hz)			Alpha Range (7.51-13.5 Hz)			Beta Range (13.51-40.0 Hz)		
Cortical region	Avg Freq	Avg Amp	Max Amp	Avg Freq	Avg Amp	Max Amp	Avg Freq	Avg Amp	Max Amp	Avg Freq	Avg Amp	Max Amp
L Frontal	1.3	26.6	57.9	6.2	15.4	38.0	9.4	22.8	52.9	25.6	18.1	37.5
R Frontal	1.5	20.6	46.6	5.6	14.6	34.0	9.5	21.5	55.6	24.7	18.1	48.6
L Central	1.6	14.2	48.8	6.2	19.7	65.6	9.5	28.5	88.9	23.6	16.4	40.0
R Central	1.9	12.2	25.7	5.8	15.8	36.3	9.5	28.3	66.0	23.3	17.6	41.1
L Occipital	1.5	21.2	177.4	6.2	20.3	157.7	9.4	34.8	145.0	22.3	16.6	161.5
R Occipital	1.2	21.8	111.6	5.7	19.2	107.5	9.5	32.0	77.0	22.5	16.6	110.7
L Temporal	1.6	9.4	56.8	6.1	11.6	31.4	9.7	17.4	51.7	25.6	17.2	37.2
R Temporal	1.6	6.9	15.8	5.6	8.0	18.6	9.8	14.1	35.2	27.1	17.2	43.8

Summary of the period/amplitude analysis resulting from processing of the EEG sample shown in Figure 1. For each of the 8 EEG channels, the average frequency, average amplitude, and maximal amplitude are provided within each of the four clinically recognized frequency ranges (delta, theta, alpha and beta). Frequency values in Hz; Amplitude values in microvolts.

Figure 1. Sample of Waking, Eyes-Closed



Sample of waking, eyes-closed, EEG recording obtained at Memorial-Hermann Hospital and used to establish the feasibility of applying existing computer-based quantitative methods as required by the experimental protocols of Specific Aims 2.1.1 and 2.1.2. The first 8 channels (Fp1-A1, Fp2-A2, C3-A1, C4-A2, O1-A1, O2-A2, T3-A1 and T4-A2) are those used by the automated analysis system to determine measures based on power spectra, period/amplitude measures and spectral coherence.

Table 2. Coherence Analysis

	Coherence (0-40 Hz)		Maximum Coherence (Hz)			
Cortical region	Peak Value	Frequency	0.5-3.5	3.51-7.5	7.51-13.5	13.51-40.0
L vs R Frontal	0.84	2.50	0.84	0.77	0.77	0.37
L vs R Central	0.75	8.50	0.65	0.71	0.75	0.36
L vs R Occipital	0.94	0.50	0.94	0.84	0.92	0.61
L vs R Temporal	0.61	8.50	0.20	0.59	0.61	0.23

Summary of the coherence analysis resulting from processing of the EEG sample shown in Figure 1. For each of the 4 major cortical regions (Frontal, Central, Occipital and Temporal) the overall maximum coherence value, as well as the maximum coherence within each of the four frequency bands, is provided. The coherence value is a measure of the similarity between two EEG channels, with a value of 1 indicating maximum similarity and a value of 0 indicating no similarity. In this example the greatest degree of similarity is observed between the left and right occipital regions, both the 0.5-3.5 Hz and 7.5-13.5 Hz frequency ranges. Figure 3 illustrates the complete range of coherence values.

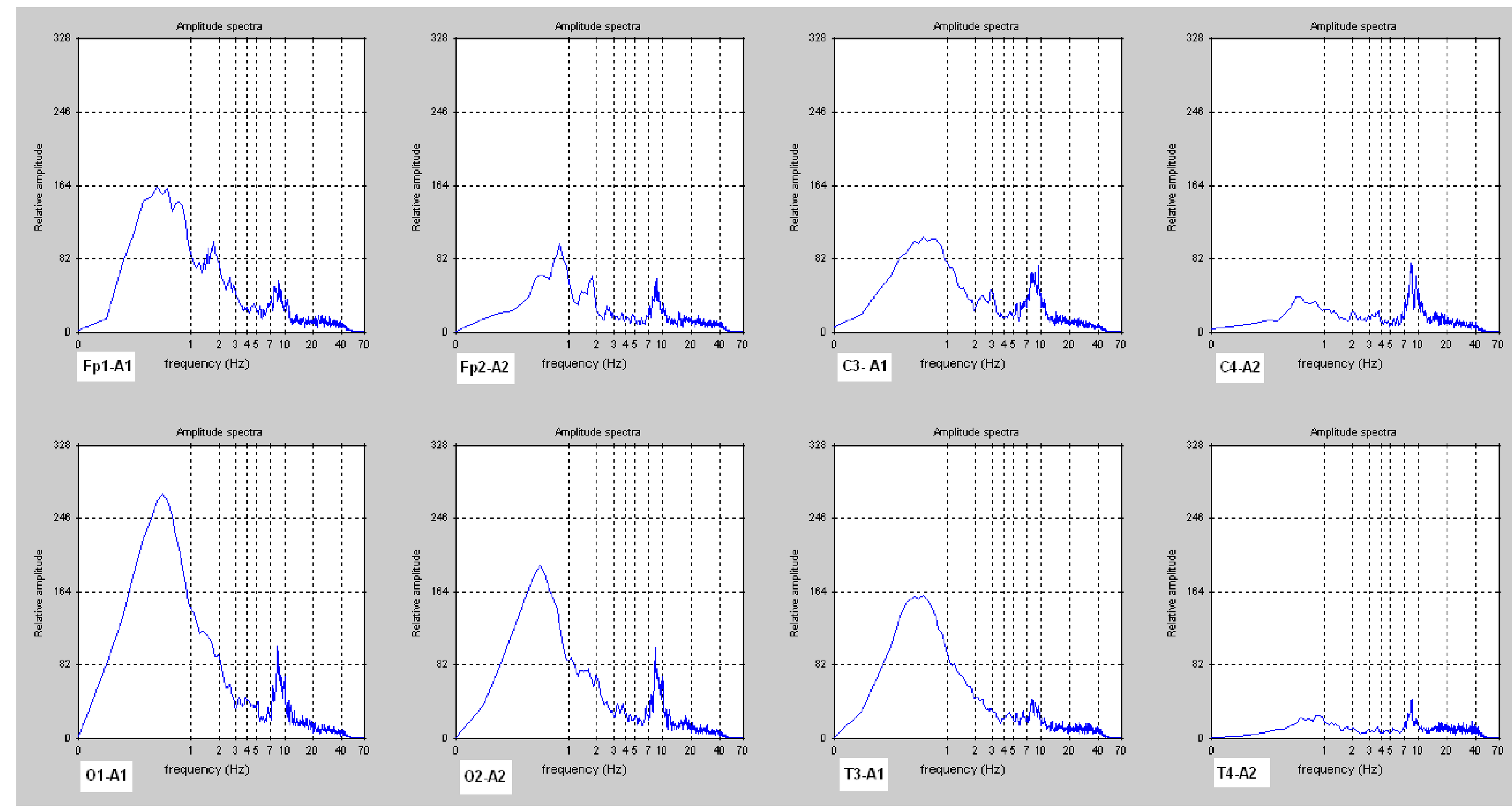
Table 3. Spectral (Fourier) Period/Amplitude analysis

Occipital rhythm parameters	Left	Right	Average
Peak frequency (HZ)†	8.4	8.4	8.4
Average frequency (Hz)^	8.9	8.8	8.9
Average amplitude (uV)^	54.2	51.1	52.7
Continuity (%)^	28.0	35.0	31.5

† Based on Fourier analysis.
^ Based on Period/amplitude analysis within +/- 1 Hz of Fourier peak value.

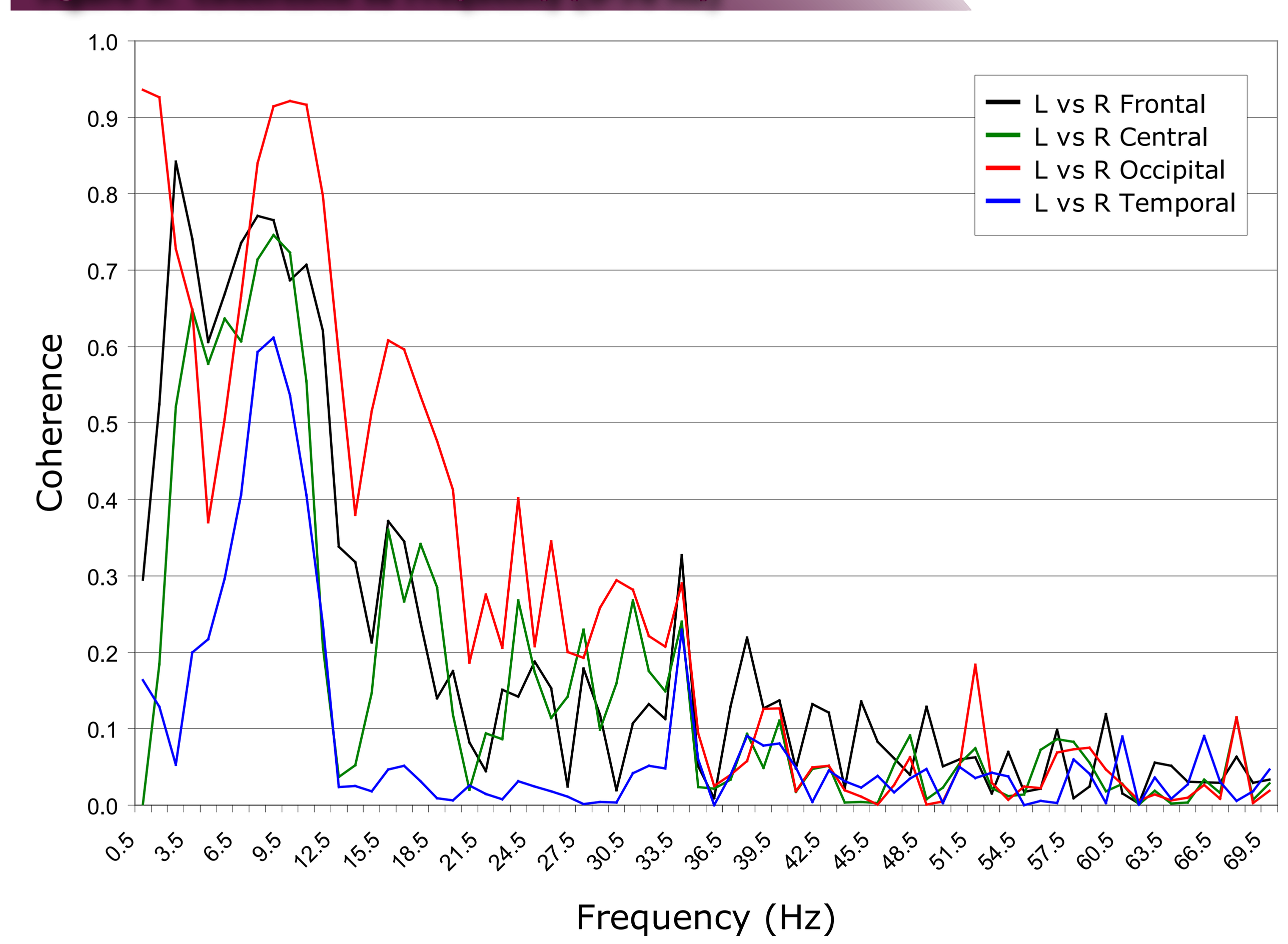
Detailed characterization of the occipital (alpha) rhythm based on a combination of spectral (Fourier) period/amplitude analysis.

Figure 2. Spectral Analysis



Power (amplitude) spectra for each of the 8 channels subjected to analysis (see Figure 1). Note the prominent spectral peak at approximately 9 Hz, most pronounced in channels O1-A1 and O2-A2, reflecting the occipital-dominant alpha rhythm.

Figure 3. Coherence vs Frequency (0-70 Hz)



Graphic display of the results of coherence analysis between right and left EEG channels in the frontal, central, occipital, and temporal regions of the sample shown in Figure 1.

References

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Acknowledgements

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