Determining the Shortest Length of Time for EEG Power Measure

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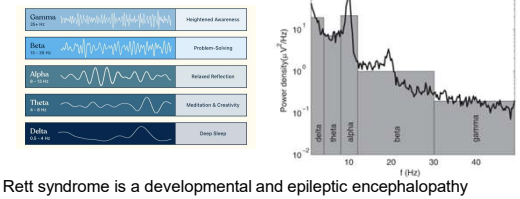
Introduction

- The objective of this study is to detect the minimum time segment necessary to get a stable measure of EEG power.
- Electroencephalography (EEG) is used to measure brain activity through summing the electrical activity of the neurons under each electrode. Different frequencies of waves recorded correspond to different cognitive states. EEG power refers to the amplitude of an oscillatory signal squared, an indicator of brain functioning across each frequency band.

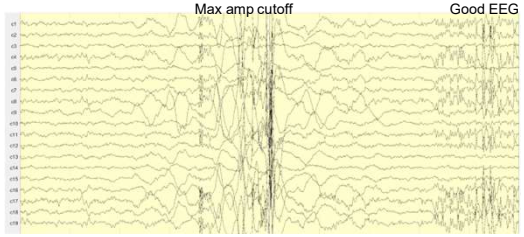


- Rett syndrome is a developmental and epileptic encephalopathy characterized by frequent and severe seizures, regression in skills, and autonomic abnormalities. Researchers use EEGs to quantify differences in Rett syndrome, yet it can be challenging to collect EEG data from children with Rett syndrome who need to stay still long periods of time.
- Waves fluctuate from second to second at rest and in the presence of external stimuli. Prior research has shown significant variability in evoked potentials within 30-minute segments in patients [1].
- A time interval, or epoch, of raw EEG data in the time domain (plotted time vs amplitude) is used to compute a Fast Fourier Transform (FFT) to generate data in the frequency domain (plotted frequency vs power).
- However, the shortest time segment (epoch) needed for a reliable measurement of EEG power has not been established through research.

Methods

- 10 subjects with Rett Syndrome who were given a placebo compared to 10 neurotypical controls, all 5 - 12 years old

Figure 1: Filtered EEG tracing before processing



Methods (cont.)

- EEG processing in MATLAB
1. Root mean square amplitude computed for feature extraction and artifact rejection with max cutoff 150 μV and values >2 standard deviations from the mean rejected
2. Frequency filtered to 1-70 Hz and notch filtered at 60 Hz
3. Log10 of average power calculated in each electrode over 4 seconds across all frequency bands (except gamma in the control group)

- Statistical Analysis
  - Engle's ARCH Test for conditional heteroscedasticity
    - Heteroscedastic refers to when variance of data is not constant
    - Null hypothesis = residuals exhibit conditional homoscedasticity
    - If fail to reject null hypothesis, then variance of power data is stable
  - Lags function (conducts ARCH test for each element consecutively)
    - Number of lags indicate number of trials until stability of variance is reached per patient for each frequency band
    - Median number of lags computed from original data and average values of randomized data set

Results

Figure 2:

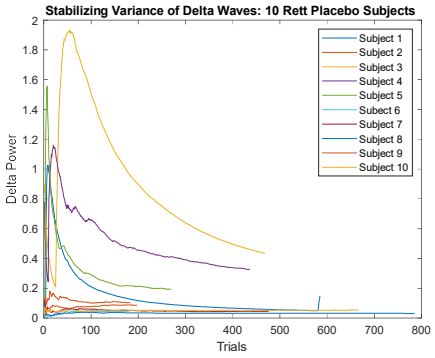
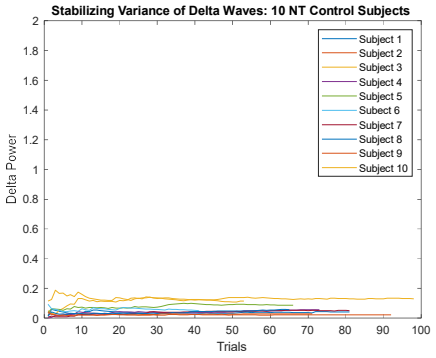


Figure 3:



Subject	Delta	Theta	Alpha	Beta	Gamma
1	270	267	260	265	241
2	0	3	0	0	0
3	25	78	160	178	180
4	36	37	47	62	181
5	29	27	15	36	53
6	0	19	56	55	0
7	5	0	0	88	112
8	30	15	206	312	348
9	18	9	0	24	12
10	0	27	0	217	278
Median	**21.5**	**23**	**31**	**75**	**146**

Median stable epoch in Rett Placebo Subjects: 1 min 26 sec – 9 min 44 sec

Table 1: Lag Data of Rett Placebo Subjects

Subject	Delta	Theta	Alpha	Beta	Gamma
1	39.91	49.07	31.1	26.24	7.74
2	2.26	1.7	2.27	2.46	2.69
3	5.75	5.54	4.47	7.09	6.99
4	9.16	7.74	6.21	7.34	2.96
5	20.4	18.2	18.45	18.76	7.98
6	1.49	2.36	1.23	1.86	1.44
7	5.61	6.39	5.41	6.02	4.65
8	7.86	12.45	10.08	9.76	4.95
9	2.54	1.82	1.34	2.52	1.8
10	5.54	6.33	5.41	7.15	2.42
Median	**5.68**	**5.935**	**5.41**	**7.105**	**3.805**

Median stable epoch in Rett Placebo Subjects: 15.22 sec – 28.42 sec

Table 2: Avg Lag Data of Rett Placebo Subjects After 100 Randomized Trials

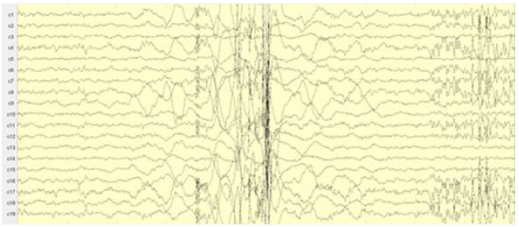
Conclusions

- The minimum time needed for a stable variance in EEG power may be fewer than 30 seconds.
- Children with Rett syndrome have a longer minimum time necessary for a stable measure of power than neurotypical children; this may be due to differences in brain development or perhaps due to differences in EEG signal processing/data collection between these groups.
- Collecting enough data is important in good study design because usable EEG data depends on how much artifact is rejected.

Future Directions

- We are refining the EEG processing to remove low amplitude artifacts impacting the lag data and conditional variance of Rett placebo subjects. Afterwards, the analysis will be repeated.

Proposed
Min amp cutoff



- We will examine other measures commonly used in quantitative EEG, such as zero crossing, and possibly apply other statistical analysis methods, such as bootstrapping.

Reference

1. Marsh, E., et al. (2010) *Epilepsia : the Journal of the International League Against Epilepsy* 51(4): 592–601

Funding

This project was (in part) supported by Award number T32NS007413 from the National Institute of Neurological Disorders and Stroke (NINDS). The content is the sole responsibility of the authors and does not necessarily represent the official views of the NINDS of the National Institutes of Health.

Funding for EEG data collection was provided from clinical trial NCT03633058 funded by the Rett Syndrome Research Trust.

Acknowledgement:
Many thanks to PURM for this opportunity to pursue this novel research question with invaluable mentorship from Dr. Marsh, Kathleen, and Joni.

Slide 1

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