Social Network Theory Applied to Resting-State fMRI Connectivity Data in the Analysis of Epilepsy Networks

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Introduction: Epilepsy is a brain disorder with the essential basis of abnormal cortical and/or subcortical networks. Currently, most of the evidence of seizure networks come from ictal EEG observations. Resting-state functional connectivity studies can be helpful to localize abnormal networks and widen the array and approach of therapeutic options. This study aims to classify patients' data from control subjects by characterizing the interictal epilepsy connectivity networks using social network topology in functional MRI.

Data set and preprocessing pipeline: FMRI Data of 19 control subjects and 8 patients who suffered from intractable medial temporal lobe epilepsy were imaged in this study. TR=1.55s, Number of volumes per run =229, with 3-8 runs per subject, resolution is 64x64x25. 36 VOIs were selected. The following is the preprocessing pipeline: 1 . Motion correction and slice timing correction. 2. Band-pass temporal filtering. (0.01-0.1Hz) 3. Gaussian spatial smoothing. (FWHM=8mm); 4. 6 rigid-body movement confounds removed.

Methodology: A symmetric connectivity matrix was obtained by correlating the mean timecourse of 36 VOIs for each subject. The absolute matrixes were then normalized based on the sum of matrix. Finally, all the elements below a fixed threshold were set to 0. Five properties of social network including: *Degree*,*Strength*,*Closeness*,*Clustering coefficient* and *Betweenness centrality* (Wasserman and Faust,1994) were used for network analysis. Boxplots for these properties were created using the control group. The total number of outliers for each subject in all the 36 VOIs was then calculated to separate the patients and the control group. In order to evaluate the classification performance, a 19-fold cross validation was conducted-- iteratively training the boxplot by using 18 control subjects and then testing the remaining 1 control subject.

Experiment results

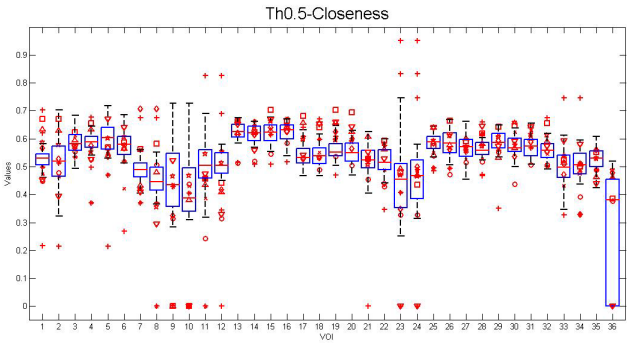

Figure 1. Boxplot example of *Closeness* . Boxplot was created by control group while markers are by patients'data . 6 out of 8 patients are outliers in 12th VOI (Left Hippocampus) .

36	38	37	36	38	36	36	38	37	38	36	37	47	36	40	37	36	40	35
41	37	37	38	39	37	39	37	36	36	36	39	45	40	39	37	37	39	40
36	39	36	35	37	37	37	37	34	37	39	40	41	40	37	35	35	36	37
47	50	42	43	44	41	42	42	42	41	44	43	43	44	43	43	41	42	44
28	30	29	27	29	28	30	28	29	30	28	31	35	28	33	29	30	30	29
71	69	68	71	71	67	70	67	65	68	68	68	72	73	69	67	65	70	68
22	25	18	24	21	21	23	22	19	18	20	20	22	23	20	19	18	22	19
47	47	45	49	51	47	50	47	45	46	46	47	48	51	49	46	45	47	49
26	43	13	23	24	21	13	24	21	13	23	33	93	22	49	11	9	19	22
6	6	5	5	5	4	4	6	4	4	6	6	5	6	7	6	4	6	8
4	2	7	6	8	9	9	6	7	6	9	8	6	7	6	10	8	6	8
1	0	2	3	2	4	2	4	2	2	3	2	3	3	2	3	3	2	3
9	10	9	9	1	2	1	1	2	0	1	2	1	1	1	0	0	0	1
4	3	6	4	3	9	9	9	9	10	10	10	10	10	10	9	9	10	9
5	5	4	4	4	4	3	4	5	3	4	5	4	5	4	4	3	4	3
3	3	4	2	4	3	2	4	4	5	5	5	5	4	5	4	4	5	5
8	8	8	8	8	9	8	8	2	3	4	2	2	2	3	4	2	2	5
6	7	6	6	7	6	6	6	6	9	8	8	10	8	10	8	9	9	8
8	10	7	9	9	8	8	8	7	8	7	7	6	6	6	6	6	6	6
7	10	8	7	11	9	11	8	9	9	9	10	9	7	9	7	7	8	8
33	30	31	30	32	30	31	31	32	32	31	32	10	8	11	9	9	8	11
5	7	7	7	10	6	10	7	5	5	6	7	9	35	34	32	32	34	31
24	22	24	23	23	25	22	22	22	22	22	23	23	21	6	5	5	8	8
5	4	4	4	4	4	4	4	4	4	4	5	4	5	4	24	23	24	25
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	
8	7	7	7	9	7	8	7	7	7	7	8	9	10	8	8	7	5	5
6	8	6	6	10	6	11	7	4	4	6	8	7	7	9	5	6	5	7

Table 1.Number of Ourliers. Each column represents 1 iteration of cross validation. The first 8 rows are patients. The 9th row is the validated control subject . The remaining rows are control subjects used for boxplot training.

By setting an appropriate threshold for the number of outliers, an average sensitivity of the 87.5% and specificity of 78.9% were achieved by 19-fold cross validation. Similar results were obtained for the other network measures.

Conclusion and future work: Small world network properties can be served as efficient features in separation of normal and patients in FMRI interictal state. To further improve the classification accuracy, other measurements such as coherence and partial correlation/coherence will be used for connectivity matrix. Influence on the network topology by various preprocessing such as RETROICOR will be investigated.

Reference

Wasserman,S.,Faust, K., 1994.SocialNetwork Analysis: Methods and Application.