

정신분열병과 양극성장애에서 뇌파 동시성의 비교분석*

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The Differences of EEG Coherence between Schizophrenia and Bipolar Disorder*

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ABSTRACT

Objectives : EEG coherence could imply the connectivity between two different areas of the brain, which is known to be important in the pathophysiology of bipolar I disorder(BPD I) and schizophrenia. The authors investigated EEG coherence in patients with BPD I and schizophrenia to examine the connectivity of the neural circuit.

Methods : EEGs were recorded in 15 schizophrenia and 14 bipolar disorder patients, and 14 age - matched normal control subjects from 16 electrodes with linked - ear reference. Spectral parameters and coherence were calculated for the alpha bandwidth(8 - 13Hz) by a multi - channel autoregressive model using 20 artifact - free 2 - seconds epochs and the differences were compared among three groups by two different statistical methods ; *F* - test and Kruskal - Wallis test. Furthermore, when there were significant differences among three groups, Scheffe's multiple comparison tests were provided and Jonckheere - Terpstra tests for the ordered alternative were given.

Results : In the intra - hemispheric comparison, left frontal coherence was increased in order of control, BPD I and schizophrenia. In the inter - hemispheric comparison, 1) inter - prefrontal coherence in BPD I was signifi-

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cantly higher than in normal controls, and 2) inter - prefrontal coherence in schizophrenia was significantly lower than in controls.

Conclusion : These results suggest that 1) both schizophrenia and BPD I are diseases having the abnormality of neural circuit connectivity in both frontal and prefrontal lobes, and 2) the abnormality is more severe in schizophrenia than in BPD I. Furthermore, the data support that a common pathogenetic process may reside in both schizophrenia and BPD I.

KEY WORDS : EEG · Coherence · Schizophrenia · Bipolar disorder.

서 론

Kraepelin (manic depressive psychosis) (dementia praecox) , (postsynaptic potentials) (coherence) (synchroni- zation) , (14) , (15)(16) Thatcher

가 .1) , 17) .2-5) , 18)(19) .6)(7) , 20) Merrin Floyd²¹⁾ 가 8) , 22)(23) 가 24) 9)(10) (connectivity) 11-13) (, , ,) 가 . 25) Flor - (Electroencephalogram ; EEG) Henry Kole²⁶⁾ (disorgani- (pyramidal cells)

zation) 가
(mania)

. Abrams Taylor ²⁷⁾

, Shagass ²⁸⁾

. Koles ²⁹⁾

가

가

(power)

Small ³⁰⁾

(temporal lobe)

. Merrin ³¹⁾

가

. Oluboka ³²⁾

(trait marker)가

³⁶⁾

- Aminobutyric Acid(GABA)

GABAB

³⁷⁾

가

가

연구대상 및 방법

1. 연구대상

14 2004 9

2005 1

15

14

가 DSM - TR

criteria³⁸⁾

20 55 9

()

(non - genetic factor)

lithium, sodium valproate

lygenic threshold model)³³⁾

(po-

가

chlorpromazine 가 (equivalent)

606.43(±601.12)mg

. Galton

(quantitative ge-

³⁹⁾

netics)

가 Reich ³⁴⁾

(quantitative trait model)

가

가

³³⁾³⁵⁾

Kelsoe³³⁾

가

가

가

(1).

가

Table 1. Demographic data of study groups(mean ± SD)

	Controls	Schizophrenia	BPD I
Numbers of patients	14	15	14
Sex			
Male	7	10	5
Female	7	5	9
Age(year)	31.5 ± 9.7	38.9 ± 6.6	35.3 ± 6.9
Education	13.0 ± 1.4	12.4 ± 2.7	12.2 ± 2.3
Duration(year)	.	14.8 ± 8.7	11.3 ± 10.3

One-way ANOVA test, No differences between groups are statistically significant, BPD I : Bipolar I disorder most recent manic

2. 연구방법

1) 뇌파의 동시성

(1)

2 (linked - ear reference) 5 10~20 system 10k (outer canthus) 1cm (electroophthalmography ; EOG) band pass filter 1~64Hz 60Hz notch filter Nyquist Theorem 128 sample/sec 12 - bit analog - to - digital conversion (artifact) 가 2 20 epoch (Fast Fourier Transforms) (algorithm) epoch (wave, 8~13Hz)

(2)

(Coh) (f) (a, b)

$$\text{Coh}_{ab}(f) = S_{ab}(f)^2 / (S_a(f) \times S_b(f))$$

(multichannel autoregressive model).¹⁶⁾
 (intrahemisphere) (inter-hemisphere)
 (P1F3, P2F8, FP1F3, FP2F4, FP1C3, FP2C4, F7C3, F8C4, F3C3, F4C4), (O1P3, O2P4, O1T5, O2T6, O1C3, O2C4, P3C3, P4C4, T5C3, T6C4) (O1FP1, O2FP2, O1F7, O2F8, O1F3, O2F4, P3FP1, P4FP2, P3F7, P4F8, P3F3, P4F4, T5FP1, T6FP2, T5F3, T6F4)
 8 (FP1FP2, F7F8A, F3F4, T3T4, C3C4, T5T6, P3P4, O1O2)

2) 통계분석

One - way analysis of variance(ANOVA) AN-OVA F - Kruskal - Wallis(K-W) F - 가 K-W 가 가 가 가 가 (ANCOVA : Analysis of Covariance) F - 가 Scheffe 가 Jonckheer - Terpstra(J-T) SPSS(Statistical Package for the social science) 11.0 for Windows 0.05

결 과

1. 성별 및 연령 분포

(1).

2. 반구내 동시성

(8~13Hz) FP1C3($F=4.87$, $p=0.013$; $K-W=10.647$, $p=0.005$), F7C3($F=4.13$, $p=0.023$; $K-W=8.45$, $p=0.015$), F3C3($F=7.84$, $p=0.001$; $K-W=13.28$, $p=0.001$), P3F3($F=4.54$, $p=0.017$; $K-W=7.749$, $p=0.021$) F8C4($F=3.35$, $p=0.045$; $K-W=6.648$, $p=0.036$)

(1).

(ANCOVA)

F8C4($F=2.11$, $p=0.13$)

가

(1, 2).

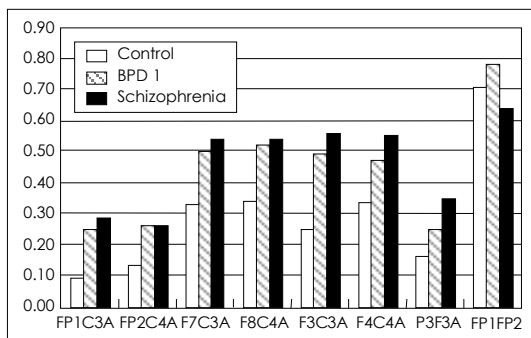


Fig. 1. Mean coherence of statistically significant pairs of electrodes among controls, schizophrenia and bipolar disorder. X-axis : significant electrodes, Y-axis : coherence values. A : alpha wave, BPD I : Bipolar I Disorder, FP2C4A($F: 2.04$, $p: 0.144$) and F4C4A ($F: 3.06$, $p: 0.058$); not significant, presented for comparison.

F4C4 $K-W$ $p=$
0.043 $F-$ (p=0.058)

가 , $J-T$

FP1F3($J-T=1.965$, $p=0.049$) ,

가

(1, 2).

가

$J-T$

, FP1C3($J-T=2.677$, $p=0.007$), F7C3 ($J-T=2.25$, $p=0.025$), F8C4($J-T=2.112$, $p=0.035$), F3C3($J-T=2.817$, $p=0.005$)

가

T6C4 T6C4($F=1.63$, $p=0.209$; $K-W=4.32$, $p=0.115$) $F-$ $K-W$

가

$J-T$ T6C4($J-T=2.14$, $p= 0.033$)

가

3. 반구간 동시성

(prefrontal lobe)

FP1FP2

($F=4.16$, $p=0.023$; $K-W=7.69$, $p=0.021$)

가

(1).

FP1FP2($J-T=2.763$, $p=0.006$)

(2).

가

고 찰

(intra-hemisphere)

(inter-hemisphere)

가

가

가

가 (pre-frontal lobe)

(pre-

Table 2. Difference of wave(8 - 13Hz) coherences at each pairs of electrodes among schizophrenia, bipolar disorder and controls

Variable	Group	Control(n=14)	SPR(n=15)	BPD I(n=14)	Test statistic		p-value
		Mean(SD)	0.7(0.46)	0.7(0.13)	0.72(0.13)	F	0.12
FP1F7	Rank-Sum	21.46	21.40	23.18	K-W	0.197	0.906
			324.5		J-T	0.382	0.703
FP2F8	Mean(SD)	0.69(0.16)	0.68(0.19)	0.71(0.16)	F	0.16	0.852
	Rank-Sum	20.82	21.63	23.57	K-W	0.392	0.822
			332.500		J-T	0.574	0.566
FP1F3	Mean(SD)	0.71(0.16)	0.61(0.16)	0.73(0.14)	F	2.4	0.103
	Rank-Sum	24.25	16.60	25.54	K-W	4.500	0.105
			394.500		J-T	1.965	0.049*1)
FP2F4	Mean(SD)	0.57(0.20)	0.55(0.20)	0.61(0.15)	F	0.5	0.609
	Rank-Sum	21.71	19.97	24.46	K-W	0.969	0.616
			334.000		J-T	0.589	0.556
FP1C3	Mean(SD)	0.09 ^a (0.08)	0.29 ^b (0.22)	0.25(0.19)	F	4.87	0.013*
	Rank-Sum	13.29	26.57	25.82	K-W	10.647	0.005**
			424.500		J-T	2.677	0.007**
FP2C4	Mean(SD)	0.14(0.09)	0.26(0.25)	0.26(0.19)	F	2.04	0.144
	Rank-Sum	17.64	22.77	25.54	K-W	3.031	0.220
			377.500		J-T	1.598	0.110
F7C3	Mean(SD)	0.33 ^c (0.14)	0.54 ^d (0.22)	0.5(0.24)	F	4.13	0.023*
	Rank-Sum	14.14	26.73	24.79	K-W	8.450	0.015*
			408.000		J-T	2.249	0.025*
F8C4	Mean(SD)	0.34(0.17)	0.54(0.23)	0.52(0.26)	F	3.35	0.045*
	Rank-Sum	14.96	25.77	25.00	K-W	6.648	0.036*
			402.000		J-T	2.112	0.035*
F3C3	Mean(SD)	0.25 ^e (0.13)	0.56 ^f (0.24)	0.49 ^g (0.27)	F	7.84	0.001**
	Rank-Sum	12.18	28.17	25.21	K-W	13.280	0.001**
			433.500		J-T	2.817	0.005**
F4C4	Mean(SD)	0.34(0.17)	0.55(0.23)	0.47(0.30)	F	3.06	0.058
	Rank-Sum	15.46	26.83	23.36	K-W	6.290	0.430
			387.000		J-T	1.777	0.076
O1P3	Mean(SD)	0.76(0.10)	0.71(0.15)	0.78(0.11)	F	1.12	0.336
	Rank-Sum	22.57	19.33	24.29	K-W	1.264	0.532
			324.000		J-T	0.371	0.711
O2P4	Mean(SD)	0.76(0.11)	0.75(0.12)	0.81(0.08)	F	1.21	0.309
	Rank-Sum	21.04	19.70	25.43	K-W	1.785	0.410
			349.000		J-T	0.957	0.339
O1T5	Mean(SD)	0.86(0.06)	0.82(0.13)	0.87(0.07)	F	1.12	0.336
	Rank-Sum	22.18	19.50	24.50	K-W	1.522	0.467
			329.500		J-T	0.551	0.581

One-way ANOVA, Mean(Standard Deviation), K-W : Kruskal-Wallis test, J-T : Jonckheere-Terpstra test, SPR : Schizophrenia, BPD I : Bipolar I disorder.

* : p<0.05, ** : p<0.01.

Scheffe's post hoc test : a<b, c<d, e<f, e<g, h<i, j<k

1) SPR<Control<BPD I, 2) Control<SPR<BPD I

Table 2. Continued

Variable	Group	Control(n= 14)			SPR(n=15)			BPD I(n= 14)			Test statistic	p-value
		Control(n= 14)	SPR(n=15)	BPD I(n= 14)	Control(n= 14)	SPR(n=15)	BPD I(n= 14)	Control(n= 14)	SPR(n=15)	BPD I(n= 14)		
O2T6	Mean(SD)	0.86(0.05)	0.85(0.07)	0.84(0.08)	F	0.32	0.731					
	Rank-Sum	23.43	21.40	21.21	K-W	0.339	0.844					
				287.000	J-T	- 0.525	0.600					
O1C3	Mean(SD)	0.45(0.17)	0.47(0.15)	0.49(0.13)	F	0.21	0.816					
	Rank-Sum	20.32	22.27	23.39	K-W	0.446	0.800					
				336.500	J-T	0.648	0.517					
O2C4	Mean(SD)	0.48(0.17)	0.47(0.15)	0.53(0.14)	F	0.57	0.568					
	Rank-Sum	20.86	20.30	24.96	K-W	1.218	0.544					
				346.500	J-T	0.876	0.381					
P3C3	Mean(SD)	0.76(0.12)	0.8(0.05)	0.77(0.06)	F	0.74	0.481					
	Rank-Sum	21.07	24.73	20.00	K-W	1.383	0.501					
				295.000	J-T	- 0.319	0.750					
P4C4	Mean(SD)	0.8(0.10)	0.81(0.09)	0.81(0.09)	F	0.09	0.916					
	Rank-Sum	20.43	22.20	23.36	K-W	0.459	0.795					
				335.500	J-T	0.668	0.504					
T5C3	Mean(SD)	0.55(0.16)	0.63(0.12)	0.64(0.12)	F	1.87	0.167					
	Rank-Sum	16.43	24.93	24.43	K-W	4.313	0.116					
				383.500	J-T	1.727	0.084					
T6C4	Mean(SD)	0.57(0.16)	0.63(0.10)	0.66(0.13)	F	1.63	0.209					
	Rank-Sum	16.96	22.57	26.43	K-W	4.323	0.115					
				400.500	J-T	2.138	0.033* ²⁾					
O1FP1	Mean(SD)	0.21(0.12)	0.21(0.17)	0.14(0.11)	F	1.14	0.329					
	Rank-Sum	24.71	22.83	18.39	K-W	1.992	0.369					
				250.000	J-T	- 1.333	0.183					
O2FP2	Mean(SD)	0.22(0.15)	0.2(0.19)	0.16(0.11)	F	0.51	0.604					
	Rank-Sum	24.32	21.53	20.18	K-W	0.832	0.660					
				269.500	J-T	- 0.879	0.379					
O1F7	Mean(SD)	0.34(0.15)	0.33(0.19)	0.27(0.12)	F	0.81	0.451					
	Rank-Sum	24.39	23.40	18.11	K-W	2.150	0.341					
				249.000	J-T	- 1.351	0.117					
O2F8	Mean(SD)	0.32(0.17)	0.37(0.22)	0.29(0.16)	F	0.72	0.494					
	Rank-Sum	21.79	24.93	19.07	K-W	1.637	0.441					
				269.000	J-T	- 0.490	0.618					
O1F3	Mean(SD)	0.21(0.10)	0.25(0.17)	0.16(0.09)	F	1.54	0.227					
	Rank-Sum	22.86	25.40	17.50	K-W	3.139	0.208					
				262.000	J-T	- 1.056	0.291					
O2F4	Mean(SD)	0.18(0.14)	0.19(0.15)	0.17(0.14)	F	0.09	0.915					
	Rank-Sum	21.71	22.83	21.39	K-W	0.111	0.946					
				303.000	J-T	- 0.114	0.909					

One-way ANOVA, Mean(Standard Deviation), K-W : Kruskal-Wallis test, J-T : Jonckheere-Terpstra test, SPR : Schizophrenia, BPD I : Bipolar I disorder.

* : p<0.05, ** : p<0.01.

Scheffe's post hoc test : a<b, c<d, e<f, e<g, h<i, j<k

1) SPR<Control<BPD I, 2) Control<SPR<BPD I

Table 2. Continued

Variable	Group	Group			Test statistic	p-value	
		Control(n=14)	SPR(n=15)	BPD I(n=14)			
P3FP1	Mean(SD)	0.11(0.10)	0.19(0.19)	0.15(0.13)	F	1.26	0.294
	Rank-Sum	18.64	24.67	22.50	K-W	1.849	0.397
				343.500	J-T	0.826	0.409
P4FP2	Mean(SD)	0.16(0.12)	0.19(0.21)	0.18(0.14)	F	0.12	0.892
	Rank-Sum	21.75	21.63	22.64	K-W	0.058	0.972
				314.000	J-T	0.137	0.891
P3F7	Mean(SD)	0.26(0.13)	0.39(0.22)	0.32(0.19)	F	1.63	0.208
	Rank-Sum	17.61	26.20	21.89	K-W	3.489	0.175
				346.500	J-T	0.870	0.384
P4F8	Mean(SD)	0.27(0.15)	0.43(0.24)	0.38(0.21)	F	2.29	0.115
	Rank-Sum	16.79	25.93	23.00	K-W	4.067	0.131
				368.500	J-T	1.364	0.172
P3F3	Mean(SD)	0.16 ^h (0.06)	0.35 ⁱ (0.21)	0.25(0.18)	F	4.54	0.017*
	Rank-Sum	15.82	28.40	21.32	K-W	7.749	0.021*
				361.000	J-T	1.215	0.224
P4F4	Mean(SD)	0.21(0.14)	0.33(0.21)	0.3(0.22)	F	1.48	0.239
	Rank-Sum	17.64	24.87	23.29	K-W	2.751	0.253
				362.500	J-T	1.246	0.213
T5FP1	Mean(SD)	0.29(0.13)	0.29(0.21)	0.21(0.16)	F	0.98	0.384
	Rank-Sum	24.43	23.37	18.11	K-W	2.109	0.348
				251.500	J-T	-1.279	0.201
T6FP2	Mean(SD)	0.29(0.16)	0.27(0.23)	0.21(0.13)	F	0.84	0.44
	Rank-Sum	24.71	22.07	19.21	K-W	1.406	0.495
				261.000	J-T	-1.072	0.284
T5F3	Mean(SD)	0.3(0.15)	0.4(0.19)	0.29(0.17)	F	1.77	0.184
	Rank-Sum	19.71	27.03	18.89	K-W	3.852	0.146
				303.000	J-T	-0.113	0.910
T6F4	Mean(SD)	0.29(0.19)	0.31(0.15)	0.26(0.20)	F	0.2	0.819
	Rank-Sum	21.79	23.77	20.32	K-W	0.568	0.753
				294.500	J-T	-0.305	0.760
FP1FP2	Mean(SD)	0.71 ⁱ (0.14)	0.64 ^k (0.15)	0.78(0.09)	F	4.16	0.023*
	Rank-Sum	22.25	15.83	28.36	K-W	7.685	0.021*
				428.000	J-T	2.763	0.006 ^{**1)}
F7F8	Mean(SD)	0.5(0.15)	0.43(0.24)	0.54(0.16)	F	1.09	0.346
	Rank-Sum	22.64	18.73	24.86	K-W	1.818	0.401
				328.500	J-T	0.464	0.643
F3F4	Mean(SD)	0.25(0.18)	0.33(0.32)	0.43(0.23)	F	1.78	0.183
	Rank-Sum	18.43	20.87	26.79	K-W	3.347	0.188
				383.500	J-T	1.698	0.090*

One-way ANOVA, Mean(Standard Deviation), K-W : Kruskal-Wallis test, J-T : Jonckheere-Terpstra test, SPR : Schizophrenia, BPD I : Bipolar I disorder.

* : p<0.05, ** : p<0.01.

Scheffe's post hoc test : a<b, c<d, e<f, e<g, h<i, j<k

1) SPR<Control<BPD I, 2) Control<SPR<BPD I

Table 2. Continued

Variable	Group	Control(n=14)	SPR(n=15)	BPD I(n=14)	Test statistic		p-value
		Mean(SD)	0.47(0.12)	0.42(0.18)	0.49(0.09)	F	0.91
T3T4	Rank-Sum	22.96	18.67	24.61	K-W	1.851	0.396
			323.000		J-T	0.345	0.730
C3C4	Mean(SD)	0.2(0.12)	0.33(0.29)	0.37(0.21)	F	2.35	0.109
	Rank-Sum	14.18	22.77	26.00	K-W	3.643	0.162
T5T6	Rank-Sum		387.000		J-T	1.786	0.074
	Mean(SD)	0.63(0.14)	0.57(0.19)	0.62(0.10)	F	0.78	0.467
P3P4	Rank-Sum	23.96	19.70	22.50	K-W	0.911	0.634
			295.500		J-T	-0.285	0.775
O1O2	Mean(SD)	0.59(0.13)	0.59(0.21)	0.68(0.11)	F	1.51	0.233
	Rank-Sum	19.39	20.33	26.39	K-W	2.677	0.262
O1O2	Rank-Sum		369.500		J-T	1.367	0.163
	Mean(SD)	0.83(0.08)	0.76(0.14)	0.83(0.08)	F	2.12	0.133
O1O2	Rank-Sum	24.14	18.00	24.14	K-W	2.638	0.267
			308.000		J-T	18.00	24.14

One-way ANOVA, Mean(Standard Deviation), K-W : Kruskal-Wallis test, J-T : Jonckheere-Terpstra test, SPR : Schizophrenia, BPD I : Bipolar I disorder.

* : p<0.05, ** : p<0.01.

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1) SPR<Control<BPD I, 2) Control<SPR<BPD I

가 , cells)가 , 가 ,
⁴³⁾⁴⁴⁾ PET fMRI ,
⁴⁵⁾⁴⁶⁾ 가 ,
 가 ,
 (inter - prefrontal connectivity) (corpus callosum) , 가
 가 ,
 가 , 가 ,⁴⁷⁾ DTI
 (corpus callosum)
 가 ,⁴⁸⁾⁴⁹⁾
³¹⁾⁴⁰⁾
 Diffusion Tensor Imaging
 (DTI)
⁴¹⁾
 가 (pruning) (synapto-
 genesis) 가 , 가
 가 ,
 (aberrant con- (am-
 nections) 가 , ygdala), (striatum), (thalamus)
 가 , (neuronal cir-
⁴²⁾
 (pyramidal circuit) 가 ,¹²⁾²⁴⁾ DTI

(white matter tracts) , 가
(integrity) ,
¹³⁾ fMRI ,
가 가 ,
⁵⁰⁾ 가 가
(corpus callosum) , (trait
marker)가 가
, lithium ³⁰⁾ 가
, Saugstad⁵¹⁾ (heritability) 가
가 가 가
(early maturers) 가
가 ,
가 , 1) 가 , 2)
, 3)
가 ,
가 가 가
Kendler ⁴⁾ . Lee ⁵³⁾ 가 가
가 가
, Crow⁵²⁾가 가
, Berrettini³⁾가 가
(8~13Hz) .
, .
³³⁾³⁴⁾ 가 가 가 Stewart) ⁵⁸⁾ Merrin ³¹⁾ ⁵⁴⁻⁵⁷⁾ Morrison -
Small ³⁰⁾
Lithium
가
가
가
가

(temporal lobe)
 가
 (neural circuit)
 가
 가
 Kelsoe³³⁾가
 stad⁵¹⁾가
 가
 가

중심 단어 :

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