

Changes of Electroencephalography & Cognitive Function in Subjects with White Matter Degeneration

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Background : Spatial analysis of EEG is a phenomenal assessment and not so informative for phase space and dynamic aspect of EEG data. In contrast, nonlinear EEG analysis attempts to characterize the dynamics of neural networks in the brain. We have analyzed the features of EEG nonlinearly in subjects with white matter change on brain MRI and compared the results with cognitive function in each.

Methods : Digital EEG data were taken for 30 seconds in 9 subjects with white matter degeneration and in 5 healthy normal controls without white matter change on MRI. Then we analyzed them nonlinearly to calculate the correlation dimension(D2) using the MATLAB software. The cognitive function was assessed by 3MS(modified mini-mental state examination). The severity of white matter change was assessed by Scheltens scale.

Results : The mean D2 value of normal control was greater than that of white matter degeneration group. The D2s of some channels were correlative with 3MS and degree of white matter degeneration significantly.

Conclusions : nonlinear analysis of EEG can be used as one of adjuvant functional studies for prediction of cognitive impairment in subjects with white matter degeneration and subcortical white matter change can be influential on cognitive function and correlation dimension of EEG.

Key Words : Nonlinear EEG analysis, White matter degeneration, 3MS

6 1993 Scheltens 가
가 (Mini
Hachinski가 Mental State Examination, MMSE)
(leukoaraiosis) 가
가 가 가 가 가
2-5 72% modified MMSE(3MS) 가 7-10
100% 가 13가 가

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1.

2001 3 2 2001 8 31

Scheltens' scale 10

11

70 9
77.1 가4 , 가5

5 (transient global amnesia, TGA) 1
4 5

2. 가
1) 가

2

(Fig. 1).

Scheltens' scale
General electric 1.5 T scanner
T1 (TR 666 msec : TE 10 msec)
T2 (TR 3500 msec : TE 100 msec)
5 mm
Interslice thickness 3 mm
Scheltens' scale 가

Scheltens' scale
(Deep White Matter Hyperintensity : DWMC) (Basal Ganglia Hyperintensity : BGH),
(Periventricular Hyperintensity : PVH)

0
0

6 12 , 0
2 6 60
(band) (cap) (cap)
1 , 2
5 mm
3 mm
5 1 , 5
6

(Fig. 1).

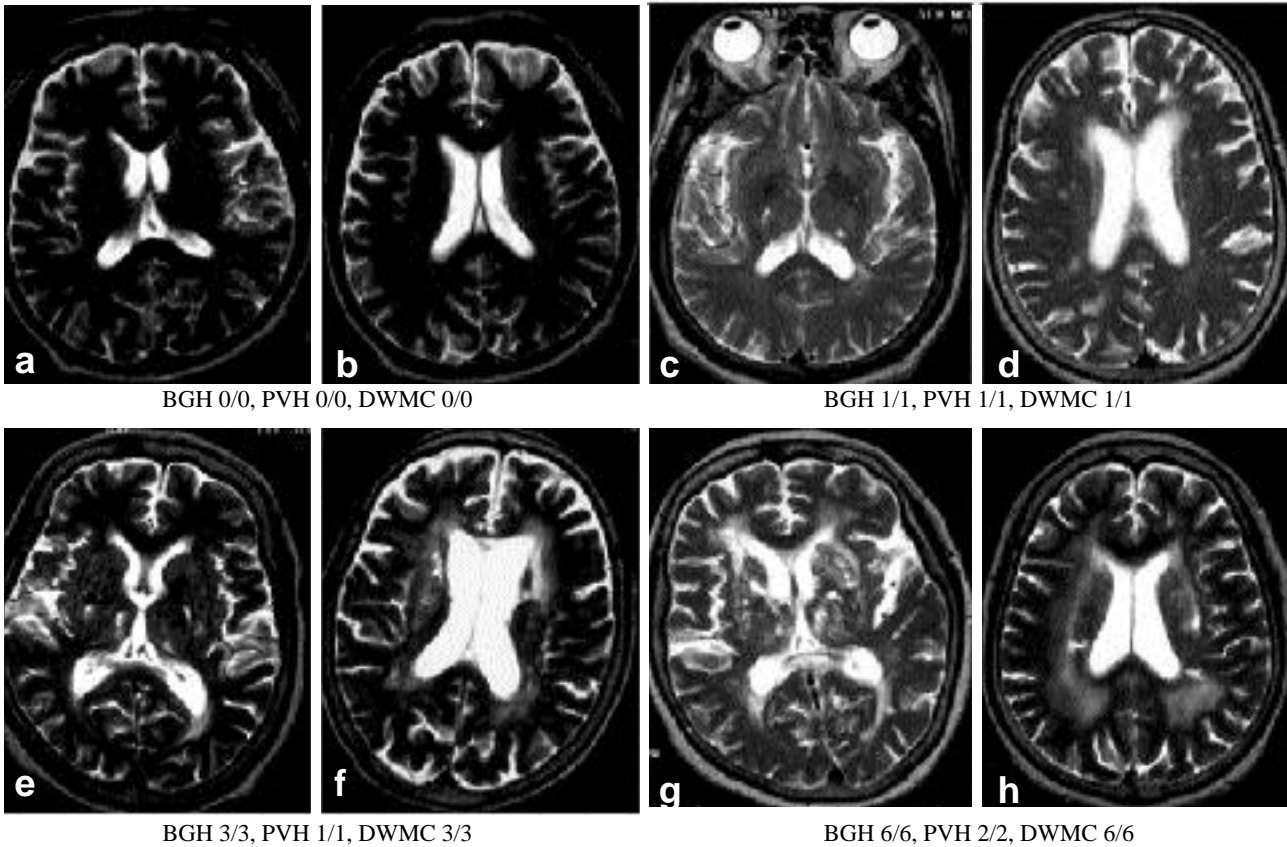


Figure 1. Some examples of Scheltens' scale

2)
 (1) "Nicolet Digital EEG System"
 10~20 19 (FP1,
 F7, T7, P7, FP2, F8, T8, P8, F3, C3, P3, O1, F4,
 C4, P4, O2, Fz, Cz, Pz)

256 Hz 7 uV/mm, 70
 Hz, 0.5 Hz
 30
 3 10

(2)
 (D2)
 3MS
 (D2)
 (D2)
 (D2)

$$D2 = \lim_{r \rightarrow 0} \frac{\log C(r)}{\log r}$$

$$C(r) = \frac{1}{Np} \sum_{i=1}^{Np} H(r - |X(i) - X(j)|)$$

D2
 $Np \cdot k(k-1)/2$
 $\log C(r) / \log(r)$
 가 가 D2
 (Fig. 2).
 (attractor)

가 가
 (Phase trajectory)

(attractor)

3) 가
 3MS 3MS
 가 가
 가
 3MS 87.20(SD=8.20)
 D2 5.0051
 (SD=0.5732). 3MS
 61.00 D2 3.5472
 3MS D2
 D2
 F7, T7, P7, F3, O1
 FP2, T8,
 P8, O2
 D2
 3MS t-test
 D2, 3MS
 (Table 1).
 D2
 Fp1, Fp2, F8,

Table 1. Results of t-test between WMC(+) & WMC(-)

Variables	WMC(-) mean ± SD	WMC(+) mean ± SD	Significance
3MS	87.2 ± 8.20	61.0 ± 11.89	0.00
D2	5.0051 ± 0.5732	3.5471 ± 2.8892	0.00

SD : standrd deviation
 WMC : white matter change

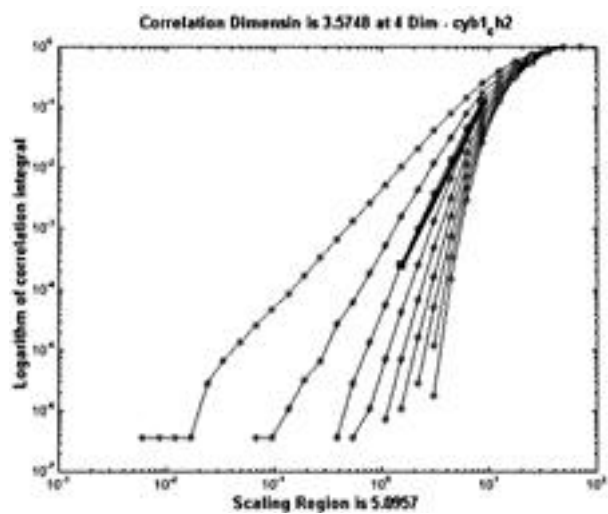


Figure 2. Calculation of D2

T8, C3, F4, O2, Fz

(fronto-temporal lobe)

DWMC

Fig. 3

Table 2. Significant categories of 3MS with respect to D2 values

Cognitive variables	WMC(+)	WMC(-)
memory	T7, P3	Pz
concentration	T7, C3, C4, Fz, Pz	
orientation	T7, P8	
fluency	O2, Pz	F8, Pz
abstract thinking	Fp2	
writing	F7, P4	
repetition	P3, C4, O2, Pz	Pz
visuo-spatial construction	P4, Pz	

WMC : white matter change

Scheltens' scale PVH, BGH, DWMC
D2 DWMC(Sig.=0.456)

PVH(Sig.=0.001) BGH(Sig.=0.020)

P7 BGH, T8
DWMC, F4 PVH, Pz DWMC

3MS D2

Table 2

3MS

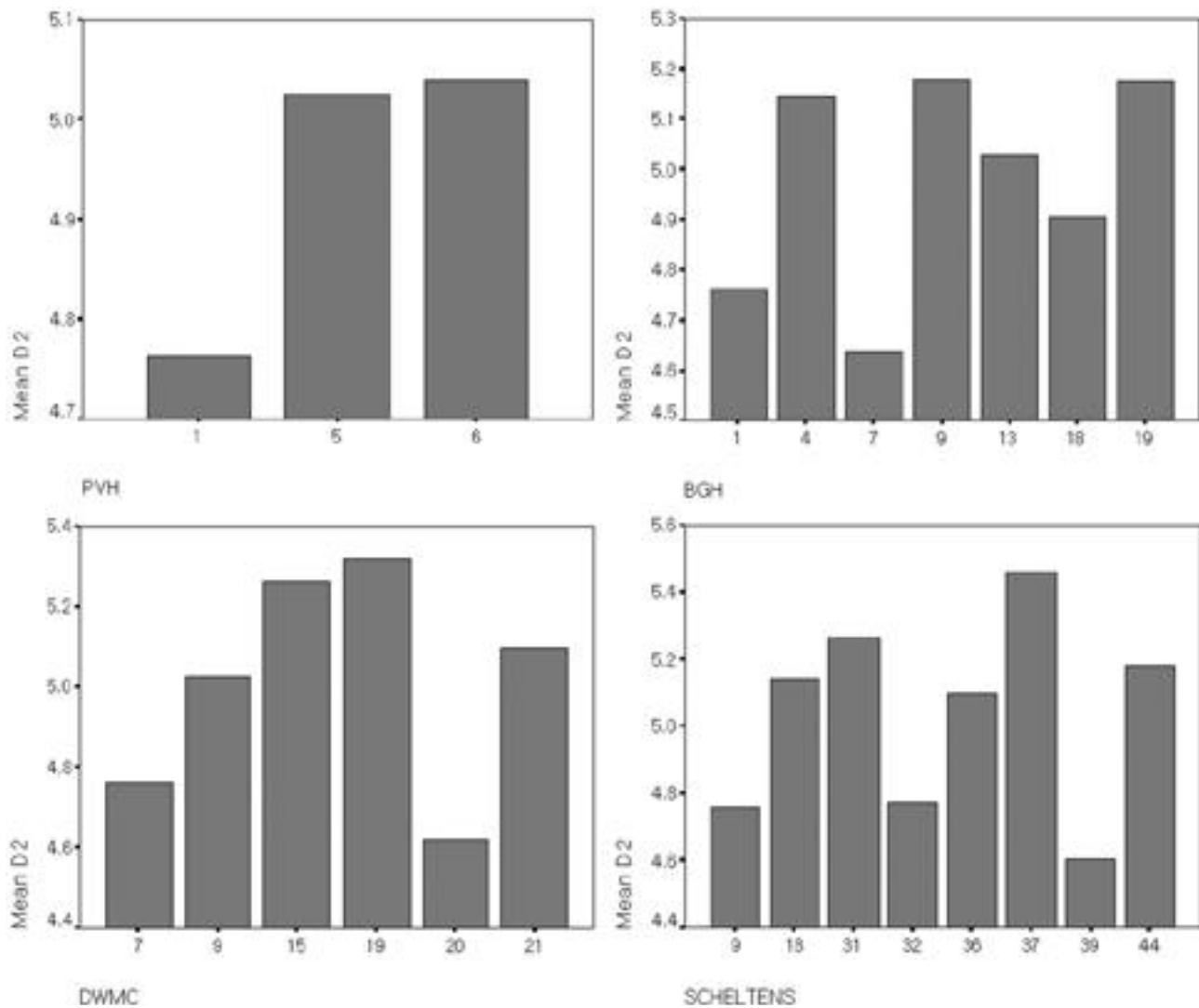


Figure 3. D2 values in relation to the severities of PVH, BGH & DWMC

가,
가,
¹²가
가
generalized burst activity
¹³
(sensorimotor cortex)
¹⁴
(quasi-stationary)
가
inspection)
(quantitative EEG; QEEG)
(parametric method) (non-parametric method)
(Fast Fourier Transformation; FFT)
(spectral analysis)
가
(power) (frequency)
가
(white noise)
AR) (autoregression; Tomberg²⁴
AR
가
3MS
(localization) 가
ics) (complex system) (nonlinear dynamics)
(chaos theory) 가 , 가 3MS
D2 가 3MS

^{15,16} D2
가 .
4~8
^{17,18}
¹⁹가
²⁰ Prichard Duke
D2
²¹ Jelles
D2
가
²² Stam
D2
3MS가
²³
D2
D2
D2
D2
D2
가 (dominant hemisphere)
3MS
Table 2
가
Fp1, Fp2, F3, F4, Fz Frontal area ,
C3, C4, Cz Central area , P7, P8, P3, O1,
P4, O2, Pz Parieto-occipital area , F7, T7,
F8, T8, Temporal area T7
O1, O2, Pz

D2
(linear property)

“Surrogate data testing method”

25

- 1.
2. D2
D2
3. D2 PVH BGH
DWMC PVH BGH
4. (T7, P3),
(T7, P8, P4, Pz)

가
가
D2

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