Journal of Affective Disorders 150 (2013) 389–392

Contents lists available at ScienceDirect

Journal of Affective Disorders

journal homepage: www.elsevier.com/locate/jad

Research report

Effects of electroconvulsive therapy on neural complexity in patients with depression: Report of three cases

Ryoko Okazaki, Tetsuya Takahashi *, Kanji Ueno, Koichi Takahashi, Masato Higashima, Yuji Wada

Department of Neuropsychiatry, Faculty of Medical Sciences, University of Fukui, Japan

ARTICLE INFO

Article history:
Received 18 January 2013
Received in revised form
12 February 2013
Accepted 19 April 2013
Available online 20 May 2013

Keywords:
Electroconvulsive therapy
Major depression
Functional connectivity
Electroencephalogram complexity
Multiscale entropy

ABSTRACT

Background: The exact neurophysiological mechanism of electroconvulsive therapy (ECT) for treating patients with depression remains elusive. Results of previous neurophysiological studies support the hypothesis that aberrant functional connectivity underlies the pathophysiology of depression, which engenders abnormal electroencephalogram (EEG) complexity.
Methods: Recently developed multiscale entropy analysis, which has underpinned aberrant functional connectivity in mental disorders, was introduced to explore changes in EEG complexity occurring with ECT in three patients with depression.
Results: All patients demonstrated a decrease in EEG complexity, especially at higher frequencies. This decrease was associated with improvement of depressive symptoms.
Limitations: The generalizability of our findings was constrained because of the small sample size and lack of a comparison with healthy controls.
Conclusions: The decrease in EEG complexity with ECT might be a result of amelioration of functional connectivity in the brain of a depressed patient. Multiscale entropy analysis might be a useful analytical method to elucidate neurophysiological mechanisms and evaluate the therapeutic efficacy of ECT in depression.

1. Introduction

Electroconvulsive therapy (ECT) is an effective option for treating patients with drug-resistant depression. Although several hypotheses of the working action of ECT have been proposed (Bolwig, 2011), the exact neurophysiological mechanism has rarely been studied. Earlier reports have provided evidence that abnormal functional connectivity plays a crucial role in the pathophysiology of depression (Fingelkurts et al., 2007; Takahashi, 2012). The recent advent of quantification of electroencephalogram (EEG) complexity has provided new insights into abnormal neural complexity and has underpinned aberrant functional connectivity in various mental disorders (Takahashi, 2012). Although several reports have described that abnormally increased EEG complexity is involved in pathophysiology in patients with depression (Ahmadlou et al., 2012; Li et al., 2008) and its amelioration in pharmacological efficacy (Mendez et al., 2011), only one case report has elucidated EEG complexity change with ECT (Thomasson and Pezard, 1999). The fact is that EEG signals of various ranges of connectivity within and across different neural subsystems might be characterized using different time scales or frequencies. Consequently, investigating the interplay between complexity of different time scales or frequencies might add another dimension to already identified aberrant functional connectivity. However, because a previous report describing EEG complexity change with ECT was based on a single scale (Thomasson and Pezard, 1999), exploring EEG complexity change with multiple temporal scales might provide useful information to ascertain neurophysiological mechanisms of ECT in depression.

Recently developed multiscale entropy (MSE) is a proposed entropy-based index of physiological complexity, evaluating signals at multiple temporal scales, in recognition of the likelihood that the dynamical complexity of biological signals might operate across a range of temporal scales (Costa et al., 2005). In fact, MSE analysis has been applied fruitfully to the assessment of EEG studies in mental disorders (Mizuno et al., 2010; Takahashi, 2012; Takahashi et al., 2010). Herein, we examined EEG complexity change with ECT in three patients with depression, using MSE to investigate changes in the functional connectivity of depression.

2. Cases

2.1. Case 1

A 66-year-old man, diagnosed as having major depression, was referred for ECT to our hospital because of his severe depressive symptoms. During the ten months before his admission, he had

* Correspondence to: Department of Neuropsychiatry, Faculty of Medical Sciences, University of Fukui, 23-3 Matsuokashimoaizuki, Eiheiji-cho, Yoshida-gun, Fukui 910-1193, Japan. Tel.: +81 776 61 8363; fax: +81 776 61 8136.
E-mail address: takahash@u-fukui.ac.jp (T. Takahashi).

0165-0327/$ - see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.jad.2013.04.029

Table 1
Physical and clinical characteristics and ECT profiles in three cases.

	Gender	Age (years)	Age of onset (years)	Medications during ECTs (mg daily)	HAM-D score			ECT treatment				Anesthesia	
					Pre-treatment	During treatment	Post-treatment	Seizure threshold for the first ECT treatment (mC)	Number of ECT (without seizure)	Mean charge (mC)	Mean seizure length (s)	Thiopental (mg)	Succinylcholine (mg)
Case 1	Male	66	55	Olanzapine (10) Quetiapine (50) Milnacipran (50) Brotizolam (0.25)	39	10	3	30% charge (98.56)	6 (0)	282.3	50	250	60
Case 2	Female	47	41	Duloxetine (60) Perospirone (4) Etizolam (20) Flunitrazepam (2) Brotizolam (0.25)	38	27	30	30% charge (149.5)	12 (4)	413.7	12.4	200	45
Case 3	Female	69	64	Duloxetine (20) Quetiapine (150) Aripiprazole (24)	45	8	2	50% charge (255.8)	6 (0)	271.3	36	200	40

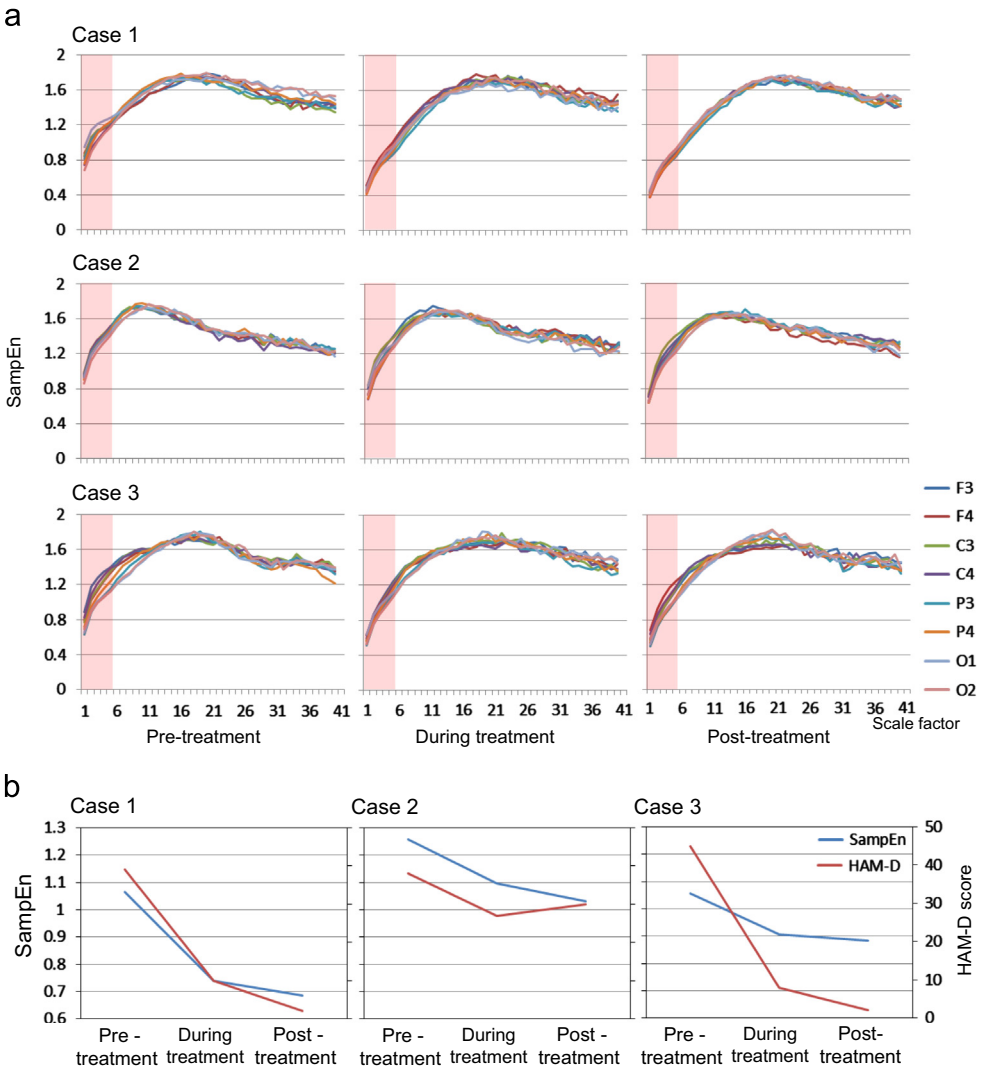

Fig. 1. (a) Multiscale entropy (MSE) analysis of three cases with depression across pre-treatment, during-treatment, and post-treatment. Decrease in sample entropy (SampEn) was observed with electroconvulsive therapy (highlighted with light red shaded area consisting of scale factors (SF) 1–5). (b) Each panel presents an association between the Hamilton Depression Rating Scale (HAM-D) score and the averaged Sample entropy (SampEn) value for each case. SampEn was calculated as a result of averaging all electrode sites and scale factors across 1–5.