Journal of Forensic and Legal Medicine 16 (2009) 59–63

Contents lists available at ScienceDirect

Journal of Forensic and Legal Medicine

journal homepage: www.elsevier.com/jflm

Original Communication

Qualitative and quantitative EEG abnormalities in violent offenders with antisocial personality disorder

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ARTICLE INFO

Article history:
Received 17 March 2008
Accepted 16 August 2008
Available online 1 October 2008

Keywords:
Electroencephalogram
Antisocial personality disorder
Violent offender
Quantitative EEG analysis

ABSTRACT

Resting eyes closed electroencephalogram was studied in a group of violent offenders evaluated at Psychiatric Department of the Legal Medicine Institute in Cuba (18 with antisocial personality disorder, ASPD, and 10 without psychiatric diagnosis). Characteristics of the EEG visual inspection and the use of frequency domain quantitative analysis techniques (narrow band spectral parameters) are described. Both groups were compared to Cuban normative database. High incidences of electroencephalographic abnormalities were found in both groups of violent offenders. The most frequent were: electrogenesis alterations, attenuated alpha rhythm and theta and delta activities increase in the frontal lobe. In the quantitative analysis theta and delta frequencies were increased and alpha activity was decreased in both groups. Differences appear for the topographical patterns present in subjects of both groups. EEG abnormalities were more severe in ASPD than in control group. Results suggest that EEG abnormalities in violent offenders should reflect aspects of brain dysfunction related to antisocial behaviour.

1. Introduction

Antisocial personality disorder (ASPD) is a relatively common psychiatric diagnosis. Prevalence estimates in the general population are 3% for men and 1% for women (DSM-IV-R, American Psychiatric Association, 2000).[1] This disorder is associated with a pervasive pattern of disregard for and violation of the rights of others, that begins in childhood or early adolescence and continues into adulthood, and not surprisingly, the highest prevalence rates of ASPD are found in prisons and forensic settings.[1] Several studies indicate an interaction between biological factors and social factors in the development of antisocial behaviour.[2–7]

In the last years there has been an increased interest in studying the neurobiology of personality disorders[8–10], and in particular ASPD.[11,12] The brain regions more compromised in antisocial populations include frontal and temporal lobes.[4,13,14] Functional alterations in these regions have been related with different types of violent behaviours while temporal lobe dysfunction may be associated with sexual offending, frontal lobe dysfunction has been claim to be associated with non-sexual violent offending.[15]

Neuroimaging studies have shown the involvement in this pathological condition of prefrontal areas, especially orbitofrontal cortex, and amygdala.[16–20] Also, impaired serotonin (5-HT) neurotransmission has been implicated, since subject with ASPD present alterations in measures of 5-HT system, such as blunted hormonal response to 5-HT pharmacological challenges and reduced 5-HT receptors numbers.[21–25]

A large number of studies have found EEG abnormalities in violent offenders. Hill and Pond (1952) and Bach-y-Rita et al. (1971) examined large samples of violent offenders and observed EEG abnormalities in about 50% of the subjects.[26,27]These findings have been replicated by other studies of murderers and other types of violent offenders.[16,28–31] One of the most frequently observed EEG abnormality consists of excessive slow wave activity. Whereas earlier studies were generally more qualitative, EEG technology has become increasingly more advanced, allowing for detailed quantitative computerized analyses instead of clinical visual inspection.

EEG studies of antisocial groups have become less common over the last several years. The reason has been due to the development of more advanced functional brain imaging techniques such as PET and fMRI that has begun to dominate the field. These techniques provide better spatial resolution and allow for the examination of specific subcortical structures, but there is evidence that EEG is sufficiently sensitive to detect differences when comparing these subjects with controls, even in relatively small sample sizes.[31,32]

However, the increasing information of neurological impairment in antisocial individual, very few studies have been conducted specifically to assess abnormal findings by means of quantitative EEG analysis in subjects with this disorder. For this reason the aim of this study was to investigate whether visual

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doi:10.1016/j.jflm.2008.08.001

and quantitative analysis of EEG could differentiate violent offenders with ASPD, and those without this psychiatric diagnosis and to quantify the nature of these differences. It is hypothesised that subject with ASPD will have increased theta activity, with reduced levels of alpha compared to normal subjects, and that violent offenders without this disorder have similar abnormalities but at a lesser degree.

2. Methods

2.1. Subjects

The study included 28 males who underwent forensics evaluation at the Psychiatric Department of the Legal Medicine Institute of Cuba for having been authors of criminal acts during the period of January 2002 to December 2005. Written informed consent was obtained from all subjects prior the study. This study was approved by the Ethics Committee of the Legal Medicine Institute.

The experimental group comprised 18 violent offenders with ASPD according to the DSM-IV-R criteria (mean age 28.5, SD = 7.82 years). The control group consisted of 10 male violent offenders (mean age of 26.7, SD = 6.5 years) whom not fulfil the criteria of the DSM-IV-R for any diagnosis of personality disorder.

The psychiatric diagnosis was made using clinical and forensic histories of all subjects, which included personal history, education, drug use, mental status, results of structured clinical interview for DSM-IV-R and psychometric tests performed by forensics psychiatrist and psychologist. None of the offenders had a history of major traumatic brain injury and all scored within the range of normal intelligence, measured by the Wechsler Adult Intelligence Scale-Revised (WAIS-R). The criteria for ASPD, included a behavioural pattern that begins before age 15 and comprised at least three of the following behaviours: repeated criminal acts, deceitfulness, impulsiveness, repeated fights or assaults, disregard for the safety of others, irresponsibility and lack of remorse. No subjects were taking any medication at the time of testing.

2.2. EEG procedure

A 21-channel digital EEG equipment from Neuronic SA (RAPTOR 26, Cuba) and an IBM compatible computer were used in the acquisition and storage of EEG data. EEG was recorded from 19 electrode sites (Fp1, Fp2, Fz, F3, F4, F7, F8, Cz, C3, C4, T3, T4, T5, T6, Pz, P3, P4, O1 and O2) according to the International 10–20 system, using surface electrodes referenced to linked ears. Impedance was kept below 5 kV. EEG was amplified by 10,600, with a bandpass at 0.5–30 Hz and sampled through a 12-bit analogue-to-digital converter at 200 Hz.

Electrodes were fitted while subjects were familiarised with the testing equipment and procedure. EEG record was carried out in a quiet, air-conditioned room with the experimenter and recording equipment present. All subjects were instructed to relax and to remain still during testing to minimise artefacts produced by ocular movements, and to avoid excessive blinking. During the recording the subjects were awake with eyes closed, lying on the bed.

Eight to ten minutes of EEG with closed eyes, 2 min of open eyes, 3 min of hyperventilation, 2 min of recuperation were obtained from each subject. In this paper only closed eyes EEG data will be presented.

2.3. Visual assessment of the EEG

Longitudinal and transverse bipolar montages were used for off-line EEG interpretation. The EEG was considered NORMAL if it had an adequate organization of the background activity (according to the subject's age), well defined spatial differentiation, rhythmical alpha activity and absence of paroxysmal activity. The SLOW EEG subgroup was characterized by the presence of persistent non-rhythmic theta–delta slow waves. PAROXYSMAL category included the EEG with activity such as spikes, sharp wave and spike and wave. EEGs with both types of previously described abnormalities were considered in the SLOW and PAROXYSMAL category. Ratios and percentages in all categories were calculated.

2.4. Quantitative EEG analysis (QEEG)

Tracings were visually inspected and edited off-line in order to eliminate epochs with movement artefacts, eye blinking, muscle activity, or drowsiness. For each subject 20–24 EEG segments (without artefact) of 2.56 s at the closed eyes state were selected. Spectral analysis using Fast Fourier Transform (FFT) was carried out in order to obtain the cross-spectral matrixes estimation in all individual records.[33,34] Cross-spectral matrices were calculated for every 0.39 Hz, from 0.78 to 19.53 Hz. All QEEG analysis was made on monopolar leads (linked ears used as reference).

2.5. Statistical analysis

Both experimental and control groups were compared with Cuban normative database by using the *Z* transform.[35] This normative database was constructed from the EEG of 211 normal subjects (105 males, 106 female) and covers an age range from 5 to 97 years. Normative coefficients were obtained by carrying out a polynomial regression with age of each log spectral value. Normalized values, expressed as the number of standard deviations from the mean of the norm, were calculated for every frequency and electrode and stored as a "*Z* spectrum"[35]. Factors like age might affect EEG data by increasing inter-individual variability.[36] The use of normalized values for statistical analysis eliminates these effects that, otherwise, should have been taken into account for comparisons between the groups.

Z values of power for each frequency of both groups were compared by a non-parametric combination of permutation tests.[37,38] This technique allows a distribution-free analysis of the data, and also controls for type I errors, while permitting multiple comparisons in order to detect significant differences in frequencies and electrodes between the groups. Analyses were performed for all measures using a specific software system developed to accomplish it. The level of significance was 0.05 in all cases.

3. Results

3.1. Visual inspection

Visual analyses of rest EEG revealed that 10 violent offenders (42.6%) had disorganization of the background activity, with amplitude of medium voltage range and alpha rhythm attenuation, sometimes barely incipient. Eight of them met ASPD criteria.

Table 1 presents details of the EEG visual analysis results. In both groups results were very similar; SLOW EEG was the category with most subjects in it (around 70%). It was followed by NORMAL EEG (around 20%). Only three subjects of both groups belong to the other two categories. Comparison by means of a Pearson Chi square test found no significant differences between the two

Table 1
Classification of the subject's EEG in both groups by visual inspection

Group	Normal	Slow	Paroxysmal	Slow and paroxysmal
Experimental	3 (16.7%)	13 (72.2%)	1 (5.6%)	1 (5.6%)
Control	2 (20%)	7 (70%)	1 (10%)	0 (0%)