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DETRENDED FLUCTUATION ANALYSIS AND PARABOLICITY INDEX IN AGED RATS WITH *STATUS EPILEPTICUS* ELICITED BY PILOCARPINE ACUTELY

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Abstract: The electrical activity of the brain has been studied by scientists specialized in different areas of the knowledge and particularly neurophysiologists. Amongst the several neurological disorders, epilepsy has drawn the most attention because this disorder can affect the life's quality of an individual even under treatment. In this paper we applied the nonlinear dynamic analysis to the electrocorticogram (ECoG) from old epileptic rats using parabolicity index (b), which is a parameter derivative from the Detrended Fluctuation Analysis (DFA). Epilepsy has higher probabilities of occurrence in children than others ages, but only a few works have been realized with old animals. Are they more resistant even when the *status epilepticus* is induced by pilocarpine ? To addresses this issue we determined the DFA α exponent and based in this α values we calculated the parabolicity index (b) aiming to detect a difference between normal and with *status epilepticus* elicited by pilocarpine acutely in aged rats.

keywords: DFA, parabolicity index, *status epilepticus*

1. INTRODUCTION

Epilepsy is a chronic neurological disorder that is characterized by recurrent unprovoked seizures. These seizures are due to abnormal, excessive or synchronous neuronal activity in the brain. For description of a neural network such as a brain, normal or epileptic, the application of nonlinear dynamics is necessary to investigate different aspects of its complexity [1]. The nonlinear analysis method is effectively applied to electroencephalogram (EEG) to study the dynamics of its complex behavior [2]. The main utility of this method as a parameter of diagnostic for mental health evaluation mainly rests on the non-invasive nature of EEG. The approach is based on the principles of nonlinear dynamics and deterministic chaos that involves the characterization of the system attractors with its invariant parameters. This method is far more superior to the traditional linear methods such as the Fourier transforms and power spectral analysis [2].

DETRENDED FLUCTUATION ANALYSIS AND PARABOLICITY INDEX (B)

The Detrended Fluctuation Analysis (DFA) of the amplitude fluctuations of the ECoG in the time intervals of 10 s were segmented and a DFA software from the physionet (www.physionet.org) was used to find a scaling exponent (α) [3]. The DFA calculates the scaling exponent by the root-mean-square fluctuation of the integrated and linearly detrended signals, $F(w)$, as a function of window size, w. For signals that have no correlation $\alpha=0.5$. For series that have power-law correlations the $0.1<\alpha<0.5$ or $0.5<\alpha<1.0$, the power law comes from the amplitude fluctuation $F(w)$ that is $F(w)\sim w^{\alpha}$; the DFA scaling exponent, α, the value indicate power-law scaling behavior and the presence of temporal correlations [3].

The deviations from Power-Law observed in the calculation of scaling exponent α in the di-log graphic was calculated by a derivative parameter ''parabolicity index,'' b, that is describe as follow: $b = 1–E2/E1$, where E1 is the mean-squared error (MSE) of the linear fit and E2 the MSE of the polynomial fit degree 2 in double-logarithmic coordinates as described elsewhere [4].

In this study, we used the nonlinear parameter b of ECoG from rats with *status epilepticus* induced by pilocarpine acutely.

2. MATERIALS AND METHODS

All tests were performed on 6 rats (400-620 g) (18 moths). The rats were anesthetized with chloral hydrate (4,7 ml/kg, 10%, i.p.) and placed in a stereotaxic apparatus. One

electrode silver-chloride positioned in a temporal area of right hemisphere. Another silver-chloride cortical electrode was put on the skull as reference ground. After the control recording of 30 minutes duration the rats received intraperitoneal injections of pilocarpine hydrochloride (350 mg kg^{-1}), and the recording continued about 1:30 hours. The *Status Epilepticus* (SE) was displayed by characteristic seizures. After recording the animals were euthanized. DFA was analyzed using segments with period of ten seconds after the recording with 2 kHz in an amplifier system (EMG System 410C). Each segment was obtained by segmentation using the Windaq 2.44 software and after segmentation we obtained the mean frequency of neocortical rhythms alpha (8-14Hz), beta (14-32Hz), theta (4-8Hz) and delta (0-4Hz) by using the OriginPro 8 software by applying a filter band pass FFT (Fast Fourier Transform). The movement artifacts and the periods of artifacts discharges were manually removed of the analysis. The significance level was set at $p < 0.05$. Statistical analysis was performed with OriginPro 8 software using an unpaired Student t test.

3. RESULTS

The table 1 shows the scaling exponent (α) values determined from DFA in control and SE conditions recorded form anesthetized rats.

	DFA Scaling exponent (α)			
Conditions	***alpha***	**beta**	**theta**	**delta**
Control	**1,7624 ±0.0158 n=36**	**1,6598 ±0.0282 n=36**	**1,8188 ± 0.0116 n=36**	**1,6406 ±0.0126 n=36**
SE	**1,7460 ±0.0216 n=36**	**1,6552 ±0.0292 n=36**	**1,8145 ±0.0152 n=36**	**1,6683 ±0.0093 n=36**

Table 1 – Scaling exponent (α) represented as mean ± standard error mean (SEM) for the oscillations in alpha, beta, theta and delta frequency bands. n is the number of segments from six rats.

All results are in agreement with the literature that predicts an α for anesthetized rats between 0.8 to 2.0, we believe that the cloralose anesthesia by itself induce deep anesthesia in ours animals, by the way values of α are large in relationship with those in awake animals. These values we did not disclose any difference between the rhythms as showed previously for awake animals. A Student t test was used for comparison and a significance level of 5% was adopted.

	Parabolicity índex (b)			
Conditions	***alpha***	**beta**	**theta**	**delta**
Control	**0.7355 ±0.0027 n=36**	**0.9018 ±0.0067 n=36**	**0.8085 ± 0.0077 n=36**	**0.8811 ±0.0054 n=36**
SE	**0.7420 ±0.0048 n=36**	**0.9019 ±0.0057 n=36**	**0.7987 ±0.0072 n=36**	**0.8608 ±0.0044 n=36**

Table 2 – Parabolicity index, b, represented as mean ± standard error mean (SEM) oscillations in alpha, beta, theta and delta frequency bands. n is the number of segments from six rats.

The table 2 shows the mean b value of the rats submitted to ECoG recordings in the control, normal and SE conditions elicited by pilocarpine. In the table 2, is showed that delta oscillations have a very significant difference for the parabolicity index for control in relation to the SE (t=2.906, p=0.00049) .The others rhythms alpha, beta and theta did not show any difference between control and SE. The difference between the b mean values for the four bands in the control and SE conditions.

4. DISCUSSION

The parabolicity index, b, disclosed a more efficient method than the DFA α exponent for detect difference between the ECoG rhythms from normal in relation to *status epilepticus* induced by pilocarpine. The higher values of α showed in the Table 1 could be resultant of deep anesthesia [5] or a recurrence the age (18 months) of the animals [6]. Further studies are necessary to compare animals of different ages. This could explain why the scaling exponent α fails to detect changes induced by pilocarpine for very small changes as acutely induced. The difference observed here may be consequence of the used parameter b that could be more accurate to see the difference between the two conditions, once the *status epilepticus* is acutely induced by pilocarpine in old rats.

5. CONCLUSION

We conclude that the parabolicity index, b, is able to detect the difference between normal and epileptic rats, even if neither difference is disclosed by the α exponent as noted for the rhythms studied here.

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