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BILATERAL PREICTAL SIGNATURE OF PHASE-AMPLITUDE COUPLING IN CANINE EPILEPSY

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Abstract:

The patients suffering from refractory epilepsy can improve their quality of life through seizure forecasting. Though the initial findings were positive, and there is no single attribute has been originating and proficient in personally symbolizing the brain crescendos during the period of seizure transition.

Recently, "Cross-frequency Phase Amplitude Coupling" has been projected and considered a forerunner of the activity of seizure. This study elaborates the presence of statistical important variance in mean amplitude coupling distribution phase between the interictal and preictal seizure states in animals (dogs) with intracranial electrodes bilateral implant.

According to results, a change of statistic significant ($p < 0.05$) of the amplitude coupling phase in the preictal phase period. This change is basically correlated with the implanted electrodes position and specifically more important within frequency bands of high-gamma.

These discoveries prominent the bilateral iEEG potential benefits assessment and the seizure forecasting feasibility which is based on the sluggish cadence of high amplitude frequency.

Keywords: ***Epilepsy, Forecasting Seizure, Practical State, Phase Amplitude Coupling, Canine Epilepsy***

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1.0INTRODUCTION:

Throughout the globe, epilepsy is the most general neurological disorder distressing all age's people. According to the reports of WHO (World Health Organization); more than fifty million persons are suffered from epilepsy over the globe. About the seizures cases, 60% of patients handled through medical therapy. Similarly, 5% of patients with epilepsy are also brain surgery candidates. The outstanding 35% affected from unmanaged epilepsy and unpredictable seizure basis (Amiri, Frauscher and Gotman, 2016).

In contrast to seizure prediction, more suitable performances are described with the detection of a seizure, and later also confirms more period for chronic implantable tools intervention. The detection of seizure basically aims to produce trigger interferences after the beginning of a seizure. Therefore, it is very problematic to abort an already dispersal seizure, and will commonly develop into a seizure which is clinically important. While several efforts have been put towards recognizing a specific and unique seizure activity precursor, no particular characteristic has been observed regarding individual capability characterizing dynamics of the brain in the ictal state transition (Gagliano et al., 2018).

The most general feature in seizure prediction is the use of spectral band power and intents to show amplitude modulations inside the prescribed band's frequency over time. This feature may enumerate phase changes, but there is a failure while recognizing connections between multiple frequencies. CFC (Cross-Frequency Coupling) between several bands of frequencies has been projected to consider the mechanism of carrier regarding local and global procedural relationships. Current iEEG ("intracranial electroencephalography) based recognitions found cortical high-frequency modulation oscillations in 40-120Hz gamma band, through slow cortical probable (Gagliano et al., 2018).

2.0MATERIAL AND METHODS:

2.1Database

The mean coupling phases in the processing time of interictal and preictal periods were mined from constant iEEG recordings which received from "mixed hounds" and with naturally happening focal epilepsy temporal. One aim of this study was to assess the consistency and magnitude of the preictal PAC in brains' both hemispheres. However, the database which basically has a big seizure regarding patient ratio was preferred (Henneaux, Pilati and Teitelboim, 2002).

The overall recordings were received from NIH organized "International Electrophysiology Portal (http://www.ieeg.org//). According to the database, dogs were entrenched with "NeuroVista ambulatory system of monitoring and all video recordings was received at 400Hz, four electrode strips. These strips inserted bilaterally on brain's both hemispheres. It is obviously true that current studies have shown a gradual transition in between states of ictal and interictal (which are described as a preictal state) but there is no preictal time which may describe as a seizure prediction gold standard. Every seizure has a timeframe of recording, which was constant one hour, with specific five minutes intervention to ignite the ictal phase. Data were randomly collected from the balance preictal data record. The basic procedure for acquisition of data and its distribution had been preapproved by "University of Minnesota Institutional Animal Care" (Maheshwari et al., 2017).

2.2PAC Extraction

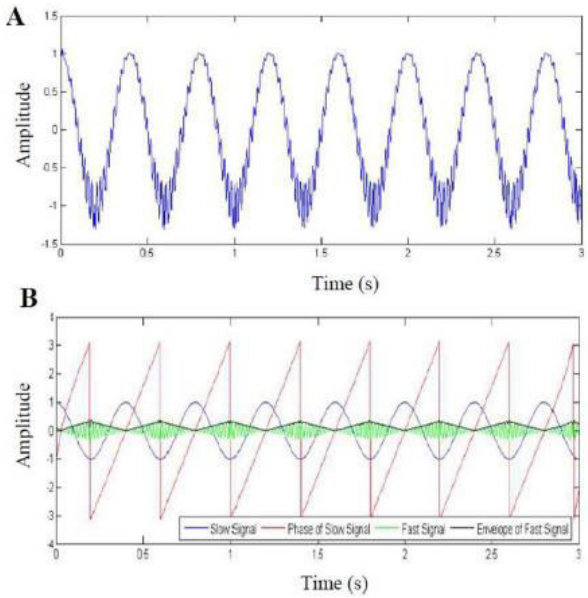
According to the description of Alvarado-Rojas et al (2014), it is basically a statistical interaction measure between different bands of frequencies regarding a single-channel recording. More specifically, the high-frequency signal module through low-frequency signals was calculated by amplitude comparing of oscillations of the fast wave to slow oscillations phase of signals of iEEG. During the ictal period of seizures, a statistically important boom has been observed and has established effective in the detection of a seizure. Practically, this feature is obtained from constant windows segmented recordings (Gagliano et al., 2018).

The time of high-frequency boom amplitude corresponds to the window's phase of average coupling. According to prior assessments (as mentioned above Alvarado-Rojas et al., 2014) we also have analyzed the coupling in delta (0.5-3Hz) or theta (3-8Hz) bands of frequency and low gamma amplitude envelope (LG: 40-70Hz), accordingly high gamma (HG: 70-140Hz) fluctuations. We separated the coupling of cross-frequency while using an algorithm (Maheshwari et al., 2017).

2.3PAC extraction algorithm Validation

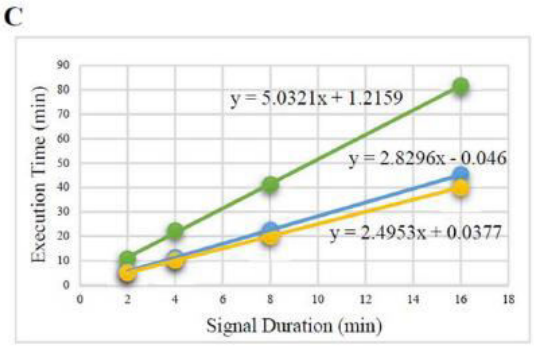
The validation of algorithm precision, it was observed and test on signals of synthetic wave-based through which we imposed π of a specific but constant phase of coupling. The composition of synthetic signals, as shown below, based on 2 waves of pure-cosine. At the frequency of 2.5Hz, the slow wave modulates the heft envelope regarding fast wave, and the fast wave frequency is based on 50Hz. More significantly, fast fluctuation

of amplitude envelope grasps its higher value when the angle of the phase of slow fluctuation is equal to π (Maheshwari et al., 2017).



(Source: Gagliano et al., 2018)

The outputs from the algorithm of cross-frequency coupling regarding synthetic signal represent a mean phase of coupling of 3.06 rads, basically, it is very near to π true coupling phase = 3.14 rad (error=2.5%).



2.4Feature Extraction Algorithm Acceleration

It is clear that multiple studies have shown gradual transition existence from ictal and interictal phase, still, the declaration has no proof that it may reproducible and have any significant output. To assess and oversimplify the lack of multiple seizures from several subjects must be assessed and compared. The main hindrance in this analysis is to implement coupling algorithm extraction with various bands of frequency for many recorded signal hours, received from sixteen channels, in an appropriate frame of time. While execution of extraction algorithm, in this study we use "Matlab's Parallel Computing" through 16 core computer specifically for paralyzing PAC extraction (Varatharajah et al., 2017).

For acceleration optimization, we also carry a speed test with the use of multiple execution frameworks: the sequential framework where there is a loop of channel parallelizes and a framework regarding window's loop parallelized. Sample duration and time of implementation of linear relationships regarding three algorithm frameworks are also exemplified in the abovementioned figure. According to that figure (c), two enhanced algorithms are faster as compared with the non-optimized algorithm. Additionally, the parallelization based channels accelerate marginally more than other parallelization which is windows' based due to recurrent redeployments of iterations on specific cores which are based to slow down the implementation. Specifically, for this point, channel parallelization has been utilized to accelerate the coupling extraction from IEEG recordings of several hours (Shukla et al., 2008).

2.5PAC and Evaluation of Change

In PAC quantitatively evaluate the change in the time of preictal phase, we studied and compared the PAC distributions in the time period of the preictal phase regarding every seizure to the swiftly sampled interictal phase balance by a non-parametric "Mann-Whitney U test" specifically at CI of 5%, this "Mann-Whitney U test" was selected for the PAC value comparison in the time period of interictal and preictal states (Richardson and Lopes da Silva, 2011).

This test further analyzed the statistical variance between two distributions, which have not particular normal output. In general PAC values were not typically dispersed, however, a non-parametric Mann-Whitney U statistical test was implemented. All these comparisons were generated for overall sixteen channels and four frequencies combinations of LG Delta, HG Delta, LG Theta and HG Theta. Furthermore, we again analyzed the magnitude dependency of variances (as per the p-values of a test of Mann-Whitney U) on frequency's combination and for each dog electrode while using mixed ANOVA (Shukla et al., 2008).

3.0RESULTS:

3.1PAC Extraction Acceleration

The extraction of PAC from the interictal and preictal sets records for four combinations of frequencies specifically for three dogs and it was finished in eight days specifically with parallelized loop channels. Utilizing the defined regression line the sequential implementation runtime across the four band frequency combinations was projected to be 127.5 days. The PAC extraction optimization algorithm was effective and attaining the factor of sixteen acceleration (Schwartz et al., 2011).

3.2Particular changes between preictal and interictal PAC periods

Completely the PAC during sixteen preictal periods of natural seizures happening in different epileptic dogs, those were observed to the PAC in the duration of periods of interictal of similar dogs. The mean of PAC distribution in all three dogs, specifically during the preictal time duration was importantly variant from the PAC distribution mean for the interictal time duration for 100% seizures, ($p< 0.05$) as observed with the help of Mann-Whitney U test (Schwartz et al., 2011).

3.3Variance in preictal PAC determined by frequencies

For the examination of the selected frequency bands' impacts of change in mean distribution PAC magnitude (through Mann-Whitney p-value). There is confidence 1% in between dog 1 and dog 3 as the interaction between frequencies combination and change magnitude of PAC, apparently, this is not particular for the dog 2. Three ANOVA tests results comprise each dog percentage of comparison (according to sixteen channels of each seizure), for which PAC distributional mean change is statistically important ($p< 0.05$, as per Mann-Whitney U test(Varatharajah et al., 2017).

3.4Location of the electrode and preictal PAC change dependency

According to the second 2 way ANOVA study is that electrode location and PAC distribution difference during the phase of preictal. Accordingly, all three dogs there are two variables of interaction are important at the 1% of confidence. The coupling change location for delta HG was analyzed for every dog and its results demonstrate that the PAC change is significant for one hundred percent each dog electrode in seizures. Additionally, the output demonstrates that the PAC change is important ($p <0.05$) according to 75% of seizures in every dogs' both hemispheres, whereas all dogs have localized epilepsy (Proddutur and Santhakumar, 2015).

4.0DISCUSSION:

This study confirms a variance of iEEG PAC statistical significant difference between preictal and interictal states in dogs with focal epilepsy. Specifically for all three dogs, one electrode may represent an important detectable state of preictal for all kinds of seizures. These outputs compliment the performance obtained seizure detection and also advised the cross frequency PAC, which may be a dependable and precursor of detectable regarding the activity of ictal. These outputs also demonstrate that important preictal variance was also detected at the level which is above chance of 13.2 percent of patients. Moreover, electrodes recordings implanted inside the SOZ were utilized in this hypothesis (Richardson and Jefferys, 2011).

Between various frequency bands combinations, delta phase PAC and high gamma amplitude represented an important statistical preictal variance for the preictal and interictal largest numbers comparisons. Moreover, the variances of preictal are constantly localized and important for every subject which advises the capabilities of promising forecasting. Recently we are analyzing the basic value of utilization of the same statistical structure in iEEG recordings of those patients who are affected through epilepsy surgery. Furthermore, in this study, it may not assess that the seizure prediction algorithm specificity is based on the variance of PAC. In futuristic studies, it is suggested and would be interesting that there must be a test of seizure forecasting performance algorithmic structure which will be based on the features of PAC (Petitmengin, Baulac and Navarro, 2006).

5.0CONCLUSION:

Concluding the study, we are able to demonstrate the existence of preictal characterized period through the statistical variance of significant PAC, namely, high gamma amplitude and delta phase coupling. However, the mutual presence of a detectable preictal state advises that the active appearance of preictal seizure phase is not partial only with SOZ. Basically, this study and work may be further considered as a resistant of practical a principal study regarding the use of CFC as a seizure activity precursor. These outputs make it prominent that forecasting feasibility is based in canine epilepsy PAC. Reflecting a preictal 1-h time duration, chosen CFC characteristics may be constantly extracted for specific online objective, though we simulate a certain latency prediction which may be relevantly insignificant considering the 1-h adopted preictal time. Potential studies analyzing the capability of forecasting of PAC may be an important significance to the progression of the implantable system of intervention development.

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