5th World Congress on Neurology and Therapeutics March 14-16, 2016 London, UK

HIGHER ORDER SPECTRAL ANALYSIS OF ALZHEIMER'S DEMENTIA SUBJECTS P300 RESPONSES

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Keywords: P300, individual response, higher order spectra, Alzheimer's.

Abstract

The paper discusses the use of higher order spectral analysis (HOSA) for the extraction of individual responses within each channel from P300 type responses from background EEG signals recordings. The focus is to separate the response to auditory stimuli (oddball paradigm) from the noise and background EEG by evoked potentials deterministic property used by HOSA for Gaussian distributed elimination. The main use of the method is of distinguishing between Alzheimer's disease and normal subjects based on an individual, non-averaged response.

1 Introduction

The classical P300 deflection emerges in a timelocked record as a distinctive peak typically appearing approximately 300 to 400 ms following stimulus presentation. As there is a lot of reported valuable work on P300 analysis done by Polich, all of this work is concerned with the average of individual responses due to the low voltage of the response that is recorded together with background EEG and noise. One novel approach used in this paper is the HOSA Method to process the input data at individual response non-averaged level.

2 Higher order spectral analysis Method for the recovery of individual P300 response

The use of higher-order statistics provides insight into signals which is not always available at lower orders. Gaussian-distributed signals have the characteristic of disappearing at higher orders. Because the noise and an important component of background EEG is Gaussian-distributed, higher-order statistics thus offer the promise of a method of deterministic Evoked Potentials individually recovering from recorded data. Computing of a signal's higher-order spectrum frequently allows insight into the nature of the signal that may not be possible in the time domain. After the Fourier transform is taken of a second-order cumulant (the covariance), the result is the power spectrum. If the Fourier transform of the third and fourth-order cumulants are generated, the results are the bispectrum and trispectrum, respectively. The bispectrum can be plotted versus two frequency axes. This method has been designed and applied to each relevant channel record and does not employ the response localisation within the brain via independent component extraction techniques out of all channels. This approach aims just to get clear individual (non-averaged) P300 response at each recorded electrode and use it to search for differences between diseased and normal subjects.

3 Data and Results

P300 evoked potentials were recorded from subjects consisting of normal controls and confirmed AD, using a large equidistant 32-channel arrangement with linked ears (A1-A2) as reference. In Figure 1 the original EEG with P300 responses signals recorded from Cz electrode from one AD subject and their average are shown.

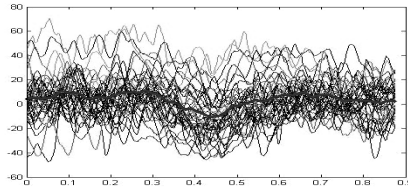

Fig 1. EEG with target P300 responses from AD subject and average Cz (μV)

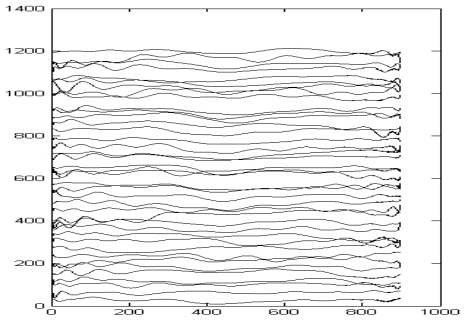

Fig 2. All Cz channel (40 individual target) recovered using the HOSA

Latency Results:

Latency of Average P300: 354.6ms

Average of individuals' recovered: 348.8ms

Standard deviation of individual's: 37.4ms

Amplitude Results:

Amplitude of Average P300: -10.27μV

Average of individuals' recovered:-12.73μV

Standard deviation of individual's: 17.01μV

4 Conclusions

As shown in the results section, the individual P300 waveform shape can be clearly visually distinguished in individual responses obtained by this strategy. Applications of this are: clinician assessment of the individual responses. and the use of statistical measure that can be derived from the successive individual trials responses to auditory target stimulus, from one subject, such as the variance of P300 latency or amplitude. Small differences between the amplitude and latency of the average from the target responses and the average of extracted individual responses. These can be explained as being due to the principle of background EEG cancellation via averaging a limited number of trials, carrying a certain shape of EEG and small changing of the averaged P300 latency and amplitude from the average of clear individual responses obtained here. Differences on individual responses between AD's and normal's were found.