Automated Alzheimer's Disease Diagnosis Using a Portable 7-Channel Electroencephalography Device

Raymundo Cassani and Tiago H. Falk
Institut National de la Recherche Scientifique, Centre EMT, University of Quebec, Montreal, QC, Canada
{raymundo.cassani; falk}@emt.inrs.ca

Abstract

The world elderly population is growing at its fastest rate ever; by 2050, 2 billion people will be aged over 60 [1]. For many individuals, age-related diseases cause cognitive decline and eventually limited functional capacity. Across North America, Alzheimer's disease (AD) has become the fifth leading cause of death in persons aged over 65 years, with an increase in death rate of 66% between 2000 and 2008 [3]. In order to tackle these problems, the World Health Organization, together with Alzheimer's Disease International, have called on governments to implement national dementia plans to improve early diagnosis. In response to this call, several new biomarkers have been found based on expensive equipment, such as single-photon emission computed tomography and functional magnetic resonance imaging. Such equipment, however, is scarce in low- and middle-income countries, as is the availability of trained medical personnel to operate them. Recent projections, on the other hand, suggest that by 2050, 71% of all people with dementia will live in low- or middle-income countries [4], thus it is crucial that lower-cost solutions be found.

Recently, the authors have proposed a new feature extracted from electroencephalography (EEG) that showed to discriminate healthy elderly patients from patients with AD with over 90% accuracy [5-7]. The proposed features characterize the cross-frequency coupling of EEG amplitude modulations, as detailed in [7]. These previously obtained results, however, relied on 20+ channel EEG systems, which can cost in the order of several tens of thousands of dollars. In this paper, we explore the use of a lower-cost solution, namely the use of the 7-channel portable COGNISION^{TM} system (Neuronetrix, USA). Data was collected across seven centers in the United States during a clinical trial led by Neuronetrix [8]. Eighty-three healthy participants (age: 73 ± 7 years; education: 15 ± 3 years; 49 female) and 93 patients with mild-AD (age: 76 ± 7 years; education: 14 ± 3 years; 49 female), matched for both age and years of education, were recruited and performed a 30-minute ERP (event related potential) test followed by a 3-minute resting (eyes-open) period.

Here, fourteen cross-frequency amplitude modulation features were extracted, for each of the seven electrodes, from the 3-minute resting period. Features were extracted after automated EEG artifact removal, as in [5]. A Kruskall-Wallis test with Dunn-Sidak posthoc correction was performed to test the discriminative power of the features. Of the 14 extracted features, six were found to provide significant difference between the two groups across the seven tested electrode sites. Features that resulted in superior separation between the two classes related to beta-theta, alpha-delta, and alpha-theta amplitude modulation couplings. These features coincide with those found with higher-density EEG systems (e.g., [5,6]), thus suggest their importance for AD diagnosis. Such findings suggest that AD risk assessment may be done *in-situ* not only in some of the poorest countries in the world, but also in remote or rural regions of developed countries that have with limited access to qualified medical personnel. In such cases, remote patient monitoring could play a key role.

References

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