The Transferal of Evidences Derived from Clinical Research to Single Patient Level: Automatic Distinction of Normal Elderly vs. Mild Cognitive Impairment Subjects by Resting EEG Data Processed by IFAST, a Novel Intelligent System

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Abstract - It has been shown that a new procedure (implicit function as squashing time, IFAST) based on artificial neural networks (ANNs) is able to compress eyes-closed resting electroencephalographic (EEG) data into spatial invariants of the instant voltage distributions for an automatic classification of mild cognitive impairment (MCI) and Alzheimer's disease (AD) subjects with classification accuracy of individual subjects higher than 92%. Here we tested the hypothesis that this is the case also for the classification of individual normal elderly (Nold) vs. MCI subjects, an important issue for the screening of large populations at high risk of AD. Eyes-closed resting EEG data (10-20 electrode montage) were recorded in 171 Nold and in 115 amnesic MCI subjects. The data inputs for the classification by IFAST were the weights of the connections within a non linear auto-associative ANN trained to generate the instant voltage distributions of 60-s artifact free EEG data. The most relevant features were selected and coincidently the dataset was split into two halves for the final binary classification (training and testing) performed by a supervised ANN. The classification of the individual Nold and MCI subjects reached 95.87% of sensitivity and 91.06% of specificity (93.46% of accuracy). These results indicate that IFAST can reliably distinguish eyes-closed resting EEG in individual Nold and MCI subjects, and may be used for large-scale periodic screening of large populations at risk of AD and personalized care.

Keywords: Mild cognitive impairment (MCI), Alzheimer's disease (AD), Electroencephalography (EEG), artificial neural networks (ANNs).

I. INTRODUCTION

In a recent paper we have presented the results obtained with the innovative use of special types of artificial neural networks (ANNs) assembled in a novel methodology named IFAST (implicit function as squashing time) capable of compressing the temporal sequence of electroencephalographic (EEG) data into spatial invariants [1].

The aim of this study was to assess the potential of this parallel and nonlinear EEG analysis technique in distinguishing between subjects with mild cognitive impairment (MCI) and Alzheimer's disease (AD) patients with a high degree of accuracy in comparison with standard and advanced nonlinear techniques.

The clinical condition called amnesic mild cognitive impairment (MCI) is characterized by objective evidence of memory impairment not yet encompassing the definition of dementia due to lack of any of the autonomies of daily living [2,3]. Amnesic MCI is considered as a precursor of Alzheimer's Disease (AD) [4] based on the high rate of progression from this state to the disease [3]. In normal aging, population annual conversion rate to AD ranges from 0.17% to 3.86% [3,5]. In MCI, that rate is remarkably higher ranging between 6 and 40% in the different series [3,6]. However, it should be remarked that a certain percentage of MCI subjects is not progressing into dementia at all [2,3,7].

In order to plan optimal therapeutic, organizational, social and rehabilitative interventions, it would be extremely important to make an early identification of amnesic MCI in a population of normal elderly subjects with the risk to develop AD as well as an early and precise distinction between those who will progress to AD from those who will not. For both purposes, analysis of electroencephalographic (EEG) rhythms would be an ideal candidate, since it is a widely diffused, non-invasive, and low-cost procedure suitable for large-scale screening of large populations. In precedence, it has been shown that compared to normal elderly (Nold) subjects, AD patients presented excessive delta rhythms (0-3 Hz) and a significant decrement of posterior alpha rhythms (8-12 Hz) [8,9,10]. Similarly, MCI subjects displayed a significant decrease of alpha power compared to Nold [11,12,13,14,15].