Chapter 7
Early Detection of Electroencephalogram Temporal Events in Alzheimer's Disease

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ABSTRACT

Alzheimer's Disease (AD) is considered one of the most debilitating illness in modern societies and the leading cause of dementia. This study is a new approach to detect early AD Electroencephalogram (EEG) temporal events in order to improve early AD diagnosis. For that, Self-Organized Maps (SOM) were used, and it was found that there are sequences of EEG energy variation, characteristic of AD, that appear with high incidence in Mild Cognitive Impairment (MCI) patients. Those AD events are related to the first cognitive changes in patients that interfered with the normal EEG signal pattern. Moreover, there are significant differences concerning the propagation time of those events between the study groups($p=0.0082<0.05$), meaning that, as AD progresses the brain dynamics are progressively affected, what is expected because AD causes brain atrophy.

INTRODUCTION

In the last decades, deep changes related to world population age structure happened with a progressive decrease of young people and a progressive increase of elderly people (Ballard, et al., 2011). The decrease of mortality and the simultaneous decrease of fertility levels have contributed to the phenomenon called overall aging of the population. The aging population has become a fact of scientific interest because

DOI: 10.4018/978-1-5225-1724-5.ch007

the elderly are most vulnerable to the onset of certain degenerative diseases (Jonker, Launer, Hooijer, & Lindeboom, 1996). Alzheimer's disease (AD) is a degenerative, chronic, progressive and irreversible illness and is the most common cause of dementia. In 2001 AD reached more than 24.3 million affected people around the world and it has the propensity to rise significantly in the coming years (Ballard, et al., 2011). AD also represents 60% of elderly diseases and has an unknown cause. As it is a cortical and progressive brain disorder, gradually, over time, most parts of the brain will suffer damage and AD symptoms will severely increase (Blennow, Leon, & Zetterberg, 2006). The first symptoms of AD are memory loss, particularly difficulty remembering newly learned information and concentration problems (Gwyther, 2001). As the disease progresses patients manifest general cognitive problems, confusion, personality / behavioral changes and also disorientation (Bird, 2001). Finally, there is a global brain atrophy and patients acquire a complete inability (Cummings, 2004). So, permanent aids of family members or caregivers are increasingly requested (Jeong, 2004).

AD progression is gradual and usually categorized into four stages. Each one presents typical symptoms of the disease progression. The pre-dementia stage is known as Mild Cognitive Impairment (MCI). At this stage subjects present subtle symptoms, daily life activities are preserved, and cognitive impairment is restricted to memory (Nestor, Scheltens, & Hodges, 2004). MCI confers a higher risk of developing AD but only between 6% and 25% of people affected with MCI actually develops AD (Shimokawa, et al., 2001). Mild and Moderate AD are the next two stages characterized by a significant increase of cognitive impairment and a marked loss of independence (Gwyther, 2001). The last stage is Severe AD where a complete deterioration of personality occurs; patients are unable to perform any tasks and caregiving becomes fully indispensable (Mesulam, 2000).

Researchers do not know yet why the brain cells deteriorate. Senile plaques and neurofibrillary tangles in the medial temporal lobe and cortical areas are two pathological hallmarks of brains destroyed by AD (Blennow, 2005; Mattson, 2004). These two abnormal structures are responsible for damaging and killing the nerve cells (Cummings, 2004). Parts of the brain start to shrink because the brain's nerve cells die. In AD the last stage, the damage is generalized, and the brain tissue volume decreases very significantly (Blennow, 2005; Blennow & Zetterberg, 2010).

Several factors are often associated with a higher risk of developing AD. Ageing is considered the main risk factor; after the age of 65, the risk of developing the disease doubles every five years. Another factor is family history; people who have a close relative who developed Alzheimer's disease have a slightly higher risk of eventually developing the disease themselves (Blennow, 2005). Gender is considered another factor; a higher percentage of women develop AD than men do. Heart diseases (namely: high cholesterol, hypertension or poorly controlled diabetes) are considered risk factors for developing AD. Many other factors, including stress, obesity, smoking, lower educational qualifications, Down's syndrome and head injuries are associated with a possible risk of developing AD (Blennow, Leon, & Zetterberg, 2006; Lahiri, Farlow, Greig, & Sambamurti, 2002).

Despite the progress in better understanding AD stages, there remains no prospect of cure at least shortly. Therapies currently available only soften and slow the symptoms progression, that is why new treatments must be developed to alter the disease process itself and not just to reduce some of the common symptoms (Ballard, et al., 2011). AD has been researched for years, but researchers have not yet discovered a good treatment for this complex and stressful disease and neither have discovered a reliable method to make an accurate AD diagnosis (Ballard, et al., 2011).

AD leads to death approximately seven years after being diagnosed (Mölsä, 1986). An early and accurate diagnosis is necessary to help intervention in order to reduce the brain damage. It is often difficult