A comparison of Delta, Theta, Alpha, Beta and Gamma waves in Different Brain Regions of Patients with MCI and Alzheimer’s Disease with Normal Controls; A Preliminary Study

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Introduction

- Understanding the pathophysiology of EEG changes in Alzheimer's disease (AD) is very complex and just some general concepts have been commented.
- Also the diagnosis of AD in early stages and MCI is still problematic.
- Previous EEG studies have shown significant increases and decreases in theta and alpha spectral powers, respectively, in mild-stage AD relative to healthy controls.
- We try to study the EEG findings of our patients with AD, MCI and normal group to be able to find any significant sign that can be used as a complementary test for diagnosing the disease in early stages.
## Subjects

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>MCI</th>
<th>AD</th>
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<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>MCI</td>
<td>Alzheimer’s</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Age 67±7</td>
<td>Age 65±6</td>
<td>Age 70±2</td>
</tr>
<tr>
<td></td>
<td>5 female</td>
<td>10 female</td>
<td>1 female</td>
</tr>
<tr>
<td></td>
<td>CDR = 0-0.5</td>
<td>CDR = 0.5-1</td>
<td>CDR = 2-3</td>
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<tr>
<td></td>
<td>MMSE = 28±1.3</td>
<td>MMSE = 27±1.3</td>
<td>MMSE = 21±5</td>
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Subjects had no history of Diabetes mellitus, kidney diseases, thyroid diseases, alcoholism, liver disease, lung disease or vitamin B12 deficiency and were not under medication with acetyl choline esterase inhibitors.
Clinical Procedure

- 26 channel EEG with Nihon Kohden EEG-1200 instrumentation
- Impedance < 10kΩ
- International 10-20 system
- Linked-ear referential electrodes (A1 and A2)
- Participants were awake and resting with eyes closed
- Greek Association of Alzheimer’s Disease and Related Disorders (Alzheimer Hellas)
Signal Processing

- 5 minutes of eye closed
- Filtered 1-45 Hz range
- Segmentation into 25-28, 10 sec epochs
- Removal of outlying Epochs
  - Pairwise Distance (Euclidean)
  - Format distance matrix
- Apply Spectral analysis
- Split the power into the 5 bands
  - Delta (0-4Hz), Theta (4-8Hz), Alpha (8-12Hz), Beta (12-30Hz) and Gamma (30-45Hz)
Statistical Analysis

- Statistical significance 5%
- Wilcoxon rank sum test
- One-way ANOVA across 3 groups
- t-test across 2 groups
Results

- A significant increase in sum of the **theta band** and also **gamma band** electrode positions and increase of theta band in **T3 and T4 in AD group**.

- A significant decrease only in the **beta band**, at the sum of the aforementioned and also the positions **Pz and P3** (posterior parietal and cingulate region) was observed in MCI group comparing to N and AD.

- There was gamma wave asymmetry in patients with MCI comparing normal group (p≤0.03).
Results

A significant increase in sum of the theta band and also gamma band

A significant decrease only in the beta band in MCI
Results

- Significant increase of theta frequency in T3 and T4 (temporal regions)
Results

- A significant decrease (p≤0.05) in the beta band, at the positions Pz and P3 (posterior parietal and cingulate region) was observed in MCI and AD group comparing to N.
Scalp alpha rhythms (8–13 Hz) mainly result from sequences of inhibitory (IPSP) and excitatory (EPSP) postsynaptic potentials at the dendrites of cortical pyramidal neurons.

Cholinergic and glutamatergic synapses are especially involved in the genesis of these potentials.

In Alzheimer's disease (AD), characterized by an early cholinergic (and possibly glutamatergic) deficit, this may produce a slowing-down of alpha rhythm and a reduction up to disappearance of alpha rhythm in the severe stages.
The role of hypoperfusion in Alzheimer’s disease (AD) is a vital component to understanding the pathogenesis of this disease. Disrupted perfusion is not only evident throughout disease manifestation, it is also demonstrated during the pre-clinical phase of AD.

It is now known that AD is associated with both global and regional cerebral hypoperfusion consistently reported in precuneus/posterior cingulate and lateral parietal cortex.
Theta rhythms are usually not appreciated in normal awakening EEG. The theta rhythms that are recorded during the learning tasks are thought to be produced by the activation of septal-hippocampal system.

In AD most symptoms may be explained by cholinergic-glutamatergic deficit. Neuronal injury/loss may include an excitotoxic component.

This insult may modify septal networks and contribute to the abnormal information processing observed in AD brain, including its hyperexcitability states. According to this theory, the increased theta production in AD would derive from hyperexcitability of the septal-hippocampal system.
The diagnosis of the initial stages of dementia is based mainly on neuropsychological testing and clinical suspicion.

Our EEG findings show alteration in posterior parietal and temporal regions. This finding correlates with reduction of cerebral blood flow and metabolism that has been observed using SPECT and PET.
The importance of posterior parietal region hypo-perfusion in early differential diagnosis of AD has been observed previously by other studies.
Previous literature, however, has shown an increase in delta band power and a decrease in beta band power only in late-stage AD, with only subtle a increase in delta band power seen with mild-AD in the occipital regions. These findings suggest that changes in slow-wave envelope dynamics may be detectable at earlier stages of the disease, thus potentially assisting clinicians with earlier diagnostics.

significant differences that were found across the two hemispheres, in gamma band of MCI comparing normal may be linked to the inter-hemispheric disconnection previously-reported for AD
Limitations

- Low number of subjects
Conclusion

- EEG may offer a promising putative biomarker that could potentially identify AD in its pre-clinical state.
- Moreover, if our continuing evaluation of this diagnostic technique should prove reliable after testing a greater number of follow-up patients, it would have broad implications for early diagnosis of AD.