ASSESSMENT OF EEG-BASED BIOMARKERS OF ALZHEIMER'S DISEASE PROGRESSION

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Introduction

Recent studies on Alzheimer's disease (AD) have suggested that brain damage and neuronal loss start several years before clinical symptoms can be recognized. Being able to diagnose AD in its early stages would provide time for patients and their families to prepare themselves emotionally and financially for the years to come. Furthermore, it is likely that the efficacy of novel drugs will be higher in early stages of the disease.

Why is electroencephalography (EEG) a promising tool to evaluate these processes in AD?

- Alternative and supporting technique to MRI, PET and neurophysiological tests, such as the Mini-Mental State Examination (MMSE).
- Portable and lower cost compared to MRI/PET
- Widely available
- Non-invasive

In this work, we explore the relationship between MMSE scores and EEG features derived from the amplitude modulation analysis [1], along with classical power band features, with the ultimate goal of identifying EEG biomarkers which could be useful for monitoring AD progression.

Methods

EEG data was derived from 20-channel eyes-closed, resting-awake recordings from 55 participants. AD patients were diagnosed by experienced neurologists according to NINCDS-ADRDA criteria. Participants were classified according their MMSE scores into three groups, namely: healthy controls (N), mild AD (AD1), and moderate-to-severe AD (AD2).

Cohort	Subjects (female)	Age [years]	Education [years]
N	21 (10)	67.2 ± 9.0	10.0 ± 5.4
AD1	20 (11)	74.8 ± 6.3	5.3 ± 3.0
AD2	14 (8)	74.6 ± 12.1	4.1 ± 3.8

Table 1. Demographics for the EEG dataset used.

EEG signals were manually selected to be artifact-free. Amplitude-modulation [1] and power-band features were computed and analyzed to assess their relationship with MMSE scores and, consequently, with AD progression. This relationship was assessed via the Pearson correlation coefficient within three different groups:

- N
- N + AD1 → results could help in early disease diagnosis
- N + AD1 + AD2 → useful for AD progression tracking.

Results

Ranking	N	N + AD1	N + AD1 + AD2
1	alpha_O1-O2' (0.64)	alpha_O1-O2 (0.52)	theta_O1 (-0.55)
2	alpha_O1 (0.61)	alpha_O1 (0.51)	theta_T5 (-0.52)
3	theta_T5 (-0.60)	theta_T5-T6 (-0.51)	theta_Oz (-0.50)
4	theta_P3-P4 (-0.57)	theta_O1-O2 (-0.50)	theta_O1-O2 (-0.49)
5	theta_O1 (-0.55)	alpha_O2 (0.50)	theta_O2 (-0.48)'
6	beta-mdelta_Fp1 (-0.55)	theta_O1 (-0.49)	theta_Pz (-0.48)
7	alpha-mdelta_O1-O2 (0.55)	theta_O2 (-0.47)	theta_T6 (-0.48)
8	beta-mtheta_Fp1 (-0.55)	alpha_Pz (0.46)	theta_P3(-0.48)
9	alpha-mtheta_O1-O2 (0.53)	alpha_Oz (0.46)	theta_T5-T6 (-0.48)
10	alpha-mdelta_O1 (0.53)	'alpha_P3-P4 (0.46)	theta_T3-T4 (-0.47)

Table 2. Ranking of the top 10 features with the highest coefficient of determination value. Correlation values reported within parentheses.

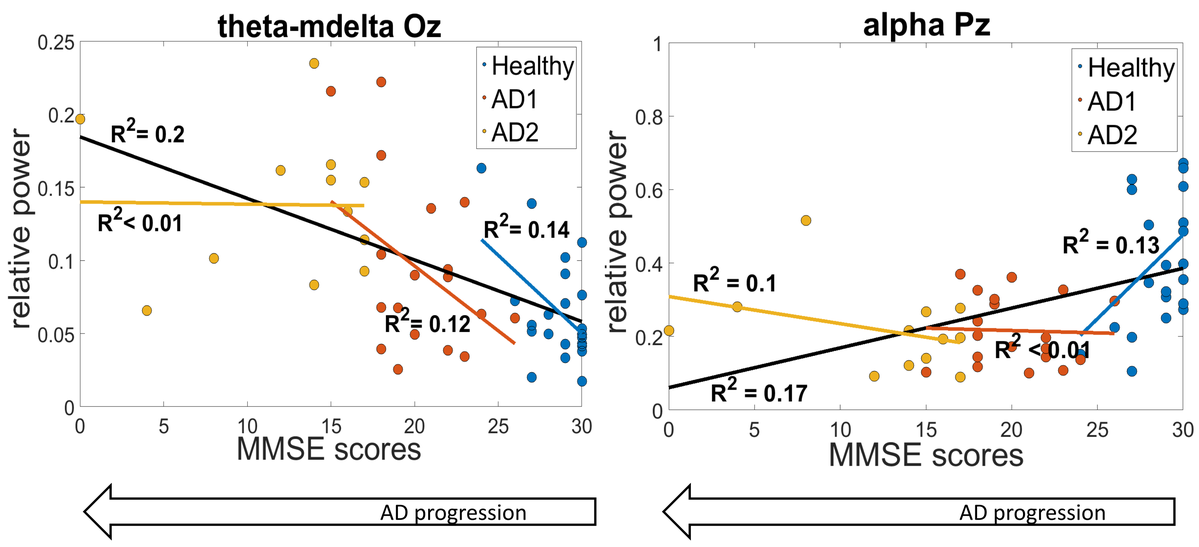

Figure 1. Average of the feature values per subject against corresponding MMSE score.

Brain region	N	N + AD1	N + AD1 + AD2
Frontal	6	1	7
Parietal	9	13	9
Central	1	1	4
Temporal	12	13	19
Occipital	22	22	11

Table 3. Number of features that belong to each brain region. Data extracted from only the top 50 features with highest Pearson correlation coefficient between the features' relative power and correspondent MMSE scores.

Conclusion

- As reported in previous studies, theta and delta frequency band power increase while alpha and beta spectral power decrease in AD subjects, thus corroborating the slowing effect of AD on the EEG signals.
- Correlation between feature relative power and MMSE scores is higher in healthy subjects and decreases with AD progression.
- The brain areas that exhibit higher correlation between MMSE scores and features relative power are occipital and temporal.

References

[1] Cassani R et al (2014) Front. Aging Neurosci. 6:55. doi: 10.3389/fnagi.2014.00055

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