Biomarker Analysis – Complexity Measurements

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The assumption of complexity in EEG signals for Parkinson's Disease (PD)

- Neural activity in the brain becomes less complex as the disease progresses

- Increased synchronization: Excessive synchrony in brain oscillations, particularly in the beta band.

- Loss of multiscale complexity: Reduced dynamic behavior across different time scales.

❖ **What is the best way to evaluate this assumption?**

Entropy Measurements

- **Entropy quantifies the randomness or unpredictability of EEG signals.**
- **Higher entropy values generally correspond to more random, less predictable behavior**

- **Approximate Entropy (ApEn)**
- **Sample Entropy (SampEn)**
- **Permutation Entropy (PE)**

Entropy Measurements - Approximate Entropy (ApEn)

- **Degree of unpredictability or randomness in a signal**
- **ApEn is then calculated using the ratio of the number of similar patterns in the series for *m* and *m*+1**

$$ApEn(m, r, N) = \phi^m(r) - \phi^{m+1}(r)$$

- **The difference between the probabilities for m and m+1 helps measure the likelihood that patterns of length m will remain similar when extended to length m+1.**

Entropy Measurements - Sample Entropy (SampEn)

- **A modification of Approximate Entropy (ApEn)**

$$SampEn(m, r, N) = -\ln\left(\frac{A}{B}\right)$$

- **A is the number of similar patterns of length m+1.**
- **B is the number of similar patterns of length mmm.**
- **N is the length of the time series.**

Entropy Measurements - Permutation Entropy (PE)

- **PE analyzes how values in a time series are ordered relative to each other**

$$PE = -\sum p_i \log(p_i)$$

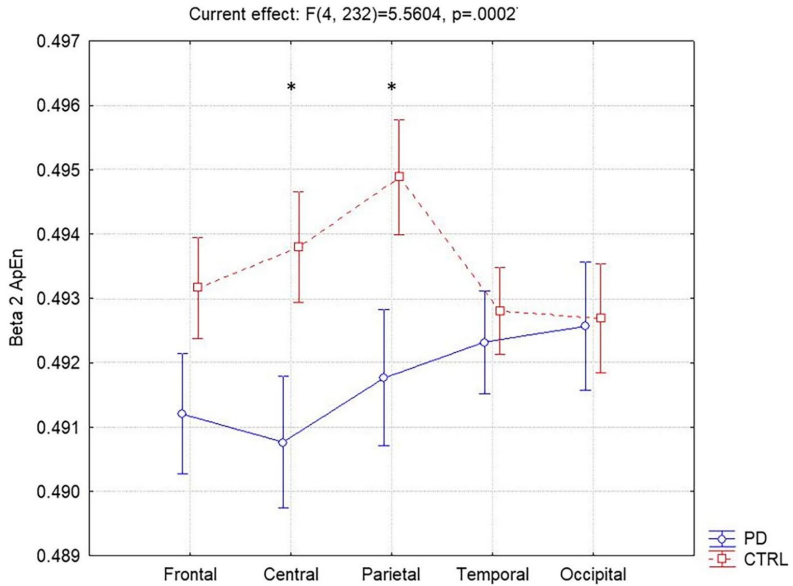
- **pi is the probability of the iii-th ordinal pattern.**

Previous Results

- **Exploring the complexity of EEG patterns in Parkinson's disease Lorenzo Nucci · Francesca Miraglia · Chiara Pappalettera · Paolo Maria Rossini · Fabrizio Vecchio**
- **Paper published 2023**
- **A total of 60 participants**

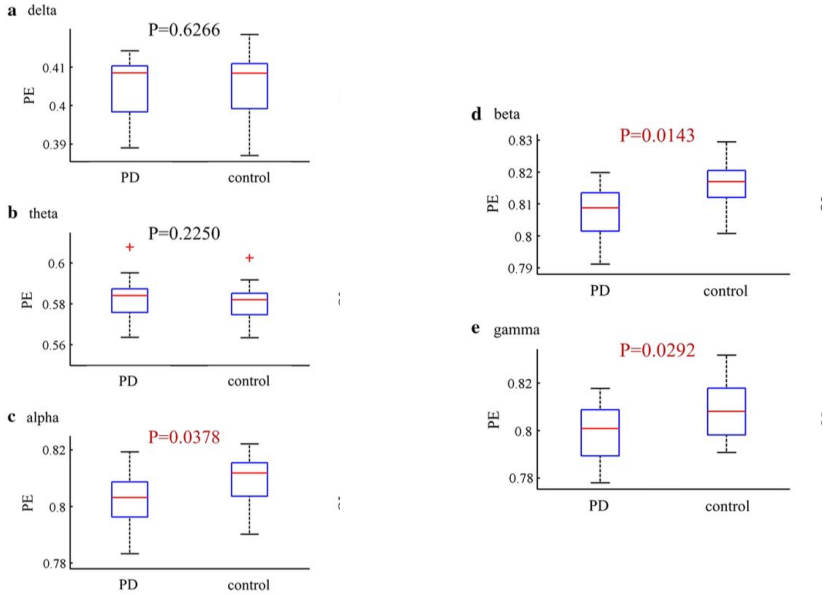
  the CTRL group of healthy subjects (n=35)

  and the PD of Parkinson's patients (n=25)



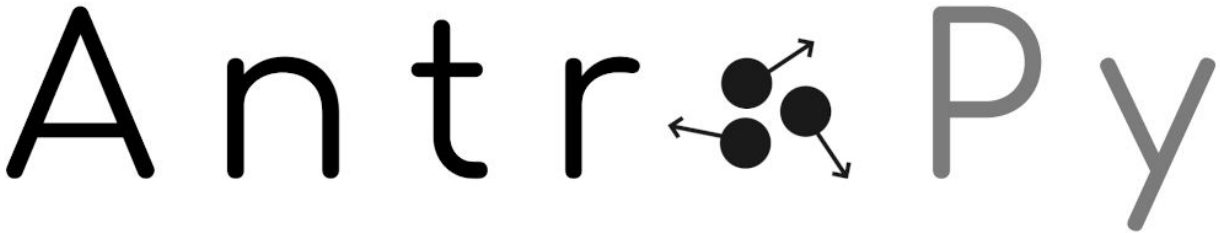
Previous Results

- **Complexity of resting-state EEG activity in the patients with early-stage Parkinson's disease**
- **Paper published 2017**
- **18 healthy subjects**
- **18 PD patients**



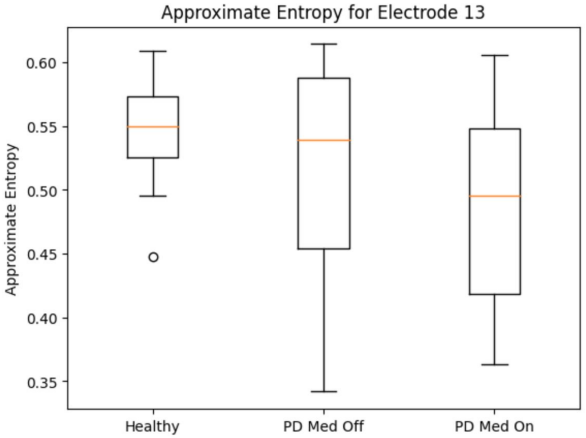
Antropy Library for complexity measurement

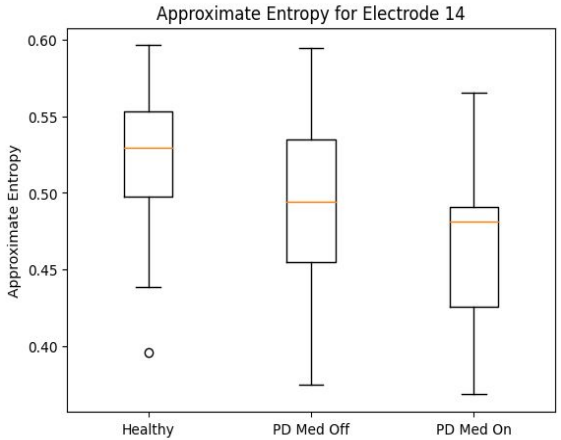
- **AntroPy is a Python 3 package providing several time-efficient algorithms for computing the complexity of time-series. It can be used for example to extract features from EEG signals.**

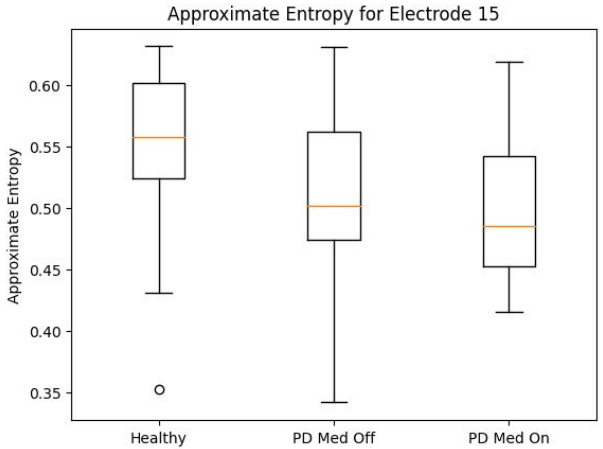


New Results - Approximate entropy

Results for central electrodes

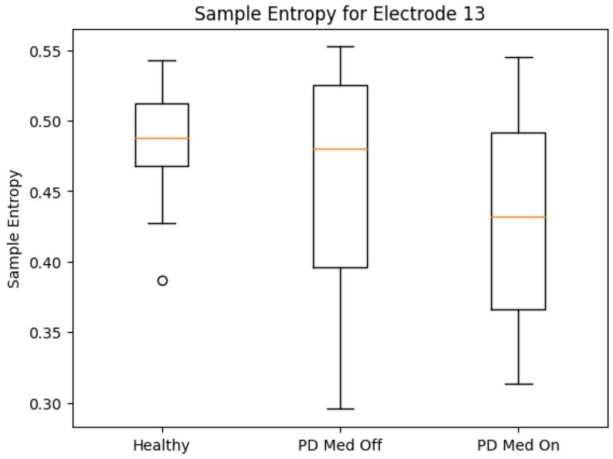


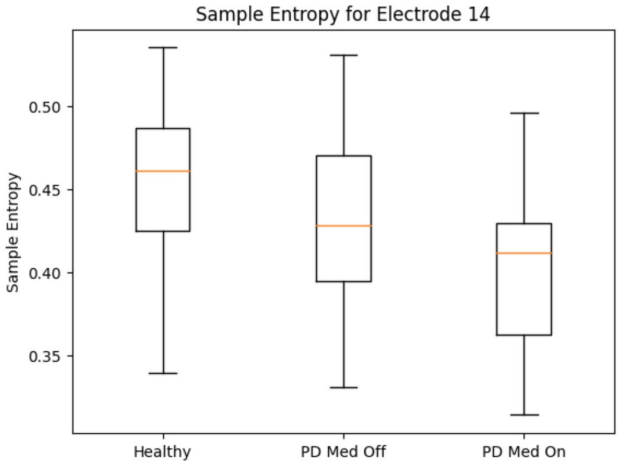


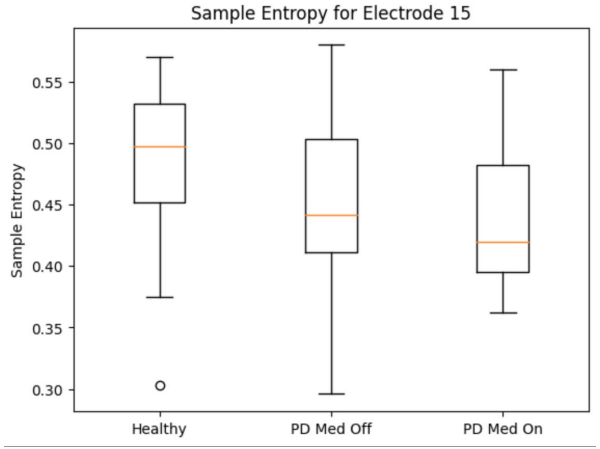


New Results - Sample entropy

Results for central electrodes

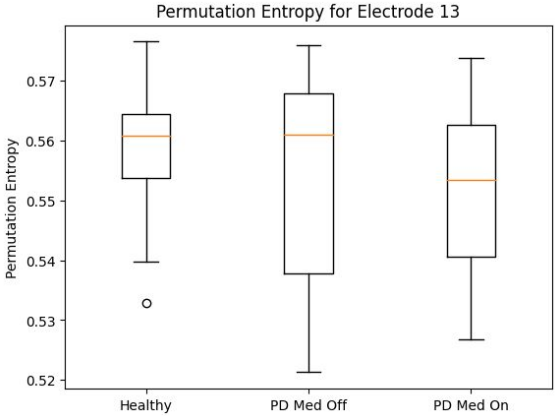


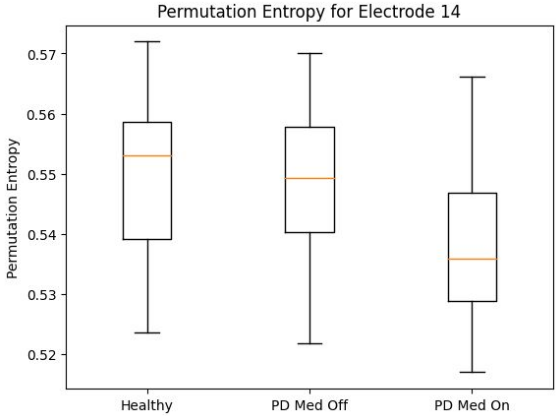


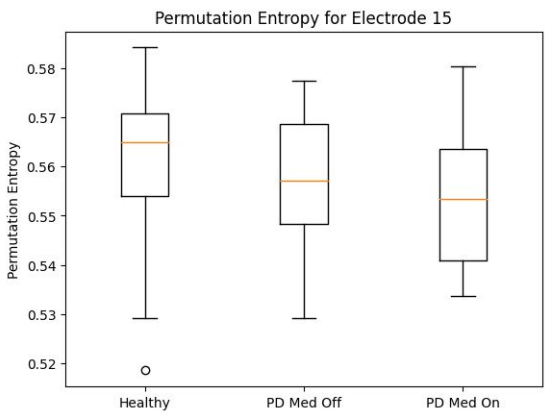


New Results - Permutation Entropy

Results for central electrodes







to be continued...