# Advanced perspectives for the diagnosis of Parkinson's and Alzheimer's disease through machine learning techniques

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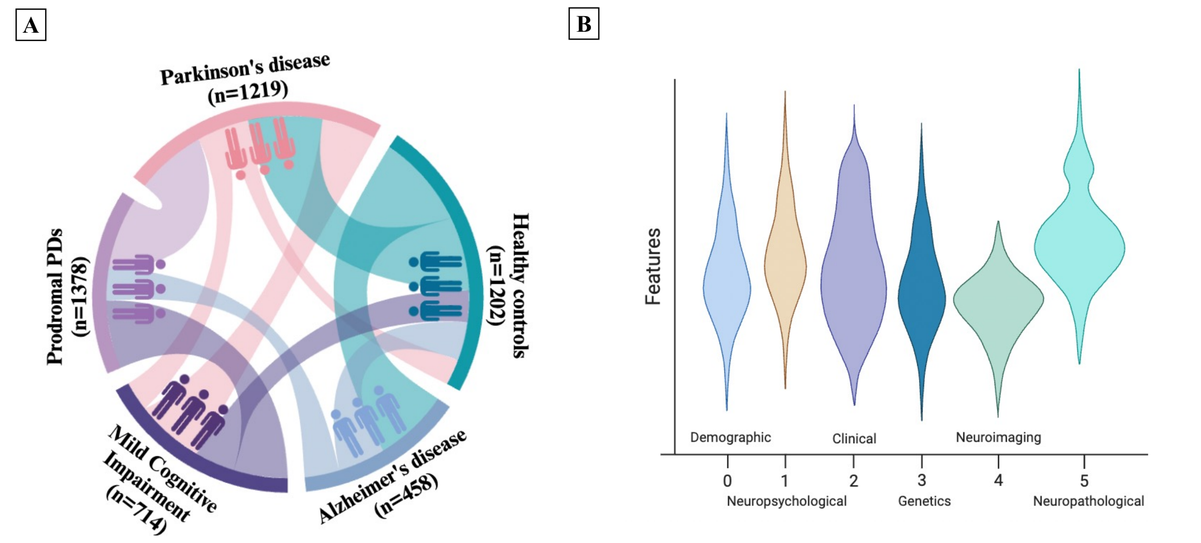
## Introduction

A new paradigm called ***Neurodegenerative Elderly Syndrome (NES)*** conceives Parkinson's disease (PD) and Alzheimer's disease (AD) as different manifestations of a single disease at very early stages [1]. No one has yet obtained a predictive model for both pathologies [2].

## Aims

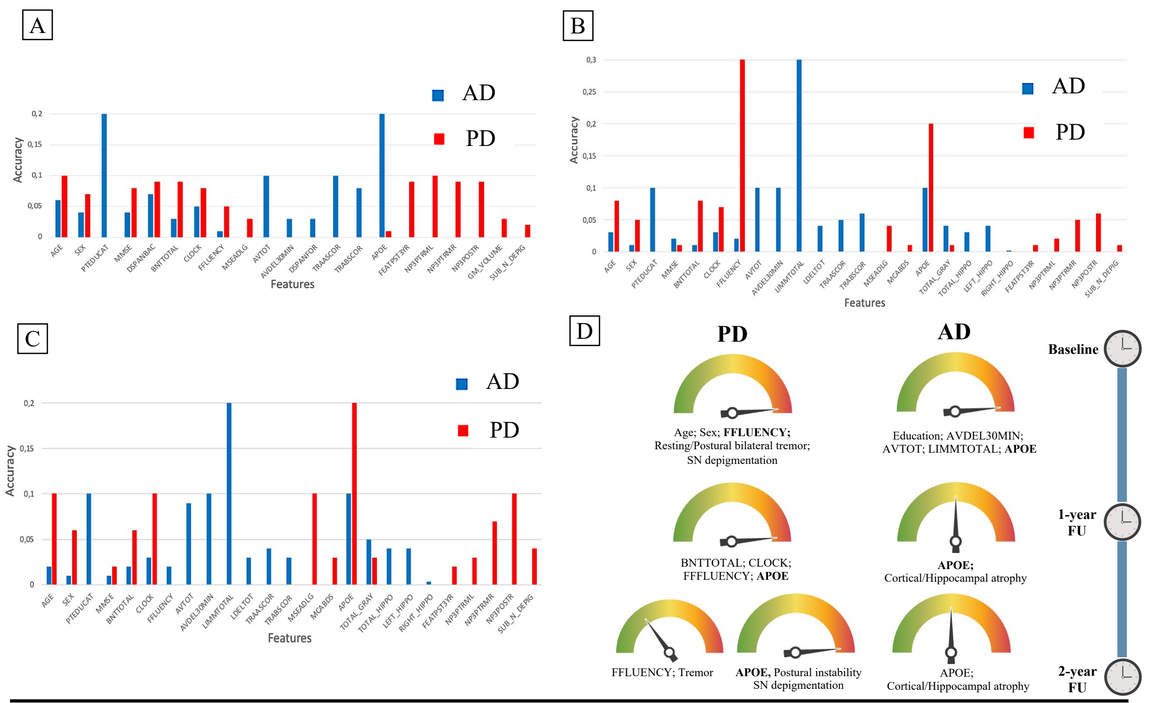
- To **observe and compare** PDs and ADs common and not features importance at baseline, 12-months and 24-months of follow-up.
- To **predict** disease conversion and **differentiate** or **classify** both pathologies at different time steps.

## Materials and Methods

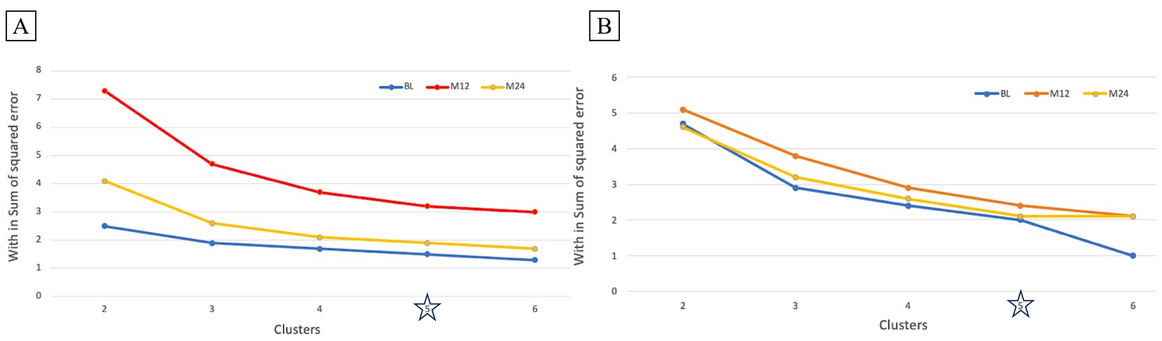



**Panel 1. (A)** Population was analyzed from Alzheimer's Disease Neuroimaging Initiative (ADNI) and Parkinson's Progression Markers Initiative (PPMI) online databases. Patients and Healthy Controls were aged from 19 to 89, according to female/male differentiation. **(B)** A combination of six groups of features was selected only if possible to match them for both AD and PD: *demographic, cognitive/neuropsychological, clinical, genetic, neuroimaging and neuropathological*. Machine Learning (ML) approaches like **Random-Forest Classifier**, **Features Importance Analysis** and **K-means Clustering Analysis** were applied. **Principal Component Analysis (PCA)** and **PCA-MAP** were used for data visualization.

## Results (I)

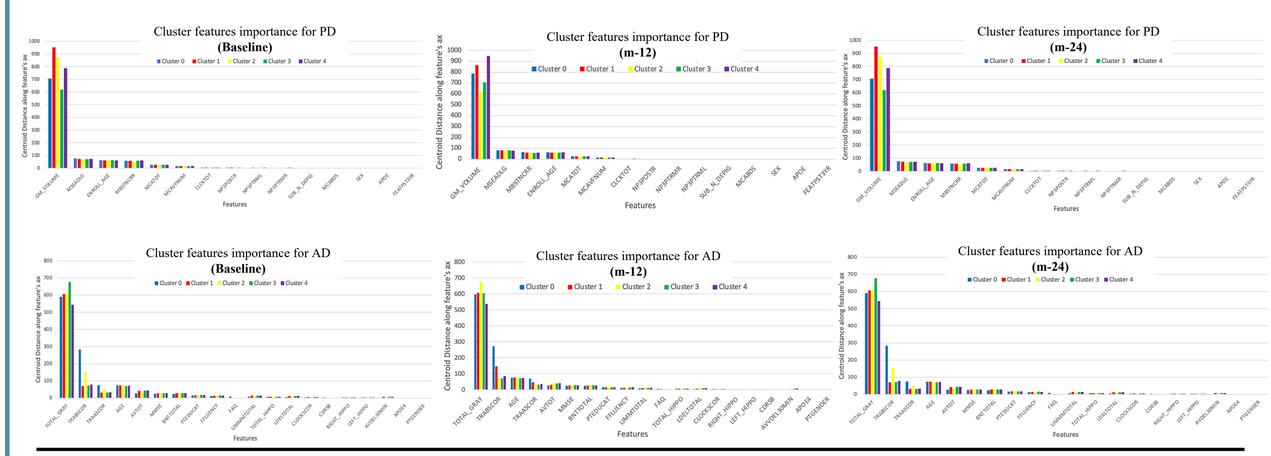



**Panel 2. Random-Forest Classifier**: Classification accuracy of 96%/86% and Precision of 92%/87% were obtained for PDs/ADs respectively; **Features importance analysis results** at **(A)** Baseline, **(B)** m-12 of FU**; (C)** m-24 of FU considering both PD and AD**; (D)** Significant differences between PDs and ADs, after features importance analysis, at baseline, m-12 and m-24 of FU respectively (from top to bottom); *p-value<0.05.*

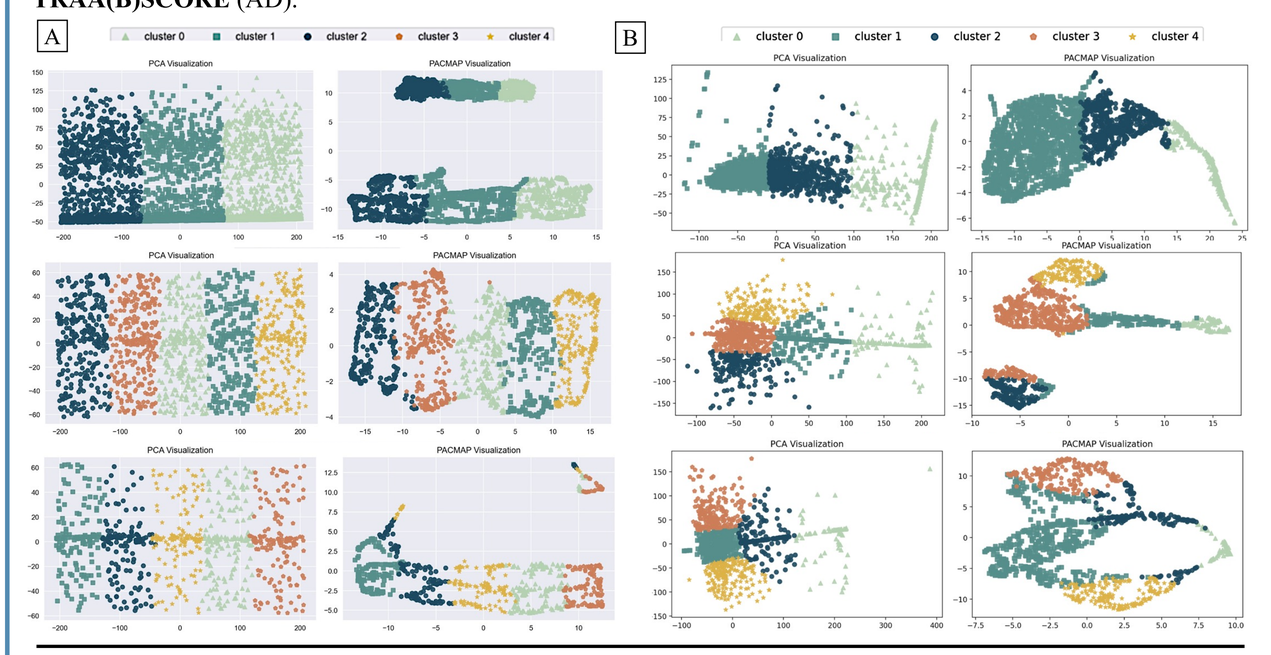



**Panel 3. Cluster analysis results**: **(A)** Baseline, m-12 and m-24 for PD; **(B)** Baseline, m-12 and m-24 for AD. *Y-axis*: Inertia or Sum of squared error; *X-axis:* Numbers of different clusters that could be obtained from the dataset. A total of **5 clusters (Cluster0/Cluster1/Cluster2/Cluster3/Cluster4)** were selected.

## Results (II)




**Panel 4. Cluster feature importance analysis** results at baseline, m-12 and m-24 for PD (top row of graphs) and for AD (bottom row of graphs), respectively. Generally, **Total gray matter volume** is the best variable for predicting patient classification (PD or AD conversion), followed by **Age** and **MSEADLG** (PD); **TRAA(B)SCORE** (AD).




**Panel 5. PCA** and **PCA-MAP** results: The two axes (*x, y*) of the graphs represent the two main components (PC1 and PC2) obtained from dimensionality reduction, for both PDs at baseline, m-12 and m-24, from top to bottom (**A**) and ADs at baseline, m-12 and m-24, from top to bottom (**B**). **PCAMAP** on the other hand uses PCA to reduce the size of the data and then maps them into one two-dimensional (or three-dimensional) space, the two axes of the graph represent the new dimensions obtained from PCA.

## Conclusions

We obtained a new **predictive model** able to **compare and classify common features in ADs and PDs** at **baseline** and during **disease progression**. Further studies are needed to validate our findings by testing and refining our predictive models on different multi and monocentric cohorts of patients in a real-life clinical setting.

## References

[1] Caligiore, D., Giocondo, F., & Silvetti, M. (2022). The Neurodegenerative Elderly Syndrome (NES) hypothesis: Alzheimer and Parkinson are two faces of the same disease. *IBRO Neuroscience Reports*, *13*, 330-343.

[2] Joshi, S., et al. (2010). Classification of Alzheimer's disease and Parkinson's disease by using machine learning and neural network methods. In *2010 Second International Conference on Machine Learning and Computing* (pp. 218-222). IEEE

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