Identifying and differentiating dementias with EEG fractal dimension distributions

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Background

- Fractal dimension (FD) quantifies a signal's similarity to itself across different time-scales.[1]
- In electroencephalography (EEG), FD decreases with neurodegeneration and with Alzheimer's disease (AD).[2]

We present a novel method of measuring fluctuations in FD. Our metric outperforms traditional measures of FD in identifying dementia and Alzheimer's disease.

Methods

- N = 148 (91 female; age 55-85)
  - 97 Control
  - 51 Dementia
    - 38 Alzheimer's disease
- 19-channel resting-state EEG
- 5 min eyes open, 5 min eyes closed
- We compared healthy subjects to subjects with dementia using:
  - Threshold-free cluster enhancement (TFCE)[3]
  - LASSO logistic regressions

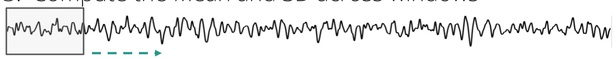
Fractal Dimension Distributions

Traditional Approach
Calculate FD using the full time-course - Katz's method[4]

Fractal Dimension (FD)

Fractal Dimension Distributions (FDD)

1. Slide 1 s window across time-course
2. Calculate FD in each window
3. Compute the Mean and SD across windows



FDD Mean, FDD Standard Deviation

FDD reveals more group differences

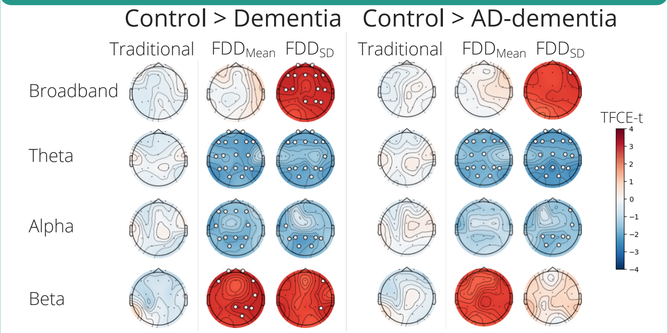


Figure 1. Electrodes with significant group differences (TFCE-p < .05)

FDD reveals larger differences

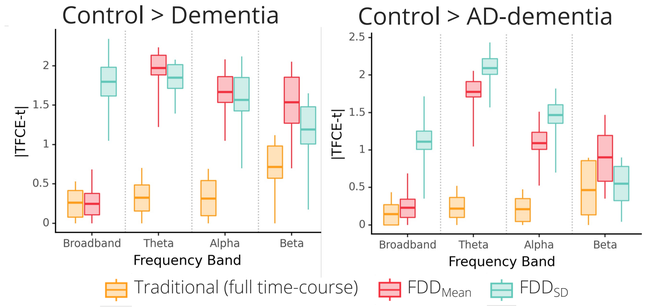


Figure 2. Effect size (absolute TFCE-t) for each FD metric

FDD reveals AD-specific signals

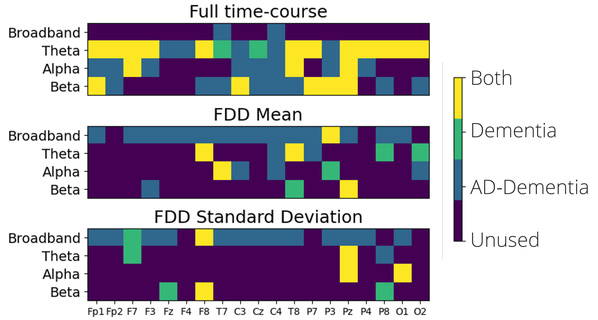


Figure 3. Features retained by LASSO Regressions

FDD improves models

Target	ΔAIC	ΔR^2
Dementia	**-1.9**	**+.15**
AD-Dementia	**-2.6**	**+.08**

Table 1. Comparison of model fit statistics

Conclusion

FDD is a novel method[5] that can identify dementia and specifically predict AD.

FDD reveals bigger differences between controls and individuals with dementia than traditional full–time-course FD.

While some FDD features are useful for detecting all-cause dementia, other features are uniquely important for identifying AD-dementia.

References

[1] Mandelbrot. *Science* 156.3775 (1967)
[2] Sun et al. *Entropy* 22.2 (2020)
[3] Mensen & Khatami. *NeuroImage* 67 (2012)
[4] Katz *Compupters in Biology & Medicine* 18.3 (1988)
[5] Yoder et al. (*under review*)