Parkinsonian patients have a broader range of time-scales of EEG motor cortex activity than healthy subjects.
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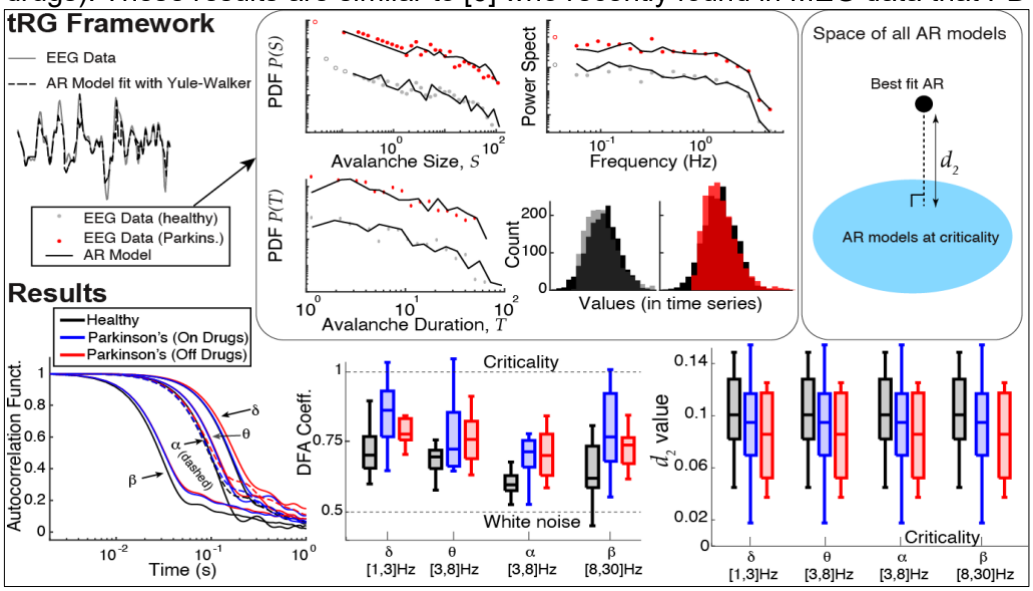
Data The EEG dataset is from [1], we focus on electrodes over the primary motor cortex (M1, just like in [2,3]), and compare 16 healthy subjects to 13 Parkinsonian patients (**PD**), well-matched to age, gender, cognitive abilities. Subjects were in the resting state for 3-minute recording sessions. EEG data were bandpassed into 4 common bands (see Fig) – then the envelope was extracted (same procedure as [2, 3]).

Using our recently developed temporal renormalization group theory (**tRG**) [4] and other standard metrics, we find on average PD are closer to criticality than healthy, i.e., activity have longer and a broader range of timescales. Our approach consists of fitting an auto-regressive (**AR**) model to each subject (Fig top row, demo is for 2 representative subjects in β band with 0.1s coarse-grained bins), with the advantage of mathematically deriving a rigorous distance calculation to criticality. AR models are known to be the best fit (with Yule-Walker method) max entropy model [5]. Notably tRG is cleaner than examining the autocorrelation function (**ACF**) decay and detrended fluctuation analysis (**DFA**); the difference in decay of ACF is barely discernable (Fig bottom row) and some subjects not well-suited to DFA, requiring piece-wise linear fits with manual tuning (not shown). Overall, ACF and DFA are generally consistent with our results (differences between healthy and both PDs is stat. signif. with med./large effect sizes in all box plots, no signif. difference between PD on vs PD off drugs). These results are similar to [6] who recently found in MEG data that PD have more frequency bands near criticality than healthy, consistent with our results where in all bands PD are closer to criticality on average.



Our results are different than others where healthy animals are closer generally to criticality than diseased (e.g., autism, epilepsy, etc.). Related works: [7a] found DFA coeff. increases in EEG (closer to criticality) with Parkinsons severity in certain bands (we found this only in α, not shown); [7b] found PD shows less 'flexibility' and more synchronization which they loosely associate with further away from criticality in MEG data.

Notably, [6] (& others) considered distance to criticality/chaos via fitting lin. SDE model to covar (of activity) matrix, using largest Re(eigenvalue), calculating distance to 0. This method is different than tRG, the results of which might be consistent with this EEG dataset but to us there is no obvious link.

References

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