REM Behavior Disorder Explainability in EEG via Spectral Band Cluster Prevalence

Sam Rusk, BS*, Chris Fernandez, MS*, Yoav Nygate, MS*, Tom Vanasse, PhD* Barry Van Veen, PhD**
Emerson M. Wickwire, PhD*** Nathaniel F. Watson, MD, MSc**** James Herdegen, MD*****

* EnsoData Research, Ensodata, Madison, WI, USA
** Department of Electrical and Computer Engineering, University of Wisconsin-Madison
*** University of Maryland School of Medicine
**** University of Washington
***** Rush University Medical Center

UW Medicine DEPARTMENT OF NEUROLOGY
UNIVERSITY of MARYLAND SCHOOL OF MEDICINE
RUSH UNIVERSITY MEDICAL CENTER
Department of Electrical and Computer Engineering UNIVERSITY OF WISCONSIN–MADISON
ensodata research

Introduction

Prior work has established substantial overlap in polysomnography features between synucleinopathy associated RBD and PTSD/TASD-associated RBD (trauma-associated-sleep-disorders). However, our mechanistic understanding remains limited. To explore RBD endophenotypes, we applied a novel analysis for clustering and categorizing PSG without AI/ML or sleep scoring, Spectral-Band Cluster-Prevalence (SBCP), to examine and compare differences in EEG characteristics between patients with RBD diagnosis versus clinical controls.

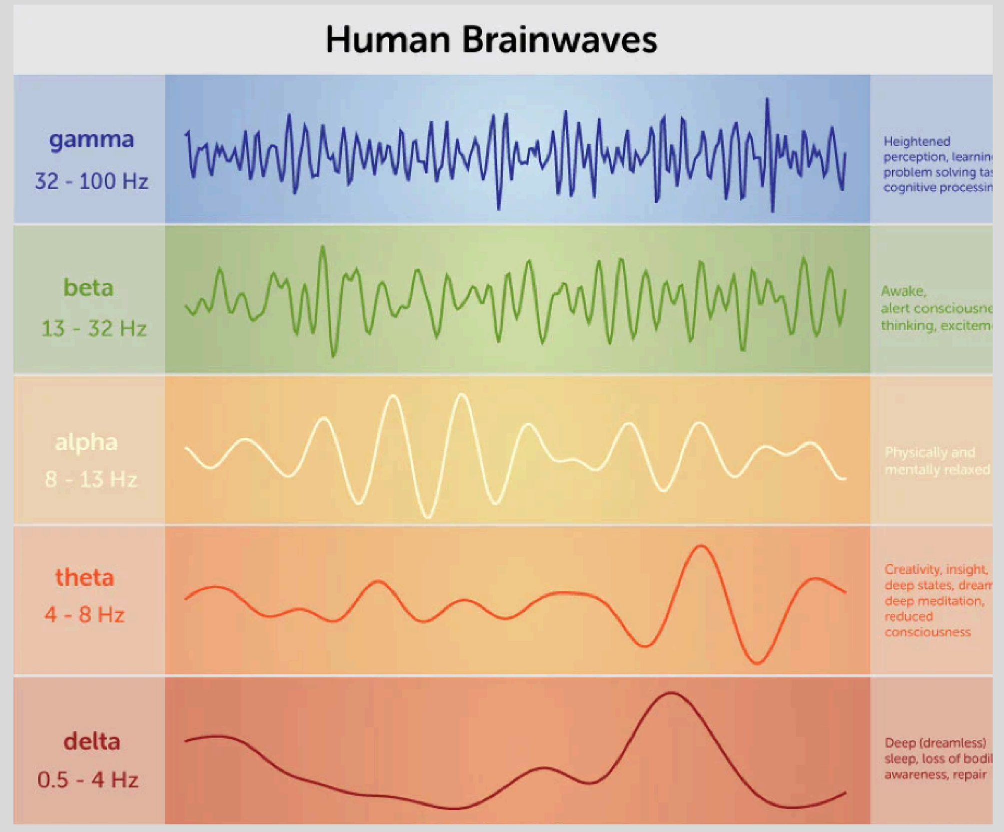
Methodology

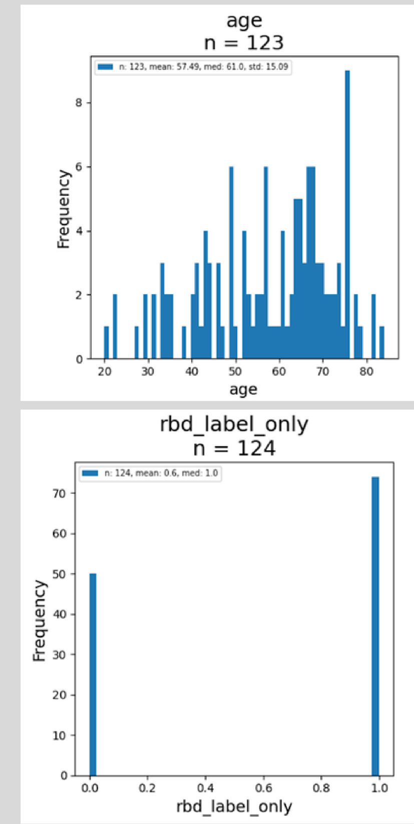
Our data source was retrospective EEG/EOG recordings from N=124 PSG participants (age=57.5 [SD=15]) including n=74 RBD diagnosed patients (defined by PSG findiings and patient-reported dream-enactment) with n=50 clinical controls (AHI< 15). EEG-channels were excluded based on artifacts, normalized to max voltage, EOG-channels were normalized to in-channel voltage, and extracted into ten-second segments.

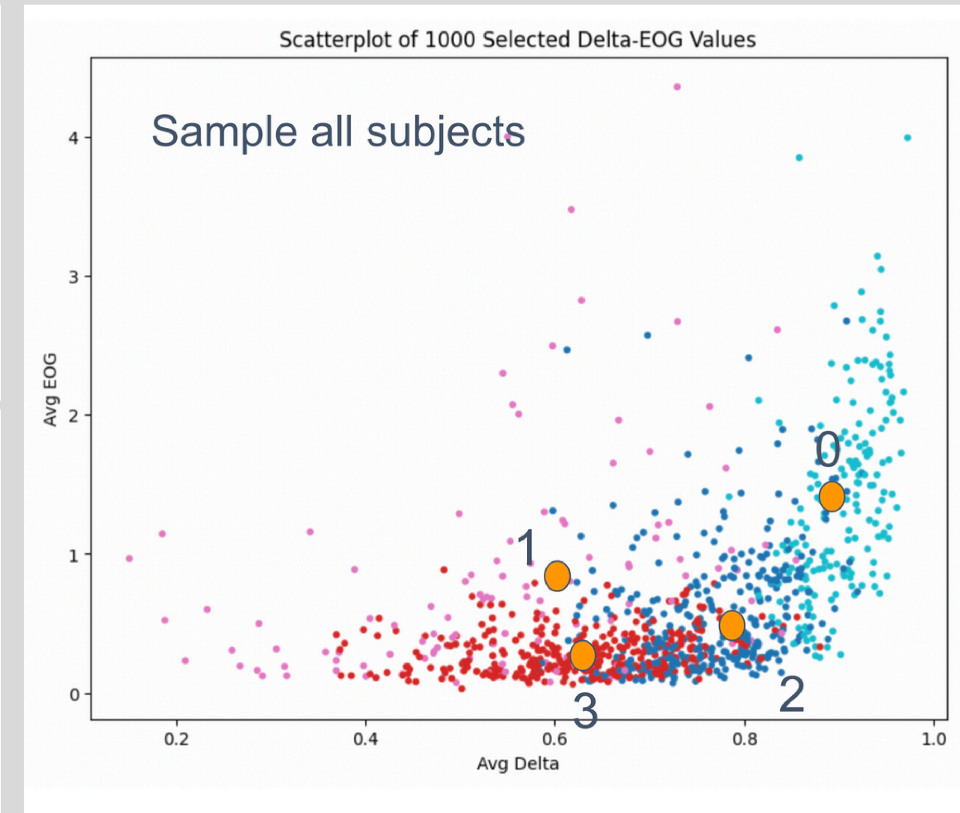
Signal features were extracted for each segment: EEG delta(1-4Hz), theta(4-8Hz), alpha(8-12Hz), beta(12-30Hz) spectral band-powers and EOG broadband-powers. Feature EEG band-powers were projected into 3- dimensional subspace, where optimal parameters for Gaussian Mixture Model (GMM) were identified to allow for mixed EEG states.

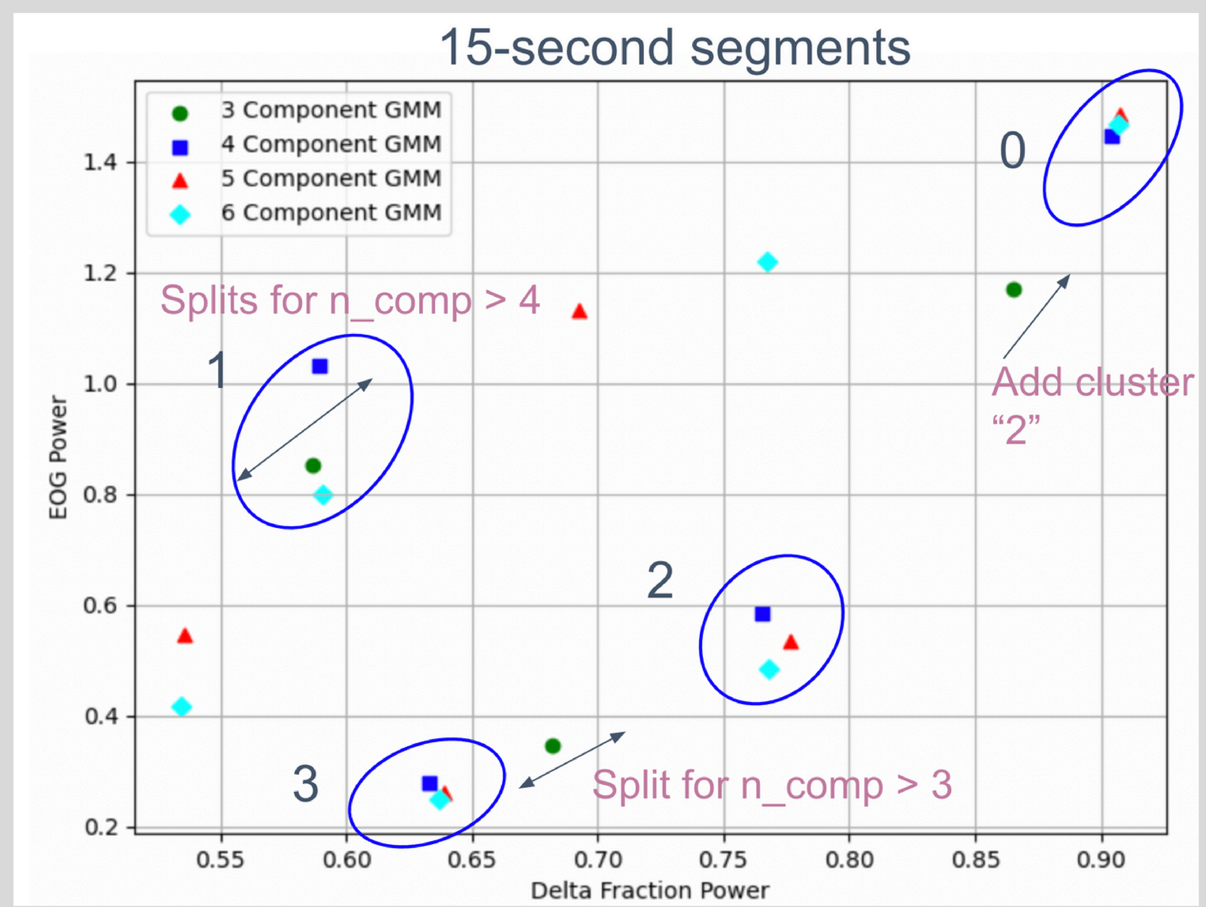
Cluster quality measures Silhouette, Davies-Bouldin, Akaike-Information-Criterion were evaluated to determine the optimal number of components (i.e. unique EEG states) required by the GMM to maximize the explained variance based on global optima in cluster quality values. Dwell-Fraction was estimated by assigning components to ten-second EEG segments, and used to report between-groups differences.

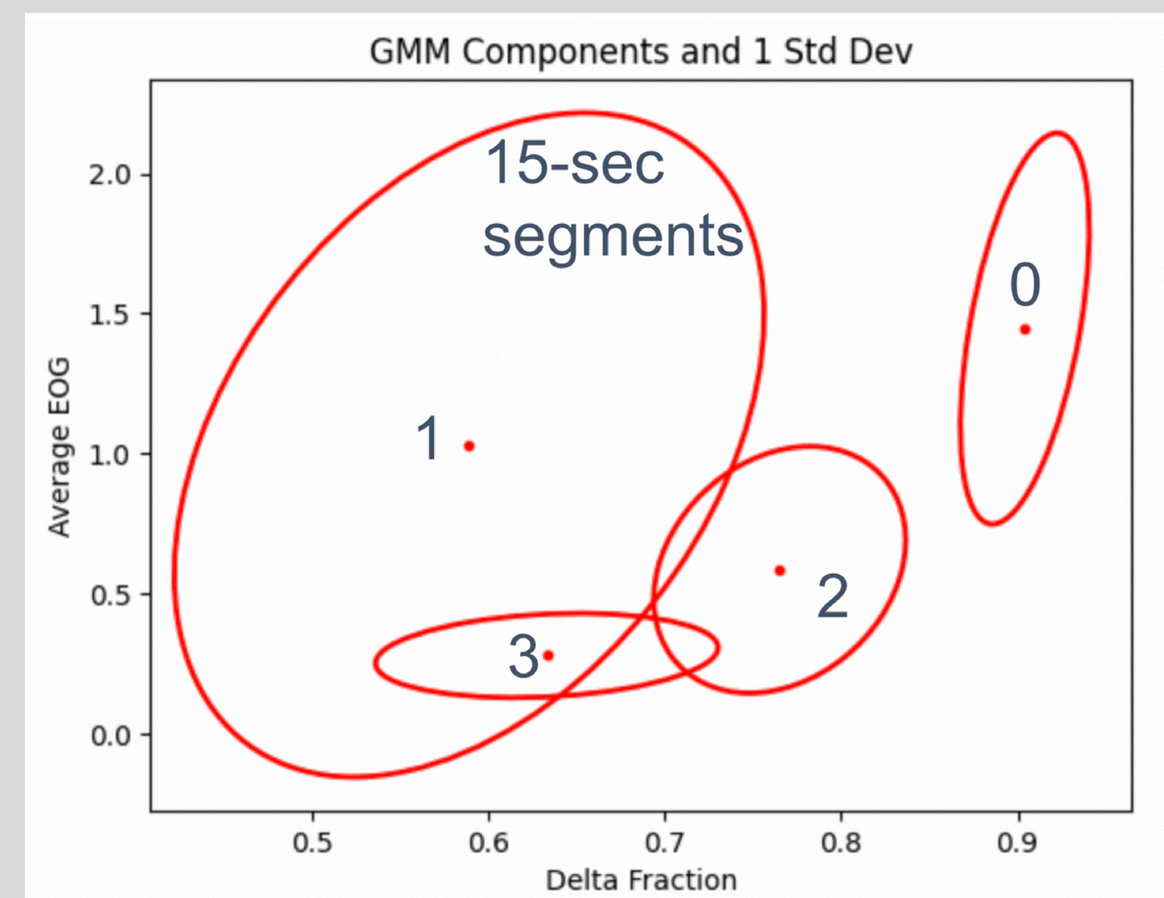
Experimental Results: GMM Clusters show significant Prevalence & Transition differences in RBD

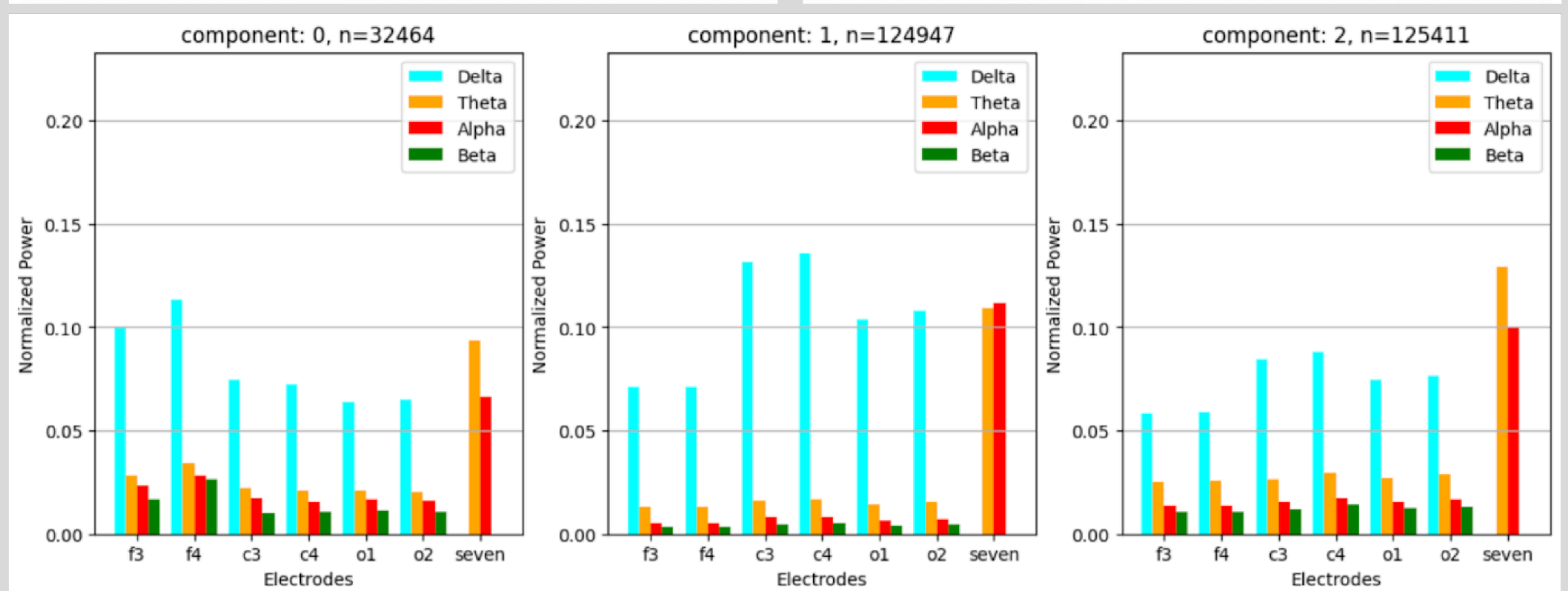




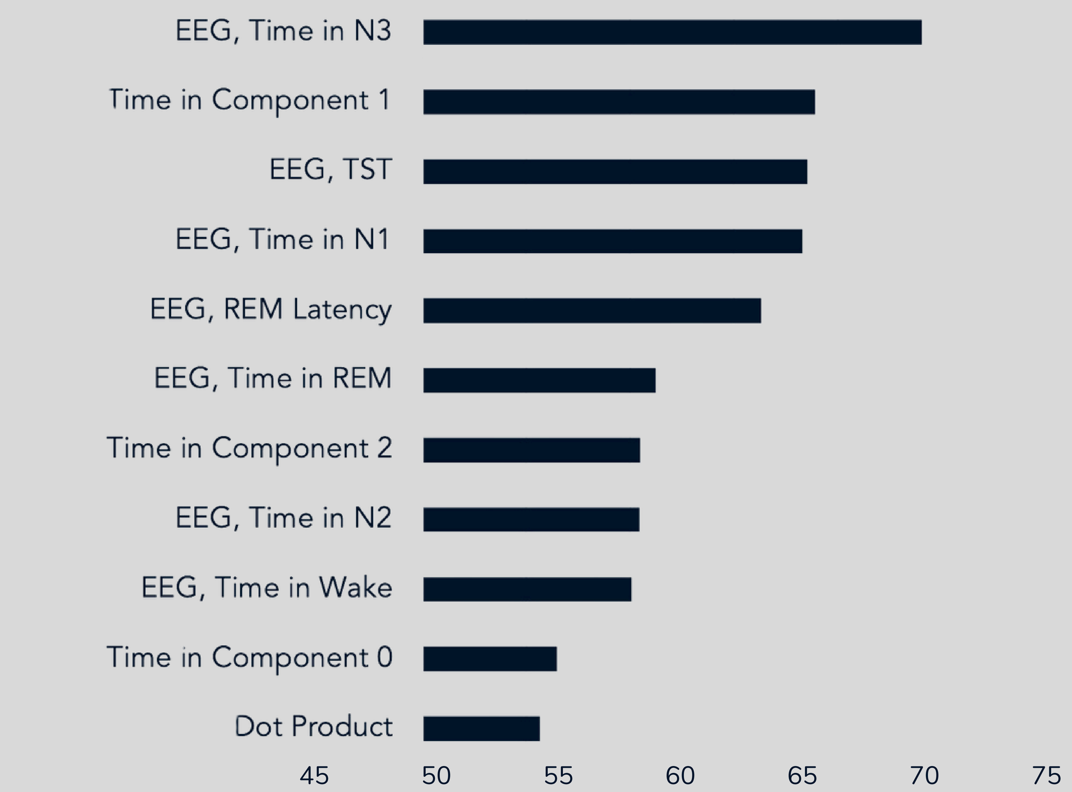








Performance Results: Sleep Stage Comparison



GMM global optima identified n=3 components as the optimal number to describe short segments of EEG/EOG measured by how well the components explain RBD-associated between-group differences, showing the highest cluster quality values observed across all 3 cluster quality measures. Dwell-Fraction (defined as: percentage of total-sleep-time spent in each component), revealed statistically significant differences associated with RBD (Component-3: RBD>Controls) and clinical controls (Component-1: Controls>RBD) based on Mann-Whitney-U and t-test results. ROC-AUCs were calculated for classifying RBD vs-Controls, based only on the Dwell-Fraction (Component-3: 0.65, Component-1: 0.57, Component-2: 0.52). Relative to Component-1, which best described controls, Component-2 best described RBD. Further, Component-2 showed band-power distributions associated with RBD including significantly higher theta/alpha band-power in EOG-channels, lower delta/beta band-power in EEG frontal-channels, and higher delta band-power in EEG central-channels.

Conclusions

Spectral-Band Cluster-Prevalence has potential applications to improve identification of RBD and RBD subtype-specific EEG biomarkers associated with synucleinopathy and PTSD/TASD.