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Peer Review

Review of: "Is There a Direct Relation Between EEG Band Spectrum and DMN Activity in fMRI? A Multivariate Exploratory Study"

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This study effectively investigates the relationship between Default Mode Network (DMN) activity (from fMRI) and EEG band powers across wake, N1, N2, and N3 sleep stages. Its utilization of an open dataset significantly enhances reproducibility and addresses a substantial, unanswered question in neuroscience by employing a comprehensive set of EEG features.

While commendable, the study's methodological details require significant improvement to facilitate full understanding and replication. Authors must provide specific dataset demographics, including participant age (e.g., mean, standard deviation, range), sex distribution, clinical status/health information (e.g., presence of disorders, comorbidities), and medication use, as these factors profoundly influence fMRI, EEG, and sleep patterns. Additionally, reporting ethnicity/race and education level can offer further contextual insights. Without these crucial details, interpreting findings, identifying confounding variables, and replicating the study become challenging.

Furthermore, precise preprocessing parameters for both EEG and fMRI, exact DMN ROI definitions, and the full EEG electrode montage are essential. The "EEG Signal Processing" section specifically needs the exact parameters for the Welch method (window type, overlap percentage, resulting frequency resolution) and precise frequency ranges in Hertz for all seven used EEG bands. These specifics are vital for accurate topographical interpretation and robust replication.

When examining the Default Mode Network (DMN), a complex, network-level phenomenon, it's more informative to observe how multiple brainwave frequencies change across the entire brain rather than focusing solely on a single frequency in one specific area. This broader perspective yields a more

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comprehensive "spectral fingerprint" of the DMN's shifting dynamic state across vigilance stages.

To truly facilitate replication, the scripts used to generate the '.mat' files and for analysis should be made available. The study's language correctly implies correlation over causality, a crucial distinction that the discussion must consistently uphold.

Statistical Validation and Future Directions

Finally, the observed patterns in feature importance require statistical validation. Robust methods such as Permutation Importance Testing, Bootstrapping, and Cross-Validation with Stability Analysis are highly recommended. Additionally, leveraging SHAP (SHapley Additive exPlanations) values can quantify individual feature contributions, which can then be subjected to appropriate inferential statistical tests to determine their overall significance. These methods collectively enhance confidence in the identified important features and move beyond mere observation to statistical validation. Future research should also address the directionality of EEG power changes, perhaps through methods like SHAP Explainer, to gain deeper mechanistic insights into the complex EEG-fMRI interplay.

Declarations

Potential competing interests: No potential competing interests to declare.

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