**Organization for Human Brain Mapping - ABSTRACT**

**Deadline December 19, 2019**

**Weak Connections in Functional Brain Networks Contribute to the Classification of Anesthetic-Modulated States of Consciousness.**

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**ABSTRACT - MAX 4000 CHARACTERS**

**Introduction:** Graph theory analysis has been successfully used to capture differences in brain dynamics across various states of consciousness. For the most part, graphs generated from functional connectivity data are often binarized to only include the strongest connections, excluding the weak, but significant, weights from the analysis. The effects of thresholding functional connectivity brain networks to generate graphs have been scantly explored. This study aimed to compare the predictive power of graphs constructed from the strongest weights, to graphs constructed from all weighted connections, for detecting states of consciousness. We used a machine learning analysis to predict baseline, anesthetic-induced unconsciousness, and recovery states from graphs constructed from high-density EEG recorded from healthy participants.

**Methods:** Nine participants underwent an anesthetic protocol while 128-channel EEG was recorded before (Baseline), during anesthetic-induced unconsciousness (Unconsciousness), and immediately prior to the recovery of consciousness (Pre-Recovery). The signal was source localized and averaged onto 82 regions of the cortex, according to the parcellations of the AAL brain atlas. Two types of functional connectivity - Amplitude Envelope Correlation (AEC) and weighted Phase Lag Index (wPLI) – were calculated across all combinations of brain regions. The resulting functional connectivity matrices were then either binarized (e.g. setting the top 10% percent of the connections to 1, and all others to 0) or kept weighted. Graph theory metrics (i.e. clustering coefficient, global efficiency, modularity and small-worldness) were calculated across both sets of matrices, and input to machine learning classification algorithms (i.e. Linear Discriminant Analysis, Linear Support Vector Machines and Random Forest) to predict 2 states of consciousness: Baseline vs. Unconsciousness, or Baseline vs. Pre-Recovery. The relative importance of the features in predicting state of consciousness were tested by comparing: functional connectivity metrics alone (i.e. mean and standard deviation); graph theory features alone (binarized or weighted); and functional connectivity metrics combined with graph theory features (binarized or weighted).

**Results:**

Envelop-based and phase-based functional connectivity had differential predictive power for different conscious states. AEC predicted unconsciousness with an accuracy of 86.4% and pre-recovery with an accuracy of 72.8%; wPLI predicted unconsciousness with an accuracy of 78.5% and pre-recovery with an accuracy of 80.4%.

The inclusion of low-weight connections significantly improved the prediction of states of consciousness. Graphs built from weighted AEC networks increased predictive power by approximately 10% in comparison to binary AEC networks (Unconscious: 50.4% (binary) to 63.8% (weighted); pre-recovery: 54.6% (binary) to 62.4% (weighted)). Graphs built from weighted wPLI networks also increased their predictive power by approximately 10% in comparison to binary wPLI networks (Unconscious: 57.2% (binary) to 65% (weighted); pre-recovery: 55.2% (binary) to 68.9% (weighted).

Notably, the inclusion of low-weight connections in network graphs differentially improved the classification accuracy of unconsciousness for envelop-based connectivity, and pre-recovery for phase-based connectivity. These correspond with the state of consciousness preferentially detected by the family of connectivity.

**Conclusions:**

The majority of graph theory analyses for the characterization of states of consciousness are currently done using only the strongest-weighted functional connectivity between nodes. Our results suggest low-weight connections contain information that is significantly predictive of state of consciousness. Future consciousness studies should consider weighted and un-thresholded functional connectivity patterns to include this significant source of information.

**References**

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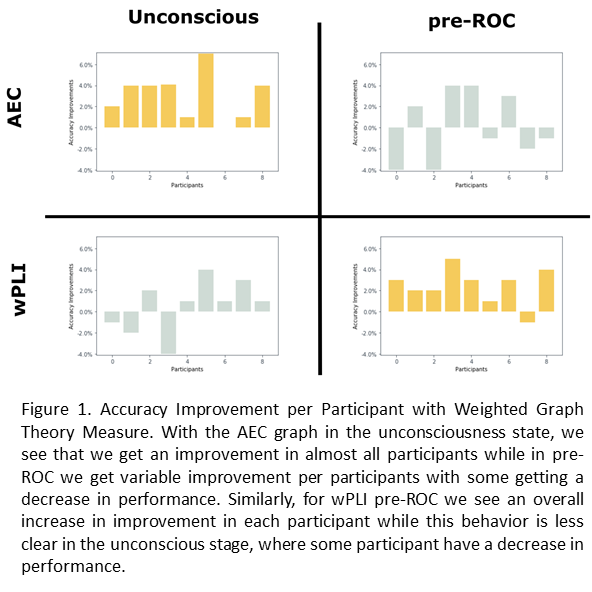
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