A Game-Theoretic Model of the Resting-State Brain

Gruber, Danielle (School: John L. Miller Great Neck North High School)

Our survival depends on the brain's adaptation of information processing to changing cognitive demands; this ability stems from the interactions of specialized brain networks. At rest, network activity alternates between segregating computations to localized functional domains and integrating information across domains, facilitating efficient transitions between states. Though readily observable via the synchrony of neural time series, fluctuations in network integration and segregation are not well understood. The present study models these cooperative and competitive interactions using game theory. At each point in time, networks evaluate payoffs for different synchronization strategies, weighing both the rewards of achieving desired within- and between-network synchrony and the energetic costs of adopting these strategies. The model's application to empirical data is assessed by extracting parameters from resting-state fMRI in ketotic and glycolytic metabolic states, where the former is hypothesized to supply the brain with more energy. Currently, the model can only recreate observed dynamics with medium accuracy. However, important insights were still gleaned. The glycolytic state relied more on network activation strategies to regulate dynamics than the ketotic state, implying that ketones help networks avoid unnecessarily costly strategies in driving neural dynamics. Additionally, variance in both cooperation and competition was lower in the ketotic state, suggesting that ketones may allow the brain to sustain the cost of more active, metabolically-demanding networks in time. Future research will improve the model's accuracy in recreating empirical data and further investigate how metabolic state impacts the balance of neural expression and resource allocation.

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