Graph-Based Comparative Analysis of fNIRS Hyperscanning

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This study investigates functional brain connectivity in parent–infant dyads using fNIRS hyperscanning. Participants were recorded simultaneously under three interaction conditions.

Why Use Graph Theory?

The human brain operates as a network. Graph theory allows us to model this structure and quantify properties such as efficiency, clustering, and modularity. By analyzing the brain as a graph, we gain insight into how information flows and how regions interact during real-life social engagement.

Dataset

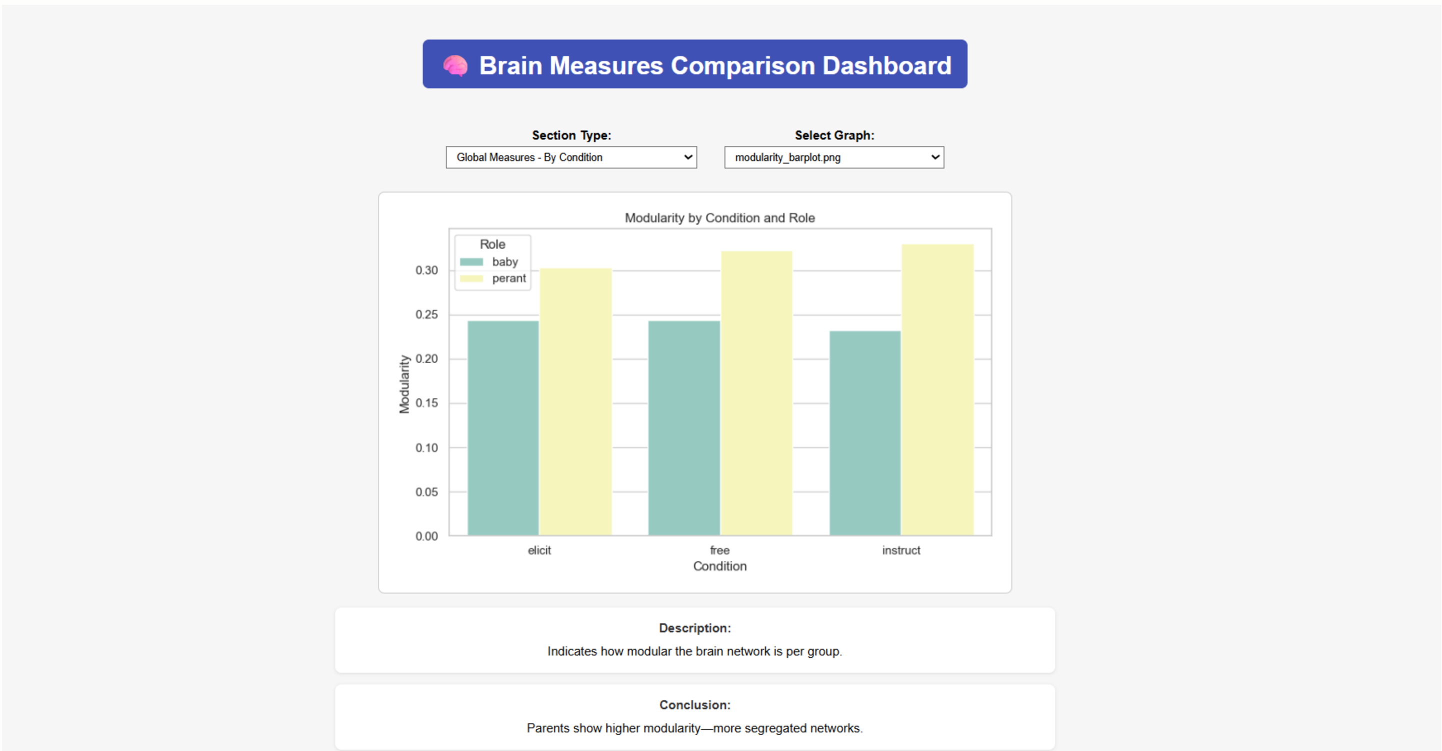
- 19 parent–infant dyads
- 3 conditions per dyad: Free, Elicit, Instruct
- 114 fNIRS recordings total (parent & infant)

Each recording:

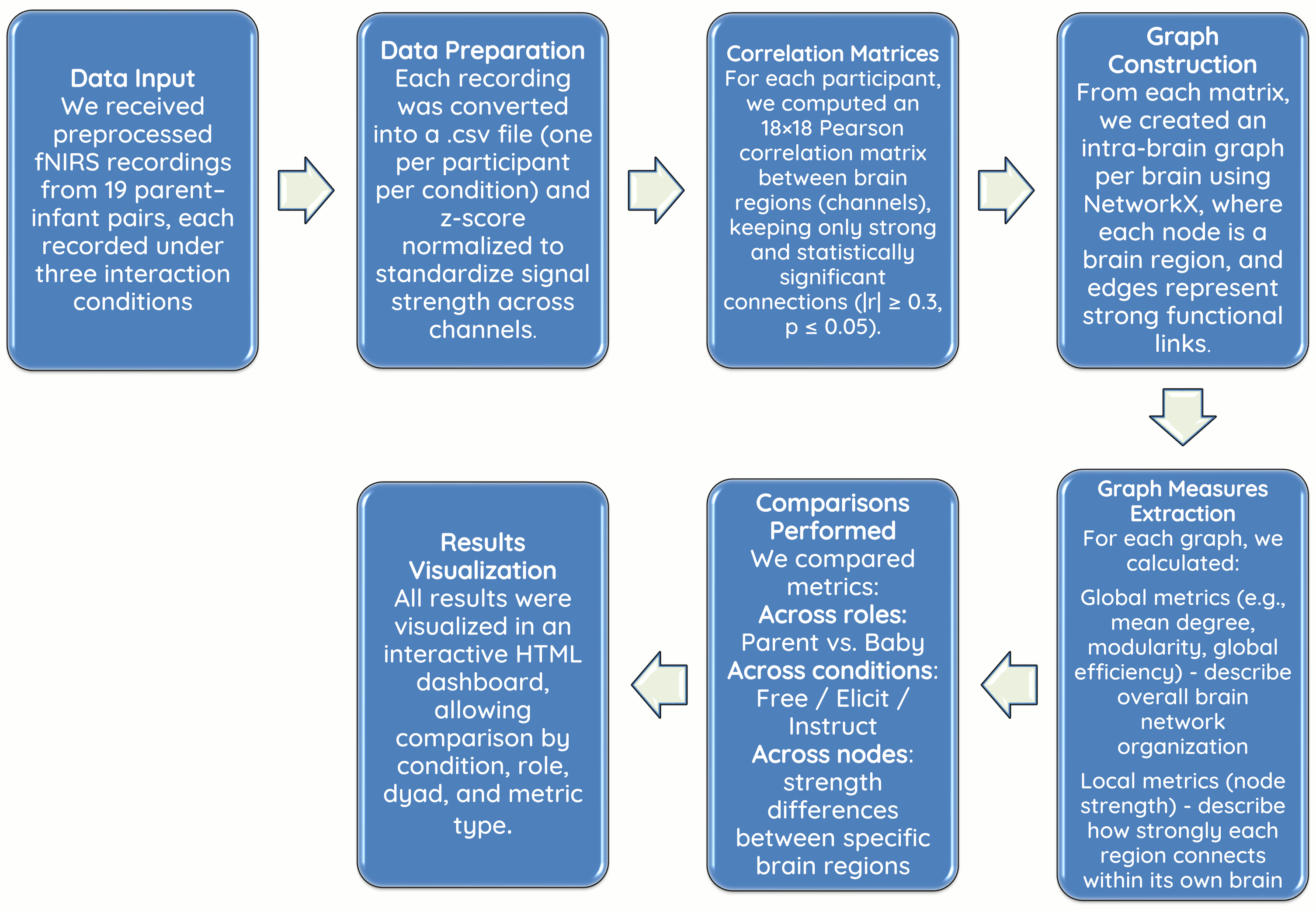
- 1892 time points × 18 channels
- Preprocessed HbO signals

Interactive Dashboard for Graph Results

The interactive dashboard enables dynamic exploration of graph results by condition, role (parent/ baby) and dyad. It displays all computed metrics with summaries and scientific interpretations.



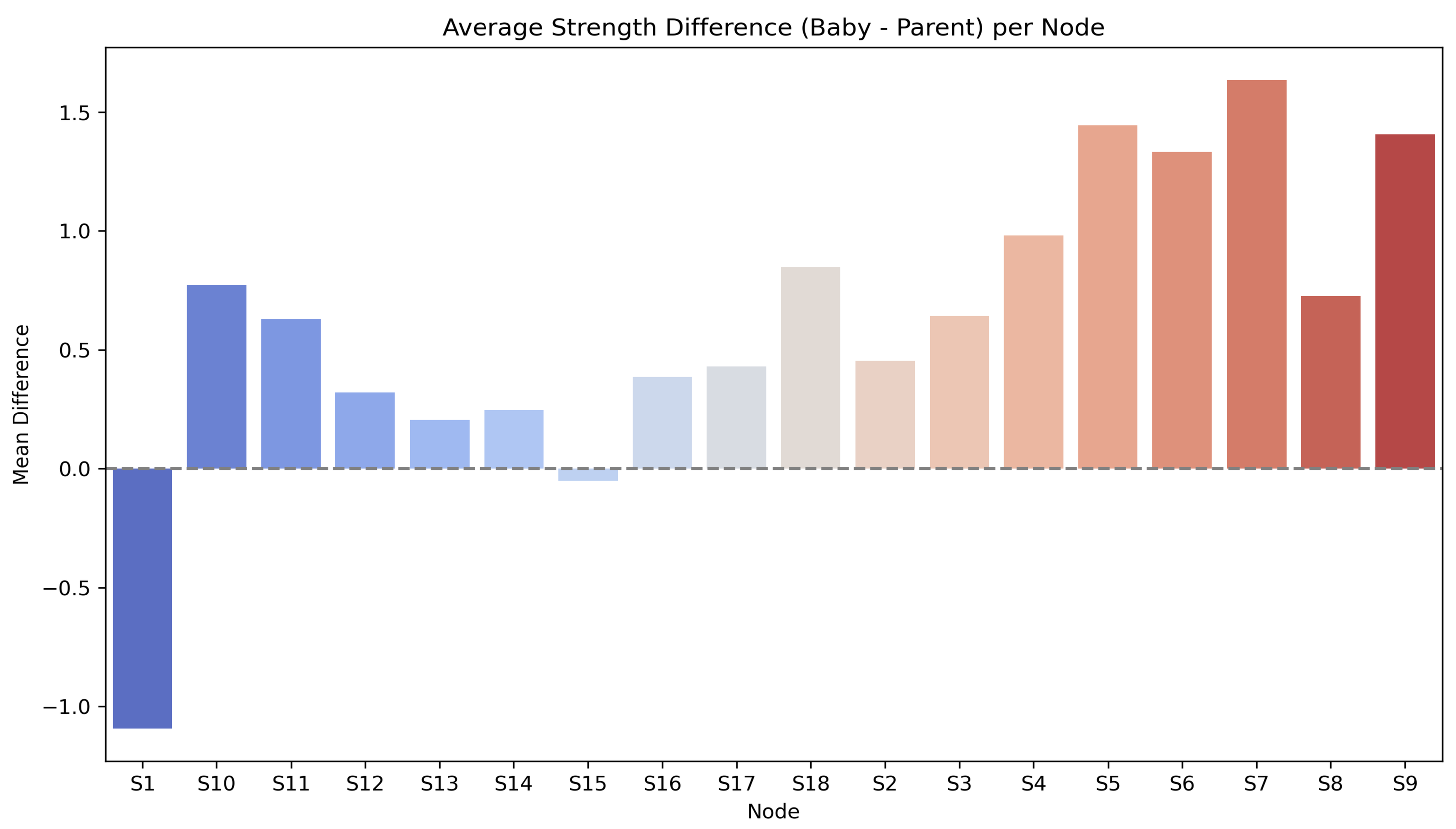
Analysis Pipeline



Local Graph Metrics – Key Findings

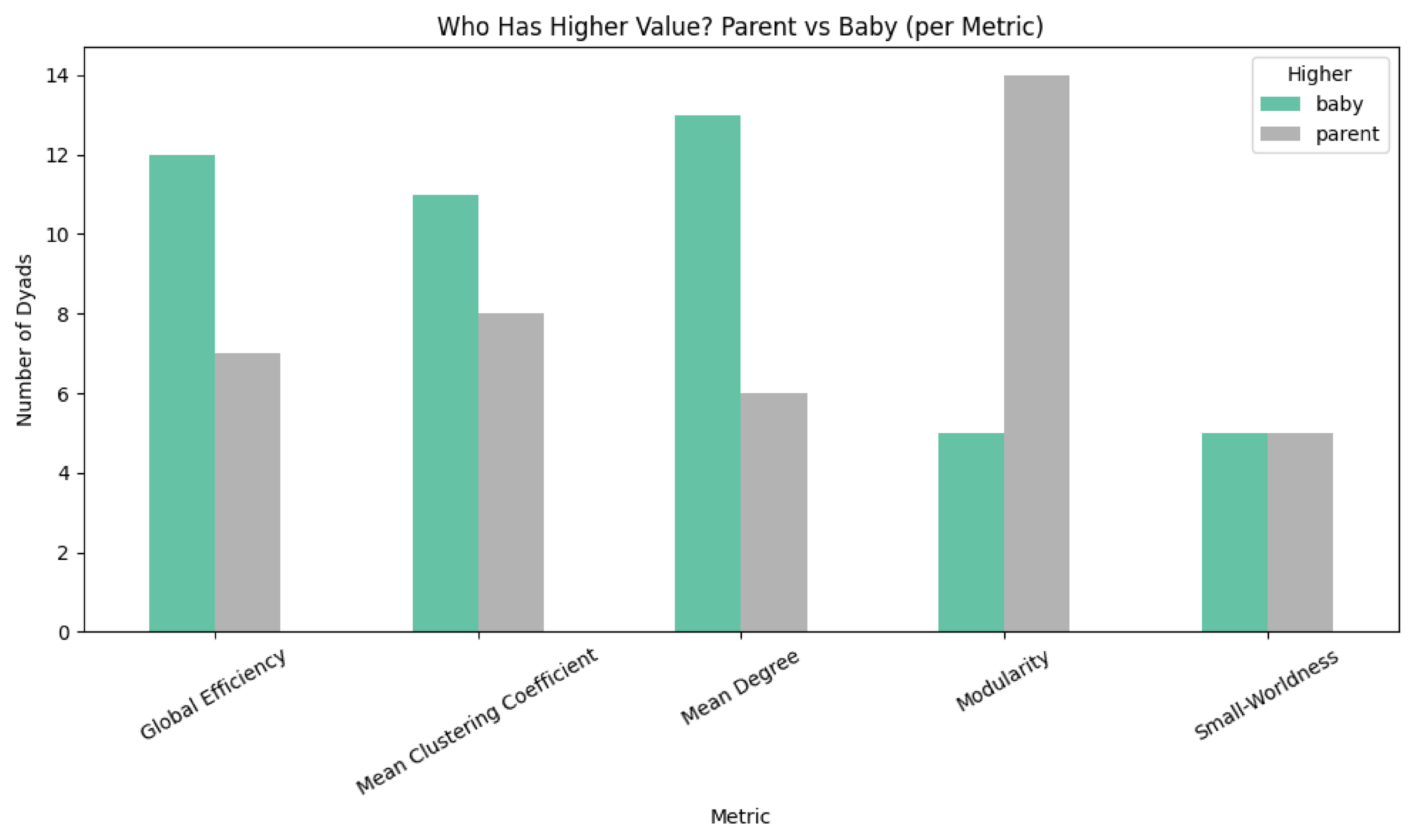
Infants demonstrated consistently higher node strength than parents across most cortical regions. Notably, channels S5, S7, and S9 showed the strongest differences, indicating that infant brains recruit widespread and robust neural resources during social interaction.

This supports the view of diffuse hyperconnectivity in early development.



Global Graph Metrics – Key Findings

Infant brain networks exhibited higher mean degree, clustering coefficient, and global efficiency, suggesting denser and more integrated connectivity. In contrast, parents showed higher modularity, reflecting more segregated and functionally specialized brain organization. These patterns are consistent across all social conditions (Free, Elicit, Instruct).



Graph Measures

Mean Degree: Number of connections each brain region has; indicates its centrality.

Clustering Coefficient: Measures how strongly a node's neighbors are interconnected.

Global Efficiency: How efficiently information travels across the entire network.

Modularity: Detects functional communities or modules within the brain network.

Small-Worldness: Describes networks with strong local clusters and global integration.

Node Strength: Sum of connection weights per node; indicates how strongly each brain region is connected within the network.