

Exploring Semantic Network Breakdown in Bengali Speaking Persons with Mild Cognitive Impairment and Alzheimer's Clinical Syndrome

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Key take away point: The first graph-theoretical semantic network study in Bengali speakers, demonstrating a hierarchical breakdown of semantic network organization, with disruption of global connectivity preceding alterations in local clustering during the progression from cognitively unimpaired (CU) to mild cognitive impairment (MCI) to Alzheimer's clinical syndrome (ACS).

Introduction

- Semantic memory impairment is one of the earliest cognitive changes in ACS.
- Graph theory provides an objective framework to quantify the structural organization of semantic networks (SN) beyond conventional word count measures.
- Most previous graph theoretical studies have been conducted in English-speaking populations, limiting the understanding of semantic network organization across other languages and cultures.

Aim

To assess semantic network disruption from CU → MCI → ACS and evaluate graph metrics as predictors of cognitive impairment.

Methodology

CU = 50, MCI = 50, ACS = 50

Neuropsychological Evaluation including Montreal Cognitive Assessment (MoCA) and Clinical Dementia Rating (CDR)

Animal fluency task (60 seconds)

Directed Semantic Network Construction

Graph metrics calculation – Average shortest path length (ASPL), average clustering coefficient (ACC), modularity value and average neighbour degree (AND)

Statistical analysis and Boosting Algorithms for classification and regression

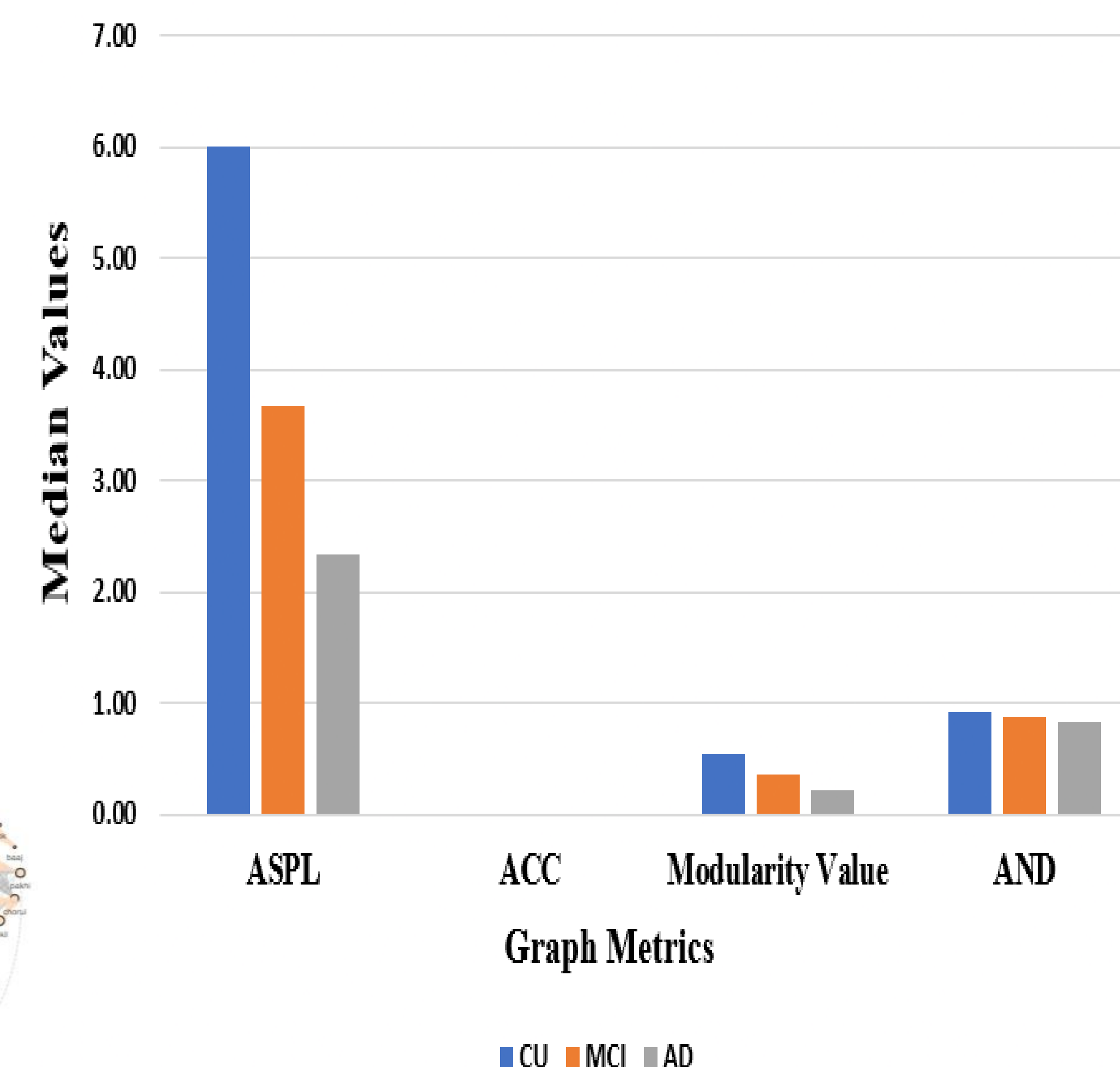
Results

- ASPL significantly decreased from CU → ACS ($p < .001$)
- Modularity significantly decreased from CU → ACS ($p < .001$)
- ACC remained near zero across groups showing that responses were predominantly organized in sequential pathways
- XGBoost predicted MoCA: $R^2 = 0.59 \pm 0.09$
- XGBoost predicted CDR-SOB: $R^2 = 0.54 \pm 0.14$
- Boosting-based machine-learning classifier and regressor exhibited good classification performance (accuracy: 0.78 ± 0.077 ; F1score: $0.79.03 \pm 0.076$) and moderately strong performance in regression task ($R^2 = 0.88572 \pm 0.08$).

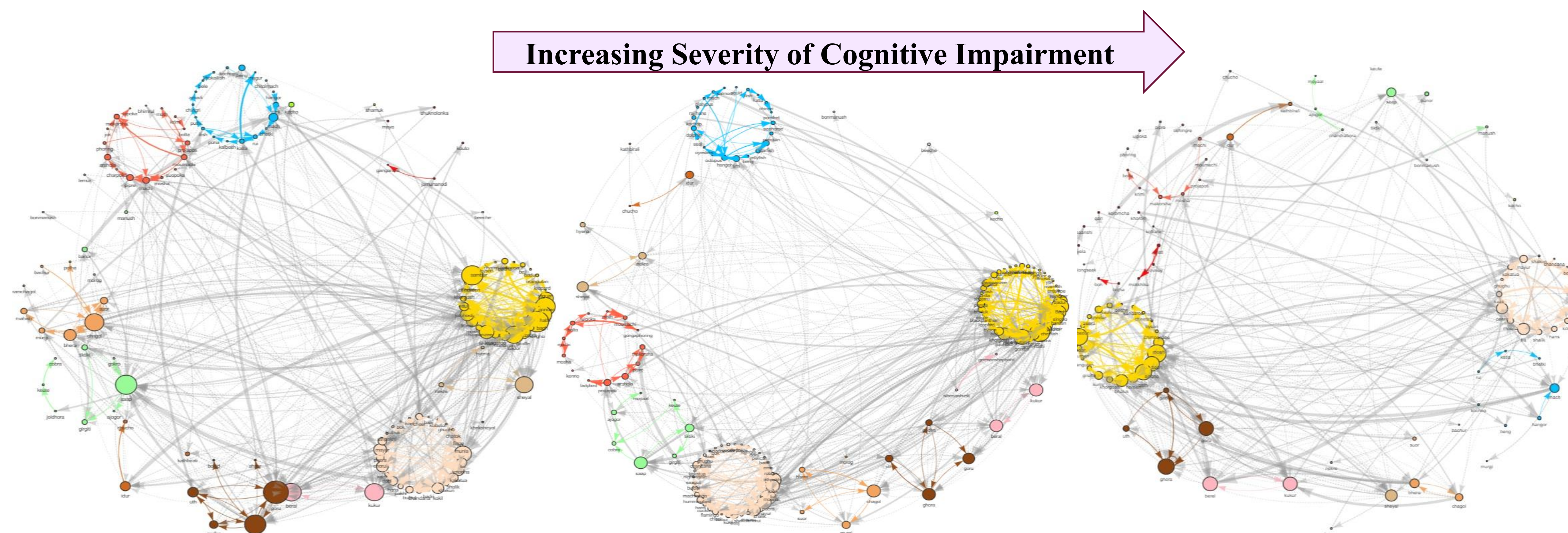
Conclusion

- Semantic networks become progressively less integrated and more fragmented with increasing disease severity.
- Global semantic network properties (ASPL and modularity) are disrupted earlier than local network properties (ACC and AND).
- Progressive reductions in ASPL across the group indicates SN simplification and loss of conceptual richness, rather than improved network efficiency
- Findings support the cross-linguistic applicability of graph-based SN analysis in Bengali-speaking individuals.

Median Values of Graph Metrics



Increasing Severity of Cognitive Impairment



Conceptual Network Graph Showing Disruption of Semantic Networks from CU → MCI → ACS

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