

Morphometric Network Alterations In Alzheimer’s and Lewy Body Dementia: A Jensen-Shannon Divergence Based Similarity Network Approach

#1529

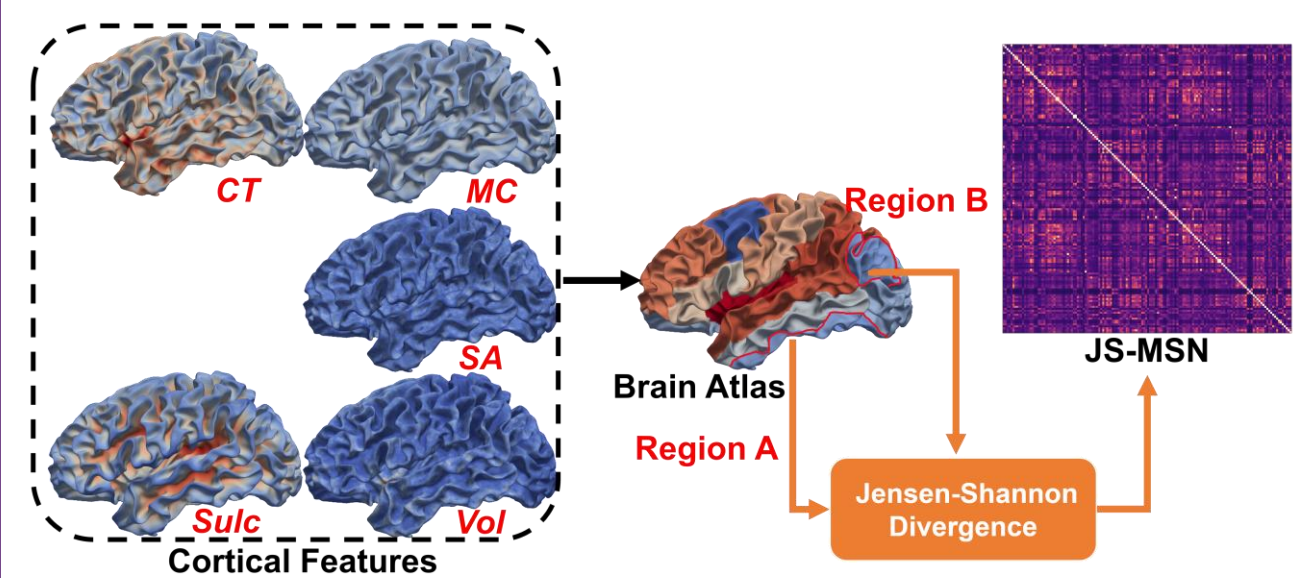
Minheng Chen¹ Tong Chen¹ Xinyan Jian^{2,3} Tianming Liu⁴ Andrew Blamire^{5,6} John O’Brien⁷ Li Su^{7,8} Dajiang Zhu¹

¹Department of Computer Science and Engineering, University of Texas at Arlington, Arlington, TX, USA ²Department of Biomedical Engineering, Case Western Reserve University, Cleveland, OH, USA ³Lerner Research Institute, Cleveland Clinic, Cleveland, OH, USA ⁴School of Computing, University of Georgia, Athens, GA, USA ⁵Translational and Clinical Research Institute, Newcastle University, Newcastle upon Tyne, UK ⁶Newcastle Magnetic Resonance Centre, Newcastle University, Newcastle upon Tyne, UK ⁷Department of Psychiatry, University of Cambridge, Cambridge, UK ⁸Sheffield Institute for Translational Neuroscience, University of Sheffield, Sheffield, UK

The main takeaway is that JS-MSN provides an interpretable individual-level brain network framework that not only differentiates AD and LBD from controls, but also captures continuous cognitive decline through MMSE prediction and a network-based severity score.

INTRODUCTION

Alterations in large-scale brain network organization are increasingly implicated in Alzheimer’s disease (AD) and Lewy body dementia (LBD). Morphometric similarity networks (MSNs) derived from structural MRI provide a promising framework for characterizing coordinated patterns of cortical morphology. However, most prior studies have primarily emphasized diagnostic group differentiation or network topology, while whether individualized MSNs can jointly support disease classification and continuous cognitive phenotyping remains less well established.



METHODS

We analyzed 303 T1-weighted structural MRI scans comprising 90 patients with AD (77.51 ± 5.68 years), 105 patients with LBD (76.79 ± 7.53 years), and 108 cognitively normal controls (CN; 75.24 ± 6.62 years) from the University of Cambridge School of Clinical Medicine. Data were preprocessed using FSL and FreeSurfer to reconstruct cortical surface meshes and extract vertex-wise morphometric features. We propose a Jensen–Shannon divergence-based MSN (JS-MSN), in which regional feature distributions are compared to construct individual-level cortical networks. Using vectorized upper-triangular MSN features, we evaluated three binary classification tasks with logistic regression, linear support vector machines, and ElasticNet-regularized models under 5-fold stratified cross-validation. Clinical relevance beyond diagnosis was assessed via within-group prediction of Mini-Mental State Examination (MMSE) scores using ridge regression, and a one-dimensional Network Severity Score (NSS) derived from cross-validated disease classifiers.

RESULTS

Across diagnostic tasks, JS-MSN demonstrated improved or comparable classification performance relative to MIND and MSNs.

Task	Logistic Regression			Linear SVM			ElasticNet		
	AUC	ACC	F1	AUC	ACC	F1	AUC	ACC	F1
AD MSN	97.7±1.3	90.4±4.4	89.1±4.8	97.5±1.4	91.4±5.0	90.3±5.2	96.8±1.7	89.9±5.3	88.3±6.2
vs MIND	98.7±1.5	94.4±4.1	93.9±4.5	98.6±1.5	93.4±5.4	92.7±6.2	98.5±1.8	92.9±5.8	92.4±6.2
CN Ours	99.1±1.6	95.4±2.5	92.8±3.0	99.2±1.4	94.8±1.9	93.8±2.2	99.0±1.5	94.4±2.9	93.8±3.4
LBD MSN	92.3±3.8	85.0±2.0	84.5±1.5	91.9±3.6	85.0±2.6	84.5±2.2	93.3±4.2	87.8±3.8	87.6±3.8
vs MIND	91.8±2.9	84.0±2.9	83.4±2.4	91.2±3.2	82.6±3.4	81.6±3.0	92.4±3.0	83.1±1.9	82.3±1.8
CN Ours	92.0±3.4	85.0±1.2	84.3±1.4	92.0±3.7	85.0±1.9	84.5±1.8	92.7±3.4	84.5±2.7	84.1±2.2
AD MSN	83.8±4.4	77.9±3.5	75.7±3.9	83.2±3.6	76.9±2.3	74.6±2.2	84.9±4.8	76.4±3.8	73.5±4.8
vs MIND	84.8±5.0	78.5±4.8	77.0±4.7	85.3±5.3	78.5±3.8	76.7±3.8	85.6±5.3	79.5±5.1	77.3±5.5
LBD Ours	84.6±1.1	79.8±1.6	77.6±2.7	84.0±0.8	78.5±2.1	76.8±3.2	85.7±1.2	77.9±3.8	76.7±5.0

MIND: Morphometric INverse Divergence, MSN: correlation-based MSN

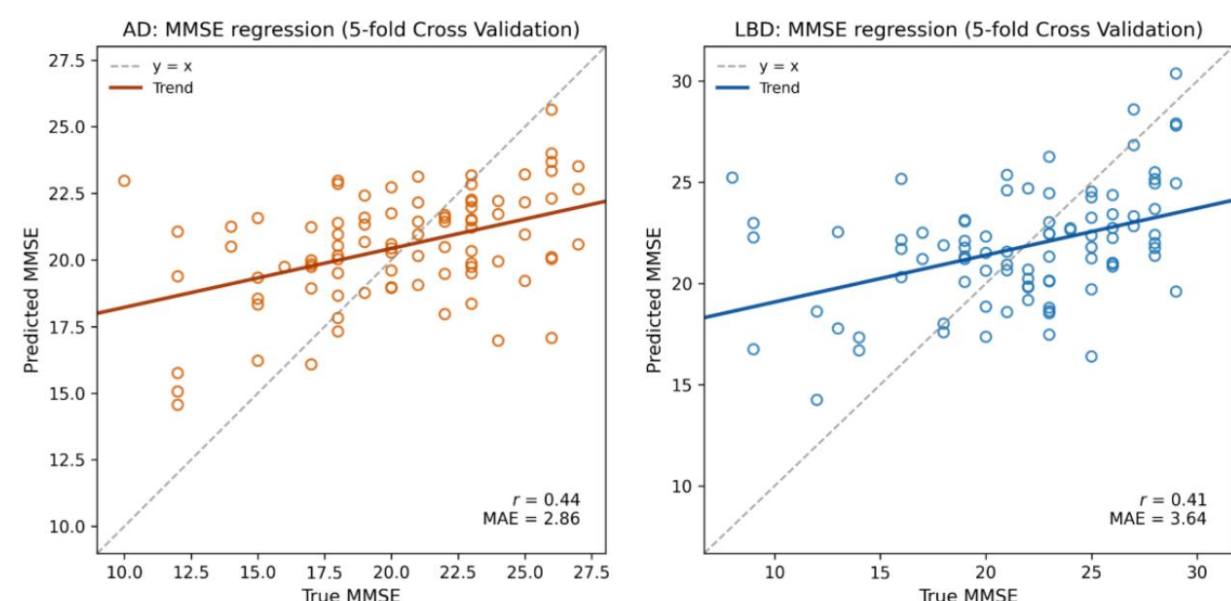


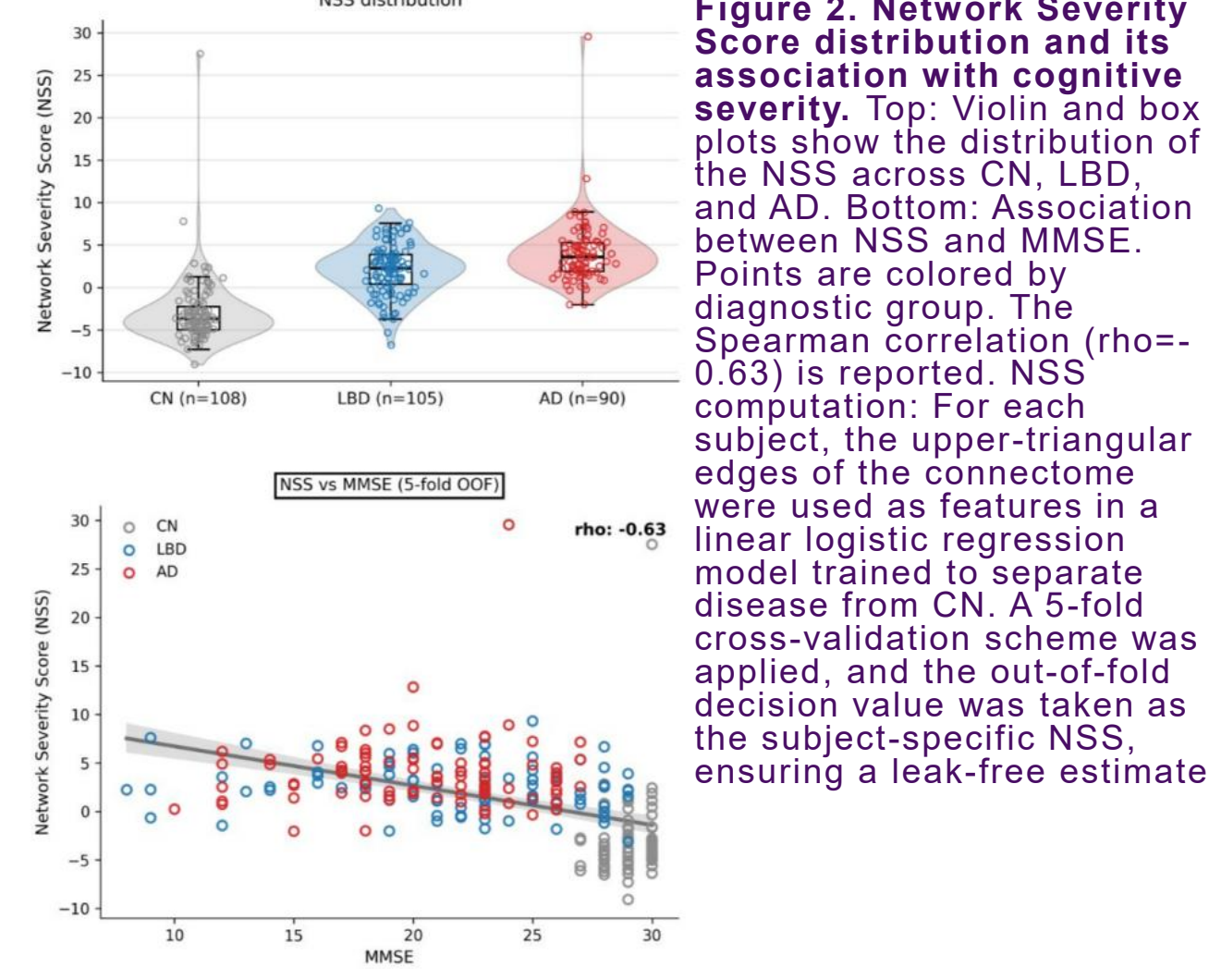
Figure 1. Within-group prediction of cognitive severity from proposed JS-MSN features. Scatter plots show cross-validated out-of-fold predictions of MMSE scores from individual-level MSN features in AD patients (left) and LBD patients (right). Each point represents one subject, with the x-axis denoting the observed MMSE score and the y-axis the predicted MMSE score obtained using a ridge regression model trained on the upper-triangular elements of the MSN. Pearson correlation coefficient (r) and mean absolute error (MAE) are reported for each group, summarizing the strength and accuracy of the within-group association between network organization and cognitive performance.

CONCLUSIONS

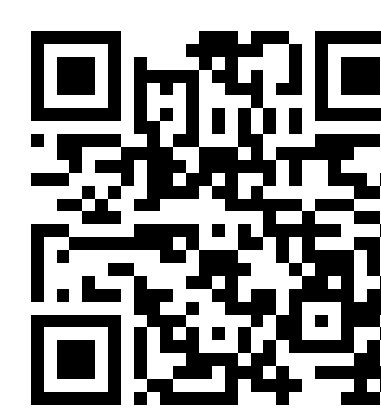
Importantly, MSN features enabled significant within-group prediction of MMSE scores in both AD (r = 0.44, MAE = 2.86) and LBD (r = 0.41, MAE = 3.64) using out-of-fold cross-validated predictions (Fig. 1). The derived NSS showed a graded distribution across CN, LBD, and AD, and was strongly associated with MMSE across individuals (Spearman ρ=-0.63), indicating sensitivity to cognitive severity rather than diagnostic labels alone (Fig. 2). JS-MSNs capture robust alterations in brain network organization across AD and LBD while also reflecting continuous cognitive decline. By unifying diagnostic differentiation and severity estimation within a single, interpretable network framework, JS-MSNs provide a clinically meaningful approach for characterizing neurodegenerative disease-related brain changes.



Figures



CONTACT



Medical Imaging and Neuroscientific Discovery Lab

