Atypicality analysis of MRI data for the discovery and analysis of brain prototypes in neurodevelopmental disorders

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Abstract

Most current neuroimaging analyses in studies of brain disorders assume a homogenous presentation of the disorder such that traditional statistical analysis methods based on Gaussian distributions can be applied. Yet, most brain disorders present with a heterogeneous spectrum of cognitive, behavioral, morphometric as well as functional manifestations. In this talk, we present a novel approach called PRAMA (Prototype Representation and Analysis via Morphological Atypicality) that embraces the heterogeneity of both typical and atypical brain morphometry. This approach employs our Multiscale Score Matching Analysis (MSMA), a global and local multiscale out-of-distribution analysis via the gradients of the log density (scores). Combining MSMA and manifold-mapping, we compute a morphospace of brain prototypes representing deviations from a population of typical subjects. Using these brain prototypes, disorder-related subtyping can be performed. Furthermore, subject-specific profiles of atypicality can be extracted and summarized per subtype. We show the application of PRAMA to the study structural MRI data of Autism Spectrum Disorder (ASD) as well as Down Syndrome (DS) at school age. The resulting analysis detects disorder-related subtypes and reveals that subtype-specific structural atypicality correlates with cognitive and behavioral outcomes. These results shed much-needed light on the understanding ASD and DS.

Biosketch

Dr. Styner is a leading expert in medical image computing with specific research on developing and applying novel neuroimaging methods and software tools for structural and diffusion MRI. His research is focused on studies of early postnatal brain development, encompassing a broad range of studies in human and non-human primate neuroimaging such as normal development, autism spectrum disorder, fragile-X, Angelman Syndrome, Down Syndrome, and intra-uterine exposure studies. Dr. Styner has co-authored over 400 papers in peer-reviewed journals and conferences. He is the director of the UNC Neuro Image Research and Analysis Laboratory (NIRAL).