Brain folding increases in sharpness and complexity over third trimester-equivalent development

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Background and Hypothesis:

Gyrification, or convolution, of the cerebral cortex is a promising transdiagnostic marker for early neurodevelopment. Previous studies have related differences in sulcogyral shape to schizophrenia, bipolar disorder, and autism spectrum disorder, but the physical mechanisms underlying these differences remain poorly understood. The focus of this study was to explore decomposed curvature metrics, the principal curvatures, as physically meaningful quantitative biomarkers to track brain development. We hypothesize that the average sharpness and complexity of sulci and gyri, reflected by principal curvatures, increase throughout third trimester-equivalent development.

Methods:

Cortical surfaces generated from magnetic resonance imaging (MRI) were obtained from the developing Human Connectome Project. Global sharpness was calculated from the principal curvature of maximum magnitude, with average sharpness defined separately for gyral (positive) and sulcal (negative) curvatures. Global complexity of folds (eg., curviness along the length of a fold) was calculated from variance in the principal curvature with minimum magnitude. Trajectory of each summary metric was fit over time using polynomial regression.

Results:

Forty-three subjects were removed due to incomplete curvature analysis or missing subject information, such that 541 preterm and term-born infants were evaluated with scan age ranging from 27 to 45 weeks postmenstrual age (PMA). Across this developmental range, sharpness and complexity increased until a plateau around term-equivalent. Average sharpness of gyri was best correlated with age of scan (R^2 = 0.877).

Conclusion and Potential Impact:

During the pre- and postnatal development period, total cortical surface area continues to increase after birth, but the overall sharpness and complexity of folding plateaus at ~37 weeks post-menstrual age. Exploring these physically meaningful curvature metrics can provide improved parameters for comparison to mechanistic models of brain folding.