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Elastic instabilities in a layered cerebral cortex: A revised axonal tension model for cortex folding[1]

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Despite decades of research, there is still no consensus regarding the mechanism(s) driving cerebral cortex folding. Two different mechanisms—axonal tension based on efficient wiring of the neurons and differential growth-induced buckling—are the prevailing hypotheses, though quantitative comparison with data raises issues with both of them. I will present a model for the elasticity of the cerebral cortex as a layered material with bending energy along the layers and elastic energy between them. The cortex is also subjected to axons pulling from the underlying white matter. Above a critical threshold force, a 'flat' cortex configuration becomes unstable and periodic undulations emerge, i.e. a buckling instability occurs, to presumably initiate folds in the cortex. This model builds on the original axonal tension model for cortex folding based on the efficient wiring of neurons but with no buckling mechanism and allows one to understand why small mice brains exhibit no folds, while larger human brains do. Finally, an estimate of the bending rigidity constant for the cortex can be made based on the critical wavelength to quantitatively test this revised axonal tensional model.

[1]This work was done in collaboration with Oksana Manyuhina and David Mayett.