Evaluation of Neonatal Brain Tissue Development Using Diffusion MRI

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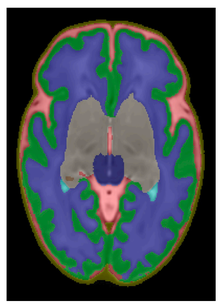
Introduction

- Between 18 and 39 weeks of gestational age, infants experience significant brain volume growth due to the development of white matter (WM) and gray matter (GM) tissues [1].
- It is known that infants born prematurely are at higher risk of developing neurological conditions [2].
- Internal structures of the WM and GM can be studied at a microscopic level with diffusion MRI, allowing the characterization of the brain's anatomy in a non-invasive way.

Goal and Hypothesis

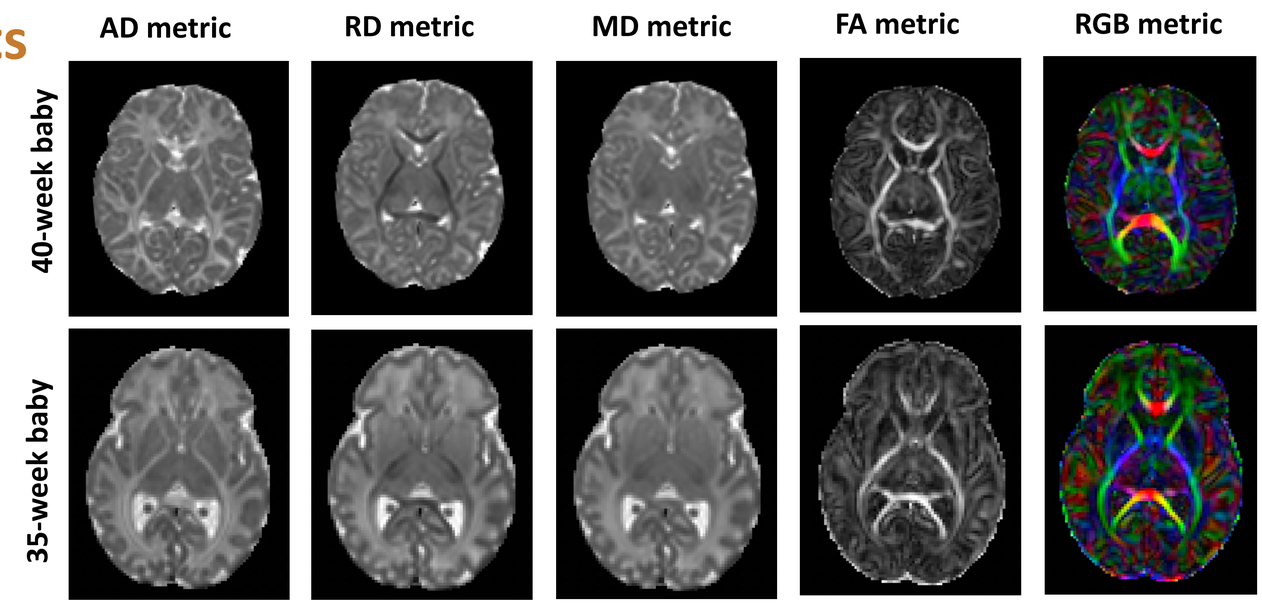
- This study aims to use diffusion tensor imaging (DTI) metrics, derived from dMRI scans, to characterize the diffusivity differences in different stages of babies' development.
- We expect to see:
  i. A decrease in axial, radial and mean diffusivity (AD, RD and MD metrics)
  ii. An Increase in fractional anisotropy (FA metric)

Material & Methods



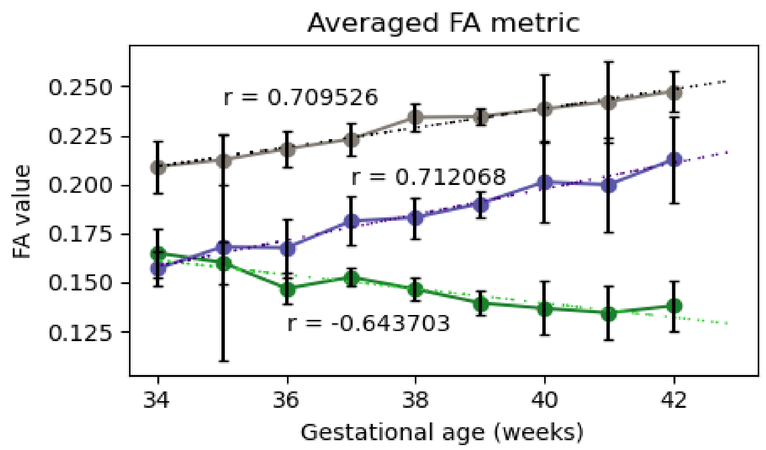
- 45 babies were acquired from The Developing Human Connectome Project
- The babies' gestational age ranges from 34 to 43 weeks (34 ≤ x < 43).
- The diffusivity and fractional anisotropy metrics were extracted using DIPY.
- The signal intensities were compared in three regions of interest: cortical gray matter (CGM), white matter (WM) and deep gray matter (DGM).

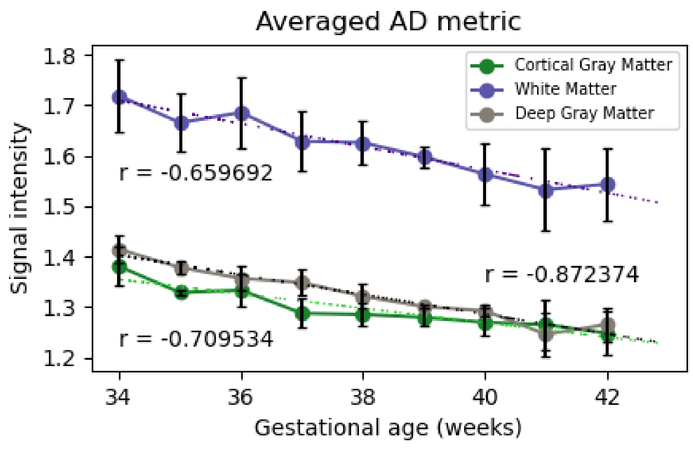
Results



Tissue brain development have clear differences between gestational ages:

i. Differences can be observed from solely observing the DTI metrics of a 35-week baby compared to a 40 week-baby
ii. Axial diffusivity (AD metric) decreases as gestational age increases. Similar results are seen in RD and MD metrics
   - That suggest a decrease in water content, hence important tissue growth
iii. The FA value increase in WM and DGM
   - That suggests a tendency for anisotropic diffusion, caused by myelination development





Conclusion

- dMRI can be used to understand brain development in neonates
- The results of this study are useful in identifying developmental differences in CGM, WM and DGM between infants

Future directives

For a deeper understanding of early tissue development, we could investigate:

- Different ROIs
- With a larger dataset

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*Equal contribution from the two first authors of the project

References

[1] Knickmeyer, R. C., et al. (2008). A structural MRI study of human brain development from birth to 2 years. *The Journal of neuroscience : the official journal of the Society for Neuroscience*, *28*(47), 12176–12182 ; [2] L., Boardman, J. P., et al. (2008). Specific relations between neurodevelopmental abilities and white matter microstructure in children born preterm. *Brain : a journal of neurology*, *131*(Pt 12), 3201–3208