Evaluation of Neonatal Brain Tissue Development Using Diffusion MRI

(An Introduction To Python-based Medical Image Analysis)

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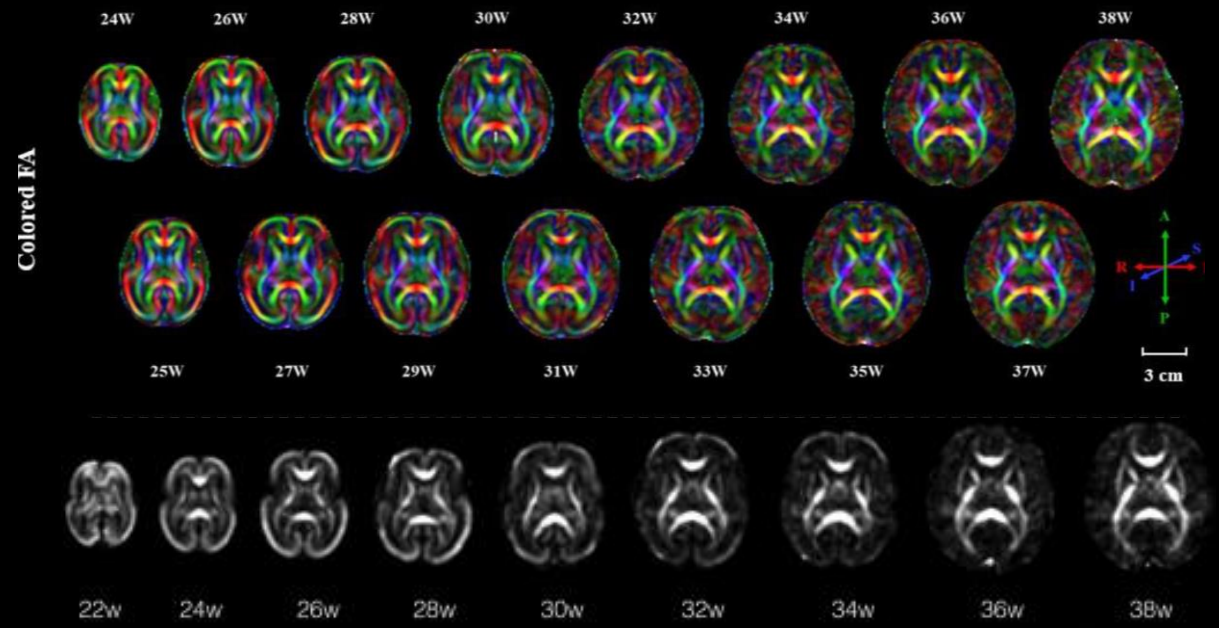
Introduction

Infant development

- Brain volume growth[1]
- Preterm infants are at a higher risk of developing neurological conditions[2]
- dMRI is useful to understanding brain tissue growth

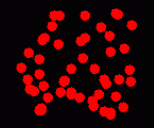


[1]Rebecca C. Knickmeyer, et al., 2008 [2]Serena J. Counsell, et al., 2008 [3]Chen2022-yo [4]Khan2019-rj

Introduction

Diffusion MRI

- Non-invasive imaging technique[1]
- Helps us understand white matter integrity in infants[2]
- Predicts the diffusivity direction along the white matter fiber tracks[2]

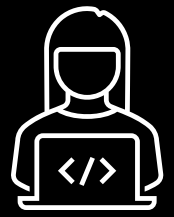


Problem

- Little Python resources exist for beginners to access diffusivity in brain tissues

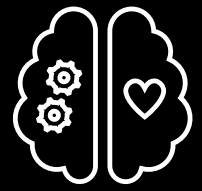
[1]Hans H. Shild., 1990 [2]Bryon A. Muelle, et al., 2015 https://cronodon.com/BioTech/Diffusion.html

Goal



Learn Python coding

Write DTI reconstruction code with Python



Understanding the brain development in infants

Democratize the knowledge

Hypothesis

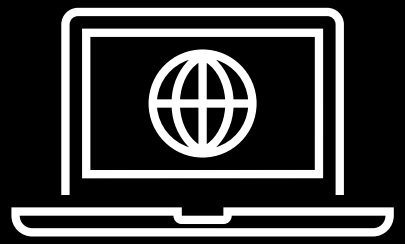
- Baby development could be characterized by a difference in diffusion MRI (DTI metrics)

What we expect

- Brain fibers in neonatal will mature over time and increase in anisotropic diffusion (FA value).
- AD, RD and MD metrics will decrease with gestational age

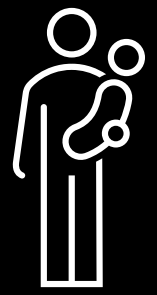
Method

Data acquisition



- Online dataset (dHCP)
- 45 participants (9 groups)
- Scanned from 34 to 42 weeks*

- Diffusion MRI (dMRI)
- Scanned post-birth



- Preterm babies (< 37 weeks*): 22
- Term babies (≥ 37 weeks*): 23

* Every week is referred to as gestational age

Method

Diffusion-Weighted Images (DWIs)

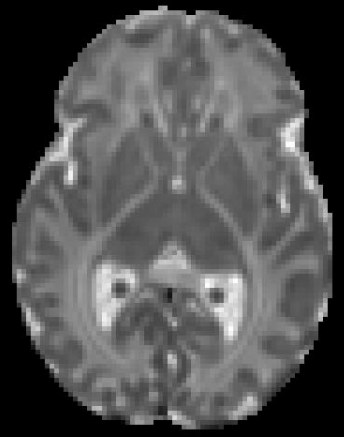
b0 b400 b1000 b2600

* sub-B037S1, 30 weeks (birth age), 33 weeks (scan age)

Method

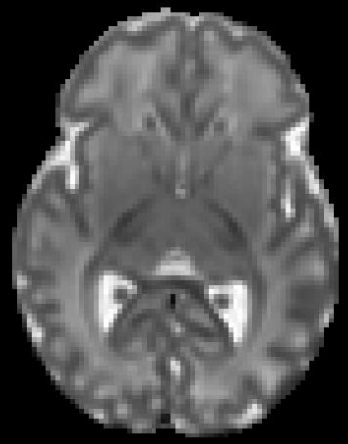
Diffusion Tensor Imaging reconstruction

AD



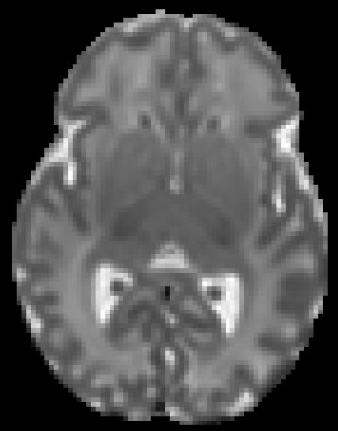
Diffusivity along the fiber

RD



Diffusivity ⊥ to the fibers

MD

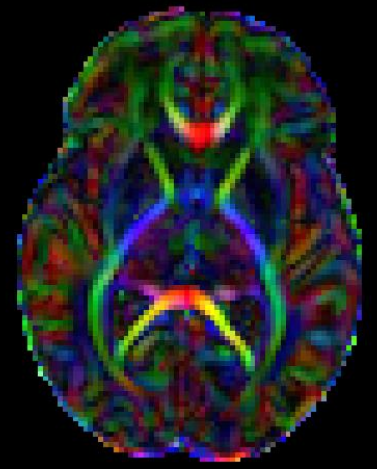


Mean diffusion in all directions

FA

Primary fiber bundles

Colored FA

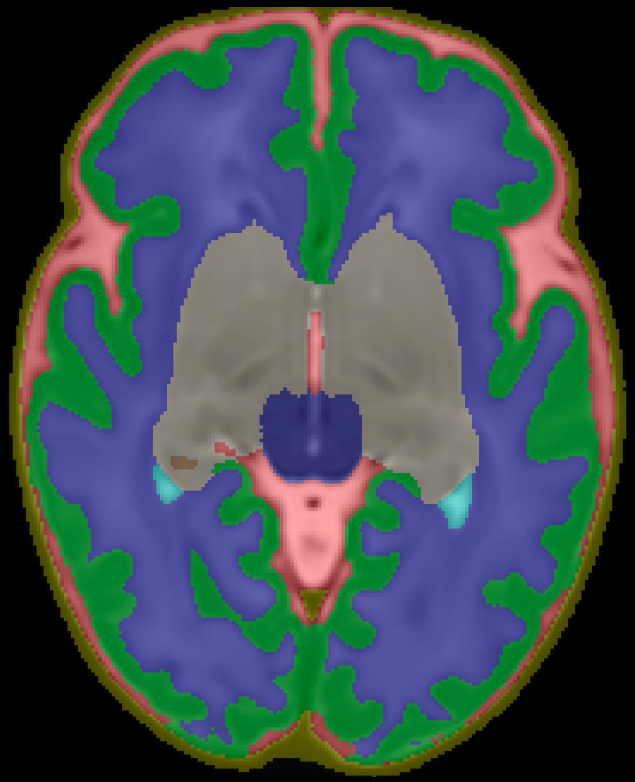


Diffusivity direction

* sub-CC00063AN06, 35.1 weeks (birth age), 35.7 weeks (scan age)

Method

Region of interests (ROIs)



Cortical gray matter

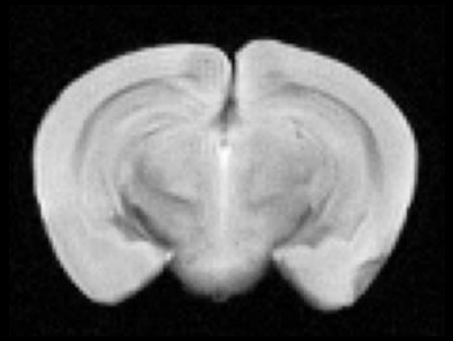
White Matter

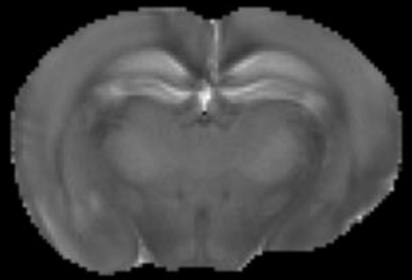
Deep gray matter

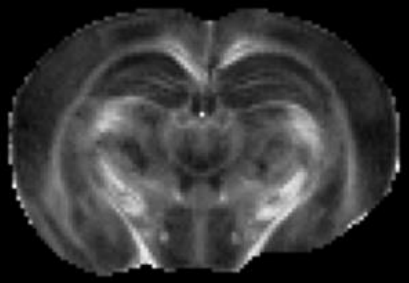
* dHCP atlas, 36 weeks

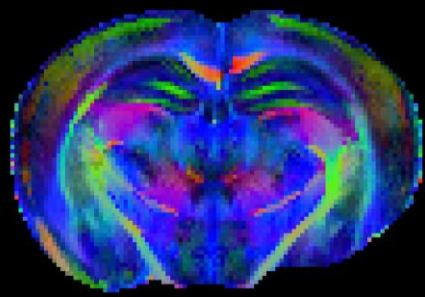
Results

DTI reconstruction

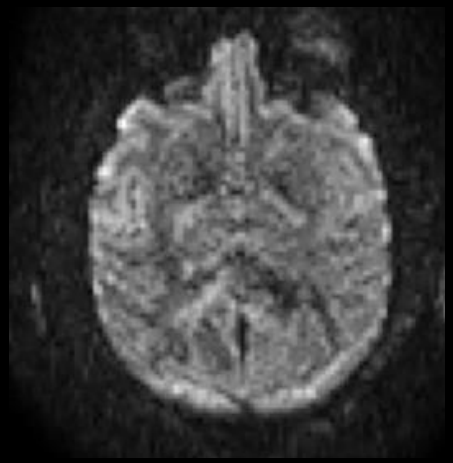


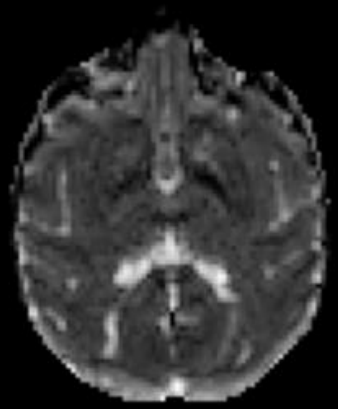


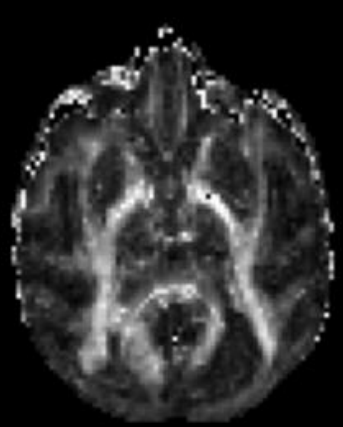


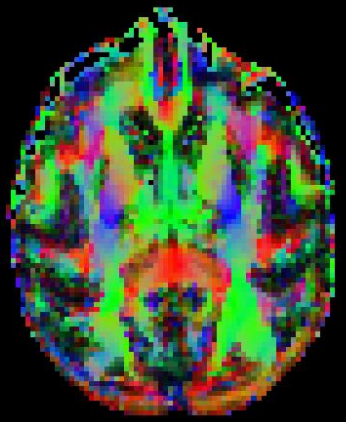


Mouse brain







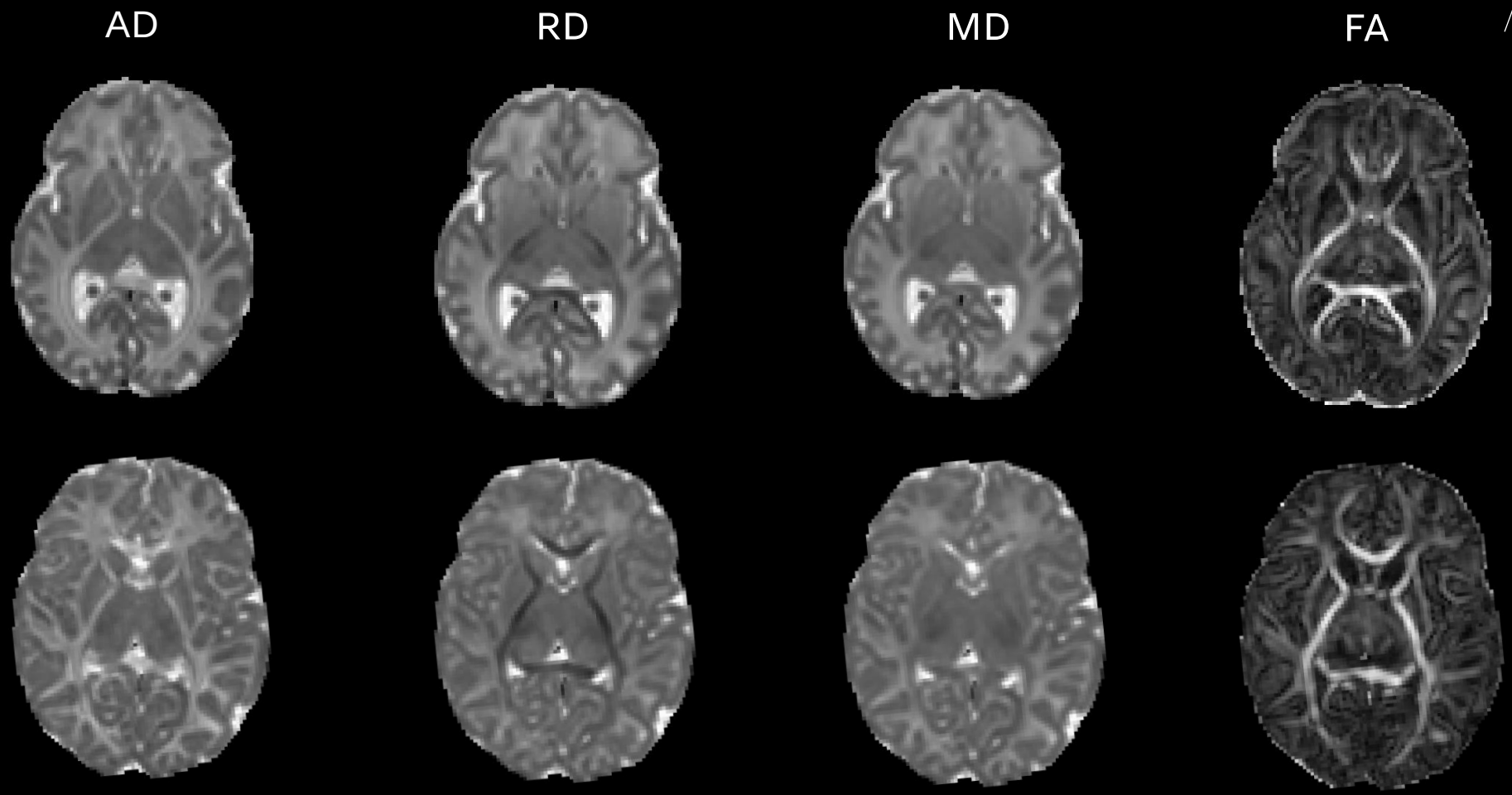


Monkey brain

* Mouse data was scanned at the Montreal Heart Institute, monkey data was from open fMRI (online)

Results

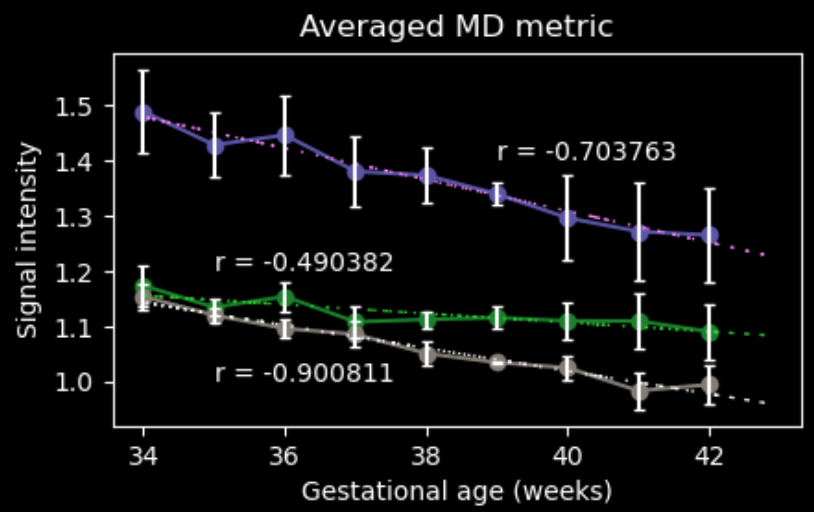
DTI reconstruction

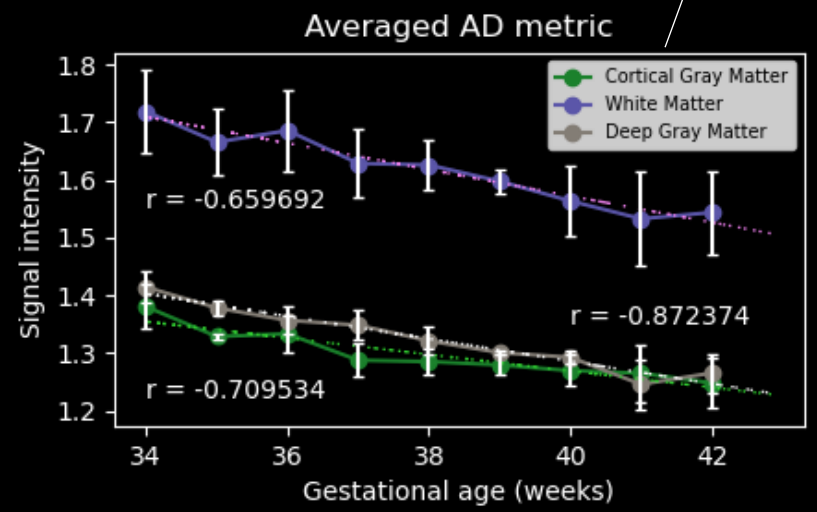


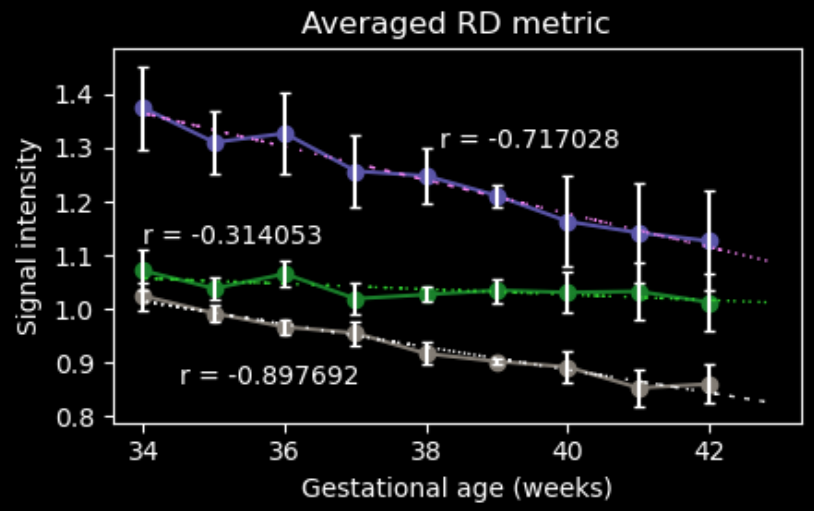
sub-CC00063AN06, 35.1 weeks (birth age), 35.7 weeks (scan age)
sub-CC00586XX18, 40.1 weeks (birth age), 40.2 weeks (scan age)

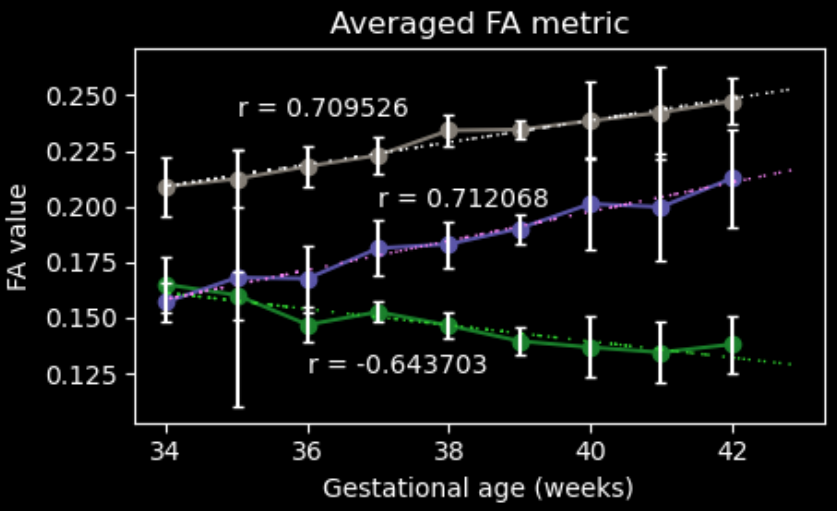
Results

- **Lower AD, RD and MD in white matter (WM), gray matter (GM) and deep GM**
  - ➢ Decrease in water content
  - ➢ GM & WM development
- **Higher FA value in deep GM and WM**
  - ➢ Increase of myelin sheet
- **Largest change in the white matter**









Conclusion

- dMRI can be used to access the brain tissue development
- Tracking infant development
- Younger babies have higher brain diffusivity compared to older babies
- Older babies have higher anisotropic diffusion characterized by an increase in myelination

Future work

- Different ROIs
- Larger dataset
- Predicting neurological conditions of infants

SCAN ME to get access to our PDF report

SCAN ME to get access to our experiment

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THANK YOU