Parcellation Scheme for a Spatio-Temporal Atlas of Fetal Brain Lobe Development

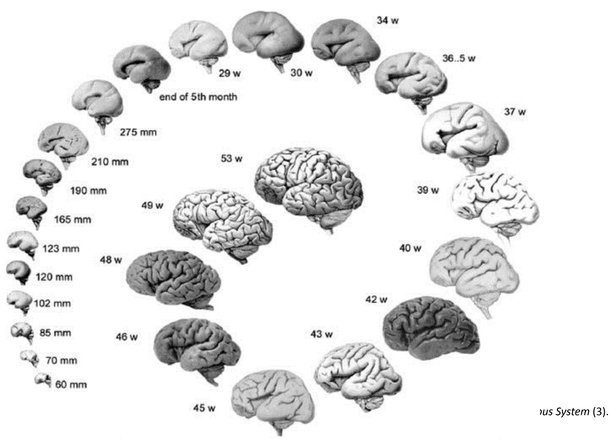
THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

Jasmine H. Kaidbey[1] and Catherine Limperopoulos[2, 3]

[1]Department of Anatomy and Regenerative Biology, George Washington University, Washington, DC, USA [2]Diagnostic Imaging and Radiology, [3]Fetal and Transitional Medicine, Children's National Medical Center, Washington, DC, USA.

Background

- During gestation the brain's cortical landscape changes from a smooth, homogenous layer into a convoluted region with a drastically increased surface area.
- The timeline of the pattern of gyration is so robust that deviations are often pathological.



ius System (3).

- MRI can track the fetal brain's developmental plan, which is why this technique is becoming the gold standard for studying brain development.
  - High resolution images
  - Minimally low risk: no sedation
  - Multimodal
- As such, it can be said that MRI facilitates the discovery of biomarkers for normal and pathological development.

  Our question : could parcellating the cortex lead to discovery of any novel biomarkers to identify high risk pregnancy?

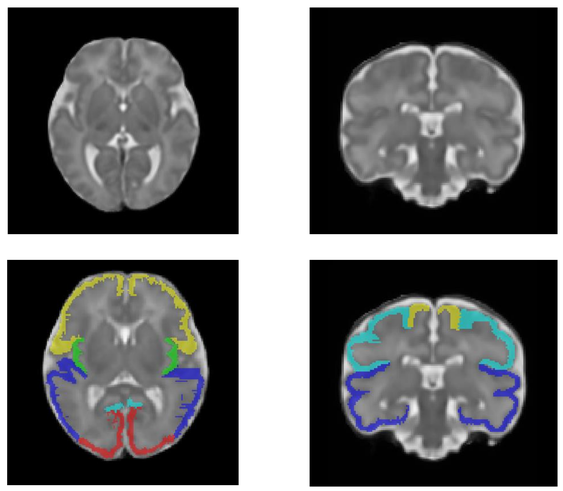
Objectives

Aim one: To devise a scheme for parcellation of the fetal brain into 5 lobes: frontal, parietal, temporal, insular, and occipital.

Aim two: To create a spatio-temporal atlas of fetal brain lobe development for the third trimester of pregnancy.

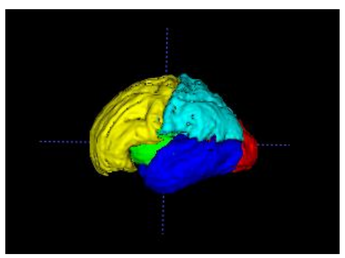
Methods

The atlas used for this research was a 4D fetal atlas of T2 weighted MR images from 80 fetuses without any known pathological conditions.
The age range used here is from gestational weeks 29 to 37 (age at the time of the scan).
ITK-Snap version 3.0 was used for the manual parcellations.

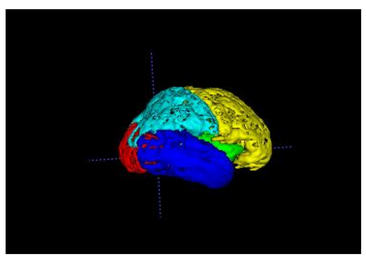


Results

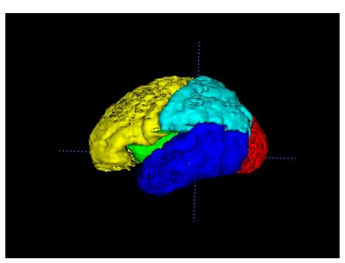
Gestational weeks (GW) from 31 to 37 were parcellated, but our youngest gestational age in the sample (GW29) could not be parcellated due to a lack of surface landmarks required in the parcelation scheme presented below.



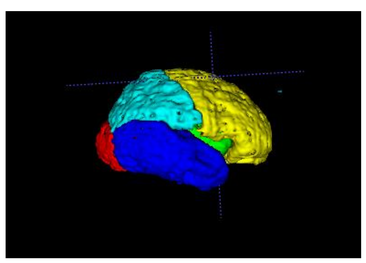
GW31



GW33



GW35



GW37

Highlight of Landmarks used in Parcellation Scheme:

- Frontal lobe: central sulcus, cingulate sulcus
- Parietal lobe: central sulcus and parieto-occipital sulcus
- Insular lobe: circular sulcus, Sylvian fissure
- Temporal lobe: temporal poles, temporo-occipital notch, Sylvian fissure
- Occipital lobe: parieto-occipital sulcus, calcarine fissure, temporo-occipital notch

Conclusion

Taken together, our results show that pre-existing conventions for the division of the third trimester brain into classic lobes are only applicable down to gestational weeks 31.

We have presented a framework for the parcelation of MR images of the fetal brain into five lobes, and applied it to gestational weeks 31, 33, 35, and 37.

Current, possible applications of this tool:

- Extract surface area and volumes of each lobe.
- A tool to compare populations to discover:
  - Relationships between *any* pathological condition of interest and the lobes.
  - Regional and hemispheric discrepancies in high-risk fetuses.

Future Directions

- Refine the parcellations
  - Define more landmarks within the lobes to parcelate the fetal brain into a greater number of areas.
- Improvements in MR acquisition and post-processing techniques will improve quality of the images.

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