A Role for Fetal and Neonatal Imaging in Autism

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Overall outline

• Overview of functional connectomes

• Why fetal and neonatal connectomes?

• What connectomes can tell us about neurodevelopmental disorders?
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What’s a Connectome??

- A comprehensive map of neural connections in the brain
  - “Wiring diagram” of the brain

- Functional connectomes
  - Functional connections or connectivity
  - Macro-level organization
Functional connectivity

Goal: find synchrony between brain areas

- High Connectivity ($r > 0.9$)
- Low Connectivity ($r < 0.1$)
Visualizing connectomes

(a) Graph representation
(b) Positive features
(c) Negative features

- PFC
- Mot
- Ins
- Par
- Tmp
- Occ
- Lmb
- Cer

# positive edges – # negative edges
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Many neural processes end at birth

Typical period for fetal fMRI
Rapid growth: single subject example

30 wks GA

34 wks GA

40 wks GA
MRI of 30 week fetus: Axial images
The brain doubles in size in <3 months
Functional MRI of 30 week fetus
Connectomes develop across the 3rd trimester

Longitudinal amygdala functional connectivity

Scheinost 2016, Pediatric Research
Similar data from cross sectional studies

Functional connectomes are detectable at birth

Doria, PNAS 2010

Smyser cerebral cortex 2010

Spann J Neurosci 2018

Kwon Neuroimage 2015

Alcauter J NeuroSci 2014

Doria, PNAS 2010
Baby connectomes are similar to adults’

Neonate

Adult

overlap: 79%
But, they still have room to grow

Gao Cerebral Cortex 2015
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A promising example study

• Preterm birth
  – Birth before 37 week gestation
  – Long-term developmental delays
  – Altered connectomes
    • Infants, children, adolescents, adults
  – Mainly attributed to postnatal factors
What about connectomes before preterm birth?

• Alterations before preterm birth
  – Suggests prenatal origins
  – Not purely postnatal factors
  – i.e. a neurodevelopmental disorder of “mis-wirings”

• Compare connectomes at 29 weeks
  – 18 fetus born term; 14 fetus born preterm
Disrupted connectomes in language regions

A) Term (T)

B) Preterm (PT)

C) PT vs T

D) PT vs T
Lower connectivity within the language network
Alterations correlates age at birth
Making sense of these data

- Altered language connectivity is a “hallmark” of preterm birth

![Infants](image1)
![Children](image2)
![Young adults](image3)

- But, origins are prenatal, not postnatal
On going and future work

• Early connectome based markers of ASD
  – Longitudinal scanning
    • Twice in the 3rd trimester
    • Once after birth
  – High risk group
    • Sibling(s) with ASD
  – Can we observe early neural correlates of ASD?
Summary

• Fetal and neonatal connectomes
  – How the brain’s “wiring” develops
  – Rapid changes in 3rd trimester
• “Mis-wiring” gives insights to neuro-developmental disorders
• Promising approach to studying ASD
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Questions?