Connectome Based Predictive Modeling of Joint Attention in Infancy

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Introduction

Background

- In the first year of life, infants begin to coordinate their attention with others, referred to as joint attention (JA) and considered a milestone of early social cognition[1]
- Joint attention suggested as a Theory of Mind (ToM) precursor[2]
- Brain networks involved in join attention emergence are mostly unknown

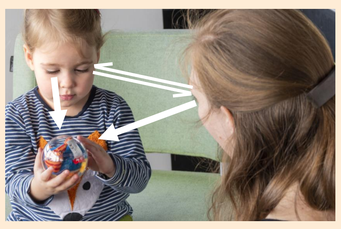
Hypothesis

Based on the networks involved in ToM and its precursors in infancy, we expected to find:

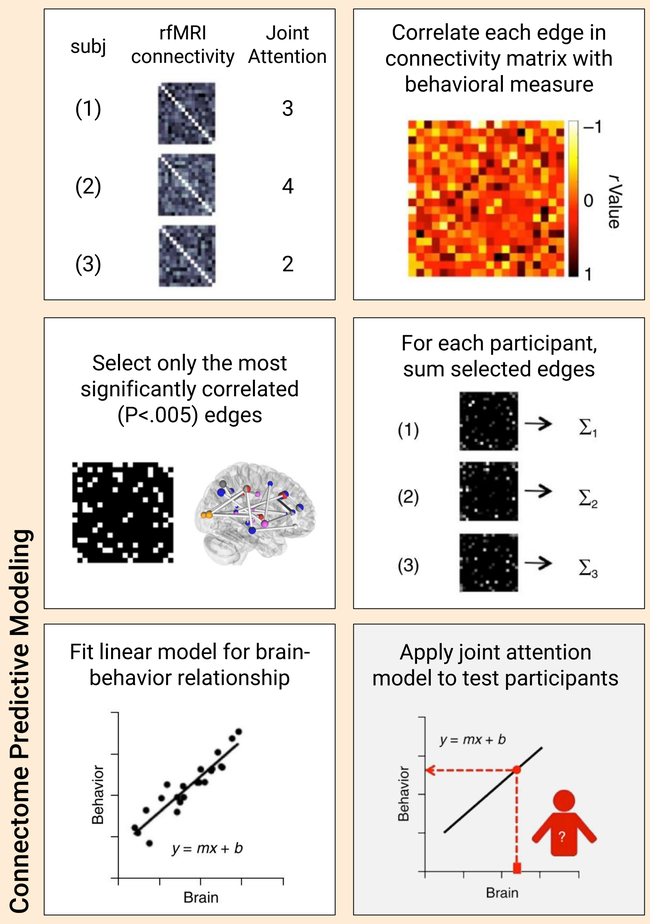
- Bottom-up attention networks (the ventral attention network, VAN)[3]
- Possibly already in interaction with the default mode network (DMN), supporting ToM[4]

Methods

- Data from Baby Connectome Project[5]: 92 infants (51 female) aged 8 to 15 months with 144 measurements
  - resting-state fMRI
  - behavioral joint attention task
  - behavioral general development (Mullen) score
- Image pre-processing: niBabies[6], CONN Toolbox[7] to obtain connectivity matrices
- Connectome Predictive Modeling[8] (see figure right):
  - Data split into training and test set
  - Predicted scores correlated with observed joint attention scores to assess model performance



Joint Attention: coordination of one's attention with another person toward an object



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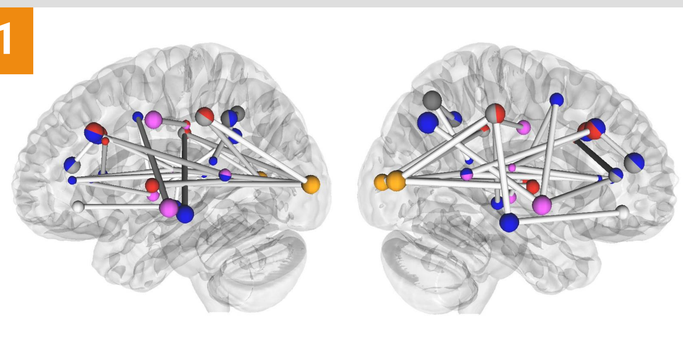
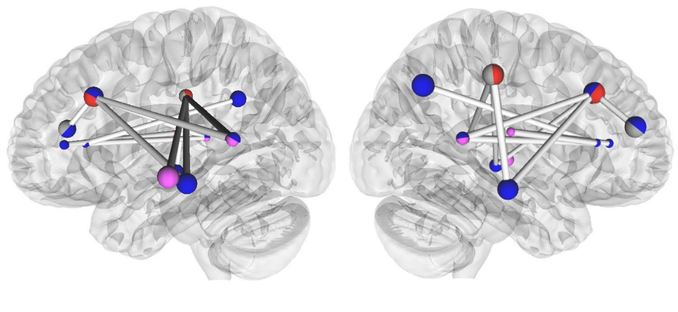


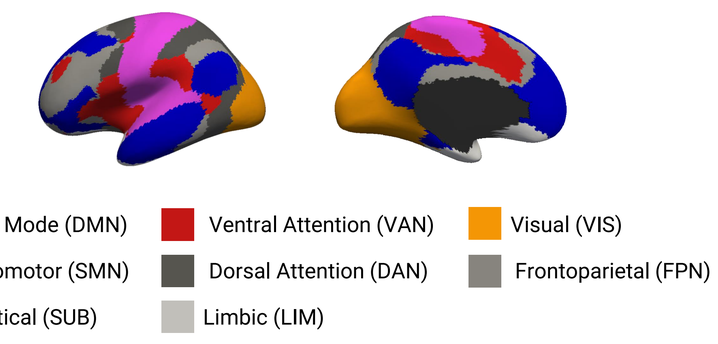
Connections of the joint attention model with nodes in the DMN or VAN

Color coded according to network definitions (see right). Nodes belonging to more than one network are double color-coded.



Connections of the joint attention model controlled for general development score with nodes in the DMN or VAN

General development score (Mullen scale) regressed out from joint attention score. Nodes color coded according to network definitions.



Network definitions

Relevant connections (edges) of the joint attention model were assigned to brain networks of the Yeo et al. 7-network atlas[9]

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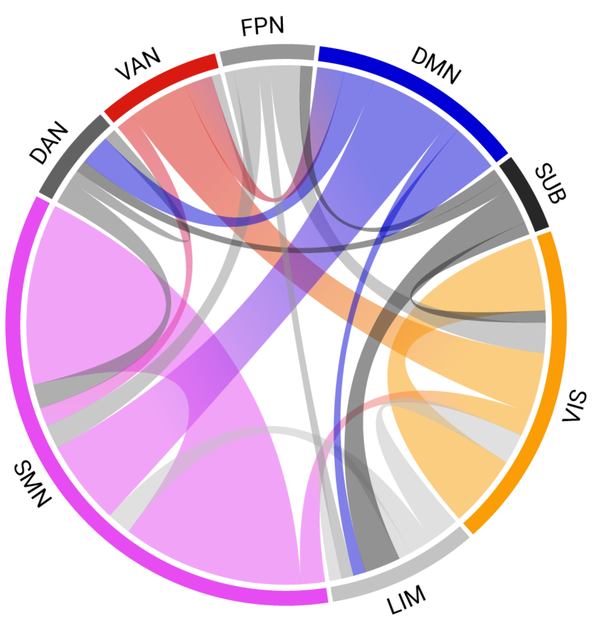
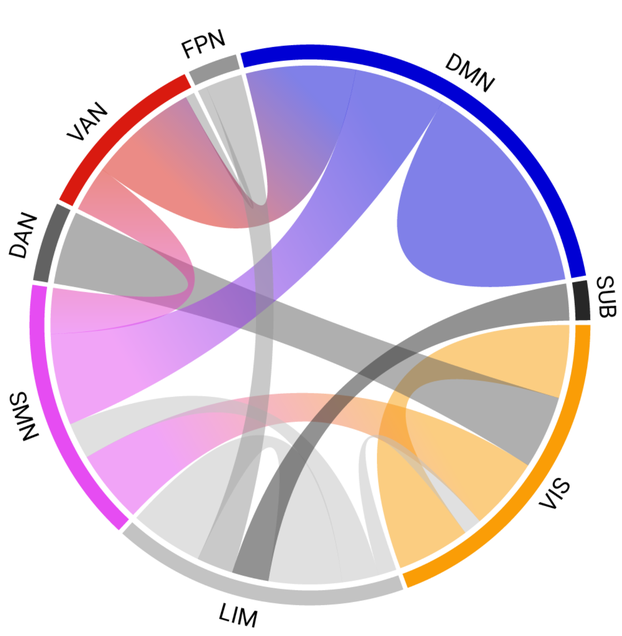


Joint attention model

- highest connectivity within SMN
- followed by DMN-SMN, within VIS and between VAN-VIS



Joint attention model controlled for general development score

- highest connectivity within DMN & between DMN-VAN
- followed by connections between DMN-SMN, within and between the sensory networks SMN and VIS and within LIM

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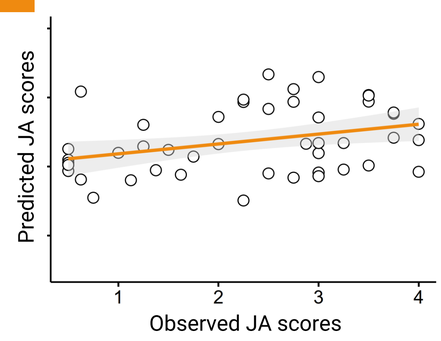
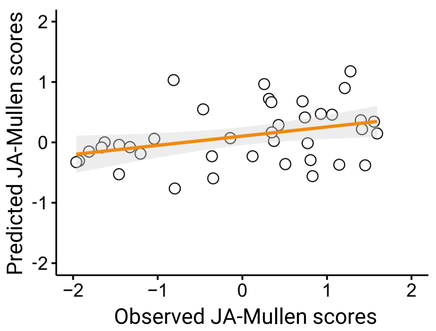


Joint attention model significantly predicted joint attention scores in test data

(n=47, Spearman rho=.329, p-value=.012)

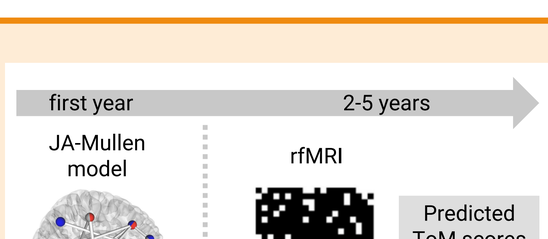


Join attention model controlled for general development score significantly predicted scores in test data

(n=39, Spearman rho=.308, p-value=.029)

Discussion

- A model trained on joint attention in 8-15-months-old infants significantly predicted joint attention scores from rfMRI connectivity in independent test infants
- The most important connections in the model predicting joint attention in infancy were within sensory networks (SMN and VIS) and their interaction with the DMN and VAN
- When controlling for infants' general development, connections within the DMN and its interaction with the VAN became dominant
- The interaction of the DMN (involved in ToM) with the VAN (observed for bottom-up social attention processes) suggests that joint attention may bridge the development from bottom-up social-attention processes in infancy to later higher-level social cognitive processes decoupled from perception
- To test this, we are currently investigating whether the joint attention model controlled for general development predicts later ToM scores in 2- to 5-year olds



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