Big discoveries from little people!

Early Brain Development and Social Communication

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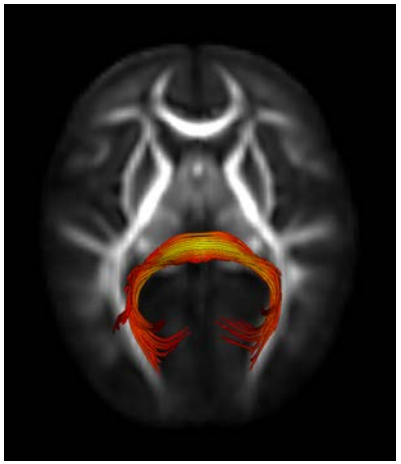


Outline

- Initial assumptions of my program of research
- Intro to infant brain development
- Joint Attention: a pivotal social communicative behavior

Initial Assumptions

1. there is sufficient data to refute the claim that DSM categories represent biologically distinct 'natural kinds'

    1. no well-developed preventive interventions based on pathophysiology and lack of anything that approaches precision medicine in mental health research

    2. reification of diagnostic categories based on behavioral sequelae, in light of ubiquitous heterogeneity including so-called comorbidities, adversely affects the search for efficacious treatments

    3. Re-considering 'mental' and 'behavioral' disorders as disorders of brain function, or rather neurodevelopmental disorders should inform biologically plausible re-classification

2. Circuits within the putative 'Social Brain' have been implicated across a variety of neurodevelopmental disorders.

3. Characterizing brain development prior to manifestation of clinically impairing profiles of behavior may yield targets for preventive intervention.

Caspar Friedrich Wolff

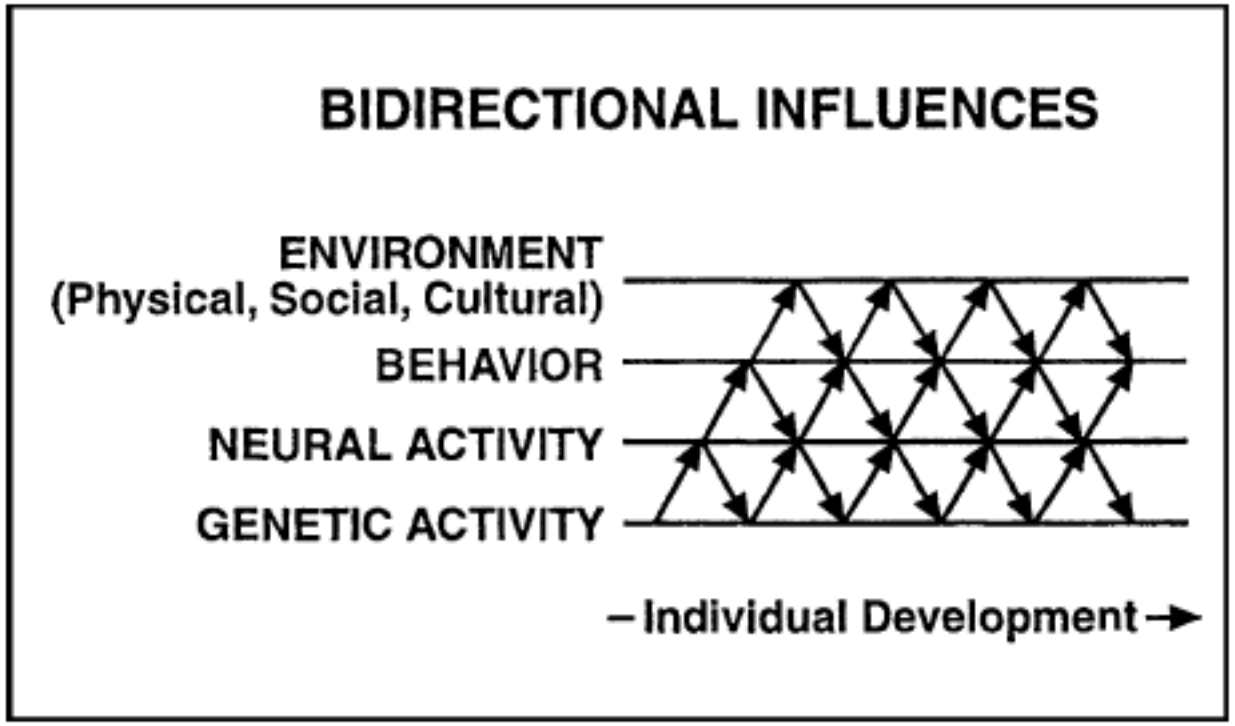
On the embryological development of the chick:

….each part is first of all an effect of the preceding part, and itself becomes the cause of the following part (1764)

# of course….

Broader contextual / environmental factors clearly play a significant role in the development of maladaptive functioning during the preschool and school-age years such as poverty, stressful / traumatic life events, maladaptive familial functioning, and parental psychopathology to name a few.

Gilbert Gottlieb



organizing theme of my research

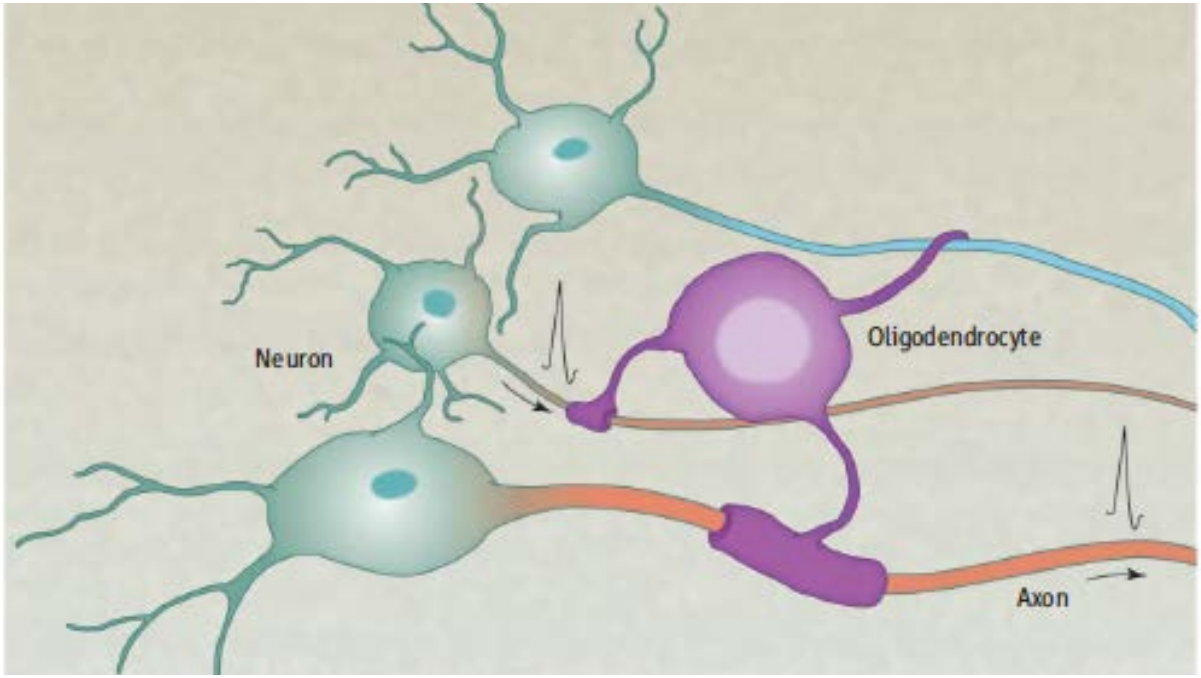
Understanding neurodevelopment trajectories that precede the onset of signs / symptoms may elucidate instantiating pathophysiology

Outline

- Initial assumptions of my program of research
- **Intro to infant brain development**
- Joint Attention: a pivotal social communicative behavior

Brain Development

- What you need to know
  - White matter
  - Gray matter
  - Synapse
  - Glia

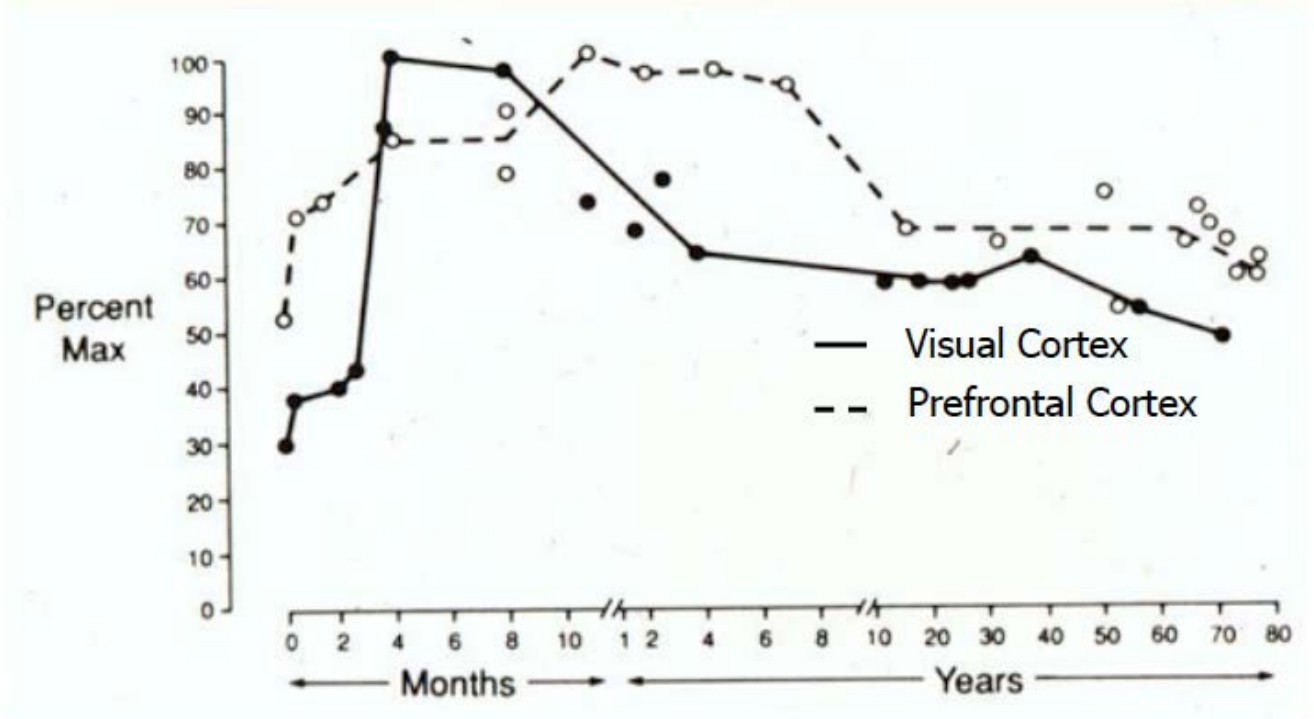


Brain Development

- Counting synapses

- Positron Emission Tomography
  - Glucose metabolism

- Rate of synapse formation and synapse elimination varies across the brain

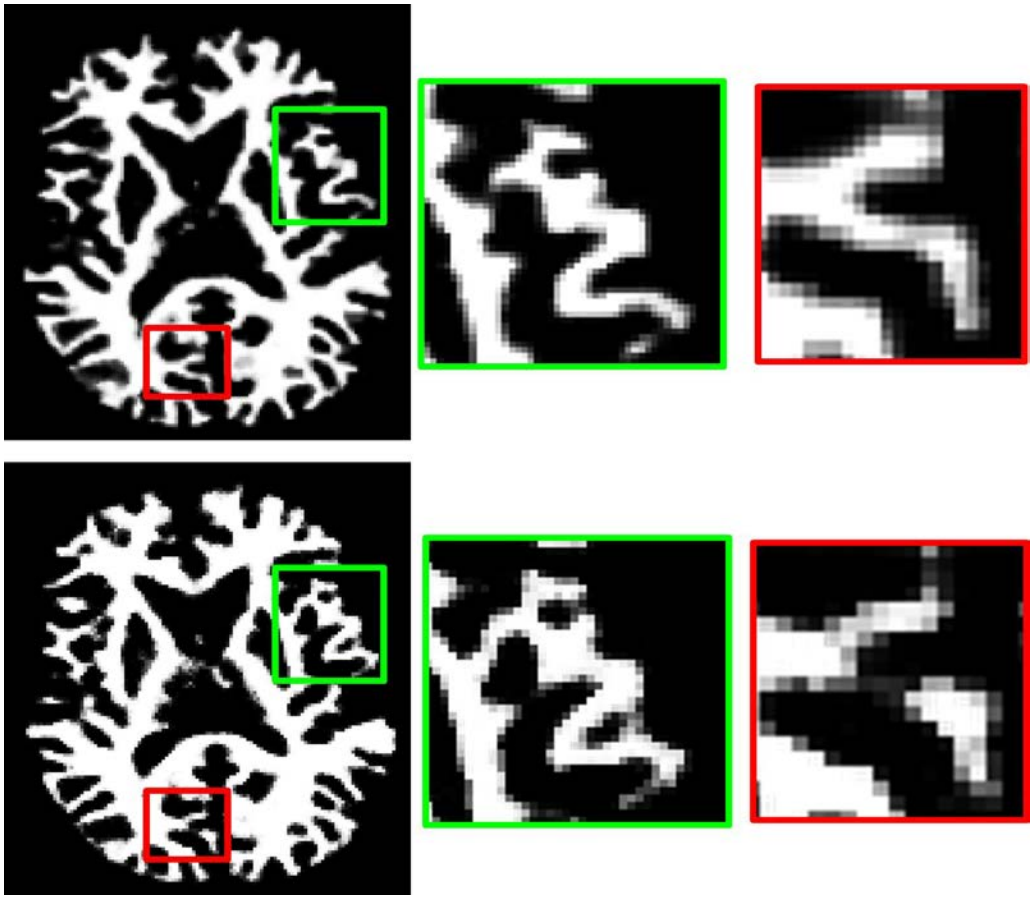


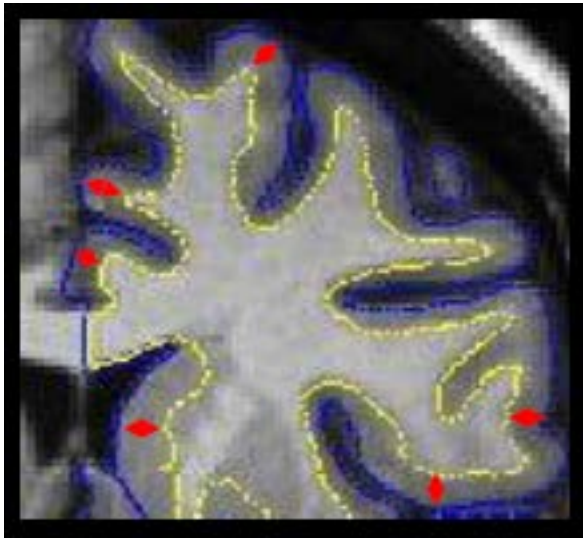
Source: Adapted from Huttenlocher, P. R. (1994), "Synaptogenesis in Human Cerebral Cortex", G. Dawson & K. W. Fischer (Eds.), Human Behavior and the Developing Brain (p. 142), New York: Guilford Press..

Brain Development

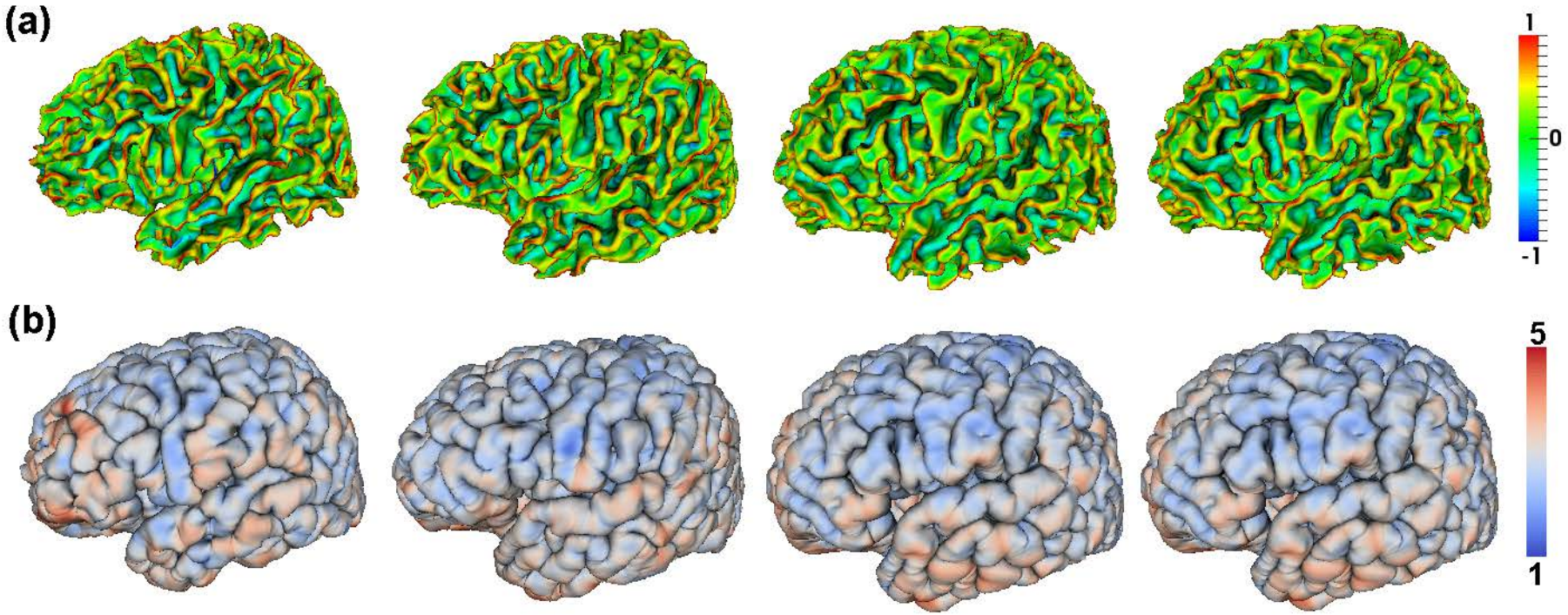
- Noninvasive in vivo methods
  - Morphometric
    - Volume
      - Surface area
        - » E.g., Gyrification index
      - Cortical thickness
  - Structural connectivity
    - Diffusion weighted imaging
  - functional connectivity
    - Resting state fMRI, spontaneous fluctuations in BOLD

it all begins with carefully acquired pictures!



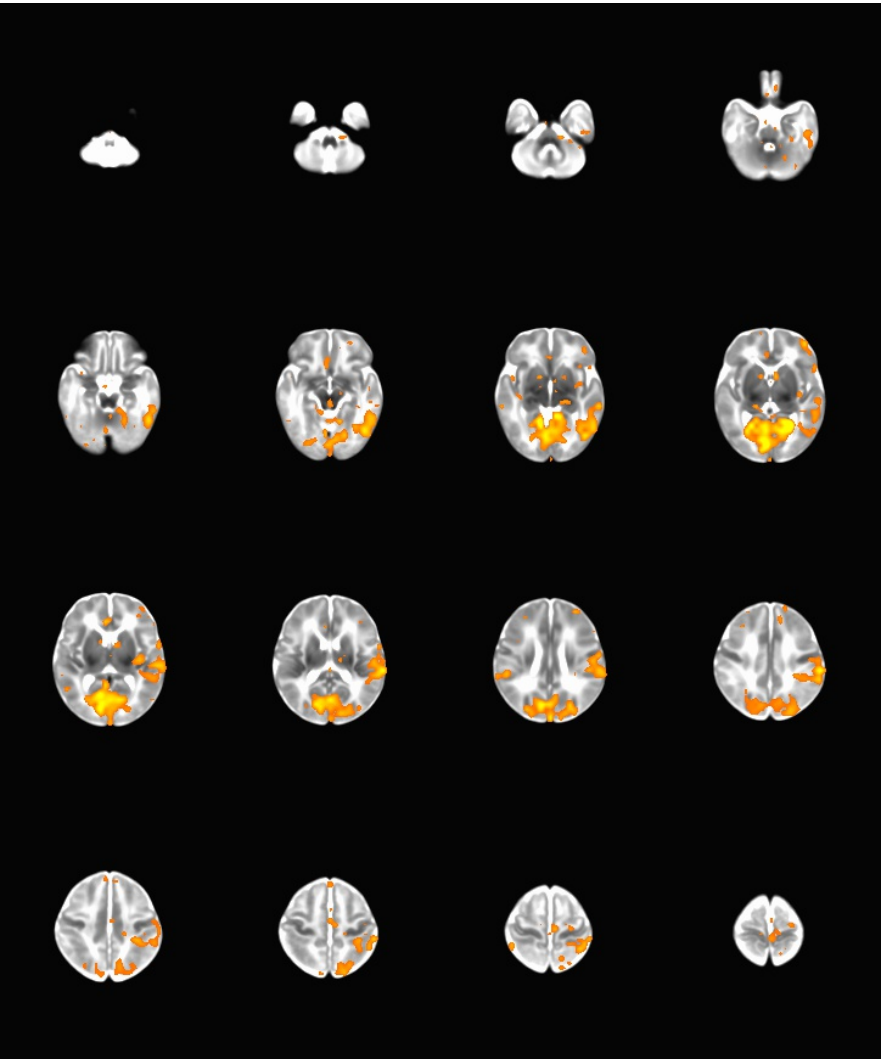


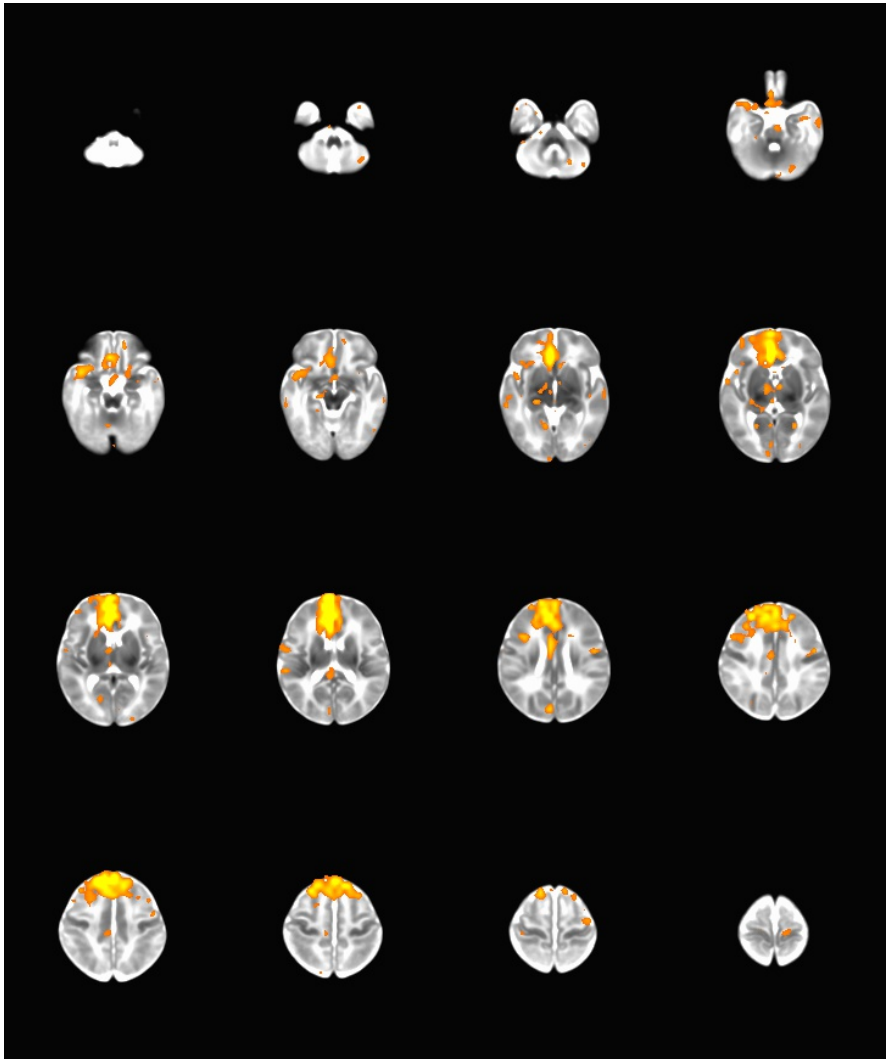
on to even more attractive pictures!



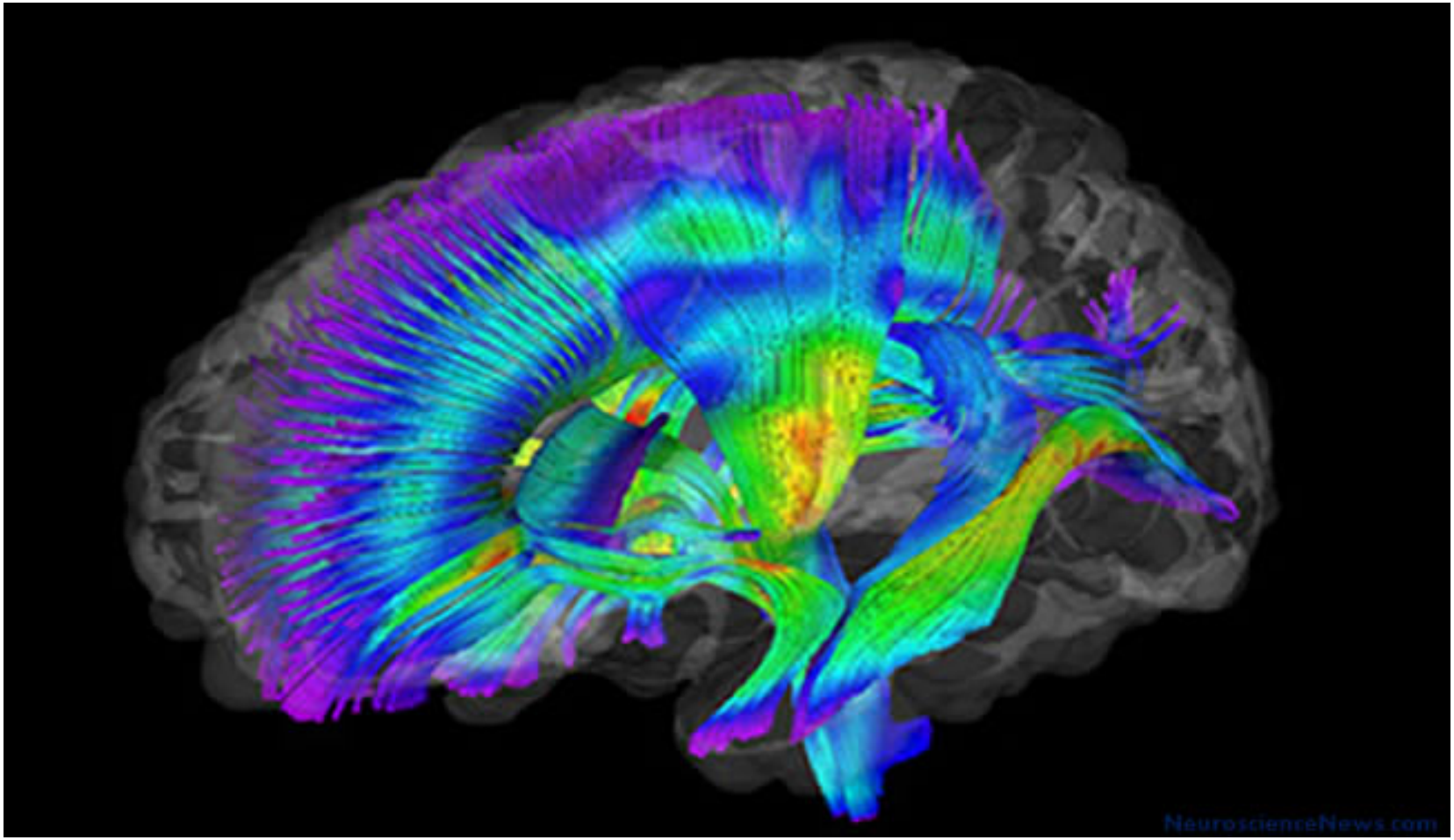
Connectivity

- Functional connectivity
  - Spontaneous fluctuations in BOLD signal
  - Areas that spontaneously activate together are functionally connected
- Structural connectivity
  - White matter fiber bundles (the brains information super highway)





Diffusion Weighted Imaging



Diffusion Weighted Imaging

Diffusion: the movement of a given *molecule* in a given *medium* at a given *temperature*

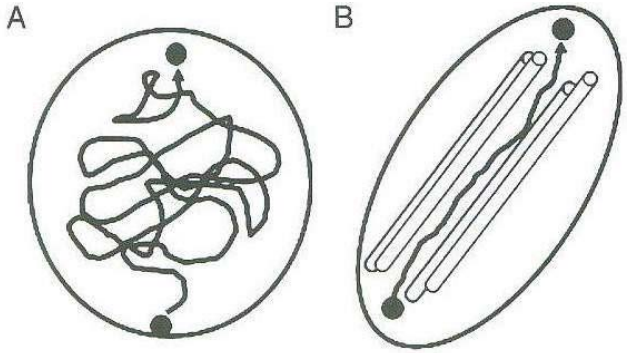
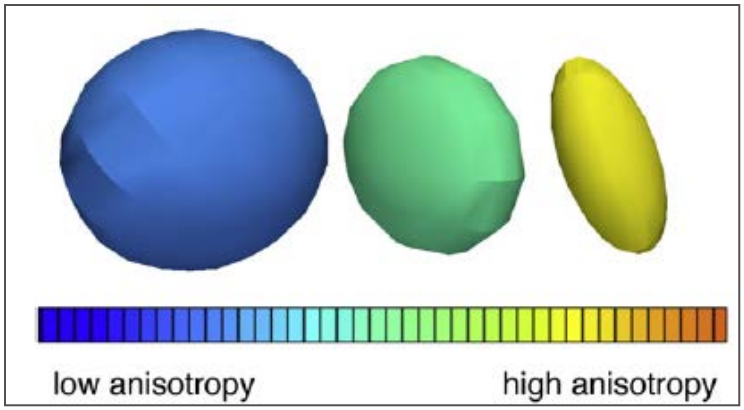


Fig. 1 Free (isotropic) (A) versus restricted (anisotropic) diffusion (B). (A) In water, molecules diffuse freely without structural impediment, such as in large fluid-filled spaces like ventricles. (B) A physical barrier to diffusion forces water molecules along a more circumscribed path. In the brain, bundles of axons encased in myelin form physical barriers that have this effect.



Diffusion Tensor Imaging

Axial Diffusivity (parallel or longitudinal diffusion) = λ_1

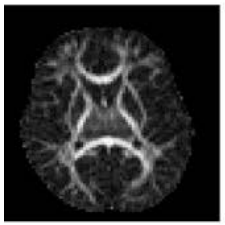
Radial Diffusivity (perpendicular diffusion) = $(\lambda_2 + \lambda_3)/2$

Fractional Anisotropy

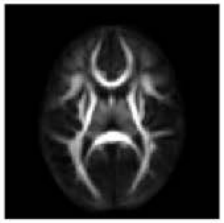
$$\mathbf{FA} = \sqrt{\frac{3}{2}}\sqrt{\frac{\left(\lambda_1 - \overline{\lambda}\right)^2 + \left(\lambda_2 - \overline{\lambda}\right)^2 + \left(\lambda_3 - \overline{\lambda}\right)^2}{\lambda_1^2 + \lambda_2^2 + \lambda_3^2}}$$

What hinders diffusion?

- Myelin
- Cell membranes (size and density of axons)
- Structural supports like microtubules

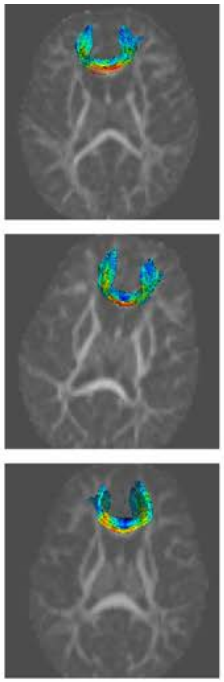


All DTI Images

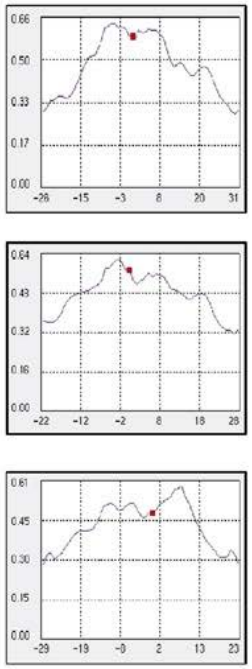


DTI Atlas

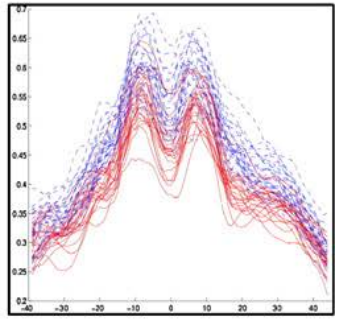
Atlas Tract



Mapped Tracts

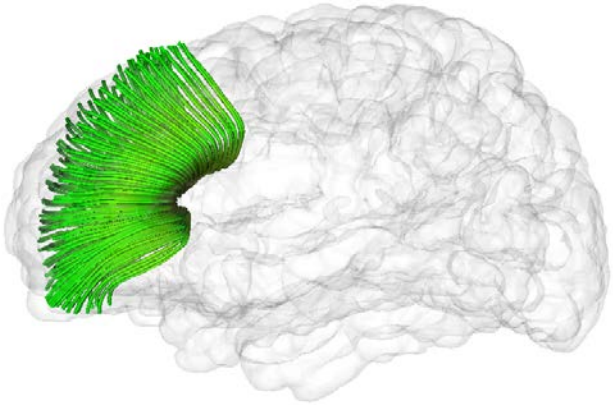


Sampled Functions



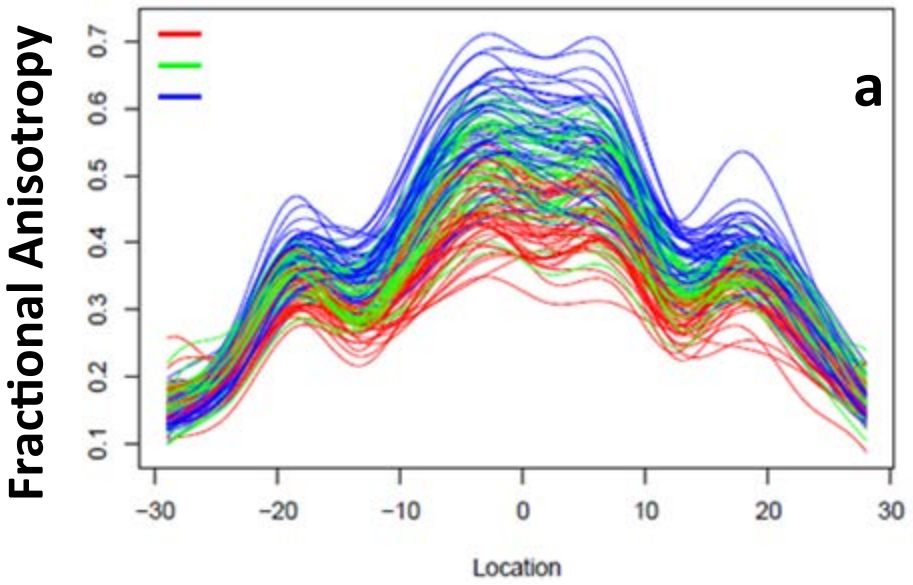
Functional Statistics

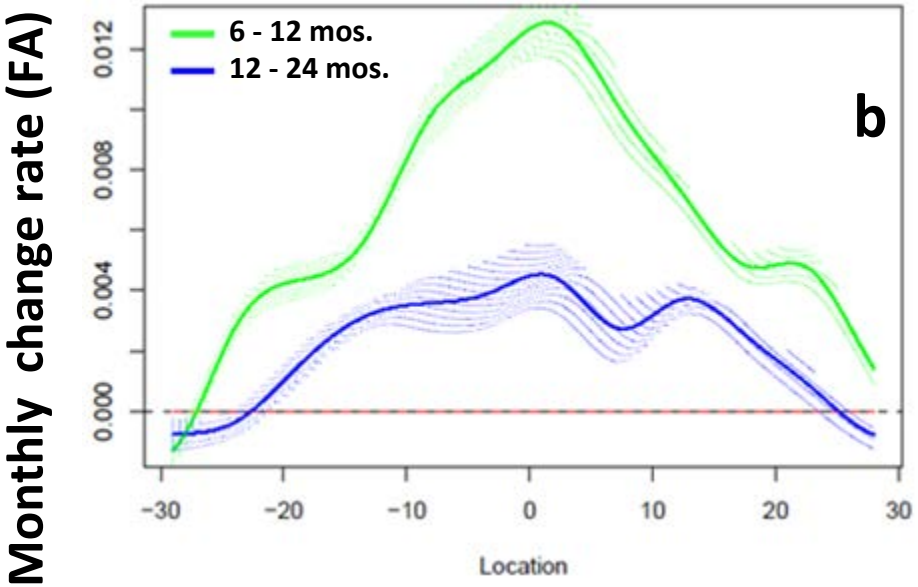
Along-fiber tract longitudinal change over the first 2 years of life



Genu of corpus callosum

N = 43 infants





Interim Summary

Characterizing 1) emerging patterns of structural and functional connectivity should elucidate fundamental aspects of cortical specialization, including specialization with social information,

and 2) longitudinal associations between emerging patterns of connectivity and cognition / social cognition should elucidate pathways to maladaptive behavioral patterns.

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- Initial assumptions of my program of research
- Intro to infant brain development
- **Joint Attention: a pivotal social communicative behavior**

Social Communication – The case of Joint Attention

In the beginning….

Baldwin (1895)

"Before he understands himself…he cannot understand others, except as they are also objects of a certain kind; but in learning to understand himself, he also comes understand them, as like himself…as themselves having objects to act toward and upon just as he does."

- 1. Persons as objects (strong sensations)
- 2. Persons are peculiar objects
- 3. Through action 'imitation,' discovery of self as subject separate from other objects
- 4. Identification of self as separate from "others" imbues others with selves of their own… [**other person perception**]

Bowlby

- Attachment Theory
  - Internal Working Model
  - **prediction of other's behaviors based on accessibility and responsiveness of his or her caregiver, anchored by proximity seeking and "testing."

Baldwin to Piaget

- Piaget—declining egocentrism through the sensorimotor phases until the capacity for representation develops after ~ 18 months (**this includes representing the mind of someone else, hypothetically)**

- Theory of Mind (ToM)

Back to Joint Attention

- What do Scaife and Bruner have to say about egocentrism in the first year of life?

Scaife and Bruner (1975)

- Rationale
  - "Little is known about how visual attention of the mother-infant pair is directed jointly to objects and events in the visual surround during the first year of life."

- Primary Question/Objective
  - What is the extent of the infants' ability to follow changes in adult gaze direction during the first year of life?

Scaife and Bruner (1975)

- Sample: (n=34) infants between 2-14 months
- Procedure: warm-up and then 2 RJA test trials
  - Eye contact, then gaze shift and head turn
- Operational Definition
  - Looking response in the same direction as the bid (within 7 seconds of bid and prior to intervening looks) indicated "joint visual attention"

Scaife and Bruner (1975) Results

Table 1 Percentage of children judged as following line of regard in one or both trials

Age (months)	No. infants	% Showing positive response
2–4	10	30
5–7	13	38.5
8–10	6	66.5
11–14	5	100

" It is possible that the ability to orient with respect to another has implications for Piaget's more complex notions of the egocentric child. In so far as mutual orientation implies a degree of **knowledge** in some form about another person's perspective[,] **then the child in its first year may be considered as less than completely egocentric**.

Transitioning to more contemporary work

Social Cognition During Infancy: joint attention as an example

"joint attention is not just two people experiencing the same thing at the same time, but rather it is two people experiencing the same thing at the same time *and* ***knowing*** *together that they are doing this"* Tomasello & Carpenter, 2007, Developmental Science.

Characteristic Pattern of Emergence

Sharing Attention (8-8.5 months)

Responding to Joint Attention (9-10 months)

Initiating Joint Attention (10.5-11.5months)

Triadic Engagement—Sharing

Triadic Engagement: RJA

Triadic/Collaborative Engagement

Initiating Joint Attention

- Proto-imperative pointing
  - request

- Proto-declarative points (most sophisticated)
  - Share for the sake of sharing

Joint Attention

Little known about the developmental processes that yield individual differences in joint attention.

…at the behavioral, cognitive, or neural levels

Measurement constraint

****competence versus performance**

Dimensional Joint Attention Assessment (DJAA)

- Deak, G.O., Flom, R.A., & Pick, A.D. (2000). Effects of gesture and target on 12- and 18-Month-Olds' Joint Visual Attention to Objects in Front of or Behind Them. *Developmental Psychology, 36(4*), 511-523.

- Flom, R., Deak, G.O., Phill, C.G., & Pick, A.D. (2004). Nine-month-olds' shared visual attention as a function of gesture and object location. *Infant Behavior and Development, 27*, 181-194.

- Presmanes, A.G., Walden, T.A., Stone, W.L., & Yoder, P.J. (2007). Effects of different attentional cues on responding to joint attention in younger siblings of children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 37(1)*, 133-144.

- Deak, G.O., Walden, T.A., Kaiser, M.Y., & Lewis, A. (2008). Driven from distraction: how infants respond to parents' attempts to elicit and re-direct their attention. *Infant Behavior and Development, 31*, 34-50.

Individual Differences in Responding to Joint Attention (RJA) Performance

Varying the Redundancy of the Cue

1. gaze shift, head turn = least redundant, most sophisticated
2. gaze shift, head turn, “look at that” = adding a verbal cue to the least redundant pres
3. gaze shift, head turn, point = adding a salient gestural cue
4. gaze shift, head turn, point, “look at that” = most redundant

Triadic Engagement--RJA

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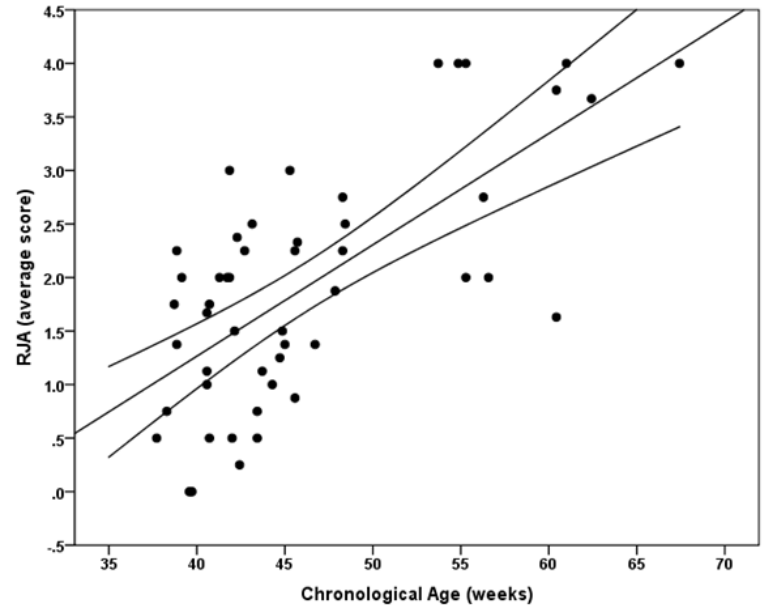
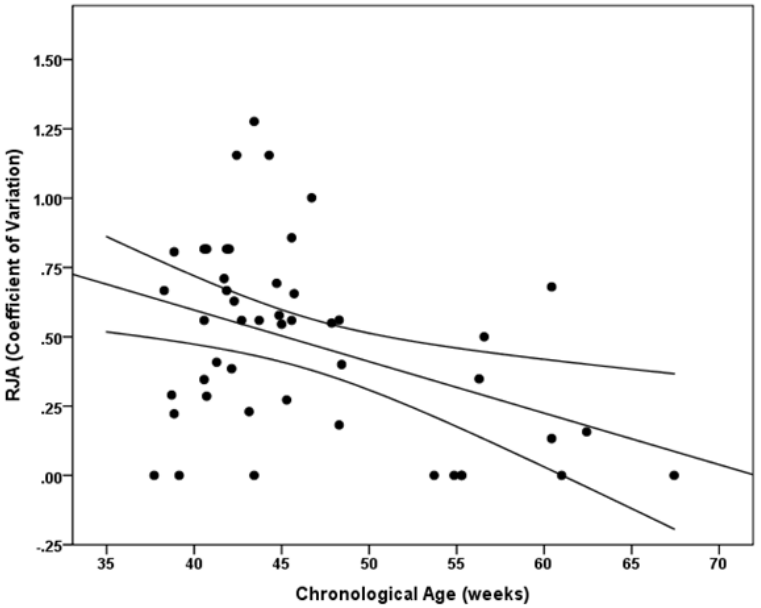
Triadic Engagement--RJA

Responding to Joint Attention

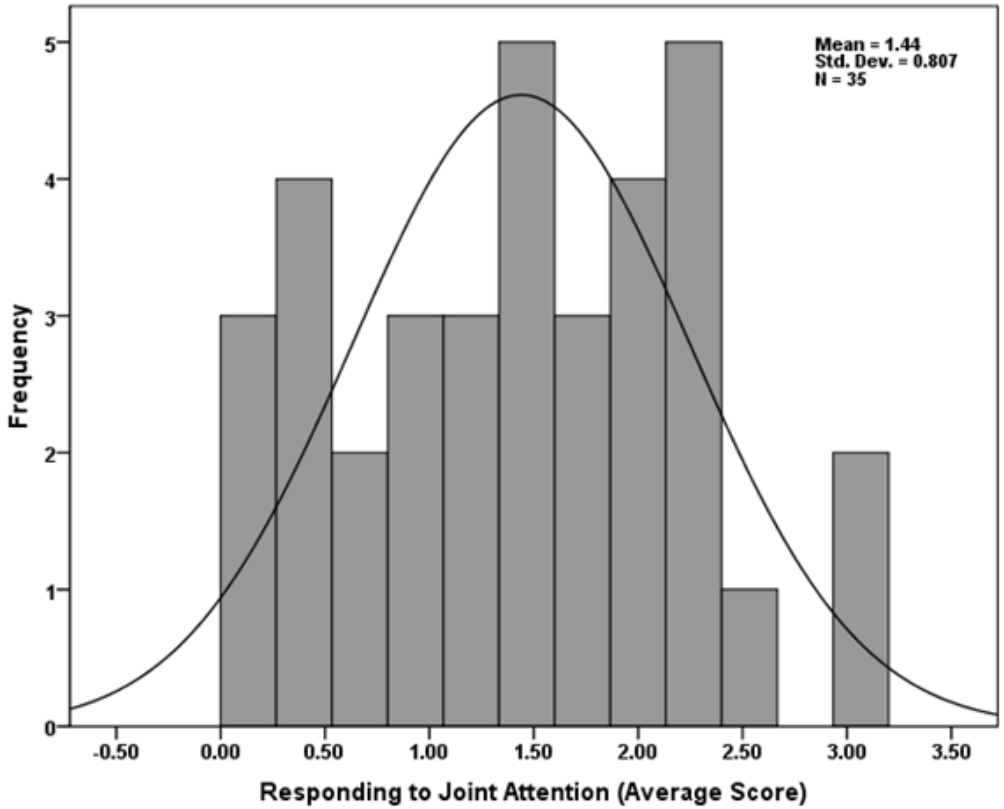
- Does our joint attention procedure elicit substantive individual differences in performance?





Responding to Joint Attention

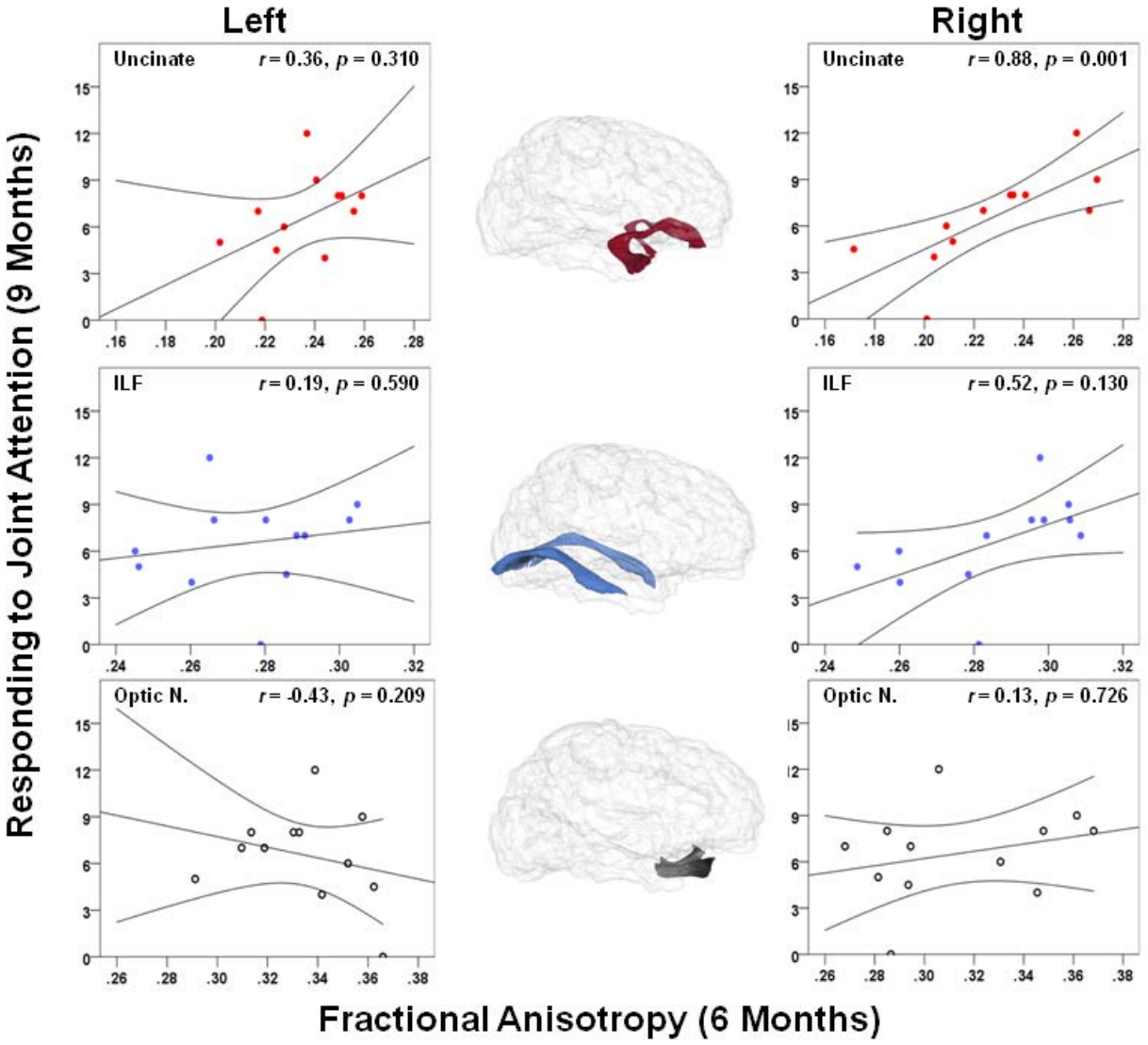
- Can we identify a time interval of maximal individual differences?



Responding to Joint Attention

- Do individual differences in white matter microstructure, assessed prior to the emergence of RJA, significantly predict individual differences in RJA performance?

Responding to Joint Attention



Responding to Joint Attention

- Caveats
  - DWI/DTI, sample size
- Conclusions
  - Individual differences in the structural organization of right lateralized frontolimbic neural circuitry predicts individual differences in later emerging, complex social cognition.

Developmental Science (2012), pp 1–11 DOI: 10.1111/desc.12015

PAPER

Frontolimbic neural circuitry at 6 months predicts individual differences in joint attention at 9 months

Jed T. Elison,[1,4] Jason J. Wolff,[1] Debra C. Heimer,[1] Sarah J. Paterson,[5] Hongbin Gu,[1,2] Heather C. Hazlett,[1,2] Martin Styner,[1,2,3] Guido Gerig,[6] Joseph Piven[1,2] and for the IBIS Network[7]

back to the psychology…

- Toward the end of the first year of life and after a rather standard sequence of events, an infant rapidly acquires the ability to represent information that stipulates 1) what I see is not necessarily what the other sees, 2) when I see something I like, I need to redirect the eyes/mind of the other in order to share attention/ intention/engagement on the distal object/event, as there may be a social reward if the prediction that the other likes the object is valid.

Summary

- The complexity of human cognition *&* social cognition are enabled by the complexity of the structural and functional connectomes.

- Joint attention is a foundational social cognitive capacity that emerges early in infancy and is functionally critical for subsequent social communicative development.

- Mapping the neural circuitry important for joint attention has implications for early emerging disorders of social communication.

Future ELAB work…

Infant Brain and Behavioral Signatures of Later Emerging Risk for Psychopathology (B-Slerp)

- HCP innovation in a longitudinal study of infants
- Developmental approach to the RDoC

Acknowledgments

ELAB

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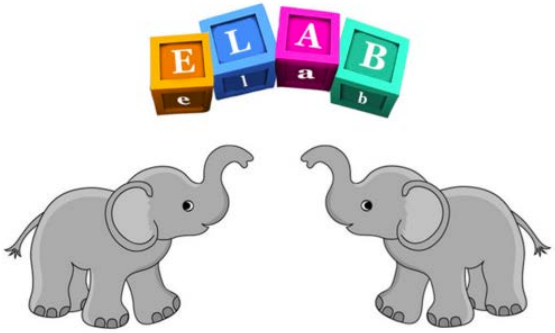

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