Analysis of White Matter Maturation In Early Brain Development

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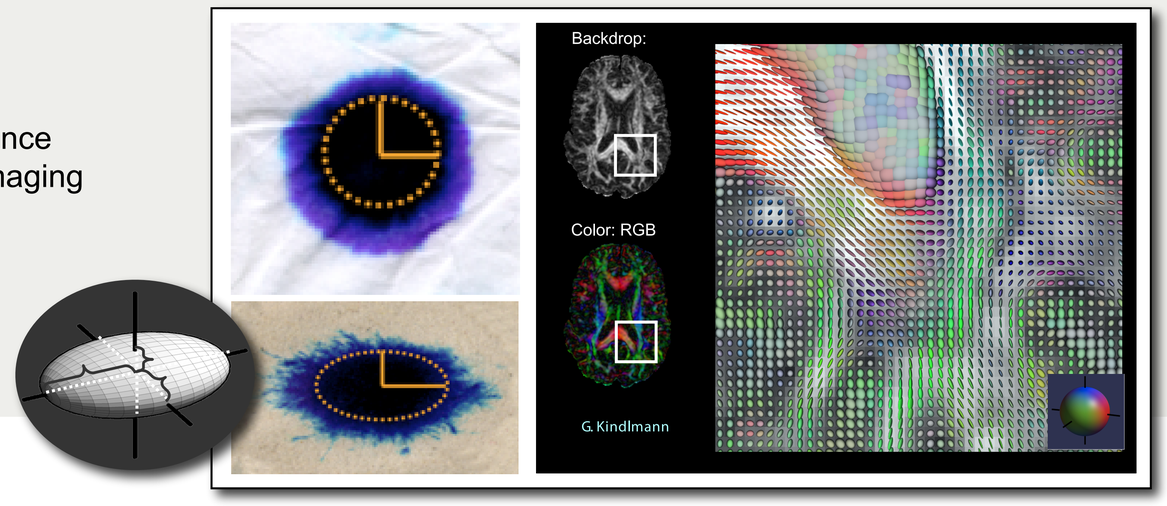
Introduction

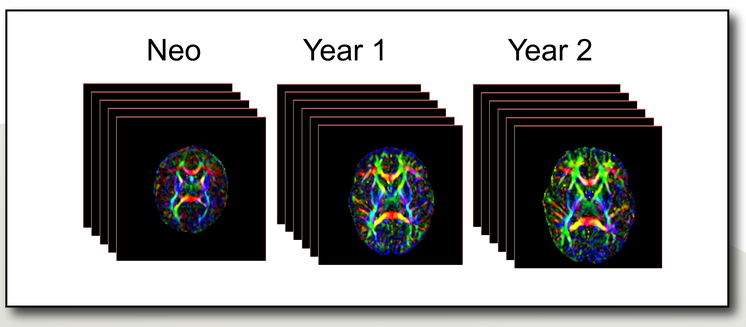
• Understanding of human brain development is of significant scientific and clinical importance
• Develop normative model of maturation pattern as is reflected in Magnetic Resonance Imaging (MRI) and Diffusion Tensor Imaging (DTI)
• Compare normative maturation pattern to children at risk of mental disorders
• Better understanding -> early diagnosis -> early therapy -> help families
• Need for quantitative analysis of longitudinal change

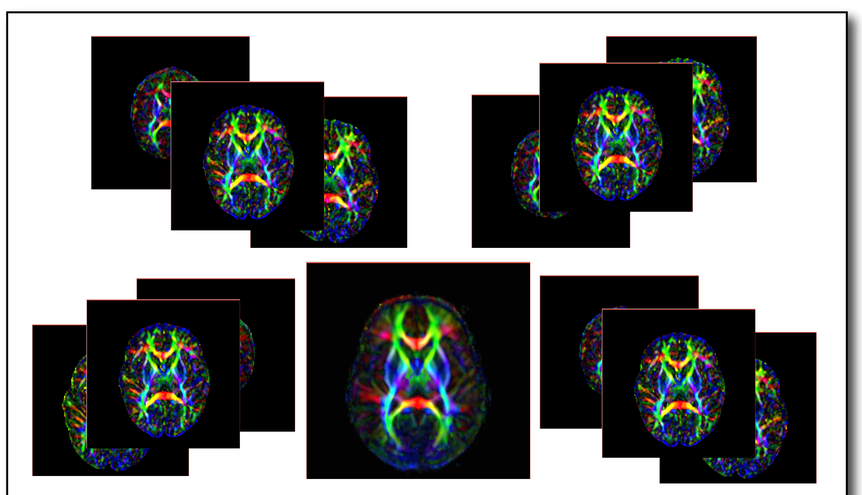


Method

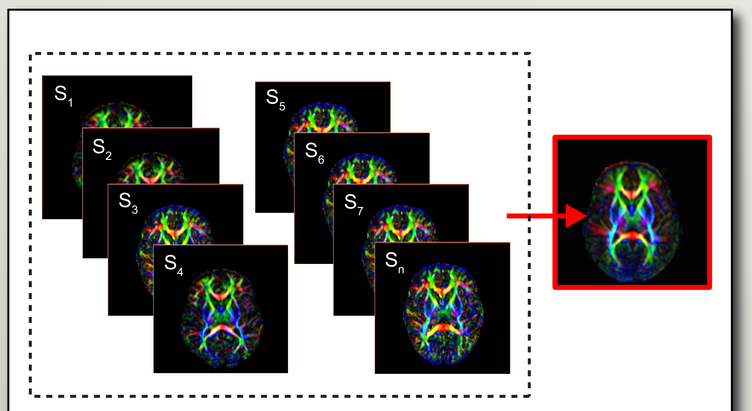
• Analysis of diffusion of water over time
• Water tends to diffuse preferentially along axonal fibers
• Reflects the underlying structure of tissue

Registration of all the subjects to a common template

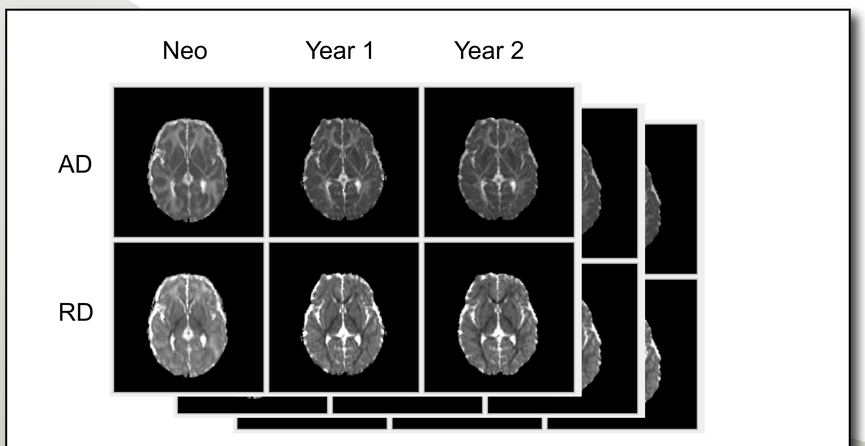




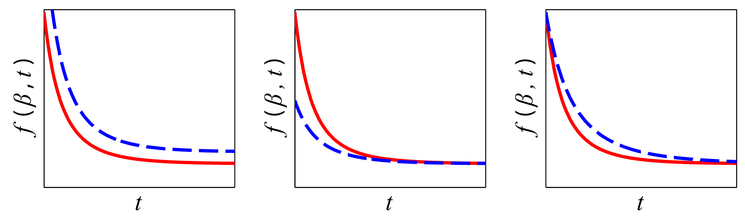
Coregistration of time (age), and subjects



Population analysis of ***several*** subjects ($\mathbf{s}_{1...n}$)

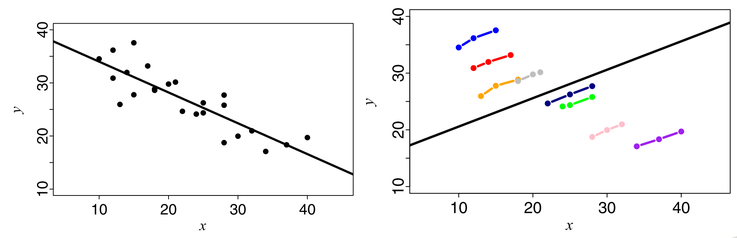


Nonlinear parametric model to answer clinical questions addressing growth trajectory characterization:
• delayed or advance growth
• accelerated or slowed growth
• can individuals catch up if they have a delayed



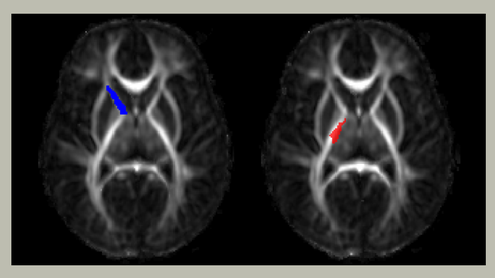
y = asymptote exp(-delay exp(-speed t))

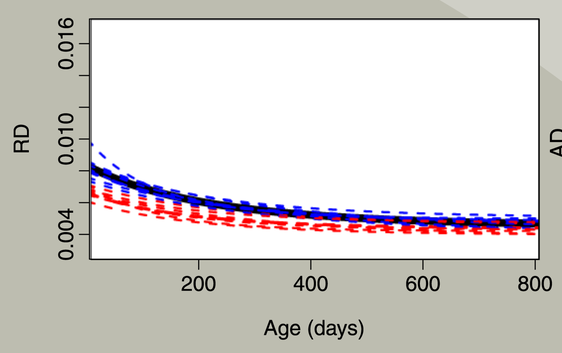
Mixed effect model: average individual growth trajectories rather than individual time points

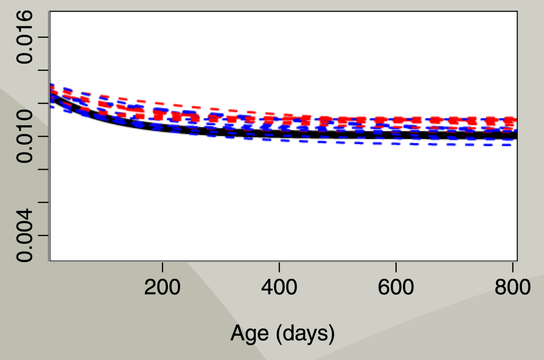


Results

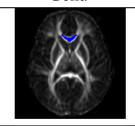
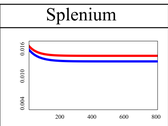
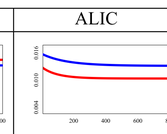
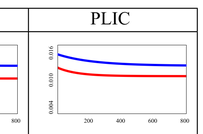
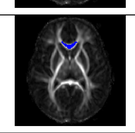
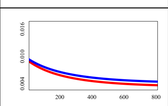
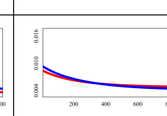
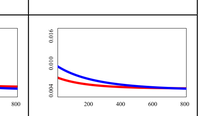
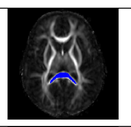
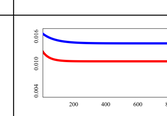
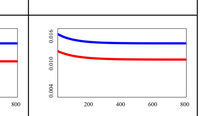
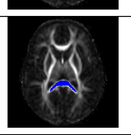
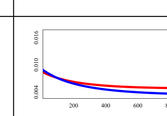
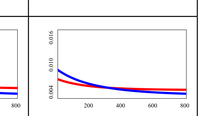
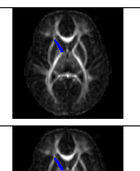
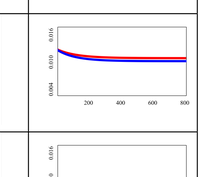
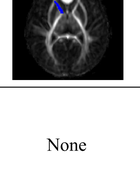
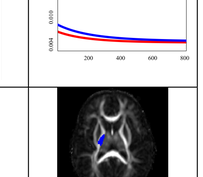
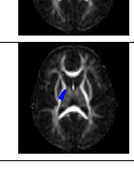
Anterior and posterior limb of internal capsule comparison, delay parameter for RD is significantly different, $p < 0.001$, whereas there were no significant differences in AD measurements.







Pairwise comparison, $p<0.001$

	Genu	Splenium	ALIC	PLIC
Genu-AD				
Genu-RD				
Sp-AD	β_1 : Genu < Sp			
Sp-RD	β_1 : Genu > Sp			
ALIC-AD	β_1 :Genu > ALIC	β_1 : Sp > ALIC		
ALIC-RD	β_1 :Genu < ALIC β_2 :Genu < ALIC	β_1 : Sp < ALIC β_2 : Sp < ALIC		
PLIC-AD	β_1 :Genu > PLIC	β_1 : Sp > PLIC	None	
PLIC-RD	β_1 :Genu < PLIC β_2 :Genu < PLIC β_3 :Genu > PLIC	β_1 : Sp < PLIC β_2 : Sp < PLIC	β_2 :ALIC < PLIC	

Conclusion

• Characterizing longitudinal patterns of tissue properties in white matter regions.
• Significant discriminating features of growth patterns (asymptote, delay, and speed parameters) within a pair of regions
•Excellent potential to explain pattern of change in disease

References

N. Sadeghi, M. Prastawa, J. H. Gilmore, W. Lin, and G. Gerig, "Spatio-Temporal Analysis of EarlyBrain Development," in Proceedings Fourty-Fourth Asilomar Conference on Signals, Systems and Computers, IEEE catalog No.: CFP10431-CDR, Nov. 2010

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