Brain-age prediction from diffusion MRI data using neural networks

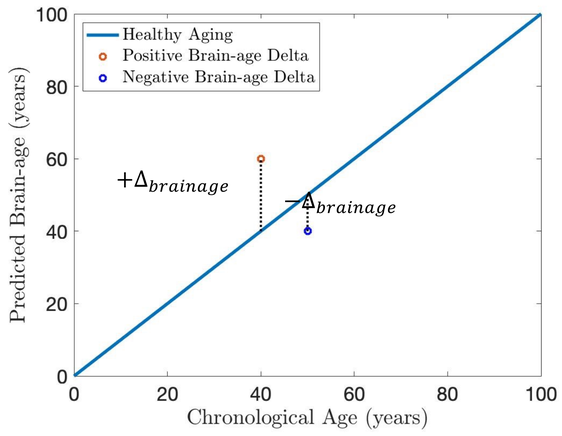
Hefner M*[1], Mendez A*[2], Anderson C*[1,2,3],
McAuley E[4]; Kramer A[5]; Burzynska, AZ[2]

[1]School of Biomedical Engineering, [2]Human Development and Family Studies/Molecular, Cell. and Integrative Neurosciences, [3]Department of Computer Science, Colorado State Univ., Fort Collins, CO; [4]Univ. of Illinois at Urbana-Champaign, Urbana, IL; [5]Northeastern Univ., Boston, MA
*Authors contributed equally

Introduction

- > 52 million people in the USA experience cognitive decline
- Treatments for dementia targeting gray matter not yet effective
- Need for new neural targets: **white matter**

- **Machine learning**: prediction of brain-age
- **Δ**brainage : early diagnosis for accelerated aging



- Most brain-age studies: T1 anatomical (Cole et al., 2018, Feng et al., 2019, Dinsdale et al., 2021) or combined T1, DTI, fMRI (Cole 2020, Cherubini et al., 2016)
- **No study using white matter only**

Aims & Hypotheses

To predict brain-age based on white matter diffusion tensor imaging (DTI) data.

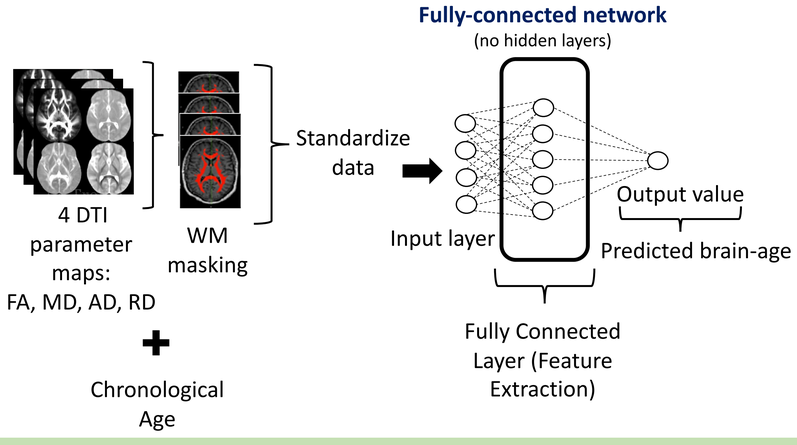
H1: Brain-age can be predicted from diffusion MRI data only
H2: Using all 4 DTI parameter maps (FA, MD, AD, RD) will improve prediction
H3: Convolutional neural network will yield better prediction that fully connected (linear) models

Methods

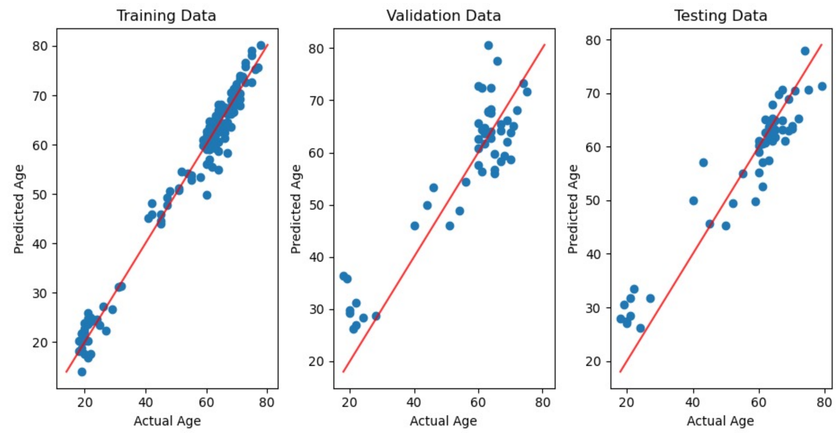
Participants:
- Young adults, n=51, age 18-33 years (Burzynska et al., 2017a)
- Middle-aged adults, n=32, age 40-60 years
- Old adults, n=170, age 60-80 years (Burzynska et al., 2017b)

DTI imaging:
- 3T Siemens Trio
- Acquisition: 30 dir., b-value=0 and 1000s/mm^2, 1.7mm^3
- Preprocessing: FDT in FSL: removal of skull + non-brain tissue, eddy current and motion correction
- MNI registration: from TBSS, nonlinear registration to FA template via FMRIB's Nonlinear Registration Tool

Fully-connected network architecture
- Optimal feature extraction
- Robust optimization algorithms to minimize the mean squared error between predicted age and actual chronological age of each training scan
- Utilized Moller's Scaled Conjugate Gradient
- Root-mean-square error (RMSE) to evaluate how close observed data points are to model's predicted values
- CNN: Two Hidden Layers with 5 and 10 units



Results



	Linear Model (RMSE*)			Convolutional neural Network (RMSE*)		
Parameter(s)	Train	Validation	Test	Train	Validation	Test
AD	3.5	8.39	8.49	5.45	8.14	9.05
FA	1.61	9.87	9.87	7.14	10.78	10.96
MD	2.36	9.79	10.07	6.32	9.47	9.94
RD	4.11	8.53	8.77	6.62	9.39	9.67
FA, MD, RD	1.91	8.42	8.47	6.87	9.44	9.82
FA, MD, RD, AD	1.99	8.05	**8.03**	4.28	8.87	9.19

*RMSE indicates the absolute fit of the model to the data

Discussion

- We confirm hypotheses on prediction from diffusion MRI only and the multimodal combination for prediction, however the linear model outperforms any convolutional neural network.
- DTI is unspecific to myelin or axons, may try water myelin imaging for prediction
- Future directions: test different algorithms and identify correlates of the Brain-age delta such as lifestyle and health

Contact

Michelle Hefner
Colorado State University
Email: Michelle.Hefner@rams.colostate.edu

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