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Kilian M. Pohl · Wesley K. Thompson ·
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Adolescent Brain Cognitive Development Neurocognitive Prediction

First Challenge, ABCD-NP 2019
Held in Conjunction with MICCAI 2019
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Editors
Kilian M. Pohl
Stanford University
Stanford, CA, USA

Ehsan Adeli
Stanford University
Stanford, CA, USA

Wesley K. Thompson
University of California, San Diego
La Jolla, CA, USA

Marius George Linguraru
Children's National Health System
Washington, DC, USA

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Preface

The ABCD Neurocognitive Prediction Challenge (2019 ABCD-NP-Challenge; https://sibis.sri.com/abcd-np-challenge) invited researchers to submit methods for predicting fluid intelligence from T1-weighted MRI of 8669 children (age 9–10 years) recruited by the Adolescent Brain Cognitive Development Study (ABCD) study—the largest long-term study of brain development and child health in the United States to date. The first ABCD-NP-Challenge was organized in conjunction with the 22nd International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI) held in October 2019 in Shenzhen, China. In total, 124 teams registered for the challenge. There were no limits or restrictions on team members as long as the team complied with the National Institute of Mental Health (NIMH) Data Archive Data Use Certification of the ABCD project and members of the team were not from labs associated with the ABCD study (https://abcdstudy.org/). Each team was instructed to use the NIMH Data Archive (NDA) portal to download the T1-weighted MRI, which the organizers had skull-stripped and affinely aligned to the SRI 24 atlas. In addition, the challenge organizers provided brain parcellations defined by the atlas and a CSV file with the corresponding volume measurements of each region of interest (ROI). Information about the ABCD Data Repository can be found at https://nda.nih.gov/abcd/about.

The NDA portal also provided the residual fluid intelligence scores of 4154 subjects for training (3739 samples) and validation (415 samples). Fluid intelligence is a major component in determining general intelligence. Determining the neural mechanisms underlying general intelligence is fundamental to understanding cognitive development, how this relates to real-world health outcomes, and how interventions (education, environment) might improve outcomes through adolescence and into adulthood. The fluid intelligence scores recorded by the ABCD study were measured via the NIH Toolbox Neurocognition battery. The scores provided by the challenge organizers were pre-residualized on data collection site, sociodemographic variables, and brain volume. The R code for computing the residual scores was accessible through the challenge website. The residual fluid intelligence scores of the 4515 subjects used to test each method were not released but had to be predicted based on the provided T1-weighted MRI. The corresponding raw fluid intelligence scores and demographic factors were first made accessible to the public via the ABCD Data Release 2.0, which was released after the submission deadline (March 24, 2019) of the challenge.

There were 29 submissions, of which 24 were accepted to the challenge after passing a single-blinded review. An eligible submission consisted of a CSV file containing the predictions of the fluid intelligence based only on the provided T1-weighted MRIs of at least 99% of the 4402 test subjects, the source code generating those predictions, and a manuscript describing the method and findings. The document needed to clearly describe the data used for prediction, the method, and findings including the prediction error during training and validation. Authors submitting

multiple manuscripts needed to describe methods and results that were different from each other and from previously published material. With these criteria, manuscripts of some submissions were merged resulting in a total of 21 papers, which are included in this book regardless of the ranking in the challenge. Each paper is described in one chapter and includes detailed implementations steps, analysis of the results, and comparison with baseline methods.

Contestants were ranked separately on the validation data set and on the test data sets. For each data set, the organizers computed the mean squared error (MSE) between their predicted scores and the pre-residual fluid intelligence scores according to publicly available R code. The error of missing predictions was the largest MSE from among the set of values produced by the same algorithm on the subjects in the dataset. Overall, 19 submissions (out of 24) were better than a naïve predictor, i.e., the mean intelligence score based on the training data. These results revealed that the 2019 ABCD-NP-Challenge was grand. Structural T1-weighted MRI should contain more information about fluid intelligence as at that age intelligence is not yet considered a result of education and thus mostly associated with family history, including genetics. Of the MRI modalities acquired by ABCD, T1-weighted MRI modalities most closely linked to genetics.

August 2019

Kilian M. Pohl
Wesley K. Thompson
Ehsan Adeli
Marius George Linguraru

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Contents

A Combined Deep Learning-Gradient Boosting Machine Framework for Fluid Intelligence Prediction 1
Yeeleng S. Vang, Yingxin Cao, and Xiaohui Xie

Predicting Fluid Intelligence of Children Using T1-Weighted MR Images and a StackNet 9
Po-Yu Kao, Angela Zhang, Michael Goebel, Jefferson W. Chen, and B. S. Manjunath

Deep Learning vs. Classical Machine Learning: A Comparison of Methods for Fluid Intelligence Prediction 17
Luke Guerdan, Peng Sun, Connor Rowland, Logan Harrison, Zhicheng Tang, Nickolas Wergeles, and Yi Shang

Surface-Based Brain Morphometry for the Prediction of Fluid Intelligence in the Neurocognitive Prediction Challenge 2019 26
Michael Rebsamen, Christian Rummel, Ines Mürner-Lavanchy, Mauricio Reyes, Roland Wiest, and Richard McKinley

Prediction of Fluid Intelligence from T1-Weighted Magnetic Resonance Images 35
Sebastian Pölsterl, Benjamín Gutiérrez-Becker, Ignacio Sarasua, Abhijit Guha Roy, and Christian Wachinger

Ensemble of SVM, Random-Forest and the BSWiMS Method to Predict and Describe Structural Associations with Fluid Intelligence Scores from T1-Weighed MRI 47
Jose Tamez-Pena, Jorge Orozco, Patricia Sosa, Alejandro Valdes, and Fahimeh Nezhadmoghadam

Predicting Intelligence Based on Cortical WM/GM Contrast, Cortical Thickness and Volumetry 57
Juan Miguel Valverde, Vandad Imani, John D. Lewis, and Jussi Tohka

Predict Fluid Intelligence of Adolescent Using Ensemble Learning 66
Huijing Ren, Xuelin Wang, Sheng Wang, and Zhengwu Zhang

Predicting Fluid Intelligence in Adolescent Brain MRI Data: An Ensemble Approach 74
Shikhar Srivastava, Fabian Eitel, and Kerstin Ritter

Predicting Fluid Intelligence from Structural MRI Using Random Forest regression 83
Agata Wlaszczyk, Agnieszka Kaminska, Agnieszka Pietraszek, Jakub Dabrowski, Mikolaj A. Pawlak, and Hanna Nowicka

Nu Support Vector Machine in Prediction of Fluid Intelligence Using MRI Data 92
Yanli Zhang-James, Stephen J. Glatt, and Stephen V. Faraone

An AutoML Approach for the Prediction of Fluid Intelligence from MRI-Derived Features 99
Sebastian Pölsterl, Benjamín Gutiérrez-Becker, Ignacio Sarasua, Abhijit Guha Roy, and Christian Wachinger

Predicting Fluid Intelligence from MRI Images with Encoder-Decoder Regularization 108
Lihao Liu, Lequan Yu, Shujun Wang, and Pheng-Ann Heng

ABCD Neurocognitive Prediction Challenge 2019: Predicting Individual Residual Fluid Intelligence Scores from Cortical Grey Matter Morphology . . . 114
Neil P. Oxtoby, Fabio S. Ferreira, Agoston Mihalik, Tong Wu, Mikael Brudfors, Hongxiang Lin, Anita Rau, Stefano B. Blumberg, Maria Robu, Cemre Zor, Maira Tariq, Mar Estarellas Garcia, Baris Kanber, Daniil I. Nikitichev, and Janaina Mourão-Miranda

Ensemble Modeling of Neurocognitive Performance Using MRI-Derived Brain Structure Volumes 124
Leo Brueggeman, Tanner Koomar, Yongchao Huang, Brady Hoskins, Tien Tong, James Kent, Ethan Bahl, Charles E. Johnson, Alexander Powers, Douglas Langbehn, Jatin Vaidya, Hans Johnson, and Jacob J. Michaelson

ABCD Neurocognitive Prediction Challenge 2019: Predicting Individual Fluid Intelligence Scores from Structural MRI Using Probabilistic Segmentation and Kernel Ridge Regression 133
Agoston Mihalik, Mikael Brudfors, Maria Robu, Fabio S. Ferreira, Hongxiang Lin, Anita Rau, Tong Wu, Stefano B. Blumberg, Baris Kanber, Maira Tariq, Mar Estarellas Garcia, Cemre Zor, Daniil I. Nikitichev, Janaina Mourão-Miranda, and Neil P. Oxtoby

Predicting Fluid Intelligence Using Anatomical Measures Within Functionally Defined Brain Networks 143
Jeffrey N. Chiang, Nicco Reggente, John Dell'Italia, Zhong Sheng Zheng, and Evan S. Lutkenhoff

Sex Differences in Predicting Fluid Intelligence of Adolescent Brain from T1-Weighted MRIs 150
Sara Ranjbar, Kyle W. Singleton, Lee Curtin, Susan Christine Massey, Andrea Hawkins-Daarud, Pamela R. Jackson, and Kristin R. Swanson

Ensemble of 3D CNN Regressors with Data Fusion for Fluid Intelligence Prediction 158
Marina Pominova, Anna Kuzina, Ekaterina Kondrateva, Svetlana Sushchinskaya, Evgeny Burnaev, Vyacheslav Yarkin, and Maxim Sharaev

Adolescent Fluid Intelligence Prediction from Regional Brain Volumes and Cortical Curvatures Using BlockPC-XGBoost. 167
Tengfei Li, Xifeng Wang, Tianyou Luo, Yue Yang, Bingxin Zhao, Liuqing Yang, Ziliang Zhu, and Hongtu Zhu

Cortical and Subcortical Contributions to Predicting Intelligence Using 3D ConvNets. 176
Yukai Zou, Ikbeom Jang, Timothy G. Reese, Jinxia Yao, Wenbin Zhu, and Joseph V. Rispoli

Author Index 187