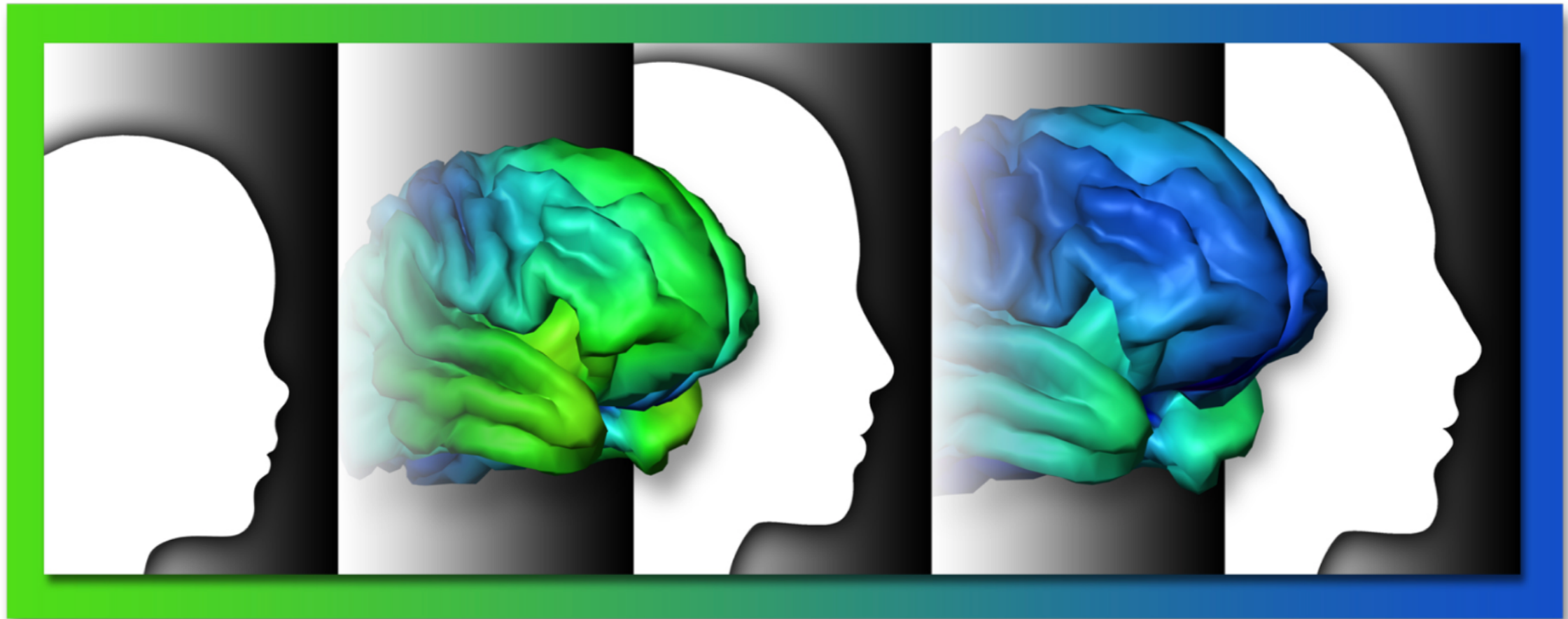# Introduction into ABCD imaging resources

Adolescent Brain Cognitive Development®

Teen Brains. Today's Science. Brighter Future.

Damien Fair, PA-C, Ph.D.
ABCD Workshop, Portland, August 2019

The Fearless Leader

Kate Mills

The Fearless Leaders

Terry Jernigan   Sandra Brown   Anders Dale   Gaya Dowling

Slides Courtesy of:

Don Hagler   Sean Hatton

Goals

- ABCD processing pipeline and characteristics of baseline data

- Data sharing

- Additional tools

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Processing Pipeline and Baseline Data

NeuroImage

Available online 12 August 2019, 116091

In Press, Journal Pre-proof

Image processing and analysis methods for the Adolescent Brain Cognitive Development Study

Donald J. Hagler Jr. [a] ✉, SeanN. Hatton [a], M. Daniela Cornejo [a], Carolina Makowski [b], Damien A. Fair [c], Anthony Steven Dick [d], Matthew T. Sutherland [d], B.J. Casey [e], Deanna M. Barch [f], Michael P. Harms [f], Richard Watts [e], James M. Bjork [g], Hugh P. Garavan [h], Laura Hilmer [a], Christopher J. Pung [a], Chelsea S. Sicat [a], Joshua Kuperman [a], Hauke Bartsch [a] ... Anders M. Dale [a]

⊞ Show more

Structural MRI

T1-weighted
T2-weighted

Processing Pipeline and Baseline Data

sMRI derived measures

- morphometric measures
  cortical thickness, area, volume, sulcal depth, and gyrification

- image intensity measures
  T_1w, T_2w, and cortical contrast (normalized gray/white difference)

- cortical surface ROIs
  using standard FreeSurfer parcellations

- subcortical ROIs
  intensity-based measures and volumes
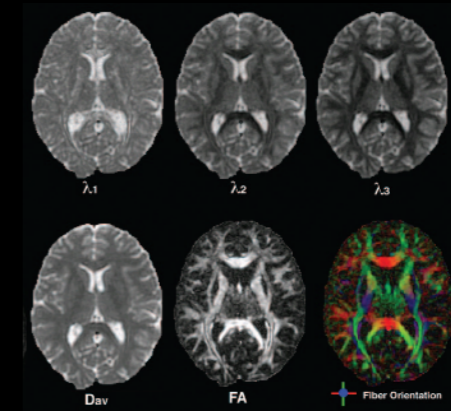

Fischl et al., 2002
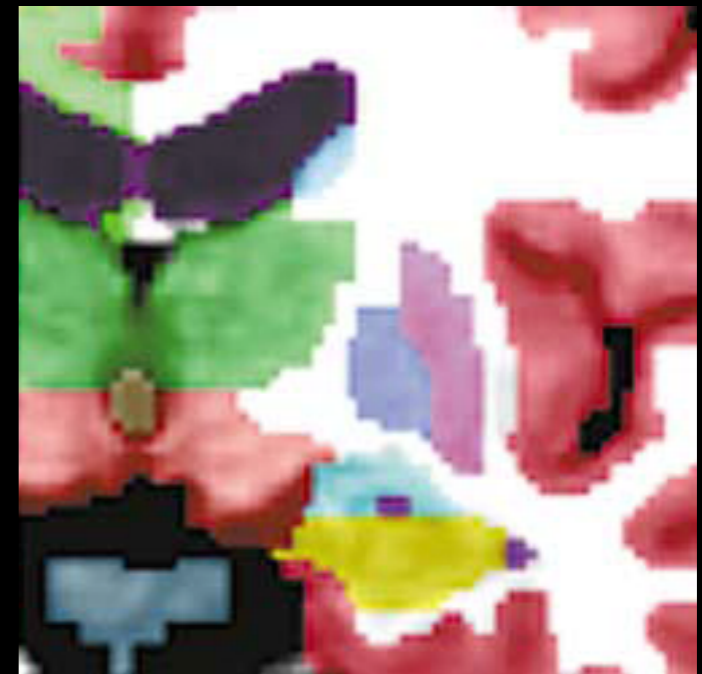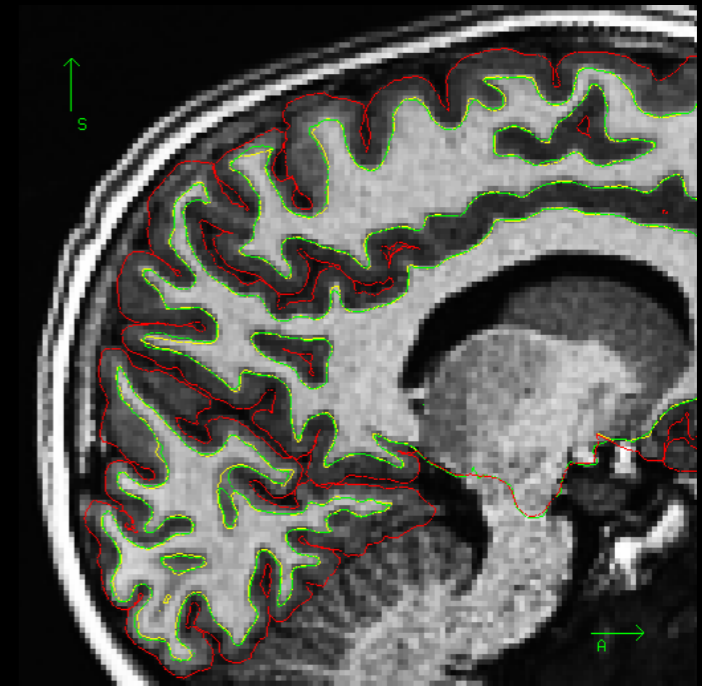
Diffusion MRI

b-values: 500 (6-dirs), 1000 (15-dirs), 2000 (15-dirs), 3000 (60-dirs)

Diffusion Tensor Imaging (DTI)
Restriction Spectrum Imaging (RSI)

Processing Pipeline and Baseline Data

dMRI-derived measures

- diffusion tensor imaging (DTI)
  estimate principal diffusion orientations, fractional
  anisotropy, and mean, radial, and axial diffusivity

- restriction spectrum imaging (RSI)
  "restricted" and "hindered" diffusion within individual voxels
  - intracellular and extracellular signal fractions

- average dMRI-derived measures
  white matter tracts, subcortical gray matter structures,
  cortical parcellations (cortical gray matter and peri-cortical
  white matter)

Mukherjee et al., 2008
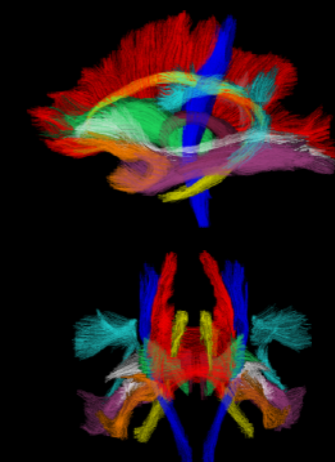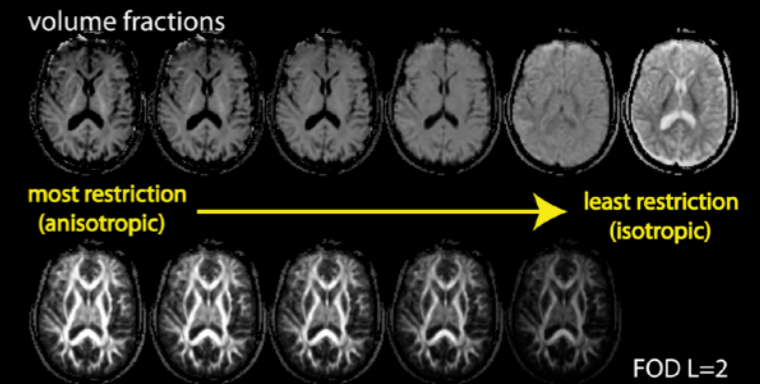
Hagler et al., 2009
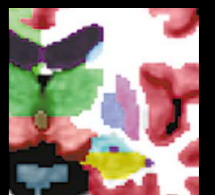
Fischl et al., 2002
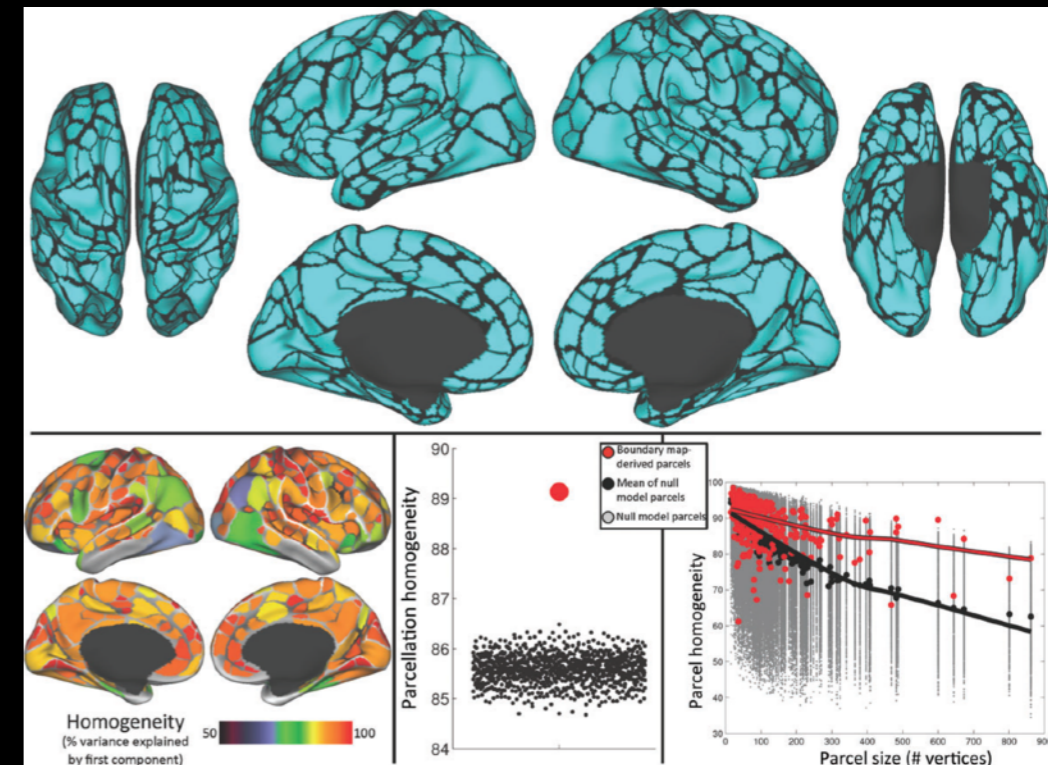
Desikan et al., 2006

Resting state fMRI

3-4 five minute runs

Processing Pipeline and Baseline Data

Seed-based correlation analysis

- average time courses

  - within cortical surface and subcortical ROIs

- pair-wise correlations between ROIs

  - functionally-defined parcels and subcortical ROIs

  - Fisher Z transform of r values

- average correlation within and between pre-defined networks

  - e.g. default, fronto-parietal, dorsal attention, etc.

- correlation between each subcortical ROI and each network

Gordon, E.M., et al., Generation and Evaluation of a Cortical Area Parcellation from Resting-State Correlations. Cereb Cortex, 2014.

Task fMRI

Monetary Incentive Delay (MID) Task
Stop Signal Task (SST)
Emotional N-Back (nBack) Task
Behavioral performance

# Processing Pipeline and Baseline Data

Tasks used for fMRI

- **monetary incentive delay (MID)**

  - events: anticipation of large, small, and no rewards and feedback for large, small, and no rewards for wins and losses

  - contrasts: anticipation of large and small reward vs. no reward, anticipation of large and small loss vs. no reward, feedback of win vs. no reward, and feedback of loss vs. no reward
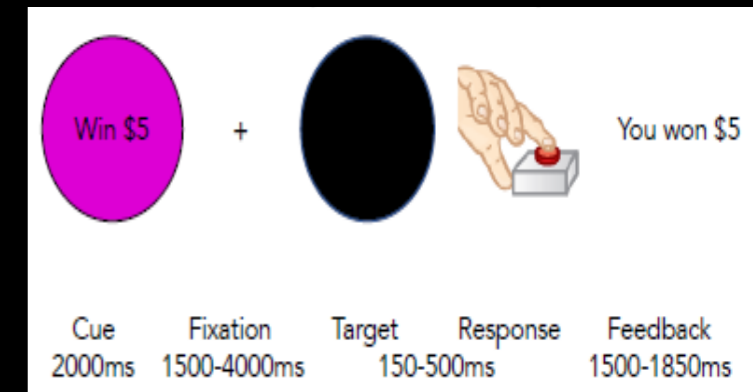
- **stop signal task (SST)**

  - events: successful go trial, failed go trial, successful stop trial, and failed stop trial; go trials following a successful or failed trial (error monitoring)

  - contrasts: successful vs. failed stop trials and successful vs. failed go trials
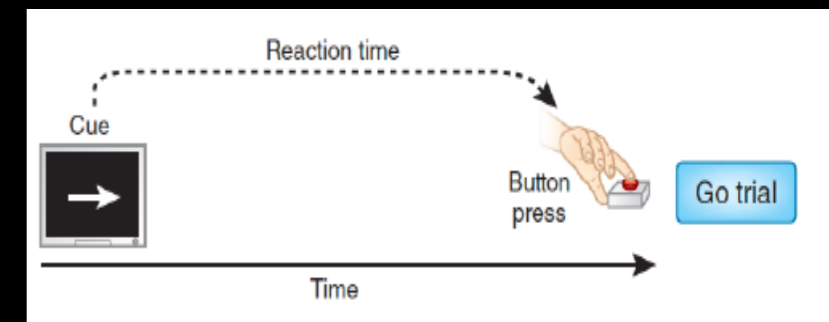
- **emotional n-back (EN-back)**

  - events: each type of stimulus (i.e. place and emotional face) in each of the n-back conditions (i.e., 0-back and 2-back) plus fixation

  - contrasts: 2-back vs. 0-back across stimulus types, emotional faces vs. places across memory loads, 2-back vs. 0-back for each stimulus type, and each memory load and each stimulus type vs. fixation
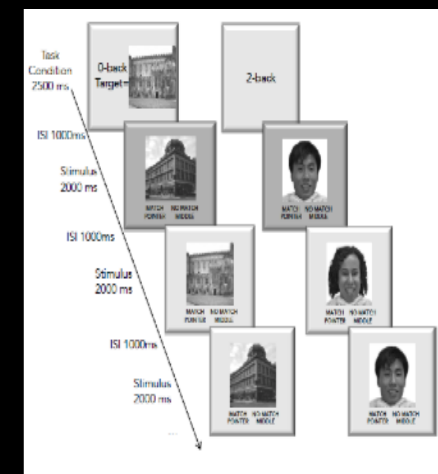
Casey et al., (2018) The Adolescent Brain Cognitive Development (ABCD) study: Imaging acquisition across 21 sites. Dev Cogn Neurosci. 2018 Aug;32:43-54.

Processing Pipeline and Baseline Data

Current/future pipeline development
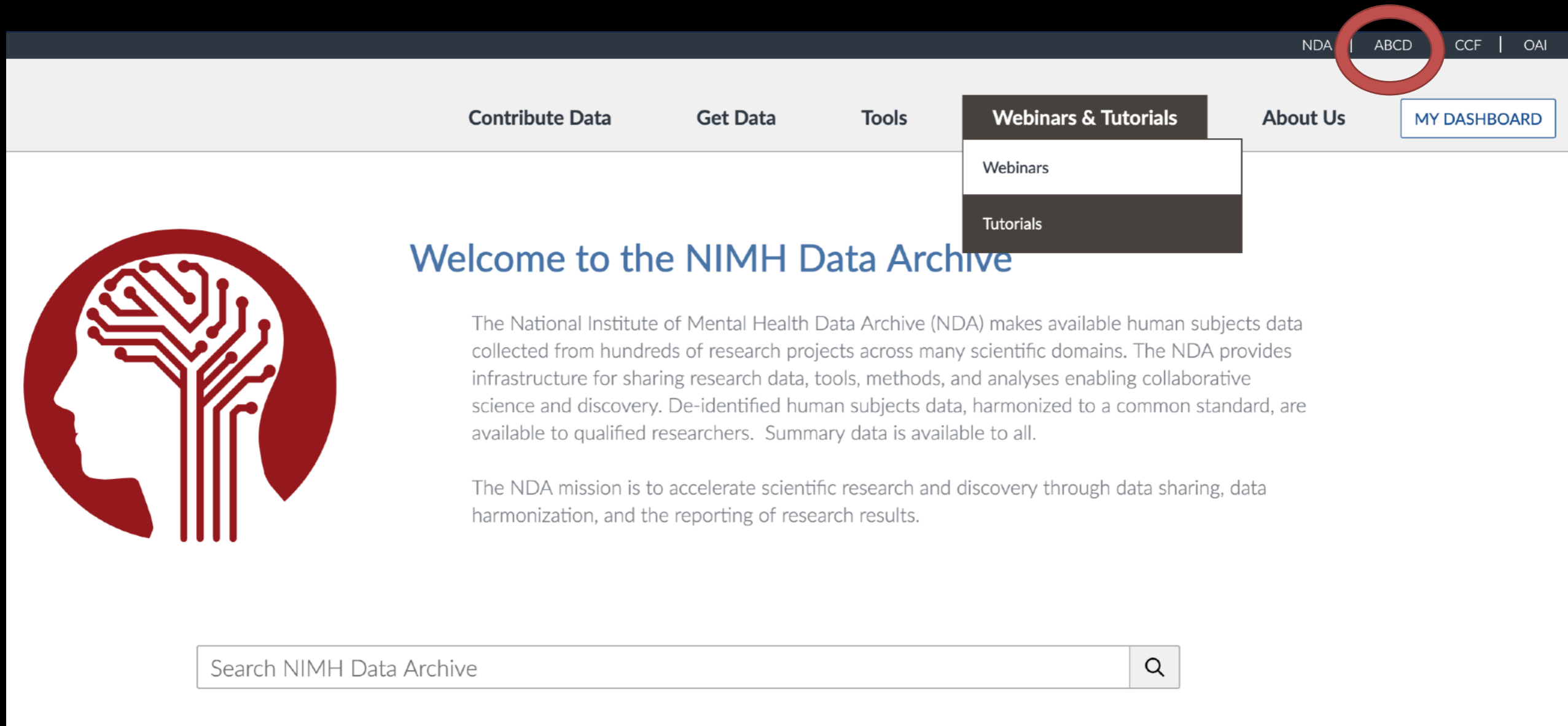
- Enhanced processing QC

- fMRI visual QC, MRIQC

- Enhanced DTI preprocessing

- Enhanced fMRI motion correction

- FreeSurfer 6/FSL 6

- Derived data in BIDS format (e.g. FreeSurfer)

- Follow-up identification

- Longitudinal metrics

- Between scan correction (T1w/T2w/DTI)

Goals

- ABCD processing pipeline and characteristics of baseline data

- Data sharing

- Additional tools

Data Sharing

nda.nih.gov

Data Sharing

nda.nih.gov/abcd

The ABCD Study's Curated Annual Release 2.0 is now available. The ABCD Study began sharing its Fast Track imaging data in July 2017. All ABCD Study data is stored in the NIMH Data Archive Collection #2573.

Problems have been identified with imaging data tables and associated data dictionaries for the following instruments: abcd_dti_p101, abcd_dti_p201, abcd_ddtidp101, abcd_ddtidp201, abcd_dmdtifp201, abcd_midasemdp201, abcd_midr1bwdp201, abcd_tr2bwdp201, abcd_midabwdp201, abcd_tmidr1semdp201, abcd_tr2semdp201. Corrected files will be available soon. An error was also discovered in imaging data collected from Siemens scanners between September 2017 and December 2017 where structural images are flipped left-right. These data will be updated in a patch release later this year.

ANNUAL RELEASE 2.0

COLLECTION 2573

FAST TRACK RELEASE INFO

VIEW COMMONLY ACCESSED DATASETS

Authorized users are now able to use the ABCD Data Exploration and Analysis Portal (DEAP). The DEAP allows users to analyze ABCD Study data online, while providing appropriate statistical models and tools that take advantage of the study design.

ACCESS DEAP

Researchers new to the NIMH Data Archive system interested in gaining access should create an account below and follow the instructions to request access. Returning researchers can log into their account using the Login button.

CREATE NEW ACCOUNT   **LOGIN**

Data Sharing

Fast Track

- Raw DICOMS continually updated

- Working towards monthly update

- Coming soon:

  - Instrument to advise changes, QC scores

  - Enhanced filter

Data Sharing

ABCD Fast Track Data

The ABCD fast-track data release contains unprocessed neuroimaging data from ABCD Study participants to date, as well as basic participant demographics (age, sex), including:

- High-resolution structural data (3D T1 - and T2 - weighted scans)
- Advanced diffusion MRI (multiple b-values and directions)
- Resting State fMRI
- Task fMRI (Monetary Incentive Delay, Stop-Signal), and Emotional N-Back), along with raw E-Prime task files for each fMRI run

Neuroimaging data are collected using a harmonized Human Connectome protocol, developed for the ABCD Study, and supported across all three major MRI scanner platforms (Siemens, General Electric, and Philips). Fast track data are in DICOM format as provided by the MRI scanners and have not undergone quality control or curation. As such, these data are most suitable for technical methods development, as the DICOM images would require pre-processing (e.g., distortion correction, movement correction, alignment) to be suitable for data analysis. Researchers intending to use Fast Track data should take note of the appropriate Acknowledgement language to include in any public disclosure of results.

How to Get Fast Track Data

Use the new NDA Query tool to access all, or a predefined subset of Fast Track data:

NDA QUERY TOOL

All ABCD Fast Track Data are also available through the image03 structure for raw imaging data in NDA. If you are interested in downloading some or all of the Fast Track dataset, and have access only to the ABCD dataset, you can follow these steps:

Data Sharing

Minimally processed data

- sMRI

  - grad unwarp, image intensity inhomogeneity correction, rigid-body registration to atlas and resamping to 1mm isotropic

- dMRI

  - B0 correction, grad unwarp, eddy current correction, and motion correction, with tensor fit outlier-based censoring and replacement of bad frames, reorienting to standard orientation

  - diffusion gradient tables (bvecs and bvals)

  - transformation matrix for registration to T1

- fMRI

  - B0 correction, grad unwarp, and motion correction

  - motion estimates

  - transformation matrix for registration to T1

Data Sharing

Tabulated Results: sMRI

- morphometric measures will include cortical thickness, area, volume, sulcal depth, and gyrification

- image intensity measures: T_1w, T_2w, and cortical contrast (normalized gray/white difference)

- cortical surface ROI-based analysis using standard FreeSurfer Desikan/Destieux parcellations

- intensity-based measures and volumes of subcortical ROIs

- quality control measures for FreeSurfer cortical surface reconstruction

  - motion, intensity inhomogeneity, pial overestimation, white matter underestimation

Data Sharing

Tabulated Results: Diffusion

- diffusion tensor imaging (DTI)

    - estimate principal diffusion orientations, fractional anisotropy, and mean, radial, and axial diffusivity

- restriction spectrum imaging (RSI)

    - allow for mixtures of "fast" and "slow" diffusion pools within individual voxels, estimating intracellular and extracellular volume fractions

- average dMRI-derived measures

    - white matter tracts

    - subcortical gray matter structures

    - cortical parcellation (Desikan): cortical gray matter and peri-cortical white matter

- quality control measures for post-processing dMRI data

    - registration to T1, residual distortion, derived image quality

    - to be included in Patch Release, Aug 2018 and beyond

Data Sharing

Tabulated Results: resting-state

- average correlation (Fisher Z-transformed) within and between pre-defined networks

  - e.g. default, fronto-parietal, dorsal attention, etc.

  - functionally-defined parcels (Gordon)

- correlation between each network and each subcortical ROIs

- low frequency BOLD signal variance in each subcortical ROI, Gordon parcel, and standard FreeSurfer Desikan/ Destrieux parcels

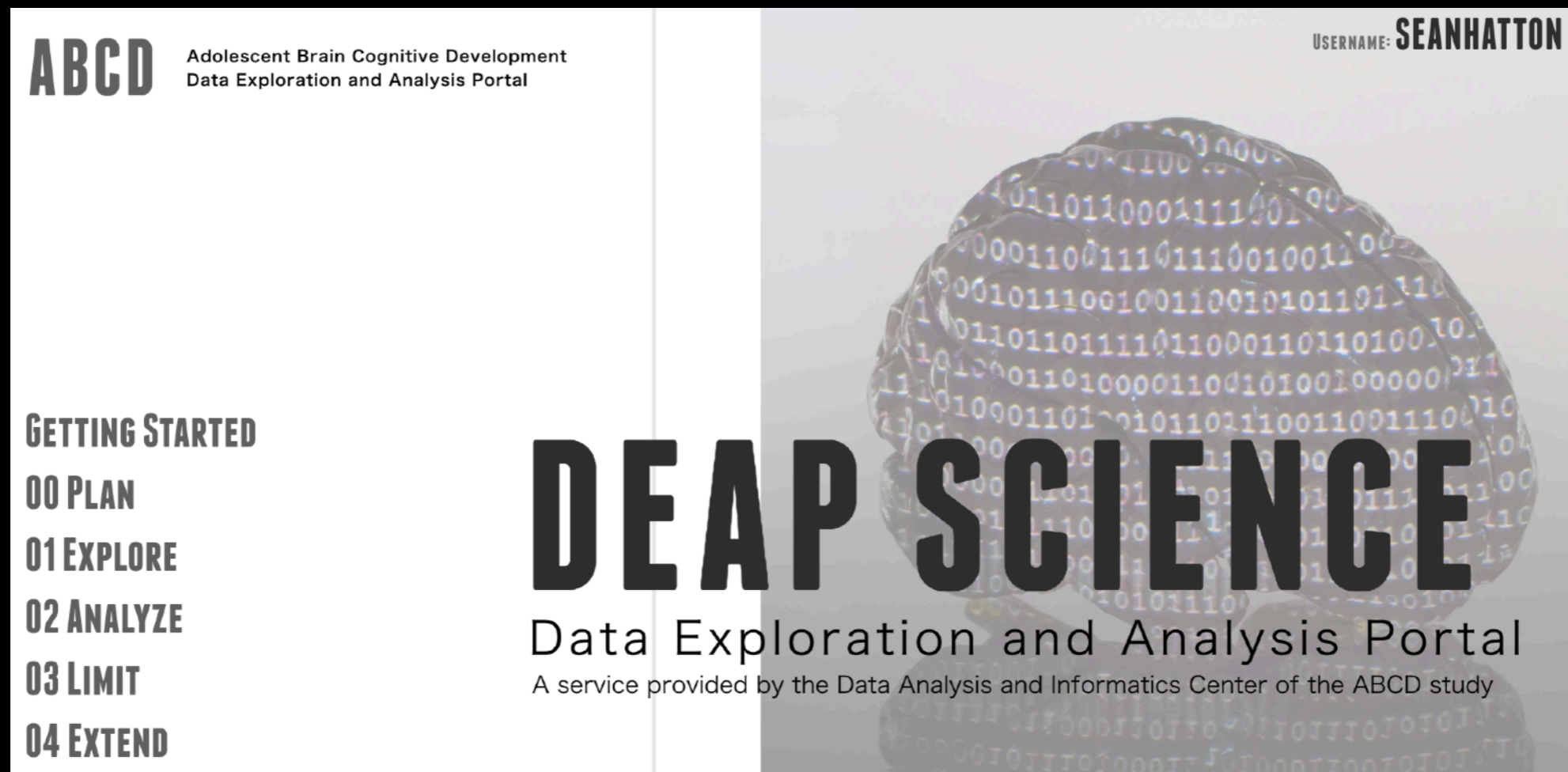- metadata (e.g. number of TRs, mean motion)

Data Sharing

Tabulated Results: task

- beta estimates and standard error of mean

  - average within ROIs

    - subcortical ROIs, Desikan parcels

  - run 1, run 2, and average across runs

  - multiple contrasts for each task

    - **Monetary Incentive Delay (MID):** anticipation of large and small reward vs. no reward, anticipation of large and small loss vs. no reward, feedback of win vs. no reward, feedback of loss vs. no reward

    - **Stop Signal Task (SST):** successful vs. failed stop trials and successful vs. failed go trials

    - **Emotional n-back:** 2-back vs. 0-back across stimulus types, emotional faces vs. places across memory loads, 2-back vs. 0-back for each stimulus type, and each memory load and each stimulus type vs. fixation

- behavioral performance measures

- metadata (e.g. number of TRs, number of degrees of freedom)

Data Sharing

Data Analysis and Exploration Portal (DEAP)

https://deap.nimhda.org

Data Sharing

Genetic data

- Affymetrix NIDA Smokescreen Genotyping Array

  - More addiction-, nicotine- and tobacco-related content

- PLINK format

  - 527,285 SNPs have call rate greater than 99 percent across ABCD samples

1. Go to https://nda.nih.gov/abcd.

2. Click on "View Commonly Accessed Datasets".

3. In the available datasets select "Release 2.0.1 Genotyping Data" to add it to your Workspace.

4. Select to Submit to Filter Cart and download as per usual.

Data Sharing

<u>Known Issues - Release 2.0</u>

- 1136 subject had their scans incorrectly flipped (left is right, right is left).

- 1 imaging session was incorrectly associated with a different pGUID

Data Sharing

DTI Known Issues - Release 2.0

DTI column name mismatches, do not use these instruments from Release 2.0

- ABCD dMRI DTI Part 1/2

- ABCD dMRI DTI Destrieux Parcellations Part 1/2

- ABCD dMRI DTI Full Part 2

Data Sharing

MID fMRI Known Issues - Release 2.0

MID fMRI column name mismatches, do not use these instruments from Release 2.0

- ABCD Task fMRI MID Average SEM Destrieux Parcellations Part 2

- ABCD Task fMRI MID Run 1 Beta Weights Destrieux Parcellations Part 2

- ABCD Task fMRI MID Run 2 Beta Weights Destrieux Parcellations Part 2

- ABCD Task fMRI MID Average Beta Weights Destrieux Parcellations Part 2

- ABCD Task fMRI MID Run 1 SEM Destrieux Parcellations Part 2

- ABCD Task fMRI MID Run 2 SEM Destrieux Parcellations Part 2

Data Sharing

Genetics Known Issues - Release 2.0

- "sex" removed from genetic (plink) files

- 34 ID mismatches

- Recommend not using genotype data from plate 461, or including plate number as a covariate

Data Sharing

Fix Release 2.0.1 Updates

- NDA 2.0.1 Release Notes Imaging Instruments

- NDA 2.0.1 Changes between Release 1.1 and 2.0_Known Issues Release 2.0

- NDA 2.0.1 Diffusion Magnetic Resonance Imaging

- NDA 2.0.1 Task-Based Functional Magnetic Resonance Imaging

- NDA 2.0.1 Genetics

Data Sharing

Future releases

- ABCD Fix Release 2.0.1 (Current Release)

  - dMRI/MID fMRI table correction

  - 1137 right-left flip correction

  - Genetics: 34 IDs correction, sex removed from plink

- ABCD Annual Release 3.0 (Summer 2020)

  - Baseline + ~½ 2 year follow up

  - Cross-sectional metrics

- ABCD Annual Release 4.0 (Summer 2021)

  - Baseline + 2 year follow up

  - Cross-sectional and longitudinal metrics

Goals

- ABCD processing pipeline and characteristics of baseline data

- Data sharing

- Additional tools

Additional Tools

NDA Computational Credits

- Request NDA computational access through Amazon Web Services (AWS)

- Credits support compute resources and short-term data storage for specific research initiatives

- https://nda.nih.gov/get/computational-credits.html

Data Sharing

Repositories

ABCD-STUDY

DCAN-Labs

Additional Tools

ABCD associated tools

- **github**

  - DEAP

  - E-prime file parsing scripts

  - Enable CIFTI for FSL/PALM and HCP Workbench

  - abcd-dicom2bids

  - abcd-hcp-pipeline/abcd-bids-pipelines

- **nitrc**

  - MMPS Docker (beta)

ABCD-HCP BIDS APP

- CONTAINERIZED SOFTWARE
- STANDARDIZED INPUTS
- MINIMALISTIC INTERFACE

ABCD-HCP BIDS APP

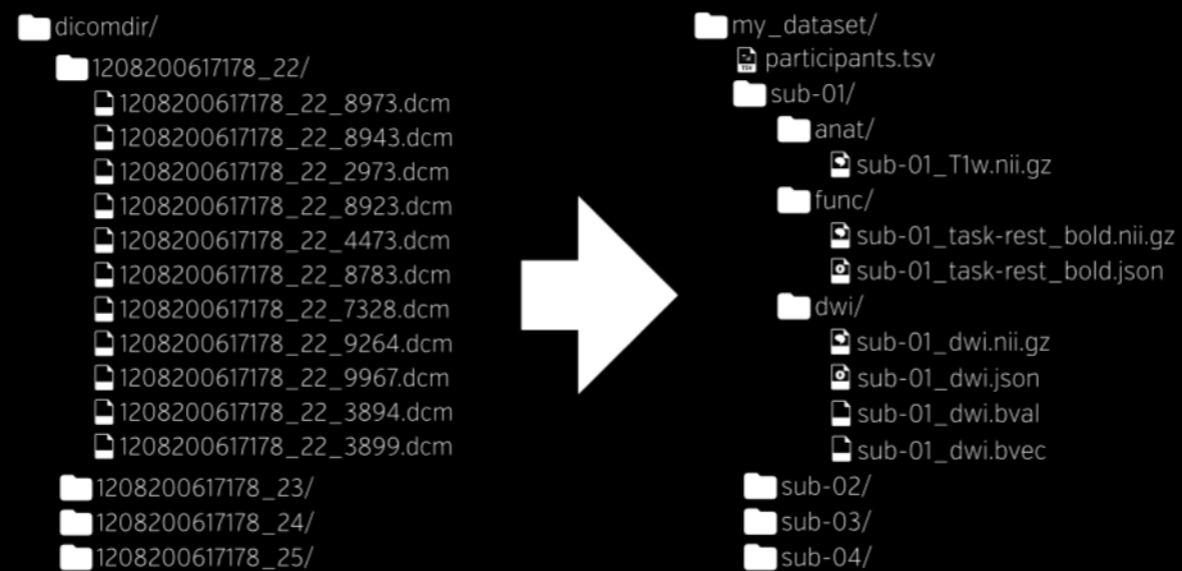## BIDS Standardized Inputs
http://bids.neuroimaging.io/

The Brain Imaging Data Structure (BIDS) folder format offers a standardized and openly discussed structure for organizing neuroimaging data.

ABCD - DCM2BIDS

https://github.com/ABCD-STUDY

ABCD-HCP BIDS APP

Minimalistic Interface

There are many additional options available, but the pipeline can be run by providing only the input and output folders.

```
docker run \
    -v /path/to/input:/bids_input  \
        -v /path/to/output:/output  \
    -v /path/to/freesurfer/license.txt:/license \
abcd-hcp-pipeline /bids_input /output –freesurfer-license=/license
                            [OPTS]
```

The arguments highlighted in yellow are the only ones the user provided here.

ABCD-HCP BIDS APP

Options/Features/Differences with HCP pipelines

1. Detects any modality configuration

2. PreFreeSurfer and PostFreeSurfer modifications to improve performance on certain datasets

3. Study Specific Template for improved Masking and Nonlinear Registration, useful for aging populations with larger ventricles

4. Functional Connectivity Preprocessing Module

5. Respiratory Artifact filtering parameters

6. Quality Control Image Module

ABCD-HCP BIDS APP

- Works with ABCD Data

- Works with Legacy/Non-ABCD Data acquisitions

- Works with Specialized populations (e.g. Aging)

ABCD-HCP BIDS APP

- *ABCD-HCP BIDS APP Available Now*

- *BIDS input data and ABCD-HCP processed data will be available for download soon*
- *Collection: #3165*

- **11,878** subjects have been scanned.

- **11,097** unique subjects have been uploaded to AWS fast track.

- **10,599** have T1w images that passed DAIC QC, have been converted to BIDS, and processed through the *ABCD-HCP BIDS App*

Additional Tools

Getting help

NDA Helpdesk

- https://nda.nih.gov/webinars-and-tutorials

- NDAHelp@mail.nih.gov

  - Request access, the status of a specific Data Access Request, or the status of access privileges and credentials.

  - How to package/download NDA data

  - Troubleshooting download issues

  - Verifying the contents of a package

  - NDA Website issues

  - Answers to known and documented scheduling, policy, or future data availability questions
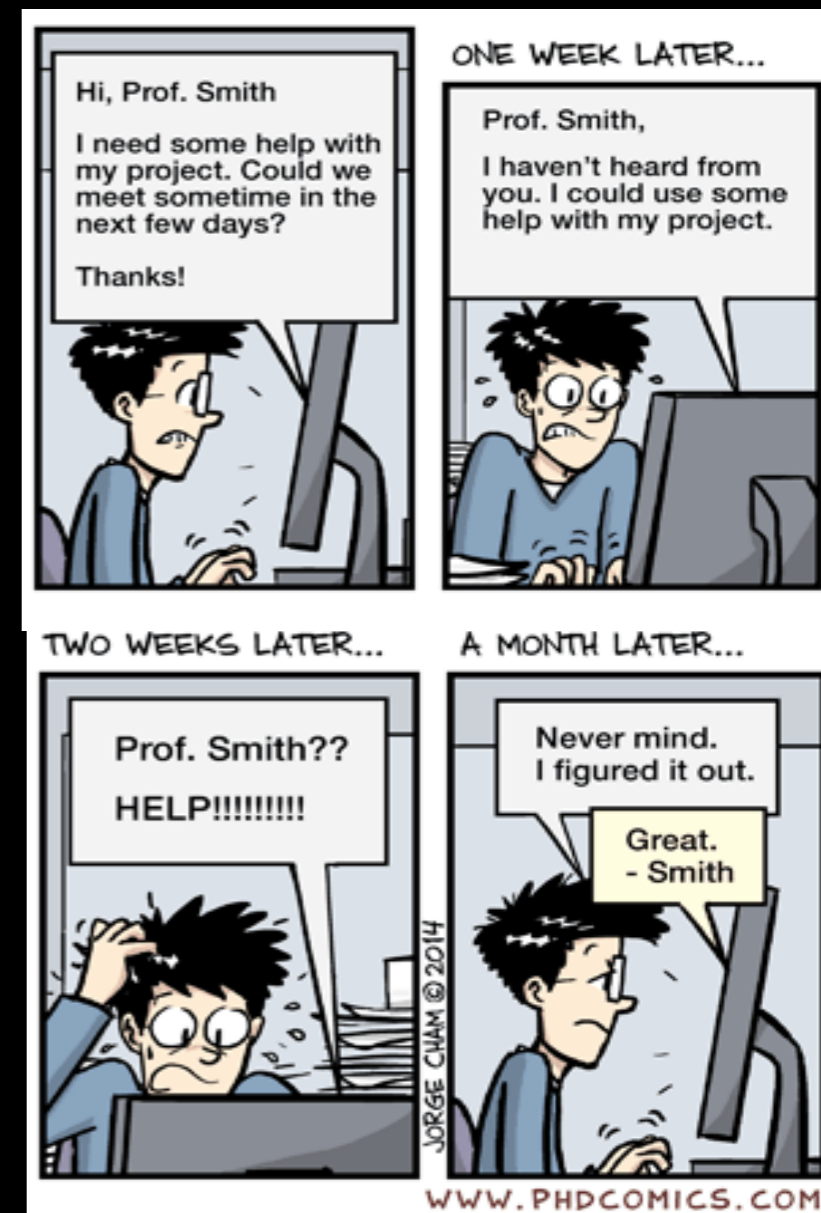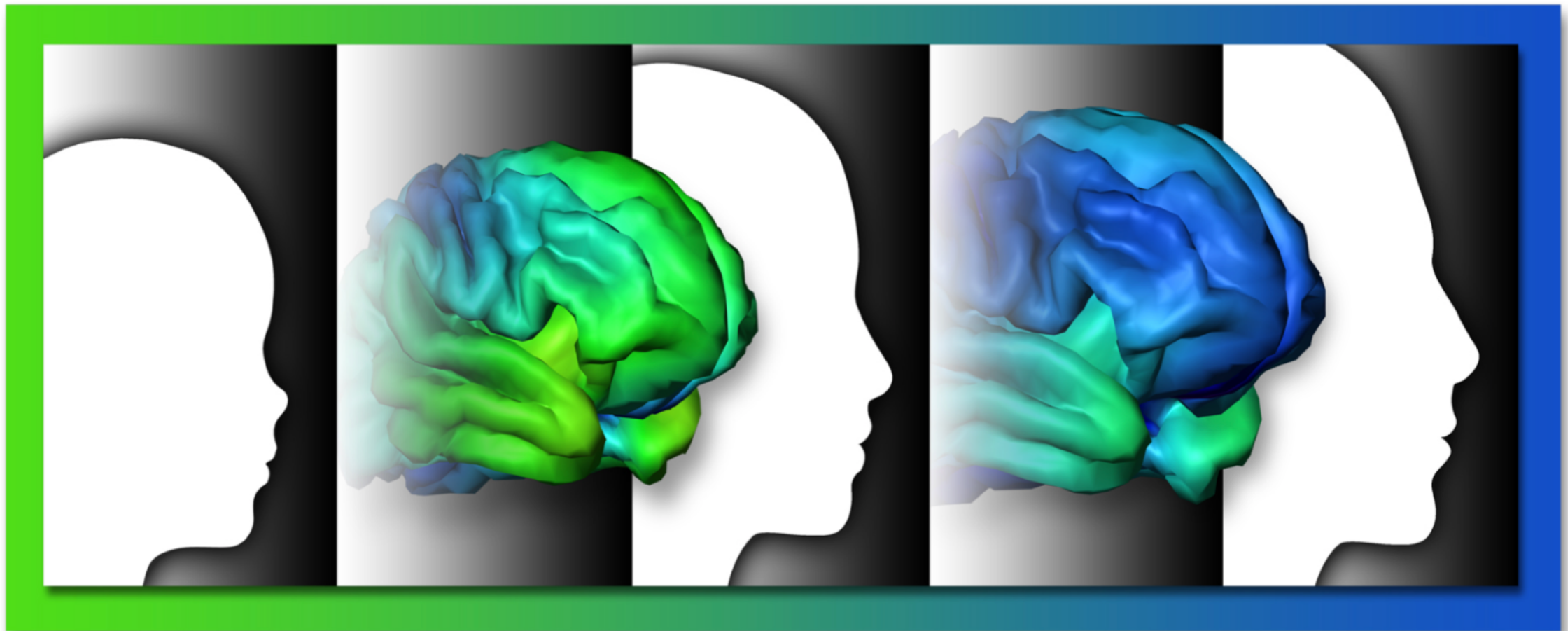
Additional Tools

Getting help

ABCD Issues

- abcd-issues@ucsd.edu

  - Contents of associated files (images), or their metadata records in image03/fmriresults01

  - Requests for elaboration or clarification of the Release Notes

  - Contents of the Curated Annual Release dataset

  - Data downloads from DEAP/NDA

- DAIC Release email list: email abcd-data-releases-l-join@mailman.ucsd.edu, a reply email will provide further instructions.

Thank You!

Don Hagler: dhagler@ucsd.edu
Sean Hatton: sehatton@ucsd.edu