The ABCD study : leveraging a cohort for developmental science

March 6 2025

CANOP team, Institut de Neurosciences de la Timone

Paysserand Andrea, PhD student

Adolescent Brain Cognitive Development®
Teen Brains. Today's Science. Brighter Future.

NeuroSchool (Aix*Marseille Université)

amU Aix Marseille Université

int institut de neurosciences de la timone

The Adolescent Brain Cognitive Development

Start in 2015, 10 years ago !!!
2018 : open data sharing first release

Objectives : initially focused on examining risk and resiliency factors associated with **substance use development**

The study expanded to investigate various aspects of **brain, cognitive, social, emotional, and physical development**

Foundings from the Nationnal Institute of Health (NIH)

The Adolescent Brain Cognitive Development

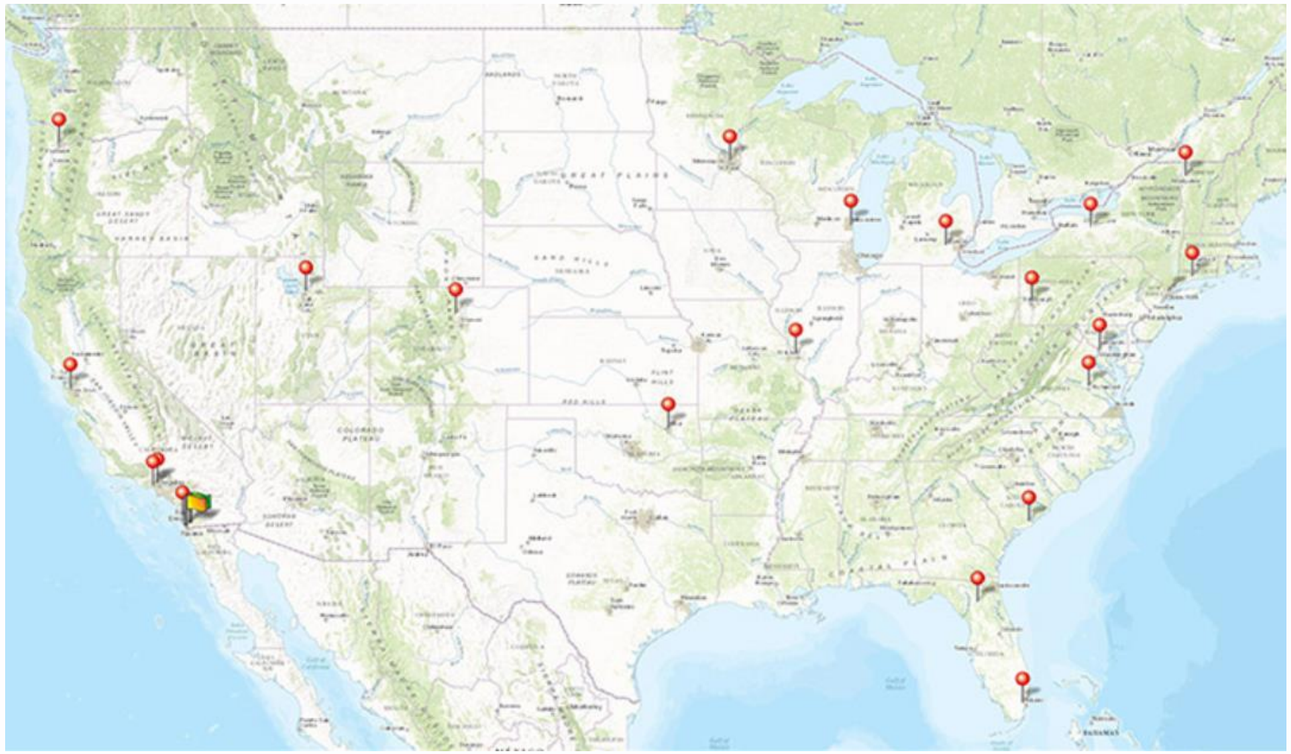
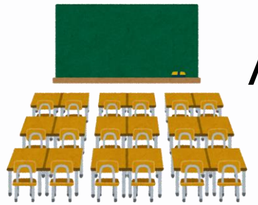


Image from Developmental Cognition and Neuroimaging Lab, University of Minnesota

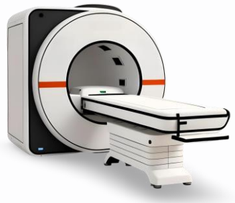
Multicentric : 21 research sites

11897 children aged 9 to 11 at baseline

Recruitment and exclusion criteria



A school-based national recruitment strategy with limited exclusion criteria



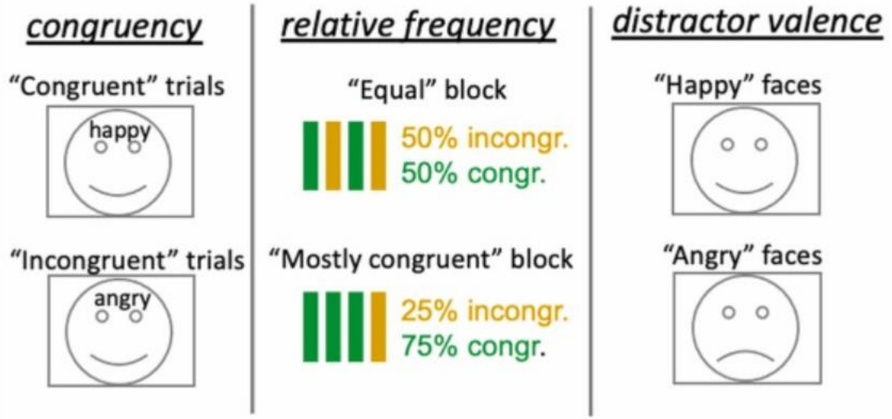
- lack of English proficiency in the child
- the presence of severe sensory, neurological, medical or intellectual limitations that would inhibit the child's ability to comply with the protocol
- an inability to complete an MRI scan at baseline.

A population-based cohort study, designed to emulate epidemiological research methodologies

Data collected

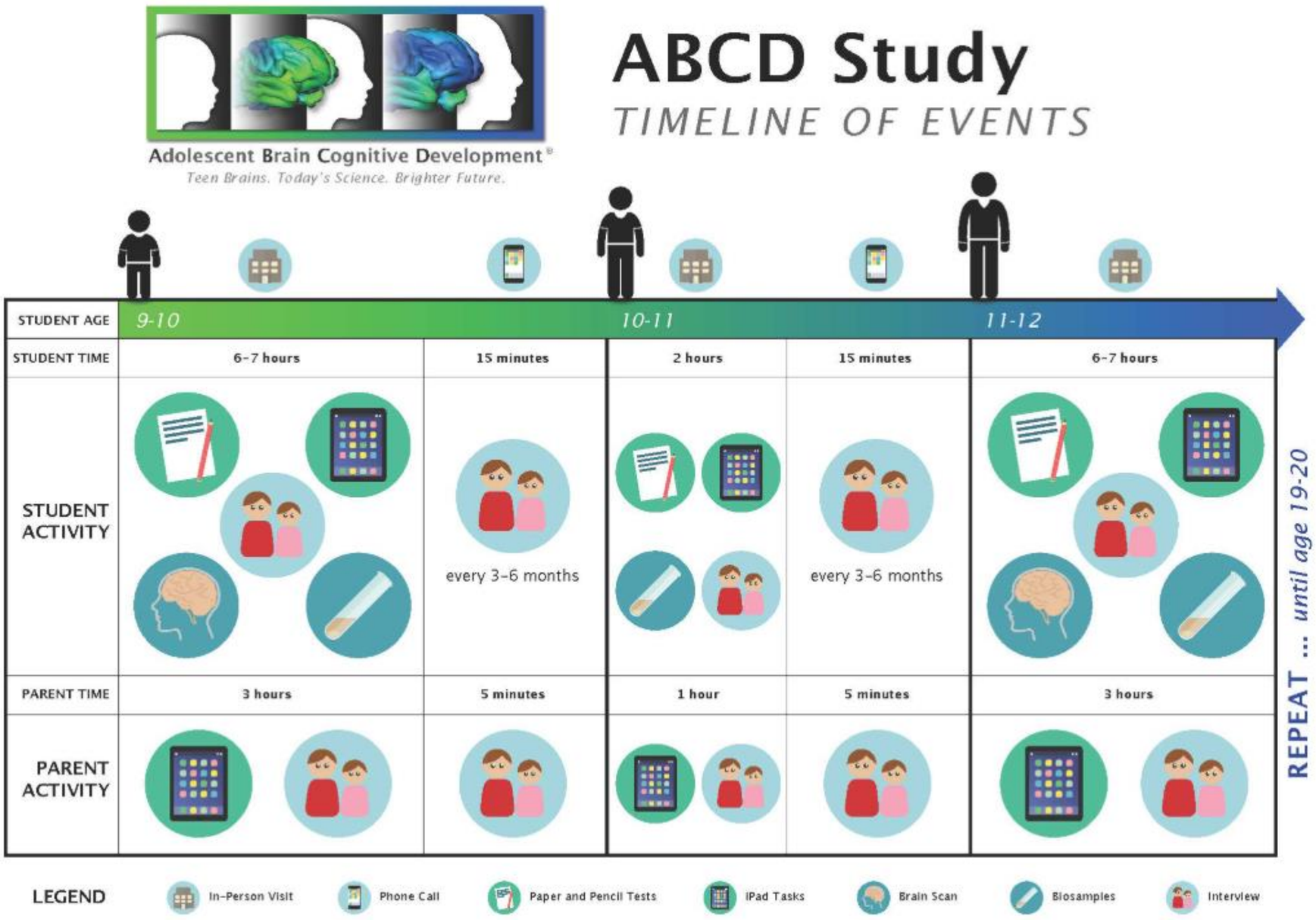
Examples

- abcd-general → i.e research site
- culture-environment → i.e. family confict
- gender-identity-sexual-health
- genetics → SNP imputed
- imaging
- linked-external-data → Data derived from adress (i.e air polluants)
- mental-health → i.e. The Child Behavior CheckList
- neurocognition → i.e. Emotional Stroop
- novel-technologies
- physical-health → i.e. Developmental History Questionnaire (perinatal complications)
- substance-use



Smolker et al. 2022

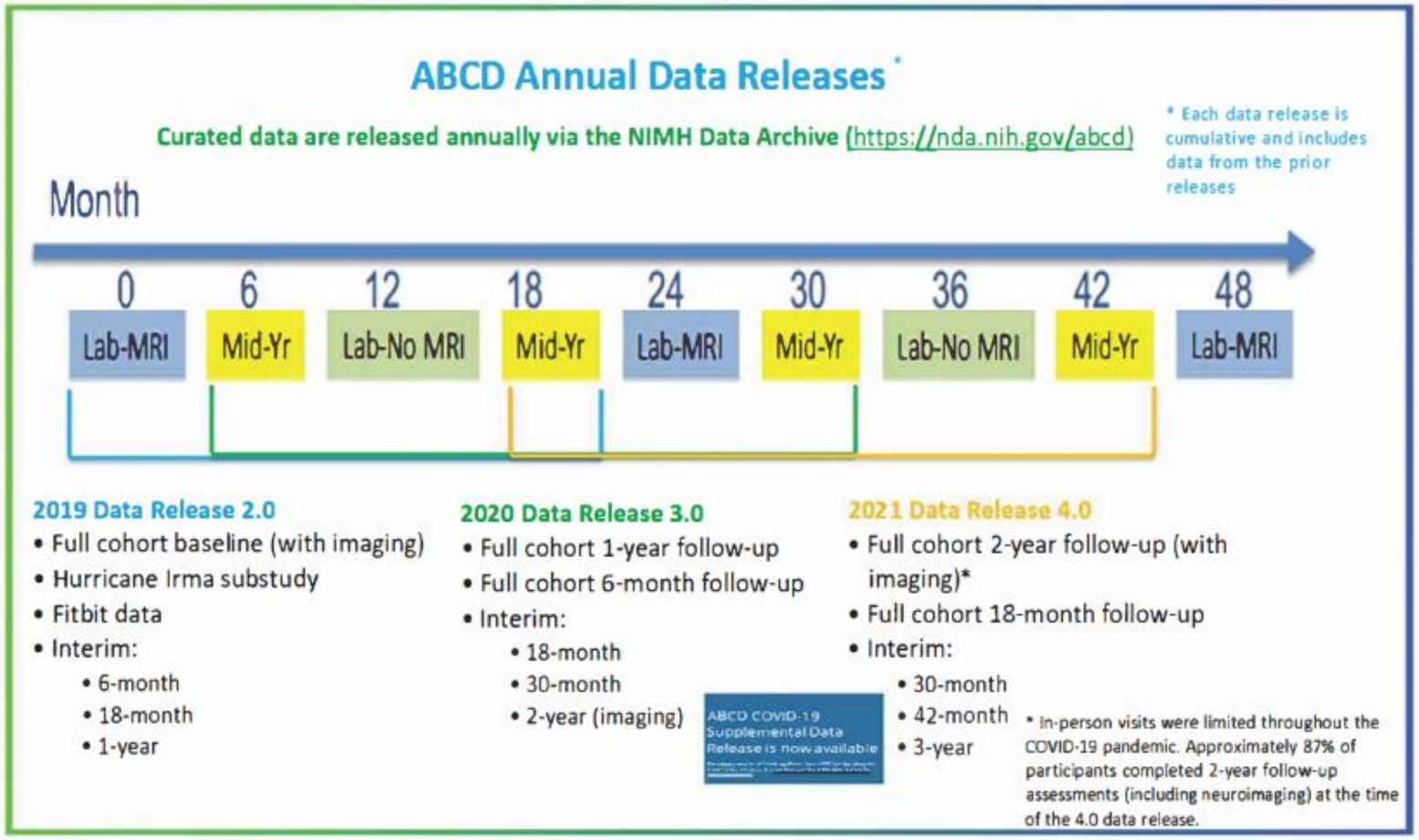
Protocol



- **Baseline : Lab MRI**
- 6 month : At home
- 12 months : Lab NO MRI
- 18 months : At home
- **24 months : Lab MRI**

Casey et al. 2018

Releases



Release 5.1 LATEST NEWS

Release 6.0 Coming Soon!

MRI in the ABCD study

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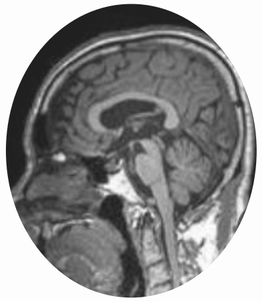
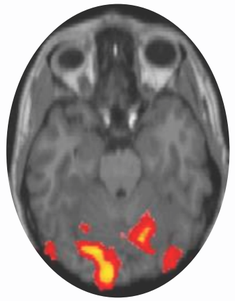
Data collected



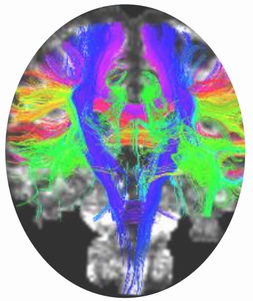
sMRI

T1 T2



fMRI

3 Tasks Resting state



Diffusion Imaging

fMRI tasks

Monetary Incentive Delay Task

reward processing, motivation

Cue

Task

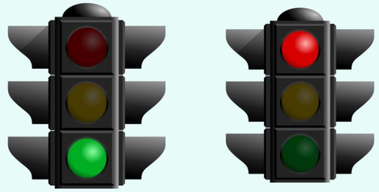
Feedback

win money *no win* *no loss* *lose money*

The stop signal task

impulsivity and impulse control

interrupt a motor response to a “Go” stimulus when it is followed unpredictably by a signal to stop



Emotional N-back task

memory and emotion regulation processes

stimuli types

\+

n-back rule

is the face curently presented a match or not a match

MRI protocols

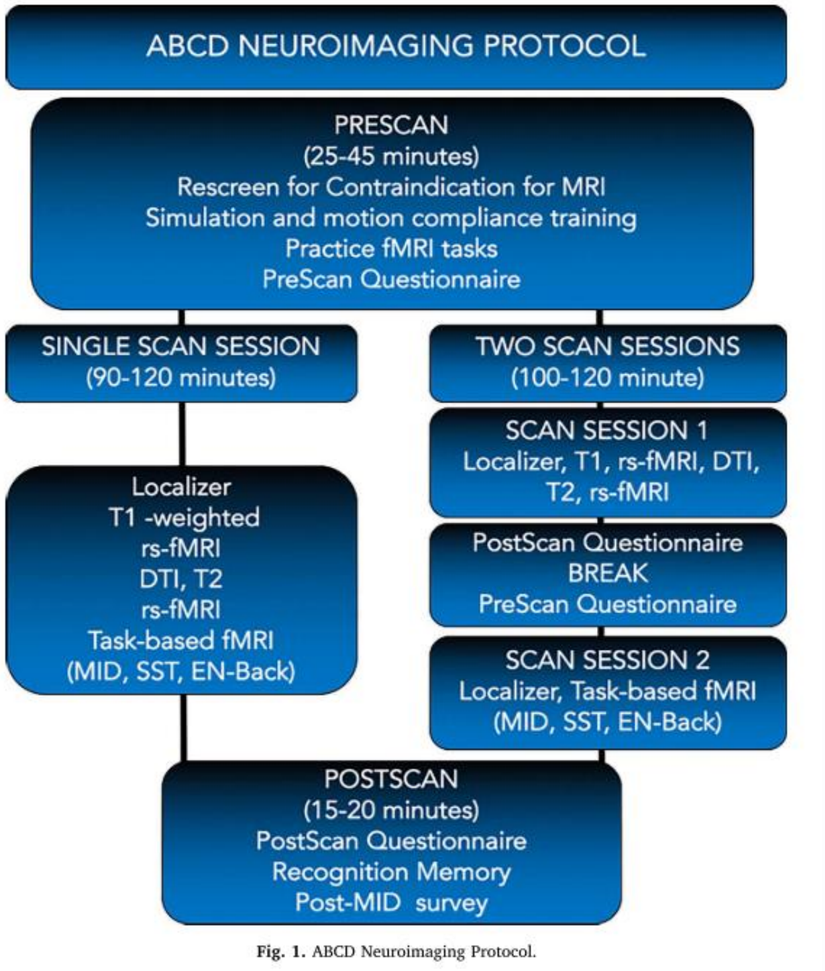


Fig. 1. ABCD Neuroimaging Protocol.

The final ABCD protocol

based on a multi-site (12 ABCD sites) pilot study
(67 children with a diversity representative of the entire sample)

T1, T2, DTI rs-fMRI (x2) and Tasks based fMRI

Casey et al. 2018

MRI and the DAIC

Centralized data management : at the Data Analysis and Informatics Center (DAIC)

1) establishing a **harmonized magnetic resonance imaging (MRI) acquisition protocol,** with comparable acquisition parameters across scanner vendors

2) **quality control of MRI images** before and after processing

3) **centralized image processing** and information extraction

4) **public sharing of data** and image processing pipelines

5) dissemination of imaging-derived measures and tools for use by the consortium and the wider scientific community.

Casey et al. 2018

MRI preprocessing

Centralized preprocessing : at the Data Analysis and Informatics Center (DAIC)

How ? lightly modified version of the image processing pipeline from the **Human Connectome Project**.

Goal : mitigating the heterogeneities in data preparation often encountered in multi-site consortia

Casey et al. 2018

MRI QC

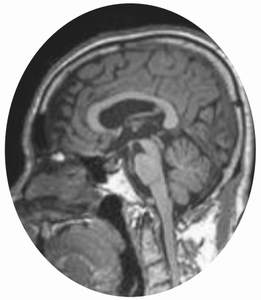
- **Visual QC prior to preprocessing :** exclude poor quality structural scan
- **Quantitative QC for image quality** (calculation of metrics such as signal- to-noise ratio (SNR) and head motion statistics)
- **Quantitative QC for derived measure** using Freesurfer 7.1.1

Recommandation of inclusion for each MRI data-type based on QC are available !

eventname	imgincl_t1w_include	imgincl_t2w_include	imgincl_dmri_include	imgincl_rsfmri_include	imgincl_mid_include	i
baseline_year_1_arm_1	1	1	1	1	1	
baseline_year_1_arm_1	1	1	1	0	1	
baseline_year_1_arm_1	1	1	0	1	1	
baseline_year_1_arm_1	1	1	1	1	1	
2_year_follow_up_y_arm_1	1	1	1	1	1	
4_year_follow_up_y_arm_1	1	1	1	1	0	

Casey et al. 2018

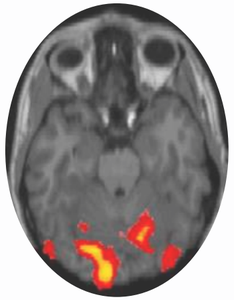
MRI derived measures available as tables (.csv)



sMRI

- **morphometric measures**

(Grey matter, white matter, cortcial volume, thickness and area, sulcal depth for both Desikan and Destrieux Atlases)



fMRI

Task

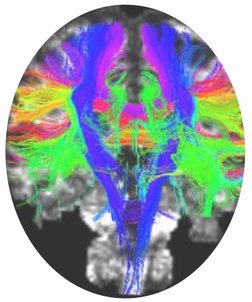
Example

- **Beta and SEM values** averaged within ROIs and tabulated **for each contrast for a given task**
- **behavioral** performance measures

Resting state

Example

- Correlations **within and between pre-defined cortical networks**
- Correlation **between each network and each subcortical RO**I



Diffusion Imaging

- **DTI** (diffusion Tensor Imaging) analyses
- **RSI** (Restriction Spectrum Imaging) analyses

Hagler et al. 2019

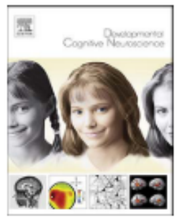
Guided use of the database

Developmental Cognitive Neuroscience 32 (2018) 43–54

Contents lists available at ScienceDirect

Developmental Cognitive Neuroscience

journal homepage: www.elsevier.com/locate/dcn



The Adolescent Brain Cognitive Development (ABCD) study: Imaging acquisition across 21 sites

B.J. Casey[a,b,*], Tariq Cannonier[a], May I. Conley[a,b], Alexandra O. Cohen[b], Deanna M. Barch[c], Mary M. Heitzeg[f], Mary E. Soules[f], Theresa Teslovich[b], Danielle V. Dellarco[b], Hugh Garavan[g], Catherine A. Orr[g], Tor D. Wager[h], Marie T. Banich[h], Nicole K. Speer[h], Matthew T. Sutherland[i], Michael C. Riedel[i], Anthony S. Dick[i], James M. Bjork[j], Kathleen M. Thomas[k], Bader Chaarani[g], Margie H. Mejia[l], Donald J. Hagler Jr.[l], M. Daniela Cornejo[l], Chelsea S. Sicat[l], Michael P. Harms[d], Nico U.F. Dosenbach[e], Monica Rosenberg[a], Eric Earl[m], Hauke Bartsch[l], Richard Watts[g], Jonathan R. Polimeni[n], Joshua M. Kuperman[l], Damien A. Fair[m], Anders M. Dale[l], the ABCD Imaging Acquisition Workgroup[1]

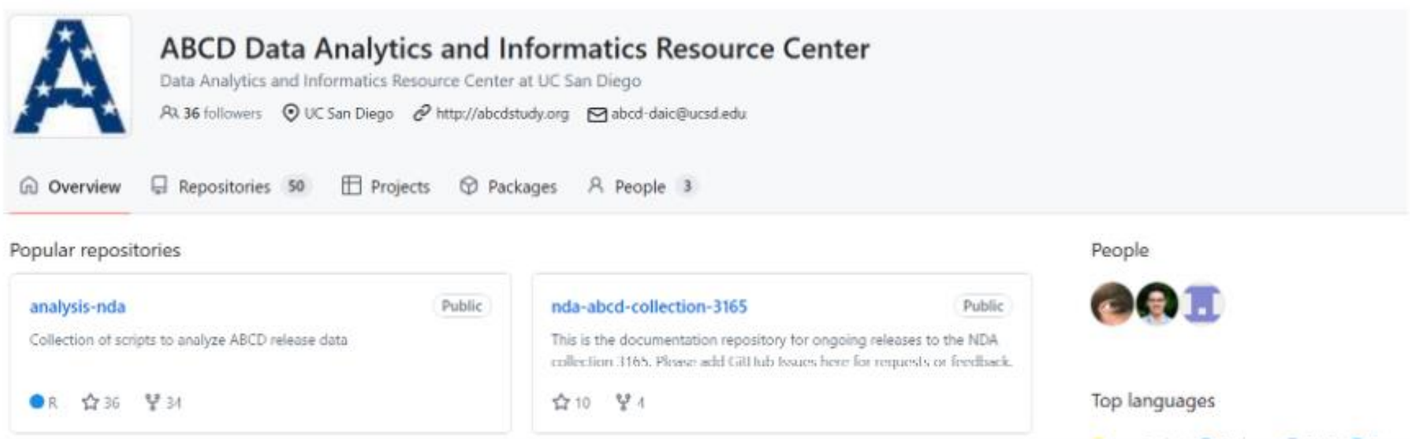
Guidelines and recommandation for

- variable selection
- dealing with outliers
- analysis

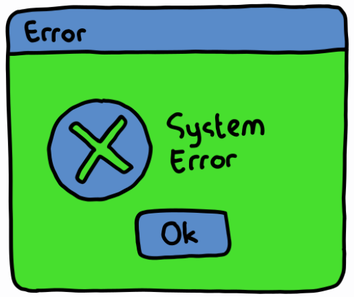
Casey et al. 2018
Hagler et al. 2019

Guided use of the database

Recommendations, tutorials, shared code scripts



Not available recently



Interactive Data Dictionnary Explorer (release 5.1)

Interactive Plateform for data analysis (Realease 4.0)

Casey et al. 2018
Hagler et al. 2019

The ABCD study is an amazing opportunity for MRI research

Multi-modal MRI data with harmonized acquisition, preprocessing and quality control

Large population-based cohort **of developping teenagers**

Open source **tools** and **guidelines**

Casey et al. 2018
Hagler et al. 2019

Supplementary

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MRI protocols

Neuroimaging Parameters

Siemens	Matrix	Slices	FOV	% FOV phase	Resolution (mm)	TR (ms)	TE (ms)	TI (ms)	Flip Angle (deg)	Parallel Imaging	MultiBand Acceleration	Phase partial Fourier	Diffusion Directions	b-values	Acquisition Time
T1	256 x 256	176	256 x 256	100%	1.0 x 1.0 x 1.0	2500	2.88	1060	8	2x	Off	Off	N/A	N/A	7:12
T2	256 x 256	176	256 x 256	100%	1.0 x 1.0 x 1.0	3200	565	N/A	Variable	2x	Off	Off	N/A	N/A	6:35
Diffusion	140 x 140	81	240 x 240	100%	1.7 x 1.7 x 1.7	4100	88	N/A	90	Off	3	6/8	96	500 (6-dirs) 1000 (15-dirs) 2000 (15-dirs) 3000 (60-dirs)	7:31
fMRI	90 x 90	60	216 x 216	100%	2.4 x 2.4 x 2.4	800	30	N/A	52	Off	6	Off	N/A	N/A	

Philips	Matrix	Slices	FOV	% FOV phase	Resolution (mm)	TR (ms)	TE (ms)	TI (ms)	Flip Angle (deg)	Parallel Imaging	MultiBand Acceleration	Half Scan Factor	Diffusion Directions	b-values	Acquisition Time
T1	256 x 256	225	256 x 240	93.75%	1.0 x 1.0 x 1.0	6.31	2.9	1060	8	1.5 x 2.2	Off	N/A	N/A	N/A	5:38
T2	256 x 256	256	256 x 256	100%	1.0 x 1.0 x 1.0	2500	251.6	N/A	90	1.5 x 2.0	Off	N/A	N/A	N/A	2:53
Diffusion	140 x 140	81	240 x 240	100%	1.7 x 1.7 x 1.7	5300	89	N/A	78	Off	3	0.6	96	500 (6-dirs) 1000 (15-dirs) 2000 (15-dirs) 3000 (60-dirs)	9:14
fMRI	90 x 90	60	216 x 216	100%	2.4 x 2.4 x 2.4	800	30	N/A	52	Off	6	0.9	N/A	N/A	

GE	Matrix	Slices	FOV	% FOV phase	Resolution (mm)	TR (ms)	TE (ms)	TI (ms)	Flip Angle (deg)	Parallel Imaging	MultiBand Acceleration	Phase partial Fourier	Diffusion Directions	b-values	Acquisition Time
T1	256 x 256	208	256 x 256	100%	1.0 x 1.0 x 1.0	2500	2	1060	8	2x	Off	Off	N/A	N/A	6:09
T2	256 x 256	208	256 x 256	100%	1.0 x 1.0 x 1.0	3200	60	N/A	Variable	2x	Off	Off	N/A	N/A	5:50
Diffusion	140 x 140	81	240 x 240	100%	1.7 x 1.7 x 1.7	4100	81.9	N/A	77	Off	3	5.5/8	96	500 (6-dirs) 1000 (15-dirs) 2000 (15-dirs) 3000 (60-dirs)	7:30
fMRI	90 x 90	60	216 x 216	100%	2.4 x 2.4 x 2.4	800	30	N/A	52	Off	6	Off	N/A	N/A	

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ABCDStudy.org

3 types of scanner :

- Siemens Prisma
- Phillips
- General Electrics 750

Harmonized MRI acquisition protocol

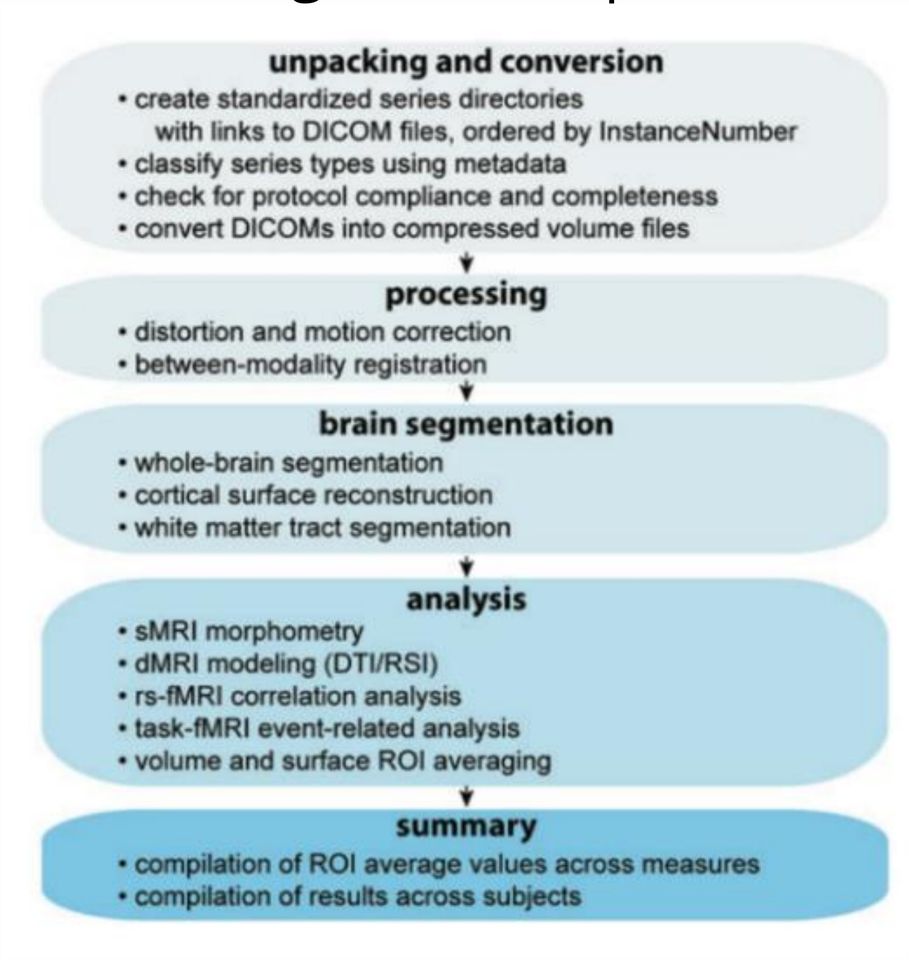
(i.e. standard adult-size coil to ensure stability of the hardware over the course of the study)

Casey et al. 2018

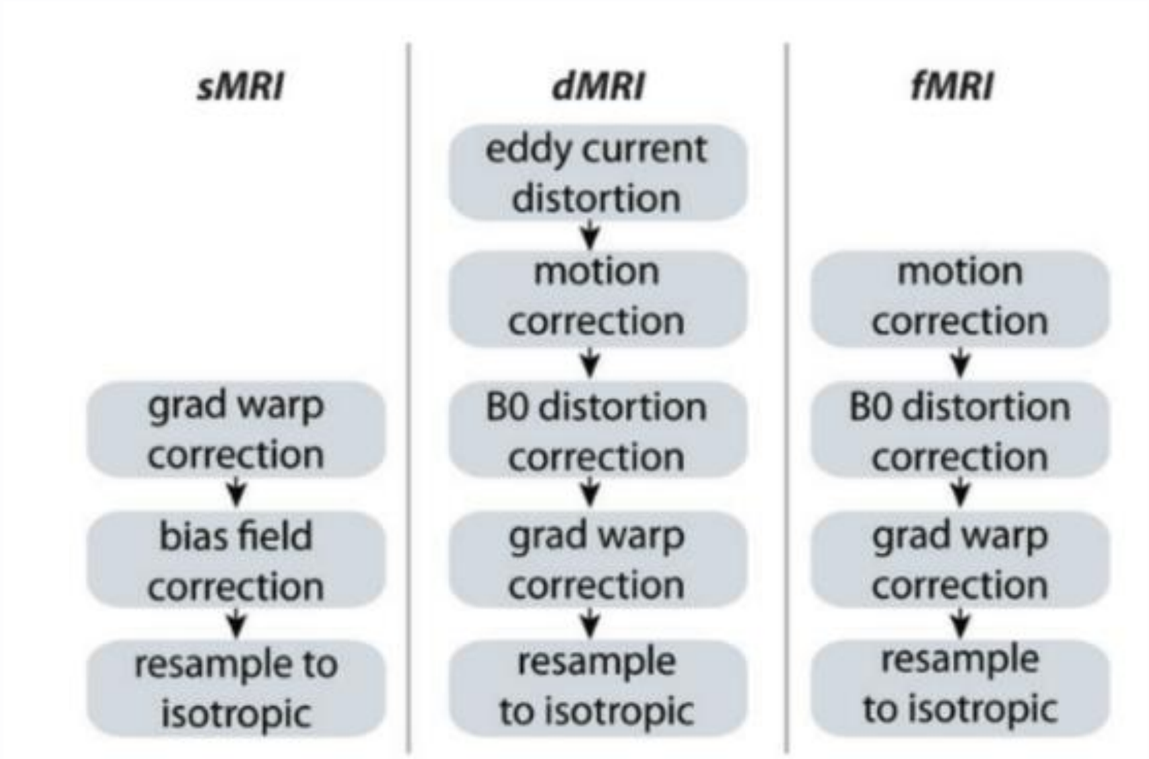
MRI preprocessing

NEW

5 general steps



Modality-specific processing steps for bias field, distortion, and/or motion correction



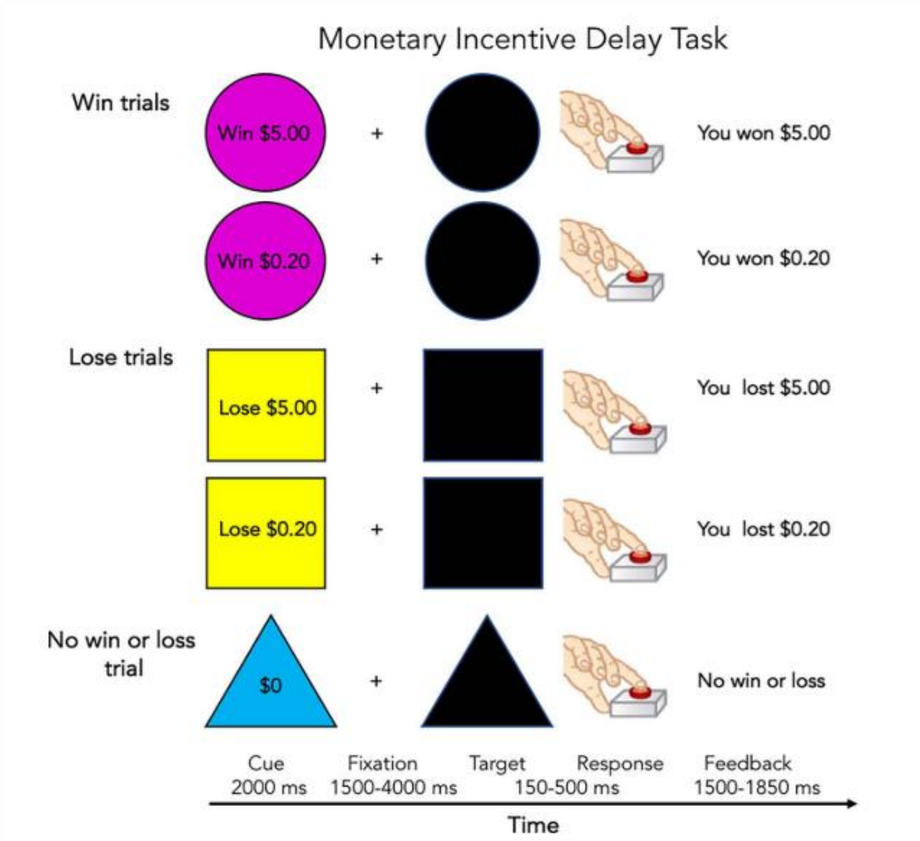
Hagler et al. 2019

Choice of fMRI taks

- validity (implication in addiction)
- developmentally appropriate (feasibility in development studies)
- specificity (well-characterized neural activations)
- reliability (reliable activation over time within subjects
- sensitivity (consistent patterns accross subjects
- generalizibility (leveraging of other complementary devel-
- opmental imaging initiatives that use similar measures)

Casey et al. 2018

Monetary Incentive Delay Task



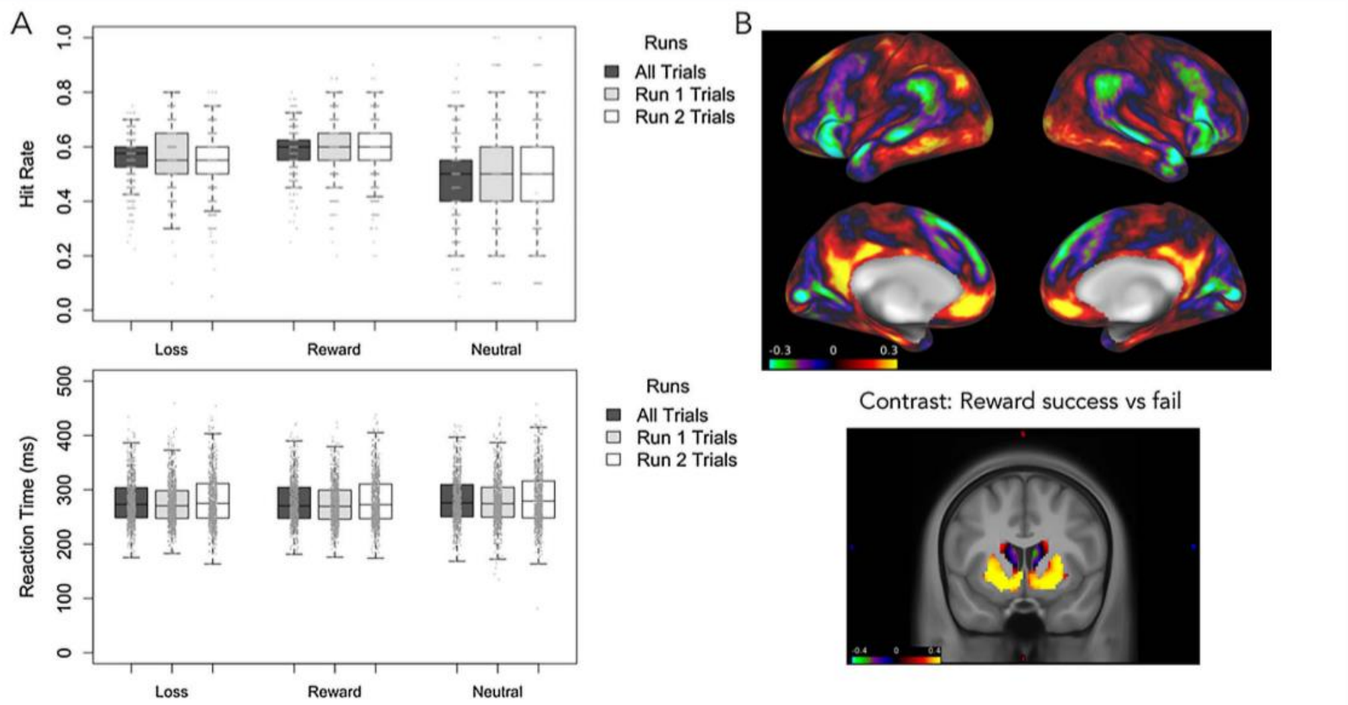
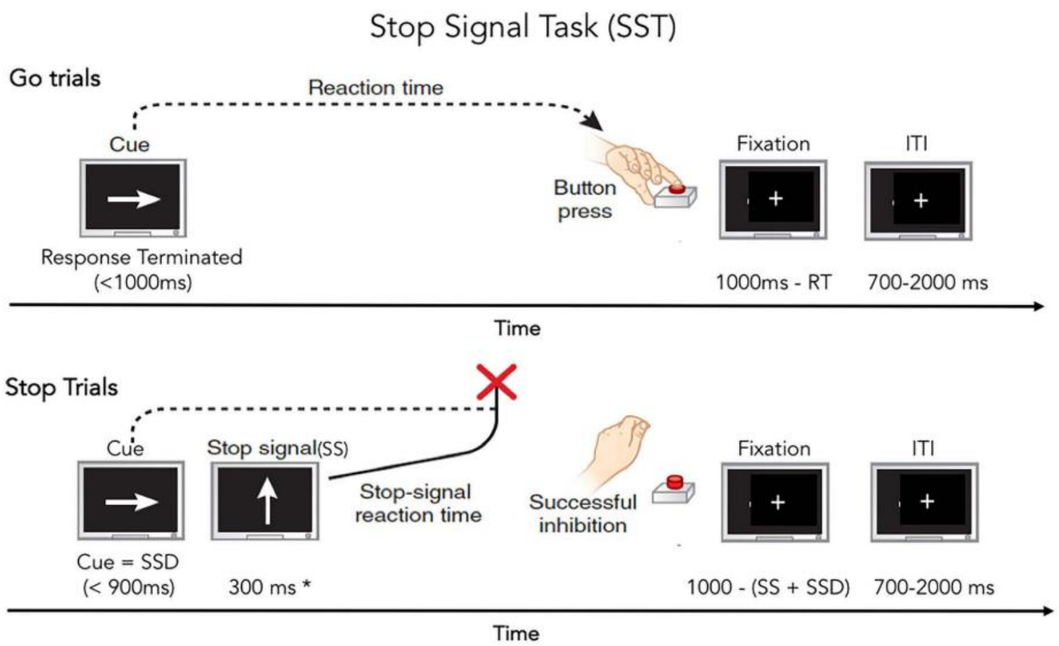


Fig. 4. Preliminary results for the MID task. A. Hit rate and reaction time are presented as a function of loss, reward and neutral trials for the first and second half of the data (Run 1 and Run 2). B. Cortical (top) and subcortical (bottom) maps for the contrast of reward success vs fail (signed Cohen's d) show reliable activation of expected brain circuitry in medial prefrontal cortex (top) and the ventral striatum (bottom).

Casey et al. 2018

Stop Signal Task



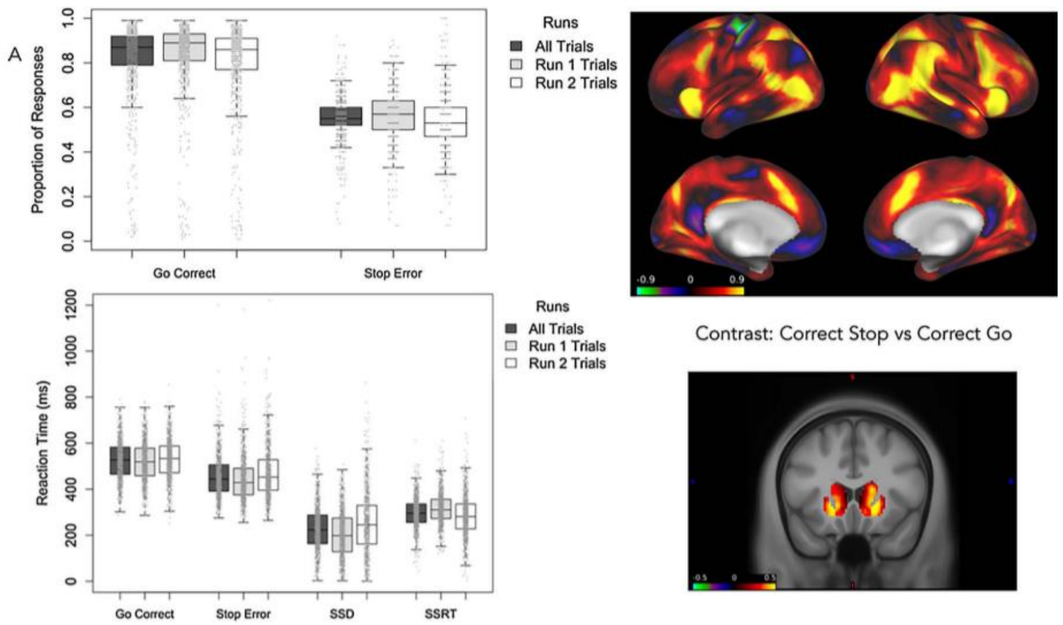
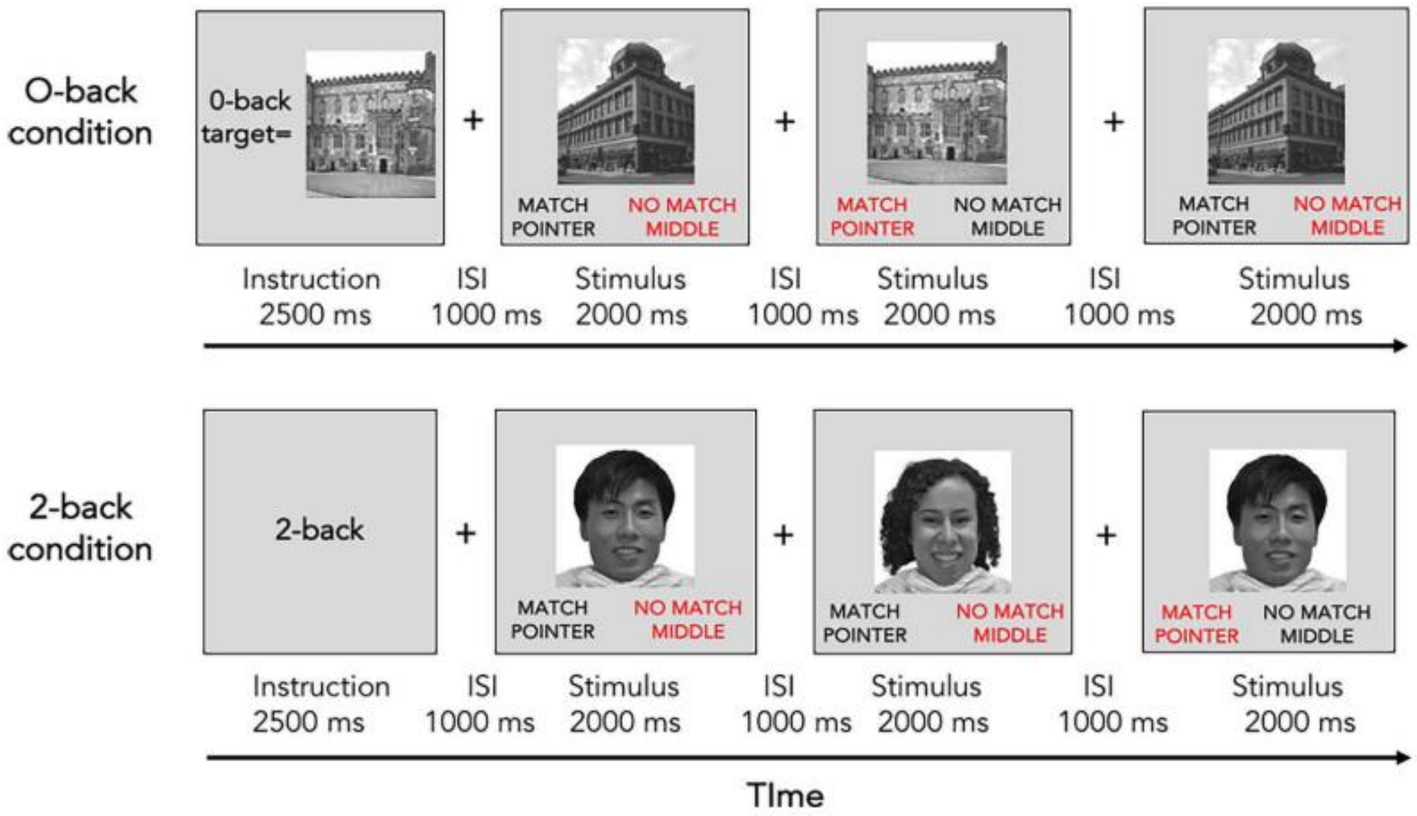


Fig. 6. Preliminary Results for the SST. A. Accuracy and reaction times are presented as function go and stop trials. B. Cortical patterns of brain activity (signed Cohen's d) for the contrast of correct stop vs correct go trials (top) and subcortical activity in the putamen for correct stop trials vs error stop trials. SSRT: stop signal reaction time; SSD: stop signal delay.

Casey et al. 2018

Emotional N-back Task



Casey et al. 2018

Emotional N-back Task

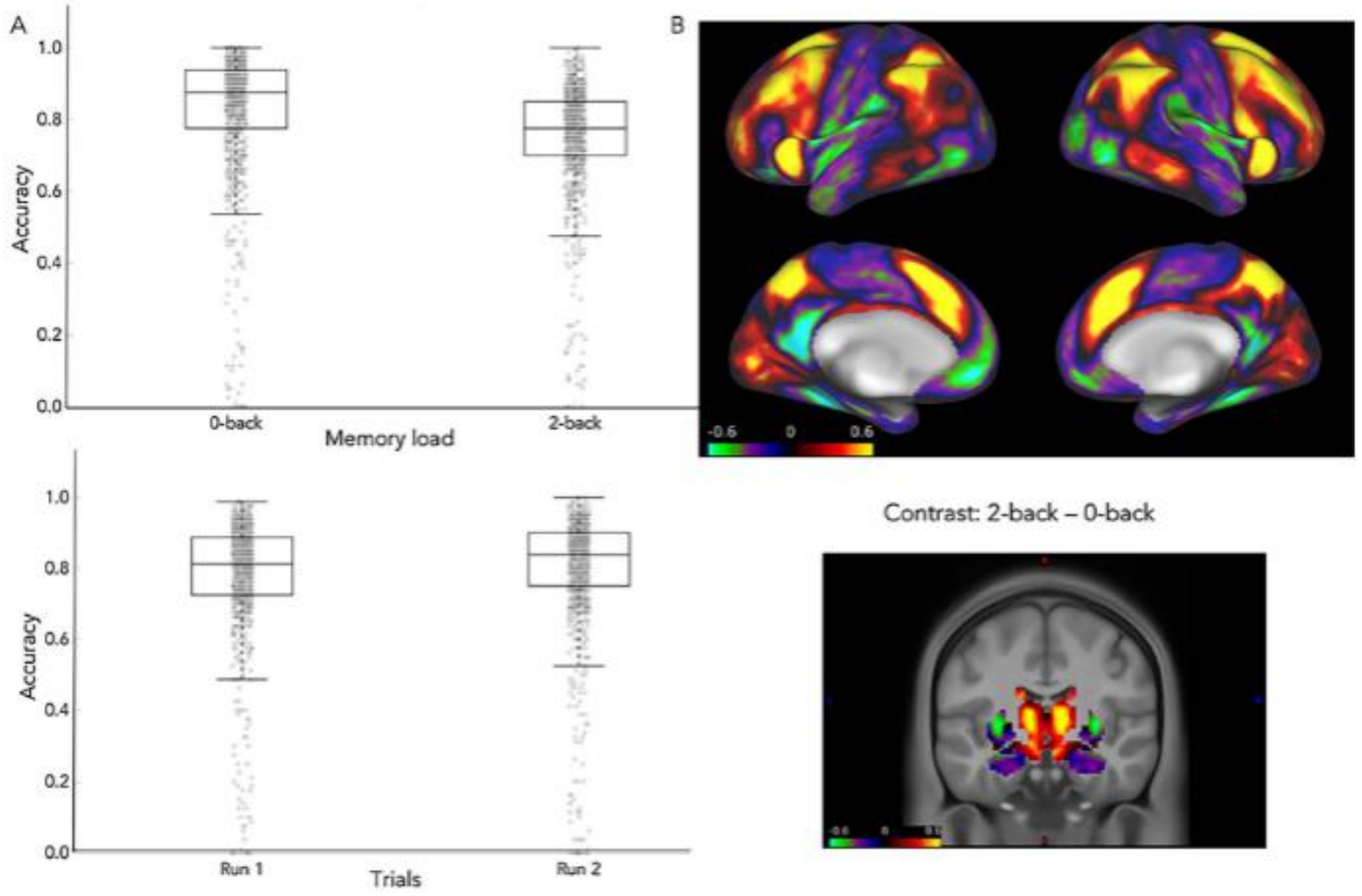


Fig. 8. Preliminary results for the Emotional n-back task. A. Behavioral results. Boxplots provide the median, first and third quartiles for accuracy on the 0-back and 2-back conditions and for each experimental run of the task. B. fMRI results. Cortical (top) and subcortical (bottom) functional maps (signed Cohen's d) for the contrast 2-back vs 0-back.

Casey et al. 2018

Experience Feedback

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Difficullty in Data Access

No existing procedures at AMU

WE DID IT FROM SCRATCH

With Direction de la recherche et valorisation

IT TOOK 8 MONTHS

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The adventure

Local Ethical Committee

Registration of our Institutional Review Board (IRB)

Get a Federalwide Assurance (FWA)

Create eRA Commons Account to access NDA (NIH Data Archive)

Difficullty in Data Access

No existing procedures at AMU

WE DID IT FROM SCRATCH

With Direction de la recherche et valorisation

IT TOOK 8 MONTHS

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The adventure

Request access : Fill the Data Use Certification

Get Data Protection Officer (DPO) approuval

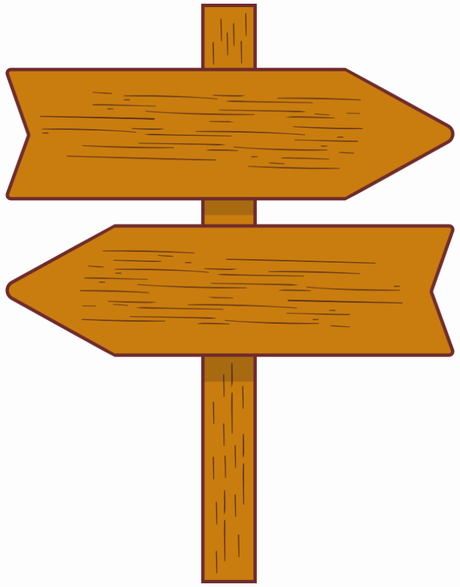
Get the approval and signature of the President of the University

Get access to the database on NDA

Data Storage

Locally

Local computer of the Institute
Local server of the Institute



Protected Data Center from our Unviersity