A protocol for visual quality control applied to the Reproducible Brain Chart database

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Authors:

Nathalia Bianchini Esper[1], Sydney Covitz[2], Alberto Castro[1], Giovanni Salum[1,3], Hamsanandini Radhakrishnan[2], Jon Clucas[1], Kahini Mehta[2], Matthew Cieslak[2], Mauricio Hoffmann[4], Steve Giavasis[1], Gregory Kiar[5], Michael Milham[1], Theodore Satterthwaite[2], Alexandre Franco[1]

Institutions:

[1]Child Mind Institute, New York, NY, [2]University of Pennsylvania, Philadelphia, PA, [3]Department of Psychiatry, Universidade Federal do Rio Grande do Sul, Porto Alegre, Porto Alegre, [4]Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul, [5]Child Mind Institute, Montreal, Quebec

First Author:

Nathalia Bianchini Esper
Child Mind Institute
New York, NY

Co-Author(s):

Sydney Covitz
University of Pennsylvania
Philadelphia, PA
Alberto Castro
Child Mind Institute
New York, NY
Giovanni Salum
Child Mind Institute|Department of Psychiatry, Universidade Federal do Rio Grande do Sul
New York, NY|Porto Alegre, Porto Alegre
Hamsanandini Radhakrishnan
University of Pennsylvania
Philadelphia, PA
Jon Clucas, M.I.S.
Child Mind Institute
New York, NY
Kahini Mehta
University of Pennsylvania
Philadelphia, PA

Matthew Cieslak, PhD
University of Pennsylvania
Philadelphia, PA
Mauricio Hoffmann
Universidade Federal de Santa Maria
Santa Maria, Rio Grande do Sul
Steve Giavasis
Child Mind Institute
New York, NY
Gregory Kiar
Child Mind Institute
Montreal, Quebec
Michael Milham, MD, PhD
Child Mind Institute
New York, NY
Theodore Satterthwaite, MD
University of Pennsylvania
Philadelphia, PA
Alexandre Franco, PhD
Child Mind Institute
New York, NY

Introduction:

Data quality is one of brain imaging research's most important confounding factors [1]. Efforts are being made to improve the quality control of MRI data by developing imaging sequences that correct for a participant's head motion [2,3] or by using automated methods to perform quality control [4]. However, at present, expert manual ratings remain the gold standard ensuring data quality in heterogenous collections of structural images.

The Reproducible Brain Charts project (RBC) initiative aims to harmonize phenotypic and neuroimaging data to build highly reproducible human brain development growth charts. This initiative contains data from five neuroimaging studies: Healthy Brain Network [5], Rockland Sample [6], Chinese Color Nest Project [7], Brazilian High-Risk Cohort [8], and Philadelphia Neurodevelopmental Cohort [9]. Here we present a workflow for trained raters to perform visual quality control of the anatomical images of the RBC initiative. Moving forward, these ratings can be used to optimize automated techniques for performing quality control in large datasets.

Methods:

The dataset contained structural MRIs from 7,047 participants distributed over the RBC dataset. Four two-dimensional slices per participant (two axial and two sagittal slices extracted per structural scan) were created to rate each scan. To ensure consistent slice selection across participants, the anatomical images were registered (linear ridged body) to the MNI152 template space prior to slice selection. Six raters (mean experience in brain imaging = 5.63 years; std = 5.76 years) were responsible for evaluating a total of 28,188 slices. We asked the rater to "pass" or "fail" those slices based on visual inspection alone. A "pass" rating would be given if an image was deemed of sufficient quality for skullstriping and segmentation of CSF, white, and grey matter. Ratings were performed using the Swipes for Science [10] platform, a web application for binary image classification. Slices were presented to the raters in random order.

Results:

The workflow consists of six phases (Figure 1). Phase 1 involves generating the ground truth for 200 images to either pass or fail. Two senior raters evaluated these images and agreed on 96% of the slices. These 8 images with disagreement were further evaluated after skulltripping and brain segmentation, using C-PACs RBC pipeline (Figure 2). These raters then reached 100% concordance through consensus of either pass or fail for each slice. In Phase 2, four additional raters completed a one-hour training on the set of ground-truth annotated images. Once raters achieved at least 85% concordance with the ground-truth established by Phase 1, they moved to the next phase. To assess reliability across all raters, in Phases 3 and 5, all 6 raters manually rated 20% of the dataset, 10% in each phase. In Phase 4, the raters were divided into two groups with balanced experience and evaluated another 20% of the slices, where group A and group B raters did not see overlapping slices. Finally, in Phase 6, we switched one rater from each group and repeated Phase 4 on the final 20% of the images. To avoid sequence type or scanner parameters biases, each Swipes for Science instance for each phase contains data from all sites.

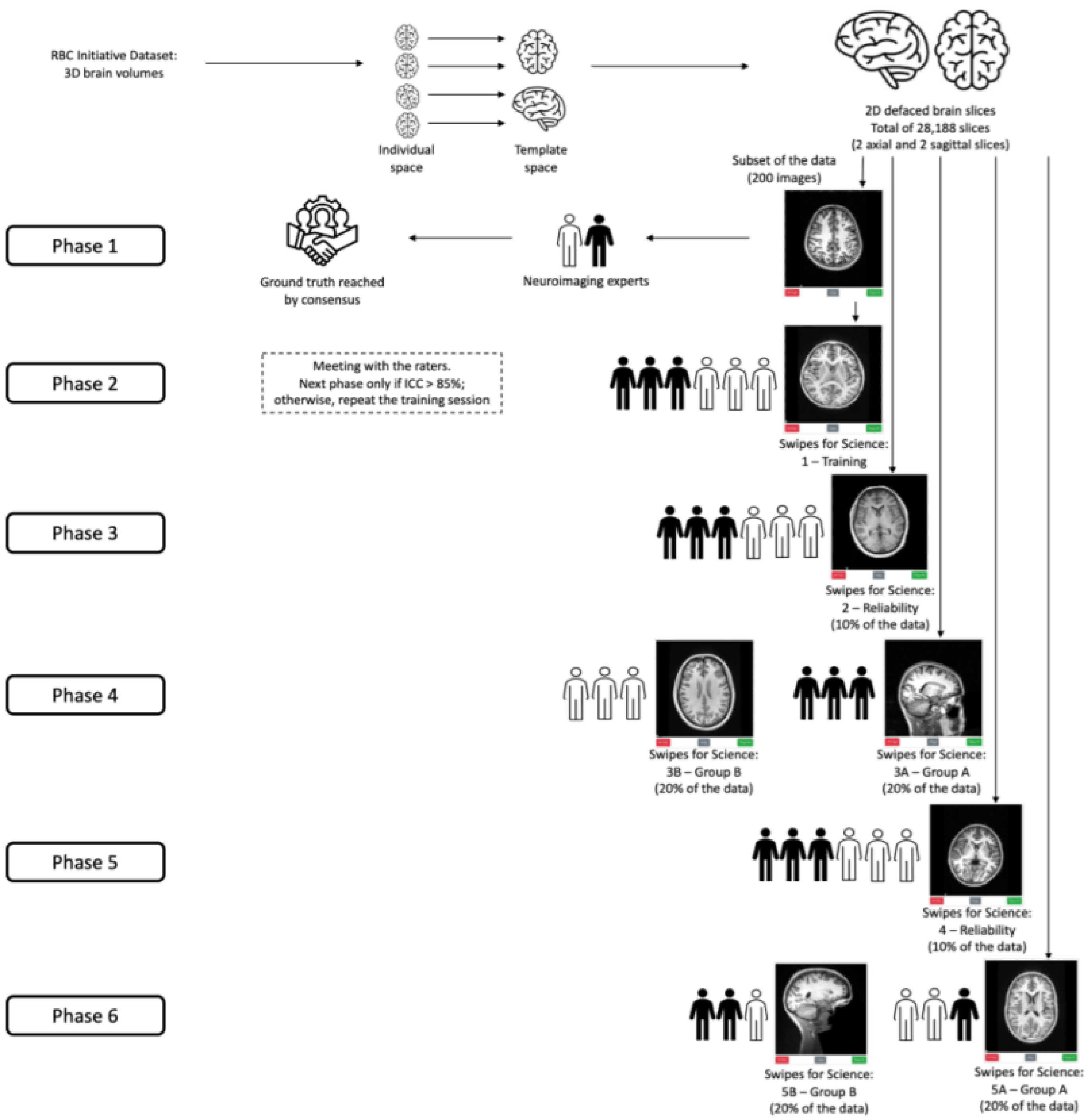

Figure 1: Overview of the visual quality control procedure used for rating the images of the Reproducible Brain Chart initiative. First, all the data were registered to the MNI152 template. Next, the 3D MRI scans were converted into 2D axial and sagittal slices, which were divided into five groups of images and loaded onto Swipes for Science, a web application to crowdsource the quality ratings. Two senior raters were responsible for creating the ground-truth on a set of 200 images, and these images were used to train all the raters prior to starting evaluating images. After each of the six raters reached at least 85% of concordance with the ground-truth set, they could start rating the dataset.

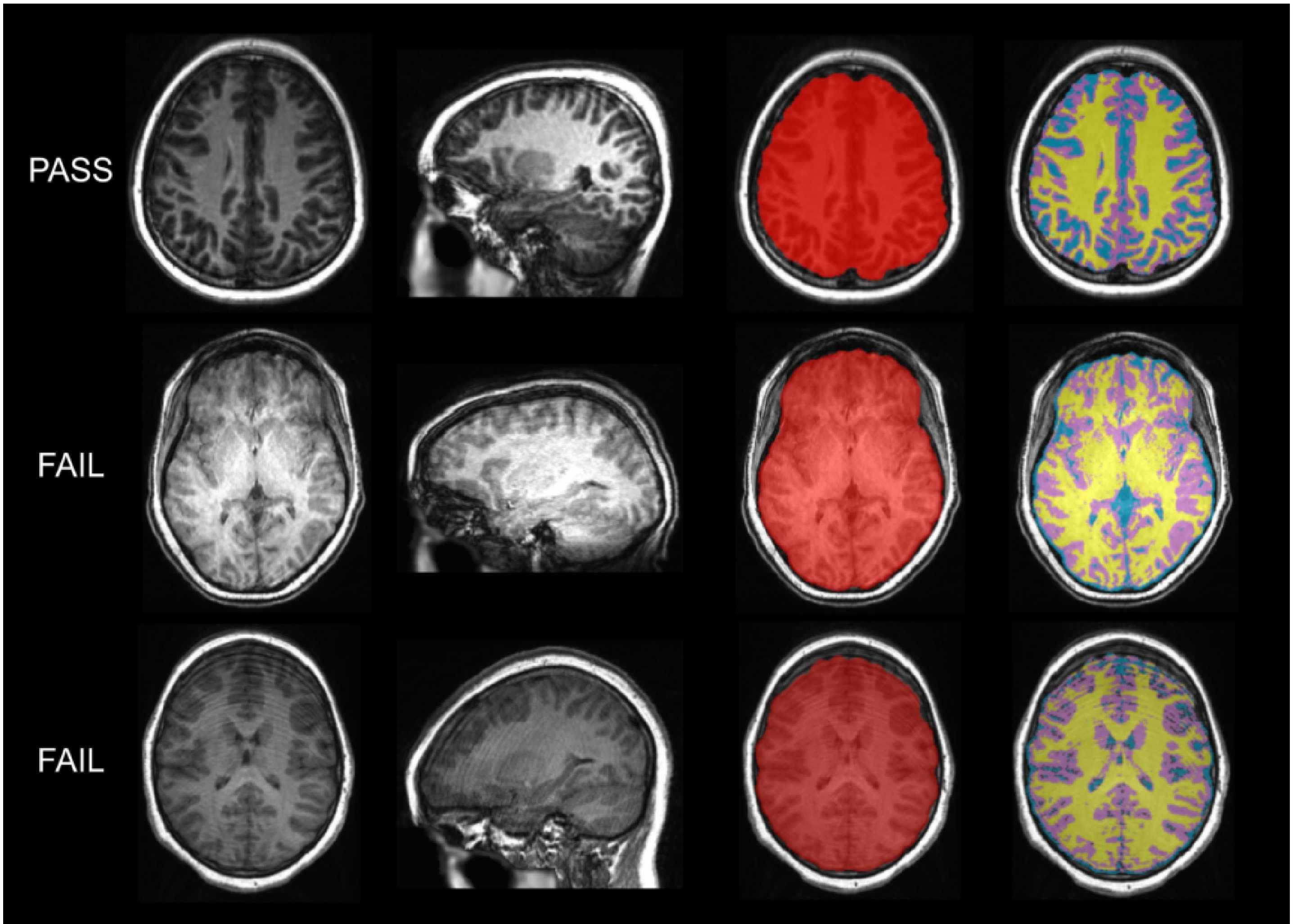

Figure 2: Examples of images that will be passes (first row) and failed (second and third rows) on visual quality control. Ringing effects might cause confusion during skullstripping (third column) or segmentation algorithms on matter boundaries, especially white and gray matter (fourth column).

Conclusions:

Swipes for Science is an easy-to-manipulate tool with a friendly interface that facilitates visual quality control. By presenting this protocol, we hope it can be helpful for others trying to analyze large-scale data using manual evaluation by trained personnel, which is becoming increasingly common. At the conclusion of this process, we will publish the dataset and QC results of the RBC dataset via the International Neuroimaging Data-Sharing Initiative (INDI). Moving forward, this manually-annotated data from diverse populations, scanners, and sequences will become an important data resource for the neuroimaging community and accelerate the development of automated tools for assessing data quality.

Lifespan Development:

Lifespan Development Other

Modeling and Analysis Methods:

Methods Development [2]
Motion Correction and Preprocessing

Neuroinformatics and Data Sharing:

Workflows [1]

Novel Imaging Acquisition Methods:

Imaging Methods Other

Keywords:

MRI
Open Data
STRUCTURAL MRI
Workflows
Other - Quality Control

[1|2]Indicates the priority used for review

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No

Please indicate below if your study was a "resting state" or "task-activation” study.

Other

Healthy subjects only or patients (note that patient studies may also involve healthy subjects):

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Not applicable

Please indicate which methods were used in your research:

Structural MRI

For human MRI, what field strength scanner do you use?

1.5T
3.0T

Which processing packages did you use for your study?

Other, Please list - C-PAC

Provide references using author date format

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