Increasing the reliability of functional brain imaging methods

Frank G. Hillary

Penn State University, University Park, PA

REVIEW

"brain parcellations, ranged from 10 to 67,632 nodes… and at least 50 distinct parcellations in 106 studies reviewed."

NETWORK NEUROSCIENCE

an open access journal

Michael N. Hallquist[1,2] and Frank G. Hillary[1,2,3]

[1]Department of Psychology, Pennsylvania State University, University Park, PA, USA
[2]Social Life and Engineering Sciences Imaging Center, University Park, PA, USA
[3]Department of Neurology, Hershey Medical Center, Hershey, PA, USA

Keywords: Graph theory, Brain disorders, Network neuroscience, Proportional thresholding

Scanning the horizon: towards transparent and reproducible neuroimaging research

Russell A. Poldrack[1], Chris I. Baker[2], Joke Durnez[1,3], Krzysztof J. Gorgolewski[1], Paul M. Matthews[4], Marcus R. Munafò[5,6], Thomas E. Nichols[7], Jean-Baptiste Poline[8], Edward Vul[9] and Tal Yarkoni[10]

Investigator degrees of freedom

Processing step	Reason	Options [suboptions]	Number of plausible options
Motion correction	Correct for head motion during scanning	• 'Interpolation' [linear or sinc] • 'Reference volume' [single or mean]	4
Slice timing correction	Correct for differences in acquisition timing of different slices	'No', 'before motion correction' or 'after motion correction'	3
Field map correction	Correct for distortion owing to magnetic susceptibility	'Yes' or 'no'	2
Spatial smoothing	Increase SNR for larger activations and ensure assumptions of GRF theory	'FWHM' [4 mm, 6 mm or 8 mm]	3
Spatial normalization	Warps an individual brain to match a group template	'Method' [linear or nonlinear]	2
High-pass filter	Remove low-frequency nuisance signals from data	'Frequency cut-off' [100 s or 120 s]	2
Head motion regressors	Remove remaining signals owing to head motion via statistical model	'Yes' or 'no' [if yes: 6/12/24 parameters or single time point 'scrubbing' regressors]	5
Haemodynamic response	Account for delayed nature of haemodynamic response to neuronal activity	• 'Basis function' ['single-gamma' or 'double-gamma'] • 'Derivatives' ['none', 'shift' or 'dispersion']	6
Temporal autocorrelation model	Model for the temporal autocorrelation inherent in fMRI signals	'Yes' or 'no'	2
Multiple-comparison correction	Correct for large number of comparisons across the brain	'Voxel-based GRF', 'cluster-based GRF', 'FDR' or 'non-parametric'	4
Total possible workflows			69,120

FDR, false discovery rate; FWHM, full width at half maximum; GRF, Gaussian random field; SNR, signal-to-noise ratio.

69,120

How do we increase reliability in findings in neuroimaging work?

Unified approaches/methods

Data sharing: ENIGMA

nature methods

ARTICLES

https://doi.org/10.1038/s41592-018-0235-4

fMRIPrep: a robust preprocessing pipeline for functional MRI

Oscar Esteban[1*], Christopher J. Markiewicz[1], Ross W. Blair[1], Craig A. Moodie[1], A. Ilkay Isik[2], Asier Erramuzpe[3], James D. Kent[4], Mathias Goncalves[5], Elizabeth DuPre[6], Madeleine Snyder[7], Hiroyuki Oya[8], Satrajit S. Ghosh[5,9], Jessey Wright[1], Joke Durnez[1], Russell A. Poldrack[1,10] and Krzysztof J. Gorgolewski[1,10*]

Preprocessing task	*fMRIPrep* includes	Alternatives (not included within *fMRIPrep*)
Anatomical T1w brain-extraction	`antsBrainExtraction.sh` (ANTs)	`bet` (FSL), `3dSkullstrip` (AFNI), MRTOOL (SPM Plug-in)
Anatomical surface reconstruction	`recon-all` (FreeSurfer)	CIVET, BrainSuite, Computational Anatomy (SPM Plug-in)
Head-motion estimation (and correction)	`mcflirt` (FSL)	`3dvolreg` (AFNI), `spm_realign` (SPM), `cross_realign_4dfp` (4dfp), `antsBrainRegistration` (ANTs)
Susceptibility-derived distortion estimation (and unwarping)	`3dqwarp` (AFNI)	`fugue` and `topup` (FSL), FieldMap and HySCO (SPM Plug-ins)
Slice-timing correction	`3dTshift` (AFNI)	`slicetimer` (FSL), `spm_slice_timing` (SPM), `interp_4dfp` (4dfp)
Intra-subject registration	`bbregister` (FreeSurfer), `flirt` (FSL)	`3dvolreg` (AFNI), `antsRegistration` (ANTs), Coregister (SPM GUI)
Spatial normalization (inter-subject co-registration)	`antsRegistration` (ANTs)	`@auto_tlrc` (AFNI), `fnirt` (FSL), Normalize (SPM GUI)
Surface sampling	`mri_vol2surf` (FreeSurfer)	MNE, Nilearn
Subspace selection methods	`melodic` (FSL), ICA-AROMA	Nilearn, LMGS (SPM Plug-in)
Confounds	*in-house* implementation	TAPAS PhysIO (SPM Plug-in)
Steady-state detection	*in-house* implementation	*Ad hoc* implementations

Sharing can increase reliability…

COMMENTARY

FOCUS ON BIG DATA

Big data from small data: data-sharing in the 'long tail' of neuroscience

Adam R Ferguson[1], Jessica L Nielson[1], Melissa H Cragin[2], Anita E Bandrowski[3] & Maryann E Martone[3,4]

NATURE NEUROSCIENCE VOLUME 17 | NUMBER 11 | NOVEMBER 2014

Number of data sets →

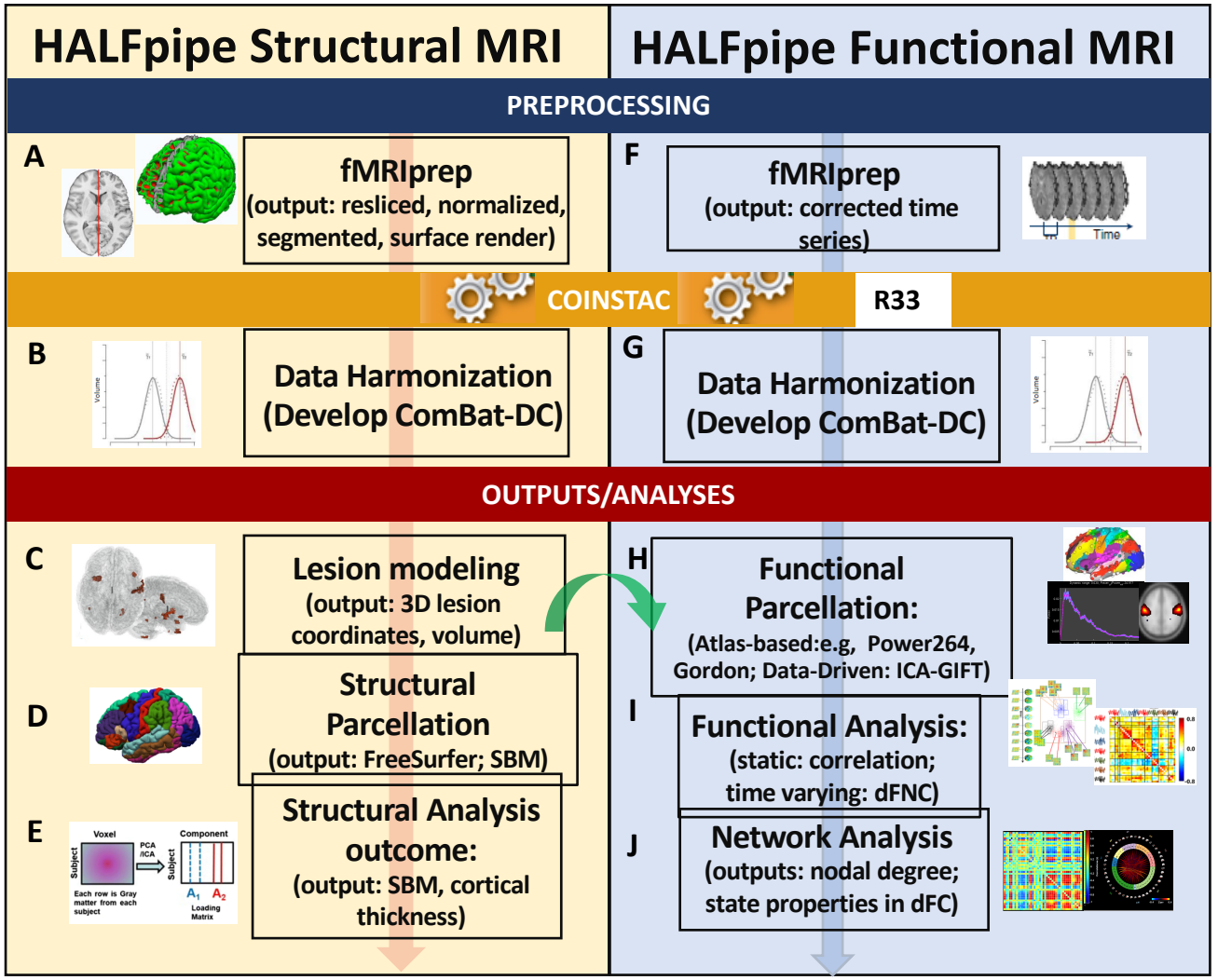
ENIGMA Adult Moderate/Severe TBI : led Drs. Alexander Olsen (alexander.olsen@ntnu.no) and Frank Hillary (fhillary@psu.edu).

ENIGMA Acute Mild TBI : led by Drs. Pratik Mukherjee (Pratik.Mukherjee@ucsf.edu) and Andrew Mayer (amayer@mrn.org).

ENIGMA Intimate Partner Violence : led by Dr. Carrie Esopenko (ce216@shp.rutgers.edu).

Efforts at Penn State: Toward a Universal MRI data processing pipeline:

NIH R61 work: HALFpipe



frontiers in Neurology

METHODS
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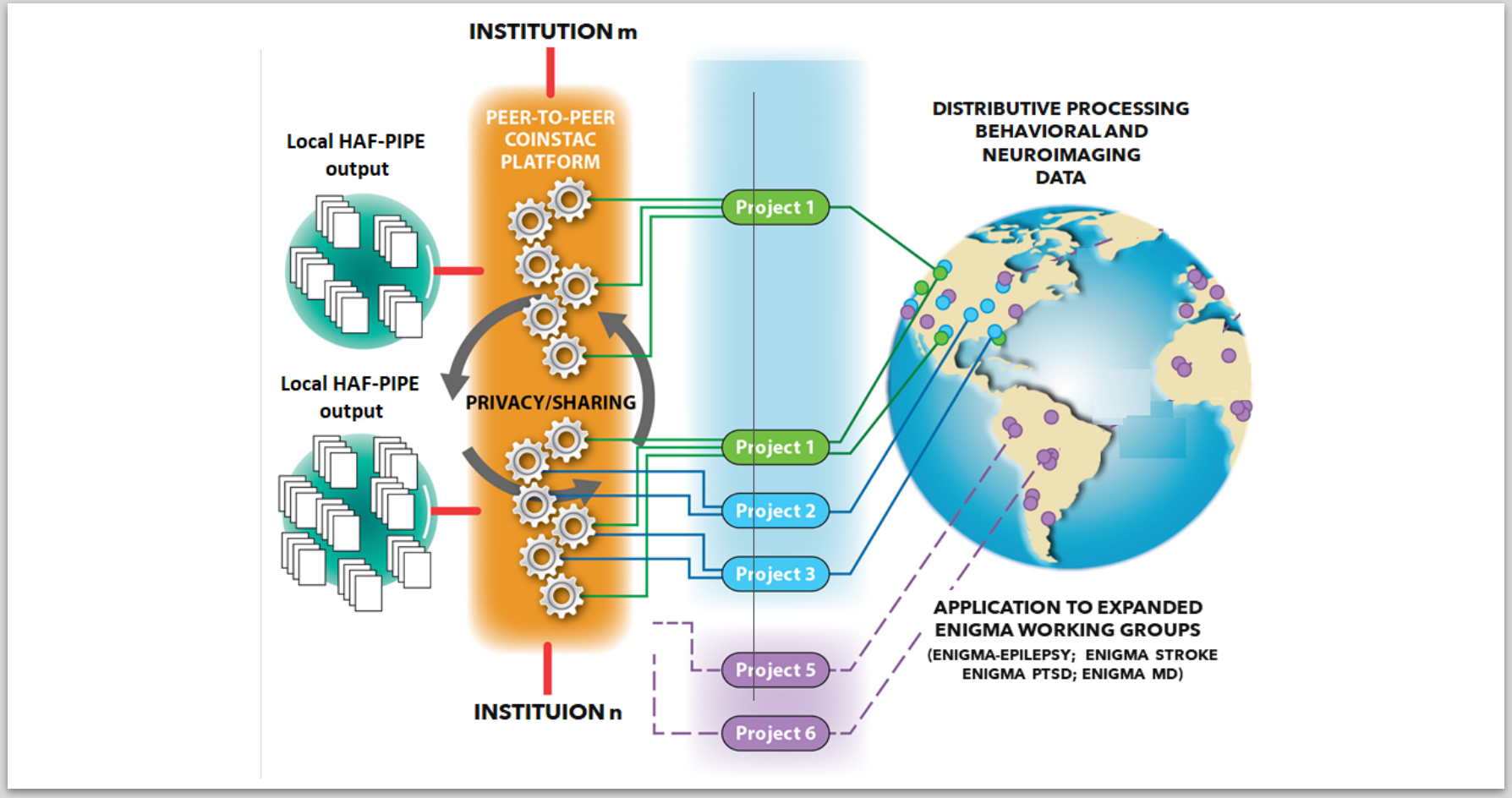
Check for updates

A Decentralized ComBat Algorithm and Applications to Functional Network Connectivity

Biozid Bostami[1,2,3*], *Frank G. Hillary*[4], *Harm Jan van der Horn*[5], *Joukje van der Naalt*[6], *Vince D. Calhoun*[1,2,3] *and Victor M. Vergara*[1,2,3*]

[1] *Department of Computer Science, Tri-institutional Center for Translational Research in Neuroimaging and Data Science, Georgia State University, Atlanta, GA, United States,* [2] *Department of Computer Science, Georgia Institute of Technology, Atlanta, GA, United States,* [3] *Department of Computer Science, Emory University, Atlanta, GA, United States,* [4] *Department of Psychology, Penn State University, State College, PA, United States,* [5] *Department of Developmental Neurology, University of Groningen, University Medical Center Groningen, Groningen, Netherlands,* [6] *Department of Medical Sciences, University of Groningen, University Medical Center Groningen, Groningen, Netherlands*

COINSTAC


INSTITUTION m
PEER-TO-PEER COINSTAC PLATFORM
Local HAF-PIPE output
Local HAF-PIPE output
PRIVACY/SHARING
INSTITUION n
Project 1
Project 1
Project 2
Project 3
Project 5
Project 6
DISTRIBUTIVE PROCESSING BEHAVIORAL AND NEUROIMAGING DATA
APPLICATION TO EXPANDED ENIGMA WORKING GROUPS
(ENIGMA-EPILEPSY; ENIGMA STROKE ENIGMA PTSD; ENIGMA MD)

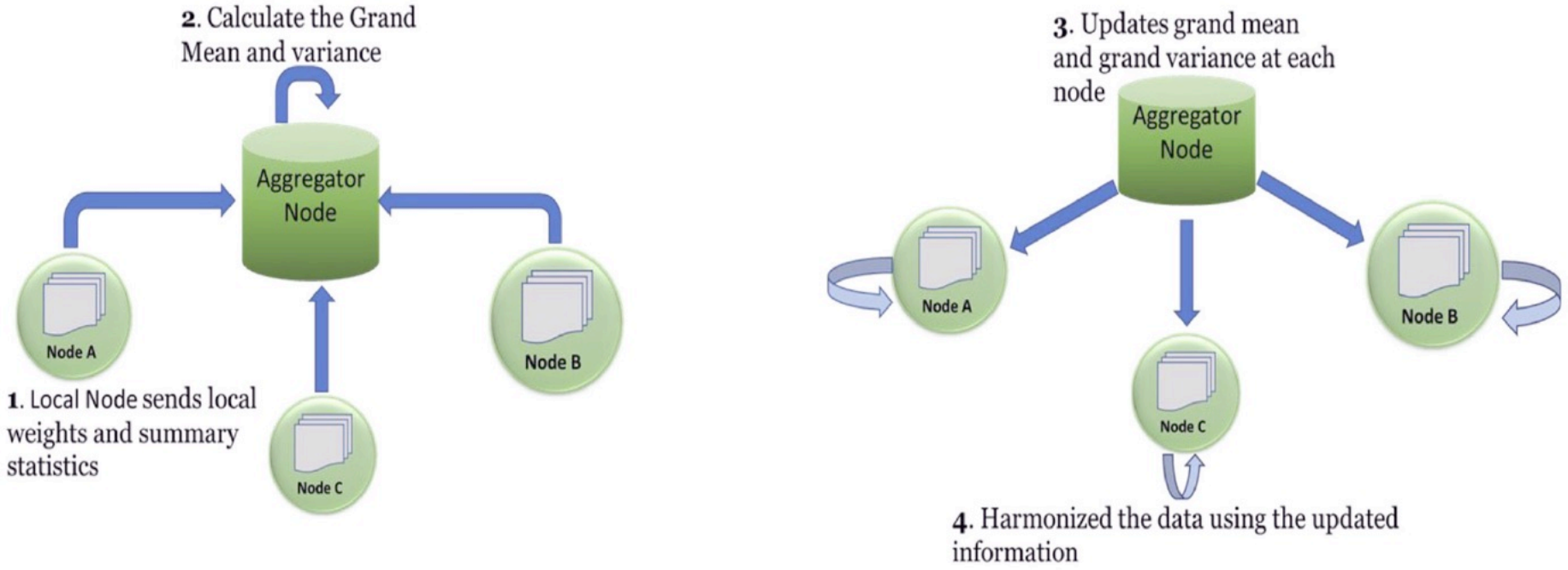
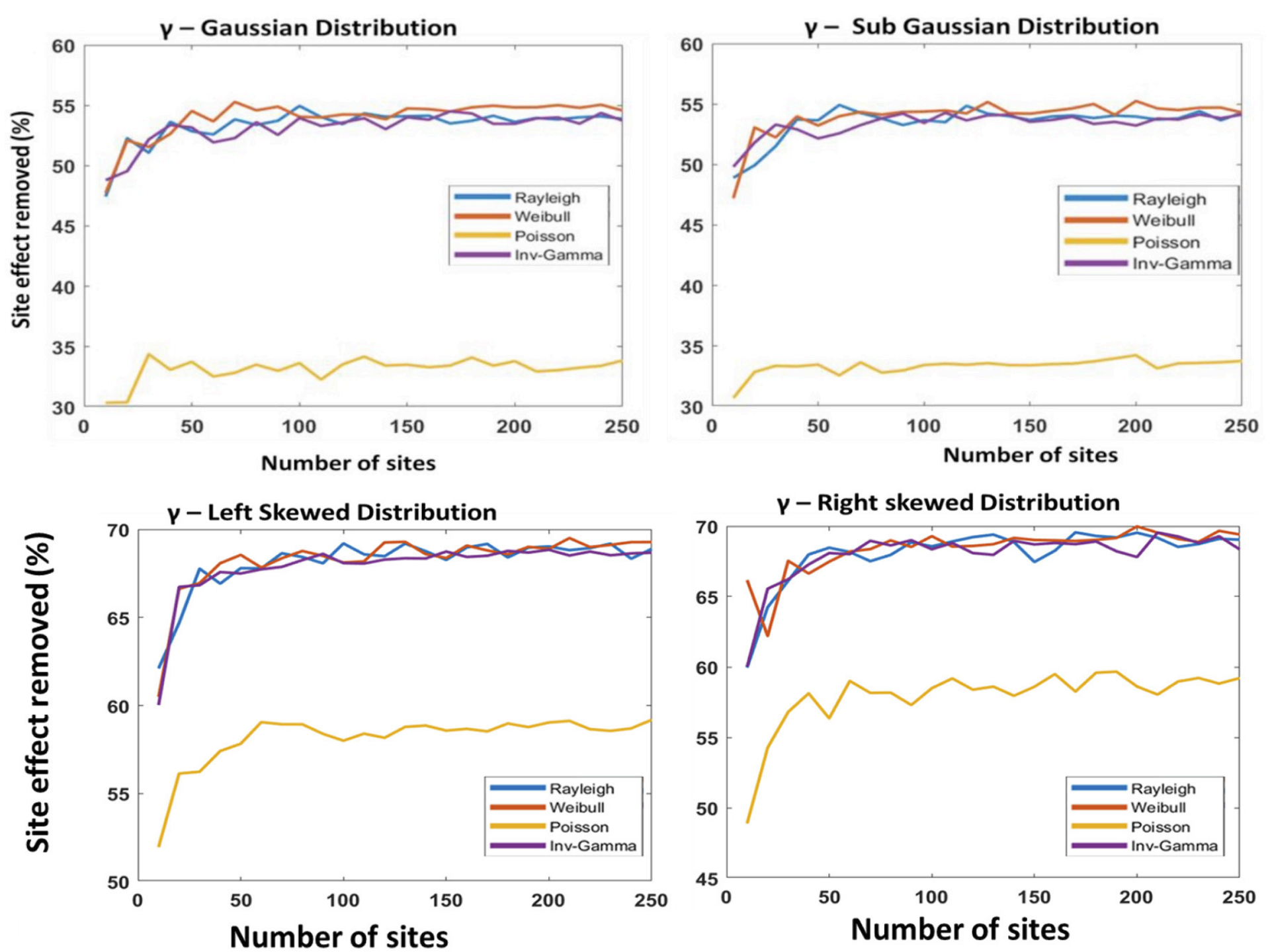


FIGURE 1 | Gives the overall picture of the decentralized ComBat algorithm and intra-communication between nodes.

Bostami et al., 2021


γ – Gaussian Distribution
Site effect removed (%)
Number of sites
Rayleigh
Weibull
Poisson
Inv-Gamma
γ – Sub Gaussian Distribution
Number of sites
Rayleigh
Weibull
Poisson
Inv-Gamma
γ – Left Skewed Distribution
Site effect removed (%)
Number of sites
Rayleigh
Weibull
Poisson
Inv-Gamma
γ – Right skewed Distribution
Number of sites
Rayleigh
Weibull
Poisson
Inv-Gamma

Summary

ENIGMA provides opportunities to foster collaboration and handle problems with scientific reliability

Enhancing reliability of science:

Addressing Small Samples
Heterogeneity (go big to get small)
Allows for combining inexact datasets
Data harmonization to address site effects

Summary

Our goals within the ENIGMA structure pose new challenges that we are currently working on including:

Curation of datasets (>10,000 cases) to promote novel discovery in the behavioral consequences of TBI

Developing Universal Methods for the TBI Community

Virtual sharing to reduce privacy/institutional concerns

Elisabeth A. Wilde, PhD
David Tate, PhD
Eamonn Kennedy

Samantha Vervoordt
Andrew Cwiek
Hollie Mullin
Elizabeth Rebuck

Thank you.

Helen Genova, PhD
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Brain Injury, Plasticity And Recovery Lab

Arnab Roy, PhD
Rachel Bernier
Emily Grossner
Einat Brenner
Kristine Dell
Sami Vervoord
Andrew Cwiek
Hollie Mullen
Diana Priestley

PENNSTATE Milton S. Hershey Medical Center College of Medicine

PM&R

Justin Hong, MD
David Gater, MD

RADIOLOGY

Jianli Wang, MD,PhD

PENNSTATE

Sarah M. Rajtmajer, PhD
Department of IST
Michele Diaz, PhD
Director: Social Life and Engineering Imaging Center
Jose Soto, PhD
Department of Psychology
Peter Molenaar, PhD
Human Dev. Fam Studies
Reka Albert, PhD
Department of Physics

NTNU Alexander Olsen, PhD

MICHIGAN MEDICINE Ben Hampstead, PhD

RIC Rehabilitation Institute of Chicago Jordan Grafman, PhD

HEALTH UNIVERSITY OF UTAH Elisabeth A. Wilde, PhD
David Tate, PhD
Emily Dennis, PhD
Eamonn Kenndey

Georgia Tech

Vince D. Calhoun, PhD
Executive Science Officer and Director, Image Analysis and MR Research

KESSLER FOUNDATION
Changing the lives of people with disabilities

Helen Genova, PhD
Ekaterina Dobryakova, PhD
Nancy Chiaravalloti, PhD
John DeLuca, PhD

NIH-NICHD: (UL Tr000127)

PA Department of Health

NEW JERSEY COMMISSION ON BRAIN INJURY RESEARCH

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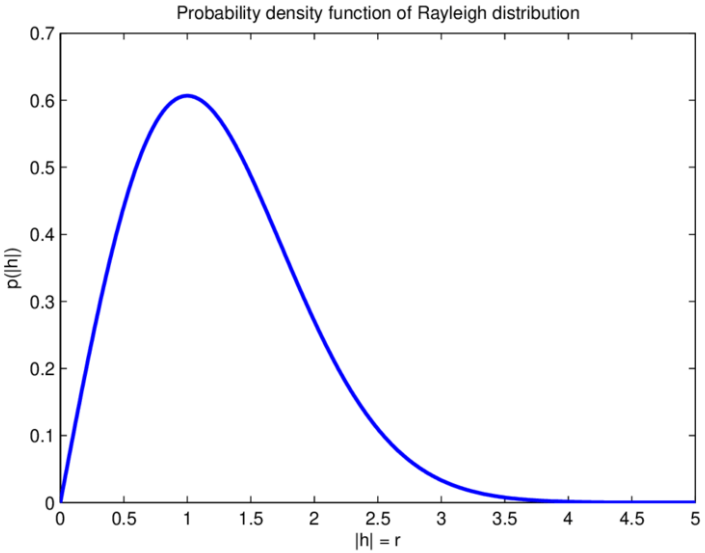

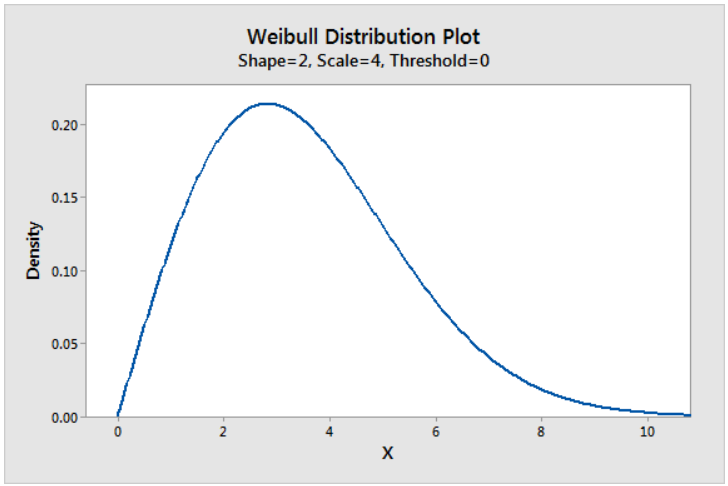

https://statisticsbyjim.com/probability/weibull-distribution