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Articles in peer-reviewed journals

1. Science in the Cloud (SIC): A use case in MRI Connectomics Gregory Kiar, Krzysztof J. Gorgolewski, Dean Kleissas, William Gray Roncal, Brian Litt, Brian Wandell, Russel A. Poldrack, Martin Wiener, R. Jacob Vogelstein, Randal Burns, Joshua T. Vogelstein *GigaScience* gix013 (Mar. 2017).

2. BIDS apps: Improving ease of use, accessibility, and reproducibility of neuroimaging data analysis methods Krzysztof J Gorgolewski, Fidel Alfaro-Almagro, Tibor Auer, Pierre Bellec, Mihai Capotă, M Mallar Chakravarty, Nathan W Churchill, Alexander Li Cohen, R Cameron Craddock, Gabriel A Devenyi, Anders Eklund, Oscar Esteban, Guillaume Flandin, Satrajit S Ghosh, J Swaroop Guntupalli, Mark Jenkinson, Anisha Keshavan, Gregory Kiar, et al. *PLOS Computational Biology* 13.3 (2017) e1005209. Public Library of Science.

3. To the Cloud! A Grassroots Proposal to Accelerate Brain Science Discovery Joshua T. Vogelstein, Brett Mensh, Michael Häusser, Nelson Spruston, Alan C. Evans, Konrad Ko- rding, Katrin Amunts, Christoph Ebell, Jeff Muller, Martin Telefont, Sean Hill, Sandhya P. Koushika, Corrado Calı, Pedro Antonio Valdés-Sosa, Peter B. Littlewood, Christof Koch, Stephan Saalfeld, Adam Kepecs, Hanchuan Peng, Yaroslav O. Halchenko, Gregory Kiar, Mu-Ming Poo, Jean-Baptiste Poline, Michael P. Milham, Alyssa Picchini Schaffer, Rafi Gidron, Hideyuki Okano, Vince D. Calhoun, Miy- oung Chun, Dean M. Kleissas, R. Jacob Vogelstein, Eric Perlman, Randal Burns, Richard Huganir, Michael I. Miller *Neuron* 92.3 (Nov. 2016) pp. 622–627. Elsevier, requested article.

4. Grand Challenges for Global Brain Sciences Joshua T. Vogelstein, Katrin, Andreas Andreou, Dora Angelaki, Giorgio Ascoli, Cori Bargmann, Ran- dal Burns, Corrado Cali, Frances Chance, Miyoung Chun, Gregory Kiar, et al. *F1000 Research* (Aug. 2016)

5. Electric localization of weakly electric fish using neural networks Gregory Kiar, Yasin Mamatjan, James Jun, Len Maler, Andy Adler *Journal of Physics: Conference Series* vol. 434 (May 2013).

Abstracts and other non-peer-reviewed publications.

1. MR Graph with Rich attribUTEs DataBase (Mr. GruteDB) Gregory Kiar, William R Gray Roncal, Disa Mhembere, Eric Bridgeford, Shangsi Wang, Carey Priebe, Randal Burns, Joshua T. Vogelstein *Organization for Human Brain Mapping* (June 2016).

2. The Open Connectome Project & NeuroData: Enabling Data Driven Neuroscience at Scale Joshua T. Vogelstein, et al. *Society for Neuroscience* (Oct. 2015).

3. Community Connectomics via Cloud Computing Utilizing m2g: a Reference Pipeline Gregory Kiar, William R Gray Roncal, Disa Mhembere, Eric Bridgeford, Daniel Clark, Michael Milham, Cameron Craddock, Randal Burns, Joshua Vogelstein *Organization for Human Brain Mapping* (June 2015).

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TITLE OF THE RESEARCH PROJECT

SCIENCE: Scalable Cloud Infrastructure Enabling Neuroscience Computation with Ease

HBHL RESEARCH THEME (Choose the one that fits closest to your research project):

- ☒ Neuroinformatics and Computational Modelling
- ☐ Mechanistic Models of Neurodegenerative Diseases
- ☐ Applied Cognitive Neuroscience of Brain Plasticity
- ☐ Population Neuroscience and Brain Health

Describe the project's alignment with HBHL's goals and objectives and how it ties into at least one of HBHL's four Research Themes (25 lines maximum).

Neuroinformatics merges the fields of neuroimaging, genetics, behavioural psychology, clinical medicine, and many others, with data science and computation. With a push towards public-data both within Canada and abroad, the neuroinformatics community currently has access to a much larger and more varied corpus of data than ever before. In parallel to this data-boom, there is an increase in the number and complexity of tools used to process the wide variety of data modalities and types. Alongside this tremendous opportunity for researchers, is an inherent difficulty and new set of skills that are required to successfully analyze datasets effectively. NeuroHub, the primary focus of the Neuroinformatics Research Theme within HBHL, will alleviate the burden on researchers of running and choosing particular analyses, and will exploit scalable and high-performance solutions to both data storage and computation that enable analysis at scale with ease. My project, SCIENCE: Scalable Cloud Infrastructure Enabling Neuroscience Computation with Ease, will enable NeuroHub to function within the cloud. Built primarily on a backbone of the LORIS imaging and genetics database, as well as the scalable compute hyper-manager CBRAIN, the pieces of NeuroHub already at a stage which enables scientists to interact with and store massive amounts of data and analyses; however, with the current implementation, as this portal becomes more widely adopted the computation and data storage resources will become relatively more scarce for researchers. SCIENCE will port the NeuroHub tools to the Amazon Web Services (AWS) cloud, enabling both HBHL to maintain scalable nodes online, and provide access for researchers to launch their own NeuroHub nodes within the network, all on the cloud. This project ties deeply into the core aims of the Neuroinformatics Research Theme, and successful implementation of this project will have potential to greatly impact each of the other aims through enabling scalable, reliable, accessible, and multi-modal analysis of the human brain.

APPLICANT'S DECLARATION

I will respect the rules of ethics for all research involving humans or experimental animals, and recognize that approval is required from the institutional ethics committee for research involving humans or human derived samples, and from the institutional animal care committee for experimentation in animals. I declare that the information provided is true and accurate and agree to the conditions described in this HBHL form for the purpose of this fellowship.

Gregory Kiar

SCIENCE: Scalable Cloud Infrastructure Enabling Neuroscience Computation with Ease

Neuroscience is amidst a shift towards accessibility, reproducibility, and scalability [1-4]. Tools like CBRAIN [5], LORIS [6], LONI [7], and many others, enable access to data and computation, significantly lowering the barrier for entry to big-data neuroscience. Current limitations of these tools is their considerable reliance on physical hardware and compute or data centres, limiting their scalability as their user communities grow and integrated tools such as advanced machine learning algorithms become more complex and computationally demanding. Further integrating these services with the cloud will enable them to scale virtually limitlessly, and allow cost to be distributed among users who wish to deploy large amounts of resources for their own private use.

Working with Dr. Alan C Evans, my project, SCIENCE: Scalable Cloud Infrastructure Enabling Neuroscience Computation with Ease, will focus on integrating the existing NeuroHub backbone, namely CBRAIN and LORIS, with the Amazon Web Services (AWS) cloud (Figure 1). Through the exposed AWS Application Programming Interface (API), I will build hooks that enables NeuroHub to interact with data and compute resources in the cloud in a manner transparent to the user. In addition, I will develop an Amazon Machine Image (AMI) that enables users or developers to launch and configure NeuroHub on their own, and integrate their instance into the global NeuroHub network.

SCIENCE will allow NeuroHub to not only support a larger community, but it will further lower the barrier to entry for young or underfunded labs desiring to perform computational neuroscience research but lack adequate resources. The SCIENCE project will enhance NeuroHub's sustainability, scalability, and accessibility, ultimately enhancing researchers' ability to make important scientific discoveries.

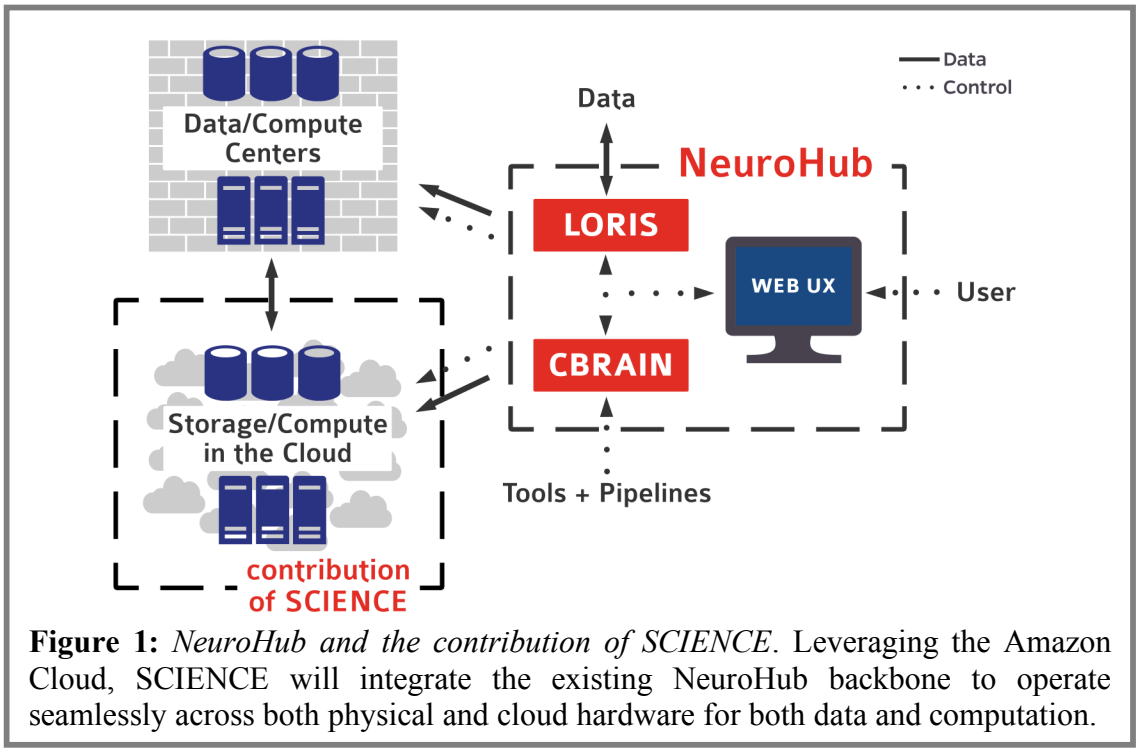

Figure 1: *NeuroHub and the contribution of SCIENCE*. Leveraging the Amazon Cloud, SCIENCE will integrate the existing NeuroHub backbone to operate seamlessly across both physical and cloud hardware for both data and computation.

References

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[2]: Gorgolewski KJ, et al. PLoS CB, 2017.
[3]: Frisoni GB, et al. NR Neurology, 2011.
[4]: Vogelstein JT, et al. Neuron, 2016.
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Letter of Motivation

Coming from a background in electrical engineering and biomedical engineering, I appreciate the need for reliability, reproducibility, accessibility, and sustainability in science and technology. Throughout my Master's I cultivated my passion for accessible science, and developed tools that aim to minimize the barrier for entry to performing big-data neuroscience. Extending my work on a scalable one-click structural connectome estimation pipeline, I developed a framework for performing science in the cloud that allowed researchers to perform analyses at an unprecedented scale in neuroscience, launching the parallel processing of thousands of open-access brains on the cloud from a computer with no dependencies, all in a single "click."

Using this work and experience as a spring-board, I wish to lower the barrier to entry to neuroinformatics as a whole. The brain is undoubtedly the most complex system known to mankind, and plays a dominant role in every aspect of our lives. Better understanding how the brain should properly function as well as the way it functions under disease models, will enable scientists and clinicians to develop and adapt treatments to reduce the burden of mental illness on individuals, their families, and society. My goal is to develop and extend the availability and reliability of infrastructure, computational tools, statistical resources, and biomedical models, thereby democratizing the field of neuroinformatics.

Throughout my PhD I will dedicate myself and my work towards enhancing the neuroscience community's ability to perform scalable science, with my project funded by the HBHL Fellowship playing an integral and necessary step towards my goal. The HBHL Fellowship will allow me to build scalable and universally deployable neuroscience infrastructure, and extend that infrastructure to provide maximum functionality and usefulness for its users while allowing users access with a minimal amount of computational savvy and background. This project is a fundamental piece of the multi-disciplinary puzzle being built that is NeuroHub, and not only enhances researcher's ability to develop, integrate, deploy, share, and analyze their own tools and data, but has potential to accelerate scientific discovery therein. The successful implementation of this project has potential to open the field of neuroscience beyond Canada, forming a global co-laboratory.

Eventually, I hope to be a professor at a Canadian university, in which I will lead research efforts towards developing statistical and computational tools for neuroscience. Having the opportunity to be a HBHL Fellow will open me up to a network of other researchers who are dedicated to better understanding the brain, and allows me to ensure that the direction of my research and the tools I develop are in concert with their goals and current limitations. Maintaining a close link with neuroscientists performing data collection, modeling, and analysis, I will be able to grasp the needs of the community and elevate the quality of their work.

The HBHL fellowship will enable one in a long-line of projects I will undertake throughout my career towards improving the field of neuroscience, and the mental health of society. It is my genuine life-long dream to develop tools, lead research efforts, and educate others, towards empowering other scientists and members of society to accomplish theirs.