

IMPACT REPORT

Krembil Centre for Neuroinformatics:

Fuelling the Engine of Innovation

2020–2021



A Note from Deborah Gillis

Thank you for your continued support of the Krembil Centre for Neuroinformatics. Your leadership has brought us to today—and the world is taking notice.

Look no further than our latest marketing effort, the Today campaign. Through real stories of real impact, we are showing people how mental health research is saving lives today. Work led by the KCNI is reaching patients at CAMH and beyond, allowing for more personalized care and better outcomes. Our goal is to inspire people in the way that you've inspired us.

It's often said that success is where preparation and opportunity meet. Today, the Krembil Centre is on the cusp of moving from a start-up to a leading global centre of excellence because of you. You've given Dr. Sean Hill and his world-class team the resources they need to meet the challenges of the past 18 months and continue moving "full steam ahead."

We are proud to share this update on the progress you have made possible. I hope, as you read, you take a moment to reflect on how far we've come together—and begin to imagine how much further we can go.

There are important opportunities ahead of us, and with your support, the Krembil Centre will be prepared to rise to the occasion. Thank you again for your partnership.

Sincerely,



Deborah Gillis

President & CEO, CAMH Foundation



Click here to see how we are showing the world data-driven care and research led by the KCNI is saving lives today.

A Message from the Directors

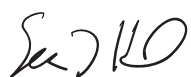
Thank you for your support of the Krembil Centre for Neuroinformatics.

As you well know, the Krembil Centre continues to mature, while becoming recognized as a global leader in neuroinformatics. The growth of our teams has been a critical part of this process. They are being awarded competitive grants, graduating students and publishing in high-impact journals. We are also raising the Krembil Centre's profile through engagement in key partnerships. From our leadership in the International Brain Initiative, our partnership in the new Max Planck – University of Toronto Centre, co-hosting the Brain Connectivity Workshop, and co-leading the infrastructure for the Temerty Centre for Artificial Intelligence, the Krembil Centre is at the forefront of key regional, national and international collaborations.

You will read about these exciting developments and more, including updates from our team leads, in this year's report. We are also thrilled to introduce the newest member of our team, Dr. Abhishek Pratap, Independent Scientist for Artificial Intelligence and Digital Health. Joining us from Sage Bionetworks in Seattle, Dr. Pratap is a recognized leader in applying machine learning and digital health. He is already hard at work and we are excited to help him grow his team and establish new collaborations for the Krembil Centre.

As we plan for the Krembil Centre team to return to our home at the College Street site, it is clear that our expanding team has outgrown our physical space during the pandemic. However, our hybrid approach, in which team members can work remotely for part of the time, demonstrates the benefits of the agile design and our collective forward thinking. We look forward to having opportunities to come together as a team and with our partners and collaborators, both in-person and virtually, to continue driving progress in neuroinformatics toward more personalized mental health care.

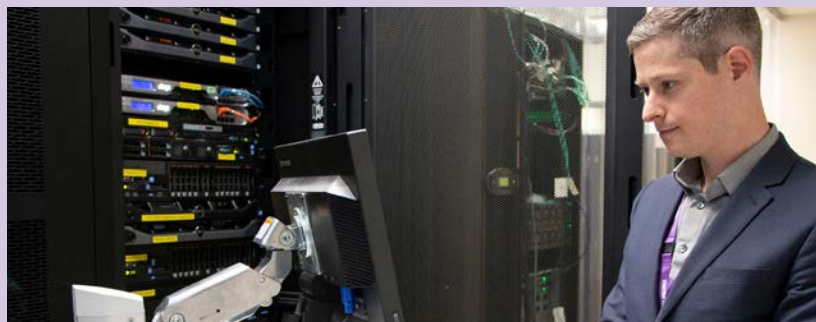
Thank you again for continuing to shape and share in our vision for the future of mental health. Together, we will accelerate brain science research and discovery into life-saving mental health care for people around the world.



Dr. Sean Hill
Scientific Director,
Krembil Centre for Neuroinformatics



Dr. David Rotenberg
Operations Director,
Krembil Centre for Neuroinformatics



Krembil Centre for Neuroinformatics

2020-2021 By the Numbers



78 Total Team Members Including **+20** New Team Members

52

Trainees Including



+17 New Trainees



17 Trainees Graduated

26



Publications



19

Grants Awarded



\$1,901,866
Grant Revenue



BrainHealth Databank

Now in its third year, the CAMH-wide BrainHealth Databank Initiative, supported by the CAMH Discovery Fund, has grown to become a major hospital-wide collaboration between the Krembil Centre for Neuroinformatics, clinicians, patients and families, and staff across CAMH. Over the past year, the BrainHealth Databank team, led by Dr. Joanna Yu, and stakeholders have continued to drive progress toward the ultimate goal of improving patient-centred mental health care. Today, the BrainHealth Databank is providing digital support for measurement-based care, integrating research measures into care pathways, developing and implementing data-driven and AI tools to enhance personalized care, and enabling open science to accelerate discovery and innovation.

Launch of First Real-Time Patient-Level Treatment Trajectory Dashboards in the Clinic

In addition to expanding the implementation of remote digital measurement-based care pathways to continue to support virtual care during the pandemic, the BrainHealth Databank has launched first versions of real-time measurement-based care clinical support dashboards in the clinic. These digital tools have been designed with clinicians to further enhance the delivery of personalized care by providing visual and analytic decision support to users. For example, Major Depressive Disorder Integrated Care Pathway (MDD-ICP) psychiatrists are now able to access a visual summarization of an individual patient's treatment trajectory in their electronic health record. This digital tool allows clinicians to rapidly evaluate an individual's treatment response as they are able to see the relationship between changes in depression symptoms and medication side effects at a glance. This information is then used to inform patient-centred treatment decisions. The goal of another digital dashboard is to provide actionable insights to support clinic operations with respect to monitoring and improving patient flow and increasing completion of patient assessments. This measurement-based care clinical operational support dashboard is being piloted in three clinics.

"The collaboration with the BrainHealth Databank team has paved the way for and enabled digital care delivery for many individuals suffering from mood disorders through digitization of Integrated Care Pathways. The digitization of measurement-based care and decision support tools supported by the BrainHealth Databank has facilitated a smooth and rapid transition of high-quality care models to virtual settings when acutely confronted with limitations and restrictions of the COVID-19 pandemic.

As a clinician, the digital tools provided for measurement-based care have definitely changed and improved my work on a daily basis through optimization of work-flows, improved overview of patients' individual clinical trajectories and areas of concern, and decreased time for documentation eventually resulting in high-quality care and more time for patients."

-Dr. Stefan Kloiber, Psychiatrist and Clinician Scientist, Medical Head Mood & Anxiety Services, CAMH

65+ 

CAMH Stakeholders

CAMH-Wide BrainHealth Databank Team
Steering Committee, Working Groups,
and Operational Teams

7 

External Scientific Advisors

Local, national and international experts in
digital health technologies, Learning Health
Systems and large-scale data initiatives

14 

Patients, Families, & Lived Experience Advisors Engaged

Participation and co-designing to
impact patient care and experience



7

Collaborative Awards

Including grants
and fellowships



Trainee Projects

Led by residents,
postdoctoral fellows,
PhD, Masters and
undergraduate students



**Visit the new BrainHealth
Databank website**

Measurement-Based Care Digitization Outcomes

(as of September 28, 2021)



20
Digital Measurement-Based Care Pathways



Implemented
Across
7 Clinics



9,400+
Enrolled Patients



Seen by
125+
Clinicians



4,418,000
Data Points

Open Science to Accelerate Discovery

The BrainHealth Databank has implemented clinical and research knowledge graph databases to bring together data from the electronic health record, biobank, wrist wearable actigraph devices, neuroimaging, and clinical assessment databases. Both clinical and research data are systematically organized using the internationally accepted Fast Healthcare Interoperable Resources data models to effectively reuse accumulated complex multi-dimensional data to answer research questions today and in the future. To date, data accumulated in the BrainHealth Databank is being used to support a variety of research and quality improvement analyses across CAMH and has also resulted in the launch of new digital health and AI tools.

Discovery



15

Quality Improvement & Research Projects in Progress

Innovation



9

New Clinical & Research Tools in Development

Operations

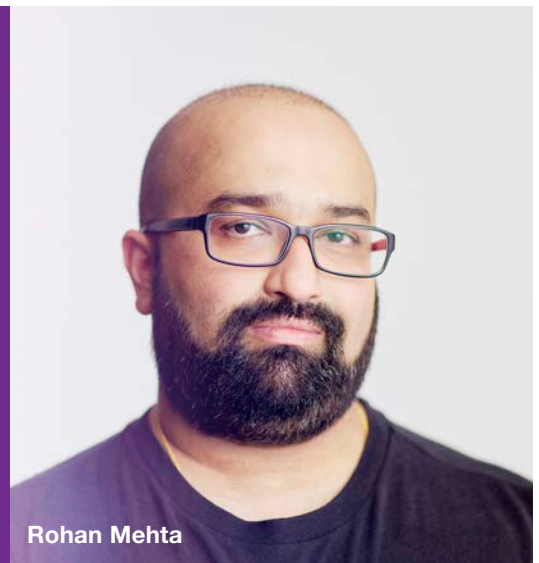
Digital Health & AI Tools



5

Clinical Support Dashboards & Natural Language Processing Pipeline

“My role as a co-lead in the BrainHealth Databank Patient Dashboard Project included interviewing stakeholders to gather requirements for the dashboard. What I really liked is that we were able to interview a fairly diverse group of individuals with lived experience, family members, and health care providers. The whole experience surely provided an impetus to my own recovery journey and self-worth. To me, this work is of paramount importance as the research findings will help in design and usability that conform to patient needs and expectations, thus enabling patients to be in joint charge of their treatment choices and outcomes.”



Rohan Mehta

-Rohan Mehta, CAMH Patient Advisory Committee Co-Chair

Integration of Research Measures into Care Pathways

Discovering new biomarkers has the potential to help clinicians identify the most effective treatment for each individual patient. To support genetic and behavioural biomarker research, the BrainHealth Databank has established the CAMH Biobank and wearable rental services. The Biobank features a new customized LabKey Molecular Informatics System to support the central and standardized management of the entire life cycle of biosamples. Operating on a cost recovery model, biobank services and LabKey are available to all CAMH researchers.

In addition to initiating recruitment to the MDD-ICP Biomarker Study later this fall, the BrainHealth Databank is providing data management support for the recently launched Toronto Adolescent & Youth (TAY) Cohort Study. The TAY Cohort Study will recruit and follow 3,000 youth over five years, collecting biosamples from all participants at six points in time over this period using the new Labkey Molecular Informatics System to support biosample management. Labkey's flexibility and configurability has enabled the TAY Cohort Study to adapt the software to the unique requirements of the study, while its easy-to-use interface has enabled the study team to get quickly trained and ready to use. The BrainHealth Databank's knowledge graph will support integration of TAY's biosample data with other collected data types including cognition, EEG, heart rate variability and more for study operations and downstream analyses.

Collaboration with TAY Cohort Study

The TAY Cohort Study aims to better understand how certain mental health symptoms can develop, who is at an increased likelihood of developing certain mental health challenges, and how we can better support young people.

[Click here to learn more](#)



Susan Conway

“As a family member of someone with mental illness, I have found it frustrating that mental illness has not received the same attention and funding that other illnesses like cancer have. I believe the BrainHealth Databank, with patients donating their mental health data, will allow science to excel at a rate we’ve seen with other illnesses. Patients will see the benefits of this acceleration in treatment options and personalized medicine.”

-Susan Conway, CAMH Family Advisory Committee Co-Chair and BrainHealth Databank Steering Committee Member

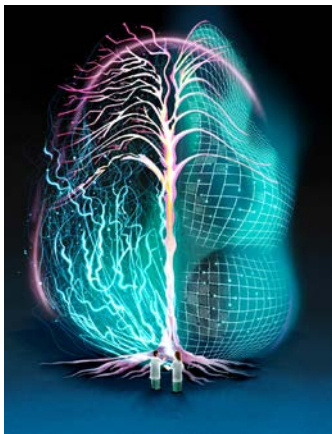
Looking Ahead

In the coming year, the BrainHealth Databank will focus on completing core deliverables including developing an operational business model, continuing to deepen the integration between research and care, and developing health intelligence and AI pipelines, as well as driving forward over ten ongoing internal and external collaborative projects. In addition, the team will develop plans to support phase two of the BrainHealth Databank, which will focus on scaling and expanding currently implemented foundational elements to bring digital health technology and AI to the clinic for more personalized mental health care at CAMH and beyond.

Growing KCNI's Profile and Partnerships

This year, the Krembil Centre for Neuroinformatics made strides toward its vision of being the global leader in neuroinformatics. The Krembil Centre leveraged earned media opportunities to enhance its profile nationally and internationally, while also cultivating new and fostering existing ones that promote the KCNI principles of open science and collaboration in the global research community and advance the field of neuroinformatics around the world.

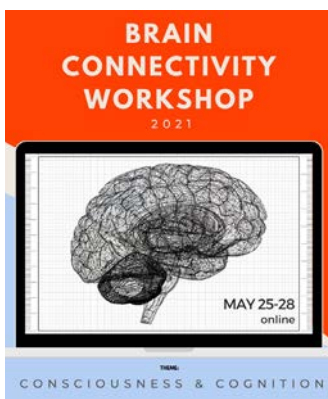
Profile-Building Highlights



The Walrus

The June 2021 cover story of The Walrus Magazine was an **in-depth feature on Dr. Sean Hill and his colleagues at the Krembil Centre for Neuroinformatics.**

The article highlights how the Krembil Centre team is working at the intersection of neuroscience, information management, brain modelling and psychiatry to create a better understanding of the biological mechanisms behind mental illness. It continues to be widely shared on social media among the global research community, generating new conversations and insights.



Brain Connectivity Workshop

The 2021 edition of the Brain Connectivity Workshop, a global event sponsored by the Krembil Foundation, explored the question, "What does the mind think of the brain?" Topics focused on consciousness and cognition, looking at the relationship between anatomical connectivity, brain dynamics and cognitive function. Dr. Sean Hill helped organize the conference and ran a workshop about the link between brain connectivity, excitability, cognition and sleep, while Dr. Andreea Diaconescu also delivered an educational session.

43 media mentions

from October 2020 to September 2021

Top Media Mentions

News Medical

Emily Henderson - April 13, 2021

Cannabis users genetically predisposed to schizophrenia may have higher risk for psychosis

Science Daily

May 3, 2021

Unique characteristics of human neurons

Walrus Magazine

Simon Lewsen - May 19, 2021

What Happens To Our Brains When We Get Depressed

Thrive Global

Erin Crabtree - August 19, 2021

Understanding the Science of the Brain

Think Podcast

June 30, 2021

What does the depressed brain look like?

Partnership Highlights



International

Max Planck Centre (MPC)
EPFL/Blue Brain Project (BBP)
Templeton World Charity Foundation (TWCF)
NeuroNex
Brain Health Nexus
World Dementia Council (WDC)
Knowledge Grid (University of Michigan)
Alliance of Centers of AI in Medicine (ACAIM)
Creative Destructive Lab (CDL)
International Neuroinformatics Coordinating Facility (INCF)



National

Canadian Open Neuroscience Platform (CONP)
New Digital Research Infrastructure Organization (NDRIO)



Regional

Compute Canada
Temerty Centre for AI Research and Education in Medicine (T-CAIREM)
University of Toronto Early Stage Technology (UTEST)
Toronto Adolescent and Youth Cohort Study (TAY)

Krembil Computational Neuroscience (KCN)
Ontario Brain Institute (OBI)
Toronto Dementia Research Alliance (TDRA)
Krembil Brain Institute (KBI)
St. Michael's Hospital
Vector Institute
Digital Research Infrastructure (DRI), University of Toronto
Dalla Lana School of Public Health, University of Toronto
Department of Psychiatry, University of Toronto
Department of Physiology, University of Toronto



International



Max Planck – University of Toronto Centre for Neural Science and Technology

The Max Planck-University of Toronto Centre (MPUTC) for Neural Science and Technology aims to create and deploy advanced technologies to study brain circuits toward improving human health, while charting new territory in the field of computing. Through the MPUTC joint supervision PhD program, PhD students can work at multiple institutions with different experts to enhance the impact of their research. Under the guidance of KCNI supervisors, Drs. Sean Hill and Andreea Diaconescu, and Max Planck supervisor, Dr. Peter Dayan, PhD student Pamina Laessing will research the neurocomputational models of escape and avoidance for suicide prevention.



EPFL/Blue Brain Project

The partnership between the Brain Circuit Modelling team, led by Dr. Etay Hay, and the Blue Brain Project will refine data-driven and detailed large-scale models of human cortical microcircuits and simulate them to compare the effects of cellular mechanisms of depression on humans and rodent brain networks in silico. This collaboration will capitalize on recent models and computer simulation results from Dr. Hay's team about the implications of reduced cortical inhibition in depression on brain deficits, which is in peer review for publication.



TEMPLETON WORLD
CHARITY FOUNDATION

Templeton World Charity Foundation

The Templeton World Charity Foundation recently funded a collaborative team to implement an open-source electronic laboratory notebook (e-notebook) to support experimental neuroscience. Working with leaders in consciousness research and the XNAT medical imaging technology platform, the e-notebook will focus on fMRI and will be deployed to support multi-site studies. The Krembil Centre has led key components of this collaborative project, including the implementation of a medical imaging data model representation pipeline to enable data integration that leverages the Blue Brain Nexus knowledge graph.

The platform aims to provide a rich “discovery service” for researchers to search and link by key experimental attributes allowing teams to aggregate, compare, and re-analyze datasets. These functionalities will promote capabilities fundamental to open, reproducible neuroscience. Through this collaboration, the Krembil Centre is helping to create the next generation of scientific publishing.



NeuroNex Working Memory

The NeuroNex Working Memory project is working to integrate transcriptomics data with cellular electrophysiology data. Toward this aim, the Tripathy lab is in the early stages of collaborating with various groups in Canada, the United States and Germany, as the labs plan and practice these challenging experiments. In addition, they have identified local labs and core facilities that can perform necessary molecular biology subsequent to sample delivery.



Canadian Open Neuroscience Platform

The Canadian Open Neuroscience Platform (CONP) provides an infrastructure for the promotion of open-science workflows and the sharing of neuroscience data. The CONP aims to propel Canada's basic and clinical neuroscience communities into a new era of commonly shared, digitally integrated, data- and algorithmic-rich neuroscience research. The Krembil Centre for Neuroinformatics is a founding CONP Member and part of the leadership that sets the overall strategic direction and priorities of the group. The Krembil Centre has representatives on the Training, Steering, and Technical Committee.



Compute Canada

The Krembil Centre for Neuroinformatics works closely with Compute Canada on several initiatives and was granted secure compute capacity from a successful research platform competition. This ability has enabled the KCNI to launch Reservoir Global, a publicly accessible knowledge graph that supports open datasets for researchers worldwide, and serves as a core "interoperability node" for data models that link datasets for other global and national initiatives, including the Canadian Open Neuroscience Platform and the Templeton World Foundation Charity e-notebook.



Temerty Centre for AI Research and Education in Medicine

The Temerty Centre for Artificial Intelligence Research and Education in Medicine (T-CAIREM) at the University of Toronto seeks to establish world-class educational programs in AI in medicine, fund research opportunities that bring together experts from a range of disciplines, and create a secure data platform to house datasets for applied AI learning and research. Dr. Sean Hill of the Krembil Centre for Neuroinformatics serves as co-lead for the Infrastructure theme in T-CAIREM.



University of Toronto Early Stage Technology Program and EspriaHealth

The University of Toronto Early Stage Technology (UTEST) program provides support to University of Toronto entrepreneurs to create research-based companies. In partnership with Toronto Innovation Acceleration Partners (TIAP) and with the financial support of the Connaught Fund, it provides companies with investment capital, mentoring, business strategy, and incubation space.

The Krembil Centre for Neuroinformatics' first 'start-up' company, EspriaHealth, was accepted into the UTEST program. Through engagement and coaching with business leaders, EspriaHealth continues to build on fundamental discoveries and foundations from the Krembil Centre. EspriaHealth's platform delivers AI-enabled evidence-based-care pathways for the personalized treatment of mental illness. With an initial focus on improving depression care, the EspriaHealth platform can offer diverse pathways to help millions of people suffering from mental illness worldwide.



COVID Rapid Response with Digital Health Innovation

If 2020 demonstrated the Krembil Centre for Neuroinformatics' flexibility and agility in action, this past year has shown how your support has enabled continued digital health innovation. The COVID-19 pandemic brought into sharp focus the value of high-quality data and need for collaboration to assess and respond to fast-changing situations. With many researchers predicting a worsening of the global mental health crisis as the pandemic persists, the Krembil Centre has adopted technologies and best practices that put data interoperability and global cooperation front and centre. Through rich and flexible semantic knowledge graphs, emphasis on rigorous quality control and established data governance for secure sharing, the KCNI's data team has laid the foundation to meet this moment and prepare for the challenges ahead.

KCNI-led COVID-based Projects at CAMH



COVID Screening Questionnaire

A digital screening tool that can be completed via tablet or smartphone for all staff and visitors to assess symptoms and advise respondents to stay home or proceed to CAMH.



COVID Staff Attestation

A simplified screening tool to streamline the screening process for CAMH staff.



COVID Vaccine Booking

Interim system to facilitate vaccine bookings for frontline staff before other solutions were up and running at CAMH.



COVID Vaccination Tracking and Dashboard

System for tracking vaccination status for all CAMH staff and volunteers, with an e-learning module for those who have not yet received the vaccine and a dashboard to display daily vaccination metrics.



COVID Antigen Test Results

A survey for unvaccinated staff to upload their three times weekly rapid antigen test results.



Supports for Health Care Workers and the Public

An online self-referral form and Clinical REDCap project for frontline workers experiencing mental health issues stemming from the pandemic, as well as a public questionnaire (bilingual) to assess stress levels during the pandemic.

Other KCNI-led Projects



CAMH E-Consent

At the onset of the pandemic, the e-consent framework was developed with the Research Ethics Board and Research Operations, Services, and Support (ROSS) to facilitate an online workflow consent. Since then, the Krembil Centre has completed system validation of the e-consent module within REDCap.



External Site E-Consent

Developed with the ROSS, Privacy and Legal teams, this process allows external collaborators without e-consent infrastructure to use the CAMH e-consent framework.



Clinical REDCap Virtual Workflows

The Krembil Centre transitioned from tablet-based, in-clinic workflows to email-based, virtual workflows, enabling patients to complete self-assessments at home prior to virtual care appointments.



Clinical REDCap Projects

The Krembil Centre is collaborating on over 20 new Clinical REDCap projects in support of virtual care.

Events & Knowledge Sharing

This year saw the Krembil Centre, fuelled by your support, continue to advance its position as a leader in supporting global knowledge sharing through KCNI-led initiatives and bridging existing knowledge gaps in neuroinformatics through participation in collaborative learning events.

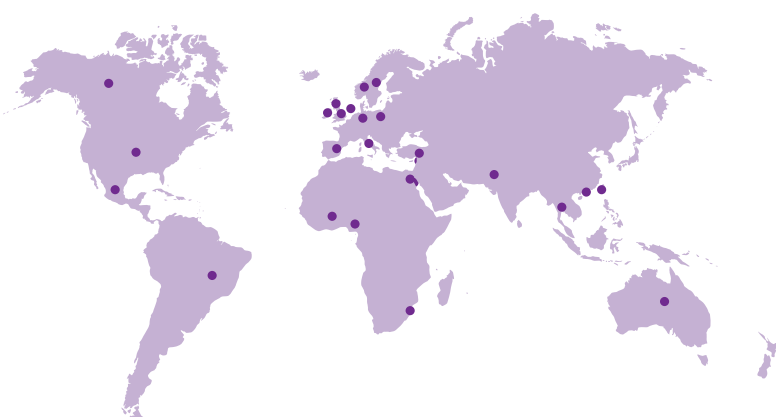
KCNI Summer School

In its second year, the KCNI Summer School session expanded from five to eight days, allowing for a more in-depth exploration of neuroinformatics research. Key curriculum additions included:

- New content from Dr. Abishek Pratap and the Digital Health and Artificial Intelligence team.
- A full day dedicated to Ethics and Fairness in Digital Health.
- A presentation from CAMH clinical staff, focused on the diagnosis and treatment of major depression.
- An “Ask Us Anything” panel at the end of the session with all students and instructors.

The digital student experience was similar to the inaugural year, with the team using the Crowdcast platform for streaming and sharing data via Github. Key improvements included:

- The ability to load neuroinformatics software from the course to any web browser using the mybinder.org platform. This update enabled students to follow along with the exercises at home on any computer simply by clicking a link.
- An online Slack workspace to provide students with opportunities for out-of-classroom networking.
- A planned partnership with the International Neuroinformatics Coordinating Facility Training to help online materials and videos reach a larger international audience.



Student Representation from 23 countries (by web server)

Australia, Brazil, Burkina Faso, Canada, Egypt, Germany, India, Ireland, Italy, Kingdom, Macao, Mexico, Nigeria, Norway, Pakistan, Poland, Spain, Sweden, Taiwan, Thailand, Turkey, United Kingdom, United States

210 REGISTERED STUDENTS

75% INCREASE FROM 2020

180 ATTENDING LIVE AT ANY POINT

137% INCREASE FROM 2020


Looking Ahead

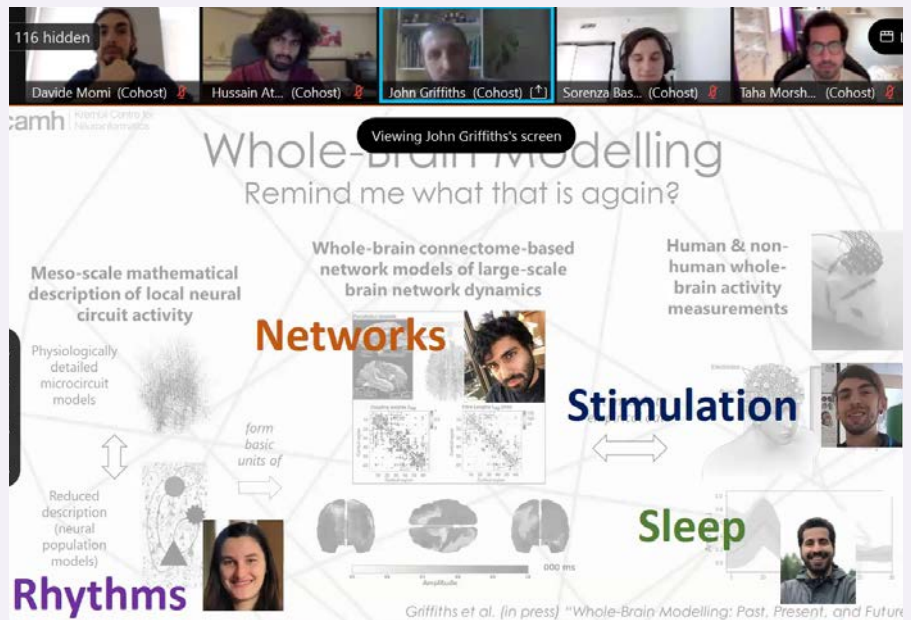
With the return of in-person classrooms, the KCNI Summer School hopes to feature a local, on-site cohort in 2022, in addition to publishing online materials to continue reaching an international audience. The team will follow best practices and closely monitor how similar educational programs and conferences proceed in the coming year before finalizing any plans.

Community Engagement

KCNI Open House

The KCNI Open House, held on June 21, 2021, helped mark the second anniversary of the opening of the Krembil Centre for Neuroinformatics. The virtual event provided more than 220 unique participants with the opportunity to learn about two years of highlights from the Krembil Centre team, as well as exciting plans for the future. In addition to presentations from team and project leads, the event featured a panel discussion on how digital health data and brain simulation can transform mental health care.

 [Click here to watch recordings from the KCNI Open House.](#)



194 PRE-REGISTERED PARTICIPANTS

220 UNIQUE SIGN-INS



KCNI Speaker Series

The KCNI Speaker Series is a monthly event that highlights exciting discoveries, advancements and collaborations in neuroinformatics. The pivot to virtual events as a result of COVID-19 has enabled the Krembil Centre to feature speakers from around the world, including Canada, United States, Germany, Portugal and Australia.



KCNI Bulletin

The biannual KCNI Bulletin provides updates on recent developments at the Krembil Centre and previews plans for upcoming months. The inaugural issue reached 603 readers in Canada and the United States, while the most recent spring issue has reached over 1,000 readers across Canada and in the United States, Australia, Dubai, Japan, Lithuania, Switzerland and UAE.

Centre Development



Fairness, Equity and Diversity Workshop

The Krembil Centre aims to produce high-quality data and predictive models that can be used to enhance research and improve patient care. Despite best efforts, biases seep into datasets, undermining research objectives and amplifying harm, especially for those disproportionately impacted by mental illness. In the workshop, led by Dr. Laura Sikstrom, an expert specializing in the intersection of evidence-based medicine, health equity and social justice, 36 Krembil Centre team members explored how bias “gets baked into” data throughout the research cycle. Key learnings that the team will incorporate into their own work include how to identify potential sources of bias in their research and promote best practices at KCNI, across CAMH and in the field of neuroinformatics.



External Scientific Advisory Committee

Established in September 2020, the External Scientific Advisory Committee meets biannually and brings together national and international expertise to guide KCNI initiatives and promote alignment on large-scale strategic directions. The ESAC features prominent leaders from renowned institutions and organizations who provide global context and subject matter expertise with their recommendations.

Education



Scientific Computing Working Group Workshops

The Krembil Centre for Neuroinformatics Scientific Computing Working Group conducted a biannual multi-day virtual workshop attended by over 70 CAMH staff and students. Topics of exploration included REDCap API, Git and GitLab, SQP and R Studio.



SPSS Workshop

Driven by increasing demand over the past several years, the SPSS Workshop Series has expanded to include 10 different topics ranging from basic SPSS usage to complex statistical analyses. This year's workshop, led by Maros Sanches, a biostatistician at CAMH, spanned 11 days and had 185 unique registrations.



Agile LabScrum

Over four days, Krembil Centre scientists and trainees attended virtual Agile LabScrum workshops. Working with specialists, the team worked to identify needs, challenges and perspectives unique to small groups, and to understand how individual needs and goals interact with large group needs and goals. These customized workshops highlighted the diversity of scientific efforts across the Krembil Centre and provided insights about implementing effective research project management practices to meet team needs and achieve goals.



Data Keepers Digest

Data Keepers Digest is the result of the growing popularity of large collections of clinical and population-based datasets that Dr. Daniel Felsky's team has accessed, downloaded and cataloged on CAMH's Scientific Computing Cluster. The data is obtained from a variety of large-scale longitudinal cohort studies that collect participant information over years and decades. These studies encompass data from across the lifespan and the spectrum of health, and the diversity of the data types make this unique repository an invaluable tool for researchers across disciplines.

As CAMH researchers increasingly express interest in accessing the shared repository, the Whole Person and Population Modelling team proactively initiated a quarterly newsletter, produced by Research Analyst Milos Milic, to update them on new developments, downloads and publications related to this evolving resource. As of its third issue, Data Keepers Digest reaches the entire Krembil Centre team and 27 researchers across CAMH.



Krembil Centre for Neuroinformatics

Team Updates

Introducing Dr. Abhishek Pratap, the new Independent Scientist for Artificial Intelligence and Digital Health

Led by Independent Scientist for Artificial Intelligence and Digital Health, Dr. Abhishek Pratap, the Augmented Intelligence and Digital Tech for Mental Health (AID4MH) team is a new addition to the Krembil Centre for Neuroinformatics. This group is focused on developing human-augmented solutions for mental health with real-world application. These research efforts will help improve long-term outcomes for people living with mental illness and move the world closer to personalized medicine in mental health care.

Dr. Pratap and his team are already collaborating with a variety of international stakeholders. Together with the University of Washington (UW), they are launching a NIMH-funded study to determine when individuals may be at highest risk for suicide using personalized online information-seeking behaviour.

They are also working with UW to assess the utility of electronic medical records in identifying localized hotspots of depression and obesity. Additionally, the group has partnered with the RADAR-CNS consortium to help quantify the human behaviour and potential biases in decentralized/hybrid studies aimed at assessing personalized mental health trajectories.

Moving forward, Dr. Pratap will continue building the team and technology base to enable the development and deployment of analytical workflows in the clinic. The team will also play a role in ramping up research at the Krembil Centre and CAMH, helping to identify key areas in which human-centred co-designed technology could improve care and the patient experience.



Dr. Abhishek Pratap

Augmented Intelligence and Digital Tech for Mental Health Team Research Areas



Digital biomarkers



Personalized health trajectories



Bias in digital mental health



Clinical utility of AI and technology

Computational Genomics Team

Team Lead: Dr. Shreejoy Tripathy

The Computational Genomics team has grown to 17 postdoctoral fellows, research staff, graduate and undergraduate students, and expanded its network of global collaborators. The team has submitted 17 publications (leading nine of those) to peer-reviewed journals that include Nature Neuroscience, Nature Communications, Biological Psychiatry, Molecular Psychiatry, PLoS Medicine, and Journal of Neuroscience.

As the Computational Genomics team aims to bring about the next generation of neuropsychiatric therapies, their work is having immediate clinical and public health impact. They have already revolutionized our understanding of the human brain and its cells (Moradi Chameh et al., 2021), are beginning to leverage this knowledge in the context of neuropsychiatric diseases (Nagy et al., 2020; Tripathy, 2020), and are in the early stages of collaboratively applying this knowledge toward developing novel therapies (Mielnik et al., 2020). Their research using population-scale datasets for the purpose of personalized psychiatry is driving system and social

change. They recently concluded that individuals with high genetic risk for schizophrenia should be strongly advised against using cannabis (Wainberg et al., 2021a). In recent work now in review at JAMA Psychiatry, the team discovered that rare, non-recurrent genetic copy number variations contribute considerable and under-appreciated risk to psychiatric disorders (Wainberg et al, in review), suggesting such knowledge can be used to guide diagnoses and ultimately individualized treatments. At CAMH, Dr. Tripathy and his team helped pilot the initial analysis of patient treatment trajectories by the Major Depressive Disorder Integrated Care Pathway, which helped demonstrate the effectiveness of the BrainHealth Databank. With grant support, the team will soon begin collecting genome-wide genotyping data from these patients and translating their findings directly to patients.





Dr. Etay Hay

Brain Circuit Modelling Team

Team Lead: Dr. Etay Hay

The Brain Circuit Modelling team has expanded to include more graduate student trainees, as well as several awarded summer graduate student trainees. One of the students has recently graduated with their Masters and will be continuing as a PhD student with the team. This continued growth has enabled the team to drive forward existing projects, while also embarking on new ones.

In the past year, Dr. Hay and his team, in collaboration with Dr. Etienne Sibille at CAMH and Dr. Taufik Valiante at UHN, completed a research project characterizing the implications of reduced inhibition on cortical microcircuit processing in depression, using novel computational models derived from live neurons resected during neurosurgery. They have compiled and submitted the results that are currently under revision in Cell Reports after very positive peer reviews. The models and code from this project will be openly shared. They also completed a project that integrated their human microcircuit models with a computational platform that enabled them to simulate the associated EEG signals, and thus characterized the EEG signatures of microcircuit changes in depression, which will serve as high-resolution biomarkers for diagnosis and monitoring. They have submitted this work for peer-reviewed publication. The EEG biomarkers will be used next year to refine depression patient stratification and diagnosis. The team has also applied the computational platform to test new CAMH-developed pharmacology, human microcircuits and cortical processing in-silico to support the translation of the drug into clinical use. Over the next year, they will compile these results into a publication.

Within the Krembil Centre, the team worked with Dr. Shreejoy Tripathy to discover cellular changes in aging and determined their implications on brain microcircuit activity. They have validated their predictions using recordings from human brain tissue and written a manuscript to be submitted for peer review. In a collaboration with Dr. Andreea Diaconescu, Dr. Hay and his team adapted their models to study the inhibitory changes underlying deficits of cortical microcircuit processing in schizophrenia, with the goal of refining biomarkers for diagnosis and establishing candidate targets for treatment.

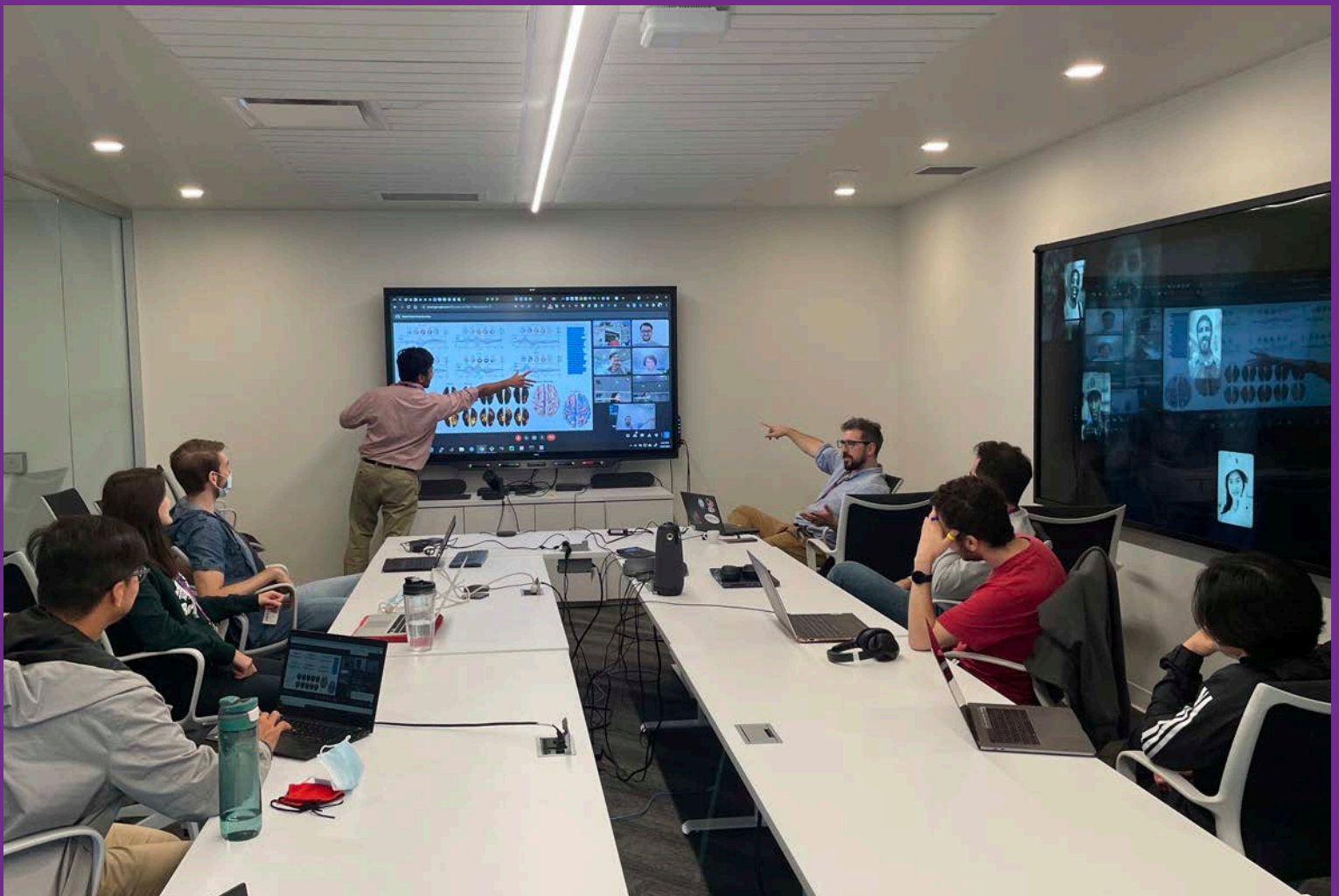
Whole Brain Modelling Team

Team Lead: Dr. John Griffiths

In January 2021, many of last year's additions to the Whole Brain Modelling team were able to come to Toronto, following travel delays caused by the pandemic. The team continues to push forward with ongoing work mapping brain stimulation networks and understanding macro-scale brain oscillations. In a new research direction of rapidly growing interest, they have been exploring ways of "fusing" the use of numerical techniques for brain activity simulations with new approaches for model parameter optimization coming from modern machine learning software libraries.

A significant development over the past year has been the establishment of the new KCNI EEG Lab on Floor 6 of the

CAMH College Street site. This new space is being jointly run by the Whole Brain Modelling and Cognitive Network Modelling teams, and will support several clinical and non-clinical research studies. The first of these—the EEG arm of the large Toronto Adolescent & Youth Cohort Study—is now ramping up, with several patient data collection sessions per month. The lab also houses mobile EEG, infrared neuronavigation camera, TMS, TDCS, and fNIRS systems. The latter is a best-in-class whole-head joint EEG-fNIRS (functional near-infrared spectroscopy) system from Silicon Valley neurotechnology company Kernel. CAMH was selected to be one of Kernel's **featured academic partners**, and the Krembil Centre will be using this new neuroimaging system brain stimulation, schizophrenia, and concussion research.





Cognitive Network Modelling Team

Team Lead: Dr. Andreea Diaconescu

The Cognitive Network Modelling team has grown to one postdoctoral fellow, two PhD students, one Master's student, two Research Analysts, and three undergraduate students from various disciplines. Under the leadership of Dr. Diaconescu, the team continues to make significant progress toward demonstrating the utility of computational modelling in the context of psychosis through leadership on two funded grants. These projects examine the application of neurocomputational modelling for treatment response predictions in (1) early psychosis and (2) treatment-resistant depression. They have also pursued multiple collaborative grants focused on neurocomputational models for suicidality predictions and clinical high risk for psychosis.

Through a partnership with the Max Planck – University of Toronto Centre for Neural Science and Technology, a new PhD student, Pamina Laessing, will join the team. Students and trainees are significant contributors to the team's research output. For instance, PhD student Daniel Hauke has independently conducted a large clinical study (N=80) using multimodal neuroimaging (EEG and fMRI) in ultra-high risk and first-episode psychosis patients. This work has been recognized at international conferences and by funding agencies.

Whole Person and Population Modelling Team

Team Lead: Dr. Daniel Felsky

In the past year, the Whole Person and Population Modelling team grew to include 14 trainees, postdoctoral fellows and staff. The team published five peer-reviewed papers (with 10 currently under review) and 16 abstracts, posters, and talks were accepted at local, national, and international conferences. They were also awarded funds as part of two CAMH Discovery Fund grants, both focusing on aspects of major depressive disorder.

The team made important progress on several trainee-led projects, including: Amin Kharaghani expanded his work on the interactions between Alzheimer's disease and glaucoma by combining genetic risk scores for over 1,300 human traits in a novel predictive model of cognitive decline; Earvin Tio tested the genetic correlates of brain inflammation for the first time in three independent datasets, providing new methodological insights into polygenic scoring in human cohorts; Katrina Hueniken identified a unique role of hopefulness in preventing lockdown-related emotional distress by applying machine learning to 2020 survey data from 6,000 Canadians.

Dr. Felsky's team is actively engaged in several major collaborative initiatives, including co-leadership of the now-active Toronto Adolescent and Youth (TAY) Cohort Study, which has recruited its first 55 participants on its way to 3,000 over five years, and the Cognitive Dysfunction in the Addictions (CDiA) Study, which will recruit its first of 600 participants in late 2021. Moving forward, the team will continue to build data resources for the entire CAMH research community and contribute to the adoption of integrative, machine learning methods across research programs with patient populations who stand to benefit. For example, building on early deep learning models of clinical trajectories in simulated data, Dr. Mohamed Abdelhack is applying his expertise in deep learning to the major depressive disorder integrated care pathway, in which the team is funded to collect genetic data for new patients. Dr. Abdelhack's aim is to predict treatment response, and Dr. Felsky and his team hope to introduce the results of this work into clinician-facing dashboards in the near future.



List of Publications

KCNI Scientist Publications (October 1, 2020 to September 30, 2021)

Kozhuharova, P., Diaconescu, A. O. & Allen, P. Reduced cortical GABA and glutamate in high schizotypy. *Psychopharmacology* **238**, 2459–2470 (2021)

Mirjalili, M., Zomorodi, R., Daskalakis, Z. J., Hill, S. & Rajji, T. K. Individualized real-time prediction of working memory performance by classifying electroencephalography signals. *Int. J. Imaging Syst. Technol.* (2021) doi:10.1002/ima.22626

Wainberg, M. *et al.* Clinical laboratory tests and five-year incidence of major depressive disorder: a prospective cohort study of 433,890 participants from the UK Biobank. *Transl. Psychiatry* **11**, 380 (2021)

O'Reilly, C., Iavarone, E., Yi, J. & Hill, S. L. Rodent somatosensory thalamocortical circuitry: Neurons, synapses, and connectivity. *Neurosci. Biobehav. Rev.* **126**, 213–235 (2021)

Eke, D. *et al.* International Data Governance for Neuroscience. (2021) doi:10.31234/osf.io/esz9b

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Hawley, S. *et al.* Digitization of Measurement-Based Care Pathways in Mental Health Through REDCap and Electronic Health Record Integration: Development and Usability Study. *J. Med. Internet Res.* **23**, e25656 (2021)

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Mirjalili, M., Zomorodi, R., Daskalakis, Z., Hill, S. & Rajji, T. K. Anticipatory Parietal Alpha Desynchronization and Working Memory Performance and Capacity. *Biol. Psychiatry* **89**, S254 (2021)

Wainberg, M., Jacobs, G. R., di Forti, M. & Tripathy, S. J. Cannabis, schizophrenia genetic risk, and psychotic experiences: a cross-sectional study of 109,308 participants from the UK Biobank. *Transl. Psychiatry* **11**, 211 (2021)

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Lipovsek, M. *et al.* Patch-seq: Past, Present, and Future. *J. Neurosci.* **41**, 937–946 (2021)

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Mirjalili, M., Zomorodi, R., Daskalakis, Z. J., Hill, S. & Rajji, T. K. Anticipatory Cue-Related Alpha Desynchronization Reflects Top-Down Disinhibitory Control During Verbal Working Memory Task. in *2021 Alzheimer's Association International Conference (ALZ)*, (2021).

Griffiths, J. D., McIntosh, A. R. & Lefebvre, J. A Connectome-Based, Corticothalamic Model of State- and Stimulation-Dependent Modulation of Rhythmic Neural Activity and Connectivity. *Front. Comput. Neurosci.* **14**, 575143 (2020)

Rich, S., Diaconescu, A. O., Griffiths, J. D. & Lankarany, M. Ten simple rules for creating a brand-new virtual academic meeting (even amid a pandemic). *PLoS Comput. Biol.* **16**, e1008485 (2020)

Mirjalili, M., Zomorodi, R., Hill, S., Daskalakis, Z. J. & Rajji, T. K. Real-time prediction of working memory performance: A machine learning-based approach towards dementia prevention. *Alzheimers. Dement.* **16**, (2020)

Hay, E. & Pruszynski, J. A. Orientation processing by synaptic integration across first-order tactile neurons. *PLoS Comput. Biol.* **16**, e1008303 (2020)

Sieberts, S. K. *et al.* Large eQTL meta-analysis reveals differing patterns between cerebral cortical and cerebellar brain regions. *Sci Data* **7**, 340 (2020)

Henco, L. *et al.* Bayesian modelling captures inter-individual differences in social belief computations in the putamen and insula. *Cortex* **131**, 221–236 (2020)

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Chameh, H. M. *et al.* Sag currents are a major contributor to human pyramidal cell intrinsic differences across cortical layers. *bioRxiv* 748988 (2020) doi:10.1101/748988

Patel, S. *et al.* Donor-Specific Transcriptomic Analysis of Alzheimer's Disease-Associated Hypometabolism Highlights a Unique Donor, Ribosomal Proteins and Microglia. *eneuro* vol. 7 ENEURO.0255–20.2020 (2020)

Thank you

Thank you for your continued support of the Krembil Centre for Neuroinformatics and CAMH. We hope you are proud of the difference you are making for mental health research and care, and for patients and their families. As we look toward the future, we see so much opportunity and hope because you are on this journey with us. Today, we can continue accelerating the growth and impact of the Krembil Centre—transforming into a global centre of excellence—and building the future of mental health together.



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