

Melisa Gumus, PhD

Computational Cognitive Neuroscientist
Department of Psychology, University of California Berkeley
Berkeley, California | melisa.gumus@berkeley.edu

Research Interests

The interplay of learning, memory, attention, and perception; multimodal neuroimaging techniques and computational models; aging & neurodegenerative diseases.

Education & Training

Postdoctoral Researcher in Cognitive Neuroscience, UC Berkeley **Sep 2025 – Present**

Supervisor: Dr. Mariam Aly
Project: How competition in memory-guided attention is resolved with learning experience

Visiting Research Fellow, University of Pennsylvania **Apr – June 2024**

Supervisor: Dr. Anna Schapiro
Project: Integrating anatomy in computational models to investigate individual differences in learning

PhD in Computational Cognitive Neuroscience, University of Toronto **2021 – 2025**

Supervisor: Dr. Michael L. Mack
PhD Thesis: Unraveling the cognitive and neural mechanisms of learning: the intricate interplay between learning, memory, and attention

MSc in Medical Science, University of Toronto **2018 – 2020**

Supervisor: Dr. Carmela Tartaglia
MSc Thesis: Identifying clinical subtypes of patients with post-concussion syndrome: evaluating brain behaviour relationship with a computational approach

Honours BSc with Distinction, University of Toronto **2014 – 2018**

Majors: Neuroscience & Mathematics | Minor: Physiology
Supervisor: Dr. Frances Skinner
BSc Thesis: Analyzing microcircuit models to help explain theta rhythm generation in the hippocampus

Research in Industry

Research Analyst in R&D, Cambridge Cognition (Winterlight Labs) **2021 – 2024**

Supervisors: Drs. Jessica Robin & Francesca Cormack
Led independent research projects and collaborations; worked towards developing speech biomarkers for neurodegenerative and psychiatric diseases

Research Coordinator in Clinical Research Team, Winterlight Labs **2021**
Supervisors: Dr. Jessica Robin
Managed research projects including documentation and ethics approvals; recruited participants; administered assessments; supported the research team

Research in Academia

Research Trainee, University Health Network **2022 – 2025**
Supervisor: Dr. Mary Pat McAndrews
Led a MEG study on hippocampal hyperactivity in aging

Pedagogical Research Assistant, Human Biology, University of Toronto **Summer 2022**
Supervisor: Dr. Franco Taverna
Implemented innovative and educational technology to improve courses

Research Analyst, Tanz Centre for Research in Neurodegenerative Diseases **2020 – 2021**
Supervisor: Dr. Carmela Tartaglia
Led research projects in concussions and neurodegenerative diseases

Research Analyst & Coordinator, Krembil Research Institute **2020 – 2021**
Supervisor: Dr. Frances Skinner
Coordinated in vivo and vitro experimental work to develop computational models of brain rhythms in brain injury

Summer Research Student, Krembil Research Institute **2018**
Supervisor: Dr. Frances Skinner
Provided empirical evidence for how mathematical and biological microcircuit models of hippocampus CA1 are linked

Research Analyst, Department of Psychology, University of Toronto **2020 – 2021**
Supervisor: Dr. Michael Mack
Developing tools to characterize hippocampal pathways in humans

Lab Manager, Department of Psychology, University of Toronto **2017 – 2018**
Supervisor: Dr. Michael Mack
Managed implementation of research projects; oversaw lab maintenance; trained personnel; recruited participants.

Undergraduate Researcher, Research Experience in Complex Systems, UofT **2015 – 2018**
Supervisor: Dr. Brad Bass
Developed agent-based simulation of amyloid beta deposition in Alzheimer's Disease; supervised dozens of undergraduate students in agent-based simulation research

Awards

School of Graduate Studies Conference Grant \$610 funded by UofT to travel to CNS Annual Meeting in Boston	May 2025
Vanier Canada Graduate Scholarship \$150,000 funded by NSERC, the Government of Canada	2022 – 2025
The Best Talk Award at Krembil Research Day \$250 funded by Krembil Research Institute	Apr 2025
SfN Trainee Professional Development Award \$1,000 & free conference registration funded by the Society for Neuroscience	Oct 2024
Michael Smith Foreign Study Supplement \$6,000 funded on top of Vanier by NSERC, the Government of Canada Visit to Dr. Anna Schapiro's lab at UPenn	Apr-June 2024
University of Toronto Fellowship Top-Up Award \$3,000 funded by the University of Toronto for receiving Vanier	2022 – 2025
Departmental Top-Up Award \$500 funded by the Department of Psychology for receiving Vanier	2022 – 2025
Canada Graduate Scholarships - Doctoral program \$105,000 funded by NSERC, the Government of Canada Declined – Unable to hold with Vanier	May 2022
Ontario Graduate Scholarship \$15,000 funded by the Province of Ontario and University of Toronto	2019 – 2020
Top-up Award by Medical Science for Receiving OGS \$2,000 funded by the University of Toronto	2019 – 2020
Canadian Traumatic Brain Injury Research Consortium (CTRC) Training Grant \$8,750 + matching funding (Canada-wide competition)	2018 – 2019
Gordon Cressy Student Leadership Award Awarded for outstanding student leadership, service, and commitment to the university; mentored over 300 undergraduate and high school students in sciences and research during undergraduate.	2018

Publications

Gumus, M; Saghati, N.A; Mack, M.L. (In preparation). Distinct White Matter Networks Support Flexible Concept Formation.

Gumus, M; Dominguez, L.G; Zhao, W.J; Wennberg, R; Mack, M.L; Zotovic, J; Lanctôt, K.L; Black, S.E; McAndrews, M.P. (In preparation). Age Influence on Repetition Suppression Revealed in the Hippocampus with MEG.

- Gumus, M;** Sigh, D; Mack, M.L; Schapiro, A. (In preparation). Integrating Anatomy in Computational Models to Investigate Individual Differences in Learning.
- Gumus, M;** Lee, Z. Z. Y.; Mack, M. L. (2025; Under Review). Concept Learning Builds Behaviourally Relevant Attentional Templates (p. 2025.09.29.679121). bioRxiv. <https://doi.org/10.1101/2025.09.29.679121>.
- Gumus, M & Mack, M. L.** (2025; Under Review). Distinct contributions of hippocampal pathways in learning regularities and exceptions revealed by functional footprints (p. 2025.09.09.674568). bioRxiv. <https://doi.org/10.1101/2025.09.09.674568>.
- Gumus, M;** Bourganos, A; Mack, M.L. (2025; Under review). In vivo Quantification of White Matter Pathways in the Human Hippocampus (p. 2025.01.13.632268). bioRxiv. <https://doi.org/10.1101/2025.01.13.632268>.
- Gumus, M;** Koo, M; Bhan A; Robin, J; Black, S.E. (2024). Linguistic Changes in Neurodegenerative Diseases Relate to Clinical Symptoms. *Front. Neurol.* <https://doi.org/10.3389/fneur.2024.1373341>.
- Gumus, M;** DeSouza, D.D; Xu, M; Fidalgo, C; Simpson, W; Robin, J. (2023) Evaluating the Utility of Daily Speech Assessments for Monitoring Depression Symptoms. *Digital Health*. Doi: <https://doi.org/10.1177/20552076231180523>.
- Salwierz, P., Sumra, V., **Gumus, M.**, Lewin, W., Martinez, M., Patel, A., Salvo, C., Swinkin, E., Tartaglia, C., Tang-Wai, D. F., & Li, M. (2023). Improving Collaboration between Palliative care and Neurology: Focus on Patient, Family & Healthcare Provider Experience. *Alzheimer's & Dementia*, 19(S5), e060197. <https://doi.org/10.1002/alz.060197>.
- Sihag, S; Naze, S; Taghdiri, F; **Gumus, M;** Tator, C; Green, R; Colella, B; Blennow, K; Zetterberg, H; Dominguez, LG; Wennberg, R; Mikulis, D; Tartaglia M.C. (2022). Functional Brain Signals Constrained by Structural Brain Connectivity Reveal Cohort Specific Features for Serum Neurofilament Light Chain. *Nature Communications Medicine*, 2(1): 1-14. Doi: 10.1038/s43856-021-00065-5.
- Gumus, M;** Mack, M.L; Green, R; Khodadadi, M; Wennberg, R; Crawley, A; Colella, B; Tarazi, A; Mikulis, D; Tator, C; Tartaglia, M.C. (2022). Brain Connectivity Changes in Post-Concussion Syndrome as the Neural Substrate of a Heterogeneous Syndrome. *Brain Connectivity*. Doi: 10.1089/brain.2021.0127.
- Gumus, M;** Santos, A; Tartaglia, M.C. (2021). Diffusion and Functional Magnetic Resonance Imaging Findings and Their Relationship to Behaviour in Post-Concussion Syndrome: A Scoping Review. *JNNP*, 92(12): 1259-1270. Doi: 10.1136/jnnp-2021-326604.
- DeSouza, D.D; Robin, J; **Gumus, M;** Yeung, A. (2021). Natural Language Processing as an Emerging Tool to Detect Late-Life Depression. *Frontiers in Psychiatry*, 12:719125. Doi: 10.3389/fpsy.2021.719125.

- Schlichting, M.L; **Gumus, M**; Zhu, T; Mack, M.L. (2021). The structure of hippocampal circuitry relates to rapid category learning in humans. *Hippocampus*, 31(11): 1179-1190. Doi: 10.1002/hipo.23382.
- Chatzikalymniou, A.P; **Gumus, M**; Skinner, F.K. (2021). Linking minimal and detailed models of CA1 microcircuits reveals how theta rhythms emerge and how their frequencies are controlled. *Hippocampus*, 31(9): 982-1002. Doi: <https://doi.org/10.1002/hipo.23364>.
- Anastassiadis, C; Vasilevskaya, A; **Gumus, M**; Santos, A; Tartaglia, M.C. (2021). Fluid biomarkers of white matter hyperintensities in cerebrovascular disease and neurodegeneration: a systematic review protocol. *JBI Evidence Synthesis*, 19(9): 2464-2473. Doi: 10.11124/JBIES-20-00210.
- Gumus, M**; Multani, N; Mack, M.L; Tartaglia, M.C. (2021). Progression of Neuropsychiatric Symptoms in Young Versus Late Onset Alzheimer's Disease. *GeroScience*, 43(1): 213–223. Doi: 10.1007/s11357-020-00304-y.
- Taghdiri, F; **Gumus, M**; Algarni, M; Fasano, A; Tang-Wai, D; Tartaglia, M.C. (2020). Association Between Cerebrospinal Fluid Biomarkers and Age-related Brain Changes in Patients with Normal Pressure Hydrocephalus. *Scientific Reports*, 10(1), 9106. Doi: 10.1038/s41598-020-66154-y.
- Gumus, M**. (2018). Switching Sides in Alzheimer's Disease: Amyloid Beta Proteins as a Protector of The Brain. Review. *Journal of Undergraduate Life Sciences*, 12(1), 34-39.
- Gumus, M**; Ricci, A. L. (2017). Modelling Neurodevelopment, Neurodegeneration, and Amyloid Beta Aggregation in the Context of Alzheimer's Using COBWEB. *Journal of Student Science and Technology*, 10(2), 38-44.

Conference Talks

- Gumus, M**; Zhao, W.J; Lee, Z.Z.Y; Mack, M.L. Emergence of Attentional Templates in Concept Learning and the Underlying Neural Mechanisms. Bay Area Memory Meeting (BAMM!). UC Davis, Davis, California, United States. Sep 10, 2025.
- Gumus, M**; Zhao, W.J; Lee, Z.Z.Y; Mack, M.L. Emergence of Attentional Templates in Concept Learning and the Underlying Neural Mechanisms. Toronto Area Memory Group (TAMeG). Toronto, Ontario, Canada. May 27, 2025.
- Gumus, M**; Dominguez, L.G; Zhao, W.J; Wennberg, R; Mack, M.L; Zotovic, J; Lanctôt, K.L; Black, S.E; McAndrews, M.P. Age influence on repetition suppression revealed in the hippocampus with MEG. Krembil Research Day. Toronto, Ontario, Canada. April 24, 2025.
Best Talk Award!

- Gumus, M;** Lee, Z.Z.Y; Mack, M.L. Category learning builds behaviourally relevant attentional templates. 2024 Annual Meeting for Society for Neuroscience (SfN). Chicago, Illinois, United States. October 5-9, 2024.
- Gumus, M & Mack, M.L.** Learning regularities and exceptions are supported by distinct hippocampal pathways as revealed by diffusion-weighted functional footprints. Context and Episodic Memory Symposium (CEMS). Philadelphia, Pennsylvania, United States. May 30-31, 2024.
- Gumus, M;** Koo, M; Bhan, A; Robin, J; Black, S.E. Speech changes in neurodegenerative diseases relate to clinical outcomes. Alzheimer's Association International Conference (AAIC). Amsterdam, Netherlands. July 16-20, 2023.
- Gumus, M;** Mack, M.L. Distinct hippocampal contributions to the rapid learning of category exceptions. 2022 Annual Meeting for Society for Neuroscience (SfN). San Diego, California, United States. November 12-16, 2022.
- Gumus, M;** Mack, M.L; Green, R; Tartaglia, M.C. Precision-medicine in post-concussion syndrome using computational models. Canadian Traumatic Brain Injury Research Consortium (CTRC) Scientific Meeting. Lake Louise, Alberta, Canada. January 22nd – 24th, 2020.
- Gumus, M;** Precision-Medicine in Post-Concussion Syndrome Using Computational Models. Tanz- CRND Seminar Series. Toronto, Ontario, Canada. December 5th, 2019.
- Gumus, M;** Identifying Clinical Subtypes of Patients with Post-Concussion Syndrome Using Computational Models. Krembil Neuroimaging Rounds. Toronto, Ontario, Canada. October 8th, 2019.
- Gumus, M;** Mack, M.L; Green, R; Tartaglia, M.C. Clinical subtypes of post-concussion syndrome: evaluating the relationship between subject specific structural-functional connectomes and cognitive/neuropsychological measures. Canadian Traumatic Brain Injury Research Consortium (CTRC) Scientific Meeting. Niagara-on-the-Lake, Ontario, Canada. June 12 – 14, 2019.
- Gumus, M.** Evaluating the Relationship between Subject Specific Functional-Structural Connectomes and Cognitive Measures in Patients with Post-Concussion Syndrome. Krembil Research Day. Toronto, Ontario, Canada. May 15, 2019.
- Gumus, M;** Mack, M.L; Green, R; Tartaglia, M.C. Evaluating Brain-Behaviour Relationship in Post-Concussion Syndrome with Computational Models. The Institute of Medical Science Research Day. Toronto, Ontario, Canada. May14, 2019.
- Gumus, M;** Mack, M.L; Green, R; Tartaglia, M.C. Evaluating the Relationship between Subject Specific Functional-Structural Connectomes and Cognitive Measures in Patients with Post-Concussion Syndrome. Neurosciences and Mental Health Symposia. Toronto, Ontario, Canada. March 21st, 2019.

Gumus, M; Mack, M.L; Green, R; Tartaglia, M.C. Constructing Patient Specific Functional and Structural Connectomes of Former Professional Athletes with Multiple Concussions to Explain Brain-Behavior Relationship. Canadian Traumatic Brain Injury Research Consortium (CTRC) Scientific Meeting. Lake Louise, Alberta, Canada. January 23rd – 25th, 2019.

Poster Presentations

Gumus, M; Zhao, W.J; Lee, Z.Z.Y; Mack, M.L. Emergence of Attentional Templates in Concept Learning and the Underlying Neural Mechanisms. Cognitive Neuroscience Society (CNS) Annual Meeting. Boston, Massachusetts, United States. May 27, 2025.

Gumus, M; Saghati, N.A; Mack, M.L. Learning exceptions to category rules is supported by distinct white matter networks. Cognitive Neuroscience Society (CNS) Annual Meeting. Toronto, Ontario, Canada. April 13-16, 2024.

Gumus, M; Lee, Z.Z.Y; Mack, M.L. Category learning builds behaviourally relevant attentional templates. 2024 Annual Meeting for Society for Neuroscience (SfN). Chicago, Illinois, United States. October 5-9, 2024. **Trainee award session!**

Gumus, M & Mack, M.L. Learning regularities and exceptions are supported by distinct hippocampal pathways as revealed by diffusion-weighted functional footprints. 2023 Annual Meeting for Society for Neuroscience (SfN). Washington, DC, United States. November 11-15, 2023.

Gumus, M; Koo, M; Bhan, A; Robin, J; Black, S.E. Speech changes in neurodegenerative diseases relate to clinical outcomes. Alzheimer's Association International Conference (AAIC). Amsterdam, Netherlands. July 16-20, 2023.

Gumus, M; Bourganos, A; Mack, M.L. Human Hippocampal White Matter Pathways and Their Relation to Cognition. Organization for Human Brain Mapping (OHBM) Annual Meeting. Montreal, Quebec, Canada. July 22nd– 26th, 2023.

Gumus, M; Mack, M.L. Hippocampus Engagement Early in Learning Supports Concept Formation. Annual Meeting of the Cognitive Science Society (CogSci). Toronto, Ontario, Canada. July 27-30, 2022.

Gumus, M; Bourganos, A; Mack, M.L. Quantifying Hippocampal Circuitry in Humans. Organization for Human Brain Mapping (OHBM) Annual Meeting. Glasgow, Scotland. June 19th – 24th, 2022.

DeSouza, D.D; **Gumus, M;** Fidalgo, C; Simpson, W; Robin, J. Characterizing depressive symptom fluctuations using automated speech assessments: a remote feasibility study. The International Society for CNS Clinical Trials and Methodology (ISCTM) Annual Meeting. Washington, DC, United States. February 23rd – 25th, 2022. ***Best poster award!**

Gumus, M; Zhu, T; Schlichting, M.L; Mack, M.L. Hippocampal white matter microstructure predicts rapid category learning. 2019 Annual Meeting for Society for Neuroscience (SfN). Chicago, Illinois, United States. October 19-23, 2019.

Chatzikalymniou, A. P; **Gumus, M;** Skinner, F.K. Translating mechanisms of theta rhythm generation from simpler to more detailed network models. 2019 Annual Computational Neuroscience (CNS) Meeting. Barcelona, Spain. July 13-17, 2019.

Gumus, M; Mack, M.L; Green, R; Tartaglia, M.C. Evaluating the Relationship between Subject Specific Functional-Structural Connectomes and Cognitive Measures in Patients with Post-Concussion Syndrome. Collaborator Program in Neuroscience (CPIN) Research Day. Toronto, Ontario, Canada. June 5, 2019.

Gumus, M; Mack, M.L; Green, R; Tartaglia, M.C. Evaluating the Relationship between Subject Specific Functional-Structural Connectomes and Cognitive Measures in Patients with Post-Concussion Syndrome. Krembil Research Day. Toronto, Ontario, Canada. May 15, 2019.

Gumus, M. (2017). The Role of Retinoic Acid and EGF in Cell Growth, Poster. HMB310 Neuroscience Lab Course, University of Toronto

Gumus, M*; Ricci, A.L*; El-Kurdi, M; Li, V; Agapova V. The Brain on COBWEB; A Hierarchy, Revisited. ROP299 Poster Fair, University of Toronto. March 2016. (*equal contributions)

Invited Talks

Gumus, M; Mack, M.L. Unraveling the cognitive and neural mechanisms underlying the interplay of learning, memory, and attention. Cognition Colloquium, UC Berkley. Sep 30, 2025. Invited by Dr. Mariam Aly.

Gumus, M; Mack, M.L. Comprehensive understanding of learning process. Temple University, Philadelphia, Pennsylvania. June 11, 2024. Invited by Dr. Nora Newcombe.

Gumus, M; Mack, M.L. Comprehensive understanding of learning process. University of Pennsylvania, Philadelphia, Pennsylvania. May 30, 2024. Invited by Dr. Anna Schapiro.

Gumus, M. Repetition suppression in older adults. University Health Network, University of Toronto, Toronto. April 5, 2024. Invited by Dr. Mary Pat McAndrews.

Gumus, M. Complex dynamic interactions: synergies between ABM and QCA. Leiden, Netherlands. April 19th-22nd 2022. Team modelled opinion dynamics on long COVID.

Teaching Experience

Course Instructor

PSY372 Fall 2024 – Human Memory, University of Toronto

2024

HMB440 Winter 2024 – Dementia, University of Toronto	2024
PSY372 Fall 2023 – Human Memory, University of Toronto	2023

Guest Lecturer

HMB490 Full Year – Health in Community, University of Toronto	2021 – 2023
HMB440 Winter – Dementia, University of Toronto	2019, 2020, & 2021
Advanced Placement AP Neuroscience – Bloor Collegiate Institute	2018

Teaching Assistant – Undergraduate Level

PSY424 Winter – Social Psychology of Interpersonal Relationships, UofT	2022 & 2023
HMB490Y Full Year – Health in Community, University of Toronto	2021 – 2023
PSY270 Winter – Cognitive Psychology, University of Toronto	2022 & 2023
HMB422 Summer – Seminar in Health & Disease, University of Toronto	2022
PSY210 Fall – Statistics I, University of Toronto	2021
HMB200 Summer – Introduction to Neuroscience, University of Toronto	2020
HMB440 Winter – Dementia, University of Toronto	2019 & 2020

Teaching Assistant – Graduate Level

MSC1090 Fall – Introduction to Computational Biostatistics, UofT	2019, 2021, & 2022
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Research Supervision – High School Level

The Foundation of Student and Science Research Co-op Program	2016 – 2019
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Research Supervision

Only a few research trainees listed here

Wen Jia (Michelle) Zhao	2023 – 2025
Work-study, Research Opportunity Program, Undergraduate Thesis, UofT	
Project: Contribution of resting state connectivity of hippocampal-cortical regions to learning	
Zoey Lee	2023 – 2025
Work-study, Independent Research Program, UofT	
Project: Behavioural indexing of attentional templates in learning	
Sima Buchnak	2023 – 2024
Undergraduate Research Thesis, UofT	
Project: Quantifying hippocampal-cortical white matter connections	
Julia Do	
Independent Research Program, UofT	2023 – 2024
Project: Attentional processed in episodic memory and concept learning	
Athanasios Bourganos	2022 – 2023
Full time research assistant	

Projects: Attention shift in learning with eye-tracking, web development for hippocampal circuit project, 2D vs 3D stimuli in learning and perception

Nahal Alizadeh Saghati	2021 – 2022
Independent Research Program	
Project: Whole brain tractography for understanding individual differences in concept learning	
Alexandra Santos	2019 – 2020
Full time research assistant	
Project: Scoping review of brain changes in post-concussion syndrome	
Teresa Zhu	Summer 2018
NSERC - Undergraduate Student Research Awards	
Project: Developing a technique to measure hippocampal connectomes	

Conference & Talk Organization

Bay Area Memory Meeting (BAMM!), UC Davis	2025
Organizer – conference planning	
Ebbinghaus Empire Talk Series, University of Toronto	2023 – 2024
Co-Organizer of talk series at the Department of Psychology	
Cognitive Neuroscience Society (CNS) Conference, Toronto	2024
Volunteer – facilitation of conference activities	
Cognitive Science Society (Cog Sci) Conference, Toronto	2022
Volunteer – facilitation of conference activities	

Science Mentorship & Outreach

Industry Career Mentor for Graduate Students	2023 – 2024
IMS Mentorship Program, Faculty of Medicine, University of Toronto	
Mentorship for High School Students with Indigenous and African ancestry	2019
Summer Mentorship Program, Faculty of Medicine, University of Toronto	
Co-Founder & Co-President of a club, advocating science and research on campus	2017 – 2019
The Foundation for Student Science and Technology - U of T Chapter	
Research Opportunity Program Peer Research Advisor	2016 – 2017
Research Opportunity Program, University of Toronto	
Trinity One Mentor, assisting students with scientific literacy, debates, research	2015 – 2017
Biomedical Health Stream, Trinity One Program, University of Toronto	

Workshop Organizer in STEM, advocating science through agent-based simulations University Research Experience in Complex Systems, University of Toronto	2015 – 2018
Mentor for incoming students to help with their transition to university University College e-Mentorship Program, University of Toronto	2015 – 2016
Event Planner, advocating mental health awareness through social events Campaign for Community, University of Toronto	2015

Technical Skills

Techniques: behavioural index, diffusion imaging, fMRI, MEG, eyetracking, computational models.

Neuroimage processing: FSL, Freesurfer, ANTs, MRtrix, C-PAC, FMRIPrep, MRIQC.

Programming: R, Matlab, Python, Bash, High Performance Computing, Git and version control.

Professional Membership

Cognitive Neuroscience Society (CNS)	2024 – 2025
Society for Neuroscience (SfN)	2019 & 2022 – 2024
Organization for Human Brain Mapping (OHBM)	2022 – 2023
Alzheimer's Disease Neuroimaging Initiative (ADNI)	2017 – 2020
Collaborative Program in Neuroscience (CPIN), University of Toronto	2018 – 2020