

Filip Morys, PhD

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Education

- 2013-2019** **PhD student/researcher**
Integrated Research and Treatment Center Adiposity Diseases, Leipzig University Medical Center;
Max Planck Institute for Human Cognitive and Brain Sciences, Decision-making in obesity: neurobiology,
behavior and plasticity group (Dr. Annette Horstmann), Leipzig, Germany
PhD thesis: Characterising and altering maladaptive behaviours and tendencies in obesity
- 2011-2013** **Master's Degree**
International Graduate Program Medical Neurosciences; final grade: 1.9¹
Charité – Medical University, Berlin, Germany
Master's thesis: Decoding task sets from human brain activity
- 2008-2011** **Bachelor's Degree**
Neurobiology; final grade: 5,0²
Jagiellonian University, Cracow, Poland
Bachelor's thesis: Neuropsychology of prospective memory
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Professional experience

- 2019-currently** **Postdoctoral fellow**
Montreal Neurological Institute, McGill University, Montreal, Canada
- 2018-2020** **Research Scientist**
CodersFirst, Warsaw, Poland.
Development of cognitive and personality testing for IT recruitment
- 2012-2013** **Research master's thesis**
Bernstein Center for Computational Neuroscience, Laboratory of Theory and Analysis of Large-Scale
Brain Signals (Prof. Dr. John-Dylan Haynes); Berlin, Germany
- 2012** **Laboratory Rotation**
Dahlem Institute for Neuroimaging of Emotions (Prof. Dr. Felix Blankenburg); Berlin, Germany
- 2012** **Laboratory Rotation**
Charité – Medical University Berlin, Working Group Cognition, Ageing, Neurorehabilitation (Prof.
Dr. Agnes Flöel); Berlin, Germany
- 2010** **Internship**
Nencki Institute for Experimental Biology, Laboratory of Preclinical Studies for Neurodegenerative
Diseases (Prof. Dr. Grazyna Niewiadomska); Warsaw, Poland
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¹ Results graded on a normalised scale from 1,0 – 'very good' ,to 5,0 – 'insufficient'

² Results graded on a normalised scale from 2,0 – 'insufficient' ,to 5,0 – 'very good'

Academic service & outreach

2023	Associate Editor – Journal of Alzheimer’s Disease
2020-2022	Secretary of the Student and Postdoc Special Interest Group of the Organization for Human Brain Mapping
2020-currently	Member of the Postgraduate Student Society Equity and Diversity Committee
2020-currently	Organization for Human Brain Mapping meeting abstract reviewer
2021	Organization for Human Brain Mapping Annual Meeting organizer and moderator of workshops and symposia of the Student and Postdoc Special Interest Group
2020	Neuromatch 2.0 Conference organization and abstract reviewer
2016-2018	Member of the Data Quality Assurance Team in the Neurology Department at the Max Planck Institute for Human Cognitive and Brain Sciences; Leipzig, Germany
2017	Organisation of International Research Training Group Autumn School, Leipzig, Germany
2012-2015	Writer and editor of the Charité Neuroscience Newsletter, a quarterly magazine devoted to newest topics in neuroscience
2012-2013	Creator of a handbook of Medical Neurosciences for future students
2011	Organization of the International Brain Research Organization Neuroscience Forum <i>Neuronus</i> , Jagiellonian University; Cracow, Poland

Awards & Honours

2023	Society for the Study of Ingestive Behavior New Investigator Travel Award for the project: ‘Influence of obesity and MAPT/ApoE genotypes on brain structure and cognition’ – 500 USD
2022	Relève étoile Jacques Genest award for best publication – 1,000 CAD
2022	Lewis Reford Travel Award, Montreal Neurological Institute – 1,500 CAD
2021	Harry R. Kissileff award for the best short oral presentation at the Annual Meeting of the Society for the Study of Ingestive Behavior
2020	Lewis Reford Travel Award, Montreal Neurological Institute – 1,500 CAD
2018	Research Academy Leipzig Travel Grant – 715 EUR
2017	Grant: Understanding the contribution of hemispheric asymmetry to overeating behaviour in obesity. PIs: Dr. Lienneke Janssen, Dr. Annette Horstmann. German Federal Ministry of Education and Research. Role: Conceptualisation of the proposed project.
2017	Research Academy Leipzig Travel Grant – 135 EUR
2017	Society for the Study of Ingestive Behavior New Investigator Travel Award for the project: ‘Neural correlates of retraining automatic action tendencies in obesity’ – 1,000 USD
2017	German Obesity Society best poster award for the project: ‘Neural correlates of retraining automatic action tendencies in obesity’ – 500 EUR
2014	Travel grant and stipend to attend Obesity Summer Bootcamp 2014 – Leipzig University – 3,000 EUR
2012/2013	Fellowship for up-and-coming scientists by the NeuroCure Cluster of Excellence; Berlin, Germany – 11,000 EUR

Teaching

2018	fMRI analysis with SPM. Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany, 2018-09 — 2018-10.
2015	Maladaptive plasticity in behavioral disorders and addictions. Lecture. Berlin School of Mind and Brain, Humboldt University Berlin, Germany, 2015-10-06 — 2015-10-08.

Invited talks

2023	<i>Neural correlates of obesity across the lifespan.</i> Centre Hospitalier Universitaire Sainte-Justine. Montreal, Canada.
2021	<i>Navigating academic career after PhD.</i> Alumni talk series. Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany.
2020	<i>Influence of metabolic syndrome on brain and cognition.</i> Modern Diet and Physiology Research Center, Yale University, New Haven, USA.
2019	<i>Does intranasal insulin administration preserve cognitive function after cardiac surgery?</i> MRI aspect of the study at the McGill University Medical Centre

Supervision and mentoring

2023	Mayuri Maheswaran (graduate, MSc program)
2023	Karl Wennberg (research assistant)
2023	Max Tweedale (undergraduate)
2022	Yuxin Zhou (undergraduate)
2022	Elena Ock (undergraduate)
2021-2022	Jessica Yu (graduate, MSc program)
2020-2023	Mari Shishikura (graduate, PhD program)
2017	Christina Breil (undergraduate)
2014	Parniane Arbab-Zadeh (undergraduate)
2014	Maram Amara (undergraduate)
2014	Mailin Krüger (undergraduate)

Funding

2023	<i>Funded:</i> Advanced MRI measures of obesity-related brain damage. <i>McConnell Brain Imaging Centre Collaboration Program FY24</i> Budget: CAD 25,000 PI: Alain Dagher Co-Applicants: Filip Morys, Claudine Gauthier, Christine Tardif McConnell Brain Imaging Centre Collaboration Program FY24 Contributions: Study conceptualisation, study design, grant writing
2023	<i>Submitted:</i> Effects of GLP1-agonist induced weight loss on brain, metabolic, and cerebrovascular health measures. <i>Canadian Institutes of Health Research. Project Grant Fall 2023.</i> Budget requested: CAD 1,780,000 PI: Alain Dagher Co-Applicants: Filip Morys, Stephanie Fulton, Claudine Gauthier, Christine Tardif, Yashar Zeighami, Xiao Wen Hu, Bratislav Misic, Michael Tsoukas Contributions: Study conceptualisation, study design, grant writing
2022-2023	Fonds de Recherche Quebec – Santé Postdoctoral Fellowship Budget: CAD 90,000

Publications

1. **Morys F**, Yu E, Shishikura M, Paquola C, Vainik U, Nave G, Koellinger P, Gan-Or Z, Dagher A. Neuroanatomical Correlates of Genetic Risk for Obesity in Children. *Translational Psychiatry*. 2023.
2. **Morys F**, Potvin O, Zeighami Y, Vogel J, Lamontagne-Caron R, Duchesne S, Dagher A. Obesity-Associated Neurodegeneration Pattern Mimics Alzheimer's Disease in an Observational Cohort Study. *Journal of Alzheimer's Disease*. 2023.
3. Yu J, **Morys F**, Dagher A, Lajoie A, Gomes T, Ock E, Kimoff RJ, Kaminska M. Associations between sleep-related symptoms, obesity, cardiometabolic conditions, brain structural alterations and cognition in the UK biobank. *Sleep Medicine*. 2023.
4. Hartmann H, Janssen L, Herzog N, **Morys F**, Fängström D, Fallon SJ, Horstmann A. Self-reported intake of high-fat and high-sugar diet is not associated with cognitive stability and flexibility in healthy men. *Appetite*. 2023.
5. **Morys F***, Shishikura M*, Dagher A. Population-based research in obesity – an overview of neuroimaging studies using big data approach. *Current Opinion in Endocrine and Metabolic Research*. 2022.
6. Yang Y, Qi L, **Morys F**, Wu Q, Chen H. Food-specific inhibition training for food devaluation: A meta-analysis. *Nutrients*. 2022
7. García-García I, Michaud A, María-Jurado Á, Dagher A, **Morys F**. Mechanisms linking obesity and its metabolic comorbidities with cerebral grey and white matter changes. *Reviews in Endocrine and Metabolic Disorders*. 2022.
8. **Morys F***, Poessel M*, Breuer N*, Villringer A, Hummel T, Horstmann A: Brain response to food odors is not associated with body mass index and obesity-related metabolic health measures. *Appetite*. 2022.
9. Yang Y, **Morys F**, Wu Q, Li J, Chen H. Pilot study of food-specific go/no-go training for overweight individuals: brain imaging data suggest inhibition shapes food evaluation. *Social Cognitive and Affective Neuroscience*. 2021.
10. Yang Y, Wu Q, **Morys F**. Brain Responses to High-Calorie Visual Food Cues in Individuals with Normal-Weight or Obesity: An Activation Likelihood Estimation Meta-Analysis. *Brain Sciences*. 2021.
11. Beyer F, Horn K, Frenzel S, Hofer E, Knol MJ, **Morys F**, Vainik U, Auwera S Van der, Wittfeld K, Saba Y, et al.: Investigating the genetic and environmental basis of head micromovements during MRI. *bioRxiv*. 2021.
12. **Morys F***, Garcia-Garcia I*, Neseliler S*, Dadar M, Yau Y, Scala S et al. Relationship between impulsivity, uncontrolled eating and body mass index: a hierarchical model. *International Journal of Obesity*. 2021.
13. **Morys F**, Dadar M, Dagher A. Association between mid-life obesity, its metabolic consequences, cerebrovascular disease and cognitive decline. *Journal of Clinical Endocrinology and Metabolism*. 2021.
14. Tremblay C, Rahayel S, Vo A, **Morys F**. et al. Brain atrophy progression in Parkinson's disease is shaped by connectivity and local vulnerability. *Brain Communications*. 2021.
15. **Morys F**, Dagher A. Metabolic syndrome increases COVID-19-related mortality in the UK Biobank sample. *Frontiers in Endocrinology*. 2021.
16. Park B, Park H, **Morys F**, Kim M, Byeon K, Lee H et al. Body mass variations relate to fractionated functional brain hierarchies. *Communications Biology*. 2020
17. **Morys F**, García-García I, Dagher A. Is obesity related to enhanced neural reactivity to visual food cues? A review and meta-analysis. *Social Cognitive and Affective Neuroscience* 2020.
18. García-García I, **Morys F**, Michaud A, Dagher A. Food addiction, skating on thin ice. A critical overview of neuroimaging findings. *Current Addiction Reports*. 2020.
19. Park B, Byeon K, Lee MJ, Chung CS, Kim SH, **Morys F** et al. Whole-brain functional connectivity correlates of obesity phenotypes. *Human Brain Mapping*. 2020.
20. **Morys F**, Simmank J, Horstmann A. DRD2/ANKK1 Taq1A but not COMT single nucleotide polymorphisms contribute to the link between temporal impulsivity and obesity in men. *bioRxiv*. 2020.
21. **Morys F***, García-García I*, Dagher A. Nucleus accumbens volume is related to obesity measures in an age-dependent fashion. *Journal of Neuroendocrinology*. 2019.
22. **Morys F**, Janssen LK, Cesnaite E, Beyer F, Garcia-Garcia I, Kube J et al. Hemispheric asymmetries in resting-state EEG and fMRI are related to approach and avoidance behaviour, but not to eating behaviour or BMI. *Human Brain Mapping*. 2019.
23. **Morys F***, Mehl N*, Villringer A, Horstmann A. Unhealthy yet avoidable — how cognitive bias modification alters behavioral and brain responses. *Nutrients*. 2019.
24. Oliva R, **Morys F**, Horstmann A, Castiello U, Begliomini C. The impulsive brain: Neural underpinnings of binge eating behavior in normal-weight adults. *Appetite*. 2019.

25. García-García I, Kube J, **Morys F**, Schrimpf A, Kanaan ASAS, Gaebler M et al. Liking and left amygdala activity during food versus nonfood processing are modulated by emotional context. *Cognitive Affective and Behavioral Neuroscience*. 2019.
26. Oliva R, **Morys F**, Horstmann A, Castiello U, Begliomini C. Characterizing impulsivity and resting-state functional connectivity in normal-weight binge eaters. *International Journal of Eating Disorders*. 2019.
27. **Morys F***, Lammert M*, Hartmann H, Janssen LK, Horstmann A. MIS – A new scoring method for the operation span task that accounts for Math, remembered Items and Sequence. *PsyArXiv*. 2019.
28. **Morys F**, Bode S, Horstmann A. Dorsolateral and medial prefrontal cortex mediate the influence of incidental priming on economic decision making in obesity. *Scientific Reports*. 2018.

* Shared first authorship

Oral presentations

1. **Morys F.**, Liu L., Senkevich K., Tremblay C., Rahayel S., Gan-Or Z., Dagher A. (2023). Influence of obesity and MAPT/ApoE genotypes on brain structure and cognition. Talk presented at the Annual Meeting of the Society for the Study of Ingestive Behavior, Portland, Oregon, USA. 11-07-2023 – 15-07-2022.
2. **Morys F.**, Shishikura M., Tremblay C., Hansen J., Misić B., Dagher A. (2022). Neuromolecular underpinnings of human obesity. Talk presented at the Annual Meeting of the Society for the Study of Ingestive Behavior, Porto, Portugal. 12-07-2022 – 17-07-2022.
3. Yu, J., **Morys, F.**, Dagher, A., Kaminska, M. (2021). Associations between sleep-disordered breathing, brain structure and cognitive decline in obesity. Talk presented at the Quebec Respiratory Health Research Network Meeting (virtual). 10-11-2021 – 11-11-2021.
4. **Morys, F.**, Yu, E., Shishikura, M., Vainik, U., Gan-Or, Z., Dagher A. (2021). Cortical thickness, volume, and white matter's fractional anisotropy confer genetic risk for obesity in adolescence. Talk presented at the Annual Meeting of the Society for the Study of Ingestive Behavior (virtual). 12-07-2021 – 16-07-2021.
5. Tremblay C., Rahayel S., Vo A., **Morys F.**, Shafiei G., Markello R.D., Misić B., Dagher A. (2021). Virtual histology of brain atrophy progression in de novo Parkinson's disease. Talk presented at the 15th International Conference on Alzheimer's & Parkinson's Diseases, Virtual Conference.
6. Tremblay C., Rahayel S., Vo A., **Morys F.**, Shafiei G., Markello R., Misić B., Gan-Or Z., Dagher A. (2021). Progression of brain atrophy in Parkinson's disease is shaped by connectome architecture and local vulnerability. Talk presented at the International Congress of Parkinson's Disease and Movement Disorders Virtual Conference (Top abstract).
7. **Morys, F.**, Dadar, M., Dagher, A. (2020). Obesity impairs cognitive function via metabolic syndrome and cerebrovascular disease: an SEM analysis in 15,000 adults from the UK Biobank. Talk presented at a virtual conference: Brain Plasticity - Influences of Lifestyle and Aging, organized by the Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany. 12-10-2020 – 13-10-2020.
8. **Morys, F.**, Dagher, A. (2020). The relationship between BMI and volume of subcortical structures is age-dependent. Talk presented at the 2020 Organization for Human Brain Mapping Annual Meeting (virtual). 26-06-26 - 2020-06-30.
9. **Morys, F.** (2020). Influence of metabolic syndrome on brain and cognition. Talk presented at the Modern Diet and Physiology Research Center, Yale University. 19-05-2020.
10. Horstmann, A., Mehl, N., **Morys, F.**, & Villringer, A. (2018). Cognitive bias modification alters behavioral and brain responses to food cues in obesity. Talk presented at 51. Congress of the German Psychological Society. Frankfurt a.M., Germany. 2018-09-15 – 2018-09-20.
11. Mehl, N., **Morys, F.**, Villringer, A., & Horstmann, A. (2018). Veränderung automatischer Verhaltenstendenzen bei Adipositas – Was passiert im Gehirn? Talk presented at the 6th Scientific Congress of the German Society for Eating Disorders. Munich, Germany. 2018-03-01 - 2018-03-03.
12. **Morys, F.**, & Horstmann, A. (2017). Dorsolateral and medial prefrontal cortex mediate influence of incidental priming on economic decisions in obesity. Talk presented at 25th Annual Meeting of the Society for the Study of Ingestive Behavior; Montréal, QC, Canada. 2017-07-18 – 2017-07-22.

13. Mehl, N., **Morys, F.**, Villringer, A., Horstmann, A. (2017). 'Neural correlates of retraining automatic action tendencies in obesity'. Talk presented at 25th Annual Meeting of the Society for the Study of Ingestive Behavior; Montréal, QC, Canada. 2017-07-18 — 2017-07-22.
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Poster presentations

1. **Morys F.**, Liu L., Senkevich K., Tremblay C., Rahayel S., Gan-Or Z., Dagher A. (2023). Influence of obesity and MAPT/ApoE genotypes on brain structure and cognition. Poster presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting. Montreal, Canada.
2. Shishikura M., **Morys F.**, Dagher A. (2023). Link between brain structure and genetic predisposition for risky and impulsive behavior in children. Poster presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting. Montreal, Canada.
3. Pastor-Bernier A., Savadjiev P., Poline JB., St-Onge E., Zhang F., O'Donnell LJ., Pasternak O., Gan-Or Z., **Morys F.**, Dagher A. (2023) Influence of body mass index on white matter structure. Poster presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting. Montreal, Canada.
4. **Morys F.**, Shishikura M., Tremblay C., Hansen J., Misić B., Dagher A. (2022). Neuromolecular underpinnings of human obesity. Poster presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting. Glasgow, UK
5. Shishikura, M., **Morys, F.**, Yu, E., Dagher, A. (2022). Differentiating subgroups in overweight and obese children using data-driven clustering approach with brain imaging data. Poster presented at the Annual Meeting of the Society for the Study of Ingestive Behavior, Porto, Portugal.
6. Kaminska, M., Yu, J., **Morys, F.**, Ock, E., Lajoie, A., Dagher, A. (2022). Associations between hypersomnolence, obesity, brain health and cognitive decline. Poster presented at the American Thoracic Society meeting.
7. Kouchache, T., Khundrakpam B. S., Vainik, U., Tremblay, C., Kirschner, M., **Morys, F.**, Vo, A., Dagher, A. (2022) Brain regions associated with differences in polygenic risks scores for smoking in typical development. Poster presented at the Organization for Human Brain Mapping (OHBM) Annual Meeting. Glasgow, UK.
8. Kouchache, T., Khundrakpam B. S., Vainik, U., Tremblay, C., Kirschner, M., **Morys, F.**, Vo, A., Dagher, A. (2022) Brain regions associated with differences in polygenic risks scores for smoking in typical development. Poster presented at the Cognitive Neuroscience Society Annual Meeting. San Francisco, US.
9. Hartmann, H., Janssen, L., Herzog, N., **Morys, F.**, Fallon, S., Horstmann, A. (2021). Associations of dietary fat and sugar and bodyweight with dopamine dependent stability and flexibility of working memory representations. Poster presented at the Annual Meeting of the Society for the Study of Ingestive Behavior (virtual).
10. **Morys F.**, Yu E., Shishikura M., Gan-Or Z., Dagher A. (2021). Obesity genetic risk is related to weight gain via structural changes in the frontoparietal network. Poster presented at the 2021 Organization for Human Brain Mapping Annual Meeting (virtual).
11. Tremblay C., Rahayel S., Vo A., **Morys F.**, Shafiei G., Markello R.D., Misić B., Gan-Or Z., Dagher A. (2021). Atrophy Progression in Parkinson's Disease is Associated with Connectivity and Synaptic Activity. Poster presented at the 2021 Organization for Human Brain Mapping Annual Meeting (virtual).
12. Tremblay C., Rahayel S., Vo A., **Morys F.**, Shafiei G., Markello R.D., Dagher A. (2020). Connectome architecture influences brain atrophy progression in de novo Parkinson's disease. Poster presented at the Grand Challenges in Parkinson's Disease Virtual Conference.
13. **Morys, F.**, Dagher A. (2020). The relationship between BMI and volume of subcortical structures is age-dependent. Poster presented at the 2020 Organization for Human Brain Mapping Annual Meeting (virtual).
14. **Morys, F.**, Dadar M., Dagher A. (2020). Obesity impairs cognitive function via metabolic syndrome and cerebrovascular disease: an SEM analysis in 15,000 adults from the UK Biobank. Poster presented at a virtual conference: Brain Plasticity - Influences of Lifestyle and Aging, organized by the Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany.
15. Yau, Y., **Morys, F.**, Dagher, A. (2020). The Dynamics of Brain Connectivity at Rest Underpins Performance in Task. Poster presented at the 2020 Winter Conference on Brain Research, Big Sky, Montana, USA.
16. **Morys, F.**, Janssen, L., Cesnaite, E., Garcia-Garcia, I., Kube, J., Schrimpf, A., et al. (2018). Hemispheric bias in resting state EEG and fMRI is related to approach/avoidance behaviors, but not BMI. Poster presented at 2018 Organization for Human Brain Mapping Annual Meeting; Singapore.

17. **Morys, F.**, & Horstmann, A. (2017). Dorsolateral and medial prefrontal cortex mediate influence of incidental priming on economic decisions in obesity. Poster presented at 33rd Annual Conference of the German Association for the Study of Obesity; Potsdam, Germany.
 18. **Morys, F.**, Mehl, N., Horstmann, A., & Villringer, A. (2017). Neural correlates of cognitive bias modification in obesity. Poster presented at 33rd Annual Conference of the German Association for the Study of Obesity; Potsdam, Germany.
 19. **Morys, F.**, Simmank, J., & Horstmann, A. (2016). BMI mediates the relationship between temporal impulsivity and cognitive restraint in women. Poster presented at 32nd Annual Conference of the German Association for the Study of Obesity; Frankfurt, Germany.
 20. **Morys, F.**, Simmank, J., & Horstmann, A. (2016). BMI mediates the relationship between temporal impulsivity and cognitive restraint in women. Poster presented at 24th Annual Meeting of the Society for the Study of Ingestive Behaviour; Porto, Portugal.
 21. **Morys, F.**, Bode, S., Murawski, C., & Horstmann, A. (2015). Influence of incidental priming with visual and gustatory cues on intertemporal choice in obesity. Poster presented at LIMIOR — 1st Leipzig International Meeting for Interdisciplinary Obesity Research; Leipzig, Germany.
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Symposia

1. *Re-envisioning the future of academic training*. Organisers: Carolina Makowski, **Filip Morys**, Phoebe Thomson, Anne Bilot. Organization for Human Brain Mapping Annual Meeting 2022, Glasgow, United Kingdom.
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Ad-hoc reviewer

1. Appetite
 2. Journal of Alzheimer's Disease
 3. Aging and Disease
 4. The Lancet Regional Health – Western Pacific
 5. International Journal of Obesity
 6. Brain Imaging and Behavior
 7. Pediatric Obesity
 8. Human Brain Mapping
 9. Plos One
 10. Neuroimage
 11. Neurobiology of Aging
 12. Psychosomatic Medicine
 13. Scientific Reports
 14. Obesity
 15. Obesity Reviews
 16. Biological Psychology
 17. Neuroscience and Biobehavioral Reviews
 18. Wiley Interdisciplinary Reviews: Cognitive Science
 19. Cerebral Cortex
 20. Neurobiology of Stress
 21. International Journal of Environmental Research and Public Health
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Technical skills

Programming languages

- MATLAB, R, Python, SQL, Bash

Neuroimaging tools

- FSL, SPM, Nilearn, Nipype, Nibabel, AFNI, Tractoflow, fMRIPrep, FreeSurfer, CAT

Chosen statistical tools

- General linear model, generalized linear model, machine learning: LASSO regression, partial least squares analysis, principal component analysis, independent component analysis