Exeter College Oxford Summer Programme
Cognitive Neuroscience: From development to energetics

Course Description

This course aims to provide you with an understanding of the biological bases of behaviour; from development to degeneration and, to discuss different contributions to the impairment observed among different neuropathologies. Lastly, this course will provide you with new knowledge in potential therapeutics for social and cognitive disorders as well as current limitations in translational research. Cognitive neuroscience studies the biological processes that underlie human cognition, focused on the relation between brain structures, activity, and cognitive functions. Cognitive neuroscience is an interdisciplinary field as it combines elements from the molecular to the social fingerprints of psychology, physiology, and neuroscience. There have been several significant advances in our understanding of, and interesting research concerning, how the brain encodes cognitive processes; this provides us with a better understanding of certain brain pathologies such as Alzheimer's disease, Parkinson's disease and schizoaffective disorders. The significant advance in our understanding of brain–behaviour/cognition relationships is in part due to technological advances such as functional brain imaging and human brain recording.

Syllabus Overview

1. Brain development – cell types and origin
2. Cellular crosstalk – circuits development
3. What is cognitive neuroscience? Historical overview
4. Introduction to memory systems and amnesia
5. Medial temporal lobe and frontal lobes
6. Brain metabolism I: energy substrates and crosstalk
7. Methods in cognitive neuroscience: neuroimaging
8. Neural and synaptic plasticity: Hidden role of the mitochondria
9. Current issues in cognitive neuroscience: Translational research
10. Introduction to developmental cognitive neuroscience and neuropsychiatry
11. Social neuroscience
12. Brain metabolism: II: Nutritional therapeutics

The course comprises 12 lectures, 6 seminars, and 4 tutorials. It requires the students to read in advance to gain an understanding of the contents to be discussed. The course will help you to sharpen your analytical skills, improve your abilities to critically interpret primary scientific data, improve your confidence in academic debate, and develop your presentation skills. It will also give you a chance to learn to

write clearly and advocate ideas for our debates (tutorials). This course is suitable for students who have a strong interest in and curiosity about brain energy utilization, therapeutics, and behaviour. There are no prerequisites, and no previous knowledge of neuroscience is necessary, but some knowledge of human neurobiology and/or cellular biology would be an advantage. The course will require that you read in advance of each lecture and will aim to be interactive and stimulate you to debate the ideas presented.

Teaching Methods and Assessment

- 12 x 1.25hr Lectures (15hrs)

- 6 x 1.25hr Seminars (7.5hrs)

- 4 x 1.25hr Tutorials (5hrs)

Twice weekly lectures will present the key points of the topics. Students will be expected to have completed the readings before the relevant lecture. A weekly seminar will focus in-depth study of lecture themes and provide opportunities to read, interpret, discuss and critique scientific literature. In addition, students will be expected to give a short oral presentation on a particular primary research article relevant to the topics discussed in the course.

Assessments:
Final assessment: An essay of no more than 3,000 words (40%), a final three-hour written examination (40%), oral presentation (10%) and participation in seminar/tutorials discussions (10%).

Lecture Schedule:

<u>First Lecture: Brain development – cell types and origin</u>

Molnár, Z., Clowry, G. J., Šestan, N., Alzu'bi, A., Bakken, T., Hevner, R. F., ... & Kriegstein, A. (2019). New insights into the development of the human cerebral cortex. *Journal of anatomy*, *235*(3), 432-451.

Luhmann, H. J., Kanold, P. O., Molnár, Z., & Vanhatalo, S. (2022). Early brain activity: translations between bedside and laboratory. *Progress in neurobiology*, 102268.

<u>Lecture 2: Cellular crosstalk – circuits development</u>

Tau, G. Z., & Peterson, B. S. (2010). Normal development of brain circuits. *Neuropsychopharmacology*, *35*(1), 147-168.

Casey, B. J., Heller, A. S., Gee, D. G., & Cohen, A. O. (2019). Development of the emotional brain. *Neuroscience letters*, *693*, 29-34.

Matejuk, A., & Ransohoff, R. M. (2020). Crosstalk between astrocytes and microglia: an overview. *Frontiers in immunology*, *11*, 1416.

Lecture 3: What is cognitive neuroscience? Historical overview

Albright, T. D., Kandel, E. R., & Posner, M. I. (2000). Cognitive neuroscience. *Current opinion in neurobiology*, *10*(5), 612-624.

Grady, C. (2012). The cognitive neuroscience of ageing. *Nature Reviews Neuroscience*, *13*(7), 491-505.

Lecture 4: Introduction to memory systems and amnesia

Weiskrantz, L. (1987). Neuroanatomy of memory and amnesia: a case for multiple memory systems. *Human Neurobiology*.

Rolls, E. T. (2000). Memory systems in the brain. *Annual review of psychology*, *51*(1), 599-630.

Lecture 5: Medial temporal lobe and frontal lobes

Fellows, L. K. (2004). The cognitive neuroscience of human decision making: a review and conceptual framework. *Behavioral and cognitive neuroscience reviews*, *3*(3), 159-172.

Squire, L. R., & Wixted, J. T. (2011). The cognitive neuroscience of human memory since HM. *Annual review of neuroscience*, *34*, 259-288.

Lecture 6: Brain metabolism I: energy substrates and crosstalk

Owen, O. E., Morgan, A. P., Kemp, H. G., Sullivan, J. M., Herrera, M. G., & Cahill, G. J. (1967). Brain metabolism during fasting. *The Journal of clinical investigation*, *46*(10), 1589-1595.

Lecture 7: Methods in cognitive neuroscience: neuroimaging

Hyder, F., & Rothman, D. L. (2017). Advances in imaging brain metabolism. *Annual review of biomedical engineering*, *19*, 485-515.

Grist, J. T., McLean, M. A., Riemer, F., Schulte, R. F., Deen, S. S., Zaccagna, F., ... & Gallagher, F. A. (2019). Quantifying normal human brain metabolism using hyperpolarized [1–13C] pyruvate and magnetic resonance imaging. *Neuroimage*, *189*, 171-179.

Lecture 8: Neural and synaptic plasticity: Hidden role of the mitochondria

Mattson, M. P. (2007). Mitochondrial regulation of neuronal plasticity. *Neurochemical research*, *32*, 707-715.

Ben-Shachar, D., & Laifenfeld, D. (2004). Mitochondria, synaptic plasticity, and schizophrenia. *International review of neurobiology*, *59*, 273-296.

Lecture 9: Current issues in cognitive neuroscience: Translational research

Carter, C. S., Barch, D. M., Bullmore, E., Breiling, J., Buchanan, R. W., Butler, P., ... & Wykes, T. (2011). Cognitive Neuroscience Treatment Research to Improve Cognition in Schizophrenia II: developing imaging biomarkers to enhance treatment development for schizophrenia and related disorders. *Biological Psychiatry*, *70*(1), 7-12.

Cohen, J. D., & Insel, T. R. (2008). Cognitive neuroscience and schizophrenia: translational research in need of a translator. *Biological psychiatry*, *64*(1), 2-3.

Lecture 10: Introduction to developmental cognitive neuroscience and neuropsychiatry

Munakata, Y., Casey, B. J., & Diamond, A. (2004). Developmental cognitive neuroscience: progress and potential. *Trends in cognitive sciences*, *8*(3), 122-128.

Lishman, W. A. (1992). What is neuropsychiatry?. *Journal of Neurology, Neurosurgery, and Psychiatry*, *55*(11), 983.

Lecture 11: Social neuroscience

Cacioppo, J. T., & Cacioppo, S. (2013). Social neuroscience. *Perspectives on Psychological Science*, *8*(6), 667-669.

Lecture 12: Brain metabolism: II: Nutritional therapeutics

Schneider, N., & Garcia-Rodenas, C. L. (2017). Early nutritional interventions for brain and cognitive development in preterm infants: a review of the literature. *Nutrients*, *9*(3), 187.

Chinna-Meyyappan, A., Gomes, F. A., Koning, E., Fabe, J., Breda, V., & Brietzke, E. (2022). Effects of the ketogenic diet on cognition: a systematic review. *Nutritional Neuroscience*, 1-21.

General reading:

Broome, M., & Bortolotti, L. (2009). Psychiatry as cognitive neuroscience: Philosophical perspectives.

American Association for Research into Nervous and Mental Diseases, Squire, L. R., & Zola, S. M. (1997). Amnesia, memory and brain systems. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *352*(1362), 1663-1673.

Goldberg, E. (2009). *The new executive brain: Frontal lobes in a complex world*. Oxford University Press.

Glover, G. H. (2011). Overview of functional magnetic resonance imaging. *Neurosurgery Clinics*, *22*(2), 133-139.

Bertholet, A. M., Delerue, T., Millet, A. M., Moulis, M. F., David, C., Daloyau, M., ... & Belenguer, P. (2016). Mitochondrial fusion/fission dynamics in neurodegeneration and neuronal plasticity. *Neurobiology of disease*, *90*, 3-19.

Johnson, M. H., & De Haan, M. (2015). *Developmental cognitive neuroscience: An introduction*. John Wiley & Sons.

Wahl, D., Coogan, S. C., Solon-Biet, S. M., De Cabo, R., Haran, J. B., Raubenheimer, D., ... & Le Couteur, D. G. (2017). Cognitive and behavioral evaluation of nutritional interventions in rodent models of brain aging and dementia. *Clinical interventions in aging*, 1419-1428.

Gilbert-Jaramillo, J., Garcez, P., James, W., Molnár, Z., & Clarke, K. (2019). The potential contribution of impaired brain glucose metabolism to congenital Zika syndrome. *Journal of Anatomy*, *235*(3), 468-480.