

## **PS4089: Neural Basis of Episodic Memory**

**Semester 1, Tuesdays 11-1, Seminar Room**

James Ainge (jaa7), Room 1.63, ex. 2057

This module will give students an advanced understanding of how the brain enables us to remember the personal events and episodes that shape our lives. We will examine how studies from different fields including behavioural neuroscience, animal behaviour, cognitive psychology and neuroimaging are combined to examine the neural basis of this psychological process.

The aim of the course is to encourage you to think independently and critically evaluate research in this field. A further aim is to demonstrate how studies examining different levels of explanation from genes and single cells to groups of behaving animals and humans can be used to address the same theoretical question. This multidisciplinary approach is a real strength of the field and throughout the course we will see numerous examples of studies that when considered alone are interesting but when combined with studies tackling the issue from another perspective produce compelling support for theory.

At the end of this document I have included a list of transferable and generic skills that will be practised and demonstrated during the course.

### **Course structure**

The course will be split between seminar and lecture format. For seminars students will present articles and then we will have small group discussions to examine questions related to the articles. At the end of each session I will briefly summarise the main points, put the articles in context of the wider field and explain any particularly complicated concepts or methods that you will need to understand for the following week. Due to new university rules all lectures are compulsory and I will be taking attendance.

The majority of the articles I have chosen are cutting edge research that use modern neuroscience techniques to examine brain function. I will meet with the presenting students the week before their presentation to go over the main points of the paper and make sure that they understand the technical details. I will also give general advice about presenting skills.

It is vital that all students read all of the papers that will be presented each week before the session. I would encourage you to do this actively. As you are reading think about whether the paper addresses the question it sets out to. Are the methods appropriate? Are there any problems with the design such as inappropriate control conditions? As we go through the course I will guide you to think critically and ask questions about the studies we are

covering. Also, remember that critical evaluation does not always need to be negative. If there are real strengths to a study then these deserve discussion as well. Make notes as you read and when you have finished reading an article make sure to summarise your thoughts so that you will be prepared for discussions. To help you with this I have included a reading sheet that you can fill in for each paper and bring to class to help summarise your thoughts and aid class discussion.

### **Assessment**

The assessment for the module will be in 2 parts:

1. 25% - An initial essay (2000 words) to be uploaded to MMS by 5PM on Friday 16<sup>th</sup> November.

Question for first assessment:

Explain with reference to the neural mechanisms that support spatial memory and navigation why we get lost.

2. 75% - 3 essay titles will be emailed to the class at 9.30 am on the morning of the assessment (tbc in the exam period) and students should write two 1000 word essays to answer two of them. These two 1000 word essays should be uploaded to MMS by 5.30pm on the same day.

### **Feedback**

The assessments are designed so that you can gain benefit from the feedback on the first assessment when completing the second. I will give written feedback (uploaded to MMS) on the initial 2000 word essay two weeks after they are handed in (16<sup>th</sup> November 5pm). Feedback for the second essays will be available the following semester.

### **Reading list:**

The articles for each week's lecture are listed below and can be downloaded from the reading list which can be found via Moodle or MMS. The link to the reading list is here:

[PS4089 reading list](#)

## Course Outline:

### September 18<sup>th</sup> Week 1: Episodic memory – why is it important?

The first week is largely an introduction to the area. I will introduce the key concepts behind episodic memory and set in context why it is important that we understand its neural basis. I will go on to briefly introduce the areas that we will cover throughout the semester and discuss how the module will be run.

#### Required Reading:

The readings for this week are review articles aimed to give you an overview of the neural system and psychological process we will be concentrating on. As well as providing a useful introduction these articles will be very useful for revision as we will have covered a lot of the material in these articles in detail by the end of the course.

SQUIRE, L. R. 2004. Memory systems of the brain: A brief history and current perspective. *Neurobiology of Learning and Memory*, 82, 171-177.

EICHENBAUM, H., SAUVAGE, M., FORTIN, N., KOMOROWSKI, R. & LIPTON, P. 2012. Towards a functional organization of episodic memory in the medial temporal lobe. *Neuroscience and Biobehavioral Reviews*, 36, 1597-608.

#### Additional Reading:

TULVING, E. 2002. Episodic memory: from mind to brain. *Annual Review of Psychology*, 53, 1-25.

#### Suggested (and not compulsory!) viewing:

MEMENTO - <http://www.imdb.com/title/tt0209144/> Available for loan from the library.

Memento is an excellent film about a character who has anterograde amnesia and consequently cannot form new episodic memories. It is remarkably accurate in its depiction of this disability. It is, of course, fiction and does have some violent scenes so please be aware of this if you choose to watch it. It is not assessed in any way.

### September 25<sup>th</sup> Week 2: Animal models of episodic memory

To understand how the brain enables us to remember things that have happened to us we need to examine the neural systems that support episodic memory. This is predominantly done in two ways; monitoring the system in organisms that are carrying out memory tasks or by manipulating the system and asking how these manipulations affect episodic memory. Many of these manipulations involve invasive techniques and as such can usually only be performed on animals. However, is it even possible to study episodic memory in animals?

#### Required Reading:

BABB, S. J. & CRYSTAL, J. D. 2006. Episodic-like memory in the rat. *Current Biology*, 16, 1317-21.

BIRD, L. R., ROBERTS, W. A., ABROMS, B., KIT, K. A. & CRUPI, C. 2003. Spatial memory for food hidden by rats (*Rattus norvegicus*) on the radial maze: studies of memory for where, what, and when. *Journal of Comparative Psychology*, 117, 176-87.

**Additional Reading:**

CLAYTON, N. S. & DICKINSON, A. 1998. Episodic-like memory during cache recovery by scrub jays. *Nature*, 395, 272-4.

KART-TEKE, E., DE SOUZA SILVA, M. A., HUSTON, J. P. & DERE, E. 2006. Wistar rats show episodic-like memory for unique experiences. *Neurobiology of Learning and Memory*, 85, 173-82.

**October 2<sup>nd</sup> Week 3: The hippocampus as a cognitive map?**

Since the study of HM we have known that episodic memory is dependent on the hippocampus. Patients with lesions of the hippocampus do not encode new episodic memories. However, we also know that the hippocampus is needed for spatial memory. Does the hippocampus encode spatial memory, episodic memory or both?

**Required Reading:**

LEUTGEB, S., LEUTGEB, J. K., BARNES, C. A., MOSER, E. I., MCNAUGHTON, B. L. & MOSER, M. B. 2005. Independent codes for spatial and episodic memory in hippocampal neuronal ensembles. *Science*, 309, 619-23.

WOOD, E.R., DUDCHENKO, P.A., ROBITSEK, R.J. & EICHENBAUM, H. 2000. Hippocampal Neurons Encode Information about different types of memory episodes occurring in the same location. *Neuron*, 27, 623-633.

**Additional Reading:**

TOLMAN, E. C. 1948. Cognitive maps in rats and men. *Psychological Review*, 55, 189-208.

**October 9<sup>th</sup> Week 4: How do we remember what happened to us? Do we use the same systems for what and where?**

Episodic memories include information about specific features in the environment. How does the brain encode these features? Is the hippocampus involved in this process?

**Required Reading:**

WINTERS, B. D., FORWOOD, S. E., COWELL, R. A., SAKSIDA, L. M. & BUSSEY, T. J. 2004. Double dissociation between the effects of peri-postrhinal cortex and hippocampal lesions on tests of object recognition and spatial memory: heterogeneity of function within the temporal lobe. *Journal of Neuroscience*, 24, 5901-8.

CLARK, R. E., ZOLA, S. M. & SQUIRE, L. R. 2000. Impaired recognition memory in rats after damage to the hippocampus. *The Journal of Neuroscience*, 20, 8853-60.

**Additional Reading:**

WAN, H., AGGLETON, J. P. & BROWN, M. W. 1999. Different contributions of the hippocampus and perirhinal cortex to recognition memory. *Journal of Neuroscience*, 19, 1142-8.

LENCK-SANTINI, P. P., RIVARD, B., MULLER, R. U. & POU CET, B. 2005. Study of CA1 place cell activity and exploratory behavior following spatial and nonspatial changes in the environment. *Hippocampus*, 15, 356-69.

## **October 16<sup>th</sup> Week 5: Finding your way, is this the same as knowing where you are?**

When navigating between two places we can use a number of different methods. We can follow a map. We can use a compass and walk in a certain direction. We can keep track of how far we have gone with an odometer or pedometer. As discussed in second year lectures we all have the ability to do these things in our head. However, is the ability to keep track of our position in space by monitoring direction and distance travelled (path integration) the same as the ability to have an internal representation of external space (a cognitive map)?

### **Required Reading:**

HARTLEY, T., MAGUIRE, E. A., SPIERS, H.J. & BURGESS, N., 2003. The Well-Worn Route and the Path Less Travelled: Distinct Neural Bases of Route Following and Wayfinding in Humans. *Neuron*, 37, 877-888.

HAFTING, T., FYHN, M., MOLDEN, S., MOSER, M. B. & MOSER, E. I. 2005. Microstructure of a spatial map in the entorhinal cortex. *Nature*, 436, 801-6.

### **Additional Reading:**

SARGOLINI, F., FYHN, M., HAFTING, T., MCNAUGHTON, B.L., WITTER, M.P., MOSER, M. B. & MOSER, E. I. 2006. Conjunctive representation of position, direction, and velocity in entorhinal cortex. *Science*, 312, 758-762.

JACOBS, J., WEIDIMANN, C.T., MILLER J.F., SOLWAY, A., BURKE, J.F., WEI, X., SUTHANA, N., SPERLING, M.R., SHARAN, A.D., FRIED, I., KAHANA, M.J. 2013. Direct recordings of grid-like neuronal activity in human spatial navigation. *Nature Neuroscience*, 16, 1188-1190.

## **Week 6: Independent learning week**

## **October 30<sup>th</sup> Week 7: Do we remember when things happened?**

The original definition of episodic memory specifically states that memory for events should include a temporal component; when did the event happen? However, is there any evidence that we have a real understanding of time and how would this be encoded by the brain?

### **Required Reading:**

ROBERTS, W.A., FEENEY, M.C., MACPHERSON, K., PETTER, M., MCMILLAN, N. & MUSOLINO, E. 2008. Episodic-Like Memory in Rats: Is It Based on When or How Long Ago? *Science*, 320, 113-115.

HOLLAND, S.M. & SMULDERS, T.V. 2011. Do humans use episodic memory to solve a What-Where-When memory task? *Animal Cognition*, 14, 95-102.

MACDONALD, C. J., LEPAGE, K. Q., EDEN, U. T. & EICHENBAUM, H. 2011. Hippocampal "time cells" bridge the gap in memory for discontinuous events. *Neuron*, 71, 737-49.

### **Additional Reading:**

FRIEDMAN, W. J. 1993. Memory for the Time of Past Events. *Psychological Bulletin*, 113, 44-66.

FORTIN, N. J., AGSTER, K. L. & EICHENBAUM, H. B. 2002. Critical role of the hippocampus in memory for sequences of events. *Nature Neuroscience*, 5, 458-62.

### **November 6<sup>th</sup> Week 8: Context as a cue to episodic memory**

Many people have difficulty remembering exact dates for events but what other cues or features of an event may be used to distinguish them from other events in our lives?

### **Required Reading:**

EACOTT, M. J. & NORMAN, G. 2004. Integrated memory for object, place, and context in rats: a possible model of episodic-like memory? *Journal of Neuroscience*, 24, 1948-53.

HASSABIS, D., KUMARAN, D. & MAGUIRE, E. A. 2007. Using imagination to understand the neural basis of episodic memory. *Journal of Neuroscience*, 27, 14365-14374.

### **Additional Reading:**

ANDERSON, M. I. & JEFFERY, K. J. 2003. Heterogeneous modulation of place cell firing by changes in context. *Journal of Neuroscience*, 23, 8827-35.

### **November 13<sup>th</sup> Week 9: Do we use the same system to imagine the future that we use to remember the past?**

It has been suggested that the ability to mentally travel in time is the underlying mechanism that allows us to re-experience events from our past and also to imagine ourselves in the future. Are these psychological processes based on the same neural systems?

### **Reading:**

HASSABIS, D., KUMARAN, D., VANN, S. D. & MAGUIRE, E. A. 2007. Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences of the United States of America*, 104, 1726-1731.

JOHNSON, A. & REDISH, A. D. 2007. Neural ensembles in CA3 transiently encode paths forward of the animal at a decision point. *Journal of Neuroscience*, 27, 12176-12189.

### **Additional Reading:**

ROBERTS, W. A. 2002. Are animals stuck in time? *Psychological Bulletin*, 128, 473-489.

ROBERTS, W. A. & FEENEY, M. C. 2009. The comparative study of mental time travel. *Trends in Cognitive Sciences*, 13, 271-277.

### **November 20<sup>th</sup> Week 10: Disentangling the processes that contribute to episodic memory**

The human experience of memory is not unitary. When retrieving information about the past, we can sometimes bring to mind details as though we are reliving our memories. Other times, our recollective experience is much more sparse. There is substantial evidence to suggest that these two different experiences rely on separable cognitive processes, recollection (R) and familiarity (F). Receiver operating characteristics (ROCs) allow us to visualise the separate contributions of R and F to memory performance. Measures obtained from ROCs yield dissociable brain regions that support each process.

#### **Required Reading:**

YONELINAS A. P. 1994. Receiver-Operating Characteristics in Recognition Memory: Evidence for a Dual-Process Model, *Journal of Experimental Psychology: Learning, Memory and Cognition*, 20(6), 1341-1354.

FORTIN, N. J., WRIGHT, S. P. & EICHENBAUM, H. 2004. Recollection-like memory retrieval in rats is dependent on the hippocampus. *Nature*, 431, 188-191.

#### **Required Tweaking:**

ROCDemonstration.xlsx spreadsheet.

Modify the values across the various sheet to see how different parameters affect the shapes of the ROCs. This will give you an insight into how contributions from different recollective experiences influence the shape of an ROC.

#### **Additional Reading:**

DASELAAR, S. M., FLECK, M. S., DOBBINS, I. G., MADDEN, D. J. & CABEZA, R. 2006. Effects of Healthy Aging on Hippocampal and Rhinal Memory Functions: An Event-Related fMRI Study. *Cerebral Cortex*, 16, 1771-1782

KEMPENICH, M., URQUHART, J. A., O'CONNOR, A. R. & MOULIN, C. J. A. 2016 - IN PRESS. Evidence for the contribution of a threshold retrieval process to semantic memory. *Quarterly Journal of Experimental Psychology*.

### **November 27<sup>th</sup> Week 11: Ageing and episodic memory**

Episodic memory is the first cognitive process to decline in Alzheimer's disease. The inability to form new episodic memories is extremely debilitating and means that most patients with dementia need 24 hour care. Understanding the changes in the neural systems that degenerate to produce these deficits is key to understanding the disorders and attempting to produce therapeutic strategies.

#### **Required Reading:**

BURKE, S. N., WALLACE, J. L., HARTZELL, A. L., NEMATOLLAHI, S., PLANGE, K. & BARNES, C. A. 2011. Age-associated deficits in pattern separation functions of the perirhinal cortex: a cross-species consensus. *Behavioral Neuroscience*, 125, 836-47.

SWAINSON, R., HODGES, J. R., GALTON, C. J., SEMPLE, J., MICHAEL, A., DUNN, B. D., IDDON, J. L., ROBBINS, T. W. & SAHAKIAN, B. J. 2001. Early detection and differential diagnosis of Alzheimer's disease and depression with neuropsychological tasks. *Dementia and Geriatric Cognitive Disorders*, 12, 265-280.

WILSON, I. A., IKONEN, S., GALLAGHER, M., EICHENBAUM, H. & TANILA, H. 2005. Age-associated alterations of hippocampal place cells are subregion specific. *Journal of Neuroscience*, 25, 6877-6886.

Title/Authors:

Hypotheses:

Methods:

Main results:

Conclusions:

Critique:

Think about; were the hypotheses clearly laid out? Were the methods appropriate? Are the results clear? Are the analyses appropriate and are all relevant analyses performed? Do the data support the conclusion?

## Graduate Attributes (Transferable and Generic Skills)

The School of Psychology and Neuroscience offers opportunities in all of its modules to obtain, practice and demonstrate many of the core skills below. Across the whole programme of modules you will be able to draw on concrete examples (i.e. evidence) for all of these skills in order to promote yourself to prospective employers and others.

In PS4089 we have particular strengths for opportunities to:

1. Demonstrate original thought
2. Construct a coherent argument or debate by demonstrating logical processing of (complex) information and deductive reasoning
3. Apply critical analysis, evaluation and synthesis to solve complex problems
4. Test hypotheses, theories, methods and evidence within their proper contexts
5. Reason from the particular to the general
6. Identify relevant techniques and concepts to solve advanced and complex problems
7. Demonstrate use of an appropriate range of resources to the task at hand
8. Evaluate relevant best practices for the task at hand
9. Engage directly with current research, developments and skills in the discipline
10. Engage with primary and secondary material and differentiate between them
11. Demonstrate active learning
12. Demonstrate reflective learning, including the ability to engage with and learn from feedback
13. Demonstrate creativity and curiosity
14. Demonstrate independence of thought and reasoning
15. Demonstrate skills in time management, self-discipline and self-motivation
16. Demonstrate skills in close textual and comparative analysis
17. Demonstrate skills in close analysis of visual material
18. Demonstrate advanced IT skills
19. Demonstrate quantitative and qualitative methods of analysis
20. Demonstrate expertise in the use of statistical software packages for recording, manipulation & analysis of data
21. Convey statistical results & methods in a manner understandable to the lay-person via written or oral reports
22. Work independently
23. Work as part of a team
24. Communicate with clarity and accuracy, orally (including presentation) and in writing
25. Engage with the views and opinions of others
26. Present work and findings in a professional manner, with attention to detail
27. Learn and use research skills

# Senior Honours - Assessment Feedback Sheet

Module Number: PS4089 ..... Student ID/Matric. No .....

Module Title: Neural basis of episodic memory ..... Date Submitted .....

<b>Content</b>	
<b>Referencing</b>	
<b>Factual accuracy</b>	
<b>Relevance</b>	
<b>Organisation and Coherence</b>	
<b>Precision of Expression</b>	
<b>Critical Evaluation</b>	
<b>Overall Comments</b>	

Overall Mark..... Markers initials **JAA**

Grade.....	0-6.9	7	8-10	11-13	14-16	17-20
<b>Content</b> (Turnitin will be used to help evaluate originality)	Little evidence of using appropriate sources OR copying* from other sources	Minimal reference to appropriate sources OR over-reliance on other work (e.g. close paraphrasing*).	Major omissions. Use of a narrow range of sources. General reliance on secondary or out-of-date material.	Major theories/ideas presented, but use of a narrow range of sources, particularly secondary sources	Covers all the major issues using wide range of appropriate and up-to-date primary sources. Some independent use of sources	Thorough and detailed grasp of the issues with widespread use of primary sources and widespread evidence of independent reading
<b>Referencing</b>	Missing references/ in-text citations	Minimal/ inaccurate use of referencing	Frequent errors in the content and/or style of references.	Reference list broadly comprehensive/some errors	Minor errors in reference list or in in-text citations	Thorough and proper referencing throughout.
<b>Factual accuracy</b>	Widespread substantive errors	Many substantive errors	Some substantive errors	One or two substantive errors or several minor errors	No substantive errors, only minor errors.	No substantive errors, no minor errors.
<b>Relevance</b>	Most material irrelevant to the question	Much of the material irrelevant to the question	Some material irrelevant to the question	Little material irrelevant to the question	Very little material irrelevant to the question	No material irrelevant to the question
<b>Organisation and coherence</b>	No organisation of material	Some development of an argument, but somewhat disjointed and list like	A discernible argument, but somewhat disjointed and list like	For the most part, clear and well-structured with the argument or central thesis well developed	Argument or central thesis well structured, developed leading to well-argued conclusion	Argument or central thesis well-structured and sustained throughout, leading to well-argued conclusions
<b>Precision of expression</b>	General failure to use terms and define concepts precisely	Some instances of scientific precision, but predominant sloppiness and redundancy	Adequate precision in overall terms, but still widespread instances of sloppiness and redundancy	General use of precise scientific language with few instances of sloppiness or redundancy	Clear analytic use of language, with precise use of concepts and negligible redundancy of expression.	Clear analytic use of language, with exact use of concepts using precise and concise expression
<b>Critical evaluation</b>	No valid evaluation of evidence	Trivial or underspecified criticisms (e.g. 'need more research') and illogical reasoning	Demonstrates awareness of the issues, but also some illogical reasoning or triviality	Identifies most issues but displays some triviality or illogical reasoning	Identifies all the main issues relating to topic. Shows evidence of original thought	Sound and thorough data evaluation. Widespread evidence of original thought.

This sheet is for guidance for markers to enhance consistency in evaluations. It is not intended to indicate an overall grade by application of weighted averages – sections will be weighted differently in the final determination of the overall grade, and furthermore this weighting might vary according to the nature of the specific assignment.

\*All instances of possible plagiarism will be referred to the Academic Misconduct Officer and may result in a grade of 0 being awarded