2016-2017 PS4071: Behavioural Neuroscience

Reward, motivation and adaptive behaviour

Meeting times: 11 AM – 1 PM, Thursdays, Seminar room 1.00

School of Psychology & Neuroscience

Assessment: Continuous assessment 25%; 2-hour examination 75%

Credits: 15

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If you are considering taking the module but are undecided…

How do we learn to change our behaviour in order to obtain reward? This module focuses on the brain systems that determine the actions of people and animals seeking reward. Much of the module will be devoted *reinforcement learning*, which is a basic form of learning in which actions become associated with consequent rewards. However, we will also discuss how organisms look to the future, weighing the risk, costs, and benefits of pursuing a given goal, and this will lead us away from simple learning more complex processes such as motivation, decision-making, selective attention, and social/economic interaction. Much of the material in the module is basic science, but we will apply that basic science to addiction and other disorders of behavioural dysregulation. Inevitably the research we will discuss will touch on the issue of whether addicts and other people who take seemingly self-destructive actions have a choice.

Overview

Behavioural neuroscience is a huge field, with thousands of researchers producing scientific reports each year. Therefore, the purpose of this module is not to make you an expert on all areas of behavioural neuroscience. Instead, we will take three examples of adaptive (and maladaptive) behaviour – reinforcement learning, goal-directed decision-making and addiction – and see how behavioural neuroscientists and psychologists apply various approaches to study them.

Adaptive behaviour is a vital process in most animals and people. It allows flexibility of behaviour in response to changing environmental conditions and physiological needs. Some of the adaptations are due to simple mechanisms, such as motor fatigue or sensory habituation. However, when animals and people learn to adapt their actions to a specific environmental context, *associative learning* is said to occur between the context and the behavioural response. In this module we will explore examples of learning mechanisms that operate during and after associative learning, focusing specifically on instances in which sensory events and actions are followed by reward. This process seems to be largely automatic and is thought to be crucial for the formation of habits. We will also study adaptive behaviour based on goal-directed deliberation in which an organism must weigh the relative risks, costs and benefits of pursuing a given goal. Psychologists have theorised that goal-directed action is based on motivation and a 'mental map' of how actions result in rewarding outcomes. At the applied level, we will compare our knowledge of these mechanisms to those of addiction, which can be viewed as a form of pharmacologically induced learning. We will also examine whether the neural mechanisms involved in reward and learning play a role in decision-making in social and economic contexts.

We will approach the question by looking at mechanisms for adaptive behaviour across six different learning situations:

(1) classical (Pavlovian) conditioning, in which sensory events are associated with rewards
(2) operant (instrumental) conditioning, in which behaviours are reinforced or punished based on their outcomes
(3) drug addiction, in which chemicals activate and change the brain circuits involved in operant conditioning
(4) acquired 'compulsive' behaviours, such as pathological gambling, video game playing, and overeating
(5) brain stimulation reward, in which a given behaviour is rewarded by pairing it with stimulation of a specific brain region
(6) adaptive decision-making in social and economic contexts

The module can be divided into three sections. The first section will provide a background on the terminology and methods used to study adaptive behaviour. The second section will cover some of the major findings in regard to how the brain learns to obtain reward. In this second section we will spend ~20 minutes in lectures 2-7 discussing a research paper, rather like a journal club. This will give you practice in extracting the essential information from a paper and evaluating its quality. The last section will be comprised of guided debates. Each student will present a summary of a research article and use its data to argue for or against a selected proposition. In order to prepare for this presentation, all students should discuss with me their selection of the relevant paper and the details of the presentation.

Module aims

(1) To provide basic knowledge required for evaluating research reports in the behavioural neuroscience of adaptive behaviour
(2) To give an overview of behavioural, anatomical & physiological methods used to study reinforcement learning
(3) To provide exposure to the process of developing formal models of adaptive behaviour
(4) To promote an awareness of addictive behaviour from the viewpoint of a behavioural neuroscientist

(5) To examine how neuroscience can enhance our understanding of suboptimal decision-making

(6) To examine how individual differences in brains structure and function are associated with addiction

(7) To raise awareness of the issues of evaluating animal models of behavioural disorders

(8) To highlight how psychology, neuroscience, and economics are converging in research on decision making

(9) To promote a discussion about the potential impact of neuroscience on society

Module objectives

By the end of this section of the module, each student should be able to:

(1) Discuss the advantages and disadvantages to various approaches taken to study the neuroscience of adaptive behaviour

(2) Identify the strengths and weaknesses of simple journal articles in behavioural neuroscience

(3) Discuss the interrelationships among the psychological and biological processes related to *decision-making, motivation*, *reward* and *reinforcement*.

(4) Describe the behavioural and neural relationships between classical conditioning and operant conditioning

(5) Describe the relationship between the neurobiology and psychology of natural and drug reinforcers

(6) Use the material covered in the model to evaluate animal models of dysfunctional behaviour (e.g., addiction)

(7) Discuss the basic properties of formal models of reinforcement learning

(8) Discuss how neuroscience is allowing us to explain paradoxical suboptimal decision-making in economic and social contexts

Transferable skills

The module will provide you experience in the following practical skills:

(1) Being an active learner by surveying the scientific research literature based on your interest.

(2) Using online bibliographic databases to search for scientific information.

(3) Summarising complex technical information in a manner understandable to the lay public.

(4) Summarising research articles to an audience familiar with the research background.

(5) Using knowledge of statistics and research design to evaluate the quality of scientific reports.

(6) Using subject-specific knowledge (psychology, neuroscience, economics) to evaluate the quality of scientific reports.

(7) Working in a team to plan and deliver a presentation.

(8) Constructing and supporting an evidence-based argument.

(9) Learning to recognise and reconcile apparent inconsistencies in the scientific literature.

(10) Considering the likely impact of current research on people.

Expectations

There are two types of reading for the module: the reading of individual research articles that we will discuss in class and independent reading. For the independent reading, it is expected that you will read 2 papers per week over the semester. Do not be alarmed if some of the articles you read seem to contradict each other – that is the nature of science. The trick to resolving such conflicts is to examine the *quality* of the articles.

It defeats the purpose of the module if you fail to ask questions or adopt a passive learning strategy. Please come to the lecture sessions prepared to discuss the assigned paper each week. Also, the last third of the module is based directly on student presentations, so you must learn to overcome any embarrassment or hesitation when talking in front of the class. In this regard please consider speaking in the module as practice that develops a necessary skill rather than as some sort of test. Although I will not let the class founder aimlessly, the ultimate success or failure of the seminar's interactive approach rests with you and your fellow students: Read… think… have a healthy scepticism… and, most importantly, discuss your ideas with others in the module.

If you speak English as a second language

The language used in neuroscience is difficult for native English speakers, and it can be even more daunting for those who have learned English as a second language. If you are having trouble understanding the lectures, then please feel free to record them if that would be helpful. Additionally, please feel free to ask questions about any word that you do not understand. Finally, even if you struggle with spoken English, the debate presentation is an excellent learning opportunity that you should not miss. All students should discuss their presentation with me, and I would be happy to provide comments on a practice presentation before the debates in class.

Examination format

The examination will be a 'seen' examination. This means that a list of 6 possible examination questions will be given in advance, at the end of the final class. The examination (2 hours) will be in essay format and conducted at the scheduled time using the standard procedure. Students will choose to answer one of two questions in each of two sections (suggested time for each section of one hour; the mark for each section counts as 50% of the mark for the examination). Thus, the examination will be comprised of 4 of the 6 potential questions given in advance, so the best strategy is to prepare for all of the questions. Please note that the point of giving advanced information regarding the questions is not simply to reduce anxiety, but to encourage students to evaluate the quality of the relevant research in addition to memorising research 'facts'. Please note that you *will not* be allowed to take notes or answer outlines into the examination hall. Also, while general discussion about the questions among students is encouraged, students are not allowed to compose group answers: Answers that are similar in structure and content will be marked harshly and outright plagiarism will not be tolerated. The examination will constitute 75% of the final grade in the module. The criteria for marking examinations are given in the Honours Handbook (http://www.st-andrews.ac.uk/media/school-of-psychology/handbooks/Psychology_Honours_Handbook.pdf).

Continuous assessment

The continuous assessment will constitute 25% of the final module grade. The continuous assessment is based on a review of the original research article that you present in the debate. The review must include all of the following sections:

(1) The full, properly formatted citation of the article, including author(s), year, title, journal, volume and pages, and web link.

(2) A summary of the article in plain English, as though it were an entry in an online 'blog' about the article. The summary should be written so that a layperson would understand it. Unavoidable technical terms must be underlined to indicate which terms you believe would benefit from an explanatory web link. Please note that the summary must not be plagiarised from the abstract of the article or any secondary description of the article (such as a blog or press release).

(3) A critical review of the strengths and weaknesses of the research design, data analysis and conclusions drawn in the article – is the research trustworthy?

(4) An analysis describing the relevance of the article to the debate topic you have chosen – In what way does it contribute to settling the question?

(5) An appendix containing the slides that you presented in the debate.

(6) If members of the University cannot access your article online because the University does not have a subscription to the relevant journal, then please submit to the main office in Psychology a title page with your name, the module number (PS4071) and date attached to a full, printed copy of the article.

Please note that there is a document template on Moodle that you must use for the assignment. There is also a mandatory PowerPoint template to be used for the oral presentation in the debate. If you encounter any problems of incompatibility between your software and the templates then please contact me (emb@st-andrews.ac.uk). Submitted continuous assessment must fulfil the requirements listed in the Honours Handbook.

Exam preparation

Lecture notes will be posted on Moodle. I encourage students to post copies of their presentations as well. However, it should be stressed again that independent reading and thought are required to receive high marks on the examination. An optional review session will be offered on an informal basis to allow students the opportunity to further discuss the material and ask questions about it.

Exam marking

A general description of the criteria form marking examinations can be found in the Honours Handbook. However, there are four aspects on which I focus specifically when marking the examination. First, I look for evidence of independent reading of material. Second, I evaluate the clarity of the argument being presented. In my experience, the answers that are given the highest marks introduce the argument of the essay in the first paragraph, saving the background material for subsequent paragraphs. Third, I will evaluate specifically the degree to which students assess the quality of the information derived from research. Fourth, I will look for independence and creativity of thought and critical analysis. In regard to the marking standard, let us suppose that you merely parrot back information provided in the lectures. The *maximum* mark you are likely to obtain is 14. If you want a higher mark, you must show signs of independent learning and thought.

Please note that in past years there has been a modest correlation between the marks given on the essay and the marks given on the examination. This is because the two forms of assessment measure different aspects of learning. The essay measures how well you analyse a single piece of work and fit it into the existing literature. The examination measures how well you have discovered, read, and understood multiple research articles across a broad topic.

Feedback

Feedback will be provided on both the continuous assessment and the examination. Individual feedback on the continuous assessment essay will be provided in electronic form (either using the *Track changes* feature of MS Word, or using 'text bubbles' in PDF documents as appropriate). Additionally, generic feedback will be given for both the essay and the examination, in part to guide the external examiners, but also to provide the students with an overview of how well the class performed. Individual feedback on the examination can be arranged by contacting me, but typically it is counted as summative (more for evaluation purposes than formative purposes).

Schedule

Date	*Topic I*	*Topic II*	*Comments*
15/9	Module mechanics Concepts related to adaptive behaviour	Behavioural dysregulation Advice on reading research articles	Sign up for debates in Moodle
22/9	Neuroscience methods: Weaknesses & strengths	Model-based *versus* model-free adaptive behaviour	
29/9	Pavlovian conditioning	Pavlovian conditioning and adaptive behaviour	
6/10	Dopamine and Pavlovian conditioning	Reward prediction error: Modelling the role of dopamine in Pavlovian conditioning	
13/10	Reward prediction error: Advanced modelling of dopamine responses	Instrumental conditioning	
20/10	Independent learning week (no lecture) Submit choice of debate paper by 21/10/16 at 5PM to Moodle forum		
27/10	Habit formation	Reward & motivation	
3/11	Decision making, economics & dopamine – value, utility, risk and uncertainty	Artificial reinforcers Drug addiction & its treatment	Deadline for approval of choice of papers for debates
10/11	Debate 1: Does brain anatomy and function determine vulnerability to addiction?		Draft presentations for Debate 2 due
17/11	Debate 2: Does dopamine control *wanting*?		Draft presentations for Debate 3 due
24/11	Debate 3: Are animal studies necessary for understanding human economic behaviour?		Continuous assessment essay due 27/11 at 5PM in MMS

Revision: 28/11-4/12
Examinations: 5/12-18/12