University of St Andrews

School of Psychology and Neuroscience

PN 4231

NEUROMODULATION

Academic session 2016-17

Organizer: Dr. Stefan R. Pulver

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Summary

Until comparatively recently the nervous system was viewed as a black and white world in which neuronal networks performed tasks using only fast chemical synaptic transmission to produce an appropriate network output. However, the output of a given neuronal network is far from fixed. Instead, it is modifiable under different behavioural or developmental circumstances. An important source of flexibility in the output of neuronal networks is "neuromodulation". Neuromodulators act more slowly than conventional fast transmitters to alter both the strengths of synaptic connections and the integrative electrical properties of the neurons within the network. In this way, neuromodulators affect both the relative weightings of inhibitory and excitatory connections and the basic operation of the network.

The central nervous system of a wide range of animals is now known to contain a diversity of different neuromodulators, ranging from conventional fast transmitters with additional neuromodulatory actions, to biogenic amines, peptides and even certain gases. Many, though not all of these neuromodulators, act via metabotropic as opposed to ionotropic receptors. The aim of this module is to introduce you to current concepts in the neuromodulation field, to familiarize you with knowledge of the underlying mechanisms of neuromodulation and to outline their importance in information processing in the nervous system. A particular focus of the module will be to attempt to understand how neuromodulation affects neural networks underlying specific patterns of motor behaviour.

Learning objectives

At the end of the module you should be familiar with:

- The conceptual differences between neurotransmission and neuromodulation and the differences between extrinsic and intrinsic network neuromodulation
- Key mechanisms through which neuromodulators affect the strength of chemical and electrical synapses
- Some of the key mechanisms through which neuromodulators affect the electrical properties of neurons to transform the way in which they integrate information
- Comparative approaches to the study of neuromodulation
- How different modulators act in concert to determine the overall output of a neuronal network

At the end of the module, you should have experience in:

- Reading and critically analyzing primary literature
- Creating scientific posters and giving oral presentations
- Analyzing physiological data and generating scientific manuscripts
- Scientific writing under time pressure

List of contributing staff and their contact details

Module organizer: Dr. Stefan Pulver (SRP), (sp96@st-andrews.ac.uk)

Other contributors: Prof. Keith Sillar (KTS) (kts1@st-andrews.ac.uk)
Dr. Bill Heitler (WJH) (wjh@st-andrews.ac.uk)
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Books:

P.S.Katz. (1999) Beyond neurotransmission: neuromodulation and its importance for information processing. Oxford University Press. Two reference copies available in the Bute Library.

Reviews and Papers:

Most of the papers relevant to a particular topic will be made available to coincide with a particular class; PDF's will be uploaded to MMS.

Class timetable and brief overview content

Class will meet on Tuesdays 11-12 and Fridays 10-11 in the Room C28 of the Bute Medical Building, unless otherwise stated. There will be a mixture of lectures, student presentations and discussion sessions. Towards the end of the module you will be involved in a neuromodulation experiment. This will generate electrophysiological and optical imaging data which you will then analyse.

Student presentations (Weeks 2-7, 11)

Student presentations will take place on Fridays. In one of these weeks you will be assigned to a group which will give a PowerPoint presentation on one or more articles related to the topic of that week. Each member of the group will be expected to make a contribution. Relevant papers will be provided the week before the presentation. Those not presenting are expected to fully engage with the Friday sessions by reading the relevant papers beforehand and questioning the presenters afterwards. The presentations are not assessed.

CONTINUOUS ASSESSMENT (50% of final grade)

i) Posters (25%)

At the start of the module you will select a poster title either from the provisional list below (or agree with the module organiser a poster topic of your own choosing) Posters should follow the format of a Society for Neuroscience Poster (Examples provided on MMS). There will be a poster session in week 8. You are all expected to attend and publically present your poster at the session. Presented posters will be posted on MMS for future PN4231 students (obviously, without marks). Some possible poster topics are listed below but you are welcome to choose your own if you wish.

Some possible poster topics:

1. Modulation of pain control circuitry in the dorsal horn
2. Intrinsic modulators of motor control networks
3. Metamodulation
4. Dopaminergic modulation of retinal circuitry
5. Functional anatomy of aminergic systems in vertebrates
6. Endocannabinoids and neural network neuromodulation
7. Serotonergic modulation and social status
8. D-serine regulation of LTP
9. Metabotropic glutamate receptor modulation of network function
10. Descending pathways and pain regulation

ii) Data analysis (25%)

Week 9 provides you with an opportunity to perform an experiment for yourselves on neuromodulation. You will participate in two experiments; one on fictive swimming in larval *Xenopus* and another on fictive crawling in the isolated nerve cord of *Drosophila* larva. In each case, once control recordings have been taken, a neuromodulator will be applied to the bathing solution and after a period of exposure to the drug, recordings will again be taken. Your task will be to analyse the data in order to quantify the effects of the applied substance. The exercise will be assessed: you will be asked to write a brief report on your findings in which the analysed data are presented and then discussed in the format of a short scientific paper. All details of how the data should be analysed, as well as the format of the paper will be provided during the practical session.

FINAL EXAM (50% of final grade)

1.5 hour examination – answer 1 question from choice of 3 - 6

MODULE TIMETABLE

Week	Date	Time	Topic	Staff
1	24 Jan 27 Jan	11am 10am	Introduction to module Principles of neuromodulation	 SRP
2	31 Jan 3 Feb	11am 10am	Intracellular modulatory pathways – introduction **Student presentations**	SRP SRP
3	7 Feb 10 Feb	11am 10am	Postsynaptic targets of neuromodulators **Student presentations**	GBM GBM
4	14 Feb 17 Feb	11am 10am	Modulation of chemical synaptic transmission **Student presentations**	WCL WCL
5	21 Feb 24 Feb	11am 10am	Modulation of vertebrate motor systems **Student presentations**	KTS KTS
6	28 Feb 3 Mar	11am 10am	Modulation of invertebrate motor systems **Student presentations**	SRP SRP
7	7 Mar 10 Mar	11am 10am	Neuromodulatory control of social behaviours **Student presentations**	WJH WJH
X	14 Mar 17 Mar	**X**	**X Easter break X**	**X**
X	21 Mar 24 Mar	**X**	**X Easter break X**	**X**
8	28 Mar 28 Mar 31 Mar	4pm 11am 3-6	POSTER PDFS UPLOADED Poster preparation / discussion Poster presentations	SRP SRP SRP
9	4 Apr* 7 Apr*	1-4pm* 1-4pm*	**Practical week 1**: lab visit - modulation of *Drosophila* and Xenopus locomotor CPG	SRP SRP
10	11 Apr 14 Apr	11am 10am	NO CLASS NO CLASS PN4299 research talks	
11	18 Apr 21 Apr	11am 10am	Guest lecture or Data analysis & discussion Guest Lecture or Data analysis & discussion	SRP SRP
12	April 24	8:00 am	Lab report due	SRP
12	25 Apr 28 Apr	11am 10am	NO CLASS EXAM REVISION Q&A SESSION	 SRP

***time subject to change**

EXAM - date to be announced

Preparing Effective Posters (extracted from the Society for Neuroscience (SFN) website; see sample poster on module MMS)

A poster should be self-contained and self-explanatory, allowing different viewers to proceed on their own while leaving the author free to discuss points raised in inquiry. The poster session offers a more intimate forum for discussion than the slide presentation, but discussion becomes difficult if the author is obliged to devote most of the time explaining the poster to a succession of viewers. Remember that the time spent at each poster figure is determined by the viewer, not the author, as in the case of slide presentations. An effective poster is neither a page-by-page printout of a journal paper nor a slide show, but balances figures and text.

Planning and Layout: For effective use of the available space, consider organizing illustrations and text using a grid plan. Arrange materials in columns rather than rows. It is easier for viewers to scan a poster by moving systematically along it rather than by zig-zagging back and forth in front of it. Place your most significant findings at eye level immediately below the title bar and the supporting data and/or text in the lower panels. For conventional multi-panel posters, five columns can be formed using poster elements printed on 11"-wide paper (or 29-30-cm wide A4 or B5 paper) with suitable spacing or borders. Materials may be mounted on colored poster board. You may want to group logically consistent sections or columns of the poster on backgrounds of the same color. Background colors should be muted; shades of gray are also effective. The increasing availability of 36"- and 54"-wide inkjet printers and page-layout software permits economical production of effective and attractive posters on a single sheet that can be transported to the meeting either in a poster tube or carefully folded (accordion-style in the long dimension, then once in the short dimension) to fit in a carry-on suitcase. Use line borders to separate areas. Avoid reflective, plastic-coated paper.

Title: Prepare a banner for the top of the poster indicating the abstract title, author(s), and affiliation(s), and the session number of the abstract. Lettering should be at least 1 inch high.

Illustrations: Figures should be designed to be viewed from a distance and should use clear, visible graphics and large type. Color can be effective if used sparingly; use saturated dark colors on white or pale backgrounds and rich, light colors on dark backgrounds. Although each figure should illustrate no more than one or two major points, figures need not be simple. The main points should be clear without extended viewing, but detail can be included for the aficionado. The sequence of illustrations should be indicated with numbers or letters at least 1 inch high. (Omit "Fig." or "Figure"; it is unnecessary and occupies too much space.)

Text: Each figure or table should have a heading of one or two lines in very large type stating the "take-home" message. Additional essential information should be provided below in a legend set in 16 point or larger type. Minimize narrative. Text that would normally appear in the body (Results and Discussion) of a manuscript can be integrated in figure legends. It should describe concisely not only the content of the figure but also the conclusions that are derived. Details of methodology should be brief and should be placed at the end of each legend. Use large type in short, separated paragraphs with unjustified (ragged right) margins. Numbered or bulleted lists are effective ways to convey a series of points. Do not set entire paragraphs in uppercase (all capitals) or boldface type. An introduction should be placed at the upper left and a conclusion at the lower right, both in large type. It is rarely necessary to post a copy of the abstract.