



Australia's
Global
University

Faculty of Medicine
School of Medical Sciences

NEUR 3221

Neurophysiology

COURSE OUTLINE AND PRAC MANUAL

SEMESTER 2, 2017

CRICOS Provider Code 00098G

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Please read this outline in conjunction with the following pages on the

[School of Medical Sciences website:](#)

- [Advice for Students](#)
- [Learning Resources](#)

(or see "STUDENTS" tab at medicallsciences.med.unsw.edu.au)

NEUR3221 Course Information

Neurophysiology (NEUR3221) is a stage three course worth six units of credit (6 UOC) administered by the School of Medical Sciences. It is delivered across 12 teaching weeks in session 2, with six contact hours per week. NEUR3221 can be undertaken upon successful completion of Physiology 1A (PHSL2101 / 2121 / 2501). The course can contribute to a study plan in Physiology or Neuroscience for the Bachelor of Science or Bachelor of Medical Sciences.

In 2017, Neurophysiology (NEUR3221) will commence in the week beginning 25 July.

The content of the course provides an understanding of how cells in the nervous system work together to perform various functions. This course complements Molecular and Cellular Neuroscience (NEUR3121) which focuses on the structure and function of individual neurons and their ion channels and receptors. Students also find that this course complements Muscle and Motor Control (NEUR3101), Neuroanatomy (ANAT3411), and Neuropharmacology (PHAR3202).

OBJECTIVES OF THE COURSE

To gain an understanding of the principles of neurophysiology by:

- using molecular, synaptic and cellular processes to explain brain function
- grasping the relationship between experimental techniques and the data they produce

COURSE CO-ORDINATOR and LECTURERS

Course Coordinator:

Dr John Power
Rm 303 Wallace Wurth Building
ph: 9385 2910 john.power@unsw.edu.au

Course Co-Coordinator

Dr. Gila Moalem-Taylor
Translational Neuroscience Facility,
Level 3 Wallace Wurth Building
ph: 9385 2478 gila@unsw.edu.au

Students wishing to see the course coordinators should make an appointment *via* email as our offices are not readily accessible. We will organize to meet you in a convenient location elsewhere in the building.

Lecturers in this course:

A/Prof Pascal Carrive	p.carrive@unsw.edu.au
Prof Gary Housley	g.housley@unsw.edu.au
Dr. Natasha Kumar	natasha.kumar@unsw.edu.au
Natalie Kwai	natalie.kwai@unsw.edu.au
Dr. Martin Héroux	m.heroux@neura.edu.au
Dr Richard Vickery	richard.vickery@unsw.edu.au
Georg Von Jonquieres	g.jonquieres@unsw.edu.au

COURSE STRUCTURE and TEACHING STRATEGIES

Learning activities occur on the following days and times:

- Lectures: Monday 9-10 am, Tuesday 11-12 pm
- Tutorials: Wednesday 11-12 pm or 12 – 1 pm
- Practicals: Monday 10-1 pm or 2-5 pm

Students are expected to attend all scheduled activities for their full duration (3 hours of lectures / tutorials per week and up to 3 hours of practical sessions per week). Students are reminded that UNSW recommends that a 6 units-of-credit course should involve about 150 hours of study and learning activities. The formal learning activities are approximately 72 hours throughout the semester and students are expected to do at least the same number of hours of additional study.

Lectures will provide you with the concepts and theory essential for an understanding of neurophysiology. To assist in the development of research and analytical skills practical classes and tutorial learning sessions will be held. These classes allow students to engage in a more interactive form of learning than is possible in the lectures. The skills you will learn in practical classes are relevant to your development as professional scientists.

APPROACH TO LEARNING AND TEACHING

The learning and teaching philosophy underpinning this course is centred on student learning and aims to create an environment which interests and challenges students. The teaching is designed to be engaging and relevant in order to prepare students for future careers.

Although the primary source of information for this course is the lecture material, effective learning can be enhanced through self-directed use of other resources such as textbooks and Web based sources. Your practical classes will be directly related to the lectures and it is essential to prepare for practical classes before attendance. It is up to you to ensure you perform well in each part of the course; preparing for classes; completing assignments; studying for exams and seeking assistance to clarify your understanding.

TEXTBOOKS AND OTHER RESOURCES

Prescribed Textbook

Neuroscience: Exploring the Brain. 4th edition, 2015
Bear, Connors & Paradiso
Williams & Wilkins, ISBN-13: 978-0781778176

Recommended Textbooks:

Neuroscience. 5th edition, 2012
Purves, Augustine, Fitzpatrick, Hall, LaMantia & White
Sinaur Associates ISBN 978-0-87893-695-3

Principles of Neural Science, 5th edition, 2012
Kandel, Schwartz, Jessell, Siegelbaum & Hudspeth AJ (Editors)
McGraw-Hill. ISBN 978-0071390118

[An advanced textbook for extended reading. Copies held in the UNSW library]

The books are available from the UNSW Bookshop, and limited copies are held by the UNSW library. Other resources:

medalsciences.med.unsw.edu.au/students/undergraduate/learning-resources

STUDENT LEARNING OUTCOMES

Specific Learning outcomes:

By the end of this course students are expected to have gained:

- a demonstrable knowledge of the scope of neurophysiology, and detailed knowledge in some areas including somatosensory system and synaptic plasticity.
- experience in applying basic physical and physiological principles to resolve questions related to brain and behaviour.
- experience and expertise in critical enquiry by designing and executing a neurophysiological experiment.
- by practical experience and critical review, an appreciation of the relationship between the experimental techniques that provide neurophysiological data, and the constraints on interpretation that the techniques impose.

Faculty of Science and UNSW graduate attributes are found at:

medalsciences.med.unsw.edu.au/students/undergraduate/advice-students#graduate

COURSE EVALUATION AND DEVELOPMENT

Each year feedback is sought from students about the course and continual improvements are made based on this feedback. Below is a summary of the feedback and our response to how we will improve this year's course delivery.

Student Feedback via MyExperience:

Student feedback indicated the best aspects of the course were the interesting content, the enthusiastic lecturers, the pre and post exam tutorials and the DIY prac. The most popular suggestions for improving the course included: improving the lab instructions and organisation, better organisation of the Moodle page, more detailed lecture notes, reducing the weight of the DIY prac, making the course easier, not having a lecture Monday morning at 9 am.

Outcomes of end of term course review:

Feedback from student representatives was considered when the course was reviewed at the end of the year. Additionally, the review covered concerns about student engagement / attendance and support for students struggling in the course. Lecture attendance was poor (~ 30%; < 15% for Monday 9 am; 60 % for Tuesday immediately before the mandatory prac session). Approximately 35 % of students downloaded or played back the lectures. Responses to open ended questions suggest that students are relying on memorisation of the slides. Many students struggled to apply knowledge on exam questions. Although, some students considered the course to be difficult, the mark distribution was similar to other courses offered by the School of Medical Sciences.

To improve student engagement the course structure will change to 2 lectures and 1 mandatory tutorial session per week. The addition of mandatory tutorials was suggested by former students and the class representatives. The tutorials will be used to solidify and build on lecture concepts, providing additional support for students struggling with lecture concepts. To allow for the additional tutorial sessions, some lectures will be converted to online lectures and there will be a consolidation of course content. To better prepare students for the practical sessions students will be required to undertake a prelab online tutorial. There will be 2 prac sessions, rather than 2 prac groups in separate rooms, so that both groups will undertake the same prac each week allowing for better integration of prac and lecture content.

An additional DIY prac session was added to provide additional assistance for data analysis and presentation, and practical report preparation.

The Moodle page has been improved and additional resources will be available.

Student Representatives

Students enrolled in the course will be invited to elect two student representatives who will meet with the course conveners on two occasions during the session, in a student feedback forum. The representatives need to seek feedback from their colleagues on the content, delivery and relevance of the course and any other issues that arise. The information gathered from this process will be used to inform any future improvements to the course.

ASSESSMENT PROCEDURES

Prelab quizzes (1% x 7)	7%
Midterm Exam	30%
DIY practical	
Group experimental plan – risk assessment - SWP	5%
Group prac report	15%
Individual peer mark	5%
End of Session Exam (2 hour duration)	38%

A penalty will apply for late submissions of assessment tasks (10% per day).

Material pertaining to both the lectures, tutorial and practical classes will be examined in both the midterm and end of session exams.

There will be **prelab quizzes for** each of the structured practicals (There will be no quiz associated with the DIY practical). These quizzes and prelab videos will be made available online the Friday prior to the practical. These quizzes based on the lecture and prelab video content serve to prepare you for the practical. You will receive immediate feedback after submitting your answers. The quizzes are to be attempted in your own time and each quiz will be close at the start of the practical session. You may attempt these quizzes as many times as you wish. You will receive 1% towards your overall grade for each quiz provided you achieve a minimum score of 80% for the quiz.

The midterm exam will be comprised of short answer questions, multiple choice and/or short calculations. The questions will be based on the material covered in the lectures, tutorial and practical classes. The purpose of the exam is to provide feedback to students on their understanding and application of the concepts developed in the course and to prepare students for the final exam.

The DIY practical. Students will, in groups, design and complete their own neurophysiology practical. Each group is to submit their experimental design, a risk assessment and safe work procedure via Moodle, prior to the mid-term break; Friday 22 September 5pm. Three prac sessions (09 October, 16 October, and 23 October) will be dedicated to the DIY prac. All students are expected to initiate their experiments during 09 October session. Students will spend the second session completing their experiments and / or analysing data. The group DIY prac report is due Thursday the 26th of October 11:59 pm. After submission of the prac report, each student will detail and evaluate the contributions of the other group members to the project and the preparation of the report. Students will receive an individual mark based on the assessment of their peers.

The end of session exam will be comprised of short answer questions, multiple choice and/or short calculations that may include some simple calculations. The short answer questions will be based on the material covered in the lectures, tutorials and practical classes. The exam is comprehensive; material covered in the progress exams may be again examined in the final exam. The lecturer who provided the question will mark the short answer questions. Students are advised to use the list of previous exam questions provided to self-evaluate their progress during the course, although questions from year to year may vary as the content of the course is developed.

GENERAL INFORMATION

The Department of Physiology is part of the School of Medical Sciences and is within the Faculty of Medicine. It is located in the Wallace Wurth building (C27). General enquiries can be made at the School of Medical Sciences Reception, located on level 2 of the Wallace Wurth building (office hours are 9.00 am - 5:00 pm).

Professor Gary Housley is Head of the Department of Physiology and appointments to see him may be made through his Administrative Assistant on 9385 2804.

There are two honours programs available through the School of Medical Sciences. The School of Medical Sciences and the School of Psychology jointly run the Neuroscience Honours program coordinated by Dr John Power john.power@unsw.edu.au. In addition, the School of Medical Sciences Honours also offers a program is coordinated by Dr Greg Smith g.smith@unsw.edu.au.

Any students considering an Honours year should discuss the requirements with the coordinator. Please see:

Neuroscience:

medalsciences.med.unsw.edu.au/students/undergraduate/neuroscience/honours

SoMS:

medalsciences.med.unsw.edu.au/students/soms-honours/overview

Postgraduate research degrees

The School of Medical Sciences offers students the opportunity to enter into a Masters (MSc) or Doctorate (PhD) program in Physiology. For further information contact the Postgraduate Coordinator, Dr Pascal Carrive: p.carrive@unsw.edu.au

Please see: medalsciences.med.unsw.edu.au/students/postgraduate-research/overview

Enrolment and administrative help

Nadia Ghafoorzada and Dylan Lewis are available to help with problems with enrolment and scheduling, and should be the first point of contact for administrative problems. They can be found in the [BSB Student Office](#), Level 1 of the BioSciences Building. ph:9385 2464, SOMSenquiries@unsw.edu.au

Attendance Requirements

For details on the Policy on Class Attendance and Absence see [Advice for Students](#) and the [Policy on Class Attendance and Absence](#).

Guidelines on extra-curricular activities affecting attendance can be found on the School of Medical sciences Website under Special Consideration.

Attendance at laboratory and tutorial classes is compulsory and must be recorded in the class roll on the day of the class. Arrival more than 15 minutes after the start of the class will be recorded as non-attendance. It is your responsibility to ensure that the demonstrator records your attendance and no discussions will be entered into after the completion of the class. Satisfactory completion of the work set for each class is essential. It should be noted that non-attendance for other than documented medical or other serious reasons, or unsatisfactory performance, for more than one practical class or one tutorial class per course may result in an additional practical assessment exam or in ineligibility to pass the course.

Special Consideration

Please see [UNSW-Special Consideration](#) and [Student Advice-Special Consideration](#)

The supplementary exam dates for Semester 2, 2017 have not yet been confirmed but will most likely be held in the week commencing 4 December, 2017.

If you unavoidably miss an exam in NEUR3221, you must lodge an application with UNSW Student Central for special consideration. If your request for consideration is granted an alternative assessment will be organised which may take the form of a supplementary exam or increased weighting of the final exam.

Academic Integrity and Plagiarism

The [UNSW Student Code](#) outlines the standard of conduct expected of students with respect to their academic integrity and plagiarism. More details of what constitutes plagiarism can be found [here](#).

Practical Classes

The practical class is an opportunity for students to develop graduate attribute 3 by behaving in an ethical, socially responsible and professional manner within the practical class.

Students must take due care with biological and hazardous material and make sure all equipment is left clean and functional. In the interests of safety, special attention should be paid to any precautionary measures recommended in the notes. If any accidents or incidents occur they should be reported immediately to the demonstrator in charge of the class who will record the incident and recommend what further action is required.

For more details see [Advice for Students-Practical Classes](#)

LECTURE and PRACTICAL OUTLINES

The course timetable is appended to these notes

The course is divided into the following themes:

Foundations: Introduction to nervous system function

Neurons and Glia [Moalem-Taylor]

Structure & Function [Moalem-Taylor]

Role of glia in pathological conditions [Moalem-Taylor]

Foundations: Neural communication

Synaptic Transmission [Power]

Simple Neuronal Networks [Power]

Dissecting Neural circuits [Power]

Sensory systems: Hearing

Introduction to Hearing: the Cochlea [Housley]

Central Auditory Pathways [Housley]

Cochlear Pathophysiology [Housley]

Sensory systems: Proprioception

Kinaesthesia [Héroux]

Kinaesthesia II [Héroux]

Kinaesthesia [Héroux]

Sensory systems: Touch and pain 1

Neural Coding [Vickery]

Peripheral Tactile [Vickery]

Neural coding tutorial [Vickery]

Sensory systems: Touch and pain 2

Central Tactile [Vickery]

Introduction to Pain [Moalem-Taylor]

Pain tutorial [Moalem-Taylor]

Experimental Planning

Designing an experiment [Power]

Higher order processing: Memory systems

Memory Systems [Power]

Higher order processing: Plasticity and Motivation

Memory & Synaptic Plasticity [Power]

Motivated learning [Power]

Learning associated plasticity [Power]

CNS dysfunction

Peripheral Neuropathy [Kwai]

Addiction [Power]

NS dysfunction [TBD]

Autonomic Systems

ANS [Kumar]

Hypothalamic Regulation of Autonomic Function [Carrive]

ANS tutorial [Kumar]

Future Therapies

Neuro-prosthetics [Vickery]

Gene therapy [von Jonquieres]

Neural Prosthetics [Vickery]

LECTURE AND TUTORIAL SCHEDULE

Wk		Lectures		Tutorial
		MON (9 – 10)	TUES (11– 12)	WED (11–12 or 12-1)
1	24/7	Foundations: Introduction to nervous system function		
		Neurons and Glia [Moalem-Taylor]	Structure & Function [Moalem-Taylor]	Role of glia in pathological conditions
2	31/7	Foundations: Neural communication		
		Synaptic Transmission [Power]	Simple Neuronal Networks [Power]	Dissecting Neural circuits [Power]
3	7/8	Sensory systems: Hearing		
		Introduction to Hearing: the Cochlea [Housley]	Central Auditory Pathways [Housley]	Cochlear Pathophysiology [Housley]
4	14/8	Sensory systems: Proprioception		
		Kinaesthesia [Héroux]	Kinaesthesia II [Héroux]	Kinaesthesia [Héroux]
5	21/8	Sensory systems: Touch and pain 1		
		Neural Coding [Vickery]	Peripheral Tactile [Vickery]	Neural coding tutorial [Vickery]
6	28/8	Sensory systems: Touch and pain 2		
		Central Tactile [Vickery]	Introduction to Pain [Moalem-Taylor]	Pain tutorial [Moalem-Taylor]
7	04/9	Experimental Planning and Exam Review		
		TBD	Practice exam	Designing an experiment [Power]
8	11/9	Higher order processing: Memory systems		
		Midterm-exam	Memory Systems [Power]	Exam review [Power]
9	18/9	Higher order processing: Plasticity and Motivation		
		Memory & Synaptic Plasticity [Power]	Motivated learning [Power]	Learning associated plasticity [Power]
BREAK				
11	09/10	CNS dysfunction		
		Peripheral Neuropathy [Kwai]	Addiction [Power]	NS dysfunction [TBD]
12	16/10	Autonomic Systems		
		ANS [Kumar]	Hypothalamic Regulation of Autonomic Function [Carrive]	ANS tutorial [Kumar]
13	23/10	Future Therapies		
		Neuro-prosthetics [Vickery]	Gene therapy [Housley or von Jonquieres]	Neural Prosthetics [TBD]

Prac Schedule

wk	date	Prac (Mon 10-1 or 2-5)
1	24/7	NO PRAC
2	31/7	Swimmy part 1 [Power] (WW G16/17)
3	7/8	Swimmy part 2 [Power] (WW G16/17)
4	14/8	Auditory Prac [Housley] (WW 120)
5	21/8	Kinaesthesia [Héroux] (WW 120)
6	28/8	Tactile Psychophysics [Vickery] (WW 120)
7	4/9	Cockroach Nerve [Vickery] (WW 120)
8	11/9	DIY prac assistance [Power] (WW 120)
9	18/9	Simulating the Nervous system [Kario] (G16/17)
BREAK		
11	9/10	DIY 1: Execution and Troubleshooting (WW 120)
12	16/10	DIY 2: Execution and analysis (WW 120)
13	23/10	DIY 3: Analysis and presentation(WW 120)

ASSESSMENT TASKS

Task	Due Date
Pre lab quizzes (7 x)	Mondays weeks 2-8
Midterm Exam	11 September
Final Exam	TBD
Student Designed Prac (Topic and Group Agreement)	11 September
Student Designed Prac (Proposal including RA and SWP)	22 September
Student Designed Prac (Group Report)	26 October
Student Designed Prac (Reflection and Peer Review)	27 October

SWIMMY THE VIRTUAL FISH

The first two computer simulation practical sessions will explore the basic principles of synaptic transmission using the neuronal simulation program Swimmy. The Swimmy program is an inquiry based neurophysiological tool developed by William Grisham, Natalie Schottler, and Franklin Krasne (Journal of Undergraduate Neuroscience Education (JUNE), Fall 2008, 7(1):A1-A8). that allows students to analyse how simple neural circuit work. Specifically, you will examine the neural circuit that controls the movement of a virtual fish.

There are two lab sessions dedicated to this project.

- Week 1 Lab
 - Learn how to use NEURON, the program that runs Swimmy
 - Observe the activity of the motor neurons that allow Swimmy to swim
 - Observe basic neuronal activity, such as action potentials (spikes), EPSPs, IPSPs, etc., in action
 - Review synaptic transmission principles
 - Find all the cells that belong to the circuit

- Week 2 Lab
 - Determine the interconnections between the swimming circuit neurons
 - Learn how to provide convincing evidence of direct neuronal connections
 - Determine which neurons generate the rhythmic pattern
 - Learn how to provide convincing evidence for your conclusion about the origin and mechanism of the rhythm

* Prac and documentation are adapted from the Swimmy two-week tutorial for public release, Creative Commons Copyright Dr. Franklin Krasne, 2008. Additional documentation can be accessed via the UCLA Swimmy Website <https://mdcune.psych.ucla.edu/modules/swimmy>

NEUR3121 Student Risk Assessment		Computer simulation practicals
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Hazards	Risks	Controls
Computer: a) Electrical hazard b) Poor posture.	a) Electric shock. b) Muscular/skeletal pain.	a) All computers electrically tested and tagged. b) Adjust chairs to the appropriate height; adjust the position of the computer screen and keyboard to ensure easy access and viewing of the screen without having to twist or turn your body. Get up and have a break from the computer at least once an hour.

Personal Protective Equipment				

Emergency Procedures

In the event that the emergency alarms sound, stop the experiment. Remove your lab coat and wash your hands. Pack up your bags. Follow the instructions of the Demonstrators.

Clean up and waste disposal

No specific requirements.

Ethics Approval

Not required.

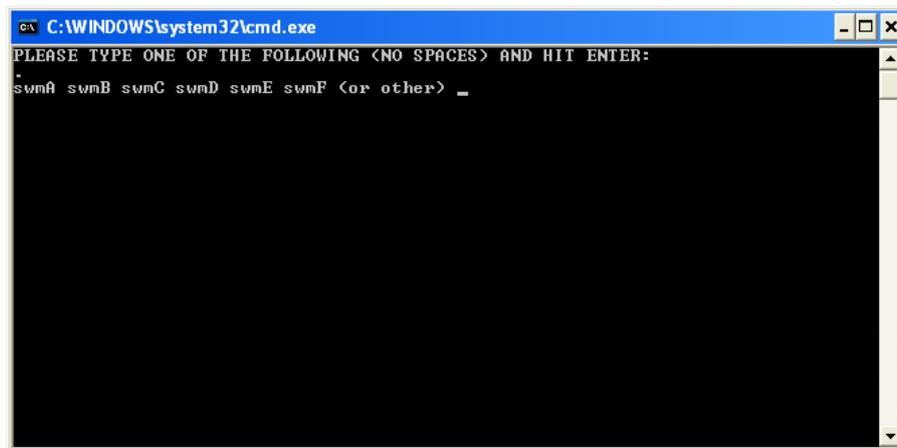
Declaration

I have read and understand the safety requirements for this practical class and I will observe these requirements.

Signature:.....Date:.....

This practical relates to the Safesys Risk assessment MED-SOMS-RMF-2955

Starting Swimmy

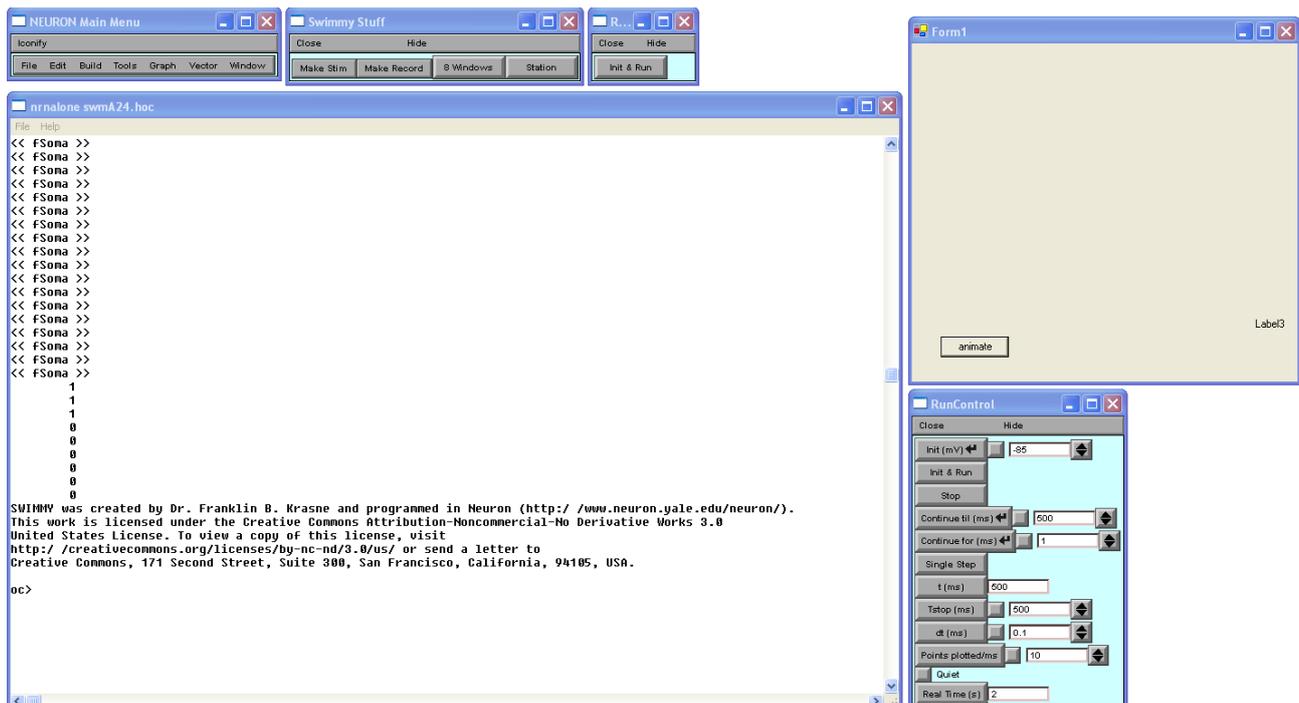


A window will appear listing the six different student versions of Swimmy. Your instructor will inform you which of these programs you will be using, as listed below; circle the one you will be using for your own reference.

- swmA
- swmB
- swmC
- swmD
- swmE
- swmF

Type the program name in the window, then hit **Return** on the keyboard.

Once the program loads, six windows will be displayed. The **nrnalone** window will be referred to as the **Command Window**. You will probably not need to use the **Command Window**, but it must be open for NEURON to run. You may minimize the window so that it does not clutter your screen.

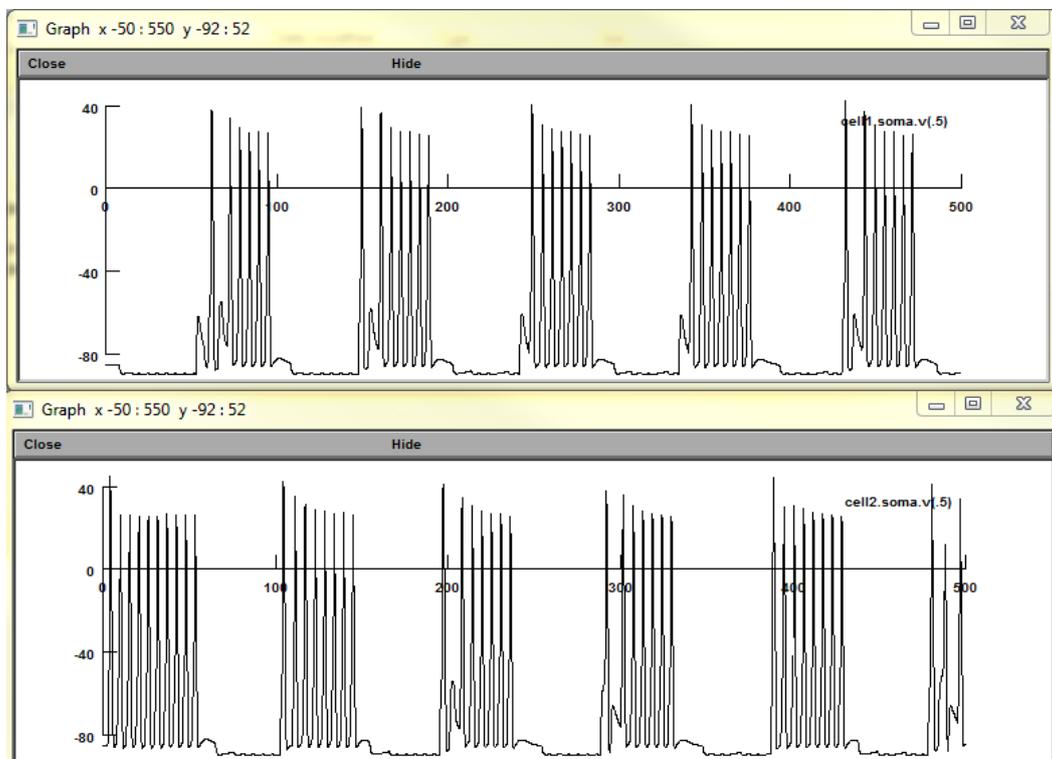


Program operation:

Displaying activity of Swimmy's motor neurons

In order to visualize Swimmy's left and right motor neurons, named **cell 1** and **cell 2** in Swimmy, you must open up a graph that displays membrane potential as a function of time for each motor neuron. To do this, select **Make Record** from the **Swimmy Stuff** window. A list of various cells will appear below this button. Select **cell 1** to open the corresponding graph. Do this again to create a graph for **cell 2**. Position your graphs so that they don't overlap.

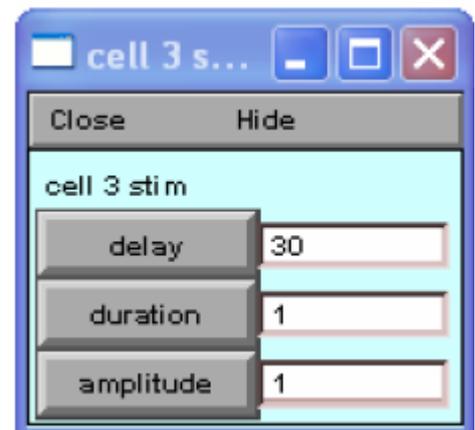
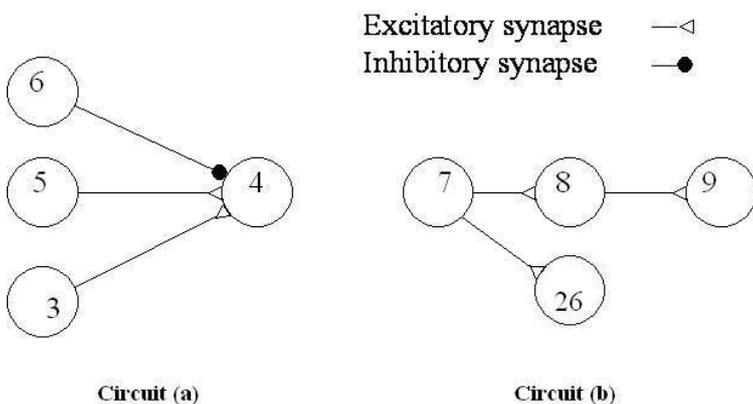
To display this activity of these cells on the graphs, click the **Init & Run** button. You will see alternating bursts of action potentials (spikes) in the two cells that resemble the activity diagrammed in **section 1**. In a real fish, this motor neuron firing pattern would cause alternating bends of the tail fin to the left and right. You should use your **Animate** window to better visualize this.



C

Session 1: Examining some known simple circuits

In this section, you will be given 2 defined circuits to explore. The instructor will guide you through the circuits explaining the principles of synaptic integration and the operation of the program. Please write your notes below.



Circuit (a)

Make a record for neurons 3, 4, 5, 6

Make a stim for neuron 3 and stimulate neuron 3

Start with a 30 ms delay, 1 ms duration and 1 nA amplitude

On the RunControl set Tstop to 100 ms

Observe the response of neurons 3-6.

Increase the increase the stimulus amplitude to determine the action potential (AP) threshold potential. Use keep lines to compare the responses (see Neuron Cheat Sheet). Use crosshairs to measure the threshold potential.

What is the threshold potential for neuron 3?

What is the delay between the peak of the AP in neuron 3 and the onset of the EPSP in neuron 4? Use the Set View on the graph window to adjust the X and Y axis.

Make a stim for neuron 5 (delay 80, duration 1) and evoke an AP in neuron 5. Explore what happens when you adjust the timing of the AP in neuron 5. **When do the EPSPs summate?**

Make a stim for neuron 6 and explore what happens when you adjust the timing of the neuron 6 AP.
Bonus: Can you find evidence of shunting inhibition?

Circuit (b)

Make a record for neurons 7, 8, 9, 10
Initialise and run the simulation

Can you infer from the time of the APs and synaptic potentials, the potential configurations of the circuit?

Is the relative timing of APs and synaptic potentials sufficient to determine the circuit?

Explore what happens when you hyperpolarise each cell (inject a negative amplitude current). Try different onsets, amplitudes and durations.

What did the hyperpolarisations tell you about the cells and connections?

Session 2: Examining some known simple circuits

Swimmy has 26 neurons, two of which are motor neurons (cells 1 and 2) which are responsible for directly stimulating the muscles involved in swimming. Not all of these 26 neurons are involved in the swimming circuit. You already know that cells 3-9 and 26 are NOT part of the Swimmy circuit. Remember that a given neurons uses the same transmitters at every synapse.

Your job is to define the circuit

- Which neurons participate in the circuit?
- How are the neurons connected?
- Which cells initiate the motor pattern?

NOTES:

Swimmy Stuff



Make stim: opens stimulation setting for selected neuron

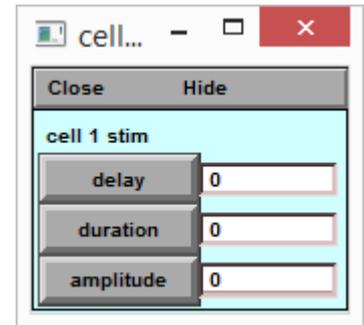
Delay: time until stimulation (ms)

Duration: duration of stimulation (ms)

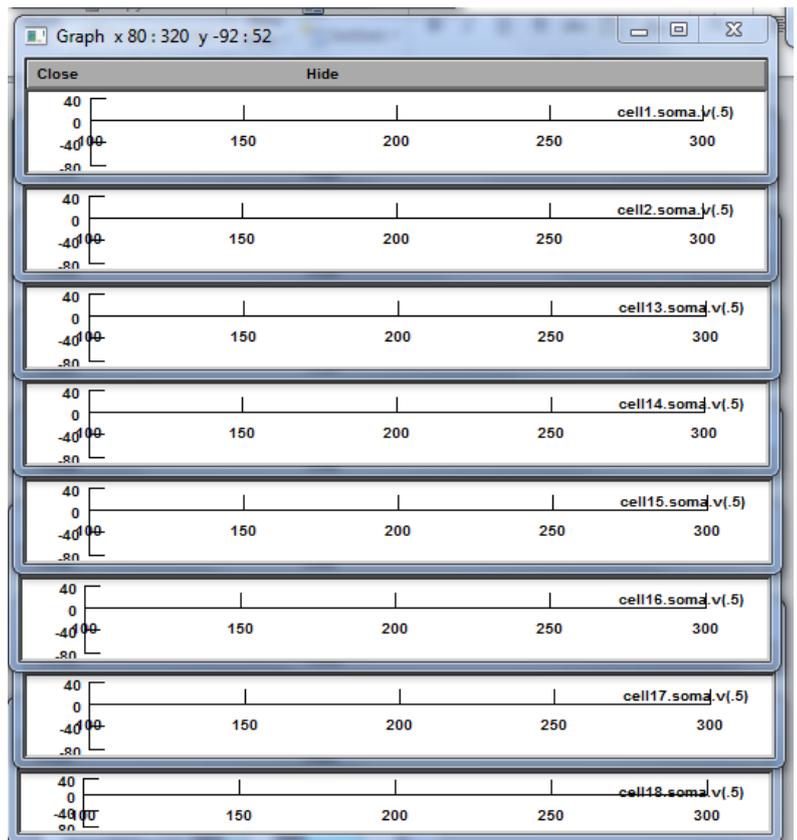
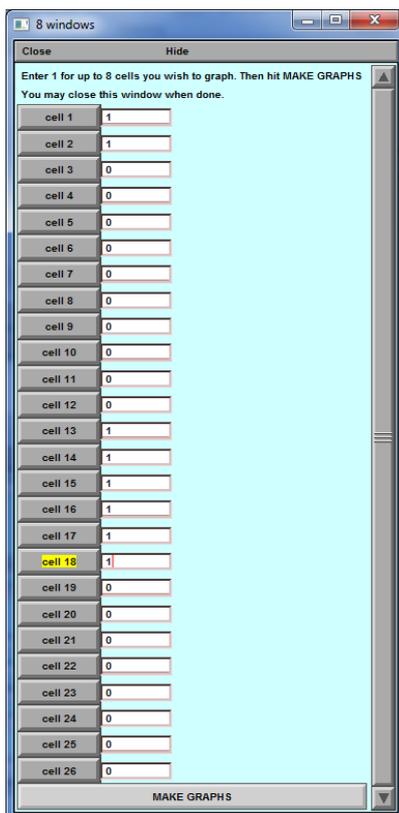
Amplitude: amplitude of stimulation (nA)

➤ Use negative values to prevent AP generation

Make record: generates a graph window for the selected neuron



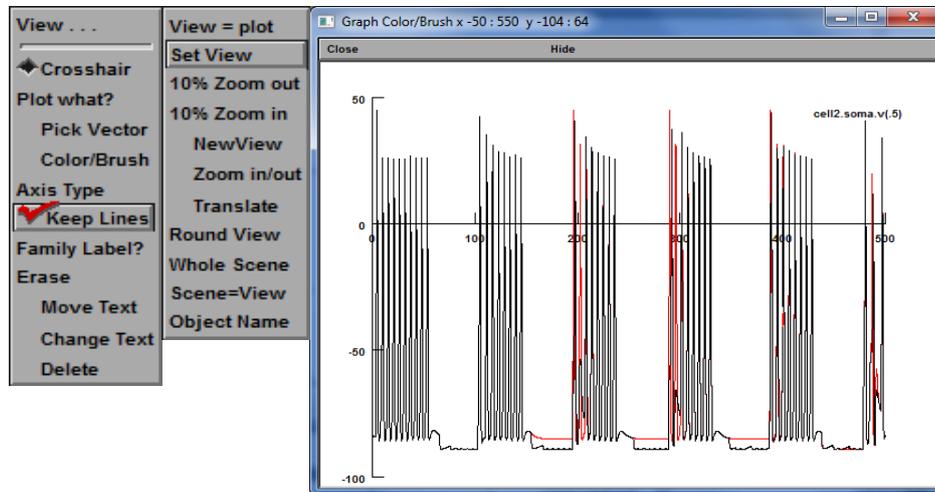
8 Windows: opens dialog for the creation of 8 graph windows



Neuron Cheat sheet

Graph Window

Right Click – opens plot menu



View

- **View = plot** : autoscales graph
- **Set View**: manually set the range of X and Y axis
- **New view**: Creates a new view window. Use the left mouse button to draw a rectangle in the view which will become the interior of a new view.
- **Translate**: Allows use of the middle button to drag the scene around the view

Crosshair: shows the coordinate value of cursor when left mouse button is pressed

Colour/Brush: opens change colour brush pallet. Select the colour then click on line to change colour.

Keep Lines: While checked, lines are saved.

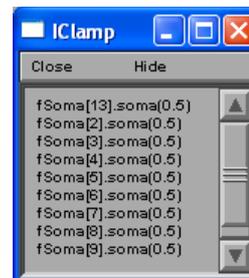
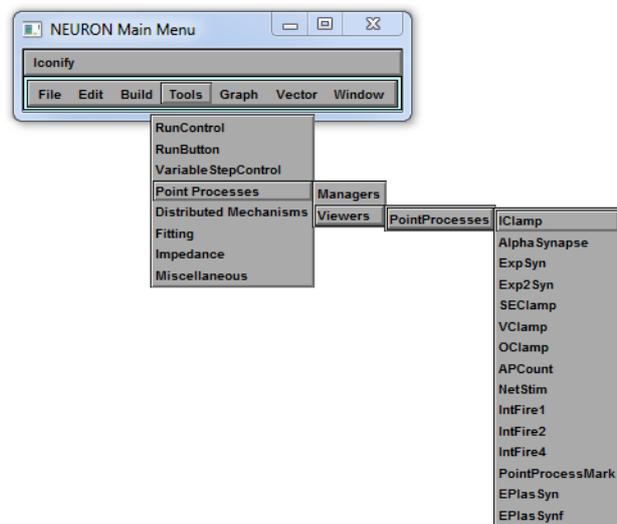
Erase: Erases lines

Recovering a closed stimulation window

Tools-> point processes->viewers->point processes -> IClamp

Double click on closed graph to reopen

DO NOT OPEN FIRST ITEM IN LIST



Tips:

To find neurons that provide monosynaptic input:

1. Stimulate putative presynaptic neuron and note effect on post-synaptic neuron.
2. Look for evidence of a 1msec synaptic delay.

NOTES:

AUDITORY PHYSIOLOGY PRAC

Physiology Teaching Laboratory Student Risk Assessment			PRAC # PHSL-27 Title: Auditory Physiology (NEUR 3221)
Hazards	Risks	Controls	
Use of headphone	a) Loud volume damage hearing	a) Software control sound generated (10V maximum).	
Use of computers a) Electrical hazard b) Poor posture	a) Electric shock b) Musculoskeletal pain	a) All computers are electrically tested and tagged. b) Workstation set-up: Adjust chairs and computer	
Personal Protective Equipment Closed shoes			
Emergency Procedures			
In the event that the emergency alarm sounds, follow the instructions of the Demonstrators and / or Floor Wardens to vacate the building.			
Clean up and waste disposal			
Not applicable			
Ethics Approval			
Not applicable			
Declaration			
I have read and understand the safety requirements for this practical class and I will observe these requirements. Signature:.....Date:.....			

This practical relates to the Safesys Risk assessment MED-SOMS-RMF- 5761

Sound Localization and Binaural Fusion

(Background)

Sound waves coming from a source on the right side of the head arrive at the right ear before they arrive at the left ear. It might be thought that in this situation, one would first hear a sound on the right side and a little later hear a second sound on the left side. Instead, one hears a single sound in the direction of the source. The phenomenon of hearing a single sound when both ears are stimulated is called **binaural fusion** and the process of determining the position of the source is called **localization**.

For any natural sound source to one side of the head, there will be a finite difference between the times of arrival of the sound at the two ears and this could serve as a localization cue. However, this is not the only possible cue. The greater distance to the farther ear and the fact that the sound must diffract around the head into the “sound shadow” mean that there will also be a difference between the intensities of sound at the two ears. Any single natural source is associated with both **time** and **intensity** differences.

a) Interaural time delay (ITD, 20 Hz - 2kHz)

The difference in the time the sound reaches the ears (Δt) may be determined by finding the difference in the distance the sound must travel to reach each ear (Δd). If the velocity of the sound is V then the relationship is:

$$\Delta t = \frac{\Delta d}{V} \quad \text{where } V = 331 \text{ms}^{-1}$$

Determining this time delay thus reduces to a simple geometrical exercise. Imagine a head positioned over a Cartesian reference frame as shown in Figure 1:

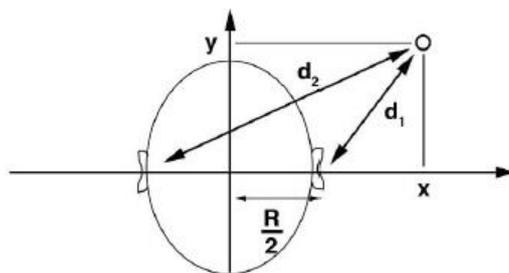


Figure 1: Relationship between spatial location and ear distances.

We can now plot the position of the source for selected time differences as shown in Figure 2.

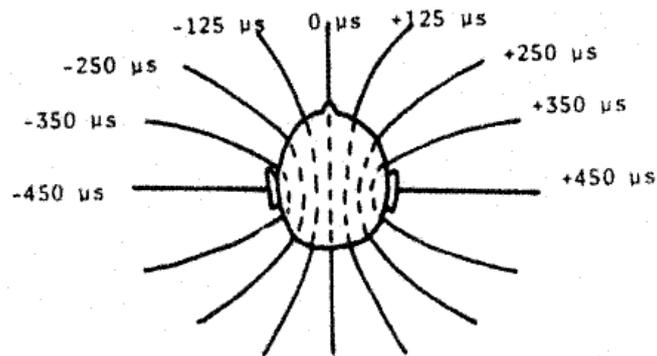


Figure 2: Ears assumed to be 16 cm apart; time difference expressed as the lag of left after right. These lines of constant time differences are hyperbolae. Beyond a certain distance they become radially directed with respect to the centre of the head.

Consider the case in which the ears receive a sound from a source positioned to give a time difference of $450 \mu\text{s}$. The subject could use this information to tell that the source is to her left, but will have difficulty in determining whether the source is behind or in front, above or below. **In an anechoic (non-echo) chamber, the pinna provides the cue available to distinguish these various directions (all lying on a hyperboloid subtending the same time difference). Owing to its asymmetric shape, incident sound waves will be reflected to a varying degree from sources located for example, in front, versus the back.**

Outside this room, however, the subject can also make use of the echoes of the source from nearby objects to remove ambiguity. For common sounds such as a person's voice, our experience provides us with a fairly good estimate of the distance of the source from us. A person yelling from some distance away may have the same loudness as a person whispering close by, but the quality of the two will be markedly different. Our estimate of the distance of a source is therefore based on its intensity or loudness, as well as a judgement based on experience.

In summary, binaural localization by the mechanism of time differences is accomplished by localizing the source on a 'line' of constant *time difference/delay* and estimating its position on this line by a combination of its *loudness* and subjective experience.

The degree to which the angular orientation of a source may be estimated depends partly on the ability of the ear to detect the time delay (Figure 3).

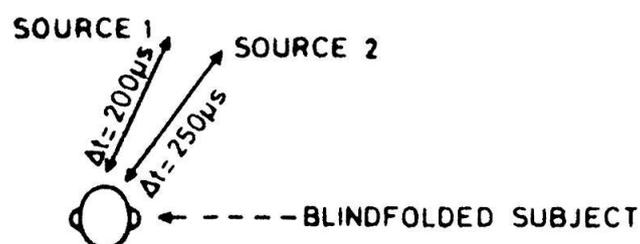
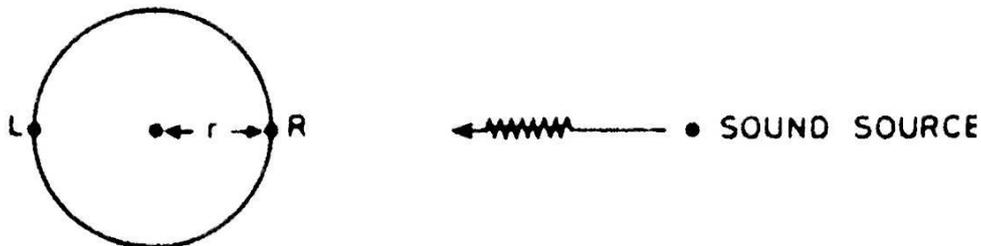


Figure 3: For the subject to be able to tell that Source 1 is to the left of Source 2, it is necessary for him/her to judge a time delay of only $50 \mu\text{s}$. This is an extremely short time in terms of the operation rate of the nervous system. For instance, it takes one millisecond (20 times longer) for an action potential to cross over a synapse. This reflects the incredibly tight regulation of gating of synaptic vesicle release at the hair cell – spiral ganglion neuron (ribbon) synapse.

b) Interaural intensity difference (IID, 2 - 20 kHz)

In addition to time differences, spatial distance between the two ears - the ‘sound shadow’ casted by the head, will cause a pressure difference in the sound waves reaching the two ears. Lord Rayleigh (1877) calculated the relationship between the sound pressures at diametrically opposed points, the radius, and the wavelength of sound (λ), for a perfect sphere (Figure 4):



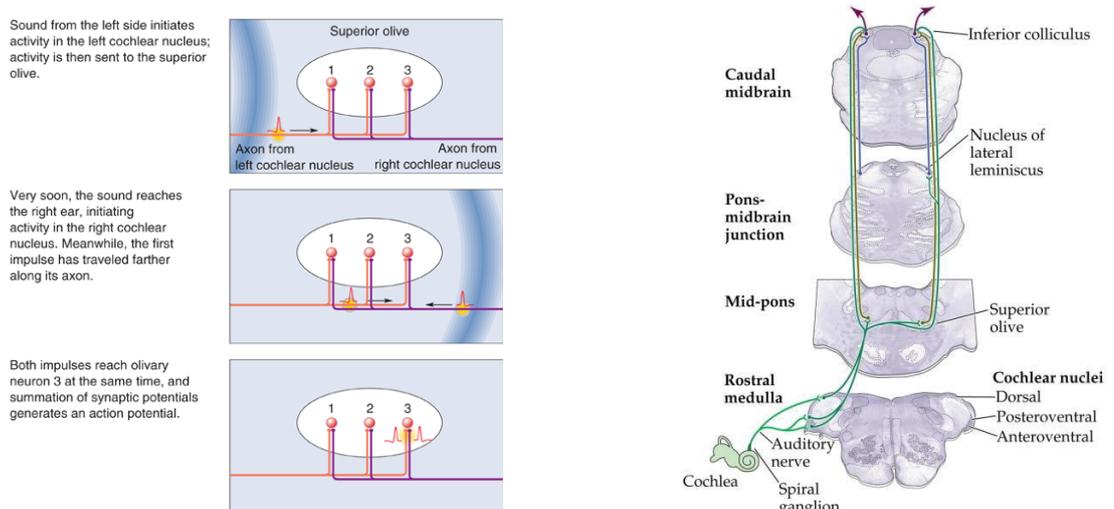
$$\text{Interaural intensity difference } (\Delta P_L - P_R) \propto \frac{2\pi r}{\lambda}$$

Figure 4: Interaural intensity difference caused by physical presence of the head as sound shadow.

Owing to the fact that real head shapes plus the pinnae, provide more complex reflectors than do spheres in the sound field, the real interaural intensity difference is a non-linear function of sound frequency. The head is effectively a sound shadow **at frequencies above ~ 2 kHz**, and a maximum attenuation of sound pressure of about 25 dB can be achieved with the sound source at 45° to the interaural line, at frequencies of 8 kHz and above. The pinna also has a very important role in directionality and in providing amplification when sounds fall on its acoustical axis.

c) Neural mechanisms of sound localization

It has been shown in the last 15 years that the sound localization cues are encoded by neurons in the lateral and medial **superior olivary nuclei**. These nuclei receive **binaural** connections from the cochlear nuclei of each side, and transmit their impulses to the inferior colliculus (Figure 5).



BCP 11.25

Figure 5: Neural pathways for sound localization

Measurement of sound levels and hearing thresholds

The decibel (dB) is used to measure sound level. It is a logarithmic unit used to describe a ratio. The ratio may be power, sound pressure, voltage or intensity.

$$L \text{ (intensity in dB)} = 20 \log_{10} (\text{sound pressure}_{\text{measured}} / \text{sound pressure}_{\text{reference}})$$

When dB is used to give the sound level for a single sound rather than a ratio, a reference level must be chosen. For sound pressure level (SPL), the reference level (for air) is usually chosen as 20 μPa – it is very low but is about the limit of sensitivity of the human ear in its most sensitive frequency range.

If you read of a sound pressure level (SPL) of 86 dB, it means that

$$20 \log \frac{p_2}{p_1} = 86 \text{ dB}$$

$$\log \frac{p_2}{p_1} = 4.3$$

$$\frac{p_2}{p_1} = 10^{4.3} = 20,000$$

So this sound has a sound pressure 20,000 times greater than that of the reference level. 86 dB is a loud but not dangerous level of sound. Humans can generally detect between 0 to 120 dB SPL. 0 dB occurs when you take the log of a ratio of 1 ($\log 1 = 0$). So 0 dB does not mean no sound, it means a sound level where the sound pressure is equal to that of the reference level. This is a small pressure, but not zero. It is also possible to have negative sound levels: -20 dB would mean a sound with pressure 10 times smaller than the reference pressure, i.e. 2 μPa .

Audiogram

An audiometry exam tests your ability to hear sounds. Sounds vary based on their loudness (intensity) and the frequency of sound wave vibrations (tone/ pitch). The test is performed in a sound proof booth designed to reduce external noise. The test does not replace a complete assessment of auditory function and professional consultation with certified audiologist is strongly recommended.

The audiometer consists of an oscillator which generates pure tones over a frequency range of 0 – 12,000 Hz at a preset output level. An attenuator enables the loudness to be adjusted from this preset level.

The sound is delivered to the ears through headphones and may be delivered to either ear or both. Because the output of the headphones is not perfectly flat at different frequencies, but instead has peaks and troughs, the audiometer has been specifically calibrated to compensate for the irregularities of this particular set of headphones. The purpose of the exercise is to measure for each ear the threshold for hearing for a series of frequencies over the range **250 to 8,000 Hz**. The resulting plot of this threshold versus frequency is called an **audiogram**. On the clinical audiometer used in this practical, the zero dB output intensity corresponds, at each frequency, to the level of sound which can only just be heard by the average individual. From this setting the volume control can be moved up

or down, so that if the loudness of a particular tone has to be increased to 30 dB above normal before it can be heard the subject is said to have a hearing loss of 30 dB at that frequency.

Hearing Loss / Disability

Hearing Disability is usually attributed to two types of hearing loss - conductive hearing loss, sensorineural hearing loss, and a mix of the two.

Conductive hearing loss is caused by impairment in sound transmission from the outer and/ or middle ear. It can be caused by anything that blocks or interrupts the passage of sound through the external (outer) and/or middle ear. Some of the causes include:

- Hardened earwax that fills the ear canal (occlusion);
- Foreign object or even water
- Abnormal growth of bones in the middle ear – e.g. otosclerosis
- Middle ear infection (otitis media) causing 'glue ear'

Conductive hearing loss can usually be corrected by treating the underlying cause. In case of genetic cause of conduction deafness, sound can still be conducted into the cochlea by means of bone conduction, which is the principle behind certain types of hearing aids.

Sensorineural hearing loss occurs when sound reaches the inner ear but damage or malfunction present in the cochlea (sensory receptor hair cells and/or supporting cells) or the auditory nerve, or the central auditory pathway prevent proper hearing. Sensorineural hearing loss leads to a loss of hearing sensitivity (loudness) and often frequency discrimination (clarity). Damage to the cochlear hair cells may result from:

- Age-related hearing loss (prebycusis)
- Noise-induced hearing loss – including impulse loud noise, repeated noise exposure
- Ototoxic drugs – including platinum-based chemotherapeutic agents, aminoglycoside antibiotics, heavy metals.
- Congenital disorders, e.g. rubella infection, birth trauma such as the lack of oxygen, jaundice
- Ménière's disease
- Infection such as meningitis
- Head injuries

Sensorineural hearing loss is permanent and is usually treated with the use of hearing aids or cochlear implants for profound deafness.

EXPERIMENT 1.1 - SEPARATION OF TIME AND INTENSITY CUES IN LOCALIZATION

In order to separate the time and intensity factors for study, a computer program driven by a soundcard will present independent stimuli to the two ears via headphones. The intensities at the two ears and the time difference between presentations can be varied independently. Stimulation of the two ears results in only a single sound being heard (**binaural fusion**), but in this case the sound appears to come from inside one's head.

The sensation of the pulse coming from inside your head arises because the sound appears very close to your ears with a time delay smaller than that expected by a single source near either ear. With reference to an earlier diagram (Figure 2), the sound therefore appears to come from somewhere along the lateral line 'inside your head', illustrated in Figure 6.

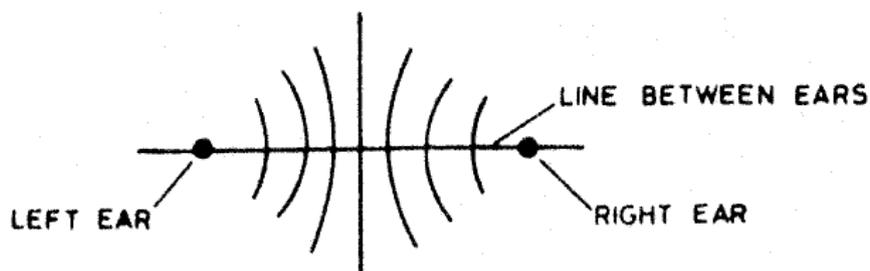


Figure 6: Varying the time or intensity difference moves the sound from side to side within the head. This phenomenon is called **lateralization** to distinguish it from the localization of external sound sources. These phenomena are demonstrated in the following experiment.

Locate the program “**sound localization**” (Class menu→ Data Acquisition...→Sensory Physiology..sound localization). The control panel of this program is shown in **Figure 7**.

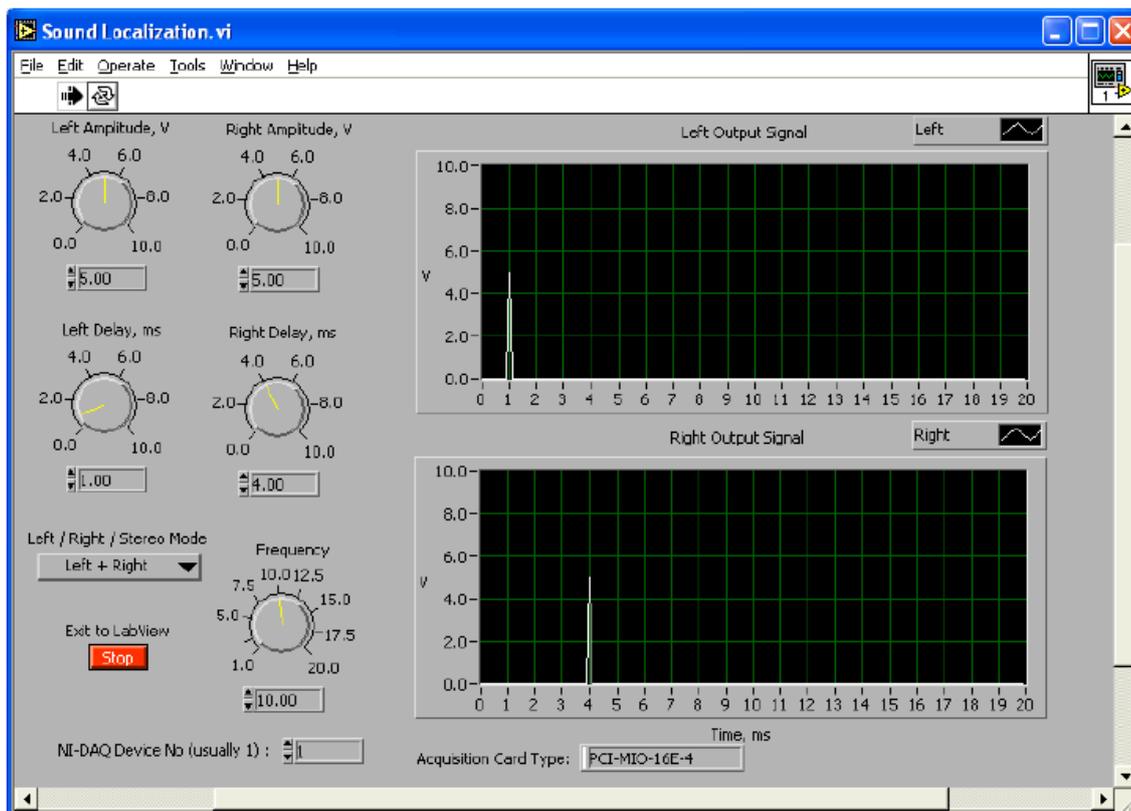


Figure 7: Control panel of Sound Localization program in PowerLab

Objectives:

- 1) **Understanding how lateralization leads to binaural fusion in hearing.**
- 2) **Compare the contribution of interaural intensity difference and interaural time difference to sound localization.**

Select output “Stereo Mode” – “Left and Right” channels

Set the following parameters:

Frequency	10 Hz
Delay	2 ms
Amplitude	~1V

Use the trace on the screen to measure the duration (ms), amplitude (V) and onset of the two pulses (Left, Right), and adjust the stimulator settings so that the two pulses are identical. Put on the headphones, check left side is on the left ear, and check that the loudness level (~1V) is comfortable.

1. Switch the output to “Right”.

Q: What do you hear?

Switch the output to the “Left”

Q: What do you hear?

Switch back to “Stereo”

Q: For each paired delivery of clicks in the train at 10 Hz, do you hear two separate clicks (one in each ear as before), or a single click in the midline of your head? The latter is an example of binaural fusion.

2. **Studying Interaural intensity difference (IID):**

This exercise is best carried out by a lab partner with the subject blinded.

Keeping the delay on both channels the same so that the pulses occur at the same time (zero time difference), adjust the **amplitude** of the pulses to one channel so that the pulses are larger to the right ear.

Q: For each paired delivery of clicks in the train at 10 Hz, do you hear two separate clicks (one in each ear as before), or a single click in the midline of your head? The latter is an example of binaural fusion.

Q: What happened to the location of the clicks? This is lateralization due to an intensity difference

Q: Hence, what is the relationship between the direction of lateralization and the ear which receives the greater intensity?

With equal delays, adjust the two **amplitude** controls until the sound appears to come from midline of the head again, note the amplitude of the sound stimulating voltage:

Left voltage (V_L):

Right voltage (V_R):

ΔV (voltage difference, $V_L - V_R$):

Now increase the amplitude on one of the pulses so that it appears to move towards one ear. Readjust the voltage so that a centered image is perceived and measure the voltage difference. Repeat this exercise 3 times, holding V_L constant. Record V_R and ΔV values and calculate the mean ΔV and its standard deviation (SD). This will give an estimate of your error in centering the image using intensity as a cue. You may find that different voltage differences occur with different absolute voltages for the pair of clicks.

a) Left voltage constant ($V_L =$)

Test	1	2	3	Mean ΔV	SD
V_R					
ΔV					

b) Right voltage constant ($V_R =$)

Test	1	2	3	Mean ΔV	SD
V_L					
ΔV					

Q: Which of the factors discussed in the background information are addressed by balancing levels between ears to get centering of sound localization?

3. Studying Interaural time difference (ITD):

This exercise is best carried out by a lab partner with the subject blinded.

With the left and right amplitudes set for a centered image (your answer from exercise 2 a)) move the time **delay** knob so that the pulse coming into the left ear occurs before the one coming into the right ear or vice versa. - By moving the delay knob back and forth, observe that the shift in the perceived location of the clicks. Now quantify this....

With the subject blinded, adjust the position of the delay knob until the pulse appears at the midline of the head. Note this delay value. Now increase the left side delay (sound appears on right side) until maximum sustained movement of perceived sound to the right – before fusion breaks down. Note this time delay. Now repeat for left side leading, noting maximum right side delay.

Test	Baseline (centred)	1	2	3	Mean Δ Time	SD
Left delay (ms) for maximum lateralization						
Right delay (ms) for maximum lateralization						

Q: For each paired delivery of clicks in the train at 10 Hz, do you hear two separate clicks (one in each ear as before), or a single click? The latter is an example of binaural fusion.

Q: What is the relationship between the direction of lateralization and the ear which receives sound first?

Q: What is the difference between maximum delay for sound lateralization and the delay which is the threshold for breakdown of binaural fusion?

4. Now with regard to binaural fusion - Determine the maximum time difference for which you can accomplish binaural fusion by setting one channel to 1 ms delay. On the other channel adjust the delay setting in small increments from about 2 ms to 5 ms.

Q: What is the maximum time difference for your binaural fusion?

EXPERIMENT 1.2 – INTERACTIONS OF TIME AND INTENSITY

Objective: Interpret how time and intensity affect lateralization in binaural hearing

You have just observed that time differences alone and intensity differences alone can produce lateralization. You will now show that lateralization due to a time difference can be balanced or compensated by lateralization due to an intensity difference. Time information and intensity information are therefore said to be “traded”.

1. Equalize and superimpose the two pulses on the screen by setting both delays at 1 ms and both amplitudes at 1 V.

Without changing the delay settings, move the voltage dial of the left channel around in both directions and then bring it back to a position at which the sound is centered in the middle of the head. Measure the amplitude on the left channel.

Left amplitude (V_L) =

At this, and all subsequent intensity pairings, repeat amplitude estimations until a consistent reading is obtained or a reasonable average value is determined.

2. By either increasing the delay on the left stimulator, or decreasing the delay on the right stimulator, increase the time difference between the two pulses to 0.5ms, 1.0 ms, 1.5 ms, 2.0 ms and 2.5 ms. Then, compensate this induced sound lateralization by increasing V_L , to bring the clicks back to the middle of the head.

For each of these time differences (τ), keep V_R constant and record the V_L (average of about 3 readings) required to bring the clicks back to the middle of the head.

Average increase in V_L for an increased Left delay, constant V_R =

Right delay (ms)						
Left delay (ms)						
Time difference τ (ms)	0	0.5	1.0	1.5	2.0	2.5
ΔV_L #1						
ΔV_L #2						
ΔV_L #3						
Mean ΔV_L						
Mean intensity difference (dB)*						

* mean intensity difference (dB) = $20 \log \frac{\Delta V_L}{\Delta V_R}$

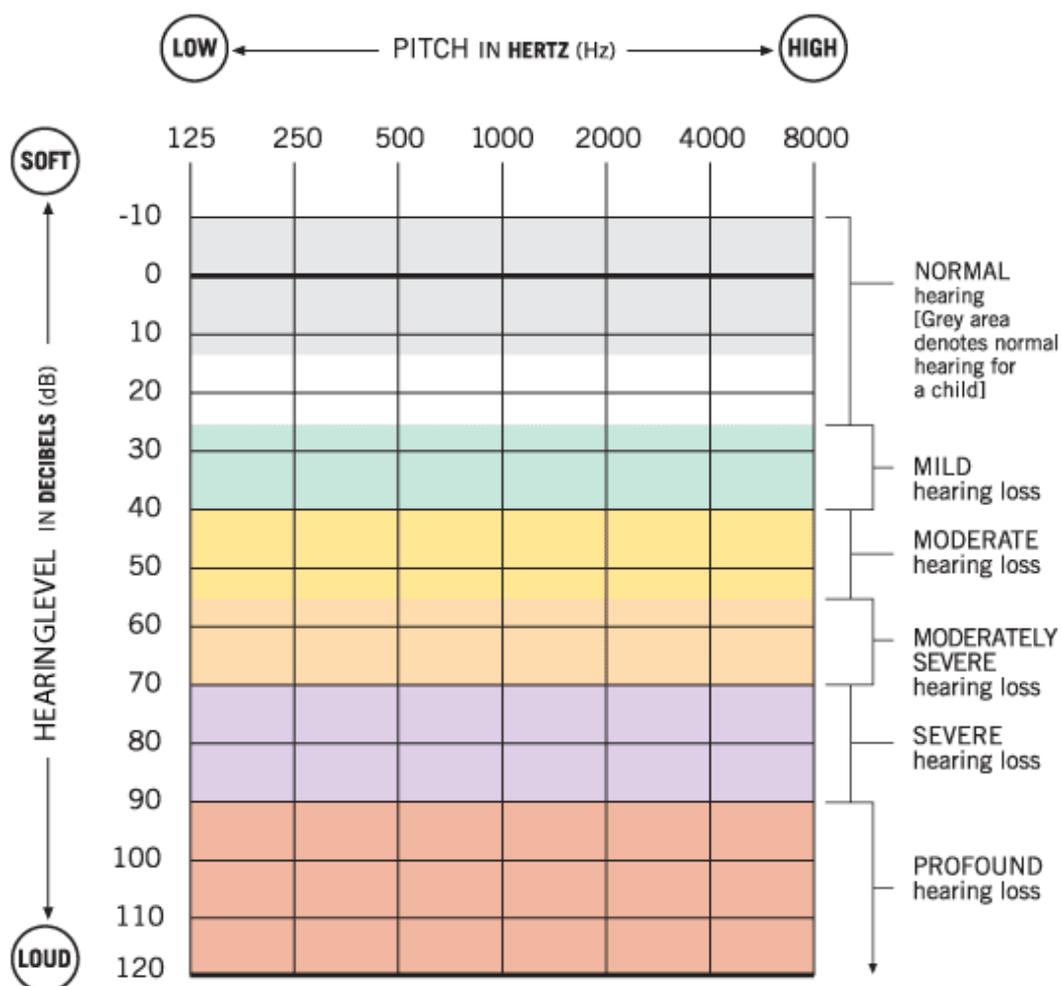
EXPERIMENT 2.1 – AUDIOMETRY

Objective: Assess hearing sensitivity in human subjects using puretone audiometry.

An audiogram will be obtained for one member of the group. The subject should not manipulate the controls nor be aware of their settings. The demonstrator will set a particular frequency, e.g. 6,000 Hz, on the oscillator, set the attenuator to 0 dB and then adjust this output using the attenuator controls until the subject is just able to hear the sound. This will be repeated for 5 to 6 different frequencies over a range. Audiograms should be plotted out for each ear separately and if time permits for binaural hearing. Over a considerable range the threshold for binaural hearing is significantly lower than for monaural hearing. Compare the audiograms between group subjects and observe any differences. Our sensitivity to frequencies above 4 kHz starts to fall off in the 20's.

It should be noted that the threshold for sound detection is somewhat higher (4-6 dB) when tested with headphones than when sounds are delivered in a free sound field. The difference is probably due to the headphones acting as a resonator ("seashell effect") or acoustic filter that dampens one frequency and boosts other frequencies.

We can generally detect 0 to 120 dB SPL.



EXPERIMENT 2.2 – TUNING FORK TESTS FOR HEARING FOR HEARING LOSS

Objective: Contrast effects of conductive and sensorineural hearing loss

The diagnose of deafness as being conductive or sensorineural can be aided by using a tuning fork (usually of 512 Hz resonance) and applying the Rinne test or the Weber test

Rinne test – the vibrating tuning fork is placed on the mastoid bone to test for bone transduction. When the subject is no longer able to hear the tone of the tuning fork, it is quickly moved so the top of the fork is opposite the pinna. The subject can usually still hear the tuning fork, due to the amplification of airborne sound pressure contributed by the outer and middle ear.

Q: What result would you expect from someone with a form of conductive or sensorineural hearing deafness?

Weber test – the base of a vibrating fork is placed on the middle of the forehead. The subject reports which ear the sound is heard louder. Normally both ears 'hear' the sound equally.

Q: What result would you expect from someone with a form of conductive or sensorineural hearing deafness?

Notes

KINAESTHESIA

Proprioception in alignment of elbow joints

Physiology Teaching Laboratory Student Risk Assessment	 UNSW THE UNIVERSITY OF NEW SOUTH WALES	PRAC # PHSL-25 Title Kinaesthesia (NEUR 3221)
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Hazards	Risks	Controls
A vibrator is used which may be an electrical hazard	Electrical hazard - Shock	The vibrators are used by a demonstrator, and the students are not allowed to use them without supervision. All electrical cords are tagged. Check tags on electrical cords for servicing details. RCD connected to the electrical circuit.

Personal Protective Equipment			
Not Required			

Emergency Procedures
Switch off power, wash hands and if required to evacuate, follow the instructions of the demonstrators or the floor wardens.

Clean up and waste disposal
N/A

Ethics Approval
Not Required

Declaration
I have read and understand the safety requirements for this practical class and I will observe these requirements. Signature:.....Date:.....

This practical relates to the Safesys Risk assessment MED-SOMS-RMF-5746

TESTS OF PROPRIOCEPTION

The apparatus for this simple test is a Perspex screen marked out in degrees. The screen is placed vertically on a table between the subject's elbows. The subject rests his/her elbows on the table top and extends the forearms forward to rest on the table top also. The wrists are kept stiff, and the fingers closed into a loose fist except for the index fingers which point towards the mid-line.

The subject, blindfolded, is instructed to touch the fingertips together at some point on the board. Fine lines are drawn along the tips of the index fingers to aid observations by the experimenters. Choose the placement of the left index finger on the board as an arbitrary reference, and record the placement of the right index finger in degrees of rotation too flexed (positive), too extended (negative), or on target (zero error). Disregard misalignments due to wrist and finger angulations (i.e. misalignments along a radius of the forearm movement).

Always take 10 readings for each experimental situation. Calculate mean, and standard error of the mean.

Experiments

1 (a) An experimenter gently lifts the subject's left hand and places it so that the index finger is against the Perspex. Precisely 10 seconds later, the subject bends his/her right elbow to move the right hand to the board in an attempt to align the fingers. The subject is not to be hurried in his/her choice, but must not touch the board until alignment is satisfactory. After each reading the subject places the hands back to their starting position on the table top. Make 10 readings of attempted alignments in mid-range and 10 at extreme range.

Q Is there any difference in the subject's accuracy? Why?

Devise another experiment to examine your reasons further.

(b) Is the subject more accurate when allowed to move both arms voluntarily, and at once, to a self-chosen point in the middle of the range of excursion.

Comment:

2. (a) Apply a physiotherapy vibrator firmly over the biceps tendon of the left arm and repeat experiment 1.

(b) Take another set of readings with the vibrator over the triceps tendon of the left arm.

Do 2(a) and 2(b) differ from control 1? What might be the mechanism of this?

PERCEPTION OF HEAVINESS

Arrange for a blindfolded subject to lift weights with corresponding body parts on each side of the body. Arbitrarily choose one side as the reference (or experimental) side. Present a weight on that side.

Ask the subject to choose a weight to be lifted by one side of the body (the indicator side), which seems of the same heaviness as that on the experimental side. To permit this choice, present weights on the indicator side and adjust them up or down between lifts in the direction requested by the subject. Always add or subtract as instructed, but "overshoot" from time to time. When both sides seem the same, record the weight on the indicator side as the perceived heaviness of the weight on the reference side.

Make 10 readings, and calculate means and standard errors of the mean.

Q: How accurately can the subject estimate the heaviness of a lifted object?

Devise an experiment of your own on the perception of heaviness (10 more readings, compare with control).

PROPRIOCEPTIVE ILLUSIONS INDUCED BY MUSCLE VIBRATION

Apply a physiotherapy vibrator over a prominent muscle tendon, and ask your blindfolded subject to align the unvibrated side, with vibrated side. This experiment should reveal a proprioceptive illusion.

Examine and discuss it, with special reference to its possible physiological basis.

Q: How long does it last?

Q: What is it? (an illusory position? an illusory acceleration? an illusory force?)

Q: Does it occur when the stimulus applied to the tendon when the joint is at the end of the range which lengthens the muscle acting through that tendon? If so, what does this tell us about CNS processing?

[A demonstration will be given of the effect of applying vibration to the Achilles tendons of a standing subject].

Notes

PSYCHOPHYSICS OF TACTILE SENSATION

Physiology Teaching Laboratory Student Risk Assessment	 <p>UNSW THE UNIVERSITY OF NEW SOUTH WALES</p>	PRAC # PHSL-24 Title Psychophysics of Tactile Sensation (NEUR 3221) DOC:PHSLSRA----
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Hazards	Risks	Controls
Students use sandpaper against the skin	scratches leading to infection	Finer grades of sandpaper are used. The students are instructed to press and move their fingers gently against the sandpaper
Students blindfolded use two brass rods kept in hot water (set at 40°C) and Ice to briefly touch the back of their hands	Electrical: shock Hot water: scalding	The Water bath will already be set at 40°C. All electrical equipment's are tested and tagged. Students touch their skin for only few seconds and remove the brass rod once they feel and be able to differentiate between hot and cold sensation.

Personal Protective Equipment			
none			

Emergency Procedures
Switch off power, wash hands and if required to evacuate, follow the instructions of the demonstrators or the floor wardens.

Clean up and waste disposal
n/a

Ethics Approval
Not Required

Declaration
I have read and understand the safety requirements for this practical class and I will observe these requirements.
Signature:.....Date:.....

This practical relates to the Safesys Risk assessment MED-SOMS-RMF- 5769

Introduction

Psychophysics is that area of perceptual psychology dealing with the relationships between sensation and the physical stimuli responsible for the sensation. This discipline had its origins in the 19th century work of Fechner and Weber, two German psychophysicists who sought to measure sensations and relate those measures to the corresponding physical stimuli.

In sensory physiology one of the aims is to account for subjective sensory capacities, as revealed by psychophysical studies, in terms of the features of neural responses. Thus, the neurophysiologist attempts to correlate stimulus values with differences in neural responses while the psychophysicist tries to correlate stimulus values with sensation magnitude. One of the difficulties for the neurophysiologist is in deciding which neural response is the appropriate one to measure. This can usually only be done by measuring neural activity in a number of ways while the particular stimulus is varied. In this way it may be possible to discover a measure of neural activity that provides a relationship with the stimulus variations that matches the relation between the same stimulus variations and psychophysical measures of sensation. If a functional relation is established between the neural responses and the stimulus variations, of the same form as that relating stimulus to sensation, then the neural response may qualify as the neural code for the stimulus attribute.

Aspects of psychophysics

Psychophysical studies are normally concerned with one of four aspects of sensory performance:

- (i) Detection
- (ii) Recognition
- (iii) Discrimination
- (iv) Scaling or ranking

Detection of sensory stimuli

The detection problem deals with the minimum amount of energy necessary for the subject to say that the stimulus is present. Although it was originally thought that this threshold should have a fixed value, it is now known to vary from trial to trial. These variations may be associated with changes in attention, fatigue or other factors. Thus, the neural signals generated by stimuli are generally superimposed on a background of 'noise' generated by the nervous system. Only when they emerge sufficiently from that noise will they generate a subjective response.

Two ways of assessing threshold are by

- (i) the method of Limits
- (ii) the method of Constant Stimuli

With the method of Limits the stimulus is initially set to a strength which is very faint and undetectable and is gradually increased until the subject says 'I detect it'. On alternate trials the experimenter starts with the stimulus at a high, obviously perceptible level and progressively reduces its intensity until the subject says 'I no longer detect it'. The mean level can then be obtained as the threshold for detection.

The second method relies on a series of fixed stimulus intensities being delivered, usually in random order, and a graph plotted of the proportion detected at each intensity. The Detection Threshold is then usually taken as the value where the probability of detection is 0.5.

Recognition of sensory stimuli

Apart from the problem of detecting a stimulus, one of the major tasks for the sensory system is that of *recognition* of the stimulus. This differs from the discrimination task considered below in that the recognition problem involves identification of a particular stimulus from a range of possible stimuli presented whereas in a discrimination task the subject has to judge whether one stimulus, a *comparison stimulus*, differs from the *reference stimulus*. The recognition or identification problem is

concerned with how many different stimuli within a continuum (for example, recognition of pitch or loudness or brightness) the subject can reliably identify. For any one sensory continuum this turns out to be rather small, usually a set of only about 7 stimuli within the range can be perfectly recognized.

Discrimination of sensory stimuli

In a discrimination task the subject is presented with paired stimuli, one being the *reference stimulus*, the other being the *comparison stimulus*. These differ normally in a single stimulus dimension (for example loudness; brightness; frequency of vibration on the skin). In a *same-different design* the subject is required to decide whether the comparison stimulus is different from or the same as the reference. An alternate experimental design called a *two-alternative forced choice* uses paired stimuli, but the subject is required to say whether the comparison stimulus is greater or less than the reference stimulus. If the comparison stimulus can take a series of values and is presented repeatedly at each of these values the experimenter can then record the proportion of deliveries on which the subject called the comparison stimulus 'different' or 'greater' for each of its different values. A graph can be constructed plotting this proportion (ordinate) against the value (abscissa) of the comparison stimulus. From the resulting curve, often known as a *psychometric function curve*, a quantitative measure of the subject's discriminative ability may be derived. For a same-different design the value of the comparison stimulus that is called 'different' 50% of the time represents the *just noticeable difference*, or JND for the subject for that reference stimulus. In a two-alternative forced choice (2AFC) design, the 50% ordinate value represents chance performance, and the value of the comparison stimulus that results in 75% of responses being called 'greater' is known as the difference limen. If the 50% value in a 2AFC experiment occurs at a value where reference stimulus \neq comparison stimulus, the subject exhibits *bias*. Bias need not be deliberate, but represents an inherent tendency of the system or subject towards a particular response, and may be related to the time interval between presenting the reference and comparison stimuli. Subjects in a same-different experiment may also exhibit bias, by using lax or strict criteria for calling 'same' or 'different' for cases where they are unsure.

The stimulus increment needed for discrimination is not a fixed value for different values of the reference stimulus, but rather, as the reference stimulus increases, the JND and difference limen also increase. This relation between the size of the JND and the size of the reference stimulus is called *Weber's Law*, given by:

$$\Delta S = KS$$

where ΔS is the size of the JND, S is the value of the reference stimulus, K is a constant, therefore: $K = \Delta S / S$

" $\Delta S / S$ " is known as the *Weber fraction*. Weber's Law indicates that the increment in the stimulus (ΔS or the JND) needed for discrimination is a function of the reference stimulus intensity. Thus, with a low intensity reference stimulus, a small increment is needed for discrimination; with a more intense stimulus a bigger increment is needed. Although Weber's Law indicates that the Weber fraction is independent of the stimulus strength this is not true for all sensory continua.

Scaling or ranking in psychophysics

In studies of sensation the issue of *scaling* arises where the subject is judging how intense the stimulus is. This problem obviously applies only to those aspects of sensation which vary in intensity or magnitude, such as brightness, weight, pressure, or loudness, but not for sensory continua where changes in the physical stimulus lead to changes in quality rather than quantity, such as colour. A sensory continuum which can change in quantity is known as a *prothetic continuum*, e.g. changes in pressure or indentation on the skin. A sensory continuum which varies qualitatively, such as the *location* of a skin stimulus, is a *metathetic continuum*.

One of the ways of scaling stimuli along a sensory continuum is by allocating the stimuli to a number of different categories, for example 1 to 8, and plotting the relation between the average category allocation on the ordinate against the actual stimulus intensity on the abscissa. The form of the relation obtained in this type of plot will vary somewhat from one sensory continuum to another but, as demonstrated by Stevens' work the relation is usually described by a *power function* or *power law* relation given by:

$$R = K S^n$$

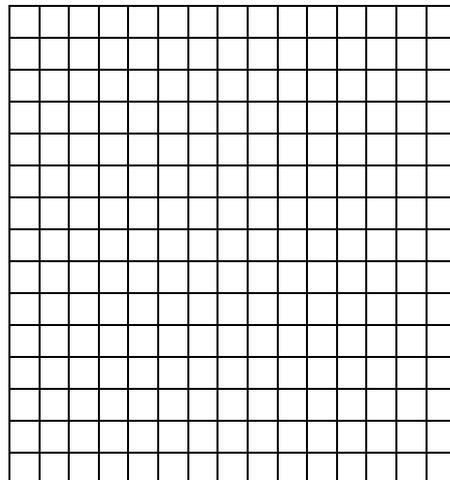
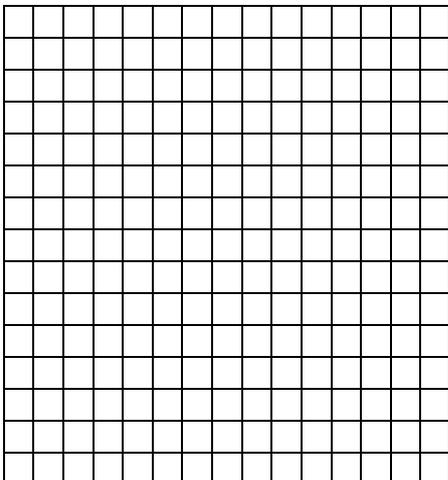
where R represents the subject's scaling estimate, S represents the intensity of the stimulus, K is a constant; n is the value of the exponent, which will vary for different sensory continua.

EXERCISE 1: TEXTURE DISCRIMINATION

Design an experiment to test the ability of the subject to discriminate different grades of sandpaper. Factors you might consider in your study include:

- static discrimination (press the finger tip onto the sandpaper) compared with discrimination with movement permitted;
- active versus passive movement (subject moves finger or experimenter moves sandpaper);
- the role of contact force;
- whether a barrier such as a glove or a sheet of paper enhances discrimination.

Protocol:



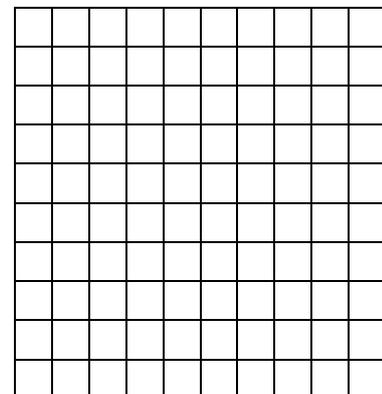
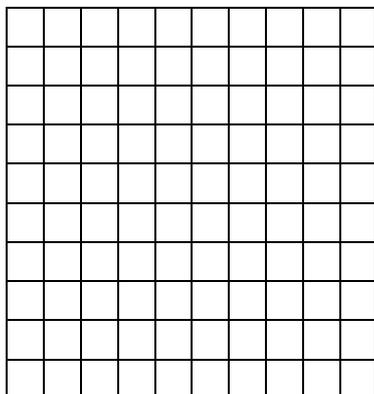
EXERCISE 2: CUTANEOUS SENSIBILITY FOR THERMAL STIMULI

Closely clip the hairs from the back of a subject's hand over an area just bigger than the rubber stamp with the grid pattern used to outline the area of study. The thermal probes are brass rods kept in water of a pre-set temperature before the tip is placed briefly in contact with the skin.

Design an experiment to test whether:

- there are non-uniformly distributed, thermal receptors in the skin
- there are separate hot and cold receptors in the skin.

Protocol:



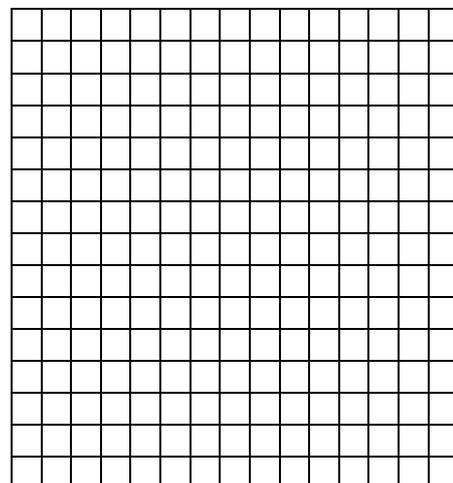
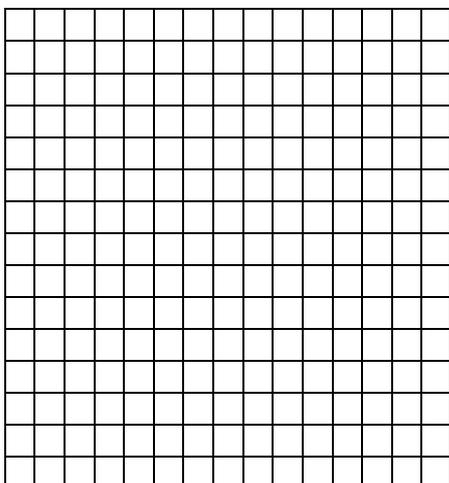
EXERCISE 3: WEIGHT DISCRIMINATION

Design an experiment to test the ability of a subject to discriminate weights held in the hand (small jars with a range of weights are used as the test material).

Factors you might consider include:

- contribution from proprioceptors
- subject handedness
- different body locations
- pressure compared with weight
- active exploration of the weights

Protocol:



EXERCISE 5: REGIONAL DIFFERENCES IN TACTILE SPATIAL RESOLUTION: TESTS OF TWO- POINT DISCRIMINATION

Design an experiment to determine the two point discrimination limit at various body sites. The 'two-point' limit measured in mm should be plotted as a vertical line on Fig. 3 below.

Protocol:

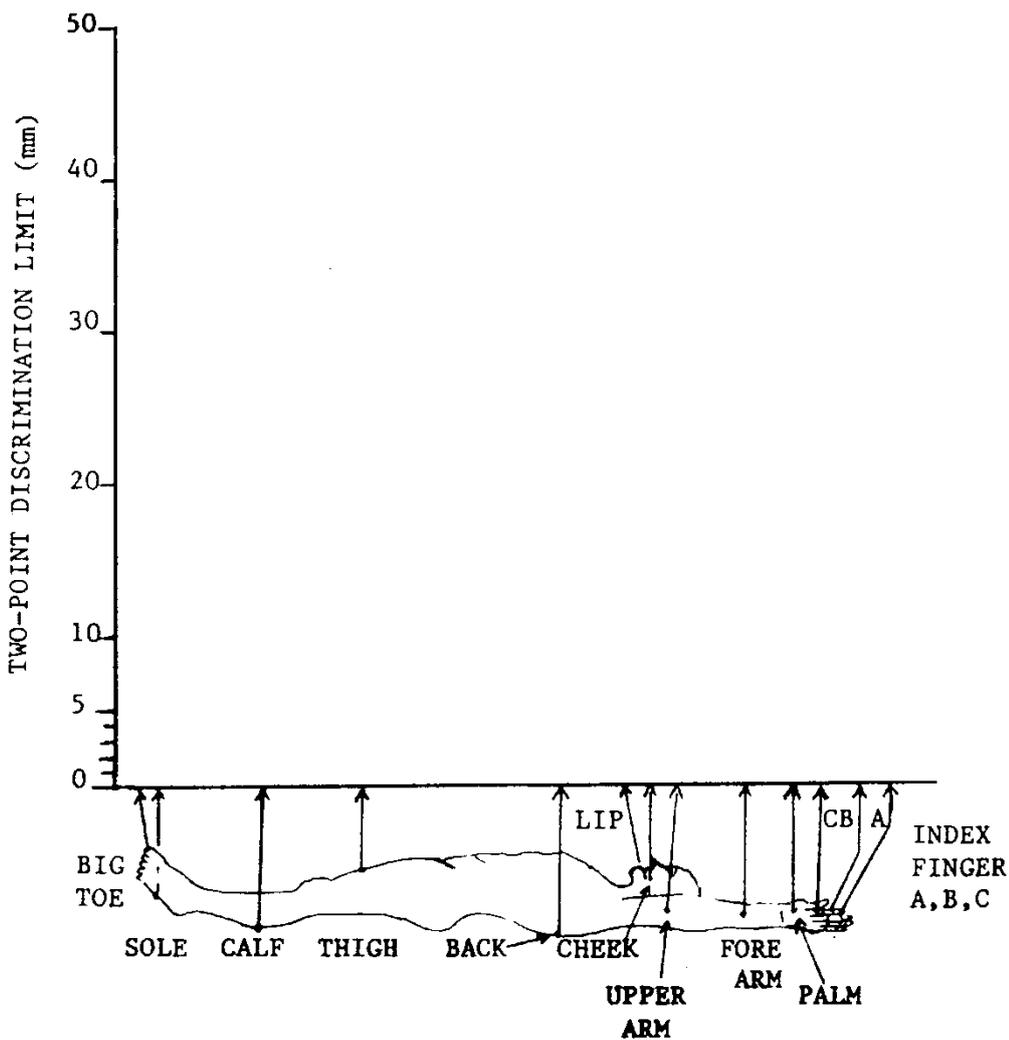


Fig. 3

Neural code underlying the perceptual response

For two of the experiments you have conducted, describe the following.

Experiment A

1) the form of the stimulus-response relationship?

2) a possible neural mechanisms for coding information about the tactile stimulus.

Experiment B

1) the form of the stimulus-response relationship?

2) a possible neural mechanisms for coding information about the tactile stimulus.

SENSORY & MOTOR NERVE RECORDING

Physiology Teaching Laboratory Student Risk Assessment		PRAC # PHSL-26 Title Sensory nerve recording (NEUR 3221)
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Hazards	Risks	Controls
Student use the power lab which could be an electric hazard.	Shock	Students are not required to connect or disconnect the Power lab power supply. The Power Lab units are tested and certified to be used on Human subjects.
Students use computers.		Refer to previous Student RA for Swimmy 1 & 2
Students use feeder roaches or Cockroaches which may be environmental pests.	Could cause infection.	Feeder Roaches are kept in boxes and are anaesthetised (cooling) by the technical staff before the practical, and the students quickly cut off one of the back legs. Students wear correct PPE.
Students use dissection tools and insect pins	Cuts/infection	Students are required to wear Lab coats, closed shoes and gloves, Students are monitored by demonstrators to ensure the appropriate use of dissecting tools, First aid kit available in the laboratory.
The use of soldering iron to activate cockroaches warm receptors	Burns & Scalding	The Soldering Iron will be handled only by the demonstrator, and kept in the safety cage when not in use. Care should be taken when handling hot iron, Gloves shouldn't be worn when handling hot soldering iron

Personal Protective Equipment			
 Closed in Footwear	 Lab. Coat	 Gloves	

Emergency Procedures
Switch off power, wash hands and if required to evacuate, follow the instructions of the demonstrators or the floor wardens.

Clean up and waste disposal
n/a

Ethics Approval
Not Required

Declaration

I have read and understand the safety requirements for this practical class and I will observe these requirements.

Signature:.....Date:.....

This practical relates to the Safesys Risk assessment MED-SOMS-RMF- 5782

Part 1. Sensory Nerves

In the first part of this experiment you will be recording single action potentials from sensory axons. You will be able to demonstrate the exquisite sensitivity of the tactile system and study how tactile information is coded. The preparation is the cockroach leg, and you will record from joint afferents and from afferents associated with the spines on the cockroach leg.

Equipment

Computer, PowerLab with BioAmp cable and headphones, 2 leads for grounding
 Retort stand with 2 micromanipulators providing 2 axes of positional control
 Recording electrodes embedded in a rubber stopper, clamped in the arm of the retort stand
 Speaker cone stimulator
 Dissecting microscope with light
 Fine forceps and scissors to dissect cockroach and position leg on recording pins
 Mechanical probe (insect pin), thermal probe (soldering iron shared between groups)

Set up

The cockroaches will be anaesthetised by cooling them for 15 minutes. **They will eventually wake up, so work quickly.**

Each group will be given a cockroach and you will carefully cut off one of the back legs as close to the abdomen as possible. Then return the cockroach to its storage cage.

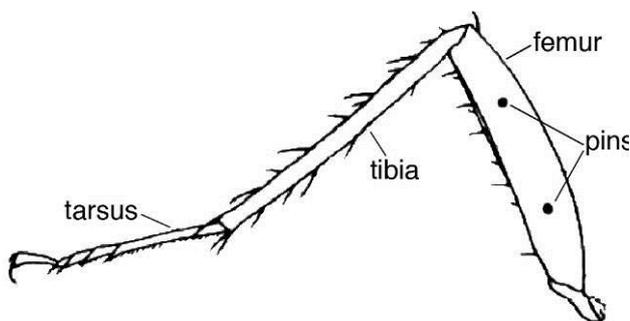


Fig 1 adapted from: *Advan Physiol Educ*, 1992; 262: 18 - 22.

The isolated leg needs to be impaled on the pins as shown in Figure 1. The pins function as extracellular recording electrodes and are connected to the BioAmp, which is a differential input amplifier in the PowerLab. The pins should go right through the leg and should suspend it above the cork. Use the fine forceps to hold the leg while you push it through the pins.

Turn on the PowerLab (switch is on the rear). Then switch on your computer and click on **LabChart** then click open and find PowerLab-> Chart Settings -> **Sensory nerve** on the network drive.

Plug the headphones into the jack on the rear of the PowerLab. Choose "Start" on the PowerLab and you should begin to see and hear your recorded trace, possibly with some clear spontaneous action potentials.

Watch and listen

Electrophysiologists consider it desirable to both hear the amplified signal from a recording electrode, and to see a trace on a screen. Your ears will often discern signals which are not easily picked up on the screen, whereas the visual appearance of action potentials can be used to tell the activity of different cells or fibres apart, even when the action potentials sound more or less the same.

For each of the following experiments, make sure you listen to the activity through headphones as well as observing the PowerLab traces.

EXPERIMENT 1.1: AFFERENT FIBRE TYPES

Objective: To characterise the classes of afferent fibres in the cockroach leg

Test the leg for tactile, joint and thermal receptors.

Run Chart and while watching and listening to the neural response try the following types of stimulation.

Use an insect pin to carefully move single spines and look for an increase in activity.

Bend the joint, trying to avoid activating spines if possible.

Let the soldering iron heat up, then disconnect it and bring it close to the leg to try and activate warm receptors.

Q: How many classes of sensory receptor were you able to confirm?

EXPERIMENT 1.2: ACTION POTENTIALS OF SENSORY AXONS

Objective: To characterise single axon responses in the cockroach leg, and explain the basis for the shape and size of the recorded action potentials.

Find two spines some distance apart along the leg that each give a good response. Capture a segment of the response to activation of each spine, and then stop Chart.

Q: How big (in mV) are the action potentials in each response?

Q: Are the shapes of the action potentials from one spine all the same?

Q: Are the shapes of the action potentials from the two spines the same?

Q: Explain the size of the action potential (given that each action potential represents a shift in axon membrane potential from about -70 mV to about $+20$ mV) and the differences in shape.

Q: Do any other parameters, such as the maximum action potential rate, differ between the responses recorded from the two spines?

Q: What evidence do you have to support the idea that the action potentials you record when you stimulate a single spine originate from a single axon?

EXPERIMENT 1.3: DIRECTIONAL CODING

Objective: To use qualitative mechanical stimulation to study the neural coding of tactile information about direction of hair displacement.

Find a spine that gives a good response. Test the response to moving the spine in different directions.

Q: Is the response to an equal sized movement of the spine about the same in each direction of displacement?

Q: If the response differs depending on direction, can you compensate in the weakly stimulating direction by giving a bigger deflection?

EXPERIMENT 1.4: CONDUCTION VELOCITY

Objective: To determine conduction velocity of cockroach spine sensory afferent fibres.

You have been provided with a mechanical stimulator that uses a speaker cone plugged into the stimulus output of the PowerLab. We will use this to make controlled deflections of a single spine where we can precisely control the timing and size of the stimulus. Go to the menu options "Set-up -> Stimulator" and familiarise yourself with the stimulus options. Initially you will deliver a single pulse of variable duration and amplitude. Later you will also deliver trains of stimuli.

Use the manipulators holding your cockroach leg to bring a single spine into close contact with the bent pin tip on the stimulator. If you like, you can use a bit of wax or superglue to ensure good contact between the spine and the pin.

Set up a brief, strong stimulus pulse (5 V amplitude; 1 ms duration) with a delay of 1 ms.

Measure the latency of the earliest action potential in response to the stimulus. The latency is taken from the start of the stimulus to the start of the recorded action potential. *Also measure the distance from the spine to the first of your recording pins.*

Q: Using the formula (speed = distance / time) work out the conduction velocity for your afferent. Remember to express measurements as metres and seconds.

Q: Is the actual conduction velocity likely to be slower or faster than your calculated value? Why?

EXPERIMENT 1.5: NEURAL CODING

Objective: To use quantitative mechanical stimulation to study the neural coding of tactile information by cockroach spine receptors.

Determine a stimulus response relation by comparing the effectiveness of different stimulus amplitudes in eliciting spikes

stimulus voltage (V)	number of spikes elicited
2	
4	
6	
8	
10	

If all the stimulus voltages elicited a spike, continue decreasing the stimulus until you reach threshold.

Q: What is happening at the receptor when the stimulus is just below threshold?

If you have glued the spine to the pin tip, or if you can slip the tip behind the spine, measure the response of the spine to deflections of the stimulator in the opposite direction.

stimulus voltage (V)	number of spikes elicited
-2	
-4	
-6	
-8	
-10	

EXPERIMENT 1.6: ADAPTATION OF SENSORY SIGNALS

Objective: To use quantitative mechanical stimulation to study adaptation of sensory signals.

Use a stimulus amplitude that elicited several spikes in experiment 5, and vary the stimulus duration to study adaptation.

stimulus duration (ms)	number of spikes elicited
1	
10	
50	
100	
500	

Q: *Is there a fixed rate of firing of the afferent (i.e. is the number of spikes in 100 ms equal to 10 x the number in 10 ms)? If not, why not?*

Q: *Does the rate of firing change throughout the 500 ms stimulus?*

Q: *How long do you need to stimulate the spine before the afferent ceases to fire?*

Q: *What is the peak rate of firing you observed? What does this indicate about the refractory period?*

Test the effect of using 1 ms pulses at 10 V to regulate firing – first give a train of 5 impulses at 10 Hz.

Q: How many spikes does each pulse generate?

Now try a train of 20 impulses at 100 Hz.

Q: How many spikes does each pulse generate? How does the spike pattern differ from that caused by a steady deflection?

Now try a train of 20 impulses at 500 Hz.

Q: How many spikes does each pulse generate? What is the peak firing rate achieved here?

Repeat the adaptation experiment on a different spine.

Q: Does its rate of adaptation differ from the first spine you tested?

Notes

VIRTUAL SOMATOSENSORY NETWORKS

Introduction

The somatosensory system describes all senses other than vision, hearing, balance, taste and smell. The somatosensory receptors are distributed all over the body and the different types of receptors respond to many different kinds of stimuli. The somatosensory system includes at least four distinct modalities and many sub-modalities; these include the senses of touch, temperature, pain and proprioception, or sensing of body position.

In this class, we will perform a series of exercises to help you understand how different sensory inputs from the body are transmitted from receptors in the skin via peripheral nerves to the central nervous system, the effects of synaptic modulation, and neural coding.

Aim

To develop an understanding of the neuronal networks involved in the senses of touch, pain, and temperature.

INSTRUCTIONS FOR THIS PRAC ARE PROVIDED ON MOODLE