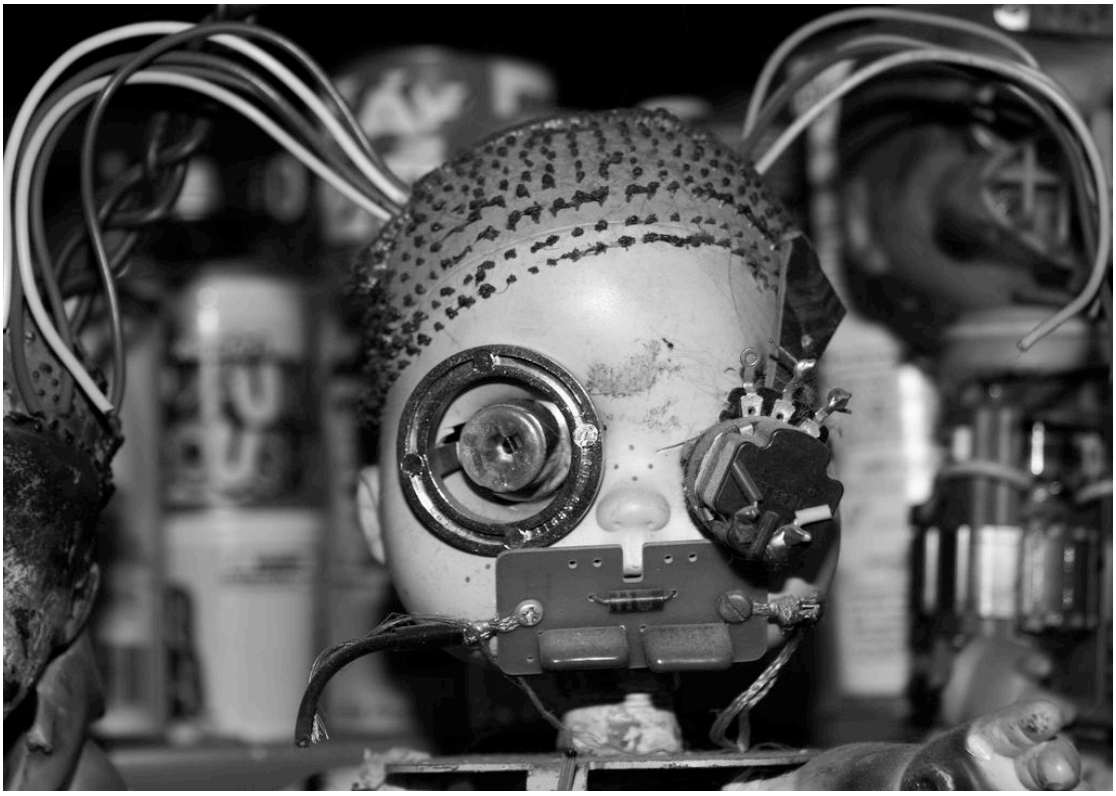
Interdisciplinary Science

PA3019

Braining IT



University of Leicester

Contents

Welcome

The Braining IT course brings together the topics of neuroanatomy and computational complexity allowing students to compare biological and electronic computational systems.

The first section of this course introduces you to neuroanatomy. You will also be introduced to the cell types present in the peripheral and central nervous system and how these are organised to produce an integrated nervous system. You will learn how the brain forms during development and the major structures that are present in the adult central nervous system. In the second section of the course is primarily concerned with what computers can do efficiently. This topic is called computational complexity and is concerned with the resources (such as the length of time or the amount of space) needed to solve a problem. Even if a problem is solvable, it is clearly pointless trying to write a program to solve it if the quickest method would still take longer than the lifetime of the Universe to run. You will investigate which problems can be solved in a “reasonable” amount of time.

Module Authors

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Cover image: Whatever Happened to Baby Jane? By Doug Bowman

http://www.flickr.com/photos/bistrosavage/3774175/

Problem Statement 01

Leicester Mercury

Ave Maria!

Judging by the sell-out crowd, it's little wonder that the second album sold as many copies on its first day of release as the first album had done in a week. We're of course talking about Maria Johnson, singer/songwriter/musician, on her whistle stop tour of the U.K. The multi-platinum, Grammy Award winner was in our back-yard, literally.

Victoria Park played host to the star last night on the second of her 10-date tour. Tickets for the open-air event have been sold out for months, with fans braving the inclement weather and anticipating one of the best live events of the year.

Maria rose to fame after the release of her first album at the age of only 17. Coming from a musical family, she plays several instruments, but came to prominence as an exceptionally gifted pianist in her early teens. Her singing ability could bring rush hour traffic to a standstill, but it is her virtuosity on the keys that has sealed her meteoric rise to stardom.

Her eclectic fusion of country, blues, jazz and soul is highlighted in many of her spectacular piano solos, the pace and tonal complexity of which has left even the harshest critics dumbfounded.

As she appeared on stage, the huge Victoria Park crowd, who'd been waiting patiently in the rain, erupted into cheers. No sooner was she seated at the piano than the stagelights ignited and the backing band played the unmistakable intro of Maria's first number one hit, Innocence. As the band died down, the artist everyone had come to see struck the first few magical notes of the debut track that had cemented her into the musical hall of fame...

Then came the moment everyone had been waiting for as she played the opening chords to her debut single, Unbelievable. It is the mark of a great live musician that they can perform a track they've played on countless occasions and still make it sound fresh. The final song was worth the ticket price alone as it touched the hearts of everyone within earshot, bringing a fitting end to a wonderful evening.

Victoria Park was a perfect venue for Maria Johnson to ply her trade and display her unique musical talents. She is a living proof that playing live in front of a crowd, no matter what size, brings out the best in some artists.

Manchester Evening News

Johnson, a Falling Star?

What a revelation it was when the young woman who could do no wrong actually left the stage half way through the penultimate show of her sold-out U.K. tour.

There were rumours that Maria Johnson had been feeling uneasy before the performance, and these were only fuelled when the support act played on for a further forty minutes.

When she finally walked on the stage and began playing her signature debut track, it became clear from her stumbling and hesitant performance that something was horribly wrong, she seemed to have lost the fluency in the control of her fingers. She carried on, but eventually her band took over as she tried to compose herself. Being a committed live artist, who insists that none of her songs are mimed, she bravely battled on for two more songs before apologising to an arena full of confused fans and leaving the stage.

Her below-par performance is particularly sad in light of the success of her previous shows, with each performance hailed as better than the last. Unfortunately, Manchester was destined to be the city where the young musician came undone. Whether it was exhaustion or just a lack of confidence, let's hope she can overcome it for her final show in the U.K, at the Royal Albert Hall.

Riviera and Sacha
Primary Care Trust

Patient Details

Name: **Maria Johnson**
NHS Number: 789 101 1121
Sex: Female
Date of Birth: 10 April 1987
Lifestyle: Musician
Healthy, with no previous problems

Patient Symptoms/Concerns

- Experiencing irregularity in hand control that started with the middle finger of her right hand and has now spread to the fingers on either side of it.
- Patient first noticed the affliction a fortnight ago, whilst playing a musical instrument (piano).
- Patient has experienced minor headaches.
- No signs of physical/mental deterioration or injury.

Prescription:
Recommend rest and referral to specialists.

N. Riviera

Problem Statement 02

Each group will tackle a different problem for their presentation. These will be assigned in the facilitation session.

Problem A: International Conference

Your department is organizing a conference on Neuroscience. Your Head of Department has asked you to investigate the possibility of a software system to maintain the records on (amongst other things) the delegates attending the conference, the papers being presented, the presenter of each paper, the preferences of the delegates as to which sessions they would like to attend, and so on. The requirements of the system include the following features:

1. The system should allow users to search through the conference papers looking for all references to a particular word or sentence. This facility should be on-line and very fast.

2. Given a particular session, the system should output a list (in alphabetical order) of all the delegates who have expressed a desire to attend that session together with (in each case) the address of the delegate. This output should be available on demand.

3. Given the information recorded about each session (including the presenter) and each delegate (including the sessions they wish to attend) the system should draw up a timetable which makes it possible for each delegate to present all the sessions they are responsible for and (if possible) avoids any delegates having clashes in the sessions they wish to attend. If it is not possible for this to be done, then the system should deliver a timetable which minimizes the number of clashes for delegates. Constraints (such as the number and capacity of the rooms and the numbers of slots available) will need to be taken into account. The timetable will need to be updated frequently in the weeks leading up to the conference (as delegates change their preferences) and this needs to be done efficiently.

Your Head of Department wants a report from you as to the feasibility of doing this. She is confident that all the relevant data can be stored on the system (this has already been checked) but she is concerned about the potential inefficiency of the system and, in particular, the possibility of creating algorithms to perform tasks 1, 2 and 3 in a reasonable time. She wants you to explain to her why such algorithms

exist (if they do) and to outline a possible method for accomplishing each of the three tasks. If there is a task for which no efficient algorithm exists (or if it is not clear whether such an algorithm exists) then she wants you to explain to her why this is the case. It is important that your information is accurate; this is a very prestigious international conference and your department is naturally very keen to make a good impression.

Problem B: Mission to Mars

You are involved in the initial planning phase for an ESA mission to Mars. The plan is to land a rover on the surface of the planet to carry out various tasks. Your team leader has asked you to investigate the possibilities for implementing the appropriate software on the rover and to foresee any potential problems in doing this. The system on the rover will have many features including a set of stored commands, an ability to observe what is happening in its immediate vicinity and a capacity for recording information. The requirements for the rover include the following features:

1. Given a command signal sent from Earth the rover must match this to one of the commands stored in its memory; it will do this by searching the received signal for one of a preset list of codes. It is imperative that, once the signal is received by the rover, the response time is very fast.

2. Having carried out a series of operations the rover must transmit all the data back to Earth. This must be done in priority order. The rover has a stored list of operations in the order they were carried out and an associated priority for each one (which will not generally be in the order of their execution). The rover must therefore be able to sort the list into the given priority order before transmitting the information.

3. The rover will have the ability to move around the terrain; one of its tasks will be to collect and analyze samples of the Martian soil. It is given instructions as to the samples it needs to take and the precise weight of each sample it needs to gather, and it will collect as many samples as it can before changing mode to analyze the samples. Moving from collecting to analyzing mode is costly in terms of resources but, as there is only a limited amount it can carry, it may need to do this before it has collected all the samples. It is intended that the rover should be able to, from the information about the samples it needs to collect, calculate the maximum weight of material it can collect before it needs to start analyzing samples.

Your team leader wants a report from you as to the feasibility of doing this. She is confident that all the necessary data can be stored on the rover (a preliminary assessment of the possible hardware has shown this to be so) but she is concerned

about the potential inefficiency of the system and, in particular, the possibility of creating algorithms to perform tasks 1, 2 and 3 in a reasonable time. She wants you to explain to her why such algorithms exist (if they do) and to outline a possible method for each of the three tasks. If there is a task for which no efficient algorithm exists (or if it is not clear whether such an algorithm exists) then she wants you to explain to her why this is the case. It is important that your information is accurate; this is a very important project and mistakes in this initial assessment could have very serious consequences as the project progresses.

Problem C: Traffic Flow System

A local authority has decided to introduce a new traffic flow system. The main idea is that there will be a set of "intelligent" traffic signals; these will receive information from a central computer and will modify their behaviour accordingly. In addition, they will each send information back to the central computer; each signal will have its own unique identifier and this will be part of the message that signal sends. You have been approached to undertake a feasibility study to see if it is possible to implement the system. The requirements for the system include the following features:

1. When the central computer receives information from a particular signal it needs to be able to identify very quickly which signal has sent the information. The computer will do this by searching the message received for one of the set of identifiers for the signals.

2. One of the most important pieces of data that each signal will transmit will be the traffic density at that signal. From the traffic information transmitted by the signals at any one time, the central system must be able to order the list of signals in terms of traffic density reported by each signal (i.e. list the signals in terms of decreasing traffic density). This operation will be repeated several times a day.

3. Part of the reason for collecting this information will be to have an efficient public transport system. The authority is proposing to situate a bus stop near each signal and to run buses between the stops. The information about the traffic densities will allow the computer to schedule the route of the buses to minimize the time taken. It will take the information about the traffic densities, choose a route that visits each stop precisely once, and then send a bus in each direction around that route (so that, whatever stop a passenger wishes to go to, a bus will arrive which will go to that stop). The route will be displayed on the front of the bus. Of course, as the traffic density changes through the day, so the routes of the buses will also change.

The local authority wants a report from you as to the feasibility of doing this. They are confident that all the necessary data can be stored on the computer and that the signals can sense and transmit the appropriate information (preliminary assessments of the possible hardware have shown this to be so). However, they are concerned about the potential inefficiency of the system and, in particular, the possibility of creating algorithms to perform tasks 1, 2 and 3 in a reasonable time. They want you to explain to them why such algorithms exist (if they do) and to outline a possible method for each of the three tasks. If there is a task for which no efficient algorithm exists (or if it is not clear whether such an algorithm exists) then they want you to explain to them why this is the case. It is important that your information is accurate; this is potentially a very expensive project and mistakes in your assessment could result in a great deal of wasted expenditure.

Problem D: Software Company

A software company has been integrating its systems. There are a great many software components available which have been produced over the years and the company wishes to deploy as many of them as possible. In addition, the company often integrates its systems with those of other companies and clients, and some components may be superseded by improved ones; so the set of components available is continually changing.

Each component has its own unique identifier which is included in the source code for that component. The "length" of a component is the number of lines of code it contains; this can be calculated very easily for any of the components under consideration.

There are various tasks that the company would like a system to be able to perform automatically:

1. At any one time the system would search through the various components looking for a particular identifier (to see whether a certain component was there or not).

2. It would be good to know the lengths of the various components available. It would be hard to get an overview of the information from an unsorted list, and so the system should be able to produce a sorted list of all the components arranged in ascending order of length.

3. One problem is that, if two components use the same name for a procedure within each of the components, then there is a clash; as a result, the two components cannot be used simultaneously. The task of going through a component changing names has been deemed too difficult and risky (it is quite likely that a mistake would be made and the component would then stop functioning properly). The company wishes, at any one time, to be able to see what is the maximum number of components it can use at once; it would like the system to return this number (and a list of all the components concerned).

Your section leader wants a report from you as to the feasibility of implementing such a system. Given the large number (and the consistently changing nature) of the components available, she is concerned about the potential inefficiency of the system and, in particular, the possibility of creating algorithms to perform tasks 1, 2 and 3 in a reasonable time. She wants you to explain to her why such algorithms exist (if they do) and to outline a possible method for accomplishing each of the three tasks. If there is a task for which no efficient algorithm exists (or if it is not clear whether such an algorithm exists) then she wants you to explain to her why this is the case.

Staff

Prof. Derek Raine	Physics
Prof. Rick Thomas	Computer Science
Dr Blair Grubb	Cell Physiology and Pharmacology

Learning Objectives

After completing this module students should be able to:

Neuroscience

- Distinguish the main types of neurones, i.e. unipolar, bipolar and multipolar.
- Understand the difference between the dendritic tree and the axon.
- Label the parts of a nerve cell, and give the names and functions of the cells which support them (oligodendrocytes, Schwann cells and astrocytes).
- Describe the conduction processes within (electrical) and between (chemical) nerve cells, both myelinated and unmyelinated.
- Measure conduction velocity, and design and perform a physiological measurement of it, and interpret it.
- Give an overview of the anatomy of the brain and understand the way in which different functions are localised in the brain, particularly those relating to sensory/motor function.
- Describe the basic classification of sensory nerve fibres into Aα, Aβ, Aδ and C fibres, and the associated sensory modality and nerve conduction velocities.
- Describe the different nerve endings in the skin which responds to different sensory input (Pacinian, Meissner, Merkels and Ruffini).
- Describe how information is transmitted from receiving sensory input to producing a voluntary motor response.
- Draw a picture of a spinal cord and label the points significant to information transmission.
- Explain what is meant by somatotopy and how the somatosensory and motor cortex are somatotopically organised.
- Describe the underlying causes and symptoms of some common motor disorders.
- Describe some brain imaging techniques.
- Demonstrate knowledge of the 3 types of motor activity, voluntary, reflex and rhythmic.

- Describe finite automata as a simple model of language acceptors.
- Explain the equivalence of deterministic and non-deterministic finite automata.
- Understand the concept of non-determinism and its specialisation to finite automata.
- Describe the method for converting a non-deterministic automaton to a deterministic one.
- Describe the limitations of finite automata.
- Explain the concepts of space and time complexity in the context of computing.
- Explain the complexity class P.
- Describe some examples of algorithmic problems with polynomial time solutions.
- Explain the complexity class NP.
- Explain what is meant by an NP-complete problem and the significance of such problems.
- Describe some examples of NP-complete problems.
- Describe non-deterministic algorithms for solving NP-complete problems.

Reading List

Course Material

- Thomas, R.M. (2009) Braining IT Course Material 5th ed.

Books

- Harel, D. & Feldman, Y. (2004) *Algorithmics – The Spirit of Computing 3rd Ed*. Addison Wesley: Chapters 1, 2, 4, 6 & 7.
- Sutton, J. (1998) *Biology*, Palgrave Macmillan: Chapters 6.4, 6.5, 17 & 30.
- Campbell, N. & Reece, J. (2005) *Biology, 7th Ed*. Pearson: Chapters 48, 49.1.
- Morris, R. & Fillenz, M. (2003) *Neuroscience – Science of the Brain*. British Neuroscience Association.
- Sewell, M.J. (1997) *Mathematics Masterclasses: Stretching the Imagination*, Oxford University Press: Chapter 2.

Websites

- http://faculty.washington.edu/chudler/image.html
  Brain Imaging.
- http://www.functionalmri.org/
  Lots of good anatomy if you click 'Neuroanatomy Tutorial'.
- http://www.pbs.org/wnet/brain/index.html
  Exploring the brain (includes neuroscience, brain imaging, lesions etc)
- http://www.pbs.org/wnet/brain/3d/
  3D Brain anatomy (the Shockwave application may take a little while to load)
- http://www.whonamedit.com/doctor.cfm/1982.html
  Broca's Area
- http://www.pbs.org/wgbh/aso/tryit/brain/
  Mapping the Motor Cortex – A History
- http://ozark.hendrix.edu/~burch/proj/autosim/
  Different Kinds of Automata Simulator (requires Java)

Additional Books

- Sherwood, L (2004) Human Physiology – From cells to systems, 5th Ed. Thomson.
- Kolb, B. & Whishaw, I.Q. (2001) *An Introduction to Brain and Behaviour*. Worth.
- Kandel, E.R. (2000) *Principles of Neural Science, 4th Ed*. McGraw-Hill: Chapter 33. (A preview of this book is available for free online if you search for "kandell" + "principles of neural science").
- Kolb, B. (2008) Fundamentals of Human Neuropsychology, Worth.
- Thompson, R.F. (1993) *The Brain: A Neuroscience Primer*, W H Freeman.
- Guyton, A.C. (1984) Physiology of the Human Body, 6th Ed. Saunders College: Chapter 11.
- Winston, R. (2006) *The Human Mind and How to Make the Most of it*, Chartered Institute of Personnel and Development.

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A Guide to Module Pacing

Session	Preparation	Learning Outcomes
FS01		Introduction to Problem Statement 01
ES01	Nervous System	
FS02	Neuroanatomy (supplementary material): Sections “Introduction”, “Cellular neuroanatomy” and “Neuroembryology”. Biology (Sutton): Sections 6.4 & 6.5 Biology (Campbell & Reece): Chapter 48.	Cellular Neuroanatomy Neuroembryology
FS03	Neuroanatomy (supplementary material): Sections “Sensory Pathways” and “Motor Pathways”. Biology (Sutton): Chapter 17. Biology (Campbell & Reece): Section 49.1.	Pathways Maria’s Case
LS01	Neuroanatomy	Neuroanatomy Workshop
FS04	Biology (Sutton): Chapter 30.	Diagnostic tests
LS02	Nerve Conduction Velocity	Nerve Conduction Velocity
FS05	Neuroscience: Chapter 15 & 17.	Feedback on Nerve Conduction Velocity experiment, Imaging Techniques
FS06	Neuroscience: Chapter 15 & 17.	Brain scans
FS07	Independent research is encouraged	
ES02	Discussion/Final Q and A	
FS08	Algorithmics: Chapter 1.	Introduction to Problem Statement 02
FS09	Braining IT Notes: Sections “Overview” and “Prerequisites”. Algorithmics: Chapters 2, 4, 6 & 7.	Algorithms
ES03	Algorithms	
FS10	Braining IT Notes: Sections “Automata” and “Non-deterministic Automata”. Algorithmics: Chapters 2, 4, 6 & 7.	Automata
ES04	Automata	
FS11	Braining IT Notes: Section “Computational Complexity”.	Computational Complexity
FS12	Braining IT Notes: Section “Non-deterministic Complexity”.	Non-deterministic Complexity
ES05	Automata	
FS13	Braining IT Notes: Section “Non-deterministic Complexity”.	NP-complete problems
ES06	Computability	
FS14	Independent research is encouraged.	

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Facilitation Sessions

Facilitation Session 01

Pre Session Preparation

Introduction to Module

An introduction to the module as a whole with a brief overview of the various topics that will be covered over the following weeks. The first Problem Statement and associated deliverables will be introduced.

Group discussion: Problem Statement 01

Within your groups discuss the trigger articles and medical letter presented in Problem Statement 01. Highlight any significant terms or symptoms. You are advised to take this opportunity to generate a list of questions to ask in the “Nervous System” expert session.

Facilitation Session 02

Pre Session Preparation

- Neuroanatomy (supplementary material): Sections “Introduction”, “Cellular neuroanatomy” and “Neuroembryology”.
- Biology (Sutton): Sections 6.4 & 6.5
- Biology (Campbell & Reece): Chapter 48.

Group Discussion: Cellular Neuroanatomy

Before attending the session read the “Introduction” and “Cellular Neuroanatomy” section, from the Neuroanatomy supplementary material. Use this material as the basis of a discussion of this topic within your group. How do you think this relates to Maria’s case?

Group Discussion: Neuroembryology

Before attending the session read the “Neuroembryology” section, from the Neuroanatomy supplementary material. Use this material as the basis of a discussion of this topic within your group. How do you think this relates to Maria’s case?

You may also like to consider how we know the functions of the regions of the brain and what are the different methods of imaging the brain.

Facilitation Session 03

Pre Session Preparation

- Neuroanatomy (supplementary material): Sections “Sensory Pathways” and “Motor Pathways”.
- Biology (Sutton): Chapter 17.
- Biology (Campbell & Reece): Section 49.1.

Group Discussion: Pathways

Before attending the session read the “Sensory Pathways” and “Motor Pathways” sections, from the Neuroanatomy supplementary material. Use this material as the basis of a discussion of this topic within your group. How do you think this relates to Maria’s case?

Group Discussion: Maria’s Case

Given the material you have read and researched so far what do you think is wrong with Maria?

Consider the entire pathway from her hands to her brain:

- What is involved in the transmission of impulses along this pathway?
- What type of cells take part in this pathway?
- How do the cells transmit pulses along their length?
- How do the cells transmit pulses between each other?

Given these prompts:

- What could go wrong at each stage and what symptoms would this produce?
- Do any of the symptoms match Maria’s?

Facilitation Session 04

Pre Session Preparation

- Biology (Sutton): Chapter 30.

Group Discussion: Diagnostic tests

In the previous facilitation session you were asked to consider a variety of problems that could be the cause of Maria's symptoms. In this session you should consider some tests that could be preformed to rule out or confirm your suspicions. You should consider how invasive each test is and whether a positive/negative result is indicative of one or more conditions. You will be given ~30 minutes to discuss this within your groups before discussing them with the rest of the class.

Class Discussion: Diagnostic tests

As a class discuss the various diagnostic tests you have considered.

Group Discussion: Diagnostic design

Within your groups finalise the diagnostic test design.

Within their groups get the students to read the laboratory script for the Nerve Conduction Velocity experiment and prepare for this laboratory session.

Facilitation Session 05

Pre Session Preparation

- Neuroscience: Chapter 15 & 17.

Group Discussion: Feedback on Nerve Conduction Laboratory

After completing the Nerve Conduction Velocity laboratory session and receiving Maria's results discuss and make notes on the following questions:

- How does Maria's conduction velocity vary from the conduction velocities you measured from healthy volunteers in the laboratory?
- What does this allow you to conclude regarding the possible origin of Maria's difficulties?
- What other investigations might you now wish to carry out?

Group Discussion: Imaging Techniques

Within your groups research the various brain imaging techniques available.

Facilitation Session 06

Pre Session Preparation

- Neuroscience: Chapter 15 & 17.

Group Discussion: Brains Scans

You will be provided with a series of brain scans to discuss within your groups.

Facilitation Session 07

Pre Session Preparation

Independent research is encouraged.

Group Work: Deliverables

You are advised to spend this facilitation session finalising work on your deliverables. It is in your own best interest to have at least a working draft of your deliverable available to get feedback from your facilitator. This is the last opportunity to ask questions relating to this part of the course.

Facilitation Session 08

Pre Session Preparation

- Algorithmics: Chapter 1

Introduction to the second half of the module

An introduction to the second half of the module with a brief overview of the various topics that will be covered over the following weeks.

The second Problem Statement and associated deliverables will be introduced and groups assigned to each sub problem.

Group discussion: Problem Statement 02

Within your groups discuss the trigger scenarios presented in Problem Statement 02. Highlight any significant terms or tasks that you must complete.

Facilitation Session 09

Pre Session Preparation

- Braining IT Notes: Sections “Overview” and “Prerequisites”.
- Algorithmics: Chapters 2, 4, 6 & 7.

Group Discussion: Algorithms

Within your groups discuss algorithms using the following questions as a starting point:

- What is an algorithm?
- What does an algorithm do?
- Why are they important (in a general context)?
- Why are they important (with respect to your deliverable)?
- What is a data type?

Prepare questions for the “Algorithms” Expert Session.

Facilitation Session 10

Pre Session Preparation

- Braining IT Notes: Sections “Automata” and “Non-deterministic Automata”.
- Algorithmics: Chapters 2, 4, 6 & 7.

Group Discussion: Automata

Within your groups discuss automata using the material covered in the supplementary material sections as a starting point. Research and discuss other related examples of automata. Consider how this topic is related to your deliverable.

Prepare questions for the “Automata” Expert Session.

Facilitation Session 11

Pre Session Preparation

- Braining IT Notes: Section “Computational Complexity”.

Group Discussion: Computational Complexity

Within your groups discuss computational complexity using the material covered in the supplementary material as a starting point. Consider how this topic is related to your deliverable.

Facilitation Session 12

Pre Session Preparation

- Braining IT Notes: Section “Non-deterministic Complexity”.

Group Discussion: Non-deterministic Complexity

Within your groups discuss computational complexity using the material covered in the supplementary material as a starting point. Consider how this topic is related to your deliverable.

Assign a topic to each group member from the following list:

- Graph Colouring
- Travelling Salesperson
- Subset Sum
- Independent Set

Prepare a short summary of your given NP-complete problem to present to your group in the next facilitation session. Remember the supplementary materials are a good place to start but your presentation must draw on additional sources.

Facilitation Session 13

Pre Session Preparation

- Braining IT Notes: Section “Non-deterministic Complexity”.

Group Discussion: NP-complete Problems

In this session, within your individual groups, you will present your summary of one of the following NP-complete problems; Graph Colouring, Travelling Salesperson, Subset Sum or Independent Set. Allow a *maximum* of 10 minutes per person.

Each group member of the group should explain what basis of the problem and approaches that have been taken to solve it. The other members of the group who are listening will mark the presentation out of 5 for the following two criteria:

- How well did he/she explain it?
- How well did I understand the presentation?

Therefore each presenter should get two marks from each group member. In this instance these marks should not be handed into the facilitator; they are to be used a formative feedback on your presentation skills.

At the end of the presentations you should forward your notes pertaining to your presentation to other group members. Remember that these will be useful for completing the CLEs as well as helping you to revise for your module exam.

Facilitation Session 14

Pre Session Preparation

Independent research is encouraged.

Group Work: Deliverables

You are advised to spend this facilitation session finalising work on your deliverables. It is in your own best interest to have at least a working draft of your deliverable available to get feedback from your facilitator. This is the last opportunity to ask questions relating to this part of the course.

Deliverables

Please name your deliverables in accordance with the standard naming convention (see the handbook for details). A sample filename is provided for you to cut and paste - please complete with submission date and username/group letter as appropriate.

All deliverables to be submitted to the subject centre.

Please note that although deliverable deadlines (except for CLEs) are at the end of the module, you are strongly urged not to leave all work on the deliverables until the final weekend! In particular, if you would like formative feedback on your works-in-progress from your facilitator and/or experts, please provide them with draft copies in good time.

DELIVERABLES	TYPE	FILENAME	DUE	WEIGHTING
CLE01:	I	PA1015_I_CLE01_*username_date*.pdf	Week 2, Day 1	30%
CLE02:	I	PA1015_I_CLE02_*username_date*.pdf	Week 3, Day 1	
CLE03:	I	PA1015_I_CLE03_*username_date*.pdf	Week 4, Day 1	
CLE04:	I	PA1015_I_CLE04_*username_date*.pdf	Week 5, Day 1	
D01: Diagnosing Maria	G	PA1015_G_D01_DiagnosingMaria_*groupletter_date*.pdf	Week 5, Day 1	25%
D02: Neuroscience Essay	I	PA1015_I_D02_NeuroEssay_*groupletter_date*	Week 5, Day 1	10%
D03: Computational Complexity Presentation	G	PA1015_G_D03_CompPresentation_	Week 5, Day 2	35%

Core Learning Exercise 01

1. What do we call ions that carry a negative charge? [2]

2. Describe what is meant by the:
   a) central nervous system (CNS) [5]
   b) peripheral nervous system [5]

3. Which of the following is true about neurons:
   a) They transmit neural impulses
   b) They support and nourish glial cells
   c) They manufacture myelin
   d) They are one kind of neurotransmitter. [4]

4. Which cell type in the CNS is the major information processing unit? [2]

5. a) Draw and label a diagram of a motor neuron from the spinal cord. [5]
   b) Receptor sites for neurotransmitters are found on which part of receiving neurons? [2]

6. a) You sit and cross your legs, and a physician taps your leg just below your knee. As a result, you kick reflexively. Which of the following are involved in your reflexive response? [4]

   White matter in the spinal cord
   The somatosensory cortex
   Afferent neurons
   The motor cortex

   - Describe, with the aid of a diagram how this reflexive response occurs.

   [5]

7. Identify four neurotransmitters from the following list: [4]

   Cortisol
   Acetylcholine
   Noradrenaline
   Insulin
   Octane
   Calcium ions
   Dopamine
   Glutamate

8. Approximately how many neurons are there in the human brain? [2]

9. Nerve fibres are classified according to conduction velocity, axon diameter and the absence or presence of myelin. The table below shows the different groups of sensory nerve fibres. Please match the modalities below to the different groups (complete the table).

Group	**Modality**	**Axon dia (μm)**	**CV (ms^{-1})**	**Myelinated**
I (Aα)		13-20	80-120	
II (Aβ)		6-12	25-75	
III (Aδ)		1-5	5-30	
IV (C)		0.2-1.5	0.5-2.5	

Modalities
Touch, pressure
Pain (dull aching)
Proprioception
Pain (sharp pricking pain) and temperature [8]

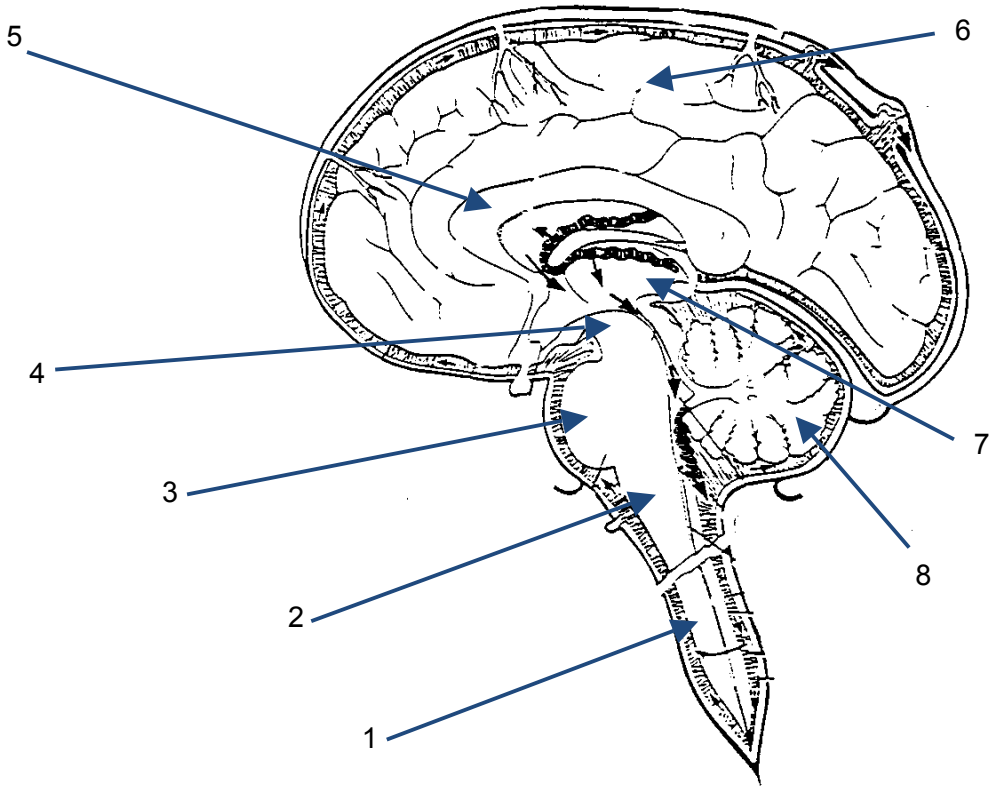
10. Draw and label a diagram of the spinal cord showing the location of the dorsal horn and ventral horn. Label the regions that have sensory and motor functions. [5]

11. a) With the aid of a diagram, draw a picture of the location of the motor cortex, and the somatosensory cortex, within the brain. [5]
    b) What is a cortical homunculus? [5]
    c) Describe the advantages of having the somatosensory and motor cortexes located next to each other. [5]

12. Which tract conveys information directly from the motor cortex to the spinal motor neurones? [2]

13. Name two types of neuron. [2]

14. This is a section through the human central nervous system. Match up the numbers with the list of brain regions given below. [8]



thalamus	medulla	spinal cord	pons
corpus callosum	midbrain	Cerebellum	cerebral cortex

15. Describe the structure of two types of sensory receptor that can be found embedded in the surface of your skin, and the type of sensation they detect.
[10]

Core Learning Exercise 02

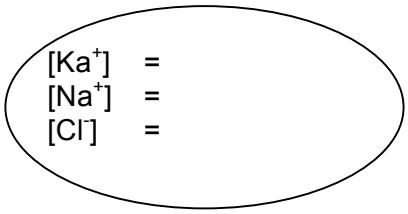
1. Match each of the following statements in the left hand column with the most suitable statement from the right hand column: [4]

Voltage dependant potassium channels	Rising phase of action potential
Voltage dependant calcium channels	Falling phase of action potential
Glutamate gated receptor channels	Neurotransmitter release
Voltage dependant sodium channels	Generate EPSP's

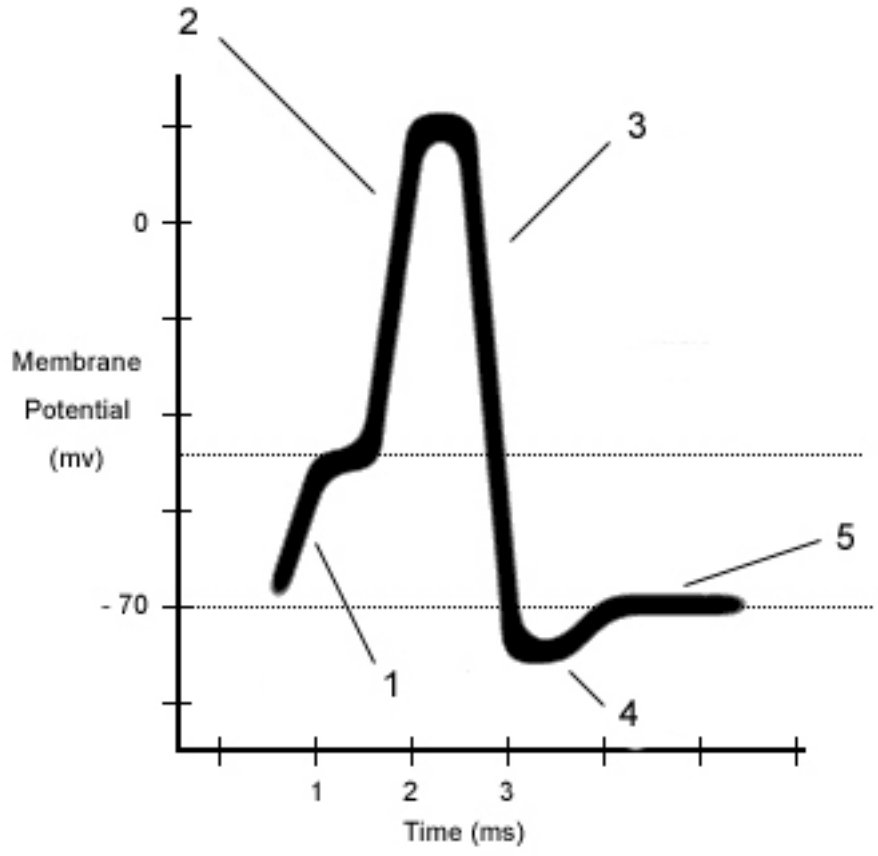
2. State the direction of flow (with respect to the neuron) when voltage gated potassium channels open. [1]

3. What happens to the membrane potential when voltage gated potassium channels open? [2]

4. Complete the following diagram with the concentrations of the ions inside and outside the cells as indicated. [6]



5. Below is a diagram showing the change in membrane potential seen at the axon hillock when an action potential is initiated. Label the diagram at the positions 1-5 with the correct description from the list given below the diagram. [5]



Undershoot
K^+ channels open
Slight depolarisation
Resting state
Na^+ channels open

6. Extracellular K^+ concentration in a person is increased with no change in the intracellular K^+ concentration. What happens to the resting potential and the action potential? Give reasons. [5]

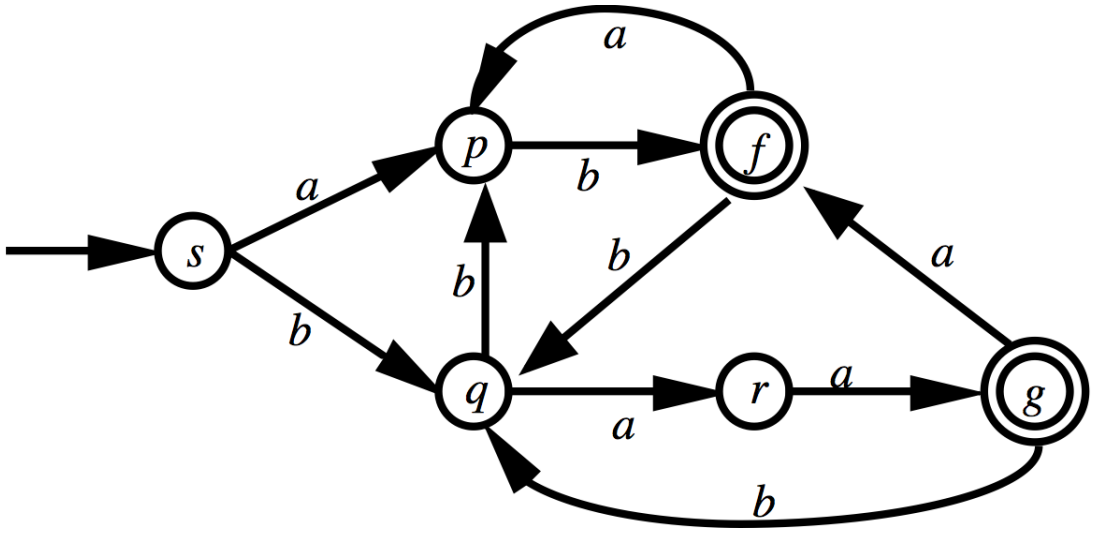
7. The compound tetraethylammonium (TEA) blocks the voltage-gated changes in potassium permeability that occur during an action potential. After the administration of TEA what changes would you expect in the action potential? Explain your answer. [5]

8. a) Describe the role of the myelin sheath in the transmission of action potentials. You may use a diagram if you wish. [5]
   b) Which type of glial cells are responsible for myelination in:
      i) The central nervous system
      ii) The peripheral nervous system [2]

Core Learning Exercise 03

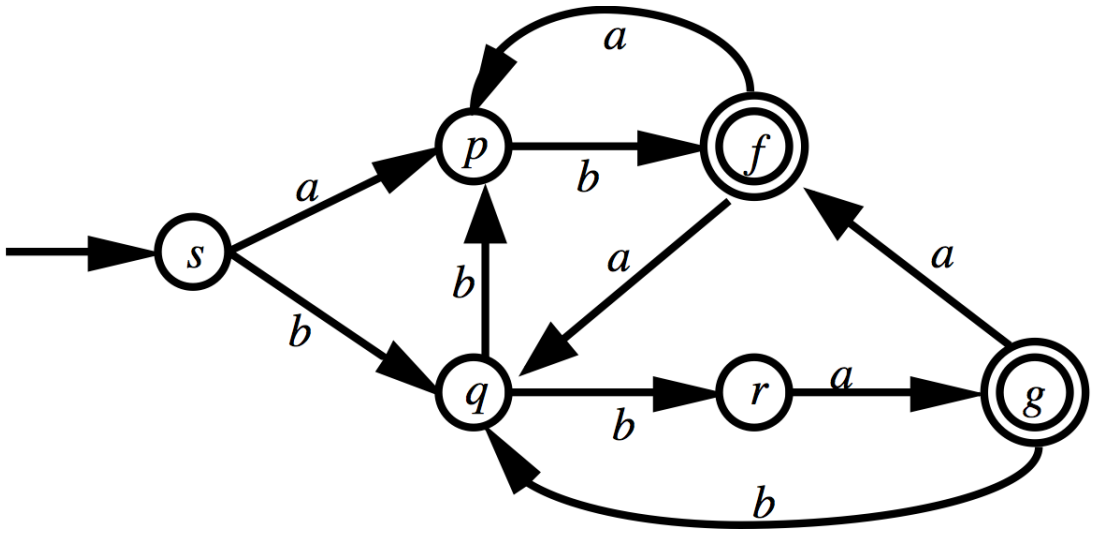
1. Explain (in your own words) what it means for a DFA to "accept a language". How does the situation change if we have an NFA instead of a DFA? [10]

2. If M is the DFA shown in the figure, give examples of two words accepted by M and two words not accepted by M, justifying your answers. [5]



3. Construct an NFA accepting all the words over the characters x, y and z that contain $xyyxyz$ as a subword. [10]

4. If M is the NFA shown in the figure, give examples of two words accepted by M and two words not accepted by M, justifying your answers. [5]



5. Which of the following languages L is accepted by a finite automaton? Justify your answer in each case.

- L is the set of all words w in the characters a and b where the number of a's in w is an odd number. [5]

b) L is the set of all words w in the characters a and b where the number of a's in w is not equal to the number of b's in w. [5]

Core Learning Exercise 04

1. You are given an algorithm that runs in (deterministic) time n^5. How useful do you feel the algorithm is (i.e. for what sort of input sizes n is it feasible to run this algorithm)? [5]

2. Which of the following deterministic algorithms solve the problem stated and run in (deterministic) polynomial time (where the input size is n in each case)? Justify your answer in each case.

   a) Searching through a list of n numbers looking for the smallest. We record the current smallest number (starting with the first number examined) and update this every time we find a smaller number. [5]

   b) Given a graph G with n vertices, we see if G contains an "isolated vertex" (i.e. a vertex which is not joined to any other vertex) by testing each vertex in turn. [5]

   c) Given a graph G with n vertices, we see if it is possible to colour the vertices of G with k colours in such a way that no two vertices joined by an edge have the same colour by testing all the possible assignments of colours to vertices. [5]

   d) Given a graph G with n vertices, we see if it is possible to colour the vertices of G with k colours in such a way that no two vertices joined by an edge have the same colour by testing one possible assignment of colours to vertices. [5]

3. Give examples of two connected graphs on six vertices, one of which contains a Hamiltonian cycle and the other does not. [5]

4. Which of the following non-deterministic algorithms solve the problem stated and run in (non-deterministic) polynomial time (where the input size is n in each case)? Justify your answer in each case.

   a) We want to see if an n-digit whole number k is composite (i.e. it is not a prime number). We guess two factors a and b and then multiply a and b together to see if the result is k. If the product is k we say that k is composite; otherwise we say that it is not. [5]

   b) We want to see if an n-digit whole number k is prime. We guess two factors a and b and then multiply a and b together to see if the result is k. If the product is not k we say that k is prime; otherwise we say that it is not. [5]

   c) A graph G has n edges. We want to see if G contains a triangle (i.e. if G contains a set of three vertices all of which are joined to each other). We guess a set of three vertices a, b and c, and we then check to see if a is joined to b, b is joined to c, and c is joined to a. If our guess results in a triangle, then we return the answer "yes". [5]

   d) A graph G has n edges. We want to see if G does not contain a triangle (i.e. if G contains no set of three vertices all of which are joined to each other).

We guess a set of three vertices *a*, *b* and *c*, and we then check to see if *a* is joined to *b*, *b* is joined to *c*, and *c* is joined to *a*. If the outcome of our guess is not a triangle, then we return the answer "yes". [5]

5. Explain why, if SS (the Subset Sum Problem) is not in P, then $\square \neq \square\square$. [5]

Deliverable 01: Diagnosing Maria

Within your group write a detailed report (~3000 words) to Maria's GP regarding your evaluation of her condition, your final diagnosis and any treatment that you plan to give her.

Remember that her GP is not a neuroscience specialist so you will need to explain the relevant neuroscience background where applicable.

Deliverable 02: Neuroscience Essay

Write a short essay (~1000 – 1500 words) about one of the following neurological diseases. In your essay you must describe how the relevant parts of the nervous system function normally, and describe how this is affected by the disease (pathopysiology). You must also describe the treatment of the disease.

Choose from:

- Parkinson's disease
- Multiple sclerosis
- Huntington's chorea
- Alzheimer's disease
- Myasthenia gravis
- Phantom limb pain
- Motor Neurone Disease
- Meningitis (neurological aspects of)

Deliverable 03: Computational Complexity Presentation

Within your groups prepare a ~10 minute presentation in response to the task you have been set. You are strongly encouraged to use a supporting PowerPoint presentation. At the end of the presentation you should expect ~5 minutes of questions.

Meta tags

Author: Grubb, B.; Raine, D.; Thomas, R.

Owner: University of Leicester

Title: Interdisciplinary Braining IT Student Document

Classification: PA1015 / Braining IT

Keywords: Neuroscience; Biology; Human Biology; Systems; Networks; Computational Complexity; sfsoer; ukoer

Description: The Braining IT course brings together the topics of neuroanatomy and computational complexity allowing students to compare biological and electronic computational systems.

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Additional Information

This module pack is the open student version of the teaching material. An expanded module pack for facilitators and additional information can be obtained by contacting the Centre for Interdisciplinary Science at the University of Leicester. http://www.le.ac.uk/iscience

This pack is the Version 1.0 release of the module.