SD329 Signals and perception: the science of the senses

Are You Ready For

Contents

1 Introduction

SD329 *Signals and Perception: the science of the senses* explores the structure and function of our sensory systems. Themes developed throughout the module include:

- detection of sensory stimuli
- transmission of information both to and from the brain
- interaction between sensory systems
- experimental techniques used to study sensation and perception
- the impact and treatment of sensory impairments

SD329 is a suitable Level 3 module for students studying Natural Sciences or Health Sciences. Whilst it is an interdisciplinary module, drawing on a range of scientific disciplines, it is likely to appeal particularly to those with a strong interest and/or prior Level 2 study in biology or health sciences because the module is predominantly concerned with sensory neuroscience. It may also be of interest to psychology students who have previously studied OU science modules at both Level 1 and 2. SD329 also provides a strong foundation in Level 3 information literacy skills and therefore would make a suitable stepping stone for students aiming to study SXL390 or a similar project module in the near future.

If you are intending to study SD329, you will want to make sure that you have the necessary background knowledge and skills to be able to enjoy the module fully and to give yourself the best possible chance of completing it successfully. This booklet is not intended to teach you these skills but rather help you find out whether or not you are ready for SD329 by enabling you to work through self-assessment questions (SAQs) based on the required knowledge to begin studying SD329. You should spend about 1 hour working through these questions before checking your answers with those at the end of this document. Whilst it is not expected that you will get all the SAQs correct, we would expect you to be able to answer the majority of questions correctly if you are ready to study SD329. This exercise will be useful for *all* prospective students of SD329 because it will allow you to judge (a) whether the module will interest you, (b) the areas where some reading beforehand would be useful and (c) whether you will be able to cope with the intellectual demands of the module. This will be the case even for those of you who have already studied other OU science modules and completed the suggested prior study (see Section 2) because it will serve as a reminder of some of the relevant facts, skills and concepts that you should be bringing with you from earlier study. In addition, you will find lists of suggested reading for sources of background information that will enable you to revise any important concepts that you have previously studied, this will be even more important if you completed your previous study of science a number of years ago. Your Regional Centre can provide details of where to find reference copies of OU module books.

If you are coming to SD329 without having studied the OU modules recommended in Section 2, then it is essential that you establish whether or not your background and experience give you a sound basis on which to tackle the work.

2 Suggested prior study

We strongly recommend that you have completed an OU Science Level 1 Module (S104 (or the now discontinued S103) or SDK125). SD329 assumes you have the basic mathematical skills taught in these modules as well as a broad knowledge of the range of scientific disciplines covered in them, many of which will be revisited in SD329. In addition to the broad foundation in science gained through Level 1 study, you should have completed *at least 60 points* of specialised Level 2 study within any area of Health Science or Natural Sciences and have the study skills at least equivalent to this level.

3 Key scientific concepts for SD329

This section provides diagnostic questions on the essential key concepts with which you should be familiar before you begin your study of SD329.

3.1 General Science concepts

SD329 will make use of a number of different scientific units both base units and derived units. As such you should be familiar with the base units found in the SI (Système International d'Unités) system.

SAQ 1

Table 1 shows the quantities, their respective units and symbols for the seven base units. The first row is completed for you. Complete the remaining rows.

Quantity	**Unit name**	**Unit Symbol**
Luminous intensity	candela	cd
Length		m
	kilogram	kg
Time	seconds	
Electric current		A
	Kelvin	K
Amount of substance	mole	

Table 1: Quantities and respective SI units

3.2 Biological concepts

In SD329 you will learn about the structure and function of cells within the nervous system that process sensory information.

3.2.1 Cell structure and function

In order to effectively study this module you should be familiar with the basic characteristics of eukaryotic cells which are found in animals, including humans. For example, you should be familiar with the different organelles found within such cells, including the nucleus, mitochondria and rough endoplasmic reticulum. In addition to containing a number of common organelles, all cells are bounded

by a membrane composed of lipids and proteins. This membrane may include receptors for specific molecules.

SAQ 2

Briefly describe the function of the (a) nucleus (b) mitochondria (c) endoplasmic reticulum.

SAQ 3

Using the lock-and-key analogy, explain how these specific molecules may alter activity of the cell.

3.2.2 Suggested further reading for Section 3.2

- S104 Exploring science: Book 5 'Life'.
- SDK125 An introduction to health sciences, a case study approach: Book 2 'Pain', Book 4 'Screening for breast cancer' and Book 6 'Trauma, Repair and Recovery'.

3.3 Chemical concepts

An understanding of chemical concepts underpins many of the processes discussed in SD329.

3.3.1 Elements, atoms, molecules and compounds

You should be familiar with the meaning of the terms element, atom, molecule and compound and be able to provide examples of each. In addition you should be able to use the chemical formulas of compounds to establish the constituent atoms.

SAQ 4

Define each of the following terms and provide an example of them: element, atom, molecule and compound.

SAQ 5

What are the relative numbers of the three different atoms calcium (Ca), carbon (C) and oxygen (O) in the compound calcium carbonate ($CaCO_3$)?

3.3.2 Chemical bonding and ions

You should have an understanding of how atoms can chemically bond with other atoms in order to achieve a stable electronic configuration. In particular you should be familiar with the fact that bonds can only be formed using an atom's outermost electrons and that how many are available for bonding depends on the specific element.

SAQ 6

Explain, in terms of electrons, how ionic and covalent bonding may arise.

SAQ 7

Give an example of a compound that contains i) ionic bonds and ii) covalent bonds.

SAQ 8

(a) In ionic compounds, potassium forms K^+ and calcium forms Ca^{2+}. How many electrons do (i) potassium and (ii) calcium use in bonding (i.e. what is the valency of each atom)?

(b) When calcium reacts with chlorine, calcium chloride ($CaCl_2$) is formed, comprising calcium ions and chloride ions (i.e. charged chlorine (Cl) atoms). What is the charge on each chloride ion, and what is the valency of chlorine in $CaCl_2$?

(c) In the covalently bonded molecule carbon dioxide (CO_2), carbon forms a double bond with each oxygen atom. What are the valencies of carbon and oxygen in this molecule?

3.2.3 Suggested further reading for Section 3.3

- S104 Exploring science: Book 4 'The Right Chemistry'.
- SDK125 An introduction to health sciences, a case study approach: Book 1 'Water and Health in an Overcrowded World' and Book 3 'Alcohol and Human Health'.

3.4 Physics concepts

The authors of SD329 have assumed very little physics background knowledge and have therefore taught the physics needed in the module itself. However it would be helpful if you have some knowledge of the electromagnetic spectrum and of basic electrical concepts.

3.4.1 The electromagnetic spectrum

SAQ 9

Which of the following types of radiation can be found in the electromagnetic spectrum?

(a) Radio waves

(b) Gamma radiation

(c) Sound waves

(d) Infra-red radiation

(e) Visible light

(f) Alpha particles

SAQ 10

Take the answers to SAQ 6 which were part of the electromagnetic spectrum and arrange them in order of increasing frequency.

3.4.2 Electricity

A study of the nervous system requires some knowledge of the electrical processes in and between nerve cells so it is helpful if you have a basic knowledge of how positive and negative charges behave and understand the meaning of terms such as potential difference, voltage and current.

SAQ 11

A solution contains both positive and negative ions. Two electrodes are inserted into the solution and connected to the terminals of a battery. Which ions go towards the electrode that is connected to the positive terminal of the battery? How is the current related to the number of charges that flow per second?

SAQ 12

Match the following units to the quantities they are used to measure:

(a) volts 1. current

(b) amps 2. resistance

(c) ohms 3. potential difference

3.4.3 Suggested further reading for Section 3.4

- S104 Exploring science: Book 3 'Energy and Light'.
- SDK125 An introduction to health sciences, a case study approach: Book 4 'Screening for Breast Cancer'

4 Mathematical skills

You should be able to perform simple calculations such as working out percentages and be comfortable converting information from percentage to decimal values, for example. The following mathematical skills are also relevant to SD329.

4.1 Graphical information

The significance of trends in data is often seen more clearly when it is presented in graphical form. You will be expected to interpret and to draw conclusions from information presented in different graphical formats, including tables, bar charts and line graphs.

SAQ 13

Figure 1 is a graph showing how the surface temperature at Milton Keynes varied over a 24-hour period (14 July 1996).

(a) At what times did the maximum and minimum temperatures occur?

(b) What was the percentage increase in temperature between 12.00 and 18.00 h? Give your answer to two significant figures.

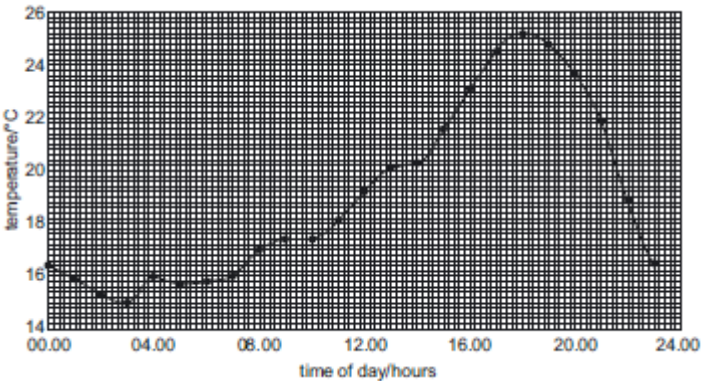

Figure 1 A graph showing how the surface temperature at Milton Keynes varied over a 24-hour period (14 July 1996).

4.2 Working with scientific notation

When examining the workings of the sensory systems, the stimuli and systems involved often operate over a very large range of values. Scientific data may therefore be presented in a very wide range of magnitudes of numbers. For instance, the light signals detected by the eye can have a frequency of 700 000 000 000 000 Hz whilst the part of a nerve responsible for transmitting nerve impulses may only be 0.000002 m in diameter. It is clearly inconvenient to express values in such a cumbersome form and therefore you should be comfortable using scientific notation.

SAQ 14

Give the following values in scientific notation:

(a) The speed of light, which is 300000000 m s^{-1}.

(b) The diameter of a cell within the nervous system, which is 0.0000033 m.

4.3 Using significant figures

Being precise is very important in scientific measurements, so as well as rounding values, in science it is often appropriate to give a decimal value to an appropriate number of significant figures, which is the number of digits that you can justify in terms of any uncertainties in the measurement.

SAQ 15

How many significant figures are there in each of the following measurements:

(a) 1.970

(b) 0.0012

(c) 2.88×10^6

As well as being able to recognise and give values to an appropriate number of significant figures, you should be able to deduce what number is appropriate for your calculations.

SAQ 16

A nerve is 25 cm long and transmits nerve impulses at a speed of 120 m s^{-1}, how long will it take for the signal to travel from one end of the nerve to another? Give your answer to an appropriate number of significant figures.

4.4 Rearranging equations

In SD329 we shall not ask you to rearrange equations but your understanding of the material will be enhanced if you can follow the stages that are necessary to do so. If you are able to rearrange simple equations then you can feel confident that you can cope with the module material.

SAQ 17

Rearrange the following equations to give an expression for a:

(a) $c = ab$

(b) $c = \dfrac{1}{(a-b)}$

(c) $\dfrac{1}{a} = \dfrac{1}{b} + \dfrac{1}{c}$

4.5 Suggested further resources for Section 4

- 'Maths for Science' https://learn1.open.ac.uk/course/view.php?id=100117
- S155 'Good Experiments Guide' Part 3.
- Northedge, A. et al. (1997) *The Sciences Good Study Guide*, Open University Press. ISBN 0 7492 3411 3.
- There are various websites offering maths resources, e.g. BBC Learning online Maths learning resources (http://www.bbc.co.uk/learning/subjects/maths.shtml).

5 Other skills

As this is Level 3 module, it is expected that you will have achieved a significant degree of competency in the skills listed below, but that you will refine and develop these skills further during your participation in the module.

Basic study skills

You need to have: an ability to organise time for study and to pace it, an ability to analyse tasks and plan how to tackle them, a willingness to seek help or information when appropriate, and to learn from feedback provided.

Obtaining, evaluating and interpreting information

You should be able to: read effectively to distinguish relevant from irrelevant or redundant information and analyse data from scientific text and images; locate and consult a range of online scientific materials appropriate for academic use including, but not limited to, the module materials, in order to obtain information and clarify complex ideas; collate and summarise information in note form; synthesise information, including being able to identify arguments and alternative interpretations.

Writing skills

You need to be able to present information in a range of formats, e.g. essays, reports, short answers to questions based on information and data abstracted from module materials and scientific texts, in each case keeping to the main points, elaborating where necessary and including figures or making references where appropriate, and ensuring that arguments, ideas and information are presented in a logical sequence.

Cognitive skills

Information processing, including ability to: recognise trends and patterns in data; use evidence to support or refute theories and arguments; assess the adequacy/limitations of explanations; apply knowledge in new contexts, including an ability to recognise associations/relationships, make predictions, extrapolate and interpolate from data.

Suggested further reading for Section 5

- Northedge, A. et al. (1997) *The Sciences Good Study Guide*, Open University Press. ISBN 0 7492 3411 3..

Some of the skills listed above relate to Information Literacy. SD329 assumes that you have the skills expected of a student who has completed Level 2 study. If you are unsure of whether you have the skills relating to information literacy you can check by working through this activity Information Literacy skills: do you have the Level 2 skills you need? As you work through this 10 minute activity, if you identify any skills which you feel you are yet to develop or would like to refresh, you will be directed to associated activities to provide you with training in these areas.

And finally…

We hope that this diagnostic booklet has given you a good idea of what prior knowledge you must have before you begin studying SD329. We trust that you have found it interesting and we look forward to welcoming you to the module. However, if, after working through these notes, you are still unsure about whether or not SD329 is the right module for you, we advise you to seek further help and advice from your Learner Support Team (via StudentHome).

6 Answers to self-assessment questions

SAQ 1

The completed table is shown below:

Quantity	**Unit name**	**Unit Symbol**
Luminous intensity	candela	cd
Length	metre	m
Mass	kilogram	kg
Time	seconds	s
Electric current	ampere	A

Temperature	Kelvin	K
Amount of substance	mole	mol

SAQ 2

(a) The nucleus is the organelle that contains the genetic material of the cell.

(b) The mitchondria are often referred to as the power house of the cell because they transfer energy into a form that can be used by the rest of the cell.

(c) There are in fact two types of endoplasmic reticulum that you may be aware of. The rough endoplasmic reticulum is important for protein synthesis which takes place on the ribosomes, whilst the smooth endoplasmic reticulum is important for lipid production.

SAQ 3

The specific molecule acts as a key and binds to a specific receptor binding site on the surface of the cell, which can be described as the lock. The receptor will only allow specific molecules to bind to it because of the shape of the binding site. Once bound the molecule can set off a chain reaction of events that may alter the activity of the cell.

SAQ 4

(a) An element is a substance which cannot be broken down into simpler components by a chemical reaction. An example would be carbon or nitrogen but you could have come up with any example from the periodic table.

(b) An atom is a particle consisting of a central nucleus, formed of positively-charged protons and neutrons (which carry no charge), and surrounding negatively-charged electrons. Because the number of protons in an atom equals the number of electrons an atom carries no overall charge. Each element is composed of a single type of atom. For example, the element hydrogen consists of hydrogen atoms.

(c) A molecule contains two or more identical or dissimilar atoms bonded together by covalent bonds. Some common elements exist as diatomic molecules, e.g. the gases oxygen (O_2), hydrogen (H_2), nitrogen (N_2) and chlorine (C_{l2}). Water (H_2O) is also a molecule.

(d) A compound is a substance made up of atoms of different elements combined in a complex structure, e.g. sodium chloride (NaCl). In each case, the chemical formula of the compound indicates the relative numbers of the different atoms that combine together in its formation.

SAQ 5

The symbols for calcium and carbon have no subscripts, so there is only one atom of each. However, the symbol for oxygen has the subscript ‘3’, so there are three atoms of oxygen indicated in the chemical formula. The relative numbers of atoms indicated by the chemical formula is therefore 1calcium: 1 carbon: 3 oxygen.

SAQ 6

Ionic bonding arises as a result of transferring electrons to form positive and negative ions (thus an ion is basically an atom with a net charge, positive or negative, resulting from the overall loss or gain of electrons). In contrast, covalent bonding arises when electrons are shared between atoms, forming molecules.

SAQ 7

You could have come up with many different examples here. Generally metals such as sodium (Na), calcium (Ca), magnesium (Mg) and iron (Fe) form ionic bonds with other atoms by transferring bonding electrons, and so themselves become positively charged ions. The atoms of the element to which the metal transfers electrons become negatively charged ions, and the resulting molecules are electrically neutral overall. Sodium chloride (common table salt, NaCl) is an example of an ionic compound. In contrast, the atoms of the gases hydrogen (H_2) and carbon dioxide (CO_2) are examples of covalently bonded molecules in which the bonding electrons are not transferred, but instead are shared between the atoms.

SAQ 8

(a) (i) The potassium ion carries only a single positive charge (+), implying that only one electron has been transferred, therefore potassium has a valency of 1.

(ii) The calcium ion carries two positive charges (2+), implying that two electrons have been transferred, therefore calcium has a valency of 2.

(b) The charge on the calcium ion is 2+, so two electrons have been transferred to chlorine atoms to form chloride ions. Calcium chloride contains twice as many chloride ions as calcium ions so each chloride ion must have received one of the electrons. Therefore, each chloride ion that is formed carries a single negative charge, 1−, written as Cl^-, and so the valency of chlorine must be 1.

(c) In CO_2, carbon forms two covalent double bonds, so two of its bonding electrons pair with two electrons on each of the two oxygen atoms. Carbon therefore has a total of four bonding electrons, so it has a valency of 4, while oxygen has a valency of 2.

SAQ 9

All except C and F are part of the electromagnetic spectrum. (Sound waves are vibrations of atoms or molecules and alpha particles are helium nuclei emitted from some radioactive substances.)

SAQ 10

In order of increasing frequency: A ‘Radio waves’, D ‘infra red radiation’, E ‘visible light’ and B ‘gamma radiation’.

SAQ 11

The negative ions will be attracted towards the positive terminal. The current is equal to the rate of flow of charge so, if the charge on each ion is e and then number of ions flowing per second is n, then the current, I , is equal to ne.

SAQ 12

(a) (volts)-3 (potential difference)

(b) (amps)-1 (current)

(c) (ohms)-2 (resistance)

SAQ 13

(a) The maximum temperature (25.2 °C) was measured at 18.00 (6.00 p.m.) and the minimum temperature (15.0 °C) was measured at 03.00 (3.00 a.m.).

(b) The increase in the temperature between 12.00 and 18.00 hours was 6.0 °C (25.2 °C − 19.2 °C). The percentage increase in temperature was therefore 6.0/19.2 × 100% = 31% (to two significant figures).

SAQ 14

(a) $3.0 \times 10^{8}\,\text{m s}^{-1}$

(b) $3.3 \times 10^{-6}\,\text{m}$

SAQ 15

(a) four (because the final zero is included when working with significant figures).

(b) two (because the leading zeros are not included when working with significant figures).

(c) three.

SAQ 16

The nerve is 25 cm or 0.25 m long. This value is given to 2 significant figures. The speed of transmission is 120 m s^{-1}. This value is also given to 2 significant figures. This means that the signal can travel 120 m in 1 second so will take 0.0020 s to travel the length of the nerve (0.25/120). This value can be given to 2 significant figures because the two values used to calculate it are given to 2 significant figures and the product of any calculation can only be given to the same number of significant figures as the least accurate value used in the calculation (ie the value given to the fewest significant figures).

SAQ 17

(a) $a = \dfrac{c}{b}$

(b) $a = \dfrac{1}{c} + b$ or $\dfrac{(1 + bc)}{c}$

(c) $a = \dfrac{bc}{(b-c)}$