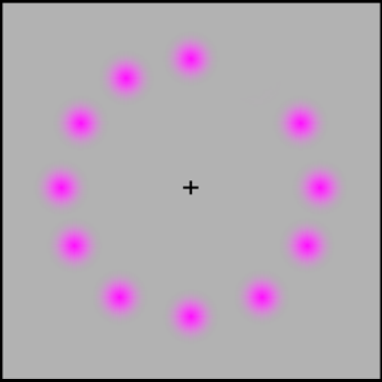


NEUR3001: Advanced Visual Neuroscience

Course Information 2016



Andrew Stockman

Course summary **NEUR3001 Advanced Visual Neuroscience**

This full unit *includes* the NEUR3045 Visual Neuroscience half-unit course.

Course summary **NEUR3001/G001/M001 Advanced Visual Neuroscience**

The course presents a multidisciplinary approach to vision. It covers anatomical, physiological, genetic, molecular and psychological approaches. The first half of the course, which can be taken as a separate half unit (NEUR3045), covers the fundamentals of visual neuroscience from the visual input at the retina to visual perception. The topics range from retinal imaging, visual transduction, the functional anatomy of the retina and LGN, cortical processing to higher level visual functions, such as colour, depth, space, and motion perception. The second part of the course, which completes the full unit, will cover advanced topics including the neural development of the retina, visual development in babies and infants, more in depth coverage of retinal and cortical processing, fMRI, object and face recognition, visual memory, vision and action colour, space, depth, motion and form perception, high level cortical processing, neurology and ophthalmology.

Course organiser **NEUR3001/G001/M001 Advanced Visual Neuroscience**

Andrew Stockman
 Institute of Ophthalmology
 11-43 Bath Street
 London
 EC1V 9EL

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 email: a.stockman@ucl.ac.uk (best contact method)

Deputy course organiser

NEUR3001/G001/M001 Advanced Visual Neuroscience

Stewart Shipp
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Course lecturers

NEUR 3001/G001/M001 Advanced Visual Neuroscience

Dr. Elaine Anderson (Ophthalmology)
 Prof. Mitchell Glickstein (Anatomy)
 Dr. John Greenwood (Psychology)
 Prof. Glen Jeffery (Ophthalmology)
 Dr. Peter Jones (Ophthalmology)
 Dr. Keith May (Computer Science)
 Prof. Gary Rubin (ophthalmology)
 Prof. Tom Salt (Ophthalmology)
 Dr. Stewart. Shipp (Anatomy)
 Prof. Andrew Stockman (Ophthalmology)
 Dr. Anthony Vugler (Ophthalmology)

External Examiner:
 Prof. Peter Giese (King's College London)

Course timetable 2016

**BLOCK G:
2-6 pm Tuesday**

Advanced Visual Neuroscience

Week 20		
Tuesday	12th Jan 2-3	1. Course introduction/ Comparative anatomy of the eye. (AS/MG).
Tuesday	12th Jan 3-4	2. Fundamentals of neuroscience: cells, axons, and synapses. (TS).
Tuesday	12th Jan 4-5	3. Fundamentals of psychophysics. (JG).
Week 21		
Tuesday	19th Jan 2-3	4. Physiological optics and the photoreceptor mosaic. (AS).
Tuesday	19th Jan 3-4	5. Photoreceptors and phototransduction. (AS).
Week 22		
Tuesday	26th Jan 2-3	6. Introduction to retina. (TS) <i>Room to be allocated.</i>
Tuesday	26th Jan 3-4	7. Historical introduction. (MG).
Tuesday	26th Jan 4-6	Demo 1. Optical demonstrations. (MG).
Week 23		
Tuesday	2nd Feb 2-3	8. Achromatic & chromatic vision. (AS).
Tuesday	2nd Feb 3-4	9. Visual psychophysics and sensitivity regulation. (AS).
Tuesday	2nd Feb 4-6	Demo 2. Colour vision demonstrations (SS).
Week 24		
Tuesday	9th Feb 2-3	10. Spatial vision. (JG).
Tuesday	9th Feb 3-4	11. Central visual pathways. (MG).
Tuesday	9th Feb 4-5	12. Multiple visual areas of cortex. (SS).
Week 25		
READING WEEK		
Week 26		
Tuesday	23rd Feb 2-3	13. Hierarchical visual processing. (SS).
Tuesday	23rd Feb 3-4	14. Depth perception/Visual Illusions. (AS).
Tuesday	23rd Feb 4-5	15. Basic motion. (KM).
Week 27		
Tuesday	1st Mar 2-5	Seminar 1. (NEUR3045), Seminars: session 1. <i>Darwin B15.</i>
Tuesday	1st Mar 2-5	Seminar A. (NEUR3001), Seminars: session A. <i>Darwin B05.</i>
Week 28		
Tuesday	8th Mar 2-3	16. The neural correlate of consciousness. (SS).
Tuesday	8th Mar 3-6	Seminar 2. (NEUR3045), Seminars: session 2.
Tuesday	8th Mar 3-6	Seminar B. (NEUR3001), Seminars: session B. <i>Darwin B15.</i>
Week 29		
Tuesday	15th Mar 2-5	Seminar 3. (NEUR3045), Seminars: session 3.
Tuesday	15th Mar 2-5	Seminar C. (NEUR3001), Seminars: session C. <i>Room to be allocated.</i>
Week 30		
Tuesday	22nd Mar 2-5	Journal Club. (NEURG045/M045/G001/M001 only). <i>Darwin B15.</i>

Course timetable 2016

**BLOCK D:
Tuesdays and Thursdays**

Advanced Visual Neuroscience

Week 21		
Tuesday	19th Jan 11-12	1. Course Introduction. (AS) <i>Anatomy B15.</i>
Tuesday	19th Jan 12-1	2. Advanced psychophysics. (JG) <i>Medawar G02 Watson LT.</i>
Week 22		
Tuesday	26th Jan 12-1	3. Spatiotemporal vision and filters. (JG) <i>Anatomy B15.</i>
Thursday	28th Jan 10-11	4. Advanced retina. (TS) <i>Medawar G02 Watson LT.</i>
Week 23		
Tuesday	2nd Feb 11-12	5. The LGN is more than a relay station. (TS) <i>Room to be allocated.</i>
Tuesday	2nd Feb 12-1	6. Neural development of the visual system. (GJ) <i>Anatomy B15.</i>
Thursday	4th Feb 10-11	7. Inherently photosensitive ganglion cells. (AV) <i>Medawar G02 Watson LT.</i>
Week 24		
Tuesday	9th Feb 12-1	8. Visual guidance of movement. (MG) <i>Anatomy B15.</i>
Thursday	11th Feb 10-11	9. Advanced color. (AS) <i>Medawar G02 Watson LT.</i>
Week 25		
READING WEEK		
Week 26		
Tuesday	23rd Feb 12-1	10. Advanced parallel processing. (SS) <i>Gordon Square (25) 107.</i>
Thursday	25th Feb 10-11	11. Low level cortical functions: colour and stereopsis. (SS) <i>Medawar G02 Watson LT.</i>
Week 27		
Tuesday	1st Mar 12-1	12. Object recognition and faces. (JG) <i>Anatomy B15.</i>
Thursday	3rd Mar 10-11	13. Attention. (SS) <i>Medawar G02 Watson LT.</i>
Week 28		
Tuesday	8th Mar 12-1	14. Advanced motion. (KM) <i>Anatomy B15.</i>
Thursday	10th Mar 10-11	15. Reading. (GR) <i>Medawar G02 Watson LT.</i>
Week 29		
Tuesday	15th Mar 12-1	16. Motion deficits. (KM) <i>Anatomy B15.</i>
Thursday	17th Mar 10-11	17. fMRI and visual brain function. (EA) <i>Medawar G02 Watson LT.</i>
Week 30		
Tuesday	22nd Mar 12-1	18. Visual memory. (SS) <i>Darwin B05.</i>
Thursday	24th Mar 10-11	19. Visual development in babies and infants. (PJ) <i>Anatomy G29 J Z Young LT.</i>
Wednesday	30th Mar (before 4:30 pm)	Last day to hand in essay

Undergraduate course assessment

- Assessment will be based upon a final 3 hour examination worth 60% and course work worth 40%.
- The course work will include:
 - i. Essay (worth 20%).
 - ii. Presentation given by the student at one of the seminars in the Visual Neuroscience half-unit (worth 10%).
 - iii. Psychophysical practical experiments, the results of which should be described in a short report (worth 10%).

Graduate course assessment

- Assessment will be based upon a final 3 hour examination worth 48%, an invigilated essay worth 10%, and course work worth 42%.
- The course work will include:
 - i. Essay (worth 16%).
 - ii. Presentation given by the student at one of the seminars in the Visual Neuroscience half-unit (worth 8%).
 - iii. Psychophysical practical experiments, the results of which should be described in a short report (worth 8%).
 - iv. Participation at a journal club (worth 10%).

Course seminar presentation

- A single 10 minute oral presentation should be presented by each student at one of the three seminars. The three seminars will be:
 - (1) Visual function
 - (2) Retina
 - (3) Pathways & cortical processing
- The available seminar titles will be posted on the course Web site: <http://www.cvrl.org>
- Each presentation title will be assigned on a first-come-first-served basis. Send your requests to me (a.stockman@ucl.ac.uk) by e-mail.
- The timetable will be decided after we know student numbers and choices.

Course essay (NEUR3001/G001/G045 only)

- The essay titles will be suggested by the lecturers and will be posted on the course Web site: <http://www.cvrl.org>
- The essay and seminar must be on distinctly different topics.
- Essays should be less than 2500 words in length. They should be word-processed and handed in electronically as well as in hardcopy. Clear diagrams are encouraged.
- The essay must be handed in to the teaching office not later than on Monday after the last week of the course.

Essays

Pick one title.

Essays should in no case should exceed 2500 words. They should be word-processed. Clear diagrams are encouraged. Note that the topic chosen *must be* different from the topic chosen for the seminar. Essays should include a bibliography that should include only the sources and papers consulted to write the essay. The word count does not include the bibliography.

If there is an area in which you are particularly interested that is not covered below, you can contact the course organiser and we will consider adding a new title (no guarantees, though!).

The date for handing in the essay can be found in the course timetable.

Please note at the top of your essay the question and the lecturer from whose list it was taken.

Course Examination

- The final examination paper will contain Basic and Advanced sections, and will last for 3 hours.
- The questions in the Basic section are based on the Visual Neuroscience half-unit (NEUR3045); those in the Advanced section are based on the advanced topics covered in the full-unit (NEUR3001).
- Candidates for must answer a total of three questions, with at least one being chosen from the Basic section, and at least one chosen from the Advanced section.

Recommended Books

Sensation and Perception
by *Jeremy M. Wolfe et al.*



Sensation and Perception by *E. Bruce Goldstein*



Recommended Books

The First Steps in Seeing
by *R.W Rodieck*



Visual Perception: Physiology, Psychology and Biology by *Vicki Bruce, Patrick Green and Mark Georgeson*



Recommended reference sources

The Visual Neurosciences by
*Leo Chalupa and John
Werner*



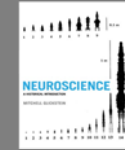
Webvision at
<http://webvision.med.utah.edu/>



For essays, seminars and background material.

Recommended reference sources

Neuroscience: a historical
introduction by *Mitchell
Glickstein*



For essays, seminars and background material.

Course website:
<http://www.cvrl.org>

Instructions for the Advanced Visual
Neuroscience (NEUR 3001) practical

Two options:

OPTION ONE: PERCEPTUAL EXPERIMENTS

Use PXLab (JAVA software to be copied to your computer) to run the series of experiments listed below. For each experiment, *briefly* outline in about a single paragraph (perhaps longer for longer experiments), the experimental technique, the results you obtain, and what you think they might mean. This is a practical book, so extensive references and background reading are *not* required. Just make clear that you have carried out the experiment, and that you have thought about the results. No more than about 5 sides of A4, please!

We welcome suggestions for improvements. Potentially, you could edit the program files yourself (see PXLab website <http://www.pxlab.de/> for further information).

You can do the experiments individually or in small groups. Extra credit will be given if you compare results across students.

If you find the setup and other instructions challenging, or if you cannot get the experiments to run on your computer, then you can try running the software directly from the website (see below, but the Stroop experiment is in German). Alternatively, the experiments will be running on computers in my laboratory at the Institute of Ophthalmology. Contact me if you want to use them. And, of course, you can also choose Option Two!

PXLab: The Psychological Experiments Laboratory by Hans Irtel

For further information see: <http://www.pxlab.de/>

These experiments should run on your computer, but they require Java to be installed.

Four Steps to Run PXLab Applications

1. Make sure that you have the latest Java software installed. You can check this by going to <http://www.java.com>, the main page for the Java runtime environment (JRE). Select 'Do I have Java?' from the choices offered on the page, then (if you have Java) press the button "Verify Java version" on the subsequent page. If the website response tells you that you have the latest Java then go to the next step (2). If you do not have the latest Java software, then download the latest Java runtime environment. Use the 'Typical setup' installation option and again use 'Do I have Java?' to check whether the installation was successful.
2. To get the experimental programs go to <http://www.cvrl.org> go to NEUR3001 and scroll down to beneath the list of lecturers to find the information about the practical. The information (this information) is contained in a pdf file. To get the software, download and save the zip file "pxlab.zip". Unzip it onto your hard drive or onto a memory stick, keeping the same directory structure. Keep a note of where it is! The distribution contains a number of programs that run psychophysical experiments.

3. Use your file explorer to find the file named `pxlab.jar` in the `/pxlab` directory (wherever you have unzipped it—note that the extension `jar` might be hidden in Windows). Double click on this file (with the Java icon) and the program will start an Open Design File dialog. If it isn't already selected, go into the subdirectory named `/pxlab/pxd` and choose a design file (a file with extension `.pxd`) from this subdirectory and the experiment will start. The file names and the experiments are listed below. Do not run the design files until you have read the instructions for the experiment given below!
4. You only need to look at the data files for a few experiments (as noted below). The raw data obtained during an experiment are saved in `/pxlab/dat/pxlab.dat`. If you want to look at the data, open the file with a text editor or other editor, and note down the data. Structured data obtained during an experiment are saved in `c:/pxlab/dtr/pxlab.dtr`. Also open this file with a text editor or other editor, and read the data. You only need to look at the structured data for the Stroop experiments (see below). Note that these data files are overwritten after each experiment, so you should record the data before running a new experiment. You will only need to look at these files for some experiments, as noted below.

You can also run the experiments directly from the website from Internet Explorer or Mozilla Firefox. Go to: <http://www.pxlab.de/> and follow the instructions there. You will need to allow pop-ups in your browser in order to be able to see the data after each experiment, which appear in a pop-up window.

The downside of using the website is that a few experiments, such as the Stroop experiment, are in German.

The following is a list of the experiments and the relevant pxd design files you must run after first running pxlab.jar. You do not necessarily need to do every experiment. If some don't work, note the problem you have encountered in the practical book, and move on. And, don't worry, this is supposed to be "fun".

For each experiment, first run pxlab.jar, then run the pxd file from the dialog.

Change Blindness: The Flicker Method

Run: change_blindness_flicker.pxd

This experiment demonstrates our blindness to stimulus changes across flicker breaks. It is similar to Experiment 1 of Rensink *et al.* (1997). Follow the on-screen instructions. Note in the practical book which part of the scene changed for each picture pair.

Rensink, O'Regan, & Clark (1997). To See or Not to See: The Need for Attention to Perceive Changes in Scenes. *Psychological Science*, 8, 368-373.

Other examples: <http://www.cogsci.uci.edu/~ddhoff/cb.html>

Many other examples can be found on the web.

The Müller-Lyer Figure

Run: mueller_lyer.pxd

Two Müller-Lyer objects. Follow the instructions and record the on-screen results, which appear after each run. Do the experiment a few times (5 or more) to obtain a mean and standard deviation for the changes in apparent length.

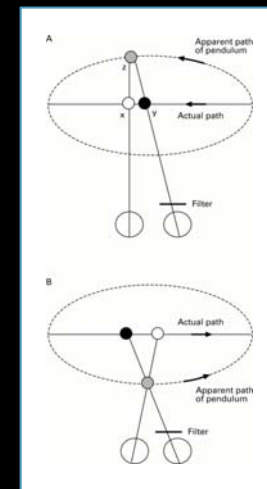
See also:

http://www.michaelbach.de/ot/sze_muelue/index.html

Pulfrich Pendulum Simulation

Run: pulfrich.pxd

This simulates a pendulum swinging in the horizontal plane. You will need to cover one eye with a dark filter (e.g., dark sunglasses) after which the pendulum will appear to swing in depth. Why? See the figure on the right. You will find other examples on the web.



Interocular transfer of Motion After Effect

Run: bene.pxd

Follow the instructions on the screen. Adapt to the moving pattern for 30 seconds with one eye and then view the stationary grating as instructed with either the same eye or the opposite eye. When the after-effect (motion in the opposite direction) disappears press any mouse or keyboard key. The length of the aftereffect is recorded and a delay of 60 s counts down until you can start the next trial. Do about 10 trials.

Interocular transfer of Motion After Effect

You will need to open `/pxlab/dat/pxlab.dat` with a text editor or other editor to view the data. The first two lines will look something like this:

```
0      Please view with SAME eye now!    7977.4806
1      Please change to the opposite eye now! 16790.1731
```

The first column is the trial number. The second tells you whether you changed eyes or not. And the third tells you the duration of aftereffect in milliseconds. Average appropriately.

Compare the mean data and standard deviation for the motion aftereffect (MAE) in the same eye with those for the MAE in the opposite eye (the Interocular transfer effect).

See, for example: http://www.michaelbach.de/ot/mot_adapt/index.html

Stroop Interference

Run: stroop_short.pxd

This experiment is a non-verbal version of the classical Stroop (1935) task. The number of trials in this version has been reduced to 12. Run this for practice only.

Read the instructions on the screen. When you see the fixation cross, press a mouse button or key to start the trial. If the colour name on the bottom is the same as the "ink" colour on the top, then press the left mouse button. If not, press the right mouse button.

Run: stroop_visual.pxd

Now run the main experiment. Keep going until the end, or press the [stop experiment] key if you get fed up (the data up to that point will be saved).

To look at the results, you will need to open `/pxlab/dtr/pxlab.dtr` with a text editor or other editor to view the data. The data are at the *end* of the file and will look something like this:

```
Trial( 0, 3, "YELLOW", "GREEN", YELLOW, CON, R_NO, 1, 1882.8742);
Trial( 1, 3, "YELLOW", "BLUE", BLUE, INCON, R_YES, 0, 1074.3945);
Trial( 2, 3, "RED", "YELLOW", YELLOW, INCON, R_YES, 0, 1210.2647);
Trial( 3, 9, "GREEN", "GREEN", GREEN, CON, R_YES, 0, 722.29);
Trial( 4, 1, "YELLOW", "YELLOW", YELLOW, CON, R_YES, 0, 554.9357);
```

and so on...

```
Trial( 0, 3, "YELLOW", "GREEN", YELLOW, CON, R_NO, 1, 1882.8742);
Trial( 1, 3, "YELLOW", "BLUE", BLUE, INCON, R_YES, 0, 1074.3945);
Trial( 2, 3, "RED", "YELLOW", YELLOW, INCON, R_YES, 0, 1210.2647);
Trial( 3, 9, "GREEN", "GREEN", GREEN, CON, R_YES, 0, 722.29);
Trial( 4, 1, "YELLOW", "YELLOW", YELLOW, CON, R_YES, 0, 554.9357);
```

The sixth word is important and defines the trial: CON means that the upper colour word and the colour in which it was printed were the same (congruent); INCON means that the upper colour word and the colour in which it was printed were different (incongruent); and NEUT means that the upper word was a non-colour, nonsense word (neutral).

The second from last element (0 or 1) is also important. A 1 means an incorrect response and a 0 means a correct response.

Finally, the last element is the response or reaction time (RT) in milliseconds.

Complicated? Not really! Average separately all the correct CON RTs, the correct INCON RTs and the correct NEUT RTs and compare the results. In the CON trials the ink and word were the same so could "reinforce" each other, perhaps making the RT quicker. In the INCON trials the ink and word are different so could "interfere" with each other, perhaps making the RT slower. The RT for the NEUT trials should be unaffected by the upper word. Is what you find consistent with this?

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, 18, 643-661. You will find lots of coverage of the Stroop effect on the web.


```
Trial( 0, 3, "YELLOW", "GREEN", YELLOW, CON, R_NO, 1, 1882.8742);
Trial( 1, 3, "YELLOW", "BLUE", BLUE, INCON, R_YES, 0, 1074.3945);
Trial( 2, 3, "RED", "YELLOW", YELLOW, INCON, R_YES, 0, 1210.2647);
Trial( 3, 9, "GREEN", "GREEN", GREEN, CON, R_YES, 0, 722.29);
Trial( 4, 1, "YELLOW", "YELLOW", YELLOW, CON, R_YES, 0, 554.9357);
```

In each line within the parentheses, the third element in quotation marks is the *word* that appeared on top, sometimes a nonsense word. The fourth element also in quotation marks is the *word* that appeared on the bottom always printed in white. The fifth word not in quotation marks is the "ink" colour in which the upper word was printed.

For example, Trial(6, 1, "BLUE", "RED", RED, INCON, R_YES, 0, 1442.588) would have appeared thus:

BLUE

RED

and Trial(0, 3, "YELLOW", "GREEN", YELLOW, CON, R_NO, 1, 1882.8742) thus:

YELLOW

GREEN

Adaptive Stimulus Control: The Horizontal-Vertical Illusion

Run: horizontal_vertical_adaptive.pxd

This experiment measures the size of the horizontal-vertical illusion, which is the tendency for observers to overestimate the length of a vertical line relative to a horizontal line of the same length.

See: http://en.wikipedia.org/wiki/Vertical%E2%80%93horizontal_illusion

The program uses the method of limits in which a staircase tracks your responses by adjusting the length of the vertical line according to your response on the previous trial. If you thought the vertical line was longer, it is made shorter on the next trial, and vice versa. The step size or amount by which the line length is changed is gradually reduced over trials so that the length converges on an estimate of the vertical line length that for you appears to match the horizontal line length.

Record the results of each experiment as shown on the screen. What is the mean relative size of the illusion?

Visual and auditory response times compared

Run: erzav.pxd

Follow the on-screen instructions. Open /pxlab/dat/pxlab.dat with a text editor or other editor to look at the results. The last column gives the response times (RTs) in milliseconds. The first four rows are auditory RTs and the last four rows are visual RTs. Do the experiment a few times and average the results. Remember to record the results after each run or they will be overwritten.

Compare the visual and auditory response times. Which is quicker?

Credits: Many thanks to Hans Irtel and his collaborators for providing PXLab.

OPTION TWO: VISUAL ILLUSIONS

Go to Michael Bach's excellent website: 94 Visual Phenomena & Optical Illusions at <http://www.michaelbach.de/ot/>

Choose 15 different illusions. For each illusion, *briefly* outline in a paragraph: the illusion, your observations, and what the results suggest about the visual system. You are writing a practical notebook, so references and extensive background reading are not required. Just make clear that you have observed each illusion and thought about what it means.

No more than about 5 sides of A4, please!

Extra credit will be given for groups of coherent choices that can conceptually be related to each other.