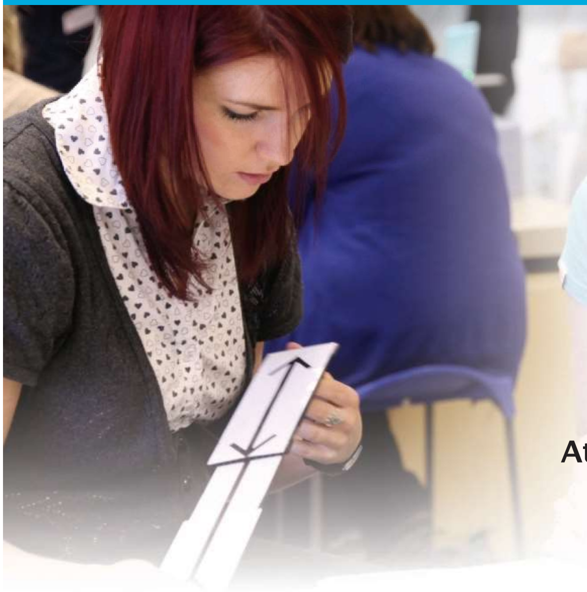

Mulling over Müller-Lyer

In Unit 3 (*Neurobiology and Communication*) of *Higher Human Biology*, in the section that includes the study of perception, a suggested learning activity is to “Plan and design investigations using the *Müller-Lyer* illusion” [1]. At SSERC we have devised a possible approach to carrying out such an activity in the classroom. The associated resources are available on the SSERC website [2].

Figure 1

The *Müller-Lyer* illusion is one of a series of so called ‘distortion illusions’ [3] and it was first noticed by Franz Müller-Lyer in 1889. Since that time it has been the subject of much study and conjecture. The phenomenon can easily be introduced to learners by asking them to draw two straight lines of exactly equal length, one immediately above the other, and then to put ‘arrows’ on one line and ‘fins’ on the other. The addition of arrows and fins in this way makes lines which are exactly the same length appear to most people to be different; the line with fins being *apparently* longer than the line with arrows (Figure 1).

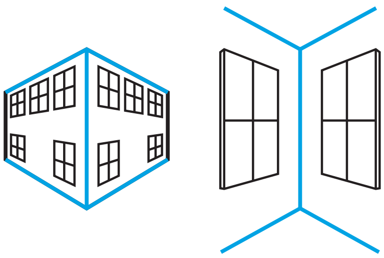

Figure 2 - (https://www.rit.edu/cla/gssp400/muller/muller.html).

The cause of the illusion is not entirely understood although various explanations have been put forward. Richard Gregory, for example, cited the misapplication of depth cues as the cause of our misperception of the length of the lines [4]. Since we live in a world of straight lines and angles, he would argue that we readily perceive the adorned lines as being distant, or closer versions of corners, by applying 3-D depth cues to this 2-D image (Figure 2).

Figure 3

Having misapplied depth cues the brain then misapplies ‘size constancy’. Size constancy happens when the brain overrides information provided by the relative size of images on the retina, for example when we look at a scene containing distant and near objects (Figure 3).

In this scene of teachers on a SSERC course, the image created on the retina by looking at the most distant person in the scene is smaller than the image created on the retina by looking at the closest person in the scene, but we do not perceive the closest person as being bigger; this is size constancy [5].

SSERC bulletin 253.indd 6 22/10/15 11:17:23

Figure 4

Gregory would argue that in the case of the *Müller-Lyer* illusion the brain having misapplied depth cues then mistakenly adjusts for size constancy. Because the brain has assumed that the line with fins is further away it ignores the retinal information about size and assumes that the line with fins must be longer.

Gregory's mistaken depth cues explanation of the *Müller-Lyer* illusion relies on the addition of shapes that make 'corners'. However, even if the depth cues referred to by Gregory are removed and replaced with an alternative to the angles of corners as in Figure 4, the illusion is still apparent.

For this reason Hans Eysenck believed that the phenomenon was caused by the brain applying more complex interactions of cues including its ability to infer the existence of three dimensions from two-dimensional images. Several other possible explanations exist and further investigation of these might interest some learners.

Having said all this it is not necessary to understand the causes of the *Müller-Lyer* illusion in order to investigate its extent under different conditions. Although the *Müller-Lyer* illusion provides a nice context for the study of depth perception and size constancy, the main purpose of the activity described here is to allow learners to engage in the process of designing an investigation which will generate quantitative data. And for learners at *Advanced Higher* level, the data generated from the investigation might be used for further statistical analysis [6].

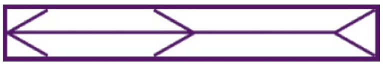

Figure 5

At SSERC we have created what we call our '*Müller-Lyer* device'. On the device the two lines in question are adjacent to each other and the arrow on the end of one doubles as the fin on the end of the other as in Figure 5.

The device can be adjusted by sliding the two sections towards, or away from, each other until the two lines **appear** to be of equal length and the scale on the back provides a means of 'measuring' the extent of illusion (Figure 6). (Of course, as an aspect of their experimental design, learners may well come up with their own method of measuring the extent of the illusion).

In the suggested experiment, the subject would adjust the device and the tester would read and record the extent of the illusion indicated on the scale on the reverse side. Here we suggest taking measurements under two conditions: 1) when the illusion is presented horizontally and 2) when the illusion is presented vertically (Figure 7). The independent variable is therefore 'orientation' and the dependent variable is the extent of the illusion.

Learners could be asked to suggest hypotheses and at *Advanced Higher* level it would be appropriate to include a 'null hypothesis'. In this case that orientation will have no effect on the apparent extent of the illusion. Issue 18 of the Wellcome Trust publication, *The Big Picture*, entitled 'Number Crunching' has a helpful explanation for learners of the null hypothesis [7].

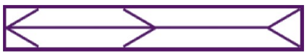


Figure 7 *- Horizontal/vertical presentations.*

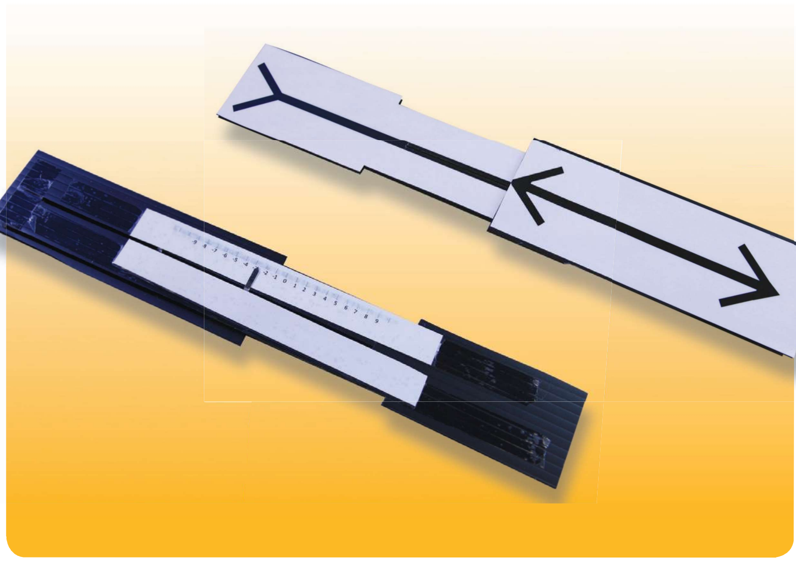

Figure 6 *- Adjustable device with scale on reverse side.*

SSERC bulletin 253.indd 7 22/10/15 11:17:26

Other aspects of the design of the investigation will need to be considered. For example, will all subjects be tested under both conditions (a within subjects design), or will different groups be tested for one of each of the conditions (a between subjects design). With a between subjects design, consideration would need to be given to random allocation of subjects to the two groups. In our student protocol we suggest a between subjects design [8]. Other considerations would be number of subjects, number of readings under each of the two conditions and how long the subject is given to adjust the device.

If the design includes a null hypothesis, the results can be analysed using a *t-test* to ascertain statistical significance of the difference between the two sets of results and, therefore, whether the null hypothesis can be accepted, or rejected. The *t-test* can be applied to the generated data most simply using a *Microsoft Office Excel* spread sheet, or other freely downloadable statistical software packages [9]. In this case, since we are only setting out to accept, or reject the null hypothesis, the *Excel t-test* is adequate.

Using the *Excel t-test*

- Open up an *Excel* spreadsheet.
- Enter the data for horizontal and vertical presentations in two separate columns, A and B.
- Go to '**more functions**', then to '**statistical**' then to '**TTEST**'.
- Because we can't predict the direction of the results i.e. we have no reason to expect that the apparent extent of the illusion will be greater for the horizontal, or for the vertical presentation, the test required is '**two-tailed**'.
- Because our design is a between-subjects design, the appropriate test is the '**unrelated t-test'**.
- In this case it is appropriate to use, '**two-sample unequal variance**'.
- The *Excel t-test* gives a probability value (*p value*). If the *p value* is less than 0.05 the difference between the two data sets is statistically significant and the null hypothesis can be rejected. If the result is not statistically significant the null hypothesis cannot be rejected.

By using the *Müller-Lyer* illusion to plan and design an investigation in this way, learners can explore:

- An approach to achieving quantitative rather than qualitative results.
- A null hypothesis.
- Within subjects or between subjects design.
- Consideration of sample size and number of replicates.
- Data quality as measured by range and central tendency.
- The use of a *t-test* for significant differences.
- The ethical use of human subjects in research.

References

[1] Course and Unit Support Notes for the NQ *Higher Human Biology* are available via the SQA website www.sqa.org.uk/ (accessed July 21st 2015).

[2] http://www.sserc.org.uk/.

[3] R.L. Gregory, *Eye and Brain: The Psychology of Seeing*, Weidenfield and Nicolson, 1979, p. 138.

[4] R.L. Gregory, *Eye and Brain: The Psychology of Seeing*, Weidenfield and Nicolson, 1979, p. 151.

[5] A useful graphic illustrating size constancy can be found on the website of the University of Calgary at http://ucalgary.ca/pip369/mod5/constancy/size.

[6] Course and Unit Support Notes for the NQ Advanced Higher Biology are available via the SQA website www.sqa.org.uk/ (accessed July 21st 2015).

[7] Wellcome Trust *Big Picture*, 'Number Crunching' available at http://bigpictureeducation.com/number-crunching.

[8] http://www.sserc.org.uk/.

[9] Downloadable statistics package called ***R*** available for free download at http://www.r-project.org/.

SSERC bulletin 253.indd 8 22/10/15 11:17:28