

MEI
Conference
2018

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Maths in Biology and Psychology

Choose either biology or psychology.
Write down the mathematics you think is needed for
A level study.

Magnification

- Magnification is the number of times larger an image is than the real size of the object.
- Example:



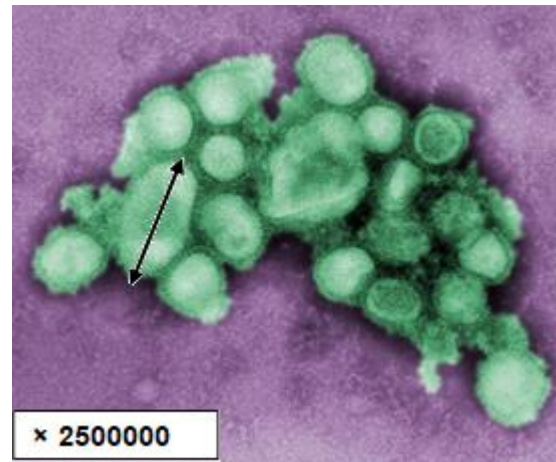
Actual size
of an egg

Magnified size
of an egg

- The magnification is the number you need to multiply the real size by to get to the magnified size.

Example

- Find the real size of the swine flu virus shown below.



the length of the virus in the image = 15mm

$\div 2500000$

$\times 15$

Image size (mm)	25000000	1	15
Actual size (mm)	1	$1 \div 2500000$	$1 \div 2500000 \times 15$

So the actual size is $1 \div 2500000 \times 15 = 0.000006\text{mm} = 6 \text{ nm}$

A psychology study

- I would like you to take part in a study but I don't want to tell you what it is about yet in case that biases the results.
- You will not have to do anything embarrassing and your data will be anonymised in the rest of the session.

Mathematics in Psychology

What was the investigation about?

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Finger length in males and females

- 2D:4D is the length of the second digit divided by the length of the fourth digit.
- 2D:4D tends to be lower for males than females.
- Typical values for the UK are 0.98 for males and 1 for females
- It is thought that 2D is a measure of exposure to oestrogen in the womb whereas 4D is a measure of exposure to testosterone in the womb

“Notes on the human hand”, Baker 1888

“(The index finger) is usually shorter than the ring finger, as in the anthropoid apes, sometimes equals it and rarely exceeds it. Ecker, for reasons which are not quite clear, considers that unusual length is a progressive character. He finds it more frequently in women and holds that it is usually correlated with a high type of mind.”

“In 85 individuals examined I found the index to equal or exceed the annularis (ring finger) in 9 cases. There was no perceptible difference in the two sexes.”

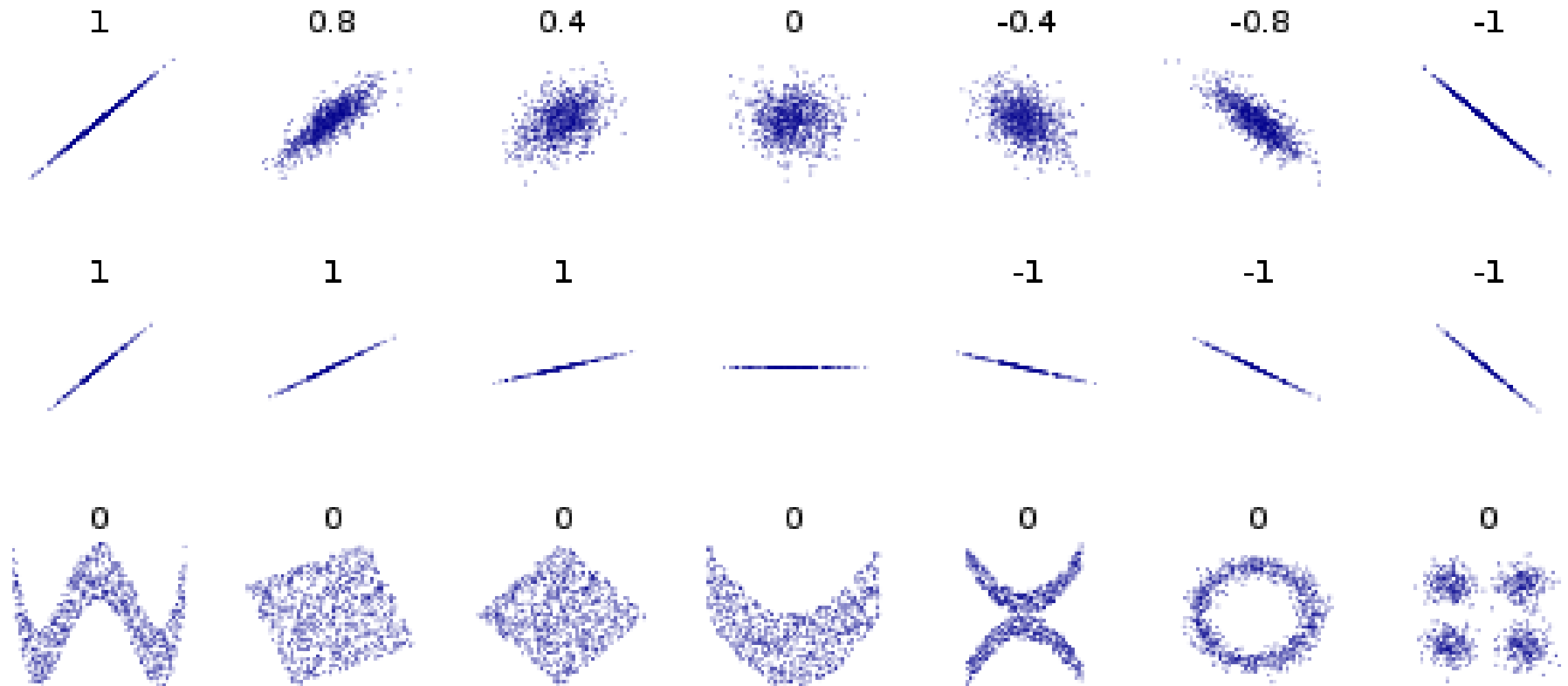
More recent studies

- There have been many recent studies of digit ratio
- Some have found a negative correlation with mental rotation ability
- Others have found no correlation
- Measurements for the right hand generally show a stronger correlation than for the left hand

What is correlation?

- Correlation is a way of measuring whether there is a straight line relationship between two variables.
- Pearson's product moment correlation coefficient is sometimes just called "the correlation coefficient"
- It is between +1 and -1.
- A value of 0 means there is no correlation.

Some correlation examples



Some things to notice

- Correlation of +1 or -1 means that the data points all lie on a straight line
- Correlation 0 means that no straight line can be drawn BUT there could still be some kind of relationship between the two variables

Dr Mark Brosnan 2007, finger length and test scores for 7 year olds

“they found that a smaller ratio (i.e. a longer ring finger and therefore greater prenatal exposure to testosterone) meant a larger difference between ability in maths and literacy, favouring numeracy relative to literacy.”

University of Bath press release

Systemising and empathising

- The systemising quotient (SQ) is a way of measuring the drive to analyse and explore systems
- The empathy quotient (EQ) is a way of measuring the drive to empathise with others.
- A large BBC internet study found some correlation between SQ and digit ratio.

Why this is difficult

- We usually have data from one sample

BUT

- We really want to know whether there is correlation in the population that the sample comes from.
- For your experiment, you have data from a sample of people but you want to know whether there would be a correlation if you could get data from everybody (the whole population).

Some guidance

- Tables are available to show how big the correlation in a sample needs to be before we can assume that there really is correlation in the population
- The next slides guide you through the process of deciding whether the correlation coefficient is big enough.

The null hypothesis (H_0)

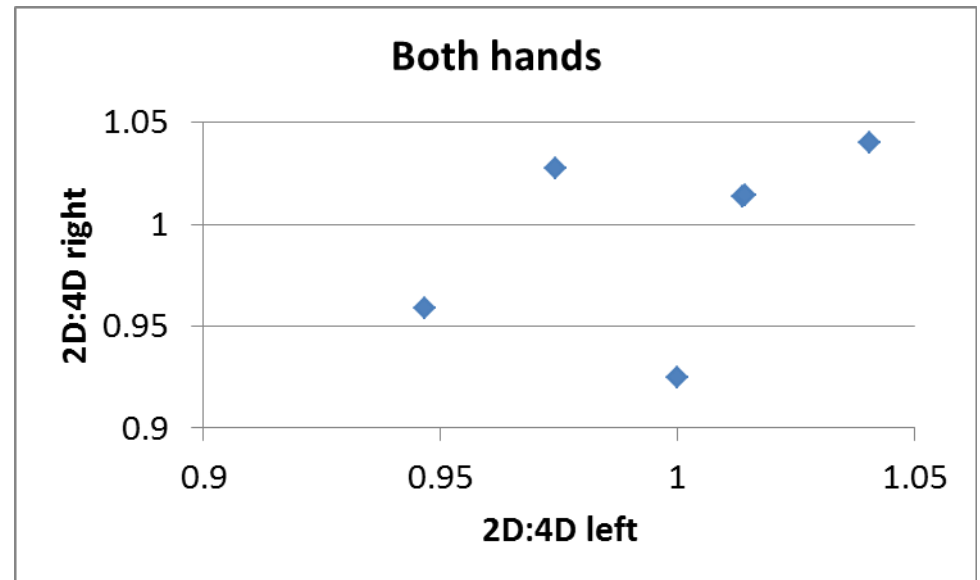
- The default position is that we assume there is no correlation in the population (until we find evidence that there is).
- This default position is called the null hypothesis.
- The symbol for the correlation coefficient for the population is ρ .
- The null hypothesis is $\rho = 0$.

The alternative hypothesis (H_1)

- The alternative hypothesis is what we look for evidence of. It can take one of three forms.
 - ❖ $\rho \neq 0$ (there is some correlation)
 - ❖ $\rho > 0$ (there is positive correlation)
 - ❖ $\rho < 0$ (there is negative correlation)

The correlation coefficient for the sample

- The correlation coefficient for the sample is given the symbol r .
- For the sample data, the correlation coefficient for digit ratios for right and left hands was 0.467



Is there enough evidence of positive correlation?

Number of points in scatter diagram	Critical value for 5% level of significance
3	0.997
4	0.950
5	0.878
6	0.811
7	0.754

What the table says

- For 5 points in the scatter diagram, a sample correlation coefficient of 0.878 is needed to provide evidence of positive correlation in the population.
- The 5% level of significance means that, even if there is no correlation in the population, 5% of samples will give a correlation as high as 0.878.

The test for the sample data (two hands)

H_0 : There is no correlation in the population

H_1 : There is positive correlation in the population

The correlation coefficient for the sample was
0.467

The critical value at the 5% level is 0.878.

0.467 is less than 0.878 so there is not enough evidence of positive correlation between digit ratios for both hands in the population.

Some things to bear in mind

- We cannot be completely sure whether there is correlation in the whole population or not. For the sample data, there is not enough evidence of positive correlation
- The tables are based on x and y having Normal distributions.
- Some tables give degrees of freedom instead of the number of data points – the degrees of freedom = data points minus 2.

About MEI

- Registered charity committed to improving mathematics education
- Independent UK curriculum development body
- We offer continuing professional development courses, provide specialist tuition for students and work with employers to enhance mathematical skills in the workplace
- We also pioneer the development of innovative teaching and learning resources