Hello and Welcome!

PSYC234: Statistics: from association to modelling causality

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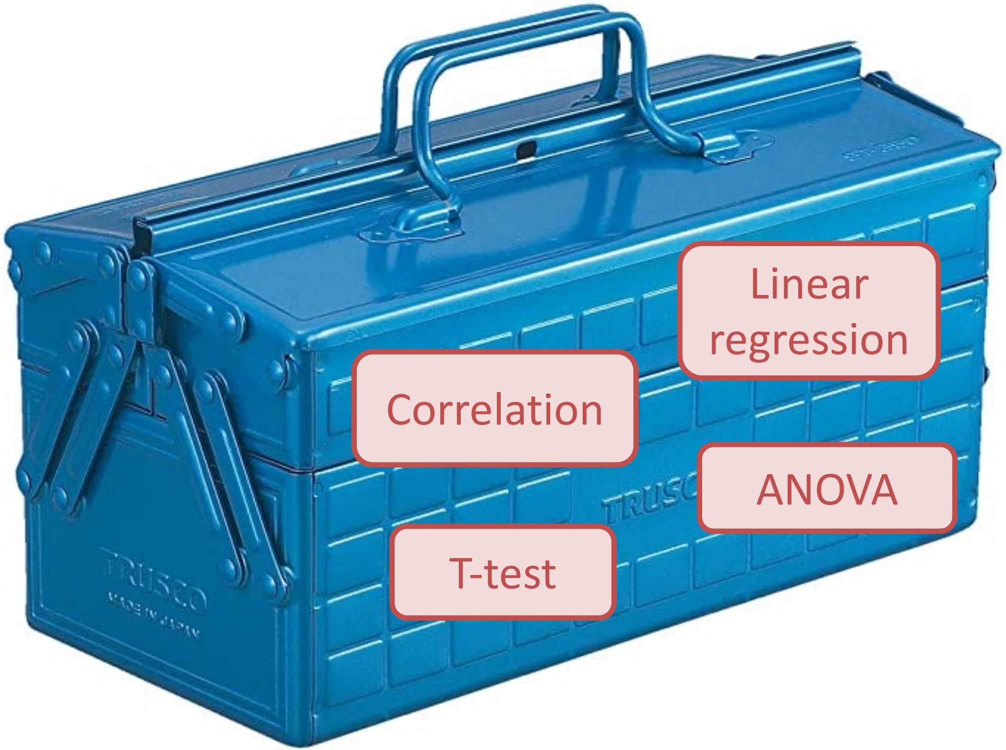
Your statistics toolbox



- Soon you will have to apply what you've learned to your dissertation
- One issue: there are relatively common situations where these tests aren't appropriate… what then?!

The plan

My aim: to add a few final statistical tests to your toolbox for when the statistical test you've learned about might not be appropriate

Week 5
(This week) → The Binomial Test → A situation where t-tests aren't appropriate

Lecture 5 – Part 2
The Binomial test

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Learning objectives

- To understand what the binomial test is and when to use it
- To understand how to conduct the binomial test in R and interpret the output

Let's think back to the one-sample t-test

You are a researcher interested in whether babies born in Germany weigh more than babies born in the UK.

Let's assume the following are true:

- The NHS keeps good records of birth weights in the UK, and that the average birth weight in the UK in 2020 was 3350g.
- The health authorities in Germany do not keep good records of birth weights.

What do we do?

Participant	Birth weight (g)
1	3004
2	3052
3	3067
4	4063
5	2134
6	2356
7	4356
8	3567
9	3432
10	3245
11	1467
12	2345
13	4532
14	4352
15	2453
16	2343
17	3453
18	3428
19	2344
20	4353

← Babies born in Germany

Mean = 3167.30g

You could collect birth weights from a sample of babies born in Germany and compare this to the known average in the UK (3350g).

Is the mean of the sample significantly different from a known value?

One-sample t-test!

Another scenario…

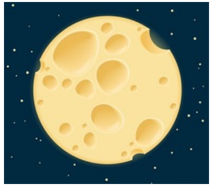
Is the moon made of cheese?

a) Yes
b) No

ID	Answer	ID	Answer
1	No	8	No
2	No	9	No
3	Yes	10	No
4	No	11	No
5	No	12	No
6	No	13	No
7	No	14	No

Does the proportion of participants answering the question correctly differ from the chance guessing rate?

Another scenario…



Does the proportion of participants answering the question correctly differ from the chance guessing rate?

ID	Answer	ID	Answer
1	No	8	No
2	No	9	No
3	Yes	10	No
4	No	11	No
5	No	12	No
6	No	13	No
7	No	14	No

How many participants answered the question correctly?

- Correct ("No") = 13/14 = 0.93

Another scenario…

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Does the proportion of participants answering the question correctly differ from the chance guessing rate?

ID	Answer	ID	Answer
1	No	8	No
2	No	9	No
3	Yes	10	No
4	No	11	No
5	No	12	No
6	No	13	No
7	No	14	No

What is chance guessing rate?

2 possible answers (yes/no)

So chance = 50%

Expressed as a proportion, this is 0.5

To convert a percentage to a proportion, divide by 100 = 50/100 = 0.5

Can we use the one-sample t-test?

Proportion correct in sample = 0.93

Chance guessing rate (proportion) = 0.5

One sample t-test: Is the mean of the sample significantly different from a known value?

Issue: we can't calculate a mean value for the sample – we have a proportion who answered correctly

So, we can't use a one-sample t-test…

What can we use?!

The Binomial Test

- The binomial test compares a sample proportion to a known value, such as…

Proportion correct in sample = 0.93

Chance guessing rate (proportion) = 0.5

- Does a sample proportion differ significantly from a known value?

- Known value may be theoretical (e.g. based on chance) or known data about the world (e.g. 26% people die from this disease)

The Binomial Test: Other examples

You notice that a lot of the insects in your garden are ants. You work out that 564 out of 712 insects are ants. You hear on a TV show that on average, 64% of insects in UK gardens are ants. Is the proportion of insects that are ants in your garden larger than UK average?

Proportion of sample that are ants are: 564/712 = 0.79

Known value (expressed as a proportion)= 0.64

You develop a new vaccine for an illness and give this to 1,000 people - 32/1000 given the vaccine get the illness within a year. You know that approximately 10% of unvaccinated people (or 0.1 expressed as a proportion) get the illness every year. Is the proportion of vaccinated people getting the illness lower than the known value for unvaccinated people?

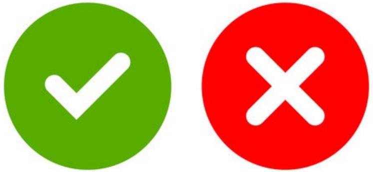
Proportion of sample that get the illness: 32/1000 = 0.03

Known value (expressed as a proportion)= 0.10

Does a sample proportion differ significantly from a known value?

Assumptions of the binomial test

1. The outcome is dichotomous:
There are only two possible outcomes



Correct/Incorrect

Pass/fail

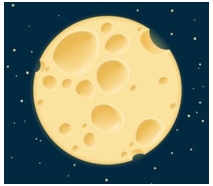
Has SEND/does not have SEND

Is a ladybird/is not a ladybird

2. The outcome can be specified as success or failure

- Success is the category we are calculating the proportion for. Failure is the other category

- Sometimes this makes sense and fits well with the outcome.



Does the proportion of participants answering the question correctly differ from the chance guessing rate?

Success = correct
Failure = incorrect

Sometimes it is less obvious…

- You notice that a lot of the insects in your garden are ants.
- You work out that 564 out of 712 insects are ants.
- You hear on a TV show that on average, 64% of insects in UK gardens are ants.
- Is the proportion of insects that are ants in your garden larger than UK average?

Success: Ant

Failure: Not ant

… and sometimes it is counterinitiative

You develop a new vaccine for an illness and give this to 1,000 people - 32/1000 given the vaccine get the illness within a year.

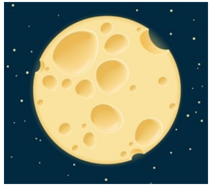
You know that approximately 10% of unvaccinated people (or 0.1 expressed as a proportion) get the illness every year.

Is the proportion of vaccinated people getting the illness lower than the known value for unvaccinated people?

Success: Get illness

Failure: Do not get illness

3. Each trial is independent



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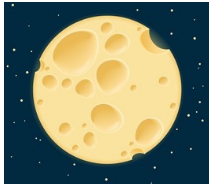
Independent

Not independent

4. The probability of ‘success’ remains the same on every trial



All participants are given the same version of the question:

Is the moon made of cheese?

a) Yes
b) No

Outcome 1: Correct = b
Outcome 2: Incorrect = a

Two versions of the question:

Is the moon made of cheese?

a) Yes
b) No

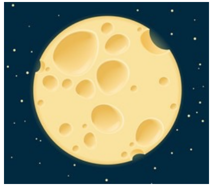
Is the moon made of cheese?

a) Yes
b) No, it never has been
c) No, but it used to be

Outcome 1: Correct = b
Outcome 2: Incorrect = a or c

Running the binomial test in R

How do I conduct a binomial test in R?



Function to run the binomial test

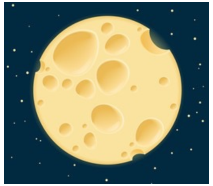
Number of successes (e.g. correct)

```
binom.test(13, 14, 0.5)
```

Number of trials in total

Known value, here expressed as a proportion (here chance guessing rate)

R output



Number of successes (e.g. correct)

Total number of trials

p-value

```
        Exact binomial test

data:  13 and 14
number of successes = 13, number of trials = 14, p-value = 0.001831
alternative hypothesis: true probability of success is not equal to 0.5
95 percent confidence interval:
 0.6613155 0.9981932
sample estimates:
probability of success
             0.9285714
```

95% confidence interval around the probability of success

Known value you specified

Probability of success, calculated by doing 13/14

How do I interpret the p-value?

```
        Exact binomial test

data:  13 and 14
number of successes = 13, number of trials = 14, p-value = 0.001831
alternative hypothesis: true probability of success is not equal to 0.5
95 percent confidence interval:
 0.6613155 0.9981932
sample estimates:
probability of success 
             0.9285714 
```

$p \leq .05$ = The observed proportion differs significantly from the known value

$p > .05$ = The observed proportion does not differ significantly from the known value

I have a significant effect…
In what direction is the effect?

Is the probability of success higher or lower than the known value?

The proportion of children answering the question correctly is significantly higher than the chance guessing rate

```
        Exact binomial test

data:  13 and 14
number of successes = 13, number of trials = 14, p-value = 0.001831
alternative hypothesis: true probability of success is not equal to 0.5
95 percent confidence interval:
 0.6613155 0.9981932
sample estimates:
probability of success
             0.9285714
```

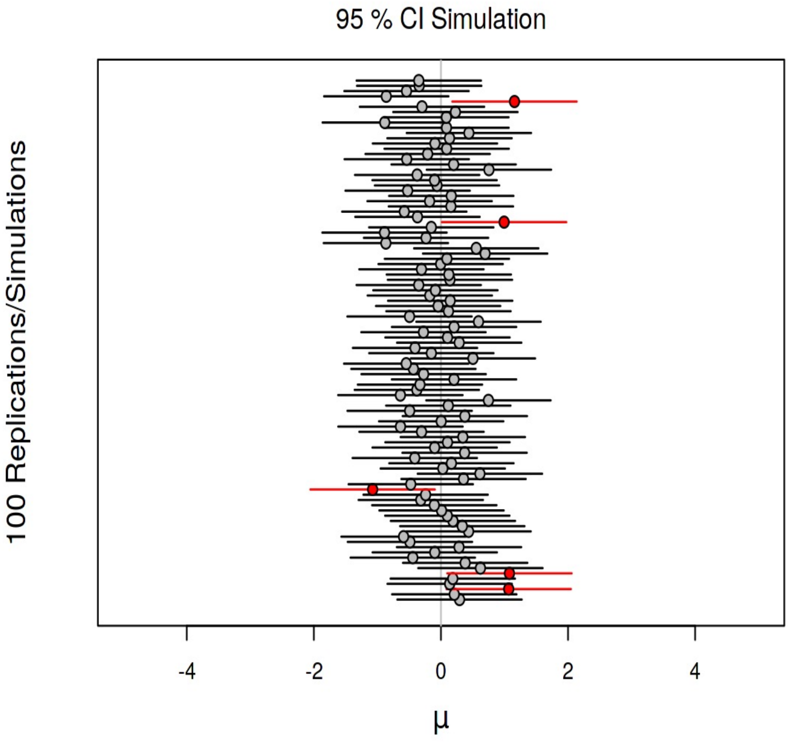
What does the 95% confidence interval tell us?

- If we repeat the sampling method many many times and compute a 95% confidence interval, 95% of the intervals would contain the true value in the population.

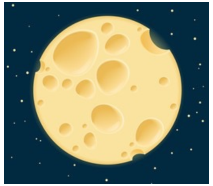
- Range that is likely to contain the true value

```
data:  13 and 14
number of successes = 13
alternative hypothesis:
95 percent confidence in
 0.6613155 0.9981932
sample estimates:
probability of success
```

True proportion of participants who answer the question correctly is likely to be between 0.66 and 1.00



Reporting in APA format



A binomial test was conducted to determine whether the proportion of participants answering the question correctly differed significantly from chance guessing rate. This revealed that that the proportion of participants answering the question correctly (93%; 95% confidence interval = 66-100%) was significantly higher than the chance guessing rate (50%; p = 0.002).

Post-lecture activities
Complete ideally **before** WBA

- Some activities to help you structure your independent study time
- Download from Moodle
- Optional, but recommended

Thank you for listening!

Please post any questions about the binomial test on the discussion board or the anonymous Qualtrics link ("The Binomial Test: Post questions anonymously" link)