Lesson: Introduction to Inferential Statistics

1. What is Inferential Statistics?

While **descriptive statistics** are valuable for summarizing and organizing data—highlighting patterns or providing single summary values like the mean or standard deviation—they do not tell us whether the findings are meaningful or applicable beyond the data collected.

Inferential statistics address this limitation by allowing researchers to **draw conclusions or make judgments** based on the data. For example, they can help determine whether changes in a dependent variable are truly caused by manipulation of an independent variable, rather than by chance.

The primary goal of inferential statistics is to assess whether the data **support the research hypothesis**. When results are obtained from a **sample**, inferential statistics also allow researchers to infer whether these results are likely to hold true for the **larger population** from which the sample was drawn.

A key concept in inferential statistics is the **null hypothesis**, which assumes that there is **no effect** or **no difference** between groups. Researchers use **statistical tests** to evaluate this hypothesis. For instance, a newspaper might report, "Statistical tests show that women are better at reading maps than men." Since it is impossible to test every woman and man in the world, a researcher tests a **representative sample** of women and men. If the sample results show women outperform men in map-reading, the researcher can **infer** that this trend likely applies to the broader population.

These statistical tests rely on **probabilities** to determine the likelihood that the observed effects are real and not due to random variation. This is the essence of inferential statistics: using sample data to make informed conclusions about a population with a certain degree of confidence.

Key Terms

- **Inferential Statistics**: Drawing conclusions about populations
- **Null Hypothesis (H_0)**: No effect or difference
- **Alternative Hypothesis (H_1)**: Real effect or difference
- **p-value**: Probability results occurred by chance
- **Statistical Significance**: Results unlikely due to chance
- **Observed Value**: Calculated test result
- **Critical Value**: Threshold for significance

Inferential statistics allows researchers to:

- Make **generalizations about a population** based on a sample.
- Draw **conclusions** from collected data.
- Determine whether results are **meaningful or due to chance**.

Example:
Instead of testing all people in the world, researchers study a **sample** and infer results for the population.

Activity 1 (Think & Reflect)

Why can researchers not study an entire population in most cases?

2. Descriptive vs Inferential Statistics

Descriptive Statistics	Inferential Statistics
Summarizes data	Interprets data
Uses mean, median	Uses statistical tests
Describes patterns	Draws conclusions

Key Idea:
Descriptive statistics **describe**, while inferential statistics **decide**.

Check Your Understanding

Which type of statistics helps determine if results are meaningful?
a) Descriptive
b) Inferential

3. Statistical Testing

The concept of significance
It turned out we found a diff erence in the level of chattiness aft er participants drank *peedUpp*compared to when they drank water. Fantastic! We can now market *SpeedUpp* as a scientific cure for shyness and make millions. Or can we?
Just because we found a diff erence in the **mean** number of words spoken in the two conditions, we do not yet know if this is what psychologists refer to as a **signifi cant** diff erence.The diff erence we found may have been no more than that which could have occurred by **chance**, that is, by coincidence or a fl uke. To fi nd this out, we need to use **statistical testing**.

The sign test
To determine whether the diff erence we have found is significant, we can use a simple statistical calculation called the **sign test**. There are a number of statistical tests ,each of which have their own conditions of use. To use the sign test:
1. We need to be looking for a *difference* rather than an association (which we are).
2. We need to have used a **repeated measures design** (which we did).
3. We need data that is organised into categories, known as **nominal data**. Our data isn't nominal (yet) but we can convert it for the purposes of this test.

Statistical tests help determine whether:

- Differences or relationships are **real (significant)**
- OR occurred by **chance**

Example:
A study finds that one group performs better than another.
Is this difference real, or just coincidence?

➡ Statistical testing provides the answer.

4. The Null and Alternative Hypotheses

he concept of the null hypothesis is rooted in the work of Karl Popper, who argued that scientific theories cannot be proven true through repeated confirmation but can be disproven by a single counterexample. For instance, observing many white swans does not prove that all swans are white, but finding one black swan is enough to disprove the claim. Based on this idea, research begins with the null hypothesis, which assumes no relationship or difference between variables. Researchers then collect data to test this assumption; if the evidence strongly contradicts it, the null hypothesis is rejected in favor of the alternative hypothesis. This process relies on calculated (observed) values compared to critical values to determine statistical significance, providing a reasonable—though never absolute—approximation of the truth.

Null Hypothesis (H_0)

- Assumes **no difference or relationship**
- Example: There is no difference between groups

When we reject the null hypothesis, it means we have enough evidence to believe that a real difference or relationship exists, so we accept the alternative hypothesis. However, this conclusion is made with reasonable certainty, not absolute proof. In simple terms, the alternative hypothesis becomes the best explanation based on the available data. In statistics, data can be of different types: nominal (categories), ordinal (ordered data), and interval (measured with equal units). The null hypothesis assumes there is no effect or relationship, while the observed value is the result calculated from a statistical test. This result is compared to a critical value, which helps us decide whether the findings are significant and whether the null hypothesis should be rejected.

Alternative Hypothesis (H_1)

- Assumes a **real difference or relationship**
- Example: One group performs better than another

Based on ideas from Karl Popper:

- Science tries to **reject the null hypothesis**
- If rejected → alternative hypothesis is accepted

Activity 2

- Identify the null hypothesis:
  "Students who study more get higher grades."

5. Observed and Critical Values

Observed (Calculated) Value

- The result obtained from the statistical test

Critical Value

- A threshold value from statistical tables
- Used to decide if results are significant

Decision Rule:

- If observed value meets/exceeds critical value → **reject H_0**

To decide if the observed value is significant this fi gure is compared to another number (the **critical value**), found in a **table of critical values**. There are different tables of critical values for each different statistical test, as you will see on the following spreads. The critical value is the number that a test statistic must reach in order for the null hypothesis to be rejected.
To find the appropriate critical value in a table you need to know four pieces of information:
• Degrees of freedom (*df*) In most cases you get this value by looking at the number of participants in the study (*N*).
• **One-tailed** or **two-tailed test** If the hypothesis was a **directional hypothesis**, then you use a one-tailed test, if it was **non-directional** you use a two-tailed test.
• Signifi cance level selected, usually $p = 0.05$ (5% level).
• Whether the observed value needs to be greater than or less than the critical value for significance to be shown. You will fi nd this information stated underneath each table of critical values.

Activity 4

What happens if the observed value is lower than the critical value?

6. Probability and p-values

What is Probability (p)?

- The likelihood that results occurred **by chance**

Common Significance Levels:

- **$p \leq 0.05$** → 5% chance (acceptable)
- **$p \leq 0.01$** → more strict
- **$p \leq 0.001$** → very strict

Interpretation:

- If $p \leq 0.05$ → results are **statistically significant**
- If $p > 0.05$ → results may be due to **chance**

Activity 3

If $p = 0.03$, are the results significant? Why?

8. Using Inferential Tests

To select and use a statistical test, you need:

- Sample size (N) or **degrees of freedom (df)**
- Type of hypothesis:
  - One-tailed (directional)
  - Two-tailed (non-directional)
- Significance level (e.g., $p = 0.05$)

Example: The Sign Test

The **Sign Test** is used when:

- Comparing **differences** (not relationships)
- Using **repeated measures design**
- Data is **nominal** (or converted to nominal)

Activity 5

Is the sign test suitable for:
a) Correlation studies
b) Repeated measures difference studies

Final Quiz

1. What does p = 0.05 mean?
a) 50% chance
b) 5% chance results are due to chance
c) Results are always correct

2. What happens when the null hypothesis is rejected?
a) Study fails
b) Alternative hypothesis is accepted
c) Nothing changes

3. Which is NOT inferential statistics?
a) Mean
b) Sign test
c) Correlation test

4. Why use inferential statistics?
a) To summarize data
b) To draw conclusions about populations
c) To collect data

Lesson Summary

- Inferential statistics helps researchers **draw conclusions**.
- It relies on **probability and statistical testing**.
- The **null hypothesis** is tested and often rejected.
- Results are judged using **p-values and significance levels**.
- Decisions are based on **observed vs critical values**.