Statistics and Data Analysis

Unit 03 – Lecture 03: Hypothesis Testing (t-test): Paired Test and Effect Size

Tofik Ali

School of Computer Science, UPES Dehradun

February 17, 2026

https://github.com/tali7c/Statistics-and-Data-Analysis

Quick Links

Overview   Paired Design   Effect Size   Exercises   Demo   Summary

Agenda

Learning Outcomes

- Differentiate paired vs independent designs

Learning Outcomes

- Differentiate paired vs independent designs
- Compute within-pair differences di

Learning Outcomes

- Differentiate paired vs independent designs
- Compute within-pair differences di
- Run a paired t-test (conceptually)

Learning Outcomes

- Differentiate paired vs independent designs
- Compute within-pair differences di
- Run a paired t-test (conceptually)
- Explain effect size and why we report it

Learning Outcomes

- Differentiate paired vs independent designs
- Compute within-pair differences di
- Run a paired t-test (conceptually)
- Explain effect size and why we report it
- Interpret results in context (not only p-value)

Paired Design: Key Points

- Same unit measured twice (before/after)

Paired Design: Key Points

- Same unit measured twice (before/after)
- Analyze differences di $=$ after - before

Paired Design: Key Points

- Same unit measured twice (before/after)
- Analyze differences di $=$ after - before
- Pairing reduces noise from individual differences

Paired Design: Key Formula

$$t = \frac{\bar{d}}{s_d/\sqrt{n}}, \quad \mathrm{df} = n - 1$$

Effect Size: Key Points

- p-value answers: evidence?

Effect Size: Key Points

- p-value answers: evidence?
- Effect size answers: how big?

Effect Size: Key Points

- p-value answers: evidence?
- Effect size answers: how big?
- Large n can make tiny effects significant

Effect Size: Key Formula

$$d = \frac{\bar{x}_1 - \bar{x}_2}{s_{\text{pooled}}}$$

Exercise 1: Compute differences

Before/After: (10,12), (12,12), (11,14), (9,10). Compute di and dbar.

Solution 1

- di: 2,0,3,1
- dbar = 1.5

Exercise 2: CI idea

If the 95% CI for mean difference excludes 0, what does it suggest?

Solution 2

- Evidence of a change (difference likely non-zero).
- Check magnitude and context.

Exercise 3: Interpret d

If Cohen's d=0.3, what does it suggest (rule of thumb)?

Solution 3

- Small effect (context dependent).
- Still may matter if cheap/safe to adopt.
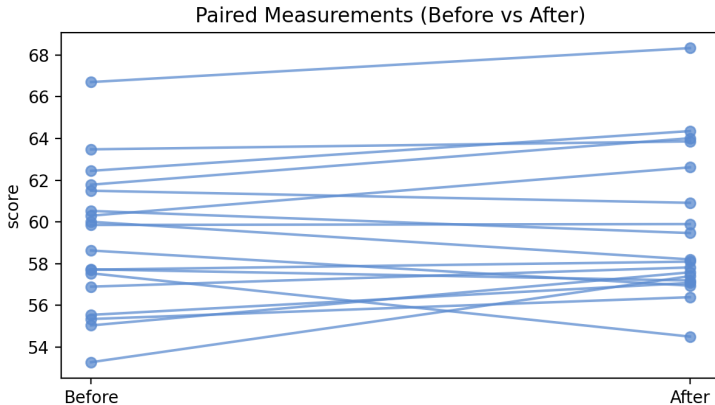
Mini Demo (Python)

Run from the lecture folder:

```
python demo/demo.py
```

Outputs:

- `images/demo.png`
- `data/results.txt`

Demo Output (Example)

Paired Measurements (Before vs After)

Summary

- Key definitions and the main formula.

Summary

- Key definitions and the main formula.
- How to interpret results in context.

Summary

- Key definitions and the main formula.
- How to interpret results in context.
- How the demo connects to the theory.

Exit Question

Why can paired designs be more powerful than independent designs?