# Statistics and Data Analysis
# Unit 03 – Lecture 03 Notes

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February 14, 2026

## Topic

Paired t-test, mean difference, effect size, and interpretation.

### 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)

## Detailed Notes

These notes are designed to be read alongside the slides. They expand each slide bullet into plain-language explanations, small worked examples, and common pitfalls. When a formula appears, emphasize (1) what each symbol means, (2) the assumptions needed to use it, and (3) how to interpret the final number in the problem context.

## Paired Design

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

## Effect Size

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

## Exercises (with Solutions)

### Exercise 1: Compute differences

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

### Solution

- 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

- 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

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

## Exit Question

Why can paired designs be more powerful than independent designs?

## Demo (Python)

Run from the lecture folder:

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

Output files:

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

## References


- Montgomery, D. C., & Runger, G. C. *Applied Statistics and Probability for Engineers*, Wiley.
- Devore, J. L. *Probability and Statistics for Engineering and the Sciences*, Cengage.
- McKinney, W. *Python for Data Analysis*, O'Reilly.