



# Between Subjects Single Factor : ANOVA

---

AGSC 4080 – EXPERIMENTAL DESIGN AND ANALYSIS

DEPARTMENT OF AGRICULTURAL AND ENVIRONMENTAL  
SCIENCES

# Objectives

---

- Understand the Between-Subjects Single Factor Design
- Comprehend Random Assignment
- Master One-Way ANOVA
- Learn to Compute the F-statistic
- Explore Post Hoc Tests

# Between-Subjects Design

---

## Definition

In a between-subjects design, each participant is tested in only one condition or treatment group.

## Example

Assigning half of 100 students to write about a traumatic event and half about a neutral event.

## Single Factor

Studies with one independent variable are called between-subjects single factor designs.

## Contrast

Different from within-subjects design, where participants experience multiple conditions.

# Random Assignment

---

1

## Purpose

Random assignment is the primary method researchers use to control for extraneous variables across conditions.

2

## Key Criteria

Each participant has an equal chance of being assigned to each condition, and assignments are made independently.

3

## Methods

Techniques include coin flips for two conditions or computer-generated random integers for multiple conditions.

4

## Importance

While not infallible, random assignment is considered a strength of research design and works well for large samples.



# Activity: Basketball Shootout

---

We want to test the accuracy of different shooting methods: left hand vs right hand vs both hands. We will randomly assign students to each group using an online random assignment tool

- Discuss the potential weaknesses of random assignment

A: Left Hand	B: Right Hand	C: Both Hands

# One-Way ANOVA Overview

---

1

## Definition

One-way ANOVA is a statistical test used when there is one independent variable with at least two levels.

2

## Comparison to t-test

For two-level designs, ANOVA gives similar results to a t-test, with F-value being equivalent to  $t^2$  value.

3

## F-statistic

The key output of ANOVA is the F-value, which is a ratio of the effect measure to the error measure.

# Understanding the F-statistic

name of statistic =  $\frac{\text{measure of effect}}{\text{measure of error}}$

$$F = \frac{\text{measure of effect}}{\text{measure of error}}$$

$$F = \frac{\text{Can Explain}}{\text{Can't Explain}}$$

1

## Concept

The F-statistic represents a ratio of what can be explained by the experimental manipulation to what cannot be explained (error).

2

## Interpretation

**F = 1:** Equal explanation and error

**F > 1:** More explanation than error

**F < 1:** Less explanation than error

3

## Example

An F-value of 5 indicates researchers can explain 5 times more variation than they can't explain, which is considered **good**.

# Computing the F-statistic

---

$$SS_{\text{total}} = SS_{\text{Effect}} + SS_{\text{Error}}$$

1

## Total Variation

The ANOVA process begins by splitting total variation in the data into two parts: variation due to manipulation and variation due to sampling error.

2

## Sums of Squares

Variation is measured using sums of squares (SS), following the formula:  $SS_{\text{Total}} = SS_{\text{Effect}} + SS_{\text{Error}}$

3

## Calculating $SS_{\text{Total}}$

Find the difference between each score and the grand mean, square the differences, and sum them up.

4

## Calculating $SS_{\text{Effect}}$ and $SS_{\text{Error}}$

$SS_{\text{Effect}}$  is calculated using group means, while  $SS_{\text{Error}}$  represents unexplained variation within groups.



# Activity: Computing $SS_{total}$ , $SS_{Effect}$ , $SS_{Error}$

---

Let's imagine we had some data in three groups, A, B, and C. The data looks like below. Let's compute  $SS_{total}$ ,  $SS_{Effect}$ , and  $SS_{Error}$

groups	scores
A	20
A	11
A	2
B	6
B	2
B	7
C	2
C	11
C	2

# Degrees of Freedom in ANOVA

---

Component	Formula	Example (3 groups, 9 scores)
dfEffect	Groups - 1	$3 - 1 = 2$
dfError	Scores - Groups	$9 - 3 = 6$

Degrees of freedom (df) are crucial in ANOVA calculations. For  $SS_{\text{Effect}}$ , df represents the freedom of group means relative to the grand mean. For  $SS_{\text{Error}}$ , df accounts for the constraints imposed by calculating group means.

# Mean Squares Calculation

---

## Purpose

Mean Squares normalize the Sums of Squares by dividing them by their respective degrees of freedom.

1

## MSError

Calculated as  $SS_{Error} / df_{Error}$ , representing the average unexplained variation.

3

## MSEffect

Calculated as  $SS_{Effect} / df_{Effect}$ , representing the average variation due to the experimental effect.

2

## Interpretation

Mean Squares provide a standardized measure of variation, allowing for meaningful comparison between effect and error.

4

# Final F-statistic Calculation

---

## Formula

$F = \text{MSEffect} / \text{MSError}$

## Interpretation

The F-statistic represents the ratio of explained variation to unexplained variation.

## Significance

A larger F-value suggests a stronger effect of the independent variable on the dependent variable.

## Next Steps

After calculating F, determine the corresponding p-value to assess statistical significance.

# Activity: Basketball Shootout

---

We want to test the accuracy of different shooting methods: left hand vs right hand vs both hands. Each member of each group will shoot using the assigned shooting method. We will record the number of shots made out of 5 and then compute the F-statistics

Individuals	Groups	Score



# Conclusion: The Power of ANOVA



## Analysis Tool

ANOVA provides a powerful method for analyzing variance in experimental data.



## Versatility

It can be applied to various research designs with different numbers of groups and participants.



## Insight

ANOVA helps researchers determine if differences between groups are statistically significant.



## Decision Making

Results guide researchers in accepting or rejecting null hypotheses and drawing conclusions.

# F-Statistic & ANOVA Challenge

---

- ❑ We will play this game in group of 3. The winner has a bonus point of 1 on ICEs
- ❑ To play the game:
  - Click on this link:  
[https://abdelawani.shinyapps.io/F-Statistic ANOVA Challenge Game Show/](https://abdelawani.shinyapps.io/F-Statistic%20ANOVA%20Challenge%20Game%20Show/)
  - or scan the QR Code

