

Module 4: Factorial Treatment Structure

Why Factorials? Treatment vs Design Structure

Recall One-way Treatment Structures

One Factor at a Time

- Multiple levels → treatments
- Compare the mean response between the treatments

What are we missing?

- Effects may depend on context
- Optimal choice may change depending on that context
- One factor doesn't always tell the full story

Example 4.1: Blood Pressure

Incidence of high blood pressure in the United States continues to rise, and optimal strategies for treatment remain an open question. Most physicians agree that effective treatment likely involves a combination of lifestyle changes and medication, rather than relying on a single approach.

Researchers plan to study middle-aged U.S. women with moderate hypertension who are otherwise healthy (i.e., eating a standard diet and not taking regular medications).

Goal: Identify optimal combinations of diet and medication for lowering and maintaining blood pressure as measured by the change in blood pressure (mmHg) for each participant.

Example 4.1: Blood Pressure

Diet (2 levels):

- Mediterranean diet (low sodium, low fat)
- Standard American diet

Medication (4 levels):

- Diuretic (D): flushes excess water and salt
- ACE inhibitor: widens blood vessels
- Beta blocker (BB): reduces heart and vessel signaling
- Placebo (P)

| 200 volunteers who meet the study inclusion criteria are recruited.

Study Design A (A common first attempt)

- First, 100 participants are randomly assigned to one of two diets (50 Mediterranean, 50 Standard American).
- Separately, 100 participants are randomly assigned to one of four medications (25 per medication).



Study Design A (A common first attempt)

Researchers then find:

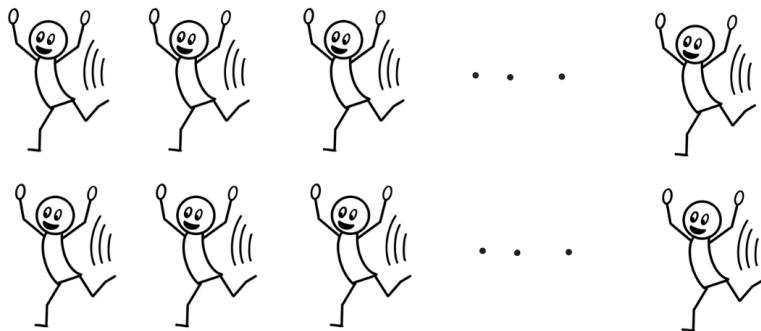
1. The Mediterranean diet lowers blood pressure, on average.
2. ACE inhibitors lower blood pressure more than other medications, on average.

Is the optimal strategy to recommend the Mediterranean diet and ACE inhibitors together?

Study Design B (A full factorial)

Each participant is randomly assigned to one **combination** of:

- Diet (2 levels)
- Medication (4 levels)



This results in $t = \underline{\hspace{2cm}}$ treatment combinations, with $r = \underline{\hspace{2cm}}$ participants per combination.

What can we learn from Design B that we can't from Design A?

Full Factorial

Definition: Full Factorial

$$(a \times b \times c \times \dots)$$

$$(a \times b \times c \times \dots)$$

A **full factorial treatment structure** (e.g., $2 \times 2 \times 2$, 3×2 or 2×2 , etc.) is a study in which there are two or more factors. Each factor will have at least two levels. The factor levels are combined to create the treatments (or treatment combinations).

Example: 2 diets \times 4 medications

- ____ \times ____ full factorial

Example (Extended): 2 diets \times 4 medications \times 2 exercise routines

- ____ \times ____ \times ____ full factorial

Treatment Structure for a Full Factorial

- Name:
- Factors:
- Levels:
- $t = \underline{\hspace{2cm}}$ with Treatments:

A 2×4 full factorial with factors Diet (2 levels - Standard American, Mediterranean) and Medication (4 levels - Diuretic, ACE inhibitor, Beta blocker, and Placebo) for a total of $t = 8$ treatment combinations (e.g., Standard American x Diuretic, Standard American x ACE, ..., Mediterranean x Placebo).

Experimental Structure for a Full Factorial

- Name:
- Experimental units: $r = \underline{\hspace{2cm}}$
- Measurement unit:

Diet and Medication treatment combinations are assigned to middle-aged U.S. women with moderate hypertension who are otherwise healthy (e.u.) in a CRD with $r = 25$. The change in blood pressure (mmHg) is measured for each woman in the study (m.u.).

Create a Full Factorial CRD in R

```
1 library(edibble)
2 library(tidyverse)
3
4 des <- design(name = "BP 2 x 4 Full Facotrial CRD") |>
5   set_units(woman = 200) |>
6   set_trts(Diet = c("Standard American",
7               "Mediterranean"),
8         Medication = c("Diuretic",
9                     "ACE",
10                    "Beta blocker",
11                    "Placebo"))
12   ) |>
13   allot_trts(Diet*Medication ~ woman) |>
14   assign_trts("random")
15
16 factorial_table <- serve_table(des)
17 factorial_table$change_bp <- NA
18
19 head(factorial_table)
```

```
# An edibble: 6 x 4
  woman          Diet  Medication change_bp
  <U(200)>      <T(2)>    <T(4)>
  <chr>          <chr>    <chr> <lgl>
1 woman001 Standard American Beta blocker NA
2 woman002 Mediterranean Beta blocker NA
3 woman003 Mediterranean ACE NA
4 woman004 Mediterranean Beta blocker NA
5 woman005 Standard American Beta blocker NA
6 woman006 Standard American Diuretic NA
```

Create a Full Factorial CRD in JMP

DOE > Classical > Full Factorial

The screenshot shows the JMP Full Factorial Design interface. In the 'Responses' section, there is one response named 'Change in Blood Pressure' set to 'Maximize'. In the 'Factors' section, two factors are defined: 'Diet' (Categorical, levels: Standard American, Mediterranean) and 'Medication' (Categorical, levels: Diuretic, ACE, Beta blocker, Placebo). A 'Specify Factors' button is present at the bottom.

The dialog box for a 2x4 Factorial design. It shows 'Run Order: Randomize', 'Number of Runs: 8', 'Number of Center Points: 0', and 'Number of Replicates: 24'. Buttons for 'Make Table' and 'Back' are also present.

Pattern	Diet	Medication	Change in Blood Pressure
11	Standard American	Diuretic	•
24	Mediterranean	Placebo	•
13	Standard American	Beta blocker	•
12	Standard American	ACE	•
12	Standard American	ACE	•
23	Mediterranean	Beta blocker	•
11	Standard American	Diuretic	•
14	Standard American	Placebo	•
23	Mediterranean	Beta blocker	•
21	Mediterranean	Diuretic	•