Experiment Design Revisited

Marco Antonio Florenzano Mollinetti[1]
[1]**University of Tsukuba, Systems Optimization Laboratory**
mollinetti@syou.cs.tsukuba.ac.jp

Before we Begin

- Go to the github repo:
  - https://github.com/Mollinetti/Statistics-R
- Download the script for this class! (in the 'scripts' folder, class_3_5.r!)
- Run the first lines to load/install the required libraries

Agenda

- Experiment Design
  - Factorial Design
  - Full factorial x Partial
- Review: The medicine experiment

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Experiment Design

- From the previous lectures, we know have the competence to design “simple” experiments
- Simple, we mean with one variable that follows normality (for now)
- Remember: Before anything, begin with the RESEARCH QUESTION

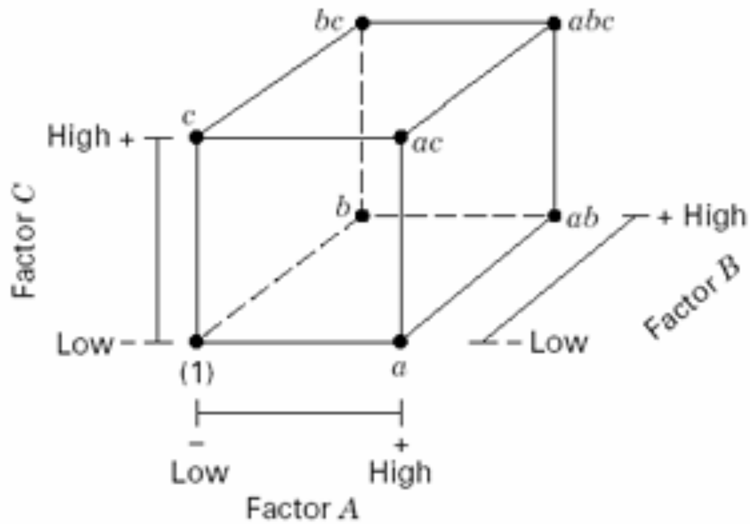
Experiment Design

- THE P-VALUE DOES NOT PROVE/DISPROVE ANYTHING
- If the experiment does not turn the way you want, blame the design/research question, but do not blame the p-value.

- Experiment Design
  - Factorial Design
  - Full factorial x Partial
- Review: The medicine experiment

Experiment Design

- An experiment has Factors and Levels



(a) Geometric view

Run	Factor A	Factor B	Factor C
1	−	−	−
2	+	−	−
3	−	+	−
4	+	+	−
5	−	−	+
6	+	−	+
7	−	+	+
8	+	+	+

(b) The design matrix

Figure 6-4 The 2^3 factorial design.

Experiment Design

- Factor: Category of a variable
- Levels: Degrees of variations of the factors
- Example: Heart Dataset
  - Sex is a factor, male/female are levels
  - Cp is a factor, none/mild/medium/acute are levels

Experiment Design

- For categorical variables it is easy to define levels
- For numerical variables, a interval of fixed values (bins) is the recommended approach
  - Ex: values ranging from 0 to 1 we discretize into 4 bins

Experiment Design

- Experiments involves permutation of levels and factors
- Bounded by 2^n permutations (very easy to explode!)
- One has to carefully define the levels and factors of their experiments

- Experiment Design
  - Factorial Design
  - Full factorial x Partial
- Review: The medicine experiment

Experiment Design

- Full factorial experiment: explore all possible permutations of levels and factors
  - Able to explore any and every interaction
  - However, it is restricted to a small number of factors/levels
- Partial experiment (blocking): some levels have fixed values
  - Explore only desired permutations
  - Does not explore all the possibilities

Experiment Design

- Example: “We want to test the effects of a new medicine on people ranging from 18 to 60 years old”
  - How many factors?
  - How many levels for each factor?
  - Should we go for partial or full-factorial?

- Experiment Design
  - Factorial Design
  - Full factorial x Partial
- Review: The medicine experiment

Review: The medicine experiment

- Time to put all of our knowledge so far in practice!
- Let’s do the following experiment:
  - “Suppose you want to test the effects of a new medicine that helps people with symptoms of insomnia. There are three groups: Control, Test and Placebo. Variable measured is the mean amount of sleep for fixed days. Suppose you have a stringent constraint on budget and measurements takes a copious amount of labor, so mistakes are not allowed. You are allowed to conduct a pilot study with 6 candidates before the main experiment.”

Review: The medicine experiment

- We will use the "sleep_exp_pilot.csv" dataset for the pilot study
- For the main experiment we will use the "sleep_exp_main.csv" dataset
- Slides with the R symbol at the corner: refer to the R code!

Review: The medicine experiment

- Before we start, **what is our research question?**

Review: The medicine experiment

- Before we start, **what is our research question?**
- **Verify whether the sleep medicine has any effect on the target population**
- **Placebo is considered to account for bias!**

Review: The medicine experiment

- Before we start, **what is our research question?**
- **Verify whether the sleep medicine has any effect on the target population**
- **Placebo is considered to account for bias!**
- **Now, let's go for our SEVEN STEPS**

Review: The medicine experiment

1. Identify the parameter of interest
2. Define your H_0 and H_1
3. Determine desired α and β
4. Determine the test statistic and critical region
5. Calculate sample size
6. Calculate statistic
7. Decide whether or not to reject H_0

Review: The medicine experiment

1. Identify the parameter of interest **mean of populations**
2. Define your H_0 and H_1
3. Determine desired α and β
4. Determine the test statistic and critical region
5. Calculate sample size
6. Calculate statistic
7. Decide whether or not to reject H_0

Review: The medicine experiment

1. Identify the parameter of interest
2. Define your H_0 and H_1 H_0: same mean H_1: not the same mean (two-sided)
3. Determine desired α and β
4. Determine the test statistic and critical region
5. Calculate sample size
6. Calculate statistic
7. Decide whether or not to reject H_0

Review: The medicine experiment

1. Identify the parameter of interest
2. Define your H_0 and H_1
3. Determine desired α and β **standard 95% and 85%**
4. Determine the test statistic and critical region
5. Calculate sample size
6. Calculate statistic
7. Decide whether or not to reject H_0

Review: The medicine experiment

1. Identify the parameter of interest
2. Define your H_0 and H_1
3. Determine desired α and β
4. Determine the test statistic and critical region

   t-test + validations
5. Calculate sample size
6. Calculate statistic
7. Decide whether or not to reject H_0

Review: The medicine experiment

1. Identify the parameter of interest
2. Define your H_0 and H_1
3. Determine desired α and β
4. Determine the test statistic and critical region
5. Calculate sample size **Power-t-test for the pilot study (z-test)**
6. Calculate statistic
7. Decide whether or not to reject H_0

Review: The medicine experiment

1. Identify the parameter of interest
2. Define your H_0 and H_1
3. Determine desired α and β
4. Determine the test statistic and critical region
5. Calculate sample size
6. Calculate statistic **p-values and means**
7. Decide whether or not to reject H_0

Review: The medicine experiment

1. Identify the parameter of interest
2. Define your H_0 and H_1
3. Determine desired α and β
4. Determine the test statistic and critical region
5. Calculate sample size
6. Calculate statistic
7. Decide whether or not to reject H_0 **based on the t-test+ validation**

Review: The medicine experiment

- We know that the expected mean value of a healthy person is 7 hours.
- Our minimal observable difference value δ^* is 1 hour

Review: The medicine experiment

- Let's start by step 4: calculating power and the ideal sample size.
- Run the power-t-test for the pilot experiment example and for the desired power

Review: The medicine experiment

- Having decided our ideal sample size n, we conducted measurements with n samples
- Open the "sleep_exp_main.csv"
- Let's validate our data, for every column test:
  - Normality **qq-plot + shapiro-wilk**
  - Heteroscedascity **fligner-kileen + residuals scatterplot**
  - Independence* **Durbin-watson**

Review: The medicine experiment

- Now, let's decide whether we will do a pairwise or a pooled t-test
- Let's verify the correlation and covariance of each column
- Based on that we make our choice and run the test

Review: The medicine experiment

- For each test, what was the p-value?
- What can be said about H_0?
- What can we concur about the results? Is the medicine effective? How so?

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