Experimental Design

Lecture 2

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Introduction

- Researchers use experiments to answer questions like:
  - Is a drug a safe, effective cure for a disease?
  - Which combination of protein and carbohydrate sources provides the
  - best nutrition for growing lambs?
  - How will long-distance telephone usage change if our company offers a different rate structure to our customers?

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What is Experiment?

- An experiment is characterized by the **treatments** and **experimental units** to be used, the way treatments are assigned to units, and the **responses** that are measured.
  - Experiments allow us to set up a direct comparison between the treatments of interest.
  - 2. We can design experiments to minimize any bias in the comparison.
  - 3. We can design experiments so that the error in the comparison is small.
  - 4. Most important, we are in control of experiments, & having that control allows us to make stronger inferences about the nature of differences

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Terms and Concepts

- **Treatments** are the different procedures we want to compare
- **Experimental units** are the things to which we apply the treatments
- **Responses** are outcomes that we observe after applying a treatment to an experimental unit
- **Randomization** is the use of a known, understood probabilistic mechanism for the assignment of treatments to units
- **Experimental Error** is the random variation present in all experimental results
- **Measurement units** (or response units) are the actual objects on which the response is measured.

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Terms and Concepts

- **Blinding** occurs when the evaluators of a response do not know which treatment was given to which unit.
- **Control**. First, an experiment is controlled because we assign treatments to experimental units. Second, a control treatment is a "standard" treatment that is used as a baseline or basis of comparison for the other treatments.
- **Placebo** is a null treatment that is used when the act of applying a treatment— any treatment—has an effect.
- **Factors** combine to form treatments.
- **Confounding** occurs when the effect of one factor or treatment cannot be distinguished from that of another factor or treatment

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Principles of Experimental Design

- A experiment is performed to decide
  - (1) whether the observed differences among the treatments included in the experiment are due only to change, and
  - (2) whether the size of these differences is of practical importance.
- Statistical inference reaches these decisions by comparing the variation in response among those experimental units exposed to the same treatment
- (experimental error) with that variation among experimental units exposed to different
- treatments (treatment effect).

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Terms and Concepts

- Thus, the three principles of experimental design are:
- **replication**, to provide an estimate of experimental error; •
- **randomization**, to ensure that this estimate is statistically valid; and
- **local control**, to reduce experimental error by making the experiment more efficient.

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Randomization

- The random assignment of experimental units to treatments results in the following outcomes.
  - It eliminates the systematic bias.
  - It is needed to obtain a representative sample from the population.
  - It helps in distributing the unknown variation due to confounded variables throughout the experiment and breaks the confounding influence.
- If the randomization process is such that every experimental unit has an equal chance of receiving each treatment, it is called a **complete randomization**

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Functions of Randomization

- To provide the random sample of observation.
- To have a valid estimate of experimental error.
- To remove the bias of assigning treatments continually to favorable experimental units.
- To protect against the effects of factors that cannot be controlled perfectly.

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Methods of Randomization

- Draw lots
- Randomization software " try "
- Table of random digits

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Replication:

- Any treatment is repeated a number of times to obtain a valid and more reliable estimate than which is possible with one observation only.
- Replication is an efficient way of increasing the precision of an experiment.
- If variance of x is σ^2 then variance of sample mean is $\bar{x}$ is $\frac{\sigma^2}{n}$. So as n increases, var $(\bar{x})$ decreases.

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Functions of replication:

- To provide for an estimate of experimental error which is used for tests of significance;
- To improve the precision of the experiment by reducing the standard error of the mean;
- To increase the scope of inference of the experiment; and
- To effect control of error variance.

Precision – the closeness to one another of a set of separated measurements of a quantity

Accuracy – closeness to the absolute or true value of the quantity measured

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Assignment 1:

The following are the factor determining replication in an experiment. Discuss. (20 marks)

- Uniformity of experimental units
- Experimental designs
- Degree of precision required
- Number of treatments
- Time allotment
- Cost and availability of funds or resources

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Local Control

- process of minimizing the experimental error
- It includes all practices or techniques used to minimize the experimental error which includes **balancing**, **blocking**, and **grouping** of experimental units

Techniques:

- Use an appropriate experimental design.
- Compare several treatments.
- Use appropriate experimental units; e.g. proper size, proper shape, etc.
- Proper handling of experimental units.
- Refinement of experimental units.

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