Lecture 21
Introduction to Design of Experiments

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Notes

Main Elements of An Experiment

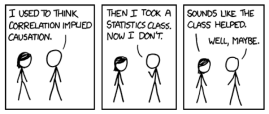
An experiment applies treatments to experimental units and measures responses.

- Want to learn about **treatments** (e.g., dose of drug; nano-tech coating for a fabric)
- **Responses** tell us how the treatment worked (patient get better; stain resistance)
- Experimenter assigns treatments to **experimental units** (e.g., a patient; a bolt of fabric)

Notes

Observational vs. Experimental Studies

- An observational study has the same triple of treatment, unit, and response, but one **observes** the assignment of treatments to units (e.g., human health studies on cigarette smoke and adverse health effects)
- What makes an experimental study special is **control**. The experimenter gets to control the assignment of treatments to the experimental units
- Experiments can make causal inference while observational studies find association



Source: Slide 5 at `http://users.stat.umn.edu/~gary/classes/5303/lectures/Introduction.pdf`

Notes

Why Designed Experiments?

- Design for direct comparison of treatments
- Design to reduce bias in comparisons
- Design to reduce and estimate the variability

Notes

Fundamental Principles: Replication, Randomization, and Blocking

- Replication: Each treatment is applied to a number of units representative of the population
- Randomization: Allocation of treatments to units, run order and measurement order need to be randomized
- Blocking: To block To divide the experimental units into groups (blocks) such that the units in each block are intended to be relatively similar

Notes

Experimental Unit

- Perhaps the most important concept in statistical design
- The experimental unit is the unit (subject, plant, pot, animal) which is randomly assigned to a treatment
- The experimental unit *defines the unit to be replicated to increase degrees of freedom*

Notes

Experimental Units vs Measurement Units

If a group of “units” must have the same treatment, they are likely measurement units (MUs) rather than experimental units (EUs)

Examples

- Fertilizer is applied to the pots. Plants are not the EUs
- Different food placed in tanks containing the fish. Fish are not the EUs

Notes

A Brief History of Experimental Design

- 1. Agricultural Era:
  - Treatment Comparisons and ANOVA
  - R.A. Fisher, Rothamsted Agricultural Experimental Station (1930, England)
  - Introduced statistical experimental design and data analysis
  - Summarized the fundamental principles: replication, randomization, and blocking
  - An influential book, The Design of Experiments

Notes

A Brief History of Experimental Design Cont’d

- 2. Industrial Era:
  - Process modeling and optimization
  - George Box and coworkers in chemical industries and other processing industries
  - Empirical modeling, response surface methodologies, central composite design
- 3. Quality Era:
  - Quality improvement and variation reduction
  - Taguchi and robust parameter design

Notes

A Brief History of Experimental Design Cont'd

- 4. Current State of Experimental Design:
  - Popular outside statistics, and an indispensable tool in many scientific/engineering endeavors
  - New challenges:
    - Large and complex experiments, e.g., screening design in pharmaceutical industry, experimental design in biotechnology
    - **Computer experiments:** efficient ways to model complex systems based on computer simulation
    - ...

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