STA 674

Regression Analysis And Design Of Experiments

Basic Principles of Experimental Design – Lecture 2

STA 674, RA Design Of Experiments:
Introduction to Comparative Experiments

- Last time, we started our discussion of design of experiments by introducing some of the terminology and looking at that in one context.
- This time, we focus on two key elements of DOE: replication and randomization.

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Exercise

- Suppose that we were to conduct an experiment as a class to answer the question:

  "Is it better to walk or to run in the rain?"

- We decide to ignore the effect of wind or other variables and assume that a suitable rain simulator has already been constructed.
- Our plan must be sufficiently detailed that someone could run the experiment without any additional input. In particular, if we provided a list of the students in the class, and our plan must tell what each student is going to do and when.

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1. **What is/are the question/s you want to answer?** On average, less wet walking or running?
2. **What variables will you modify?** 1. speed of pedestrian (walking or running). Pedestrian themselves are not really a variable...but can change them to address replication of study
3. **What values of the variables will you test?** speed - 3 mph walking, 6 mph running
4. **What are your subjects?** pedestrian(s)
5. **How many subjects will you need?** 5 each doing both speeds 2x
6. **How will you assign these variables to the subjects?** subjects do both, but at random permutations (i.e., run, run, walk, walk; run, walk, run, walk, etc.)
7. **What response will you measure?** weight before, weight after test...total weight of water

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Principles of Experimental Design

1. **Replication**:

Every treatment should be applied to multiple experimental units.

1. demonstrates reproducibility,
2. insures against aberrant results,
3. increases precision, and
4. allows us to estimate the error in an experiment.

(i.e., only one result...there's no error or variation...can't estimate variability/confidence intervals, etc.

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2. **Randomization**:

Treatments should be assigned randomly to the experimental units (within the constraints of the design*).

1. determines the sampling distribution,
2. required for valid inferences, and
3. protects against unknown factors that might affect the response.

* For example, assigning a treatment to each experimental unit at random would allow the possibility that all experimental units receive the same treatment. This would not be good!

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3. **Blocking**:

When possible, groups like experimental units and compare treatments within each group.

1. reduces the experimental error,
2. produces more precise inference, and
3. increases the power of tests.

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Balanced Design and Unbalanced Designs

Balanced Design

- Every treatment is replicated the same number of times.

Unbalanced Design

- Treatments are replicated different numbers of times.

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Completely Randomized Design

- A **completely randomized design** is a balanced design in which every experimental unit has the same chance of receiving each treatment. (I.e., treatments are assigned completely at random.)
- Note: this requires that the number of experimental units is a multiple of the number of treatments

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Randomization for Balanced Designs

Two Treatments, n experimental units

- Flip a coin to decide on treatment for each unit.
- Stop when one treatment has $^{n}/_{2}$ units.
- Assign remaining units to open treatment.

General case – t treatments, n experimental units

- Randomize treatments to each unit – how?
- Stop assigning to a particular treatment when it has $^{n}/_{t}$ units.

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Example: Testing a Cancer Drug

- Suppose that a new cancer drug is to be tested in a double-blind clinical trial. Ten patients are recruited from each of 6 hospitals to create a cohort (study group) of 60 patients. Each patient is to be randomized to the new cancer drug or the current therapy. At the end of the study the time to recurrence for each patient will be compared. What are the

  comparative experiment or observational study — research hypotheses: recurrence of cancer is longer with new drug treatment...so... average recurrence time is greater with new drug

  factors and treatments: 1 factor is drug, 2 treatments are new drug and current drug — experimental and observational units: both are the patient

- Which of the following would be an appropriate method of randomization for a ***completely randomized design***:

  1. toss a coin to choose current treatment or new drug for each patient. Not completely randomized because it doesn't specify when to stop flipping the coin...so could turn out unbalanced

  2. place 30 pieces of paper marked "new drug" and 30 marked "current treatment" in a hat and draw one for each patient.

  3. place 5 pieces of paper marked "new drug" in a hat and 5 marked "current treatment" in a hat and draw one for each patient, repeating for each hospital. Not completely randomized because each hospital receives same number of each treatment

  4. place 3 pieces of paper marked "new drug" and 3 marked "current treatment" in a hat and draw one for each hospital. Not completely randomized because all patients from one hospital receive same treatment