Research Methodology: Experimental Research

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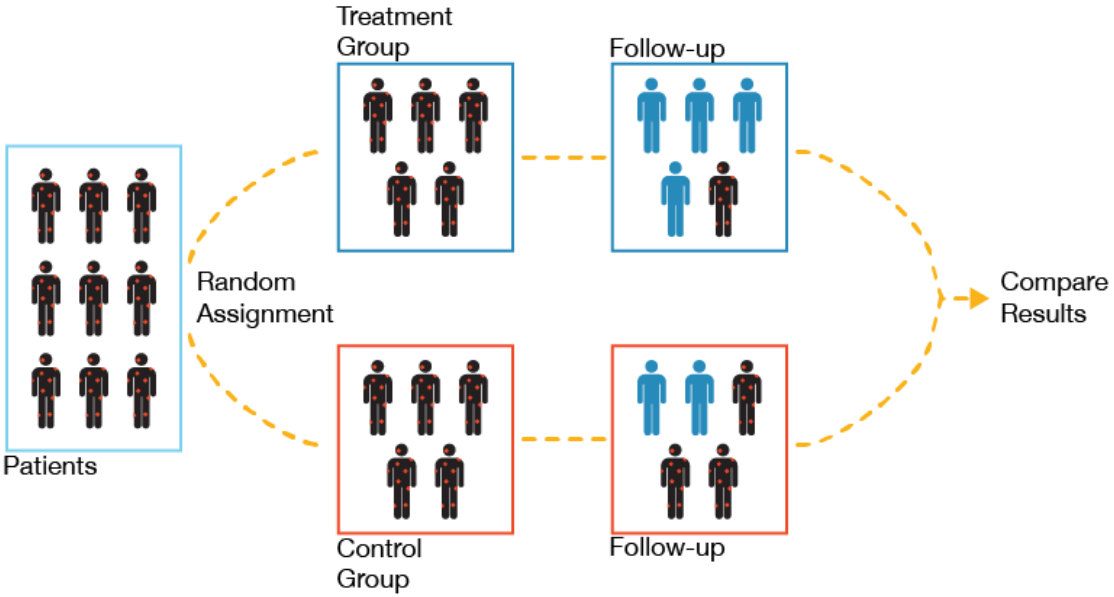
Introduction

- Used to establish cause and effect relationships convincingly.
- Considered as the **Gold Standard** in research designs.
- One of the most rigorous of all research designs.
- In this research, we not only observe, but we systematically *manipulate* the situation.
- This kind of research has clearly identifiable independent and dependent variables.
- **Independent Variable**: Variable which has possible effects on one of more other variables.
- **Dependent Variable**: Potentially influenced by an independent variable, i.e., its value *depends* to some degree on the value of the independent variable.
- One or more independent variables are manipulated by the researcher (as treatments), subjects are randomly assigned to different treatment levels (random assignment), and the results of the treatments on outcomes (dependent variables) are observed

Experimental Research in detail

- Best suited for explanatory research rather than (descriptive or exploratory) research.
- The goal is to establish cause-and-effect relationships.
- Can be conducted in laboratory or field settings.
- Laboratory experiments: high in internal validity, but low in external validity (generalizability).
- Field experiments : high in both internal and external validity.
- Such field experiments are relatively rare, because of the difficulties associated with manipulating treatments and controlling for extraneous effects in a field setting.
- Treatment and Control Groups: subjects are administered one or more experimental stimulus called a treatment (the treatment group) while other subjects are not given such a stimulus (the control group).

Schematic Diagram



Example: Treatment of Dementia Patients

- Test the effects of a new drug intended to treat dementia.
- Sample of dementia patients randomly divided into three groups: first group receiving high dosage, second group receiving low dosage and the third group placebo/sugar pill.
- Two experimental groups and one control group.
- After administering the drug for a period of time, if the condition of the experimental group subjects improved significantly more than the control group subjects, we can say that the drug is effective.
- Can also compare the conditions of the high and low dosage experimental groups to determine if the high dose is more effective than the low dose.

Treatment Manipulation

- Unique feature of experimental research designs.
- Separates it from other types of designs.
- Helps control the "cause" in the cause-and-effect relationships.
- Validity of the experiment depends on how well the treatment was manipulated.
- Must be checked using pretests and pilot tests prior to the experimental study.
- Pretest Measures: Measurements conducted before the treatment is administered.
- Posttest Measures: Measurements conducted after the treatment is administered.

Random selection and Assignment

- **Random Selection** : Process of randomly drawing a sample from a population or a sampling frame.
- **Random Assignment**: Randomly assigning subjects to treatment or control group.
- Random selection is related to sampling, and more closely related to external validity (generalizability) of the findings.
- Random assignment is related to design, and is more closely related to *internal validity* of the study.

Threats to Internal Validity

- Experimental studies are not immune to internal validity threats.
- Example: a study of the impact of a special remedial math tutoring program for improving the math abilities of high school students.
- **History Threat**: An unrelated event influences the outcome. Eg. students' post-remedial math score improvement may have been caused by their preparation for a math exam at their school, rather than the remedial math program
- **Maturation Threat**: The outcomes of the study vary as a natural result of time. Eg. a general improvement in their intellectual ability to understand complex concepts.
- **Testing Threat**: The pre-test influences the outcomes of the post-test. Eg. if same test is administered pre-test and post-test.
- **Instrumental Threat**: Different measures are used in pre-test and post-test phases. Eg. posttest having a higher or lower degree of difficulty than the pretest.
- **Mortality Threat**: subjects may be dropping out of the study at differential rates between the treatment and control groups due to a systematic reason. Eg. dropouts were mostly students who scored low on the pretest.
- **Regression Threat**:There is a statistical tendency for people who score extremely low or high on a test to score closer to the middle the next time. This problem tends to be more prevalent in non-random samples and when the two measures are imperfectly correlated.

Regression to the Mean / Regression Threat

- First worked out by Sir Francis Galton.
- Rule: **in any series with complex phenomena that are dependent on many variables, where chance is involved, extreme outcomes tend to be followed by more moderate ones.**
- According to (Campbell, 1969): "Take any dependent measure that is repeatedly sampled, move along it as in a time dimension, and pick a point that is the highest (lowest) so far. On the average, the next point will be lower (higher), nearer the general trend."

Regression to the mean diagram

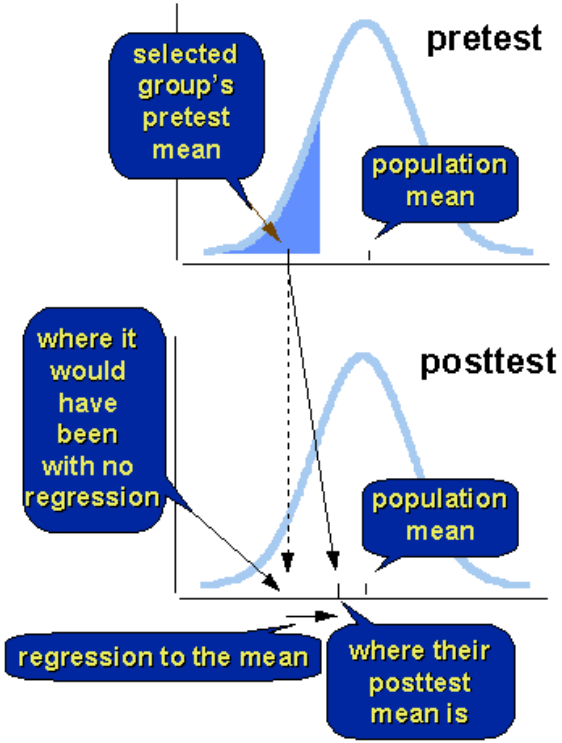


Figure 1: Source: Regression to the mean

Explanation of the diagram

- Sample consisted of exclusively the low pretest scorers.
- What would we predict the posttest to look like?
- First, let's assume that your program or treatment doesn't work at all (the "null" case). Our naive assumption would be that our sample would score just as badly on the posttest as they did on the pretest.
- But they don't!
- The bottom of the figure shows where the sample's posttest mean would have been without regression and where it actually is.
- In actuality, the sample's posttest mean wound up closer to the posttest population mean than their pretest mean was to the pretest population mean.
- The sample's mean appears to **regress toward the mean of the population** from pretest to posttest.
- **The more extreme the sample group, the greater the regression to the mean.**

Another Example

- Example One day at school, the children viewed the 20-minute cartoon (Control condition). Two days later, the Generalization Probe was conducted. Then, in a class the following week, the children viewed the 20-minute interactive video (Experimental condition). The plan was to administer a second Generalization Probe two days after that. However, at this point, the experimenter realized that she had insufficient funding to complete the study and would only be able to retest ten children. She selected the ten poorest performing children on the first Generalization Probe, the mean score of which was 0.1. Their mean score on the second Generalization Probe was 2.5. We conclude that the 20-minute interactive video improved the children's self-protection skills in a potential abduction situation.
- Non Example One day at school, the children viewed the 20-minute cartoon (Control condition). Two days later, the Generalization Probe was conducted. Then, in a class the following week, the children viewed the 20-minute interactive video (Experimental condition). The plan was to administer a second Generalization Probe two days later. However, at this point, the experimenter realized that she had insufficient funding to complete the study and would only be able to retest ten children. She wrote the name of each child on a separate slip of paper, put all the slips in a bowl, and the first ten names she pulled out were selected for the second Generalization Probe. Their mean score on the first Generalization Probe was 1.1 and their mean score on the second Generalization Probe was 2.5. We conclude that the 20-minute interactive video improved the children's self-protection skills in a potential abduction situation.

Analysis

- First example is regression to the mean. Sample selected consisted of lowest scores. According to the **principal of statistical regression**, these children will score higher on second probe.
- Second example: children selected for re-testing randomly. The pre-test mean score represents value closer to the population mean. More confidence that the improved scores were not the result of regression to the mean. Below are some more resources to understand the regression to the mean:
- Regression to the mean
- Regression Toward the Mean: An Introduction with Examples
- Regression to the mean

Experimental Research Continued

- Experimental research can be grouped into two broad categories:
  - true experimental designs.
  - quasi-experimental designs.

Two-Group Experimental Designs

- It is the simplest true experimental design involving one treatment group and one control group.
- The two basic true-group designs are the **pretest-posttest control group design** and **posttest-only control group design**.

Pretest-Posttest Control Group Design

- Pretest-Posttest Control Group Design: Subjects are randomly assigned to treatment and control group.
- Pre-test measurement for the dependent variable of interest in both groups.
- Treatment is group is given the treatment.
- Both groups (treatment and control) are measured again - Posttest measurement.

R	O_1	X	O_2	(Treatment group)
R	O_3		O_4	(Control group)

Figure 2: Pretest-posttest control group design

- E (Effect of the experimental treatment) = (O 2 – O 1) – (O 4 – O 3)
- Handles maturation, testing, and regression threats because it is expected to influence both the groups in a random manner.

Posttest-only Control Group Design

- A simpler version of the pretest-posttest design where pretest measurements are omitted.

R	X	O_1	(Treatment group)
R		O_2	(Control group)

Figure 3: Posttest control group design.

- E (Effect of experimental treatment) = (O 1 – O 2)
- Simple design than pretest-posttest control design in terms of internal validity.
- The design controls for maturation, testing, regression, selection, and pretest-posttest interaction, though the mortality threat may continue to exist.

Quasi-Experimental Designs

- The prefix *quasi* means resembling.
- Almost identical to true experimental designs, but lack one key ingredient: random assignment.
- Example: one entire class section or one organization is used as the treatment group, while another section of the same class or a different organization in the same industry is used as the control group.
- This lack of random assignment potentially results in groups that are non-equivalent.
- Possibility of selection bias.
- Are inferior to true experimental designs in **internal validity**.
- Possibility of confounding variables.
- Variety of selection related threats exist: selection-maturation threat, selection history threat, selection-regression threat, selection-instrumentation threat, selection-testing and selection-mortality threat.
- Given these selection threats, it is generally preferable to avoid quasi-experimental designs to the greatest extent possible.

Non-equivalent groups design (NEGD)

- quasi-equivalent version of pretest-posttest control group design.

N	O	X	O
N	O		O

Figure 4: Non-equivalent groups design

- the resulting groups are likely to be dissimilar in some ways.
- Example: a researcher wants to evaluate a new method of teaching fractions to third graders.
- Select a treatment group consisting of one class of third-grade students and a control group consisting of another class of third-grade students.
- Students are not randomly assigned to classes by the researcher, which means there could be important differences between them, hence this design is called the NEGD.
- Systematic differences in the assigning of students class to teachers.
- Other factors could be different teaching styles, differing class room environments might affect the achievement scores.
- Difference among classes cannot be solely attributed to the different in teaching methods.

NEGD continued..

- Steps can be taken to ensure that the 2 groups are similar.
- Select two classes at the same school.
- Such that the two classes have similar scores on a standardized math test.
- Teachers are of same gender of same age having similar teaching styles.
- This will enhance the internal validity of the study by eliminating the confounding variables in the study.
- In absence of true random assignment, possibility of confounding remains.

Perils of Experimental Research

- Much of the current experimental research is atheoretical.
- Without theories, the hypotheses being tested tend to be ad hoc, possibly illogical, and meaningless.
- Reliability and accuracy of measurement instruments used in experimental research, not comparable across studies.
- Most experimental studies have suspect internal validity.
- To design an adequate and appropriate task, researchers should use prevalidated tasks if available, conduct treatment manipulation checks to check for the adequacy of such tasks (by debriefing subjects after performing the assigned task), conduct pilot tests.

Next Lecture is on Qualitative Research Methods. Friday 4-5pm.

References

Campbell, D. (1969), 'Reforms as experiments.', *American Psychologist* (409-429).