Empirical Methods: Experimental Design

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The Experiment

"Refers to that portion of research in which variables are manipulated and their effects upon other variables observed"

Campbell & Stanley 1963

Purpose of the Experiment

Exploring cause - effect relationships

The design

- The design is a schema that models the experiment
- It sets the elements in an experiments
  - The variables,
  - the treatment that determines the cause
  - the sequence of activities to perform,
  - the resource to allocate to the experiment,
  - the individuals involved in the experiment
- It predicts the type of output

Types of Experimental Designs

- Pre-Experimental
- True Experimental
- Quasi-Experimental

For further details see Neutens, pp. 76-86

Design Definitions

- A group is a set of individuals, objects, entities, … on which an experiment is run
- A group on which the treatment is supplied is called experimental group a group without any treatment is called control group

Design Notation

- **X** an independent variable that is manipulated through the treatment (X potential "cause")
- **O** a specific observation (i.e. measurement of the effect)
- **R** subjects are randomly assigned to groups
- When X's and O's appear on the same line, this means that the apply to the same subject(s)
- **(X)** treatment not relevant
- **---** dashed lines between groups indicate no random assignment of subjects to groups

Design Issues

- Internal Validity Issues
  - The basic minimum without which any experiment is non interpretable
- External Validity
  - Asks the question of generalizability:
    - To what populations, settings, treatment variables, and measurement variables can this effect be generalized?
- Construct Validity
- Content Validity

From: Campbell & Stanley, 1963

Distinction between types of validity

- External Validity
- To whom and under what circumstances can the results be generalised?

- Internal Validity
- Is the experiment, in the particular case, responsible for the observed change(s)?

Threats To Internal Validity

- Depending on the design of an experiment, there may be explanations for changes other than the treatment

An example

- Some subjects develop a piece of software that controls a NASA shuttle
- A pre-test post-test experiment has been administrated
  - The subjects are tested on the quality of their production before and after the experiment
- A treatment X has been administrated; X="use of eXtreme Programming to develop the software"
- Suppose to observe an average gain of 9 points from pretest to posttest:
  - They improved the quality of the product of 9 points

Threat to internal validity: Maturation

- Another possibility is the internal threat called Maturation:
  - Perhaps, subjects matured during the period between the pretest and posttest: they became more adult and responsible
  - Increase may be due to maturation and not to treatment

Pre-Experimental Designs

- Poor internal validity
- Useful designs to detect the rival variables to internal validity

Types of Experimental Designs

- Pre-Experimental Designs
  - One-shot case study
  - One-group pretest-posttest
  - Static-group comparison

Pre-Experimental Designs

- If X then Y
  - If the program is given,
    then the outcome occurs
- 3 types

Problems encountered when using Pre-Experimental Designs

- One Shot Case Study
  - Nothing to compare result to
- One-Group Pretest-Posttest
  - No control group – no way to tell if extraneous variables are really causing a change
- Static Group Comparison
  - Since there was no random assignment of subjects, we cannot assume groups were equally heterogeneous from the beginning

One Shot Case Study

X O

One-Group Pretest-Posttest Design

O_1 X O_2

Static-Group Comparison Design

X O

O

True Experimental Designs

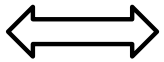
- Involve random assignment to treatments
- Strong in terms of their internal validity
- Three types

True Experimental Designs

- If X, then Y

and

- If not X, then not Y



- Also said the *if only if* design
- Example: If the treatment is given, then the outcome occurs and if the treatment is not given, then the outcome does not occur

True Experimental Designs

- True Experimental Designs
  - Posttest-only control group design
  - Pretest-Posttest control group design
  - Solomon four-group design

True Experimental Designs

Pretest-Posttest Control Group Design

R	O_1	X	O_2
R	O_3		O_4

Posttest-Only Control Group Design

R	X	O_1
R		O_2

Solomon Four-Group Design

R	O_1	X	O_2
R	O_3		O_4
R		X	O_5
R			O_6

Advantage / Disadvantages of pretest

- Can determine how much each group has gained
  - Not just whether they are different at the end of the experiment
- It can sensitise subjects to the experimental treatment
  - In effect, become part of the treatment
- Example. Experimental course
  - Subjects can gain an overview of what will be covered, in how much depth the material will be covered, etc.

Advantage of Solomon randomised four-group design

- Can compare the first two groups
  - Determine how much gain is made
- Can compare the last two groups
  - Determine whether the treatment is more effective than the control condition in the absence of a pretest (without pretest sensitisation)
  - Understand whether pretest is influencing the conclusions

Potential drawback of Solomon randomized four-group design

- Must have a reasonably large pool of subjects to begin with
  - So that when they are divided into four groups, each of the groups will have a sufficient number to yield reliable results
- Probably would be unwise to use the four-group design instead of a two-group design if you have a total pool of only 48 subjects

Quasi-experimental design

- It looks a bit like an experimental design but in general lacks the key ingredient -- random assignment.
- They give the experimental purists a queasy feeling
- With respect to internal validity, they often appear to be inferior to randomized experiments

Types of Experimental Design

- Quasi-experimental Designs
  - **Time series experiment**
  - **Non equivalent Control Group Design**
  - **Separate Sample Pretest-Posttest Design**
  - Separate Sample Pretest-Posttest Control Group Design
  - Multiple Time-Series design

Time Series Design

- Includes repeated measures on only one group before and after the treatment, represented by following diagram
- No control group and randomization

Time Series Design

O_1 O_2 O_3 O_4 X O_5 O_6 O_7 O_8

Non-equivalent Control Group Design

- This design is identical to the Pretest-Posttest Control Group design, with the exception of randomization
- Comparison groups are naturally-occurring but chosen to be as similar as possible in all experimentally-relevant aspects.

Non Equivalent Control Group Design

O_1 X O_2

O_3 O_4

Separate-samples pre test post test design

- Randomization of both samples
- One group pre test only and a (X) treatment not relevant
  - X is not relevant because no observation afterwards
  - Alone makes little sense
- and one group post test only and a treatment

Separate-samples pretest post-test Design

R O_1 (X)
R X O_4

Exercise

- Define an real case experiment that foresees each of the quasi experimental design