PLS 506
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Lecture Notes: Experimental & Quasi-Experimental Designs

- Vocabulary of Experiments
  - *Experiment*: a study in which an intervention (treatment) is deliberately introduced to observe its effects
  - *Randomized experiment*: an experiment in which units are assigned to receive a treatment or alternative condition by a random process such as a coin toss or random number generator
  - *Quasi-experiment*: an experiment in which units are not assigned to conditions randomly
  - *Natural experiment*: Not really an experiment because the cause usually cannot be manipulated. A study that contrast a naturally occurring event with a comparison condition
  - *Correlational study*: usually synonymous with nonexperimental or observational study where the study observes the size and direction of a relationship among variables.
- Experimental designs
  - The basic principle of a good design is the simple idea of doing only one thing at a time – allow the independent variable to vary while controlling for the rest
  - For the results of an experiment to be as unequivocal as possible, the only plausible explanation for the changes in the dependent variable must be the manipulated independent variable
- Design elements used in constructing experiment and quasi-experiments
  - Assignment to treatment and control groups
    - Random assignment
    - Cutoff- based assignment
    - Other nonrandom assignment (altering assignments)
    - Matching and stratifying
    - Masking (blinding the investigator to the assignment) – blind/double-blind
  - Measurement
    - Posttest observations
      - Single post tests
      - Nonequivalent dependent variables
      - Multiple substantive posttests
    - Pretest observations
      - Single pretest
      - Retrospective pretest
      - Proxy pretest
      - Repeated pretests over time
      - Pretests on independent samples
    - Moderator variable with predicted interaction
    - Measuring threats to validity

- Comparison groups (depends on what you want to compare or control for)
  - Single nonequivalent groups
  - Multiple nonequivalent groups
  - Cohorts
  - Internal versus external controls
  - Constructed contrasts
    - Regression extrapolation contrasts
    - Normed contrasts
    - Secondary data contrasts
- Treatment
  - Switching replications
  - Reversed treatments
  - Removed treatments
  - Repeated treatments

- Randomized assignments
  - Random assignment is achieved by any procedure that assigns units to conditions based only on chance (e.g., coin toss – heads control, tails treatment)
  - Conditions most conducive to using random assignment
    - When demand outstrips supply randomization can be a credible approach to allocating a service or treatment fairly
    - When an innovation cannot be delivered to all units at once you can implement the innovation in some places and not others on a random assignment basis when everyone cannot be exposed to the treatment at once.
    - When experimental units can be temporally isolated. For example, if 24 groups of people received 2-week training programs you could randomly assign the groups if there was no interaction among the people in the groups
    - When the experimental units are spatially separated or inter-unit communication is low.
    - When change is mandated and solutions are acknowledged to be unknown.
    - When a tie can be broken or ambiguity about need can be resolved. If need for a treatment is ambiguous, then randomly assigning individuals may be justifiable.
    - When some persons express no preference among alternatives
    - When you can create your own organization to manage the randomization process or create an organizational culture that accepts randomization
    - When you have control over experimental units or funders insist upon it. It is more problematic when you are a guest in an organization
    - When lotteries are expected as a means of allocating people to services (e.g., magnet schools)
  - Random assignment is not random sampling.
    - Two procedures share the idea of randomness but the purposes are quite different
    - Random samples are drawn from a population and ensure that answers from the sample approximate what we would get if we asked the entire population
    - Random assignment makes sure the samples randomly similar to each other whereas random sampling makes a sample similar to a population

- Why randomized assignment helps facilitate causal inference
  - It ensures alternative causes are not confounded with a unit's treatment condition
  - It reduces the plausibility of threats to validity by distributing them randomly over conditions
  - It equates groups on the expected value of all variables at pretest, measured or not
  - It allows the researcher to know and model the selection process correctly
  - It allows computation of a valid estimate of error variance
- Internal validity is still an issue with randomized assignments
  - The only threat to internal validity that randomization prevents is selection bias
  - It may help reduce the likelihood that the other threats are confounded with the treatment but it doesn't eliminate the threats.
- Varieties of random assignment
  - *Simple random assignment*: any procedures for assigning units to conditions by chance with a nonzero possibility.
    - Typically done with random number generators.
  - *Restricted random assignment to force equal sample sizes*: used with small sample sizes when randomization will result in unequally sized groups.
    - Preferred technique is to assign using matches or strata (see below)
  - *Restricted random assignment to force unequal sample sizes*: can be done to cope with practical limitations on how many receive a treatment or ethical objections to denying treatments
  - *Batch randomization*: small groups that have more units than the experimental conditions but not the whole sample is available to be randomized to conditions.
    - Might apply treatments to different batches of patients and then test for differences in batches later.
  - *Trickle process randomization*: Units trickle in slowly and assignment must be made from batches that are smaller than the number of experimental conditions.
    - You have to be sure that desired proportions are assigned to conditions over time.
  - *Adaptive randomization strategies*: methods for correcting imbalances in the desired proportions assigned to conditions by changing the proportions over time.
    - Can be unbiased if unit characteristics remain stable or analytic adjustments may be required.
  - *Random assignment from matches or strata*: placing units into groups and then assigning separately for each group.
    - In matching, groups contain as many units as conditions.
    - In stratifying, groups contain more units than conditions.
    - Always helps to control proportion assigned to conditions.
  - *Haphazard assignment*: A procedure that is not formally random but has no obvious bias.
    - Examples might be selecting based on odd or even social security numbers.
    - Some approximate randomized assignment quite well and may be a good choice if randomized assignments are not possible or feasible.
    - Better than self-selection but they can still have a bias or result in unequal sample sizes.
    - If you can use this technique you usually can use a randomized procedure.

- Lessons about randomized assignment
  - Plan in advance how to explain the nature and purpose of randomization to those who will be affected and how you will respond to arguments about why randomization should or should not be done and how to provide incentives for doing randomization
  - Pilot test the randomization procedures to discover problems that can be remedied with further planning
  - Develop clear procedures for implementing, controlling, and monitoring the randomization process throughout the entire experiment
  - Have meetings to negotiate the randomization procedures with those who will be affected by them
  - Develop fallback options that can be used to bolster estimates of program effects in the event that randomization fails
  - Take advantage of naturally occurring opportunities that facilitate the conduct of randomization
  - Carefully examine the match between the proposed design and those factors that make randomization more likely to be successful in the particular context of the experiment
- Ethical and legal issues with experiments
  - Is it ethical to experiment on human beings
    - Many professions have ethical codes
    - Informed consent of participants
    - Institutional review boards
  - Is it ethical to withhold a potentially effective treatment from a control or comparison group of participants
    - Is it ethical to apply a treatment with unknown effects?
    - Maybe being in the treatment group turns out to be a bad thing because it is undesirable?
    - Maybe resources make it impossible to treat everyone?
    - Maybe there are alternative treatments with equal desirability
  - Should participants be assigned randomly rather than based on merit or need
    - If the treatment is known to be effective, it is hard to see how it is ethical to withhold it
    - Randomization might be fair if demand exceeds supply because it prevents some other biased form of selecting participants
    - May not know if treatment works or it is the only way to find out if it works
  - When should experiments be discontinued for ethical reasons
    - Sometimes experiments are stopped when it becomes clear they are not working or having unintended consequences
    - Who makes these decisions? The researcher of some safety and monitoring board?
  - Legal problems with experiments
    - Confidentiality of some information
    - Violations of due process or challenges to studies on fairness grounds

- Partial remedies to ethical problems with random assignment
  - Use a regression discontinuity design to assign based on need or merit rather than randomly
  - Use a safety valve mechanism for treating the most needy participants
  - Divide participants into strata by need, assigning proportionately more of the most needy to the treatment
  - Assign proportionately more participants to the treatment in highest demand
  - Use a dose-response design (all receive a dose from lower to higher)
  - Use an adaptive design to increase the proportion of assignment over time to the most successful condition
  - Use informed consent procedures to ensure that participants are willing to be assigned to all conditions
  - Use public lotteries for assignment to increase perceived fairness
- Options when withholding treatment is problematic
  - Use dose-response designs
  - Offering all participants an intervention prior to randomization so that everyone gets something.
  - Using a "treatment-on-demand" control and then dropping from the control group if they exceed some threshold of treatment

- Quasi-experimental designs
  - A causal inference must still meet the basic requirements for all causal relationships
    - Cause precedes effect (quasi-experimental design ensures this condition0
    - Cause covaries with effect (accomplished with statistical techniques)
    - Alternative explanations are implausible
  - Rely on other principles to show that alternative explanations are implausible
    - Identify and study plausible threats to internal validity
    - Primacy of control by design: by adding design elements (pretests, control groups, etc.) to prevent confounding of a threat to validity or provide evidence related to the plausibility of the threat
    - Coherent pattern matching. The more complicated the pattern that is successfully predicted, the less likely that alternative explanations could generate the same pattern so the more likely the treatment had a real effect.
- Case control designs
  - Can be used when it is unethical or not feasible to experiment
  - It is widely used in epidemiology
  - One group consists of cases that have the outcome of interest. The other group consists of controls who do not have the outcome
    - Smoke-free or smokers, married or divorced, dead or alive, improved or not improved
    - Outcomes are usually dichotomous
    - Retrospective data is then used to see if the cases experienced the hypothesized cause more often than the controls
    - Useful in many situations
      - Excellent technique for generating hypotheses about causal connections
      - More feasible in cases when the outcome is rare or takes years to develop
      - They are often cheaper and logistically easier to conduct

        - May decrease needless risk to participants
        - Allow the examination of multiple causes of a condition
    - There are numerous threats to validity associated with
        - Reading up on the field and what gets published
        - Specifying and selecting the study samples
        - Executing the experimental exposure
        - Measuring exposure and outcomes
        - Analyzing the data
        - Interpreting the analysis
- Other variations on quasi-experimental designs
    - Regression discontinuity designs
        - Basic design assigns participants to treatment or control based on whether they fall above or below a cutoff score
        - Assignment variable may be any variable measured before the treatment, including a pretest on the outcome variable
    - Time series analysis
        - Basic design requires one treatment group with many observations before and after a treatment