Lecture Notes

# Chapter 12: Experimental Research: Weak and Strong Designs

## Learning Objectives

* 1. Explain how experiments produce evidence of causality.
  2. Describe the different ways an independent variable can be manipulated.
  3. Explain the importance of control in experimental research and how control is achieved.
  4. Explain the different ways of controlling the influence of potentially confounding variables.
  5. Explain why some experimental research designs are weak designs and others are strong designs.
  6. Compare and contrast factorial and repeated-measures designs.
  7. Explain the concept of an interaction effect.

## Chapter Summary

In this chapter, we talk about what experiments are, how to control for extraneous variables, and two sets of experimental designs (weak designs and strong designs).

## Annotated Chapter Outline

1. Introduction
   1. After discussing many of the things that must be considered when planning a research study, we now proceed to developing a research design that will help us answer our research questions.
   2. In this chapter we begin by discussing the different settings in which experimental research can be conducted. Next, manipulating the independent variable is discussed. This is followed by learning how to control confounding variables. The final section of the chapter differentiates strong and weak experimental research designs as well as describing several specific research designs.
2. The Experiment: experiments provide the strongest evidence of cause-and-effect relationships. With experimental research, often external validity is sacrificed for enhanced internal validity.
   1. **Experiment:** an environment in which the researcher attempts to “objectively” observe phenomena that are made to occur in a strictly controlled situation in which one or more variables are varied and the others are kept constant.
      1. This means that we observe a person’s response (phenomena) to a set of conditions that the experimenter presents.
      2. The observations are made in an environment in which all conditions other than the ones the researcher presents are kept constant or controlled.
      3. The conditions that the researcher presents are systematically varied (the independent variable) to see whether a person’s responses change (dependent variable) with the variation in these conditions.
      4. Discussion Question: Explain how experimental research studies demonstrate the impact of one variable on another.
3. Experimental Research Settings: experimental research studies are conducted in many different settings. Each setting had different attributes that are discussed in this section.
   1. **Field Experiment:** an experimental study that is conducted in a real-life setting.
      1. Excellent for determining of a manipulation works in a real-world setting.
      2. A disadvantage is that this type of research does not control for the impact of extraneous variables in the way a laboratory research setting does.
   2. **Laboratory Experiment:** a study conducted in a controlled environment where one or more variable are precisely manipulated and all or nearly all extraneous variables are controlled.
      1. The ability to control for the influence of extraneous variables is an advantage.
      2. Disadvantage is the experiment takes place in a controlled, artificial environment.
   3. **Internet Experiment:** an experimental study that is conducted over the Internet
      1. Advantages
         1. Ease of access to demographically and culturally diverse participant populations.
         2. Ability to bring the experiment to the participants rather than the participants to the experiment
         3. High statistical power attained through accessing large samples.
         4. Cost saving of laboratory space,
      2. Disadvantages: multiple submissions, lack of experimental control, self-selection, and dropouts from study.
   4. Discussion Question: Compare and contrast the different experimental research settings in terms of their strengths and weaknesses.
4. Independent Variable Manipulation: in experiments, the researcher manipulates an independent variable that is assumed to chase a change in the dependent variable. Thus, researchers must identify the independent variable and decide how to manipulate it to change the research question.
   1. Ways to manipulate an Independent Variable
      1. The research question identifies the independent variable but does not describe how it will be manipulated.
      2. At least three ways of manipulation of independent variable (see Figure 12.1)
         1. **Presence or absence technique:** manipulating the independent variable by presenting one group the treatment condition and withholding it from the other group. This is often what we do when we have a control group.
         2. **Amount technique:** manipulating the independent variable by giving the various comparison groups different amounts of the independent variable.
         3. **Type technique:** manipulation the independent variable by varying the type of condition presented to the different comparison groups.
      3. Discussion Question: Compare and contrast the three ways of manipulating an independent variable. Also think of examples of research that use each of the three ways of manipulating the independent variable.
5. Control of Confounding Variables: extraneous variables that threaten internal (causal) validity so researchers should work to control these variables.
   1. **Experimental control:** eliminating and differential influence of extraneous variables.
      1. Most extraneous variables(e.g., intelligence, motivation, age) cannot be eliminated so they are controlled through the elimination of and **differential influence** (the influence of an extraneous variable that is different for the various comparison groups) that the extraneous variable may have.
         1. The researcher would need to **equate the groups** (experimenter’s goal of constructing comparison groups that are similar on all confounding extraneous variables and different only on the independent variable).
      2. The researcher’s goal is to equate the groups on all extraneous variables so that differences in the dependent variable can be attributed to independent variable not the extraneous variables.
   2. **Random Assignment:** a procedure that makes assignments to conditions on the basis of chance and in this way maximizes the probability that comparison group will be equated on all extraneous variables.
      1. The most important technique used to control for confounding variables because it has the ability to control for both known and unknown confounding extraneous variables. Because of this characteristic, you should randomly assign whenever and wherever possible.
         1. Random assignment is different from random selection.
         2. The purpose of *random selection* is to generate a sample that represents a larger population.
         3. The purpose of *random assignment* is to take a sample (usually a convenience sample) and use the process of randomization to divide it into two or more groups that represent each other. That is, you use random assignment to create probabilistically “equivalent” groups.
         4. Note that random selection (randomly selecting a sample from a population) helps ensure external validity, and random assignment (randomly dividing a set of people into multiple groups) helps ensure internal validity.
         5. Because the primary goal is experimental research is to establish firm evidence of cause and effect, random assignment is more important than random selection in experimental research. If that is counterintuitive to students, then please reread it as many times as is necessary, so they can commit it to memory.
      2. Random assignment makes the groups similar on all variables at the start of the experiment.
      3. Random assignment is the mark of an excellent experimental design.
      4. See Figure 12. 2.
      5. Discussion Question: How do random selection and random assignment differ. Remember to discuss the purposes of each technique.
   3. **Matching:** equating comparison groups on one or more variables that are correlated with the dependent variable.
      1. Individuals can be matched but so can groups (selecting groups that have similar average scores and distribution of scores on a specific variable).
      2. See Figure 12.3.
      3. Can be used to change a weak experimental design into a **quasi-experimental design** (a design that is stronger than the weak designs but not as strong as the strong or randomized designs).
      4. The key limitation of matching (individual or group) is that the groups are only equated on the matching variables identified by the researcher.
      5. Discussion Question: explain why random assignment a better method of experimental control than matching.
   4. Holding the Extraneous Variable Constant
      1. The extraneous variable is held constant across comparison groups by limiting it to a single value or type.
      2. This improves internal validity of the study but it also reduces the external validity of the study.
      3. See Figure 12.4.
      4. Discussion Question: explain how holding an extraneous variable constant limits the external validity of a study.
   5. Building the Extraneous Variable Into the Research Design
      1. This technique takes a confounding extraneous variable and makes it an additional independent variable in your research study.
      2. This technique is especially useful when you want to study any effect that the potentially confounding extraneous variable might have (i.e., you will be able to study the effect of your original independent variable as well as the additional variable(s) that you built into your design).
      3. See Figure 12.5.
      4. Discussion Question: Discuss how including the extraneous variable into the research design is a better solution than holding the extraneous variable constant.
   6. **Analysis of Covariance:** a control method that can be used to statistically equate groups that differ on pretest or some other variable; also called ANCOVA.
      1. Analysis of covariance statistically adjusts the posttest scores for the differences that exist in the pretest variables and thus statistically equates the comparison groups.
      2. When selecting variables to control for, note that the only relevant extraneous variables are those that also affect participants’ responses to the dependent variable.
      3. As an example, in a learning research study you might want to control for intelligence because if there are more brighter students in one of two comparison groups (and these students are expected to learn faster), then the difference between the groups might be because the groups differ on IQ rather than the treatment variable; therefore, you would want to control for intelligence.
      4. Discussion question: Explain, in your own words, how ANCOVA equates groups.
   7. **Counterbalancing:** administering all experimental conditions to all participants but in different orders.
      1. Only relevant for a design in which the participants receive more than one treatment condition (e.g., such as the *repeated measures design* that is discussed later in the chapter)
      2. **Sequencing effects:** biasing effects that can occur when each participant must participate in each experimental treatment condition.
      3. **Order effects:** a sequencing effect that occurs due to the order in which the treatments are administered. 
         1. For example, as people complete their participation in their first treatment condition, they will become more familiar with the setting and testing process. When these people participate, later, in their second treatment condition, they may perform better simply because are now familiar with the setting and testing that they acquired earlier. This is how the order can have an effect on the outcome. Order effects that need to be controlled.
      4. **Carryover effect:** a sequencing effect that occurs when performance in one treatment condition is influenced by participation in a prior treatment condition.
         1. That is, participants’ performances in a later treatment are different because of the treatment that occurred prior to it. When this occurs, the responses in subsequent treatment conditions are a function of the present treatment condition as well as any lingering effect of the prior treatment condition. Learning from the earlier treatment might carry over to later treatments. Physical conditions caused by the earlier treatment might also carry over if the time elapsing between the treatments is not long enough for the earlier effect to dissipate.
      5. Counterbalancing is a control technique that can be used to control for order effects and carryover effects.
         1. You counterbalance by administering each experimental treatment condition to all groups of participants, but you do it in different orders for different groups of people.
         2. For example, if you just had two groups making up your independent variable you could counterbalance by dividing you sample into two groups and giving this order to the first group (Treatment 1 followed by Treatment 2) and giving this order to the second group (Treatment 2 followed by Treatment 1).
      6. Discussion Question: Compare and contrast order and carryover effects. Explain how counterbalancing controls for these effects.
6. Experimental Research Designs: Research designs can be weak or strong depending upon the extent to which they control for the influence of confounding variables.
   1. **Research Design:** the outline, plan, or strategy that is used to answer a research question.
   2. Weak Experimental Research Designs: These designs do not control for the influence of many potentially confounding extraneous variables. Figure 12. 7 summary of threats to internal validity of weak experimental designs.
      1. **One-Group Posttest-Only Design:** administering a posttest to a single group of participants after they have been given an experimental treatment condition. See Figure 12.8.
         1. The lack of pretesting limits conclusions that can be made about posttest data and if the treatment produced an effect.
         2. You do not know whether a confounding extraneous variable affected participants’ responses on the dependent variable.
         3. The design is improved by adding a pretest.
      2. **One-Group Pretest-Posttest Design**: administering a posttest to a single group of participants after they have been pretested and given an experimental treatment condition. See Figure 12.9.
         1. This is a better design than the one-group posttest-only design because it includes a pretest that indicates how the participants did prior to administration of the treatment condition.
         2. In this design, observed score changes from pretest to posttest cannot automatically be interpreted as an effect produced by the independent variable.
         3. Does provide evidence that there was a change between pretesting and posttesting.
         4. It does not control for potentially confounding extraneous variables such as history, maturation, testing, instrumentation, and regression artifacts, so it is still difficult to identify the effect of the treatment condition.
      3. **Posttest-Only Design With Nonequivalent Groups:** comparing posttest performance of a group of participants who have been given an experimental treatment condition with that of a group that has not been given the experimental treatment condition. See Figure 12.10.
         1. Two groups are NOT equated on variables other than the independent variable that could have an impact on posttesting.
         2. The addition of a pretest, matching, and/or random assignment could be used to provide evidence of equating the comparison groups.
      4. Discussion Question: For each weak experimental research design, describe the threats to validity that are present and how they can be addressed.
   3. Strong Experimental Research Designs: the influence of confounding extraneous variables is controlled. Table 12.2 presents a summary of the threats to internal validity for strong experimental designs.
      1. Strong experimental research designs control for confounding extraneous variables by including a control and experimental group and random assignment to groups.
         1. **Experimental group:** The group that receives the experimental treatment condition.
         2. **Control group:** The group that does not receive the experimental treatment condition. It is a comparison and a control for rival hypotheses.
         3. **RCT:** A popular term for experimental designs with random assignment of participants to experimental and control groups and, if possible, use of double-blind procedures.
         4. **Double-blind procedures:** design in which neither the researcher nor the participant knows the specific condition (experimental or control) that the participant is in.
         5. **Single-blind procedure:** design in which the participant does not know the specific condition he or she is in.
      2. Pretest–Posttest Control-Group Design: A research design that administers a posttest to two randomly assigned groups of participants after both have been pretested and one of the groups has been administered the experimental treatment condition. See Figure 12. 11.
         1. This is an excellent research design because it includes a control or comparison group and has random assignment.
         2. This design controls for all of the standard threats to internal validity. Differential attrition may or may not be a problem depending on what happens during the conduct of the experiment.
         3. Note that while this design is often presented as a two-group design, it can be expanded to include a control group and as many experimental groups as are needed to test your research question. See Figures 12.12.
      3. **Posttest-Only Control-Group Design:** Research design in which a posttest is administered to two randomly assigned groups of participants after one group has been administered the experimental treatment condition. See Figures 12.13 and 12.14.
         1. This is an excellent research design because it includes a control or comparison group and has random assignment.
         2. Just like the previous design, it controls for all of the standard threats to internal validity. Differential attrition may or may not be a problem depending on what happens during the conduct of the experiment.
         3. This design does not include a pretest of the dependent variable, but this does not detract from its internal validity because it includes the control group and random assignment which means that the experimental and control groups are equated at the outset of the experiment.
      4. Discussion Question: Discuss how these two strong experimental designs control for threats to internal validity.
   4. **Factorial Designs:** A design in which two or more independent variables, at least one of which is manipulated, are simultaneously studied to determine their independent and interactive effects on the dependent variable. Strong experimental design. See Figure 12.15.
      1. Allow us to investigate simultaneously several independent variables and the interaction among those independent variables.
         1. **Cell:** a combination of two or more independent variables in a factorial design.
         2. **Main effect:** the effect of one independent variable on the dependent variable. There can be as many main effects as there are independent variables.
         3. **Interaction effect:** the effect of one independent variable on the dependent variable depends on the level of another variable.
      2. Research participants are randomly assigned to as many groups are there are cells of the factorial design if both of the independent variables can be manipulated.
      3. The research participants are administered the combination of independent variables that correspond to the cell to which they have been assigned and then they respond to the dependent variable.
      4. Number of participants need equals the number needed in one cell or experimental condition times the number of experimental conditions or cells.
      5. The data collected from this research give information on the effect of each independent variable separately and the interaction between the independent variables. To understand the data collected, they are often tabulated and graphed. Examples are given in Figures 12.16A, 12.16B, 12.16C, 12.16D, and 12.16E.
         1. **Marginal mean:** the mean of scores in the cells of a column or a row of a table representing factorial design outcomes. See Figure 12.16A.
         2. **Disordinal interaction effect:** an interaction effect represented graphically by crossed lines on a graph plotting the effect. See figure 12.16D.
         3. **Ordinal interaction effect:** an interaction effect represented graphically by nonparallel lines plotting the effect that do not cross. See Figure 12.16E.
      6. Discussion Question: Discuss what is meant by a factorial design, main effect, interaction effect, disordinal interaction effect, and ordinal interaction effect.
   5. **Repeated-Measures Designs:** A design in which all participants participate in all experimental conditions, all participants are repeatedly measured. See Figure 12.17.
      1. Within-subjects independent variable: an independent variable of which all participants receive all levels.
      2. Between-subjects independent variable: an independent variable of which each participant receives only one level.
      3. Require fewer participants than other strong designs based on the fact that all participants participate in all experimental conditions.
      4. No worry about participants in different groups being equated because the same participants participate in all experimental conditions.
      5. If counterbalancing is used with this design, then all of the standard threats to internal validity are controlled for. Differential attrition may or may not be a problem depending on what happens during the conduct of the experiment. See Figure 12.18.
      6. Discussion Question: Discuss the repeated measures designs in terms of the number of participants needed, equating groups in these designs, and the need for counterbalancing.
   6. Factorial Designs Based on a Mixed Model: A factorial design in which different participants are randomly assigned to the different levels of one independent variable but all participants take all levels of another independent variable. See Figure 12.19.
      1. Can include as many independent variables as are considered necessary.
      2. All of the standard threats to internal validity are controlled for with this design if counterbalancing is used for the repeated measures independent variable. Differential attrition may or may not be a problem depending on what happens during the conduct of the experiment.
      3. Discussion Question: Describe the strengths of factorial designs based on a mixed model.