UNIT 5: LECTURE 1

Between-Subject Research Design and the Independent-Measures t-test

This Unit introduces you to research **design**, which is different from a hypothesis test. Research design refers to **HOW** researchers "set up" their studies. We will focus on 2 research designs: Between-Subject Designs and Within-Subjects Design. The research design that a researcher chooses will guide his or her choice of hypothesis tests. This lecture (Unit 5: Lecture 1) focuses on the between-subject two-group design and its corresponding hypothesis test: the independent measures t-test. Unit 5: Lecture 2 focuses on the within-subject design and its corresponding hypothesis test: the dependent measures t-test.

Read the textbook for background information. The textbook discusses, at length, the mathematical formula calculations for both the independent-measures t-test (Chapter 10), and the dependent-measures t-test (Chapter 11). While you should understand these formulas, it is more important to remember the overall hypothesis testing formula covered in the last unit and referred to in this lecture. There is no need to memorize specific formulas.

Overall, in this unit, you should aim to be able to (1) understand the research designs (2) choose the appropriate hypothesis test as a function of the research design, (3) run the appropriate hypothesis test on SPSS, and (4) ***interpret*** and (5) write up the SPSS results.

Between-Subject Research Design and the Independent-Measures t-test

As you may recall from previous lectures, researchers are interested in studying populations, but populations are often too big to study. Therefore, instead of studying the entire population, researchers select a sample from the population and study the sample. As you may also recall, it is the set of **inferential statistics** (e.g. hypothesis tests) that allow researchers to study samples and infer the sample results back to the population.

Further, you may recall that the Z-test compared a population mean (μ) to a sample mean (M). You may also recall that if you KNOW the population parameter (σ), then you are able to select a sample from the population, provide the sample with the independent variable (IV), collect data, and conduct a Z-test to compute the difference between the sample (M) and the population mean (μ), and then compare that difference to the difference expected "just by chance" (ERROR). This comparison will provide a test statistic (the mathematical answer) with a certain probability of occurrence, which will allow you to make a decision about the null hypothesis (reject or fail to reject the null hypothesis) and conclude whether or not the data support the researcher's hypothesis.

However, when the researcher does NOT KNOW the population parameter, (μ and σ), then the researcher does not have a population mean to which the researcher can compare his or her sample mean to see whether or not there is a significant difference between the two. Therefore, the researcher needs to “come up with” his or her own comparison; that is, a group that the researcher can compare the group which received the independent variable (IV).

Let us start by looking at the Between-Subject Research Design:

Population
↓
Random Sample
↓
(Random assignment)

Control group	Experimental group
↓	↓
Placebo	IV
(Measure DV)	(Measure DV)
3 5 6 7	3 4 2 1
4 7 6 6	8 5 5 3
M	M

Let’s begin by getting clear on what each of the terms in the above design mean

First, recall that a **population** is the **entire** group that the researcher wishes to study. However, rather than studying entire populations, researchers select samples. Ideally, the researcher would select a **random sample.**

The **definition** of a random sample is that everyone in the population **has an equal chance to be selected for the sample.** Why do you think that is important?

The answer is based on the important fact that researchers want to study populations, but cannot study the population directly; therefore, again, they study samples. BUT, the point of studying samples is to be able to **generalize (infer)** the results of the study (based on the sample) back to the population of interest. Therefore, random sampling is important because it allows the researcher **to assume** that the sample **represents** (looks like the population). This **assumption** is what allows the researcher to be able to “**generalize**” the results of a study conducted on a sample back to the population: to say that what was true of the sample findings is also true of the population.

Once the researcher has selected a random sample for the study, the next step is to **randomly assign** the sample to a minimum of two groups. A 2-group design is as many groups as we will cover in this unit. **Random assignment** is a cornerstone of experimental design for reasons that I hope will soon become clear.

Remember that if the researcher knew the population parameters (μ and σ), then a single sample design and running a Z-test would be appropriate; that is, the researcher could just treat (provide the IV) to the sample and compare the sample data (M) to the known population mean (μ). But, when the population parameters are not known, there is NO COMPARISON for the sample mean; therefore, the researcher has to come up with HIS OR HER OWN COMPARISON. As you may have guessed, the **comparison** is the **control group**.

The researcher has to **randomly assign** the participants (in the sample) to either the control or the experimental group. The **definition** of **random assignment** is that everyone in the sample **has an EQUAL chance of being put into the control group or the experimental group.** This is the most important part of this research design because random assignment allows a researcher to make an important and necessary assumption.

What assumption does random assignment allow a researcher to make?
It allows the researcher to **assume** that **before** the experiment begins <u>both groups are about equal on all individual variables (IQ, age, education, etc.) except for the independent variable</u>.

Why is it crucial for researchers to be able to make this assumption?
It is crucial because it is necessary that the only difference between the groups is the independent variable. Why? Remember that the point of running an experiment is to establish a cause and effect relationship between an independent variable and a dependent variable. Imagine that a researcher wants to test the hypothesis that a new drug will have an effect on memory. One group, the control group, would NOT get the drug, but rather a placebo. And the other group, the experimental group, would get the drug. In order to conclude that the drug IS the cause of the observed effect on memory and not any other variable, it is paramount that the only difference between the group who did not take the drug (the control group) and the group who did take the drug (experimental group) is the drug so that the differences observed between the control group mean and the experimental group mean IS BECAUSE OF THE ONLY DIFFERENCE BETWEEN THE GROUPS: the drug.

How would NOT using random assignment limit the conclusions that the researcher can make about his or her study?

IF the researcher did NOT use random assignment, then the researcher could NOT assume that the ONLY difference between the groups is the independent variable. If the ONLY difference is the independent variable, then the researcher CAN conclude that the IV is the CAUSE of the observed effect. BUT, if random assignment is NOT used, and OTHER variables (other than the independent variable) also differ between the groups, then ANY other of those variables could also be the CAUSE of the observed effect. Therefore, the limitation is that the researcher cannot attribute the CAUSE to the INDEPENDENT VARIALBE, which, again, is the whole point of running an experiment: to establish a cause and effect relationship between the independent variable and the dependent variable.

Recognizing a Between-Subjects Design

What makes the above design a Between-Subject Design is that the random sample is randomly assigned so that that half of the participants in the sample wind up in the control group and half the participants in the sample wind up in the experimental group. A between subjects design is defined by the fact that a sample is randomly assigned to at least two groups and the groups are made up of different participants; that is, participants who are in the control group are not the same participants who are in the experimental group. This is important enough to repeat: the defining feature of a between-subject research design is that there is random assignment of the sample to different groups and those groups consist of different participants in each group. And, also important is that each participant is only measured once.

Assume that in the above design, the researcher was running a drug study to see if a new drug has an effect on memory. In this experiment, it is likely that the control group would get a placebo (fake drug) and the experimental group would get the real drug (IV). After a few months of being on the drug, the researcher would measure all the research participants with a standardized memory scale. The researcher would get a mean for the memory scores (M) for the control group and a mean for the memory scores (M) for the experimental group. The researcher would wind up with 2 means, the numerator of the hypothesis test (you may recall). The researcher would want to compare this difference (the difference due to the drug) to the difference between the groups "just by chance" to be able to conclude whether he or she can conclude that the drug did have an effect on memory.

The correct hypothesis test to analyze these data is called the INDEPENDENT MEASURES t-test. And it looks like this:

$$t = \frac{M - M}{S_{m-m}}$$

This formula is a bit "simplified" for instructional purposes. You can gain "the full story" in the required readings, but it is not necessary to get the "general story" provided in this lecture.

Notice that the numerator follows the general logic of hypothesis testing. The numerator is the difference between the means that the researcher can attribute to the IV, and the denominator is the ERROR, the difference between the means "just by chance". In the t-test, the denominator is called the "Estimated Standard Error."

Following our researchers hypothesis, a new drug will have an effect on memory, the researcher would want to analyze the data to see if there is a statistical difference between the control group mean (M) and the experimental group mean (M), again a bit simplified, but it gets to the general idea, to find out if the drug had an effect or not. The appropriate hypothesis test to compare these two means, again, is the Independent-Measures t-test. You will run this test on SPSS.

At this point, you should view and study the Video-Lecture on Between-Subjects Design to get clearer on the information presented here as well as how to conduct the 4-step process of the Independent-Measures t-test.