1.3: Threats to Internal Validity and Different Control Techniques

Internal validity is often the focus from a research design perspective. To understand the pros and cons of various designs and to be able to better judge specific designs, we identify specific **threats to internal validity**. Before we do so, it is important to note that the primary challenge to establishing internal validity in social sciences is the fact that most of the phenomena we care about have multiple causes and are often a result of some complex set of interactions. For example, X may be only a partial cause of Y or X may cause Y, but only when Z is present. Multiple causation and interactive effects make it very difficult to demonstrate causality. Turning now to more specific threats, Figure 1.3.1 below identifies common threats to internal validity.

Figure 1.3.1: Common Threats to Internal Validity

Threat	
History	Any event that occurs while the experiment is in progress might be an alternation; using a control group mitigates this concern.
Maturation	Normal changes over time (e.g., fatigue or aging) might affect the dependent variable; using a control group mitigates this concern
Selection Bias	If randomization is not used to assign participants, the groups may not be equivalent
Experimental Mortality	If groups lost participants (e.g., due to dropping out of the experiment) they may not be equivalent.
Testing	A pre-test may confound the influence of the experimental treatment; using a control group mitigates this concern
Instrumentation	Changes or difference in the process of measurements might alternatively account for differences
Statistical Regression	The natural tendency for extreme scores to regress or move towards the mean

Different Control Techniques

All of the common threats mentioned above can introduce extraneous variables into your research design, which will potentially confound your research findings. In other words, we won't be able to tell whether it is the independent variable (i.e., the treatment we give participants), or the extraneous variable, that causes the changes in the dependent variable. Controlling for extraneous variables reduces its threats on the research design and gives us a better chance to claim the independent variable causes the changes in the dependent variable, i.e., internal validity. There are different techniques we can use to control for extraneous variables.

Random assignment

Random assignment is the single most powerful control technique we can use to minimize the potential threats of the confounding variables in research design. As we have seen in Dunn and her colleagues' study earlier, participants are not allowed to self select into either conditions (spend $20 on self or spend on others). Instead, they are randomly assigned into either group by the researcher(s). By doing so, the two groups are likely to be similar on all other factors except the independent variable itself. One confounding variable mentioned earlier is whether individuals had a happy childhood to begin with. Using random assignment, those who had a happy childhood will likely end up in each condition group. Similarly, those who didn't have a happy childhood will likely end up in each condition group too. As a consequence, we can expect the two condition groups to be very similar on this confounding variable. Applying the same logic, we can use random assignment to minimize all potential confounding variables (assuming your sample size is large enough!). With that, the only difference between the two groups is the condition participants are assigned to, which is the independent variable, then we are confident to infer that the independent variable actually causes the differences in the dependent variables.

It is critical to emphasize that random assignment is the only control technique to control for both known and unknown confounding variables. With all other control techniques mentioned below, we must first know what the confounding variable is before controlling it. Random assignment does not. With the simple act of randomly assigning participants into different conditions,

we take care both the confounding variables we know of and the ones we don't even know that could threat the internal validity of our studies. As the saying goes, "what you don't know will hurt you." Random assignment take cares of it.

Matching

Matching is another technique we can use to control for extraneous variables. We must first identify the extraneous variable that can potentially confound the research design. Then we want to rank order the participants on this extraneous variable or list the participants in a ascending or descending order. Participants who are similar on the extraneous variable will be placed into different treatment groups. In other words, they are "matched" on the extraneous variable. Then we can carry out the intervention/treatment as usual. If different treatment groups do show differences on the dependent variable, we would know it is not the extraneous variables because participants are "matched" or equivalent on the extraneous variable. Rather it is more likely to the independent variable (i.e., the treatments) that causes the changes in the dependent variable. Use the example above (self-spending vs. others-spending on happiness) with the same extraneous variable of whether individuals had a happy childhood to begin with. Once we identify this extraneous variable, we do need to first collect some kind of data from the participants to measure how happy their childhood was. Or sometimes, data on the extraneous variables we plan to use may be already available (for example, you want to examine the effect of different types of tutoring on students' performance in Calculus I course and you plan to match them on this extraneous variable: college entrance test scores, which is already collected by the Admissions Office). In either case, getting the data on the identified extraneous variable is a typical step we need to do before matching. So going back to whether individuals had a happy childhood to begin with. Once we have data, we'd sort it in a certain order, for example, from the highest score (meaning participants reporting the happiest childhood) to the lowest score (meaning participants reporting the least happy childhood). We will then identify/match participants with the highest levels of childhood happiness and place them into different treatment groups. Then we go down the scale and match participants with relative high levels of childhood happiness and place them into different treatment groups. We repeat on the descending order until we match participants with the lowest levels of childhood happiness and place them into different treatment groups. By now, each treatment group will have participants with a full range of levels on childhood happiness (which is a strength...thinking about the variation, the representativeness of the sample). The two treatment groups will be similar or equivalent on this extraneous variable. If the treatments, self-spending vs. other-spending, eventually shows the differences on individual happiness, then we know it's not due to how happy their childhood was. We will be more confident it is due to the independent variable.

You may be thinking, but wait we have only taken care of one extraneous variable. What about other extraneous variables? Good thinking.That's exactly correct. We mentioned a few extraneous variables but have only matched them on one. This is the main limitation of matching. You can match participants on more than one extraneous variables, but it's cumbersome, if not impossible, to match them on 10 or 20 extraneous variables. More importantly, the more variables we try to match participants on, the less likely we will have a similar match. In other words, it may be easy to find/match participants on one particular extraneous variable (similar level of childhood happiness), but it's much harder to find/match participants to be similar on 10 different extraneous variables at once.

Holding Extraneous Variable Constant

Holding extraneous variable constant control technique is self-explanatory. We will use participants at one level of extraneous variable only, in other words, holding the extraneous variable constant. Using the same example above, for example we only want to study participants with the low level of childhood happiness. We do need to go through the same steps as in Matching: identifying the extraneous variable that can potentially confound the research design and getting the data on the identified extraneous variable. Once we have the data on childhood happiness scores, we will only include participants on the lower end of childhood happiness scores, then place them into different treatment groups and carry out the study as before. If the condition groups, self-spending vs. other-spending, eventually shows the differences on individual happiness, then we know it's not due to how happy their childhood was (since we already picked those on the lower end of childhood happiness only). We will be more confident it is due to the independent variable.

Similarly to Matching, we have to do this one extraneous variable at a time. As we increase the number of extraneous variables to be held constant, the more difficult it gets. The other limitation is by holding extraneous variable constant, we are excluding a big chunk of participants, in this case, anyone who are NOT low on childhood happiness. This is a major weakness, as we reduce the variability on the spectrum of childhood happiness levels, we decreases the representativeness of the sample and generalizabiliy suffers.

Building Extraneous Variables into Design

The last control technique building extraneous variables into research design is widely used. Like the name suggests, we would identify the extraneous variable that can potentially confound the research design, and include it into the research design by treating it as an independent variable. This control technique takes care of the limitation the previous control technique, holding extraneous variable constant, has. We don't need to excluding participants based on where they stand on the extraneous variable(s). Instead we can include participants with a wide range of levels on the extraneous variable(s). You can include multiple extraneous variables into the design at once. However, the more variables you include in the design, the large the sample size it requires for statistical analyses, which may be difficult to obtain due to limitations of time, staff, cost, access, etc.
