

1.12: Conducting Experiments (2 of 2)

Learning Objectives

- Avoid overgeneralization of experiment results.

Let's summarize what we know about experiments:

- The goal of the experiment is to provide evidence for a cause-and-effect relationship between two variables.
- A well-designed experiment controls the effects of confounding variables to isolate the effect of the explanatory variable on the response.
- Two commonly used methods for controlling the effects of confounding variables are *direct control* and *random assignment*.
- Random assignment uses random chance to assign participants to treatments. This creates similar treatment groups. With random assignment, we can be fairly confident that any differences we observe in the response of treatment groups is due to the explanatory variable. In this way, we have evidence for a cause-and-effect relationship.

Now we discuss a few more strategies that are commonly used to control the effects of confounding variables.

In an experiment, we manipulate the explanatory variable to determine if it has an effect on the response variable. Could the change we observe in the response variable happen without manipulating the explanatory variable? Maybe what we observe would have happened anyway.

For this reason, it is important to include a **control group**. A control group is a group that receives no treatment. The control group provides a baseline for comparison.

Example

Control Groups

Music and rats: In David Merrell's experiment with rats, he wanted to examine the relationship between music and the ability of rats to run a maze. He had three treatment groups: exposure to music by the heavy metal band Anthrax, exposure to music by Mozart, and no exposure to music. The group of rats that did not listen to music is the control group. Merrell's experiment lasted 1 month. With a month of practice, the rats in all the groups would probably get faster at running the maze. The control group provides a baseline for comparison. At the end of 1 month, the rats in the Mozart group were much faster at running the maze than were the rats in the other two groups. Comparison to the control group shows that the improvement in the Mozart group is not due to the rats being more experienced with the maze.

Hernia treatments for children: In this experiment, researchers compared two different surgeries. The response variable was recovery time, so it would not have made sense to have a no-treatment group. However, one type of surgery was the standard treatment for hernias, and children who received this surgery represented the control group. This group provides a baseline for comparing recovery times.

In experiments that use human participants, use of a control group may not be enough to establish whether a treatment really has an effect. A substantial amount of research shows that people respond in positive ways to treatments that have no active ingredients, a response called the **placebo effect**. A placebo is a treatment with no active ingredients, sometimes called a "sugar pill."

Example

The Placebo Effect

An article published in the *Washington Post* in 2002 illustrates the placebo effect in medical experiments.

After thousands of studies, hundreds of millions of prescriptions and tens of billions of dollars in sales, two things are certain about pills that treat depression: Antidepressants like Prozac, Paxil and Zoloft work. And so do sugar pills. A new analysis has found that in the majority of trials conducted by drug companies in recent decades, sugar pills have done as well as – or better than – antidepressants....The new research may shed light on findings such as those from a trial last month that compared the herbal remedy St. John's wort against Zoloft. St. John's wort fully cured 24 percent of the depressed people who received it, and Zoloft cured 25 percent – but the placebo fully cured 32 percent.

The placebo effect can confound the results of medical experiments. It is uncertain what is behind the placebo effect, but because people in medical experiments improve when taking a placebo, a placebo group provides a baseline for comparing treatments. We

cannot eliminate the placebo effect on a treatment group. Both the placebo group and the drug group experience the placebo effect. If a treatment produces better results than a placebo, then we have evidence that the treatment (and not the placebo effect) is responsible for the improvement.

In experiments that use a placebo, participants do not know whether they are receiving the drug or a placebo. The participants are *blind* to the treatment to prevent their own beliefs about the drug (or placebo) from confounding the results.

Example

Blinding

Recall our discussion of the experiment conducted by the Women's Health Initiative to study the health implications of hormone replacement therapy. In this experiment, researchers randomly assigned over 16,000 women to one of two treatments. One group took hormones. The other group took a placebo. The experiment was also double-blind, meaning that neither the women nor the researchers knew who had which treatment.

In a *single-blind*, experiment only one of the two (either the researcher or the participants) do not know which treatment the participants receive.

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To end our discussion of experiments, we consider one last question: *If an experiment is well-designed, can we generalize the results?*

Recall the hormone replacement experiment. This experiment has all of the features of a well-designed experiment:

- A large number of participants (over 16,000 women)
- Use of a placebo group
- Random assignment of women to hormone treatment or placebo
- Double-blind design

After 5 years, the group taking hormones had a higher incidence of breast cancer and heart disease. Researchers were so alarmed by the results that the experiment was ended early to prevent further harm to the health of the women participating in the hormone group.

As a result of this experiment, the use of hormone replacement therapy fell by 66%.

Yet the British Menopause Society and the International Menopause Society questioned this reaction. The Women's Health Concern, a British nonprofit group that provides independent and unbiased information about women's health, wrote:

It must be remembered that the WHI data on which the concerns were raised related to overweight North American women in their mid-sixties and not to the women that are treated with HRT for their menopausal symptoms in the United Kingdom, who are usually around the age of menopause, namely 45–55 years.

The concerns expressed here do not challenge the validity of the results of the WHI experiment. Instead, they question whether the results apply to a larger group of women: women who are younger and not overweight when they go through menopause.

This is an important consideration. If our goal is to generalize the results of an experiment to a more general population, we must consider issues of sampling design as well as random assignment.

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An Important Point about the Role of Random Chance

We now know that in an experiment we intentionally manipulate the explanatory variable to observe changes in the response variable. We use the explanatory variable to create different treatments. If we see different responses in the different treatments, we want to be able to say that the differences are the result of the explanatory variable. We must rule out other possible explanations for the differences we observed, so we use direct control and random assignment, as well as a control group, a placebo group, or blinding as appropriate.

But none of these strategies will rule out the influence of **chance variation**. When we randomly assign participants to treatments, we produce similar groups most of the time. But there is a small chance that we will end up with treatment groups that are not similar.

For example, in the hernia experiment with children, we saw that random assignment creates two groups with average ages that are close. But there is a very small chance that we could get two groups that significantly differ in ages. This will not happen very often, but it could. And if it does happen, the results of our experiment are confounded by age.

Similarly, when we investigated how well a random sample estimates the proportion of students receiving financial aid in the population, we saw that the proportions from random samples gave good estimates – most of the time. Occasionally, a random sample did not give a good estimate. Larger random samples varied less, but they still varied.

What's the Main Point?

Good study design is important. Random selection in sampling can control bias. Random assignment in experiments can control the effects of confounding variables. But there is always a small chance, even when we randomly sample, that the results we observe in a poll do not represent the population well. Similarly, there is always a small chance, even when we use random assignment, that the differences we observe in an experiment are due to random variation and not the explanatory variable. For this reason, we have to understand how random chance behaves. This is the role of probability. We study probability later in the course, before we learn more formal statistical methods for determining if what we observe could be a result explained by chance.

Let's Summarize

- The goal of an experiment is to provide evidence for a cause-and-effect relationship between two variables.
- A well-designed experiment controls the effects of confounding variables to isolate the effect of the explanatory variable on the response.
- Two commonly used methods for controlling the effects of confounding variables are *direct control* and *random assignment*.
- Random assignment uses random chance to assign participants to treatments, which creates similar treatment groups. With random assignment, we can be fairly confident that any differences we observe in the response of treatment groups is due to the explanatory variable. In this way, we have evidence for a cause-and-effect relationship.
- Other strategies for controlling confounding variables include use of a control group, use of a placebo group, and blinding.
- A well-designed experiment provides evidence for a cause-and-effect relationship. But even in a well-designed experiment, differences in the response might be due to chance. We learn to describe chance behavior when we study probability later in the course.

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