# Introduction to Experimental Design

Lauren Cappiello

February 3, 2020

# Objectives

- Understand necessary terminology for experiments and experimental design.
- Design basic experiments based on the principles of experimental design.
- Start to think critically about how research is done and how it's reported on.

# Experiments

An **experiment** assigns **treatments** to subjects or objects (experimental units) in order to observe a **response**.

Whenever an experiment utilizes randomly assigned treatments, we say that it is a **randomized experiment**.

# Experiments

- A treatment is anything a researcher assigns to an experimental unit.
  - This could be medication, a new teaching method, plant fertilizer... you name it!
- Treatments are assigned by **level** or magnitude.
  - Medication might be administered at levels 0, 5, and 10 mg.
  - Fertilizer might have levels for Brand A, Brand B, and Brand C.

# Consider

Design a simple experiment to test whether dry dog food causes dogs to gain weight.

# Principles of Experimental Design

Key principles:

1. Formulate research goals in advance
2. Comparison and control
3. Replication
4. Randomization
5. Blocking

# Formulating Goals in Advance

Formulating goals in advance helps maintain scientific integrity.

- If we mess around with the data long enough, there's a good chance we will find something interesting.
  - This is especially true with more complex datasets.
  - Random false positives are to be expected!
- Goal: learn whether dry dog food causes dogs to gain weight.

This will also make your life easier!

# Comparison

Good experiments are **comparative**.

- Ex: compare weight gain in dogs eating dry dog food to weight gain in dogs eating canned dog food.

By setting clear levels of a treatment, we achieve more effective comparison.

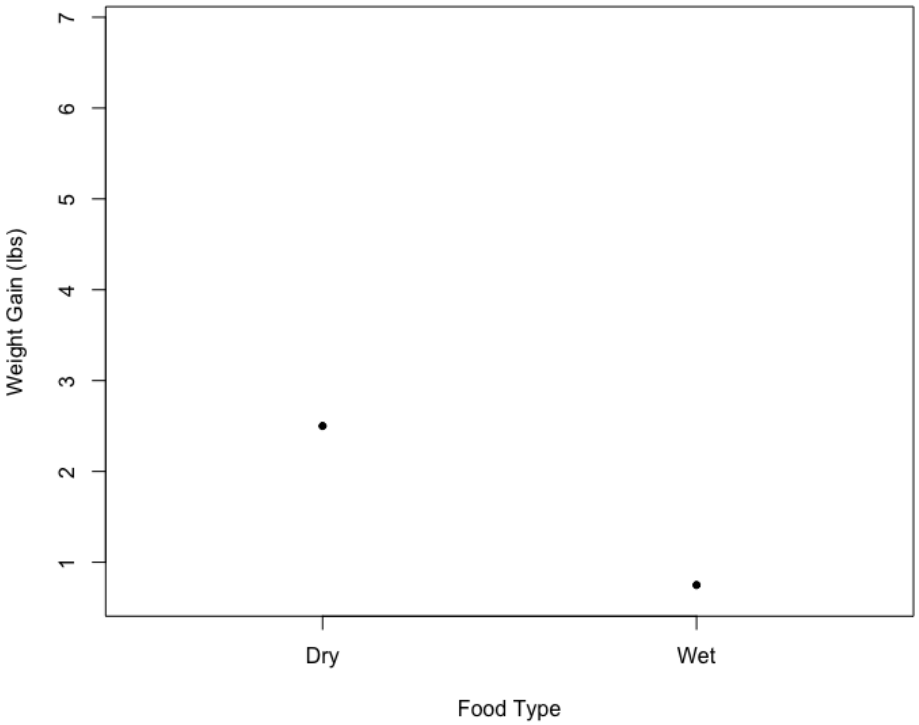
# Control

When treatments are assigned to cases, researchers do their best to **control** any other differences in the treatment groups.

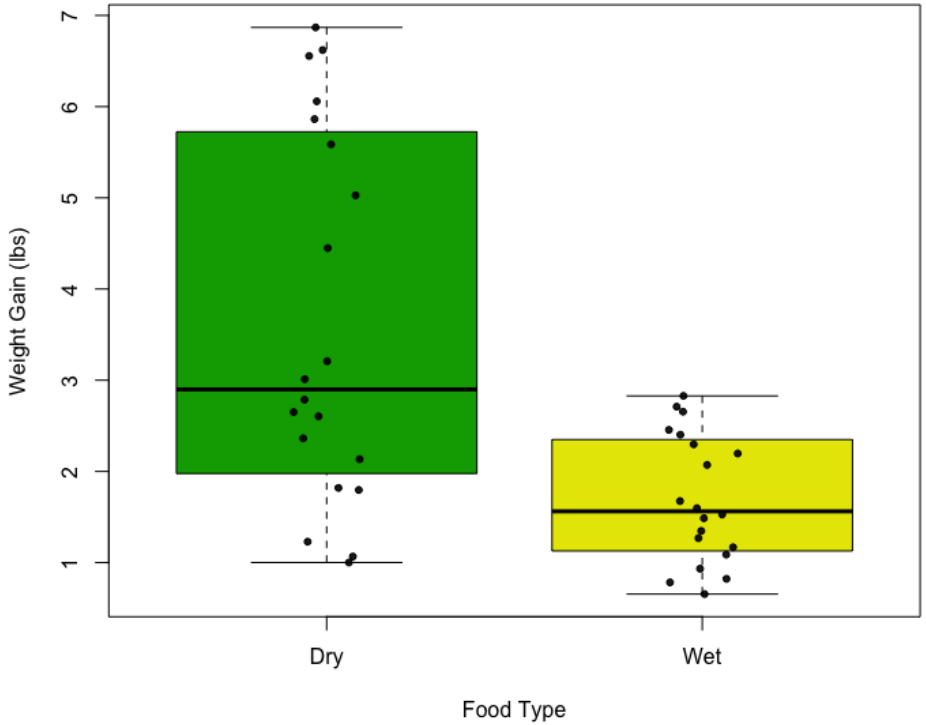
- Ex: if we have a dry dog food group and a wet dog food group, we might feed each dog at 8am and 6pm based on each food's specific feeding instructions.

# Replication

One dog per group.




20 dogs per group.



# Replication

The more information we have, the more confident we can be in our results! We gather more information through **replication**.

- Reduce the effect of uncontrolled variation.
- Helps quantify uncertainty.

# Randomization

Researchers **randomize** cases into treatment groups.

- This helps account for any unmeasured variables.
- Ex: dog breed may have an impact on how likely a dog is to gain weight. Randomization will help ensure that we have a similar spread of breeds in each sample.
- This helps minimize bias in our data.

# Blocking

If we suspect that other variables are important in influencing a response, we can group cases into **blocks**.

- Cases within each block are then randomly assigned to each treatment.
- For example, we might block our dogs by small, medium, and large dogs. Then half of the dogs in each block will get dry food and half will get wet food.
- This serves a similar purpose to randomization, but gives us more control.

# Principles of Experimental Design

- Always formulate your research goals in advance.
- All experiments will use some form of comparison/control, replication, and randomization.
- Blocking is not always utilized, but can be very useful.

# Activity

Get into groups of 3-5 and critique the following research plan. See if you can come up with a better way to approach the research question.

Suppose I want to know how well a new chickenpox vaccine works. I plan to take a random sample of 10 people and give half the vaccine. In eight weeks, I will check to see how many people in each group contracted chickenpox. I will then test whether more people in the vaccine group or in the control group contracted chickenpox.

# Bias in Human Experiments

Randomized experiments are the gold standard, but even they have their limitations!

Experiments involving people are especially prone to **bias**.

# Example: Heart Attack Drugs

Suppose we are interested in whether a new drug helps to prevent repeated cardiac events in patients who have already had at least one heart attack.

- We get a random sample of 100 people who have had a heart attack in the past.
- 50 of them are randomly assigned to the treatment (our new drug). This is our **treatment group**.
- The other 50 do not receive the drug. This is our **control group**.

Can you think of anything that could bias our results?

# Sources of Bias

- People who get the new drug expect it to work.
- People who did *not* get the drug may wonder if their study participation was worth the risk.
- Doctors may inadvertently affect the results through their optimism (or lack thereof) when administering the drug.

# Reducing Bias in Human Experiments

We can reduce bias by

- Keeping patients uninformed about their treatment group.
  - We call these studies **blind**.
  - One way to keep studies blind is to give the control group a **placebo**.
- Keeping doctors uninformed about which treatment groups their patients are in.
  - We call these studies, where neither patient nor medical provider know the treatment group, **double-blind**.

# What We Learned

- Experimental design concepts.
- Critical examination of research design.

# What's Next?

Experimental design is a framework for developing research that can be analyzed using the methods you will learn in this course.

Next:

- Common study designs and their analyses.