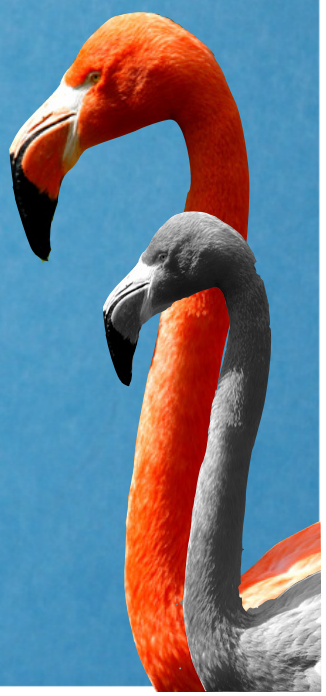
CHAPTER 4
Designing Studies

4.2d
Experiments



The Practice of Statistics, 5th Edition
Starnes, Tabor, Yates, Moore

Bedford Freeman Worth Publishers

Experiments

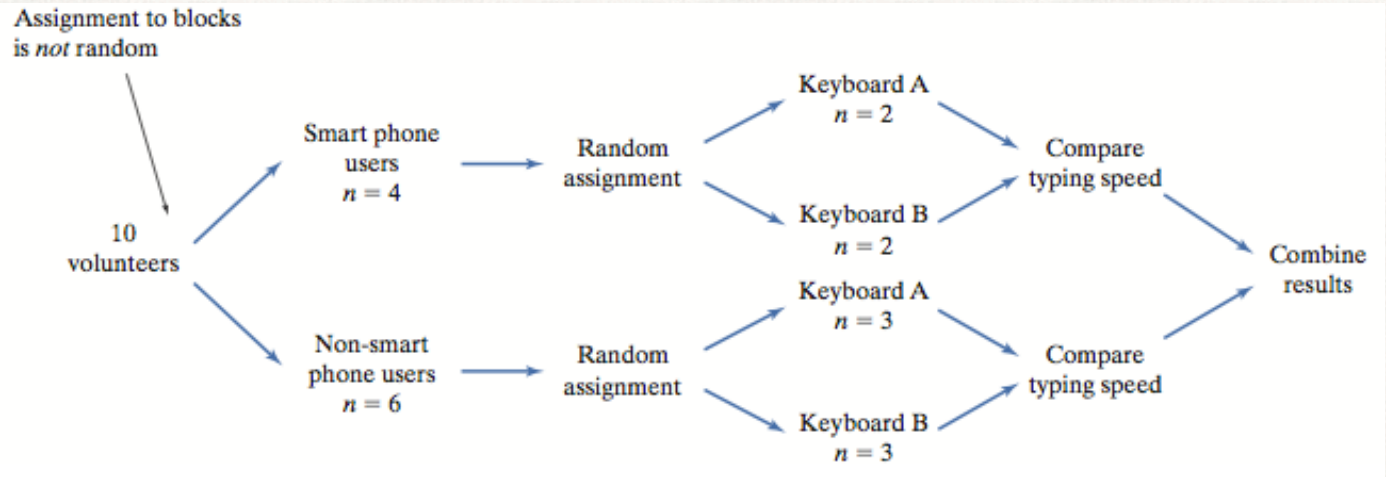
Learning Objectives

After this section, you should be able to:

- ✓ DISTINGUISH between an observational study and an experiment.
- ✓ EXPLAIN the concept of confounding.
- ✓ IDENTIFY the experimental units, explanatory and response variables, and treatments in an experiment.
- ✓ EXPLAIN the purpose of comparison, random assignment, control, and replication in an experiment.
- ✓ DESCRIBE a completely randomized design for an experiment.
- ✓ DESCRIBE the placebo effect and the purpose of blinding in an experiment.
- ✓ INTERPRET the meaning of statistically significant in the context of an experiment.
- ✓ EXPLAIN the purpose of blocking in an experiment. DESCRIBE a randomized block design or a matched pairs design for an experiment.

Blocking

When a population consists of groups of individuals that are "similar within but different between," a stratified random sample gives a better estimate than a simple random sample. This same logic applies in experiments.



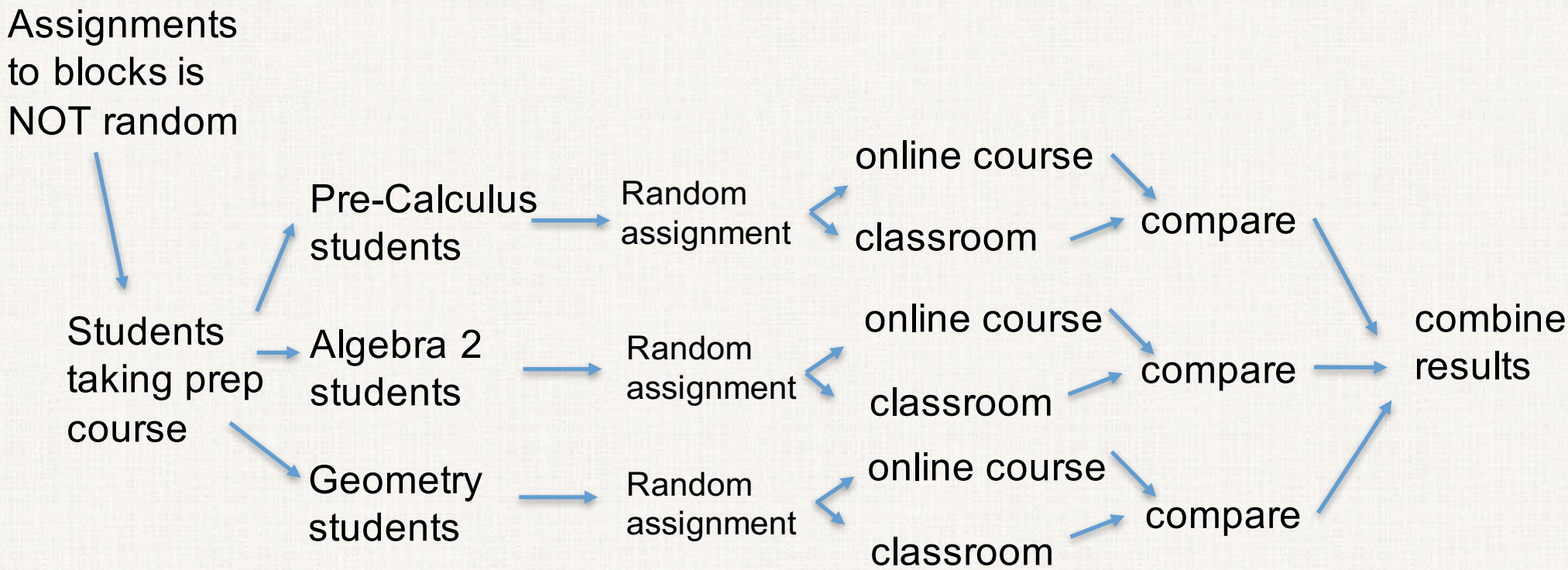
A **block** is a group of experimental units that are known before the experiment to be similar in some way that is expected to affect the response to the treatments.

In a **randomized block design**, the random assignment of experimental units to treatments is carried out separately within each block.

SAT prep

- A previous textbook example discussed an experiment looking at the effectiveness of an online SAT prep course. A student's current math class might be a source of variability in their SAT improvement. In the completely randomized design, we hope the random assignment would roughly balance the Pre-calculus students, the Algebra 2 students, the Geometry students, and so on between the online and classroom SAT courses. There could be a lot of variability in the results if students in each course experience different levels of improvements. This might make it difficult to detect a difference in the effectiveness of the two courses.
- To account for this potential variability, we can separate the students into groups (blocks) based on their current math class and randomly divide the members of each block into the online and classroom SAT courses. This randomized block design help us account for the variation in improvement due to one's current math class.

SAT Prep Course Blocking Diagram



Blocking Tips

- Don't confuse blocks and treatment groups.
  - Blocks are not assigned randomly.
  - They are formed by grouping experimental units that are similar in some way that is expected to systematically affect the response to the treatments.
  - Each block should be very different from other blocks.
  - Treatment groups are formed at random, with the goal that treatment groups be as similar as possible.
- Be able to explain why a particular variable is used when forming blocks
  - Best blocking variables are those with the strongest association with the response variable (best predictors of response variable)
  - In context!
  - "I will block on current math class because this variable is a good predictor of SAT success"
- Don't confuse blocking with stratified random sampling
  - Both help to account for variability created by other variables
  - Stratified random sampling is done only when taking a sample from a population
  - Blocking happens only when assigning units to treatments in an experiment.

Microwave Popcorn

A popcorn lover wants to know if it is better to use the "popcorn button" on her microwave oven or use the amount of time recommended on the bag of popcorn. To measure how well each method works, she will count the number of unpopped kernels remaining after popping. To obtain the experimental units, she goes to the store and buys 10 bags each of 4 different varieties of microwave popcorn (butter, cheese, natural, and kettle corn), for a total of 40 bags.

- Explain why a randomized block design might be preferable to a completely randomized design for this experiment.

A completely randomized design ignores the difference between the four types of popcorn, which will probably result in a great deal of variability in the number of unpopped kernels for both treatments. For example, if there are many more unpopped kernels in bags of cheese popcorn and kettle corn than the other two varieties, it will be harder to tell if there is a difference in the methods of popping. A randomized block design considers each variety of popcorn separately, which allows us to account for the variability in the number of unpopped kernels created by the difference in varieties.

Microwave Popcorn

- Outline a randomized block design for this experiment. Describe how you would carry out the random assignment required by your design.

We will randomly assign 5 bags of each variety to each of the two treatments. To perform the random assignment, place all 10 bags of a particular variety in a large grocery bag. Shake the bag and then randomly select 5 bags to be popped using the "popcorn button." The remaining 5 bags will be popped using the instructions on the bags. Repeat this process for the remaining 3 varieties. After popping each of the 40 bags in random order, count the number of unpopped kernels in each bag and compare the results within each variety. Then combine the results from the 4 varieties after accounting for the difference in average response for each variety.

Matched Pairs Design

A common type of randomized block design for comparing two treatments is a **matched pairs design**. The idea is to create blocks by matching pairs of similar experimental units. Thus, it's a special case of randomized block design that uses blocks of size 2.

A **matched pairs design** is a randomized blocked experiment in which each block consists of a matching pair of similar experimental units.

Chance is used to determine which unit in each pair gets each treatment.

Sometimes, a "pair" in a matched-pairs design consists of a single unit that receives both treatments. Since the order of the treatments can influence the response, chance is used to determine with treatment is applied first for each unit.

Matched Pairs Experiment – Get your heart beating

Are standing pulse rates generally higher than sitting pulse rates?

1. Completely randomized design

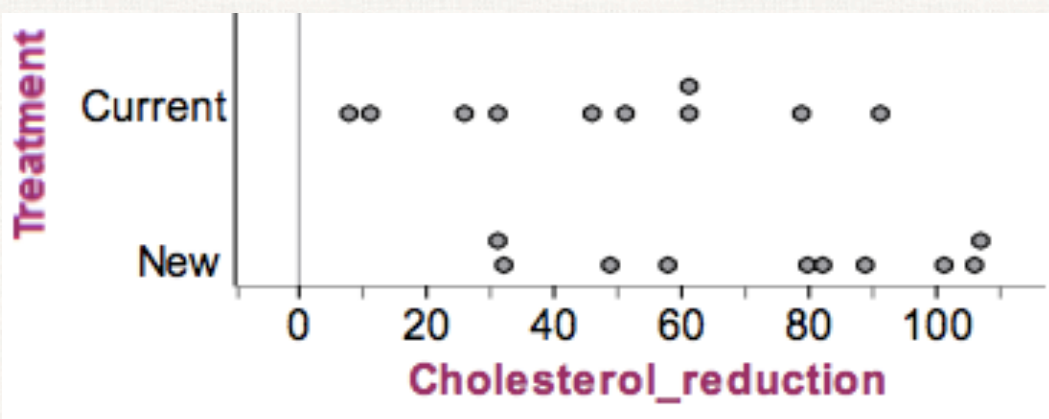
We will randomly assign half of the class to stand and the other half to sit. We will measure pulses for one minute. Record data in parallel dotplots.

2. Matched pairs design

Each student will receive both treatments in random order. Since you already did one (and that was assigned randomly), each person will do the opposite now and measure pulse for one minute. Record data as a difference of pulses (standing – sitting).

Matched Pairs Example – Cholesterol Drugs

- Matched pairs often using the same individual to receive both treatments, but it can also pair individuals that start with a very similar variable.
- A pharmaceutical company wants to compare its new cholesterol drug to the current recommended drug. They recruit 20 similar aged men for their experiment.
- Using a completely randomized design (randomly assigning 10 to the new drug, 10 to the current drug) results in this data:

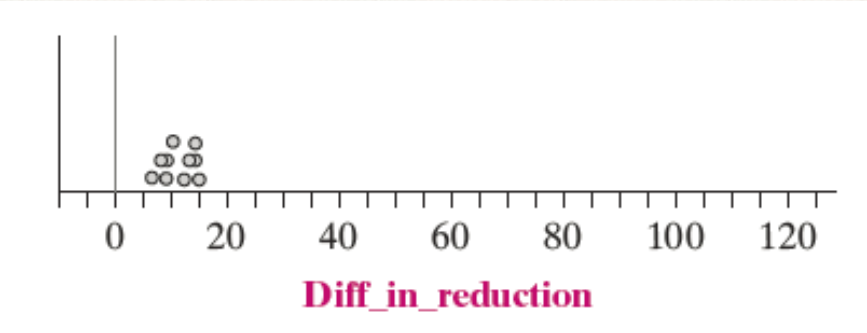


Some of the variables that may contribute to differences in cholesterol reduction may be age, weight, and initial cholesterol level. The best variable to pair individuals is the variable that has the strongest association with the response variable—the best predictor of the response.

Matched Pairs Example – Cholesterol Drugs

- Pair the individuals based on initial cholesterol level. Randomly assign one of each pair to the new drug, and the other to the current drug.

- Matched pairs allowed to to account for a big source of variability in the results – individual effect.



Pair	Subject	Initial Cholesterol	Age	Weight	Individual Effect
1	2	183	45	190	9
1	17	187	49	165	10
2	3	191	42	138	19
2	6	197	51	159	20
3	20	205	42	170	29
3	13	209	46	153	30
4	7	228	43	105	39
4	12	229	41	154	40
5	19	252	50	156	49
5	11	268	56	241	50
6	8	270	52	167	59
6	14	285	50	130	60
7	1	299	58	255	69
7	15	303	42	230	70
8	9	310	42	175	79
8	4	318	60	217	80
9	16	321	53	252	89
9	5	329	52	151	90
10	10	338	56	290	99
10	18	350	58	264	100

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Section Summary

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Read p. 251-258 ccc 75, 77, 79, 81, 85