Principles of experimental design

1. *Control:* Compare treatment of interest to a control group.
2. *Randomize:* Randomly assign subjects to treatments, and randomly sample from the population whenever possible.
3. *Replicate:* Within a study, replicate by collecting a sufficiently large sample. Or replicate the entire study.
4. *Block:* If there are variables that are known or suspected to affect the response variable, first group subjects into *blocks* based on these variables, and then randomize cases within each block to treatment groups.

More on blocking

- We would like to design an experiment to investigate if energy gels makes you run faster:
  - Treatment: energy gel
  - Control: no energy gel
- It is suspected that energy gels might affect pro and amateur athletes differently, therefore we block for pro status:
  - Divide the sample to pro and amateur
  - Randomly assign pro athletes to treatment and control groups
  - Randomly assign amateur athletes to treatment and control groups
  - Pro/amateur status is equally represented in the resulting treatment and control groups

Why is this important? Can you think of other variables to block for?

Practice

A study is designed to test the effect of light level and noise level on exam performance of students. The researcher also believes that light and noise levels might have different effects on males and females, so wants to make sure both genders are equally represented in each group. Which of the below is correct?

(a) There are 3 explanatory variables (light, noise, gender) and 1 response variable (exam performance)

(b) There are 2 explanatory variables (light and noise), 1 blocking variable (gender), and 1 response variable (exam performance)

(c) There is 1 explanatory variable (gender) and 3 response variables (light, noise, exam performance)

(d) There are 2 blocking variables (light and noise), 1 explanatory variable (gender), and 1 response variable (exam performance)

Difference between blocking and explanatory variables

- Factors are conditions we can impose on the experimental units.
- Blocking variables are characteristics that the experimental units come with, that we would like to control for.
- Blocking is like stratifying, except used in experimental settings when randomly assigning, as opposed to when sampling.

More experimental design terminology...

- *Placebo:* fake treatment, often used as the control group for medical studies
- *Placebo effect:* experimental units showing improvement simply because they believe they are receiving a special treatment
- *Blinding:* when experimental units do not know whether they are in the control or treatment group
- *Double-blind:* when both the experimental units and the researchers who interact with the patients do not know who is in the control and who is in the treatment group

Practice

What is the main difference between observational studies and experiments?

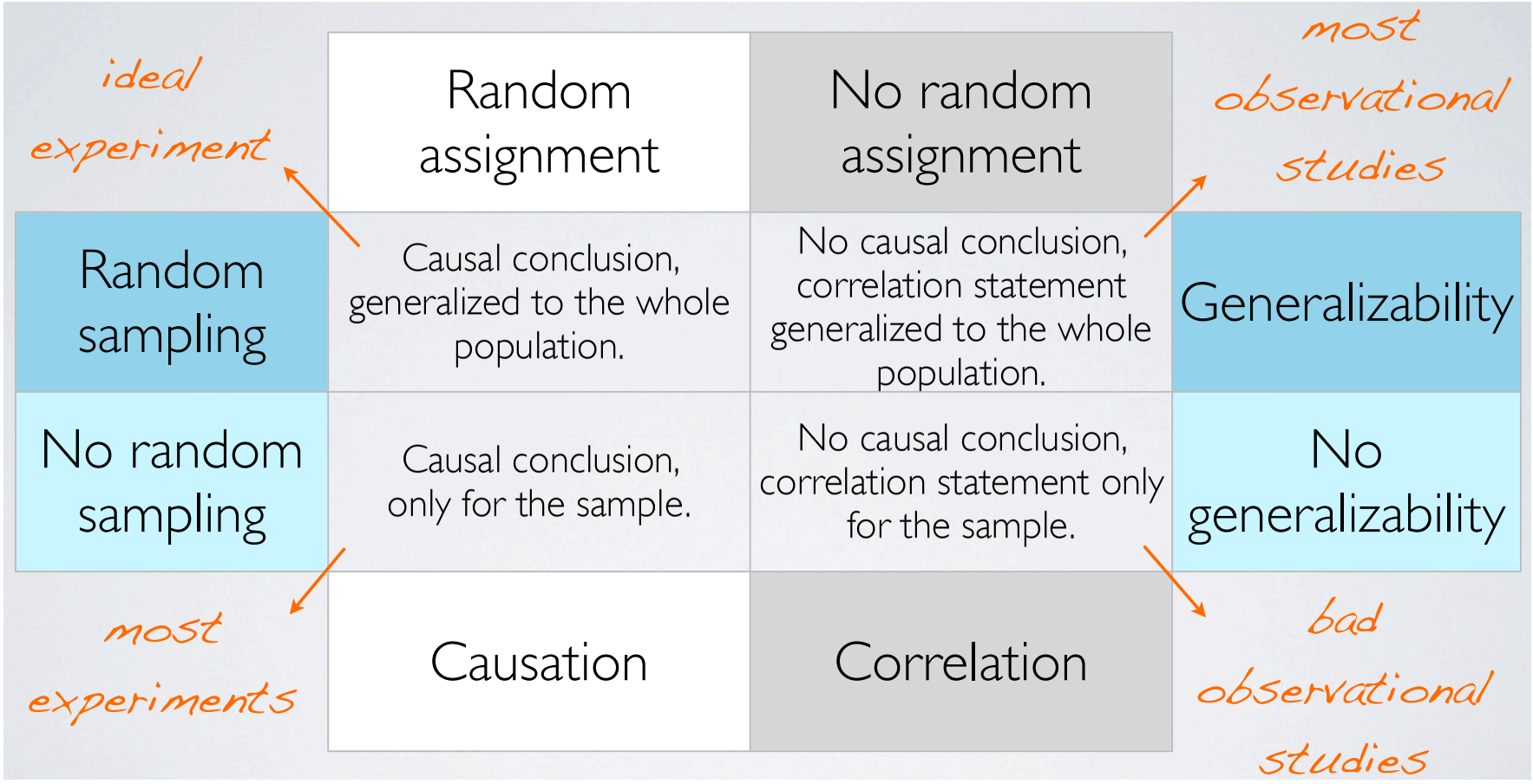
(a) Experiments take place in a lab while observational studies do not need to.

(b) In an observational study we only look at what happened in the past.

(c) Most experiments use random assignment while observational studies do not.

(d) Observational studies are completely useless since no causal inference can be made based on their findings.

Random assignment vs. random sampling



HOMEWORK from Chapter 1.5

30. **Stressed out, Part II**

In a study evaluating the relationship between stress and muscle cramps, half the subjects are randomly assigned to be exposed to increased stress by being placed into an elevator that falls rapidly and stops abruptly and the other half are left at no or baseline stress.

(a) What type of study is this?

(b) Can this study be used to conclude a causal relationship between increased stress and muscle cramps?

31. **Light and exam performance**

A study is designed to test the effect of light level on exam performance of students. The researcher believes that light levels might have different effects on males and females, so wants to make sure both are equally represented in each treatment. The treatments are fluorescent overhead lighting, yellow overhead lighting, no overhead lighting (only desk lamps).

(a) What is the response variable?

(b) What is the explanatory variable? What are its levels?

(c) What is the blocking variable? What are its levels?

32. **Vitamin supplements**

In order to assess the effectiveness of taking large doses of vitamin C in reducing the duration of the common cold, researchers

recruited 400 healthy volunteers from staff and students at a university. A quarter of the patients were assigned a placebo, and the rest were evenly divided between 1g Vitamin C, 3g Vitamin C, or 3g Vitamin C plus additives to be taken at onset of a cold for the following two days. All tablets had identical appearance and packaging. The nurses who handed the prescribed pills to the patients knew which patient received which treatment, but the researchers assessing the patients when they were sick did not. No significant differences were observed in any measure of cold duration or severity between the four medication groups, and the placebo group had the shortest duration of symptoms.Audera:2001

(a) Was this an experiment or an observational study? Why?

(b) What are the explanatory and response variables in this study?

(c) Were the patients blinded to their treatment?

(d) Was this study double-blind?

(e) Participants are ultimately able to choose whether or not to use the pills prescribed to them. We might expect that not all of them will adhere and take their pills. Does this introduce a confounding variable to the study? Explain your reasoning.

33. **Light, noise, and exam performance**

A study is designed to test the effect of light level and noise level on exam performance of students. The researcher believes that light and noise levels might have different effects on males and females, so wants to make sure both are equally represented in each treatment. The light treatments considered are fluorescent overhead lighting, yellow overhead lighting, no overhead lighting (only desk lamps). The noise treatments considered are no noise, construction noise, and human chatter noise.

(a) What is the response variable?

(b) How many factors are considered in this study? Identify them, and describe their levels.

(c) What is the role of the sex variable in this study?

34. **Music and learning**

You would like to conduct an experiment in class to see if students learn better if they study without any music, with music that has no lyrics (instrumental), or with music that has lyrics. Briefly outline a design for this study.

35. **Soda preference**

You would like to conduct an experiment in class to see if your classmates prefer the taste of regular Coke or Diet Coke. Briefly outline a design for this study.

36. **Exercise and mental health**

A researcher is interested in the effects of exercise on mental health and he proposes the following study: Use stratified random sampling to ensure representative proportions of 18-30, 31-40 and 41- 55 year olds from the population. Next, randomly assign half the subjects from each age group to exercise twice a week, and instruct the rest not to exercise. Conduct a mental health exam at the beginning and at the end of the study, and compare the results.

(a) What type of study is this?

(b) What are the treatment and control groups in this study?

(c) Does this study make use of blocking? If so, what is the blocking variable?

(d) Does this study make use of blinding?

(e) Comment on whether or not the results of the study can be used to establish a causal relationship between exercise and mental health, and indicate whether or not the conclusions can be generalized to the population at large.

(f) Suppose you are given the task of determining if this proposed study should get funding. Would you have any reservations about the study proposal?

37. **Chia seeds and weight loss**

Chia Pets – those terra-cotta figurines that sprout fuzzy green hair – made the chia plant a household name. But chia has gained an entirely new reputation as a diet supplement. In one 2009 study, a team of researchers recruited 38 men and divided

them randomly into two groups: treatment or control. They also recruited 38 women, and they randomly placed half of these participants into the treatment group and the other half into the control group. One group was given 25 grams of chia seeds twice a day, and the other was given a placebo. The subjects volunteered to be a part of the study. After 12 weeks, the scientists found no significant difference between the groups in appetite or weight loss. Nieman:2009

(a) What type of study is this?

(b) What are the experimental and control treatments in this study?

(c) Has blocking been used in this study? If so, what is the blocking variable?

(d) Has blinding been used in this study?

(e) Comment on whether or not we can make a causal statement, and indicate whether or not we can generalize the conclusion to the population at large.