Good or Bad?

What makes some studies, especially some experiments, convincing? Why should we ignore others?

**Thought Question**

In a study at Nova Southeastern University in Florida, students chose whether to take the course online or in class, and a test was given at the end of the course to measure their learning. The authors claim that students taking undergraduate courses online were “equal in learning” to students taking the same course in class.

(i) *Can you think of any problems with comparing the in-class and online students?*

(ii) *What might be a better approach?*
Terminology

- **Response variable:** variable that measures the outcome of a study.
- **Explanatory variable:** variable that we think causes changes in the response variable.
- **Subjects:** individuals studied in an experiment.
- **Treatment:** any specific experimental condition applied to the subjects.

Example: Online Learning

*Subjects:* college students

*Explanatory variable:* the setting for learning (in class or online)

*Response variable:* student’s score on a test at the end of the course
How to experiment badly: fail to account for all factors

Terminology

- **Lurking variable**: has an important effect on the relationship among the variables in a study but is not an explanatory variable.

- **Confounded variables**: their effects on a response variable cannot be distinguished from each other. Can be explanatory variables or lurking variables.

Example: Online Learning

Example: Breast Feeding

Breastfeeding has been linked to higher IQ and improved health for children.

What (lurking) variables might be confounding factors?

education, wealth, health, socio-economic background
Example: Pig Whipworms

Crohn’s disease is a chronic inflammatory bowel disease. An experiment reported in a British medical journal claimed that a drink containing thousands of pig whipworm eggs was effective in reducing abdominal pain, bleeding, and diarrhea associated with the disease. Patients in the study reported reduced symptoms after using the drink.

*Do you think that this study demonstrates that pig whipworm eggs are an effective treatment for Crohn’s disease?*

No, the study doesn’t account for the placebo effect.

**Terminology**

- **Clinical trial**: experiment that study the effectiveness of medical treatments.
- **Placebo**: dummy treatment with no active ingredients.
- **Placebo Effect**: many patients respond favorably to a placebo.

Example: Pig Whipworms

*How would you design a better study?*

Include a group of subjects who receive only a placebo. This would allow us to see whether the treatment being tested does better than a placebo.
Randomized Comparative Experiments: A Better Approach

Terminology

- **Randomized Comparative Experiments**: randomization is used to assign subjects to treatments. Two or more treatments are compared.

- **Control Group**: subjects receive no treatment or a standard treatment to control the effects of lurking variables.

The Logic of Experimental Design

- **Randomization**: produces groups of subjects that should be similar, on average, in all respects before we apply the treatments.

- **Comparative design**: exposes all groups to similar conditions other than the treatments they receive. Any additional lurking variables that arise after randomization operate equally on all groups. So, on average, groups differ only in the treatments they receive.

- **Therefore**: differences in the response variable must be due to effects of the treatments.

Case Study: Sickle-Cell Anemia

Carried out by the National Institutes of Health (NIH), 1995.

**Objective**: to determine if the drug hydroxyurea can treat sickle-cell anemia.

**Individuals**: 299 adult patients who had had at least 3 episodes of pain from sickle-cell anemia in the past year.
Method:

1. 152 patients were randomly selected to receive hydroxyurea.
2. 147 patients were randomly assigned to receive a placebo that looked and tasted the same.
3. The number of pain episodes was recorded.

Results: Patients who received hydroxyurea had many fewer pain episodes (in fact the study was stopped early because the evidence was so compelling!).

Why is this study better than the one on pig whipworm eggs?

It uses two groups, one receiving hydroxyurea and one receiving a placebo, to control the impact of the placebo effect.

Principles of Experimental Design

- **Control** the effects of lurking variables on the response, most simply by comparing two or more treatments.

- **Randomize** - use impersonal chance to assign subjects to treatments.

- **Use** enough subjects in each group to reduce chance variation in the results.
Importance of Results

If an experiment or observational study finds a difference in two (or more) groups, is this difference really important?

Terminology

- **Statistical significance**: the observed effect is of a size that would rarely occur by chance if there is no difference in the treatments.

Warnings

- Statistically significant does not necessarily mean practically important.

- Even if there is no difference in the treatments, large effects can still be observed by chance.
Living with Observational Studies

When can’t we use randomized comparative experiments?

Example: Church

Does regular church attendance lengthen lives?

Problem: you can’t randomly assign religious beliefs.

Example: Heart Disease

Do doctors discriminate against women in treating heart disease?

Problem: you can’t randomly assign gender.

Example: Texting and Driving

Does texting while driving cause accidents?

Problem: it’s unethical to ask people to text and drive.

Good Observational Studies

• should still be comparative.

• can combine comparison with matching of similar subjects.

• can measure and adjust for confounding variables.