

Experiments and Observational Studies

Stat 120

April 01 2022

Explanatory and Response

If we are using one variable to help us understand or predict values of another variable, we call the former the **explanatory variable** and the latter the **response variable**

Association and Causation

Two variables are **associated** if values of one variable tends to be related to values of the other variable

- e.g. Families with many cars tend to own many television sets

Two variables are **causally associated** if changing the value of the explanatory variable influences the value of the response variable

- e.g. Studies show that taking a practice exam increases your score on an exam

College Education and Aging

“Education seems to be an elixir that can bring us a healthy body and mind throughout adulthood and even a longer life,” says Margie E. Lachman, a psychologist at Brandeis University who specializes in aging. “For those in midlife and beyond, a college degree appears to slow the brain’s aging process by up to a decade, adding a new twist to the cost-benefit analysis of higher education - for young students as well as those thinking about returning to school.”

Which of the following is true?

1. Explanatory Variable = brain aging; Response Variable = elixir
2. Explanatory Variable = brain aging; Response Variable = college degree
3. Explanatory Variable = college degree; Response Variable = brain aging

College Education and Aging

Based on this passage, should we conclude that obtaining a college degree causes a slowdown in the brain's aging process?

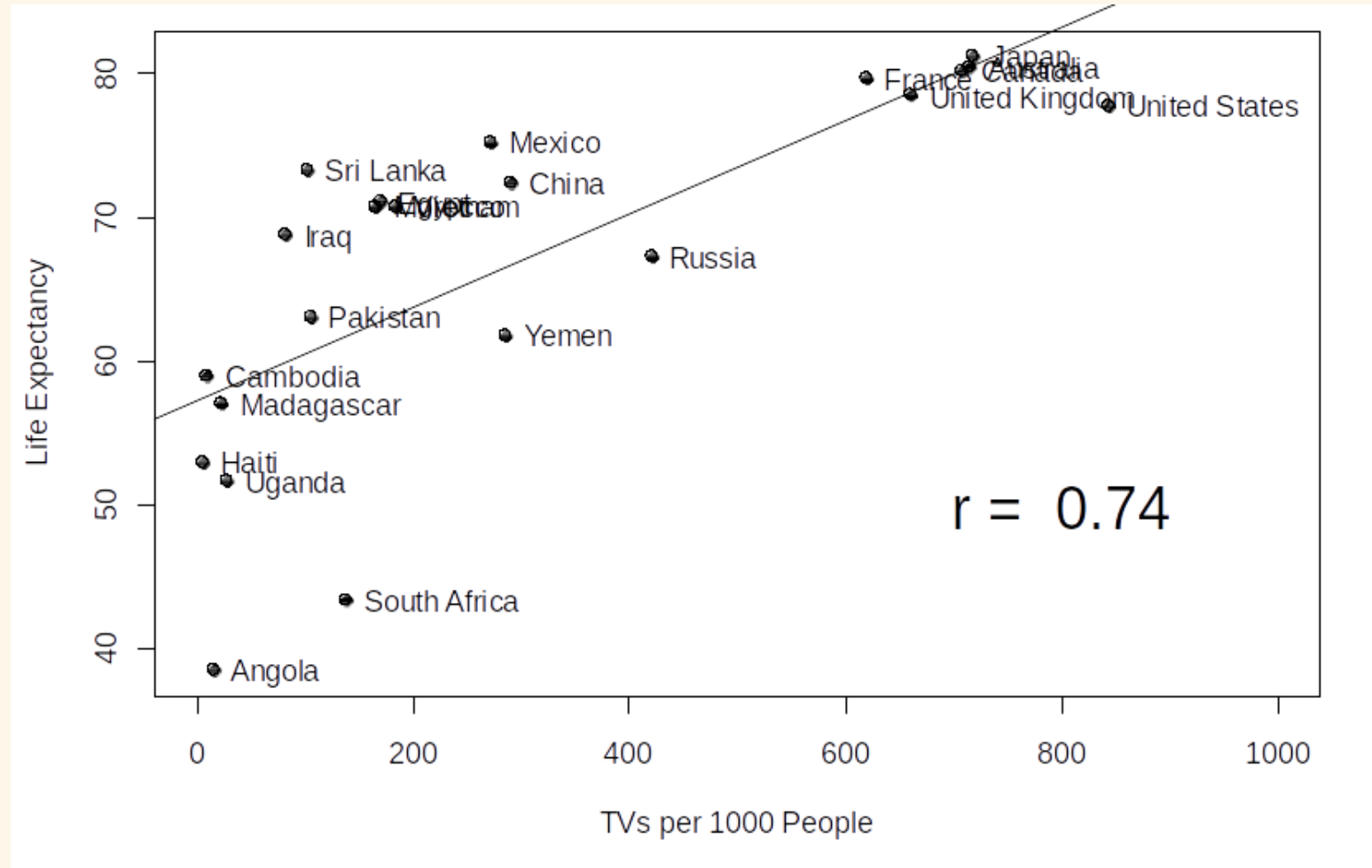
- Yes
- No

Explanatory, Response, Causation

Does the following headline imply a causal association?

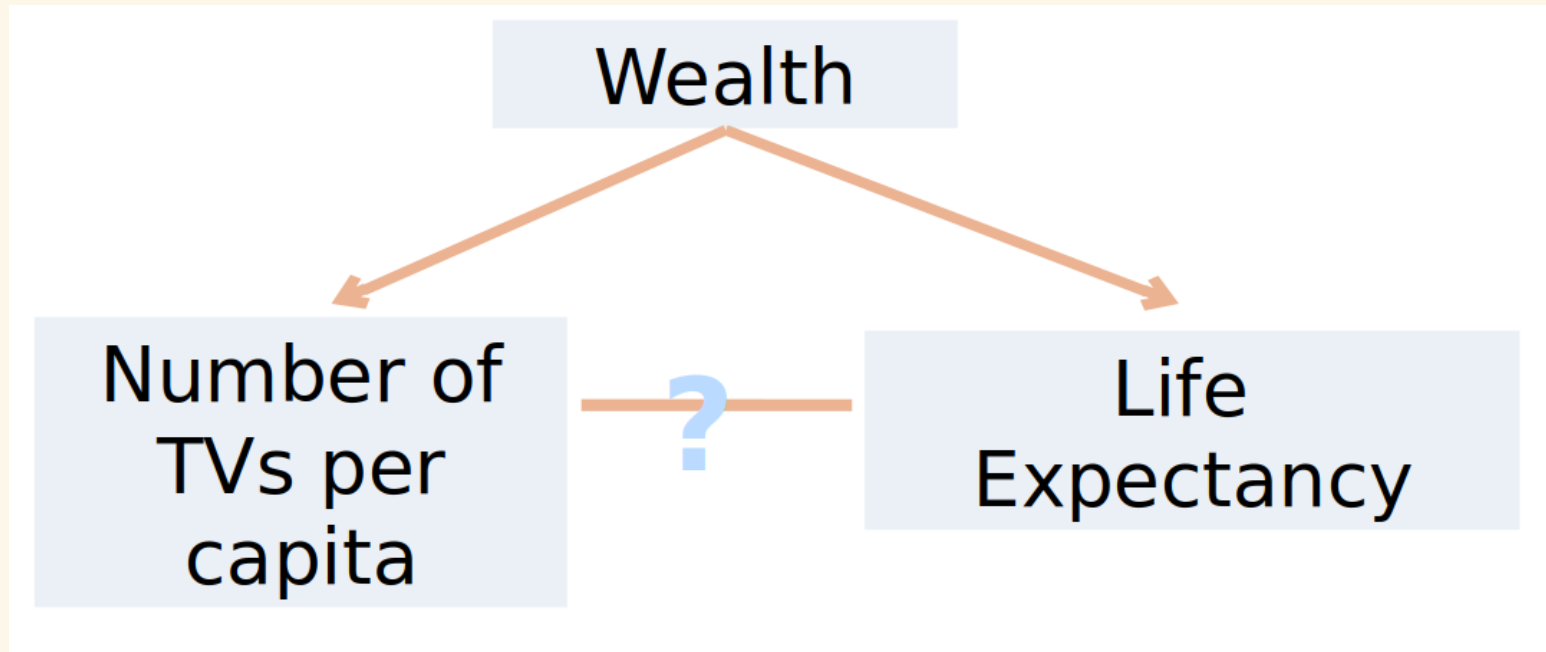
1. "Daily Exercise Improves Mental Performance"
2. "Want to lose weight? Eat more fiber"
3. "Cat owners tend to be more educated than dog owners"

Should you buy more TVs to live longer?



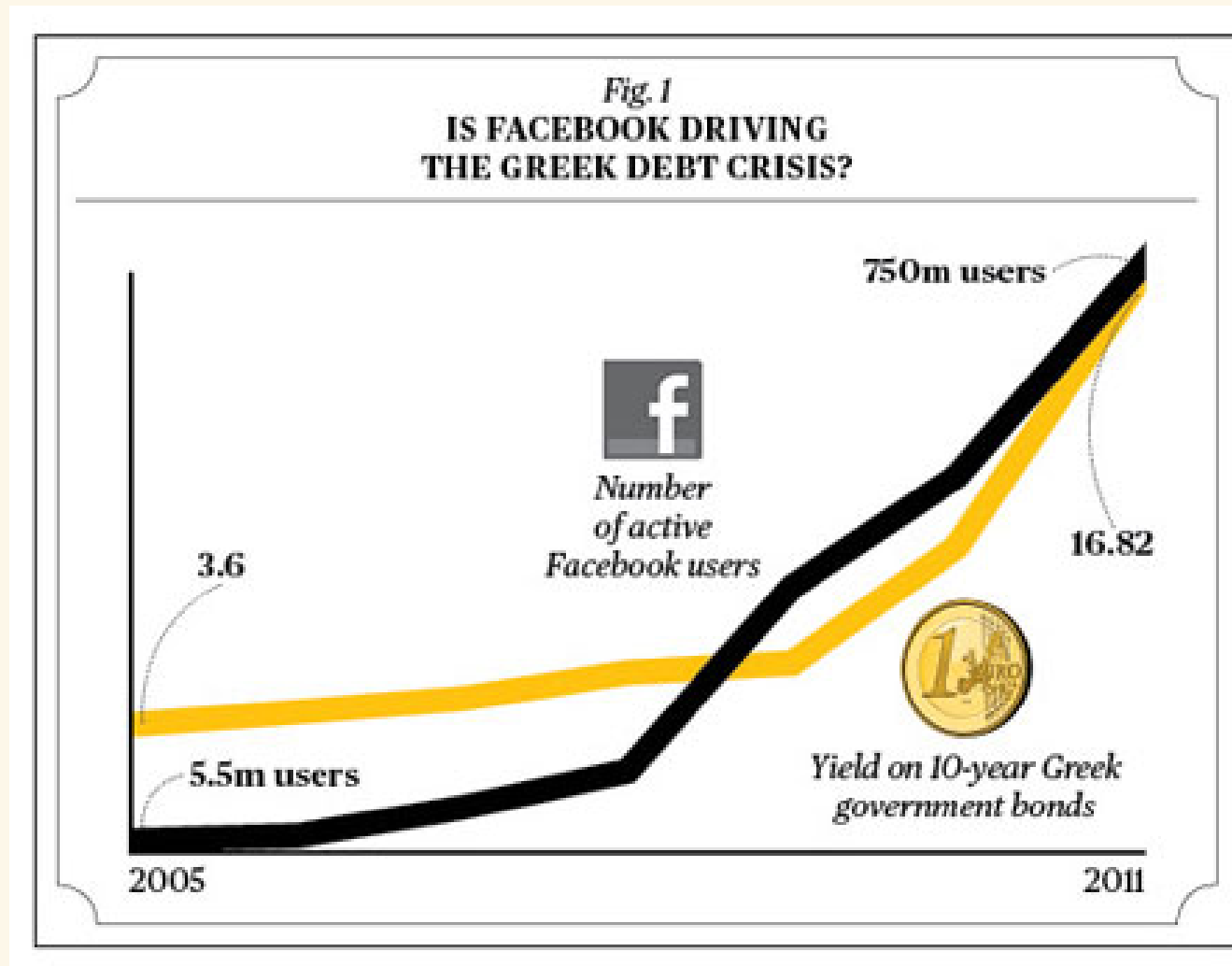
Life expectancy Vs Number of TVs

TVs and Life Expectancy

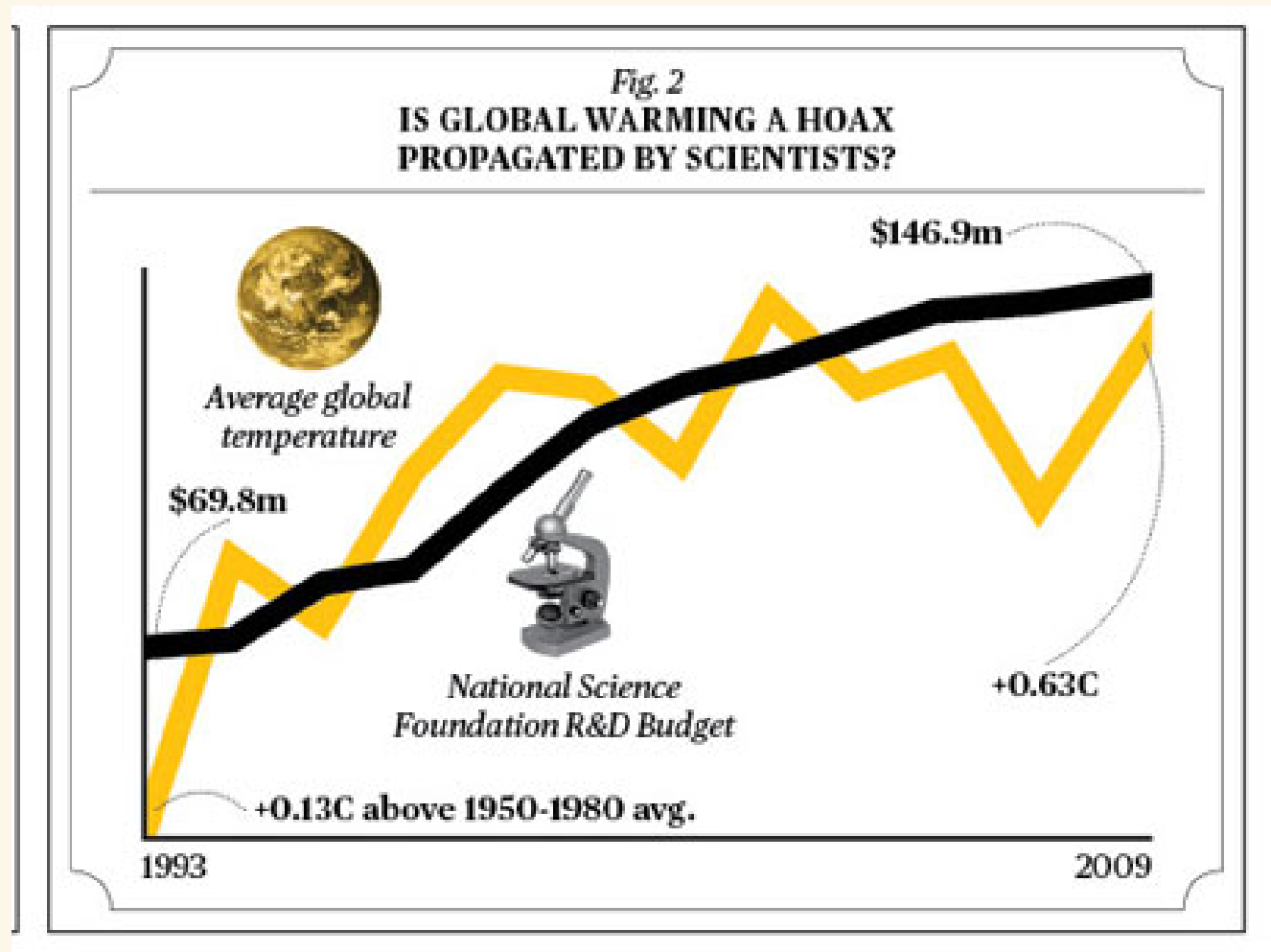


Extra lurking variable

Facebook and Greek Debt Crisis



Global Warming and Scientists



Confounding Variable

A third variable that is associated with both the explanatory variable and the response variable is called a **confounding variable**

A confounding variable can offer a plausible explanation for an association between the two variables.

Whenever confounding variables are present (or may be present), a causal association **CANNOT** be determined!

Experiment Vs Observational Study

An **observational study** is a study in which the researcher does not actively control the value of any variable, but simply observes the values as they naturally exist

An **experiment** is a study in which the researcher actively controls one or more of the explanatory variables

Experiment or Observational Study?

To examine whether playing music in a store increases the amount customers spend, we randomly assign some stores to play music and some to stay silent and compare the average amount spent by customers. Does this describe an experiment or an observational study?

- Experiment
- Observational Study

Experiment or Observational Study?

To examine whether farm-grown salmon contain more omega-3 oils if water is more acidic, we collect samples of salmon and water from multiple fish farms to see if the two variables are related.

- Experiment
- Observational Study

Observational Studies and Confounding Variable

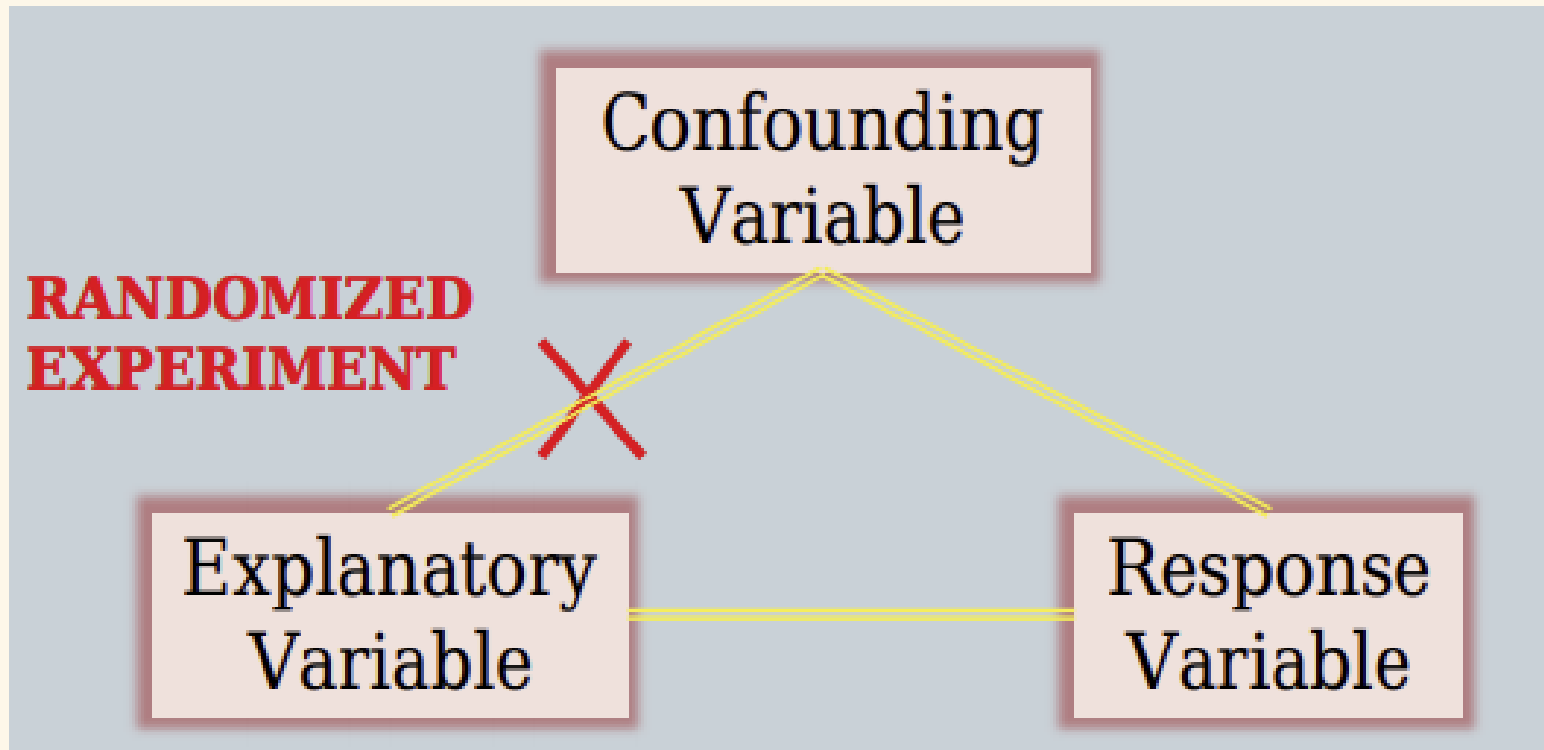
- There are almost always confounding variables in observational studies
- Observational studies can almost never be used to establish causation!!

To avoid confounding variables: Randomly assign values of the explanatory variable!

Randomized Experiments

- In a **randomized experiment**, the explanatory variable for each unit is determined randomly, before the response variable is measured
- The different levels of the explanatory variable are known as **treatments**
- Randomly divide the units into groups, and randomly assign a different treatment to each group
- Observe the response variable after treatments are applied

Elimination of confounding variables



Because the explanatory variable is randomly assigned, it is not associated with any other variables. Confounding variables are eliminated!!!

Exercise and the Brain

- A sample of mice were divided randomly into two groups. One group was given access to an exercise wheel, the other group was kept sedentary
- "The brains of mice and rats that were allowed to run on wheels pulsed with vigorous, newly born neurons, and those animals then breezed through mazes and other tests of rodent IQ" compared to the sedentary mice

Is this evidence that exercise causes an increase in brain activity and IQ, at least in mice?

Randomized experiment can yield causal conclusions!

Knee Surgery and Arthritis

Researchers conducted a study on the effectiveness of a knee surgery to cure arthritis. It was randomly determined whether people got the knee surgery. Everyone who underwent the surgery reported feeling less pain

- Is this evidence that the surgery causes a decrease in pain?

Need a control or comparison group. What would happen without surgery?

Control Group

- When determining whether a treatment is effective, it is important to have a comparison group, known as the **control group**
- All randomized experiments need either a control group, or at least two different treatments to compare

Knee Surgery for Arthritis

- In the knee surgery study, those in the control group received a **fake knee surgery**. They were put under and cut open, but the doctor did not actually perform the surgery. All of these patients also reported less pain!
- The improvement was **indistinguishable** between those receiving the real surgery and those receiving the fake surgery!

What is the reason?

Placebo Effect

- People can experience the effect they think they should be experiencing, even if they aren't actually receiving the treatment
- One study estimated that 75% of the effectiveness of anti-depressant medication is due to the **placebo effect**

Can Video Games Help Teens Beat Depression?

- 168 teens, 2/3rd girls
- Half of the group was randomly assigned to treatment (video game)
- Other half received traditional counseling



Source: Brand X Pictures

44% of those who played video game recovered completely from depression, compared with 26% of those in regular treatment

Placebo and Blinding

- Control groups are often given a **placebo**, a fake treatment that resembles the active treatment as much as possible
- If possible, randomized experiments should be **double-blinded**: neither the participants or the researchers evaluating participants should know which treatment the participants are actually getting

Types of Randomized Experiments

- Randomizing cases into different treatment groups is called a **randomized comparative experiment**
- We can also give each treatment to each case, and just randomize the order in which treatments are received: **matched pairs experiment**
- There are other, more complicated types of randomized experiments (blocking, split plots, ...)

More on Randomization

- Doing a randomized experiment on a random sample is ideal, but rarely achievable. (why?)
- If the focus of the study is using a sample to estimate a population parameter, you need a random sample but do not need a randomized experiment (example: election polling)
- If the focus of the study is establishing causality, you need a randomized experiment and can settle for a non-random sample (example: drug testing)

Randomization in Data Collection

