

# Math 107

Collecting Data: Experiments & Observational Studies  
(Section 1.3)

1. Association vs. Causation

2. Experiments vs. Observational Studies

## Explanatory vs. Response

When we are investigating **relationships** between variables, we often think about two types of variables.

- The result/outcome of interest is called the **response variables**
- The variable(s) used to understand/predict the response variable are called **explanatory variables**

# Association vs. Causation

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

Two variables are **causally associated** if changing the value of the explanatory variable changes the values of the response variable.

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## Your Turn

Come up with two variables that are associated, but not causally.

Come up with two variables that are causally associated.

Turn to the person next to you and discuss for two minutes. I'll then ask for a couple of you to share your thoughts.

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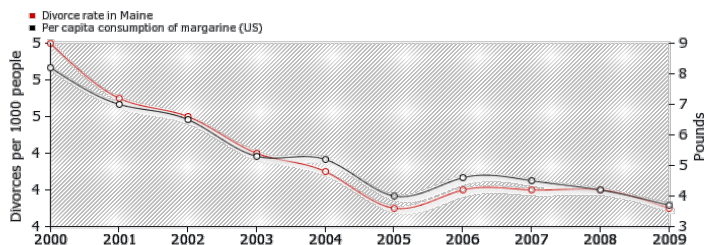
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## Divorce rate in Maine & US per capita margarine consumption?



Source: <http://www.tvlervigen.com/>

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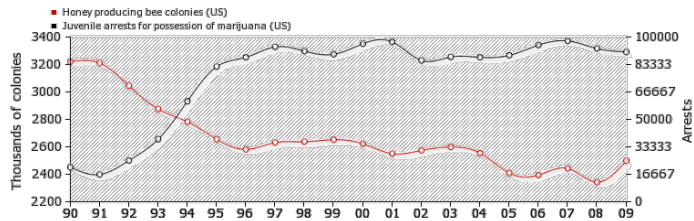
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## US honey producing bee colonies & US juvenile arrests for marijuana possession?



Source: <http://www.tvlervigen.com/>

## College Education & Aging

A Sharper Mind, Middle Age and Beyond  
-NY Times, 1/19/12

*"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."*

Are you convinced that a college degree slows the brain's aging?

## Confounding

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

It can offer a plausible explanation as to why two variables are related

→ causal association cannot be determined when present

## Experiments vs. Observational Studies

In an **observational study** the researcher simply observes what happens.

→ Confounding variables typically present

In an **experiment** the researchers actively manipulates at least one explanatory variable.

→ A *well designed* experiment can account for confounding variables

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## Your Turn

An article about handwriting appeared in the October 11, 2006 issue of the *Washington Post*. The article mentioned that among students who took the essay portion of the SAT exam in 2005-06, those who wrote in cursive scored significantly higher on the essay, on average, than students who used printed block letters.

- Is this an experiment or an observational study?
- Is it reasonable to conclude that writing in cursive caused higher scores on the essay?

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## Your Turn

The same *Washington Post* article also mentioned a different study in which the identical essay was shown to many graders, but some graders were randomly chosen to see a cursive version of the essay and the other graders were shown a version with printed block letters. The average score assigned to the essay with the cursive style was significantly higher than the average score assigned to the essay with the printed block letters.

- Is this an experiment or an observational study?
- Is it reasonable to conclude that writing in cursive caused higher scores on the essay?

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# Establishing Causation

In order to establish causation, an experiment must

1. **Manipulate** explanatory variables (sometimes called factors) to create treatments
2. **Randomly assign** subjects (experimental units) to treatment groups
3. **Compare** the responses of experimental units across treatment groups

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