

# Reasoning About and Graphing Causes

THE FAMILY CIRCUS



"I wish they didn't turn on that seatbelt sign so much! Every time they do, it gets bumpy."

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## Clicker Question

- In an experiment, an investigator
- Measures the independent variable
  - Manipulates the independent variable
  - Manipulates the dependent variable
  - None of the above

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## Clicker Question

- To stop an event from happening you should
- Eliminate a sufficient cause
  - Supply a sufficient cause
  - Eliminate a necessary cause
  - Supply a necessary cause

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## Clicker Question

Plentiful rainfall is

- A sufficient cause of wildflowers blooming
- A contributory cause of wildflowers blooming
- Not a cause of blooming because it is not sufficient to cause blooming
- Too ultimate to count as a cause of wildflowers blooming

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## John Stuart Mill



- Described methods for selecting actual causes among possible causes (before the development of statistics!)
  - Start with variables assumed to include the possible causes
  - Use correlation to separate actual causes from possible causes
    - Mill did not have modern statistics available, so he used eye-ball correlations based on simple tables
  - Failure of a putative cause to correlate with the effect in the right way indicates lack of causation
    - Or better, our inability to find the cause! 5

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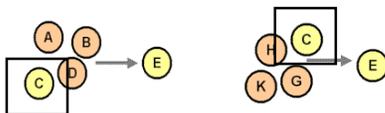
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## Method of Agreement

- Find cases in which the effect has occurred
  - Determine if there is only one thing that they all share
  - If there is, that is (the likely) cause
- Example: some cities have markedly lower rates of tooth decay
  - If fluoride in the water is the only (potentially relevant) thing in common, then it is the likely cause



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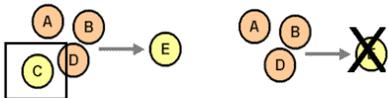
## Table for Method of Agreement

	Dental Education Program	Free Dental Clinics	Fluoride in Water	High salaries for dentists	Low rates of tooth decay
Dullsville	Yes	No	Yes	No	Yes
Bedroom Town	No	Yes	Yes	Yes	Yes
Golfville	No	No	Yes	No	Yes
Megacity	Yes	Yes	Yes	No	Yes

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## Method of Difference

- Find two things that differ in that one has the effect and the other doesn't
  - If there is only one factor on which they differ, that is the likely cause
- Example: two people apply for a loan, but only one gets it
  - The only difference is that the one who was denied once declared bankruptcy
  - The declaration of bankruptcy is the likely cause of the loan being turned down



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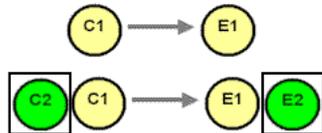
## Table of Method of Difference

	College Education	Earn over \$80K	Own Business	Declared Bankruptcy	Loan Approved
Victor	Yes	Yes	No	Yes	No
Crystal	Yes	Yes	No	No	Yes
Tad	Yes	Yes	No	No	Yes
Chin	Yes	Yes	No	Yes	No

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## Method of Residues

- If there are two (or more) causes and one accounts for one aspect of the effect alone but not another,
  - then the second cause explains that effect
- Horse A alone pulls a cart at 6 miles per hour, but when horse B joins in, they pull the cart at 10 mph
  - Horse B is responsible for the additional 4 mph



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## Method of concomitant variation

- If one potential cause varies in the same or inverse manner as the effect
  - view it as the cause

	Amount of Water	Amount of Fertilizer	Amount of Sunlight	Crop Yield
Plot A	13	2	51	8
Plot B	14	3	45	12
Plot C	12	4	46	16

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## Clicker Question

You call Tom and Ray because your car makes a funny noise. They inquire and learn that you always drive with your pet bird in the back seat. They ask you to leave the bird at home while you drive and you find there is no noise.

- Method of agreement
- Method of difference
- Method of residues
- Method of concomitant variation

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## Clicker Question

A researcher weighs a monkey by stepping on the scale with the monkey in her arms; if her own weight is 132 pounds, and the scale reads 141, then the monkey must weigh 9 pounds.

- Method of agreement
- Method of difference
- Method of residues
- Method of concomitant variation

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## Mill's methods and correlation

- Mill's methods only identify factors that are correlated with the effect
  - But correlation does not establish causation
    - What gives?
- Mill's methods work to sort among possible causes
  - Experiments operate like Mill's methods— finding real causes amongst possible causes
- Must be able to independently identify possible causes before correlation can help establish causation

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## Diagramming causal relations

- To use correlational evidence in assessing causation, it helps to portray hypothesized causal relations clearly
- Using causal diagrams we can evaluate
  - Whether correlational evidence does support causation
  - What manipulations we need to perform when conducting an experiment
  - What factors must be controlled for when experiments are not possible
- Use nodes (boxes) and arrows to represent actual and possible causal relations
  - Nodes represent variables
  - Arrows represent causal relations between variables

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## Developing causal graphs



Representing relations between a battery, a switch, and a fan

Three **variables**, each in a box with its possible values



Use arrow to represent hypothesized causal relation between variables

If the value of the switch causally affects the fan, put an arrow between them



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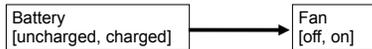
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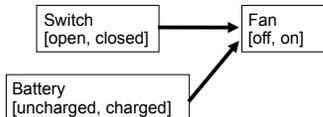
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## Developing causal graphs - 2

Does the state of the battery causally affect the fan?



If there are two independent causes, use an arrow for each



No arrow from *Switch* to *Battery* if the value of *switch* does not affect the value of *battery* and vice versa

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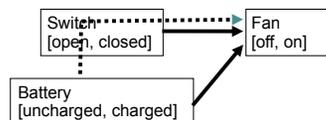
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## Developing causal graphs - 3

These are NOT circuit diagrams: power flows from the battery through the switch, but there is no causal affect of the battery on the switch



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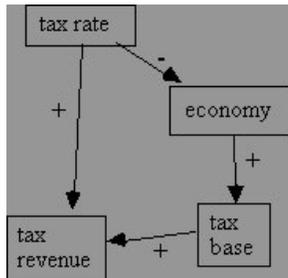
## Negative causation

- Sometimes a cause reduces (rather than increases) the value of the effect variable
  - Flu shots and flu
- Still use arrow between nodes



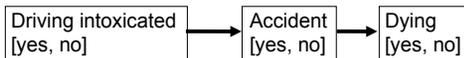
But add *minus sign* to indicate direction of effect

## Example Causal Graph



## Diagramming Indeterministic/ Partial Causes

- In diagramming, we do not distinguish between sufficient and partial/contributory causes

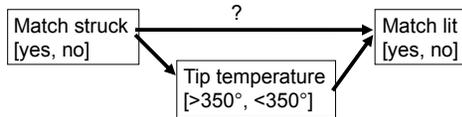


The arrows in this diagram are justified if the probability of having an accident is raised by driving intoxicated and the probability of dying is raised by having an accident

And there is no intermediate or common causes

## Causal intermediates

- Consider lighting a match
  - What is directly produced by the striking action?



In this case, if the match tip does not get above 350°, the match will not light, no matter how much it is struck

Therefore, no direct arrow from *Match struck* to *Match lit*

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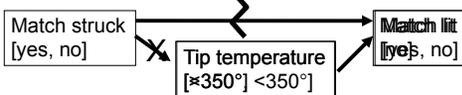
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## How do we detect causal intermediates?



- What if we prevent the temperature of the tip from exceeding 350°?
  - The correlation between match striking and match lighting is lost
    - Preventing the temperature of the tip from exceeding 350° *screens off* the match lighting from the match striking—now no change in the value of *Match struck* can affect the value of *Match lit*

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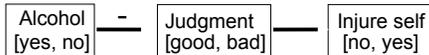
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## Clicker Question

Which statement describes this causal diagram?



- Drinking alcohol promotes good judgment and good judgment causes self injury
- Drinking alcohol impairs good judgment and good judgment causes no self injury
- Drinking alcohol impairs good judgment and good judgment causes self injury
- Drinking alcohol causes good judgment and good judgment causes self injury

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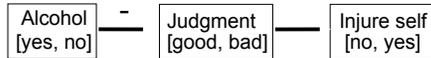
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## Clicker Question

The lack of an arrow directly between alcohol and injure self indicates



- Drinking alcohol does not cause self injury
- Drinking alcohol causes self injury
- Only bad judgment can cause self injury
- The causal effect of alcohol on self injury is mediated/screened off by bad judgment

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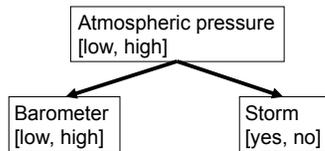
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## Common Causes

- One way events can be correlated without one causing the other is that they are both effects of a common cause
  - Low barometer readings and the occurrence of storms are correlated, but storms do not cause low barometer readings
  - Rather, low atmosphere pressure is a cause of both storms and low barometer readings



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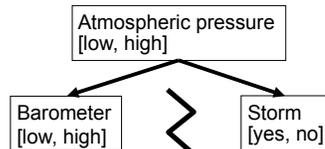
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## Common causes - 2

- What is the difference between direct causation and common cause?
  - Altering the value of *Barometer* alone will not affect the value of *Storm*
  - Altering the value of *Storm* alone will not affect the value of *Barometer*
  - *Storm* is **screened off** from *Barometer*



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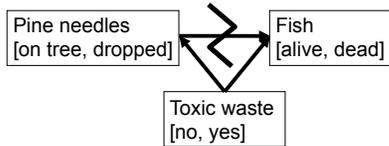
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## Lurking common causes

- Over several weeks the needles from the pine trees along the Moreau river fell into the water.
- Shortly thereafter, many dead fish started washing up on the river banks.
- The Moreau River Chemical Company claimed that it is obvious that the pine needles had killed the fish.



Could the chemical company be hiding something?

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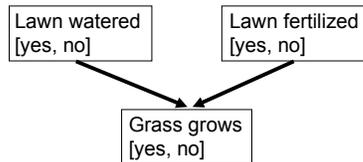
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## Common effects

- No where is it written that a variable can have only one cause



No screening off relation!

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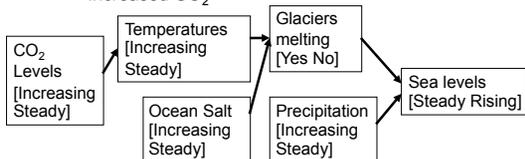
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## Developing Causal Hypotheses

- Consider an effect—rising sea levels
- What might cause that effect?
  - Melting glaciers
  - Increasing precipitation
- What might cause glaciers to melt?
  - Warmer temperatures
  - Increased salt in ocean
- What might cause warmer temperatures?
  - Increased CO<sub>2</sub>




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## Mistakes in reasoning about causes

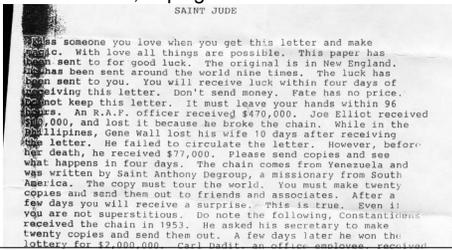
- There are a variety of ways in which people mistakenly infer causal relations when they do not exist

CLASSIC PEANUTS® by Charles Schulz



## Treating coincidence as cause

- Joe gets a chain letter that threatens him with dire consequences if he breaks the chain. He laughs at it and throws it in the garbage. On his way to work he slips and breaks his leg. When he gets back from the hospital he sends out 200 copies of the chain letter, hoping to avoid further accidents.



## Post hoc, ergo propter hoc

- We are prone to see causation when one event precedes another
  - Much superstition begins in this way:
    - The sun disappears in a solar eclipse
    - The members of a community beat drums
    - The sun returns

- Conclusion:



- Contemporary example:

- You sit outside on a damp, cold day and the next day you have a cold

## Confusing cause and effect

- Even when a causal relation seems likely, it is not always clear which is cause and which is effect.
  - Is a child difficult because the parents are short-tempered?
  - Or are the parents short of temper because the child is difficult?



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## Clicker Question

What causal fallacy is illustrated in this example: You heated popcorn in the microwave, and afterwards it would not work. You broke the microwave.

- Ignoring a common cause
- Treating coincidence as a cause
- Post hoc, ergo propter hoc
- Confusing cause and effect

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