Reasoning About and Graphing Causes

Review

- Distinguish **necessary** and **sufficient** causes
- Most causes are neither necessary nor sufficient
  - Rather, **contributory or partial**
  - Increase or decrease the likelihood of an effect
    - Attending class increases the likelihood of doing well on the exam
- Distinguish **proximate** and **ultimate** causes

Clicker Question

Plentiful rainfall is

A. A sufficient cause of wildflowers blooming
B. A contributory cause of wildflowers blooming
C. Not a cause of blooming because it is not sufficient to cause blooming
D. Too ultimate to count as a cause of wildflowers blooming

Review – 2

- Mill's methods: designed to identify the likely cause from amongst possible causes
  - **Method of agreement**
    - Start with cases that agree in the effect and find what possible cause they have in common
  - **Method of difference**
    - Start with cases that differ in the effect and find if there is one possible cause on which they differ
  - **Method of concomitant variation**
    - Find a possible causal variable that varies (directly or inversely) with the effect
  - **Method of residues**
    - Find possible causal variable that is left over once all other effects have been traced to causes

Review – 3: Which method?

Clicker Question

Which of Mill's methods is illustrated in this example:
You and a friend both sign up for Introduction to Politics but are in different sections. Your friend gets an A while you get a C+. You compare yourselves and discover that you each had the same SAT, same GPA going in, skipped three classes, studied 2 hours a week. The TA in your section did not give quizzes but the TA in your friend's class did. Maybe the quizzes made the difference.

A. Method of agreement
B. Method of difference
C. Method of residues
D. Method of concomitant variation

Clicker Question

Which of Mill's methods is illustrated in this example:

Periodically your computer crashes. You tend to run several programs at once. You decide to keep track of which programs you are running. On four occasions when your computer crashed you were running Dynamical Demon. You conclude that this is the cause of your computer crashing.

A. Method of agreement
B. Method of difference
C. Method of residues
D. Method of concomitant variation

Clicker Question

Which of Mill's methods is illustrated in this example:

On Sunday, Tuesday, and Thursday nights you are unable to sleep. Each of those nights you go to a study session where coffee is served. On Monday, Wednesday, Friday, and Saturday you sleep fine and on those nights you don't drink any coffee.

A. Method of agreement
B. Method of difference
C. Method of residues
D. Method of concomitant variation

Clicker Question

Which of Mill's methods is illustrated in this example:
You have three flashlights. One shines brightly, one shines weakly, and the third is barely visible. You take out the batteries from the three flashlights and test them. The first registers a full charge, the second a medium charge, and the third has nearly no charge.

A. Method of agreement
B. Method of difference
C. Method of residues
D. Method of concomitant variation

Review

- In Kentucky the governor approved use of the death penalty and was defeated. In Tennessee the governor refused to impose the death penalty and was reelected.
- In six states the governor seeking reelection is defeated. In each of those states the defeated governor had signed a tax increase bill.
- In five states Governors who approved increased tuition for state colleges were denied reelection, although their stances on other issues varied. In five other states the Governors had similar records to these five on the other issues, but rejected tuition increases. They were all reelected.

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

The Importance of Hypotheses

- Understanding the world is not just a matter of observing it
  - There is no simple procedure for figuring out what is causing something
- Need to start with a good hypothesis
  - In order to figure out what caused TB, Pasteur and Koch had to advance a hypothesis—there was something living that was passed from one ill person to another (a germ)
- Once a cause is proposed (a hypothesis is advanced), one can test whether it is responsible

Diagramming causal relations

- To use correlational evidence in assessing causation, it helps to portray clearly what causal relations are being hypothesized
- 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

Developing causal graphs

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

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

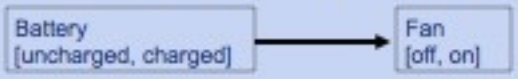
Battery [uncharged, charged]	Switch [open, closed]	Fan [off, on]

Use arrow to represent hypothesized causal relation between variables

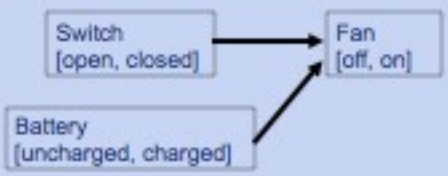
If the value of the switch causally affects the fan, put an arrow between them

Developing causal graphs - 2

Does the state of the battery causally affect the fan?



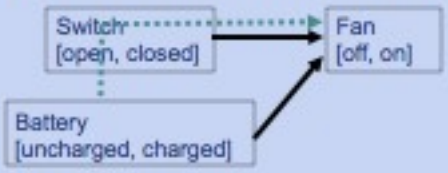
If there are two independent causes, use an arrow for each



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

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

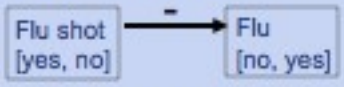


Note: with the above circuit diagram, there will be conditions under which the switch will not affect the fan

but as long as there are conditions under which it will, a causal arrow is used

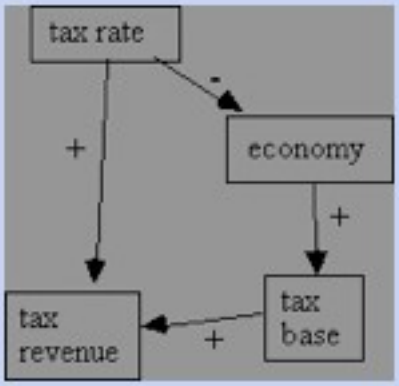
Negative causation

- 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

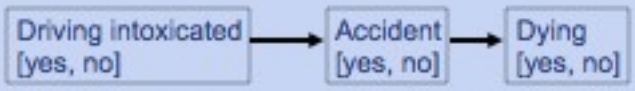


Indeterministic/Partial Causes

- When causes suffice to produce their effects, we speak of them as *determining* their effects
  - *Causal determinism*
- Causation does not require determinism
  - Some causes are only *contributory*
- Such causes raise the probability of the effect without insuring its occurrence
  - Example: smoking and lung cancer

Diagramming Indeterministic/ Partial Causes

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

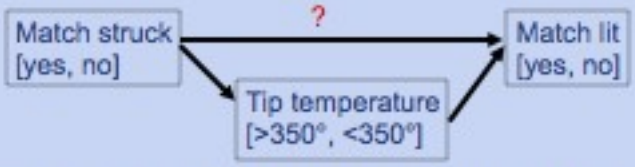


The arrows in this diagram are justified if the probability of having an accident is raised by driving intoxicated and the probability of dying is raised by having an accident

And there is no other causes that are intermediate or common that **screen off** the effects

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*

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* affect the value of *Match lit*

Mediated (ultimate) cause vs. direct (proximate) cause

- Consider the light in your refrigerator. What happens when you close the door?

Case	Door	Light
1	Open	On
2	Closed	Off

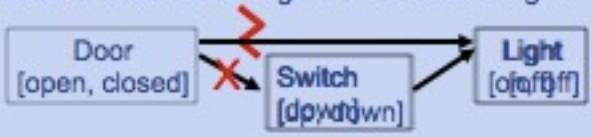
It looks like the causal graph should be

Indirect (ultimate) vs direct (proximate) causation

- But then you discover the light switch

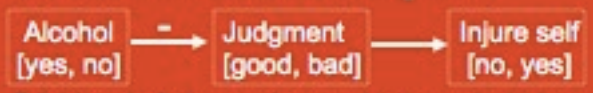
Case	Door	Switch	Light
1	Open	Up	On
2	Open	Down	Off
3	Closed	Down	Off

No situation in which changing the value of the door variable *alone* will change the value of the light



Clicker Question

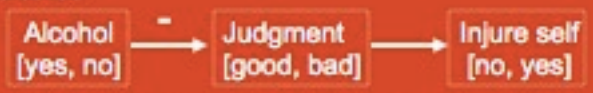
Which statement describes this causal diagram?



A. Drinking alcohol promotes good judgment which causes self injury
B. Drinking alcohol impairs good judgment which causes no self injury
C. Drinking alcohol impairs good judgment which causes self injury
D. Drinking alcohol causes good judgment which causes self injury

Clicker Question

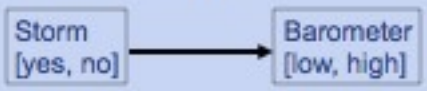
The lack of an arrow directly between alcohol and injure self indicates



A. Drinking alcohol does not cause self injury
B. Drinking alcohol causes self injury
C. Only bad judgment can cause self injury
D. The causal effect of alcohol on self injury is screened off by bad judgment

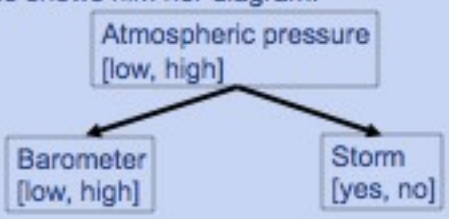
Direct cause or common cause?

A thunderstorm wakes Joe up in the middle of the night. He goes downstairs to get some milk to help him get back to sleep. On the way to the refrigerator, he notices that the barometer has fallen a great deal. Joe concludes that the storm caused the barometer to fall, and draws the following causal diagram:



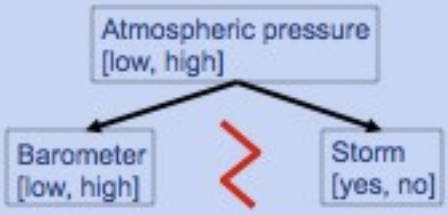
Common causes

- In the morning Joe tells his wife about his conclusion and shows her his diagram.
  - She is not very impressed and tells him that it was a drop in atmospheric pressure that caused both the barometer to drop and the storm.
  - She shows him her diagram:



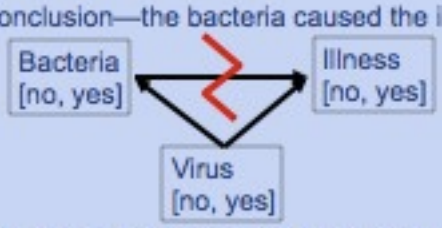
Common causes - 2

- 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*



Lurking possibility of a common cause

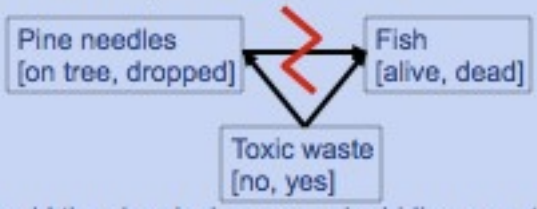
- You are feeling ill and go to the doctor. The doctor does a blood test and it reveals the presence of an abnormal number of bacteria.
  - Conclusion—the bacteria caused the illness?



Perhaps the bacteria like you because your body is already weakened by illness (e.g., due to a virus).

Lurking common causes

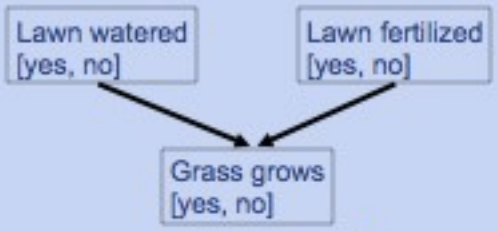
- Over several weeks the needles from the pine trees along the Moreau river fell into the water.
- Shortly thereafter, many dead fish started washing up on the river banks.
- The Moreau River Chemical Company claimed that is it was obvious that the pine needles had killed the fish.



Could the chemical company be hiding something?

Common effects

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



No screening off relation!

Analyzing causation: what causes malaria

- Consider the variable *Has malaria*.
  - Round up the suspects (aka develop hypotheses)

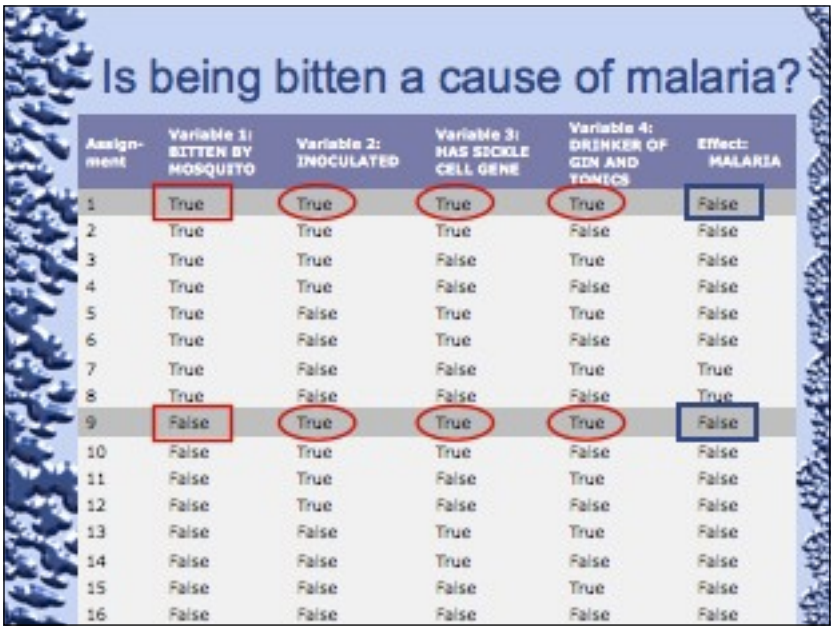
Bitten by mosquito
[yes, no]

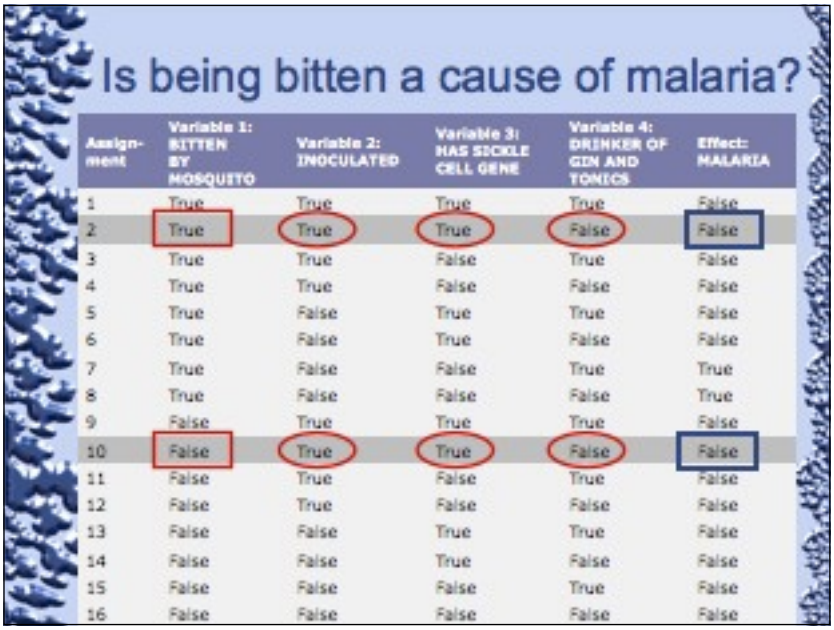
Inoculated
[no, yes]

Has sickle cell gene
[no, yes]

Drinks gin and tonics regularly
[no, yes]

To determine the relation between these and *has malaria* we need to consider the possible values on these variables and whether, for each variable, there is a case in which it makes a difference


Is being bitten a cause of malaria?
Assign-ment
Variable 1: BITTEN BY MOSQUITO
Variable 2: INOCULATED
Variable 3: HAS SICKLE CELL GENE
Variable 4: DRINKER OF GIN AND TONICS
Effect: MALARIA
1 True True True True False
2 True True True False False
3 True True False True False
4 True True False False False
5 True False True True False
6 True False True False False
7 True False False True True
8 True False False False True
9 False True True True False
10 False True True False False
11 False True False True False
12 False True False False False
13 False False True True False
14 False False True False False
15 False False False True False
16 False False False False False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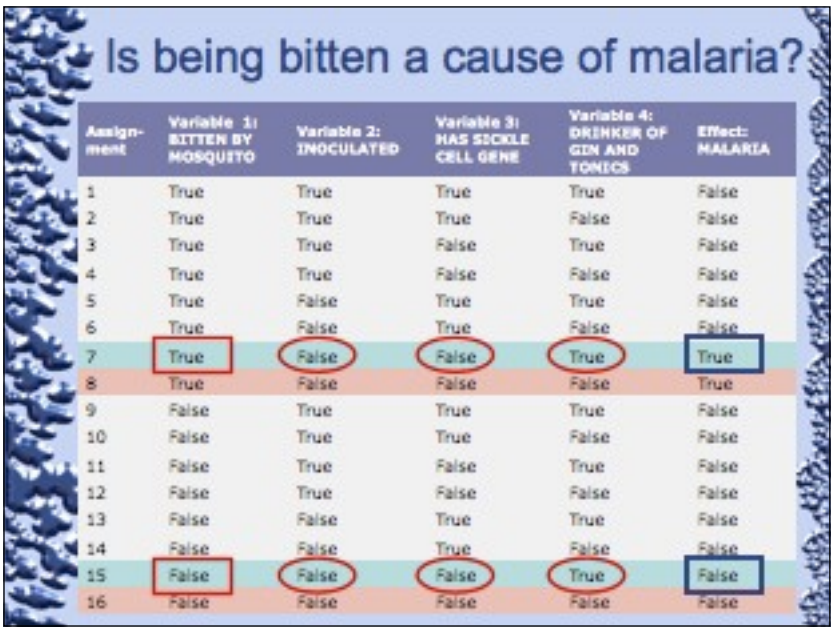
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Assign-ment
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4 True True False False False
5 True False True True False
6 True False True False False
7 True False False True True
8 True False False False True
9 False True True True False
10 False True True False False
11 False True False True False
12 False True False False False
13 False False True True False
14 False False True False False
15 False False False True False
16 False False False False False

Is being inoculated a cause of malaria?

Assign-ment	Variable 1: BITTEN BY MOSQUITO	Variable 2: INOCULATED	Variable 3: HAS SICKLE CELL GENE	Variable 4: DRINKER OF GIN AND TONICS	Effect: MALARIA
1	True	True	True	True	False
2	True	True	True	False	False
3	True	True	False	True	False
4	True	True	False	False	False
5	True	False	True	True	False
6	True	False	True	False	False
7	True	False	False	True	True
8	True	False	False	False	True
9	False	True	True	True	False
10	False	True	True	False	False
11	False	True	False	True	False
12	False	True	False	False	False
13	False	False	True	True	False
14	False	False	True	False	False
15	False	False	False	True	False
16	False	False	False	False	False

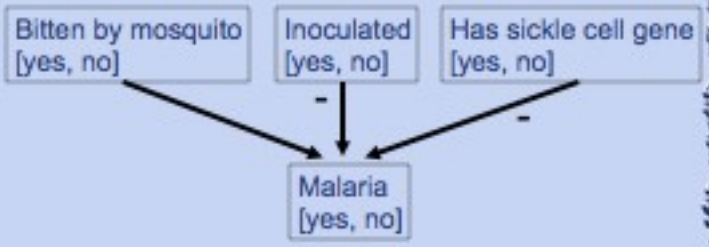
Is having sickle cell gene a cause of malaria?

Assign-ment	Variable 1: BITTEN BY MOSQUITO	Variable 2: INNOCULATED	Variable 3: HAS SICKLE CELL GENE	Variable 4: DRINKER OF GIN AND TONICS	Effect: MALARIA
1	True	True	True	True	False
2	True	True	True	False	False
3	True	True	False	True	False
4	True	True	False	False	False
5	True	False	True	True	False
6	True	False	True	False	False
7	True	False	False	True	True
8	True	False	False	False	True
9	False	True	True	True	False
10	False	True	True	False	False
11	False	True	False	True	False
12	False	True	False	False	False
13	False	False	True	True	False
14	False	False	True	False	False
15	False	False	False	True	False
16	False	False	False	False	False

Is drinking gin and tonics a cause of malaria?

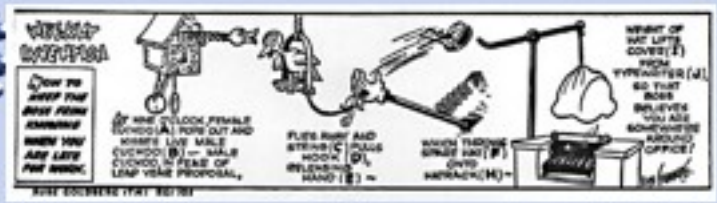
Assign-ment	Variable 1: BITTEN BY MOSQUITO	Variable 2: INNOCULATED	Variable 3: HAS SICKLE CELL GENE	Variable 4: DRINKER OF GIN AND TONICS	Effect: MALARIA
1	True	True	True	True	False
2	True	True	True	False	False
3	True	True	False	True	False
4	True	True	False	False	False
5	True	False	True	True	False
6	True	False	True	False	False
7	True	False	False	True	True
8	True	False	False	False	True
9	False	True	True	True	False
10	False	True	True	False	False
11	False	True	False	True	False
12	False	True	False	False	False
13	False	False	True	True	False
14	False	False	True	False	False
15	False	False	False	True	False
16	False	False	False	False	False

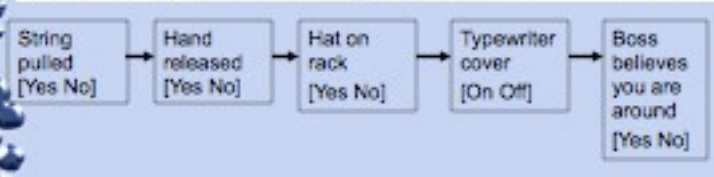
Causal graph for malaria



Drinks gin and tonics regularly [yes, no]

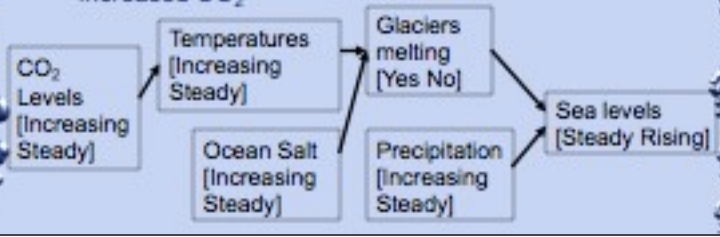
Causal Graph of Rube Goldberg Device for Keeping the Boss from Knowing you are Late





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_2



Causal cycles

- Sometimes two variables are related so that each causes an increase in the other

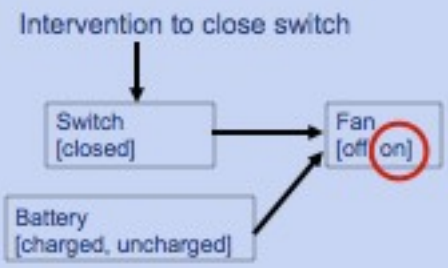
Positive feedback: sometimes results in run-away systems
Negative feedback: used to achieve control

Experiments: testing causation by manipulating causal variable

- Basic principles of causal reasoning:
  - If C causes E, then if we alter the value of C, we should, at least under some conditions, alter the value of E
  - If C does not cause E, then if we alter the value of C alone, we should not alter the value of E
- If the causation is direct, there should be no way to screen off E from C

Reasoning about manipulations

- Manipulations set the value of one of the variables in an effort to determine the effect on another

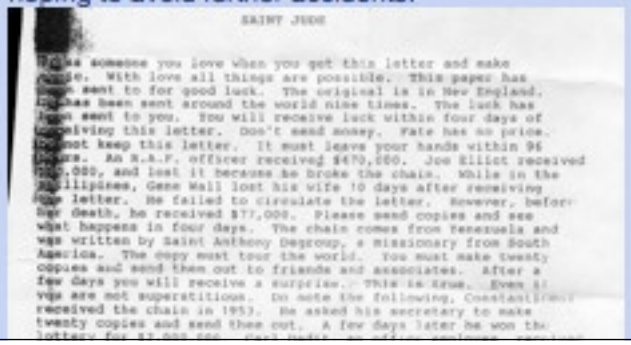


Mistakes in reasoning about causes

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

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.


SAINT JUDE

...s someone you love when you get this letter and make ...e. With love all things are possible. This paper has ... sent to for good luck. The original is in New England, ...has been sent around the world nine times. The luck has ... sent to you. You will receive luck within four days of ...eiving this letter. Don't send money. Fate has no price. ...not keep this letter. It must leave your hands within 96 ...rs. An N.A.F. officer received $470,000. Joe Elliot received ...,000, and lost it because he broke the chain. While in the ...illipines, Gene Wall lost his wife 10 days after receiving ... letter. He failed to circulate the letter. However, before ... death, he received $77,000. Please send copies and see ...at happens in four days. The chain comes from Venezuela and ... written by Saint Anthony Degroup, a missionary from South ...erica. The copy must tour the world. You must make twenty ...copies and send them out to friends and associates. After a ...few days you will receive a surprise. This is true. Even if ... are not superstitious. Do note the following, Constantine ...received the chain in 1953. He asked his secretary to make ...twenty copies and send them out. A few days later he won the ...lottery for $1,000,000. [illegible]

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:

Post hoc, ergo propter hoc - 2

- You are feeling sick.
  You go to the doctor.
  A few days later you begin to feel better.
  Conclusion:

Post hoc, ergo propter hoc - 3

- When the street lights start to come on, the sun goes down. Thus, the turning on of the street lights causes the sun to go down.
- Roosters crow just before the sun rises. Therefore, roosters crowing causes the sun to rise.
- You have a headache so you stand on your head and six hours later your headache goes away. Therefore, . . .
- You put acne medication on a pimple and three weeks later the pimple goes away. Therefore, . . .

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?

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.

A. Ignoring a common cause
B. Treating coincidence as a cause
C. Post hoc, ergo propter hoc
D. Confusing cause and effect

Clicker Question

What causal fallacy is illustrated in this example: Ted leaves bagels for a long time in his cupboard. After a while they have green mold on them. He concludes that they went bad and that caused them to develop mold.

A. Ignoring a common cause
B. Treating coincidence as a cause
C. Post hoc, ergo propter hoc
D. Confusing cause and effect

Need for Experiments or Well-Controlled Observations

- The best evidence as to whether something is a cause of some effect is whether manipulating it changes the value of the effect
- When that isn't possible, one must rely on controlled observations that rule out other possible causes (confounds)