Causal Explanation

Review

- Cause: something which brings about or increases the likelihood of an effect
- Correlations point to and give evidence of causal relations, but do not themselves demonstrate causation
  - Correlation is symmetrical
  - Causation is directional
- Differentiate variables
  - *Independent variable*: possible cause, what is manipulated
  - *Dependent variable*: possible effect, depends on the independent variable

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Clicker Question

In an experiment, an investigator
- A. Measures the independent variable
- B. Manipulates the independent variable
- C. Manipulates the dependent variable
- D. None of the above

Review - 2

- Strongest evidence for causation comes from experiments
  - Manipulate the independent variable and detect effect on the dependent variable
  - Speak of *manipulated* independent variable
- When manipulation is not possible
  - *Measured* independent variable
- In either case, the dependent variable is *measured*

Review - 3

- Testing causal claims
  - Often requires operationally defining the variable or developing measures in terms of which we can secure data
  - To confirm a causal hypothesis
    - Identify a prediction that would not be true if the causal hypothesis were not true—i.e., would not be true if the null hypothesis were true
      - If the prediction is true, reason by modus tollens to the truth of the hypothesis
  - To falsify a causal hypothesis
    - Identify a prediction that would be true were the causal hypothesis true
      - If the prediction is not true, reason by modus tollens to the falsity of the hypothesis

Clicker Question

Which is the conditional premise you would use to confirm the hypothesis that X is the cause of Y?

A. If X is a cause of Y, then there will be a statistically significant difference in Y when X is present

B. If X is a cause of Y, then there will not be a statistically significant difference in Y when X is present

C. If X is not a cause of Y, then there will not be a statistically significant difference in Y when X is present

D. If X is not a cause of Y, then there will be a statistically significant difference in Y when X is present
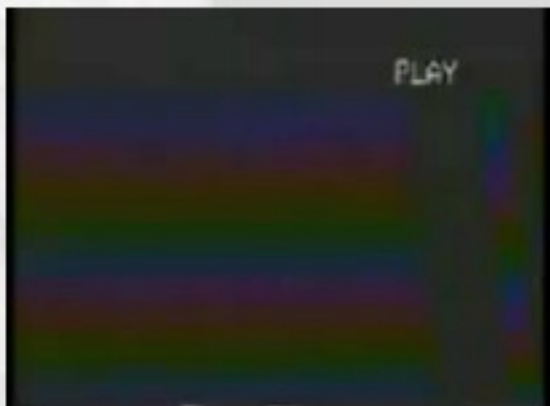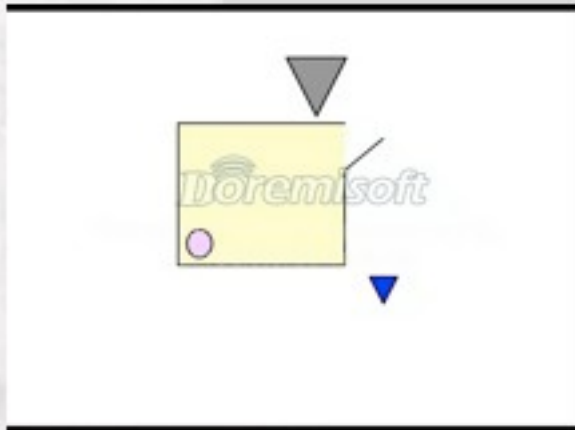
Seeing Causes

- A tradition in philosophy, whose roots lie with David Hume, maintains that we never see causation, only events preceding other events
- But some visual displays such as those developed by Albert Michotte are hard to see in any other way

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Describe what you see

Telling Causal Stories Can be Fun

- Correlation: Amount of ice cream sold correlates with increased deaths by drowning:

  "Increases in nuclear power generator accidents (Chernobyl, Three Mile Island...) have resulted in greenhouse gas increases, ozone layer reduction, average world temperature rise and increases in the fraction of heavy water in rain. Concerns about nuclear catastrophe have resulted in increases in eating disorders, especially among those with a genetic predisposition to obesity. Heavy water in rain has resulted in an increase in the specific gravity of cream produced by cows, while the increasing world temperature has resulted in an increasing attendance at beach resorts, coupled with increased consumption of ice cream. The increased weight of fat worried people whose centre of gravity has been lowered by a rising consumption of heavy ice cream has caused an increased number of deaths by drowning."
  Dr. Paul Gardner, Monash University, Australia

Beyond Seeing and Story Telling

- If a causal relation exists between two variables, then if we can directly manipulate values on one (the independent variable), we should change values on the other (the dependent variable)
- An experiment is precisely an attempt to demonstrate causal relations by manipulating the independent variable and measuring the change on the dependent variable.

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Recall the Logic of Necessary and Sufficient Conditions

- Conditional relations between statements captured with the connective "if, then"
  - If the score is tied, then we will play another round
- The score being tied is **sufficient** for playing another round
- Playing another round is **necessary** when the score is tied
  - Better captured by
    - Only if we play another round was the score tied
- We can extend the notions of *necessary* and *sufficient* to causes

What is a cause?

- A variable, some of whose values bring about or increase the value of the effect variable
- Two more specific notions of cause:
  - The cause is sufficient to bring about the effect
  - The cause is necessary to bring about the effect
- Neither notion of cause captures a large percentage of the cases in which we invoke causation
  - but each is suggestive of important features of causation and help us understand how to test causal claims

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Sufficient causes

- Examples of factors sufficient to bring about an effect
  - Dead battery is sufficient for car not starting
  - Placing water in a normally operating freezer is sufficient for it freezing
  - Ingesting (enough) hemlock is sufficient for dying
  - Increased exercise without eating more is sufficient for weight loss.

The value of sufficient causes

- A sufficient cause gives us a recipe for producing an effect we want
  - If you don't want someone to drive your car, totally run down (or remove) the battery
  - If you want to loose weight, exercise
    - "Whenever I get the urge to exercise, I lie down until the feeling passes away."
      Robert M. Hutchins, former President of the University of Chicago
    - I have never taken any exercise, except for sleeping and resting, and I never intend to take any. Exercise is loathsome.
      —Mark Twain, Essays: Seventieth Birthday

The difficulty with sufficient causes

- For many conditions in which you think you have found a sufficient cause, an exception can be found
  - If you take an antidote with your hemlock (should one be found), you *might* escape death
  - If you put salt in the water, it may not freeze even when temperature is less than 32° F

The difficulty with sufficient causes

- Few factors we identify as causes are really sufficient to bring about their effect
  - They suffice only in the context of background conditions that are assumed to be in place

Turning the ignition switch will start the car, but *only if* it is hooked up to the rest of the ignition system, there is an engine in the car, there is gas, oxygen is available, . . .

Often need to specify a conjunction of factors to arrive at a sufficient cause
- and it is very difficult (perhaps impossible) to note all of them

Necessary causes

- Something that is necessary to produce an effect:
  - Sex is necessary for producing babies
  - Oxygen is necessary for combustion
  - *Herpes zoster* is necessary for chickenpox
  - Early exposure to language is necessary for normal language development

For want of . . .

- For want of a nail, the shoe was lost,
- For want of the shoe, the horse was lost,
- For want of the horse, the rider was lost,
- For want of the rider, the battle was lost,
- For want of the battle, the kingdom was lost,
- And all for the want of a horseshoe nail!

The value of necessary causes

- Provide a way of preventing something
  - Avoiding sex does prevent babies (and AIDs)

  - Eliminating oxygen does stop fires

  - Keeping *Herpes zoster* away from you prevents chickenpox

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The difficulty with necessary causes

- For many supposed necessary causes, there are alternatives
  - Sex is not strictly necessary for producing babies—*in vitro* fertilization can replace it
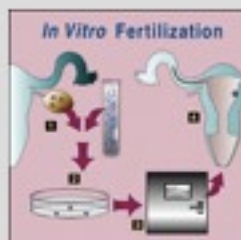
Recap

	Quick description	Value of identifying	Inadequacy as a full characterization of 'cause'	Practical difficulties
Sufficient Causes	A sufficient cause can bring about an effect, (e.g. ordinarily, pulling a trigger of a loaded gun suffices to fire a gun).	If we know sufficient causes, we can be empowered to bring about desired effects, (e.g. if we know how to fire the gun, we can.)	Events which we may want to call causes aren't strictly speaking sufficient, since we can imagine contexts in which the causes fail to suffice, (e.g. pulling a trigger fires a gun, but not if the bullets are duds).	Sufficient conditions are difficult to identify, and, perhaps, impossible to perfectly specify, since such a specification would require an exhaustive description of the relevant background conditions.
Necessary Causes	A necessary cause is a precondition that must obtain for the effect to manifest, (e.g. guns need a hammer to fire.)	If we know necessary causes, we can prevent effects, (e.g. remove the hammer and the gun will not fire).	Preconditions don't do anything (just because a gun has all its parts, doesn't mean it will fire.)	Necessary conditions are also difficult to identify since the scientific enterprise can reveal, unexpectedly, that what was once supposed necessary is not (pin firing)

Clicker Question

Putting a jar over a candle is
- A. A necessary cause for the candle burning
- B. A necessary cause for putting out the candle
- C. A sufficient cause for putting out the candle
- D. Both a necessary and sufficient cause of putting out the candle

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Clicker Question

To stop an event from happening you should
- A. Eliminate a sufficient cause
- B. Supply a sufficient cause
- C. Eliminate a necessary cause
- D. Supply a necessary cause

Clicker Question

A major challenge in specifying a sufficient cause is

A. There may be alternatives that can produce the effect
B. Further research might identify an alternative way to produce an effect
C. There may be no way to manipulate the sufficient cause
D. One may be assuming background conditions that one has failed to include in the cause

Partial or contributory causes

- Tad: "The problem with our schools is the teachers. There are too many incompetent teachers who either don't know how to teach, or just don't care about teaching any more."
- Ruby: "I think parents are a big part of the problem too. Lots of parents fail to read to their children, never help them with homework, and don't make sure their kids get to bed on time."
- Tad: "So you're saying bad teachers have nothing to do with it?"
- Ruby: "No, I'm saying parents have a lot to do with it too."

Partial or contributory causes

- A factor that increases the likelihood of the event occurring but may not be **either necessary or sufficient** for the effect
  - Viewing TV violence and aggressive behavior
  - Icy roads and car accidents
  - Looking at pornography and abusive treatment of women
  - Genetic factors and heart attacks
  - Fast food diet and heart attacks
  - Vigorous exercise and heart attacks

Uncle John Exception

- My uncle John smoked two packs of cigarettes a day for 75 years, and he never got lung cancer. See, smoking doesn't cause lung cancer.
- This would be an effective *counterexample* if the claim were that smoking is a sufficient cause of lung cancer
- But if the claim is that smoking is a contributory cause, one or even many counterexamples are not telling
  - Rather, what one must do is show that over a population there is no increase in lung cancer among those who smoke

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Why care about contributory causes?

- Even though changes in contributory causes cannot either:
  - Totally prevent the effect
  - Bring about the effect by themselves
- They can significantly **increase** or **decrease** the likelihood of the effect
  - Eliminating fast foods from your diet can **reduce** the risk of heart attacks

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Proximate/ultimate causes

- What was the cause of the Cedar Fire?

- A hunter's flare?

Proximate/ultimate causes

- Failure to remove the dry brush through forest thinning?

Dry conditions

Proximate/ultimate causes

- The growth of seedlings into trees?

The big bang?

Proximate/ultimate causes

- There is generally a history of events, each of which plays a role in bringing about the event of interest
  - Sometimes we are interested in events in close proximity to the effect we wish to explain—proximate cause
  - Sometimes we are interested in events further back in the chain of causation—ultimate causes

- Proximate and ultimate causes are not competitors
  - They are relevant for different explanatory projects

John Stuart Mill

- 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 simple, eye-ball correlations
  - 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!

Method of agreement

- "If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree, is the cause (or effect) of the given phenomenon."
- 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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Method of Agreement

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

Method of Agreement at Work

- Five patients all show amnesia after brain injury:
  - *Patient 1*--damage to the prefrontal cortex and the hippocampus
    Patient 2--damage to the hippocampus, amygdala, and entorhinal cortex
    Patient 3--damage to the thalamus and hippocampus
    Patient 4--damage to the prefrontal cortex, hypothalamus, hippocampus, and amygdala
    Patient 5--damage to the hippocampus and amygdala

Method of difference

- "If an instance in which the phenomena under investigation occurs and an instance in which it does not occur, have every circumstance in common save one, that one occurring only in the former, the circumstance in which alone the two instances differ, is the effect, or the cause, or an indispensable part of the cause, of the phenomenon."

Method of difference - 2

- 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

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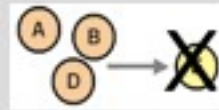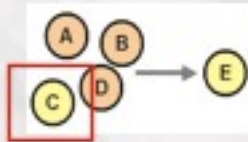
Method of Difference - 3

- Example: two people apply for a loan, and 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

The Example of Yellow Fever

- Once Walter Reed suspected mosquitoes as the transmitter of yellow fever
  - He had one set of volunteers sleep on the soiled clothes and beds of yellow fever patients in a room screened so that no mosquitoes could get in.
    - None of these people contracted the disease.
  - He had another group of volunteers stay completely away from sick patients, except he let mosquitoes that had been allowed to feast first on people sick with the disease bite the patients.
    - These volunteers did get sick.

Joint method of agreement and difference

- The methods of agreement and difference can be used jointly:
  - Find something in common amongst all cases where the effect appears
  - Find matches for all these cases except that they lack the effect and the common ingredient
- Example: Five factory workers are found to be inefficient relative to others who are doing the same work.
  - The efficient workers and the inefficient workers were found to be similar in all relevant ways except one: the inefficient workers were not part of a profit sharing plan.
  - Conclusion: profit sharing causes efficiency.

Method of residues

- "Subduct from any phenomenon such part as is known by previous inductions to be the effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents."

C1 → E1

C2 C1 → E1 E2

Method of residues - 2

- Distinguish three features of a plant's growth pattern:
  - The development of large, healthy green leaves
  - The development of strong stems and root structure
  - The production of fruit and flowers
- Applying a 10-10-10 fertilizer (nitrogen-phosphorus-potassium) results in all three. What causes what? We know that
  - Nitrogen promotes the healthy growth of leaves
  - Potassium encourages the development of stronger stems and roots
- In addition to these, our fertilized plants also produce fruit and flowers more prolifically than usual.
  - Since we know what caused the improved growth of leaves, stems, and roots
    - we infer that the "residue", the increase in the number of fruit and flowers, was caused by the phosphorus

Method of concomitant variation

- "Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner is either a cause or an effect of that phenomenon or is connected with it through some fact of causation."

	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

What is Mill saying?

- Once you have identified the plausible candidate causes
  - Correlation (of a simple matching sort) can isolate the actual (or at least a good candidate) cause
- Assumption behind Mill's methods: one and only one factor is *the* cause, and it is one you have considered
  - But beware, this can sometimes backfire:
    - A man *"drank rye and water on the first night and became drunk. On the second night, he drank scotch and water and became drunk again. On the third night, he got drunk on bourbon and water. He therefore decided that the water was the cause of his getting drunk because it was the common element each time."* (Christiansen, 1994, p. 76)

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.

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

Clicker Question

In January 1997, 2001, and 2004 San Diego had unusually high rainfall. Each of those years there was a strong El Niño.

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

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.

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

Mill's Methods: Probative, but not Definitive

- As the alcohol and water example shows, Mill's methods do not always correctly identify the cause
  - Something might correlate with the effect but not be the cause
  - The causal structure might be complex, involving interactions of multiple factors
- Nonetheless, Mill's methods are useful in clarifying our understanding of cause and how we test for it
- The development of modern statistics came after Mill and provided a much more potent tool for identifying the factors Mill was seeking to identify