

**Chapter 9 – Scientific experiments and inference to the best explanation
Answers to select “Getting familiar with...” exercises.**

Getting familiar with... confirmation and disconfirmation.

A. For each of the following observations and causal claims, construct a simple experimental model.

[There are many possible tests in each case. These are just suggestions.]

1. “I have allergic reactions. Shellfish probably causes them.”

O: I have allergic reactions.

H: Shellfish causes allergic reactions.

I: Eating only shellfish will cause allergic reactions while eating anything else won't.

If shellfish causes my allergic reactions, then eating only shellfish will cause allergic reactions while eating anything else won't.

[Notice that our test implication includes a contrast class (eating anything else won't). This helps prevent confirmation bias. Even if shellfish causes allergic reactions, that doesn't mean nothing else does. So even if you experience an allergic reaction while eating seafood, something else may be giving you the allergic reaction. You can't be sure it's the shellfish. We include a contrast class in each of our experiments.]

3. “Many people have allergic reactions. I bet they are all caused by eating shellfish.”

O: Many people have allergic reactions.

H: Shellfish causes allergic reactions.

I: Most people who eat shellfish will have allergic reactions while most people who don't have no allergic reactions.

If shellfish causes allergic reactions, then most people who eat shellfish will have allergic reactions while most people who don't have no allergic reactions.

5. "I cannot sleep at night. I probably drink too much tea."

O: I cannot sleep at night.

H: Drinking too much tea prevents me from sleeping at night.

I: I will not be able to sleep on the nights I drink tea, and I will be able to sleep on nights I drink anything else or nothing at all.

If drinking too much tea prevents me from sleeping at night, then I will not be able to sleep on the nights I drink tea, and I will be able to sleep on nights I drink anything else or nothing at all.

B. State two initial conditions and at least one auxiliary hypothesis that might affect the results of experiments on these hypotheses.

[There are many possible tests in each case. These are just suggestions.]

1. Ethanol makes gasoline less efficient.

IC₁: The same type of combustion is used throughout the experiment.

IC₂: Each sample is burned for the same amount of time.

AH: Our test for efficiency is reliable.

3. Eating a lot of cheese and beer raises bad cholesterol levels.

IC₁: The same cheese and beer is used throughout the experiment.

IC₂: The test subjects were not eating cheese or drinking beer outside of the experiment.

AH: Food is the primary cause of cholesterol levels.

5. Changing time zones causes jet lag.

IC₁: The same number of time zones are crossed in each test.

IC₂: The speed of the travel in each experiment is comparable (car travel is compared with car travel; air travel is compared with air travel).

AH: Jet lag is measurable.

C. Short answer.

1. Explain the limitations of simple models of confirmation and disconfirmation.

The simple models are subject to various biases, such as hidden variables and vagueness. The more precise the test implication, the more reliable the experiment will be.

3. Come up with two examples of an observation and a hypothesis. Construct a simple experimental model for each.

3.a.

Observation: Cats knead on soft blankets.

Hypothesis: Kneading simulates the movement kittens use to get milk from their mothers' teats.

I: Bottle-fed kittens will not knead on soft blankets when they are adults, whereas naturally fed kittens will.

If kneading simulates the movement kittens use to get milk from their mothers' teats, then bottle-fed kittens will not knead on soft blankets when they are adults, whereas naturally fed kittens will.

3.b.

Observation: My vehicle is not getting the same fuel efficiency (miles per gallon) as it used to.

Hypothesis: Inexpensive gasoline is less fuel efficient than expensive gasoline.

I: Using expensive gasoline will increase fuel efficiency, whereas using inexpensive gasoline will decrease fuel efficiency.

If inexpensive gasoline is less fuel efficient than expensive gasoline, then using expensive gasoline will increase fuel efficiency, whereas using inexpensive gasoline will decrease fuel efficiency.

5. Based on your understanding of this chapter and the last, why are experiments so important for causal arguments?

Experiments are important for identifying the actual cause of event, as opposed to mere correlations, coincidences, and temporal orderings. They introduce control conditions that help us rule out other potential causes and determine the extent to which a hypothesized cause is actually responsible for an observation.

Getting familiar with... formal experiments.

A. For each of the following causal claims, explain how you would set up a randomized experimental study. (i) Identify some relevant controls for your test group; (ii) explain a specific test implication; (iii) explain how you would conduct the experiment.

1. Eating a bag of potato chips every day leads to weight gain.

(i) I would choose test subjects that are within the same age range, and who have a variety lifestyles, gender, and past medical histories.

(ii) This causal claim is confirmed if the experimental group gains at least three pounds after consuming 8 ounces of potato chips a day for 35 days.

(iii) I would randomly distribute the test subjects in a control group, in which subjects abstained from eating potato chips but otherwise lived normally for 35 days, and an experimental (or test) group, which subjects lived normally except they eat 8 ounces of potato chips each day for 35 days. I would have research assistants weigh each test subject prior to the experiment and after each 7 day period. I would have research assistants collect the data and present it blindly so that I wouldn't know which results were from the control group and which were from the experimental group.

3. Taking large doses of vitamin C reduces the duration of a cold.

(i) I would make sure all participants are adults, have a cold (and not something else) that started roughly around the same time, and have no allergic reactions to vitamin C.

(ii) This causal claim is confirmed if taking 1000 mg of vitamin C per day during a cold reduces the cold's duration by at least 25%.

(iii) I could randomly distribute test subjects into a control group, which takes only pain and sinus pressure relieving medications with no vitamin C, and an experimental group, which, in addition to normal pain and sinus relieving medications, takes 1000 mg of vitamin C per day. I would then have research assistants monitor the duration of each test subject's cold and compile the data for each group. I would have research assistants present the data blindly so that I wouldn't know which results were from the control group and which were from the experimental group.

5. Drinking protein shakes after weight lifting increases strength.

(i) I would select a sample of men and women between the ages of 20 and 40 who consistently but relatively recently (within the first two years) began weightlifting, both men and women, who weightlift between three and five times per week.

(ii) The causal claim is confirmed if the experimental group experiences 25% more strength (or more) in bench press and dead lift than the control group after weightlifting for three months.

(iii) I would split the test subjects into a control group that drinks 15 oz. of water before and after weightlifting, and an experimental group that drinks 15 grams of whey protein before and after weightlifting. I would have each participant track the weights he or she uses for bench press and dead lift. Also, at the end of each week, lab assistants will have subjects demonstrate a “max lift” for both exercises and track the weights. At the end of three months, the increases between the two groups will be compared.

B. For each of the following causal claims, explain how you would set up a prospective study. (i) Identify some relevant controls for your test group. (ii) Explain a specific test implication. (iii) Explain how you would conduct the experiment.

1. Smoking marijuana causes short-term memory loss.

(i) I would select a group of men and women between the ages of 18 and 35, some of whom have recently started smoking at least one marijuana cigarette at least twice a week (the experimental group) and some of whom never smoke marijuana (the control group). I would control for other drug use and health conditions (especially head trauma).

(ii) The causal claim is confirmed if the experimental group has significantly lower short-term memory retrieval than the control group.

(iii) Once a week for six weeks, I would assign each group a set of short-term memory exercises. After six weeks, lab assistants would display the results in a blinded chart to see if the experimental group had significantly worse short-term memory retrieval.

3. Chevy trucks are safer in accidents than other models.

(i) I would select a sample of Chevy truck drivers (the experimental group) and a group of those who drive other makes of truck (the control group). I would control for past accident history, types of driving (city or highway), and amount of driving time.

(ii) The causal claim is confirmed if subjects in the experimental group experience fewer injuries in accidents over a five year period than those in the control group.

(iii) I would have participants self-report any accidents they have, describing the accidents, including the driving conditions and the nature of the damage, and including any documents from insurance companies, law enforcement, and medical facilities. After five years, I would compare the data from the two groups.

5. Cigars are much less harmful than cigarettes.

(i) I would select a sample of men and women between the ages of 20 and 40, some of whom smoke cigarettes (no more than 1 pack per day) and some of whom smoke cigars (no more than 1 per day). I would control for the use of other substances (alcohol, hookah, chewing tobacco, prescription medication), medical history, and lifestyle.

(ii) The causal claim will be confirmed if cigar smokers experience at least 25% fewer smoking-related illnesses over a ten year period (including shortness of breath, emphysema, bronchitis lung cancer, mouth cancer, and heart disease).

(iii) Subjects would be asked to complete a self-assessment report of their daily tobacco use as well as their lifestyles and health problems once a month for ten years. Each participant would get a medical physical each year of the study. At the end of ten years, I would compare the illness rates between the two groups.

C. For each of the following observations, explain how you would set up a retrospective study to discover a relevant cause. (i) Identify some relevant controls for your test group; (ii) explain how you would conduct the experiment.

1. My allergy attacks have increased.

(i) I would select a group of people who are similar to you (in age and gender) whose allergy attacks have increased over the past two years. I would control for obvious factors that were not like you own, such as recently moving to a new geographic region, recently getting a pet, and changing prescription medications.

(ii) The hypothesis that X is the cause will be confirmed if more than 65% of test subjects experienced the same change over the past two years.

(iii) I would have you and the participants list all major changes to their lives and compare the lists. If there is a single change running through more than 65% of them, the hypothesis will be that this explains the increased allergies. If there is not a single change, further investigation into similarities and differences should be conducted.

3. An overall sense of well-being.

(i) I would select a group of people who are similar to you (in age and gender) who have recently experienced an overall sense of well-being. I would control for short-term factors that merely relieve certain sorts of anxiety, such as getting a job and falling in love.

(ii) The hypothesis that X is the cause will be confirmed if more than 65% of test subjects recently made a similar lifestyle change.

(iii) I would ask participants about their lifestyle and eating behaviors, looking for patterns of eating a certain type of food (e.g., raw vegan or pescatarian) and specific behaviors (e.g., yoga for stress relief, picking up a sport or hobby). If there is a single change running through more than 65% of them, the hypothesis will be that this explains the overall sense of well-being. If there is not a single change, further investigation into similarities and differences should be conducted.

5. More white people are employed at company X than black people.

(i) I would select a sample of the notes from past hiring decisions kept on file by Human Resources, including the number of applicants, the races of the applicants, the experience and education of each applicant, and the reasons given for the decisions made.

(ii) The hypothesis that X is the cause will be confirmed if more than 75% of the hires are either explicitly or implicitly explained by X.

(iii) I would look at the racial distribution of the applicants. If only 10% of the employees are black and only 10% of the applicants are black, there are no obvious racial concerns. If only 10% of the employees are black and 50% of the applicants were black, then I would look at education and experience, and then the hiring notes. If at least 75% of applicants were clearly chosen on the basis of their qualifications and education, the explanation for the observation may simply be chance. If at least 75% of

applicants were clearly chosen for a biased reason (a cultural name, gender, prejudicial comments), the explanation for the observation may be a type of prejudice.

Getting familiar with... informal experiments.

A. For each of the following informal experiments, explain which of Mill's Methods is being used.

1. You get sick after eating lobster for the first time and conclude that it probably was the lobster.

Method of Agreement. Eating lobster co-occurs with (or agrees) with getting sick. This is likely a hasty generalization. More testing would be needed to rule out other causes.

3. Susan has to weigh her cat at the vet, but the cat won't sit still on the scale by herself. So, the nurse records Susan's weight first, which is 120 pounds. Then she has Susan and her cat step on the scale, notes that the scale now reads 130 pounds, and records the cat's weight as ten pounds. Which of Mill's methods did the nurse utilize?

Method of Residues. The cat's weight are the pounds left over after subtracting Susan's weight. It is the residue left after the experiment.

5. Zoe sneezed every time she went into the basement. Her parents tried to figure out what was causing it by vacuuming, dusting, and scrubbing the floors, in various combinations, and having her go in the basement afterward. Zoe still sneezed, no matter if the basement was: vacuumed, but not dusted or scrubbed; dusted, but not vacuumed or scrubbed; scrubbed but not vacuumed or dusted; vacuumed and dusted, but not scrubbed; vacuumed and scrubbed, but not dusted; dusted and scrubbed, but not vacuumed; vacuumed, dusted, *and* scrubbed. One thing that stayed the same throughout the vacuuming, dusting, and scrubbing events, however, was that the fabric softener sheets (which gave off a strong lilac smell) were present every time Zoe went into the basement. Zoe's parents then removed the fabric softener sheets and sent Zoe into the basement. Finally, she stopped sneezing! They put the fabric softener sheets back, and guess what happened? She sneezed again. They have since stopped using the fabric softener sheets and Zoe no longer sneezes when she goes into the basement. So, from this whole ordeal, Zoe and her parents reasoned that the fabric softener sheets were what caused the sneezing.

Joint Method of Agreement and Difference. There are four possible causes: a substance that vacuuming could eliminate, a substance dusting could eliminate, a substance scrubbing could eliminate, and the scent of the

dryer sheets. After showing that sneezing does not “agree” with any of the first three or combinations thereof, the only remaining factor that co-occurs with the sneezing is the scent of the dryer sheets.

B. Set up one of Mill’s Methods to identify the cause of each of the following observations.

1. “I suddenly feel sick after eating at that restaurant. How could I tell if it was something I ate?”

Method of Difference. Compare all you ate with what others ate. Of those who didn’t eat what you ate, did any get sick? If not, then the cause of your sick feelings may be what you ate.

3. “There are at least four reasons for my headaches: stress, allergies, head injury, and brain tumors. How can I tell which one?”

Method of Residues. Since brain tumors are the most difficult to get rid of, try to subtract stress, allergies, and head injuries from your life. After subtracting each, consider whether you still have a headache. If not, the item most recently removed might be the cause of your headaches.

5. “When I visit some people, I get really hungry, when I visit others I don’t. What might cause that?”

Method of Agreement. Compare what is in each person’s house (objects, scents, colors). If those where you are hungry have similar scents or colors or something else, that may be what triggers your hungry feeling.

Getting familiar with... inference to the best explanation.

A. For each of the following, identify both the explanation and the observation being explained.

1. Flowers are able to reproduce because bees transfer pollen from flower to flower as they gather pollen for honey.

Observation: Flowers reproduce with one another without moving or touching.

Explanation: Bees move pollen from one flower to another, thereby facilitating reproduction. Therefore, the bees' transferring pollen explains how flowers can reproduce without moving or touching.

3. Of course your eyes no longer itch. Benadryl stops allergic reactions.

Observation: My eyes were itching, but now they are not.

Explanation: Itching eyes are caused by allergic reactions. Benadryl stops allergic reactions, and you took Benadryl. So, taking Benadryl explains why your eyes no longer itch.

5. The car is out of gas. That's why it won't start.

Observation: The car won't start.

Explanation: The car is out of gas. Cars need gas to start. Thus, the car's not having gas explains why the car won't start.

B. Using the theoretical virtues, construct one plausible and one implausible explanation for each of the following observations.

1. I don't have my wallet.

Plausible: You often leave your wallet lying around. And I remember your putting it on the table while we were at dinner. You probably left it on the table.

This explanation is plausible because it is simple (it explains with a minimum number of assumptions and objects); it is conservative, appealing to your typical behavior with your wallet; it is fecund, because we can go back to the table and check; it is independently testable if there are others who know your behavior with your wallet; and it has explanatory power because it fully explains why you don't have your wallet.

Implausible: Zeus is angry with you because last week you were mean to that guy with one eye. Zeus is hiding your wallet to punish you.

This explanation is implausible because it lacks simplicity (because it seems unnecessary to invoke Zeus to explain a missing wallet); it is not conservative (it appeals to Zeus, whom very few people believe exists); it lacks fecundity because it does not help us learn more about what makes Zeus angry or how to stop it; it is not independently testable since we

cannot tell whether Zeus is really angry by any other means and whether he was involved in any other punishing events.

3. I feel strange after drinking that glass of milk.

Plausible: You are developing lactose intolerance.

This is plausible because it is conservative (lactose intolerance is a common condition); it is simple (it appeals to only one condition); it is independently testable because we could conduct experiments to see if you really are lactose intolerant; while it does not have a broad explanatory scope (it doesn't explain many strange feelings), it does explain this case specifically, so it has explanatory depth.

Implausible (suggestion 1): The milk was bad.

This has all the virtues of lactose intolerance but it is less plausible because it is not conservative (few people can drink bad milk without realizing it is bad).

Implausible (suggestion 2): The milk was poisoned.

This is implausible because it is not simple (it requires motive and poison, which are not already included in the description of the case—this may be different in, say, a crime novel); it lack conservativeness because few people are poisoned.

5. My boyfriend just freaked out when I asked him about his sister.

Plausible: He has a bad relationship with his sister.

This is plausible because bad sibling relationships are common (conservative); it is independently testable and fecund; and it has some explanatory scope because it might explain many of his reactions related to his sister.

Implausible: He has a sexual relationship with his sister.

This is implausible because incestuous relationships are rare (not conservative; it is not simple (there would have to be a complex set of social factors for this to happen); it is unlikely to be independently testable if he or his sister is unwilling to talk about it.

C. In each of the following there is an observation and two possible explanations. Using at least one theoretical virtue, identify the best of the two explanations.

1. Observation: This shrimp tastes funny.

Explanation A: The shrimp is bad.

Explanation B: It is not shrimp.

Explanation A is more plausible because, even though there are shrimp substitutes, few are convincing (so it isn't conservative). Also, there would have to be a reason someone would substitute something else for shrimp (this is possible—the restaurant ran out of actual shrimp—but rare; mostly someone would just say they are out of shrimp). And shrimp goes bad fairly easily (conservative).

3. Observation: This guitar string keeps going out of tune.

Explanation A: The string is old.

Explanation B: Someone keeps turning the tuner when I'm not looking.

Explanation A is more plausible because even though B is possible (especially with a prankster bandmate), it is less conservative and more complex than the common occurrence that old strings regularly go out of tune.

5. Observation: An oil spill in Prince William Sound, Alaska

Explanation A: Members of Green Peace bombed the tanker.

Explanation B: The tanker hit a reef due to the negligence of an overworked crew.

Both events are rare, so it is difficult to say without more information which is more plausible. We might know that Green Peace is particularly concerned to protect the environment, and that causing an oil spill would have to be a by-product of some other goal, and therefore, a mistake on their part. Bombing a tanker and making a mistake is less likely than just bombing the tanker. Also, there is some evidence that blue collar employees like tanker pilots are often overworked, so this explanation has some plausibility on grounds of conservatism. Both have roughly equal explanatory scope and depth. Explanation B is simpler than A because no people other than the ship's crew are needed for B.

D. In each of the following there is an observation and two more complicated possible explanations. Using at least two theoretical virtues, identify the best of the two explanations.

1. Observation: “That landscape is represented perfectly on this photo paper! How is that?”

Explanation A: A small demon lives inside cameras and each has the unique ability to paint pictures very quickly and very accurately.

Explanation B: Thin papers, treated with chemicals to make it sensitive to the light of the three primary colors (yellow, red, blue), are exposed to the light reflected from a scene (such as a landscape). This produces a reverse image of the scene called a “negative.” A chemical reaction with silver halide causes the negative to transfer (by a process called “diffusion”) into a positive image, or, the image you wanted to capture.

Explanation A is vastly simpler than B, but it is also vastly less conservative (we don’t generally believe demons exist, or, at least, if we do, we don’t think they’re employed by artists). Explanation B is more plausible because of its scope and fecundity—we can explain more and do more with the information in B than with the information in A.

3. Observation: “Hey, these two pieces of steel get warm when you rub them together quickly. Why is that?”

Explanation A: There is a liquid-like substance called “caloric” that is warm. When an object has more caloric it is warmer than when it has less. Caloric flows from warmer objects to cooler just as smoke dissipates into a room. When you rub two pieces of steel together, the caloric from your body flows into the steel.

Explanation B: Objects are made of molecules. Heat is a function of the speed at which molecules in an object are moving. If the molecules move faster, the object becomes warmer; if the molecules slow down, the object becomes cooler. Rubbing two metal pieces together quickly speeds up the molecules in the metal, thereby making it warmer.

Both explanations are consistent with our experience of heat, and both explain heat widely and in depth. Explanation B is simpler in that it relies only on the physical elements we already believe make up objects and does not require the extra substance “caloric.” The important factors will be independent testability and fecundity after we construct some experiments.