

# **Business Logic**

## **Lecture 11: Inductive Reasoning**

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## Lecture Learning Objectives:

At the end of the lecture, you will be able to:

1. Distinguish deductive arguments from inductive argument.
2. Appraise analogical arguments.
3. Show that a given argument is mistaken by refuting through logical analogy.
4. Examine the concept of cause and causal connections.

## Inductive Arguments and Statistical Generalizations

An **inductive argument** is an argument whose conclusion is supposed to follow from its premises with a high level of probability, rather than with certainty. This means that although it is possible that the conclusion doesn't follow from its premises, it is unlikely that this is the case. We said that **inductive arguments** are "defeasible," meaning that we could turn a strong inductive argument into a weak inductive argument simply by adding further premises to the argument. In contrast, **deductive arguments** that are valid can never be made invalid by adding further premises. Recall our "Tweets" argument:

1. Tweets is a healthy, normally functioning bird
2. Most healthy, normally functioning birds fly
3. Therefore, Tweets probably flies

Without knowing anything else about Tweets, it is a good bet that Tweets flies. However, if we were to add that Tweets is 6 ft. tall and can run 30 mph, then it is no longer a good bet that Tweets can fly (since in this case Tweets is likely an ostrich and therefore can't fly). The **second premise**, "most healthy, normally functioning birds fly," is a statistical generalization. **Statistical generalizations** are generalizations arrived at by empirical observations of certain regularities. **Statistical generalizations** can be either universal or partial. **Universal generalizations** assert that all members (i.e., 100%) of a certain class have a certain feature, whereas partial generalizations assert that most or some percentage of members of a class have a certain feature. **For example**, the claim that "67.5% of all prisoners released from prison are rearrested within three years" is a partial generalization that is much more precise than simply saying that "most prisoners released from prison are rearrested within three years." In contrast, the claim that "all prisoners released from prison are rearrested within three years" is a universal generalization. As we can see from these examples, deductive arguments typically use universal statistical generalizations whereas inductive arguments typically use partial statistical generalizations. Since statistical generalizations are often crucial premises in both deductive and inductive arguments, being able to evaluate when a statistical generalization

is good or bad is crucial for being able to evaluate arguments. What we are doing in evaluating statistical generalizations is determining whether the premise in our argument is true (or at least well supported by the evidence). **For example**, consider the following inductive argument, whose premise is a (partial) statistical generalization:

1. 70% of voters say they will vote for candidate X
2. Therefore, candidate X will probably win the election.

This is an inductive argument because even if the premise is true, the conclusion could still be false (for example, an opponent of candidate X could systematically kill or intimidate those voters who intend to vote for candidate X so that very few of them will actually vote). Furthermore, it is clear that the argument is intended to be inductive because the conclusion contains the word “probably,” which clearly indicates that an inductive, rather than deductive, inference is intended. Remember that in evaluating arguments we want to know about the strength of the inference from the premises to the conclusion, but we also want to know whether the premise is true! We can assess whether or not a statistical generalization is true by considering whether the statistical generalization meets certain conditions. There are **two conditions** that any statistical generalization must meet in order for the generalization to be deemed “good.”

1. Adequate sample size: the sample size must be large enough to support the generalization.
2. Non-biased sample: the sample must not be biased

A **sample** is simply a portion of a population. A **population** is the totality of members of some specified set of objects or events. **For example**, if I were determining the relative would be the total number of cars and trucks that drive down my street on a given day. If I were to sit on my front porch from 12- 2 pm and count all the cars and trucks that drove down my street, that would be a sample. A **good statistical generalization** is one in which the sample is representative of the population. When a sample is representative, the characteristics of the sample match the characteristics of the population at large. **For example**, my method of sampling cars and trucks that drive down my street would be a good method as long as the proportion of trucks to cars that drove down my street between 12-2 pm matched the proportion of trucks to cars that drove down my street during the whole day. If for some reason the number of trucks that drove down my street from 12-2 pm was much higher than the average for the whole day, my sample would not be representative of the population I was trying to generalize about (i.e., the total number of cars and trucks that drove down my street in a day). The “adequate sample size” condition and the “non-biased sample” condition are ways of making sure that a sample is representative. In the rest of this section, we will explain each of these conditions in turn.

It is perhaps easiest to illustrate these two conditions by considering what is wrong with statistical generalizations that fail to meet one or more of these conditions. **First**, consider a case in which the sample size is too small (and thus the adequate sample size condition is not met). If I were to sit in front of my house for only fifteen minutes from 12:00-12:15 and saw only one car, then my sample would consist of only 1 automobile, which happened to be a car. If I were to try to generalize from that sample, then I would have to say that only cars (and no trucks) drive down my street. But the evidence for this universal statistical generalization (i.e., “every automobile that drives down my street is a car”) is extremely poor since I have sampled only a very small portion of the total population (i.e., the total number of automobiles that drive down my street). Taking this sample to be representative would be like going to Flagstaff, AZ for one day and saying that since it rained there on that day, it must rain every day in Flagstaff. Inferring to such a generalization is an informal fallacy called “hasty generalization.” One commits the fallacy of hasty generalization when one infers a statistical generalization (either universal or partial) about a population from too few instances of that population. Hasty generalization fallacies are very common in everyday discourse, as when a person gives just one example of a phenomenon occurring and implicitly treats that one case as sufficient evidence for a generalization. This works especially well when fear or practical interests are involved. **For example**, Jones and Smith are talking about the relative quality of Fords versus Chevys and Jones tells Smith about his uncle’s Ford, which broke down numerous times within the first year of owning it. Jones then says that Fords are just unreliable and that that is why he would never buy one. The generalization, which is here ambiguous between a universal generalization (i.e., all Fords are unreliable) and a partial generalization (i.e., most/many Fords are unreliable), is not supported by just one case, however convinced Smith might be after hearing the anecdote about Jones’s uncle’s Ford.

The non-biased sample condition may not be met even when the adequate sample size condition is met. **For example**, suppose that I count all the cars on my street for a three-hour period from 11-2 pm during a weekday. Let’s assume that counting for three hours straight give us an adequate sample size. However, suppose that during those hours (lunch hours) there is a much higher proportion of trucks to cars, since (let’s suppose) many work trucks are coming to and from worksites during those lunch hours. If that were the case, then my sample, although large enough, would not be representative because it would be biased. In particular, the number of trucks to cars in the sample would be higher than in the overall population, which would make the sample unrepresentative of the population (and hence biased).

Another good way of illustrating sampling bias is by considering polls. So, consider candidate X who is running for elected office and who strongly supports gun rights and is the candidate of choice of the NRA. Suppose an organization runs a poll to determine

how candidate X is faring against candidate Y, who is actively anti-gun rights. Suppose that the way the organization administers the poll is by polling subscribers to the magazine, Field and Stream. Suppose the poll returned over 5000 responses, which, let's suppose, is an adequate sample size and out of those responses, 89% favored candidate X. If the organization were to take that sample to support the statistical generalization that "most voters are in favor of candidate X" then they would have made a mistake. If you know anything about the magazine Field and Stream, it should be obvious why. Field and Stream is a magazine whose subscribers who would tend to own guns and support gun rights. Thus, we would expect that subscribers to that magazine would have a much higher percentage of gun rights activists than would the general population, to which the poll is attempting to generalize. But in this case, the sample would be unrepresentative and biased and thus the poll would be useless. Although the sample would allow us to generalize to the population, "Field and Stream subscribers," it would not allow us to generalize to the population at large.

Let's consider one more example of a sampling bias. Suppose candidate X were running in a district in which there was a high proportion of elderly voters. Suppose that candidate X favored policies that elderly voters were against. For example, suppose candidate X favors slashing Medicare funding to reduce the budget deficit, whereas candidate Y favored maintaining or increasing support to Medicare. Along comes an organization who is interested in polling voters to determine which candidate is favored in the district. Suppose that the organization chooses to administer the poll via text message and that the results of the poll show that 75% of the voters favor candidate X. Can you see what's wrong with the poll—why it is biased? You probably recognize that this polling method will not produce a representative sample because elderly voters are much less likely to use cell phones and text messaging and so the poll will leave out the responses of these elderly voters (who, we've assumed make up a large segment of the population). Thus, the sample will be biased and unrepresentative of the target population. As a result, any attempt to generalize to the general population would be extremely ill-advised.

Before ending this section, we should consider one other source of bias, which is a bias in the polling questionnaire itself (what statisticians call the "instrument"). Suppose that a poll is trying to determine how much a population favors organic food products. We can imagine the questionnaire containing a choice like the following:

Which do you prefer?

- a. products that are expensive and have no FDA proven advantage over the less expensive products

b. products that are inexpensive and have no FDA proven disadvantage over more expensive products

Because of the phrasing of the options, it seems clear that many people will choose option “b.” Although the two options do accurately describe the difference between organic and non- organic products, option “b” sounds much more desirable than option “a.” The phrasing of the options is biased insofar as “a” is a stand-in for “organic” and “b” is stand-in for “non-organic.” Even people who favor organic products may be more inclined to choose option “b” here. Thus, the poll would not be representative because the responses would be skewed by the biased phrasing of the options. Here is another example with the same point:

Which do you favor?

a. Preserving a citizen’s constitutional right to bear arms

b. Leaving honest citizens defenseless against armed criminals

Again, because option “b” sounds so bad and “a” sounds more attractive, those responding to a poll with this question might be inclined to choose “a” even if they don’t really support gun rights. This is another example of how bias can creep into a statistical generalization through a biased way of asking a question.

**Random sampling** is a common sampling method that attempts to avoid any kinds of sampling bias by making selection of individuals for the sample a matter of random chance (i.e., anyone in the population is as likely as anyone else to be chosen for the sample). The basic justification behind the method of random sampling is that if the sample is truly random (i.e., anyone in the population is as likely as anyone else to be chosen for the sample), then the sample will be representative. The trick for any random sampling technique is to find a way of selecting individuals for the sample that doesn’t create any kind of bias. A common method used to select individuals for a random sample (for example, by Gallup polls) is to call people on either their landline or cell phones. Since most voting Americans have either a landline or a cell phone, this is a good way of ensuring that every American has an equal chance of being included in the sample. Next, a random number generating computer program selects numbers to dial. In this way, organizations like Gallup are able to get something close to a random sample and are able to represent the whole U.S. population with a sample size as small as 1000 (with a margin of error of +/- 4). As technology and social factors change, random sampling techniques have to be updated. For example, although Gallup used to call only landlines, eventually this method became biased because many people no longer owned landlines, but only cell phones. If some new kind of technology replaces cell phones and landlines, then Gallup will have to adjust the way it obtains a sample in order to reflect the changing social reality.

**Exercise 1:** What kinds of problems, if any, do the following statistical generalizations have?

If there is a problem with the generalization, specify which of the two conditions (adequate sample size, non-biased sample) are not met. Some generalizations may have multiple problems. If so, specify all of the problems you see with the generalization.

1. Bob, from Silverton, CO drives a 4x4 pickup truck, so most people from Silverton, CO drive 4x4 pickup trucks.

**Answer:** Hasty generalization (you can't infer something general from just one case here—the sample size is way too small). There is also a sampling bias present: even if many others people from Silverton, CO drove pickups, it doesn't follow that people generally do. There is a high percentage of trucks in Silverton because the rough roads there almost require trucks.

2. Tom counts and categorizes birds that land in the tree in his backyard every morning from 5:00-5:20 am. He counts mostly morning doves and generalizes, "most birds that land in my tree in the morning are morning doves."

3. Tom counts and categorizes birds that land in the tree in his backyard every morning from 5:00-6:00 am. He counts mostly morning doves and generalizes, "most birds that land in my tree during the 24-hour day are morning doves."

4. Tom counts and categorizes birds that land in the tree in his backyard every day from 5:00-6:00 am, from 11:00-12:00 pm, and from 5:00- 6:00 pm. He counts mostly morning doves and generalizes, "most birds that land in my tree during the 24-hour day are morning doves."

5. Tom counts and categorizes birds that land in the tree in his backyard every evening from 10:00-11:00 pm. He counts mostly owls and generalizes, "most birds that land in my tree throughout the 24-hour day are owls."

6. Tom counts and categorizes birds that land in the tree in his backyard every evening from 10:00-11:00 pm and from 2:00-3:00 am. He counts mostly owls and generalizes, "most birds that land in my tree throughout the night are owls."

**Answer:** This seems to be a good generalization, assuming that he keeps up this regimen on multiple days. The difference, of course, is that instead of making his generalization cover the whole day, his generalization is only about the birds that land in his tree during the night.

7. A poll administered to 10,000 registered voters who were homeowners showed that 90% supported a policy to slash Medicaid funding and decrease property taxes. Therefore, 90% of voters support a policy to slash Medicaid funding.

8. A telephone poll administered by a computer randomly generating numbers to call, found that 68% of Americans in the sample of 2000 were in favor of legalizing recreational marijuana use. Thus, almost 70% of Americans favor legalizing recreation marijuana use.

9. A randomized telephone poll in the United States asked respondents whether they supported a) a policy that allows killing innocent children in the womb or b) a policy that

saves the lives of innocent children in the womb. The results showed that 69% of respondents choose option “b” over option “a.” The generalization was made that “most Americans favor a policy that disallows abortion.”

10. Steve’s first rock and roll concert was an Ani DiFranco concert, in which most of the concertgoers were women with feminist political slogans written on their t-shirts. Steve makes the generalization that “most rock and roll concertgoers are women who are feminists.” He then applies this generalization to the next concert he attends (Tom Petty) and is greatly surprised by what he finds.

### **Explanation and the Seven Explanatory Virtues**

**Explanations** help us to understand why something happened, not simply convince us that something happened. However, there is a common kind of inductive argument that takes the best explanation of why x occurred as an argument for the claim that x occurred. **For example**, suppose that your car window is broken and your iPod (which you left visible in the front seat) is missing. The immediate inference you would probably make is that someone broke the window of your car and stole your iPod. What makes this a reasonable inference? What makes it a reasonable inference is that this explanation explains all the relevant facts (broken window, missing iPod) and does so better than any other competing explanation. In this case, it is perhaps possible that a stray baseball broke your window, but since (let us suppose) there is no baseball diamond close by, and people don’t play catch in the parking garage you are parked in, this seems unlikely. Moreover, the baseball scenario doesn’t explain why the iPod is gone. Of course, it could be that some inanimate object broke your window and then someone saw the iPod and took it. Or perhaps a dog jumped into the window that was broken by a stray baseball and ate your iPod. These are all possibilities, but they are remote and thus much less likely explanations of the facts at hand. The much better explanation is that a thief both broke the window and took the iPod. This explanation explains all the relevant facts in a simple way (i.e., it was the thief responsible for both things) and this kind of thing is (unfortunately) not uncommon—it happens to other people at other times and places. The baseball-dog scenario is not as plausible because it doesn’t happen in contexts like this one (i.e., in a parking garage) nearly as often and it is not as simple (i.e., we need to posit two different events that are unconnected to each other—stray baseball, stray dog—rather than just one—the thief). Inference to the best explanation is a form of inductive argument whose premises are a set of observed facts, a hypothesis that explains those observed facts, and a comparison of competing explanations, and whose conclusion is that the hypothesis is true. The example we’ve just been discussing is an inference to the best explanation. Here is its form:

1. Observed facts: Your car window is broken and your iPod is gone.
2. Explanation: The hypothesis that a thief broke the window and stole your iPod

provides a reasonable explanation of the observed facts.

3. Comparison: No other hypothesis provides as reasonable an explanation.

4. Conclusion: Therefore, a thief broke your car window and stole your iPod.

Notice that this is an inductive argument because the premises could all be true and yet the conclusion is false. Just because something is reasonable, doesn't mean it is true. After all, sometimes things happen in the world that defy our reason. So perhaps the baseball-dog hypothesis was actually true. In that case, the premises of the argument would still be true (after all, the thief hypothesis is still more reasonable than the baseball-dog hypothesis) and yet the conclusion would be false. But the fact that the argument is not a deductive argument isn't a defect of the argument, because inference to the best explanation arguments are not intended to be deductive arguments, but inductive arguments. Inductive arguments can be strong even if the premises don't entail the conclusion. That isn't a defect of an inductive argument, it is simply a definition of what an inductive argument is!

As we've seen, in order to make a strong inference to the best explanation, the favored explanation must be the best (or the most reasonable). But what makes an explanation reasonable? There are certain conditions that any good explanation must meet. The more of these conditions are met, the better the explanation. The first, and perhaps most obvious condition, is that the hypothesis proposed must actually explain all the observed facts. **For example**, if, in order to explain the facts that your car window was broken and your iPod was missing, someone were to say offer the hypothesis that a rock thrown up from a lawnmower broke the window of your car, then this hypothesis wouldn't account for all the facts because it wouldn't explain the disappearance of your iPod. It would lack the explanatory virtue of explaining all the observed facts. The baseball-dog hypothesis would explain all the observed facts, but it would lack certain other explanatory virtues, such as "power" and "simplicity." In the remainder of this section, I will list the seven explanatory virtues and then I will discuss each one in turn. The **seven explanatory virtues** are:

1. **Explanatoriness**: Explanations must explain all the observed facts.

2. **Depth**: Explanations should not raise more questions than they answer.

3. **Power**: Explanations should apply in a range of similar contexts, not just the current situation in which the explanation is being offered.

4. **Falsifiability**: Explanations should be falsifiable—it must be possible for there to be evidence that would show that the explanation is incorrect.

5. **Modesty:** Explanations should not claim any more than is needed to explain the observed facts. Any details in the explanation must relate to explaining one of the observed facts.

6. **Simplicity:** Explanations that posit fewer entities or processes are preferable to explanations that posit more entities or processes. All other things being equal, the simplest explanation is the best. This is sometimes referred to as “Ockham’s razor” after William of Ockham (1287-1347), the medieval philosopher and logician.

7. **Conservativeness:** Explanations that force us to give up fewer well-established beliefs are better than explanations that force us to give up more well-established beliefs.

Suppose that when confronted with the observed facts of my car window being broken and my iPod missing, my colleague Jeff hypothesizes that my colleague, Paul Jurczak did it. However, given that I am friends with Paul, that Paul could easily buy an iPod if he wanted one, and that I know Paul to be the kind of person who has probably never stolen anything in his life (much less broken a car window), this **explanation** would raise many more questions than it answers. Why would Paul want to steal my iPod? Why would he break my car window to do so? Etc. This explanation raises as many questions as it answers and thus it lacks the explanatory **virtue of “depth.”**

Consider now an explanation that lacks the explanatory **virtue of “power.”** A good example would be the stray baseball scenario, which is supposed to explain, specifically, the breaking of the car window. Although it is possible that a stray baseball broke my car window, that explanation would not apply in a range of similar contexts since people don’t play baseball in or around parking garages. So not many windows broken in parking garages can be explained by stray baseballs. In contrast, many windows broken in parking garages can be explained by thieves. Thus, the thief explanation would be a more powerful explanation, whereas the stray baseball explanation would lack the explanatory virtue of power.

**Falsifiability** can be a confusing concept to grasp. How can anything having to do with being false be a virtue of an explanation? An example will illustrate why the possibility of being false is actually a necessary condition for any good empirical explanation. Consider the following explanation. My socks regularly disappear and then sometime reappear in various places in the house. Suppose I were to explain this fact as follows. There is an invisible sock gnome that lives in our house. He steals my socks and sometimes he brings them back and sometimes he doesn’t. This explanation sounds silly and absurd, but how would you show that it is false? It seems that the hypothesis of the sock gnome is designed such that it cannot be shown to be false—it cannot be falsified. The gnome is invisible, so you can never see it do its thing. Since there is no way to observe it, it seems you can never prove nor disprove the existence of the sock gnome. Thus, you can neither confirm nor disconfirm the hypothesis. But such a hypothesis is a

defective hypothesis. Any empirical hypothesis (i.e., a hypothesis that is supposed to explain a set of observed facts) must at least be able to be shown false. The sock gnome hypothesis lacks this virtue—that is, it lacks the explanatory virtue of being falsifiable. In contrast, if I were to hypothesize that our dog, Violet, ate the sock, then this hypothesis is falsifiable. **Falsifiability** requires only that it be possible to show that the hypothesis is false. If we look for evidence that would show that the hypothesis is false, but we won't find that evidence, then we have confirmed that hypothesis. In contrast, an unfalsifiable hypothesis cannot be confirmed because we cannot specify any evidence that would show false, so we can't try to look for such evidence (which is what a rigorous scientific methodology requires).

The explanatory virtue of "**simplicity**" tells us that all other things being equal, the simplest explanation is the better explanation. More precisely, an explanation that posits fewer entities or processes in order to explain the observed facts is better than an explanation that posits more entities and processes to explain that same set of observed facts. Here is an example of an explanation that would lack the **virtue of simplicity**. Suppose that all three of our cars in our driveway were broken into one night and that the next morning the passenger's side rear windows of each car were broken out. If I were to hypothesize that three separate, unrelated thieves at three different times of the night broke into each of the cars, then this would be an explanation that lacks the virtue of simplicity. The far simpler explanation is that it was one thief (or one related group of thieves) that broke into the three cars at roughly the same time. In the domain of science, upholding simplicity is often a matter of not positing new entities or laws when we can explain the observed facts in terms of existing entities and laws. My earlier example of the sock gnome stealing the socks vs. our dog Violet taking the socks is a good example to illustrate this. Sock gnomes would be a new kind of entity that we don't have any independent reason to think exists, but our dog Violet clearly already exists and since the observed facts can be explained by Violet's actions rather than that of a sock gnome, the Violet explanation possesses the explanatory virtue of simplicity, whereas the sock gnome explanation lacks the explanatory virtue of simplicity. However, sometimes science requires that we posit new kinds of entities or processes, as when Copernicus and Galileo suggested that the sun, rather than the earth, was at the center of the "solar system" in order to explain certain astronomical observations. In physics new entities are often posited in order to explain the observations that physicists make. **For example**, the elementary particle dubbed "the Higgs boson" was hypothesized by Peter Higgs (and others) in 1964 and was confirmed in 2012. Much earlier, in 1897, J.J. Thompson and his collaborators, drawing on the work of earlier German physicists, discovered the electron—one of the first elementary particles to be discovered. So there is nothing wrong with positing new laws or entities—that is how science progresses. Simplicity doesn't say that one should never posit new entities; that would be absurd. Rather, it tells us that if the observed facts can be explained without having to posit new entities, then that

explanation is preferable to an explanation that does posit new entities (all other things being equal). Of course, sometimes the observations cannot be explained without having to change the way we understand that world. This is when it is legitimate to posit new entities or scientific laws.

The last explanatory **virtue—conservativeness**—tells us that better explanations are ones that force us to give up fewer well-established beliefs. Like simplicity, **conservativeness** is an explanatory virtue only when we are considering two explanations that each explain all the observed facts, but where one conflicts with well-established beliefs and the other doesn't. In such a case, the former explanation would lack the explanatory virtue of conservativeness, whereas the latter explanation would possess the virtue of conservativeness. Here is **an example** to illustrate the virtue of conservativeness. Suppose that there are some photographs that vaguely seem to indicate a furry, bipedal humanoid creature that does not look human. My friend Chris offers the following explanation: the creature in those photos is Bigfoot, or Sasquatch. In contrast, I maintain that the creature in the photos is a person in a Bigfoot suit. Given just this evidence (the blurry photos), Chris's explanation lacks the virtue of conservativeness since his explanation requires the existence of Bigfoot, which is contrary to well-established beliefs that Bigfoot is merely folklore, not a real creature. In contrast, my explanation possesses the virtue of conservativeness since there is nothing about someone dressing up in a costume and being caught on camera (or even someone doing so to play a practical joke or to perpetuate a false belief in a certain population) that conflicts with well-established beliefs. My explanation doesn't require the existence of Bigfoot, but just the existence of human beings dressed up to look like Bigfoot.

**Exercise 2** : Identify which explanatory virtues, if any, the following explanations lack and explain why it lacks that particular virtue. If there is a better explanation, suggest what it might be.

1. Bob explains the fact that he can't remember what happened yesterday by saying that he must have been kidnapped by aliens, who performed surgery on him and then erased his memory of everything that happened the day before returning him to his house.

**Answer:** This could be any number of them, including: depth (why would the aliens have kidnapped him and then returned him to his home?), power (this explanation cannot be used in a range of different circumstances—a better explanation is simply that he has some kind of amnesia), or simplicity (if we don't have any other reason to admit there are aliens, then we should simply chalk it up to some kind of amnesia).

2. Mrs. Jones hears strange noises at night such as the creaking of the floor downstairs and rattling of windows. She explains these phenomena by hypothesizing that there is a 37-pound badger that inhabits the house and that emerges at night in search of Wheat Thins and Oreos.

3. Edward saw his friend Tom at the store in their hometown of Lincoln, Nebraska just an hour ago. Then, while watching the World Cup on television, he saw someone that looked just like Tom in the crowd at the game in Brazil. He hypothesizes that his friend Tom must have an identical twin that Tom has never told him about.
4. Edward's friend Tom died two years ago. But just yesterday Tom saw someone who looked and spoke exactly like Tom. Edward hypothesizes that Tom must have come back to life.
5. Edward's friend Tom died twenty years ago when Tom was just 18. But just yesterday Edward saw someone who looked and spoke exactly like Tom. Edward hypothesizes that Tom must have had a son that he did not know about and that this person must have been Tom's son.
6. Elise has the uncanny feeling that although her family members look exactly the same, something just isn't right about them. She hypothesizes that her family members have been replaced with imposters who look and act exactly like her real family members and that no one can prove that this happened.

### **Analogical Arguments**

Another kind of common inductive argument is an argument from analogy. In an argument from analogy, we note that since something x shares similar properties to something y, then since y has characteristic A, x probably has characteristic A as well. **For example**, suppose that I have always owned Subaru cars in the past and that they have always been reliable, and I argue that the new car I've just purchased will also be reliable because it is a Subaru. The **two things** in the analogy are 1) the Subarus I have owned in the past and 2) the current Subaru I have just purchased. The similarity between these two things is just that they are both Subarus. Finally, the conclusion of the argument is that this Subaru will share the characteristic of being reliable with the past Subarus I have owned. Is this argument a strong or weak inductive argument? Partly it depends on how many Subarus I've owned in the past. What this illustrates is that better arguments from analogy will invoke more relevant similarities between the things being compared in the analogy. This is a key condition for any good argument from analogy: the similar characteristics between the two things cited in the premises must be relevant to the characteristic cited in the conclusion.

Here is an ethical argument that is an argument from analogy.<sup>1</sup> Suppose that Bob uses his life savings to buy an expensive sports car. One day Bob parks his car and takes a walk along a set of train tracks. As he walks, he sees in the distance a small child whose leg has become caught in the train tracks. Much to his alarm, he sees a train coming towards the child. Unfortunately, the train will reach the child before he can (since it is moving very fast) and he knows it will be unable to stop in time and will kill the child. At

just that moment, he sees a switch near him that he can throw to change the direction of the tracks and divert the train onto another set of tracks so that it won't hit the child. Unfortunately, Bob sees that he has unwittingly parked his car on that other set of tracks and that if he throws the switch, his expensive car will be destroyed. Realizing this, Bob decides not to throw the switch and the train strikes and kills the child, leaving his car unharmed. What should we say of Bob? Clearly, that was a horrible thing for Bob to do and we would rightly judge him harshly for doing it. In fact, given the situation described, Bob would likely be criminally liable. Now consider the following situation in which you, my reader, likely find yourself (whether you know it or not—well, now you do know it). Each week you spend money on things that you do not need. For example, I sometimes buy \$5 espressos from Biggby's or Starbuck's. With the money that you could save from forgoing these luxuries, you could, quite literally, save a child's life.

Given these facts, and comparing these two scenarios (Bob's and your own), the argument from analogy proceeds like this:

1. Bob chose to have a luxury item for himself rather than to save the life of a child.
2. "We" regularly choose having luxury items rather than saving the life of a child.
3. What Bob did was morally wrong.
4. Therefore, what we are doing is morally wrong as well.

The two things being compared here are Bob's situation and our own. The argument then proceeds by claiming that since we judge what Bob did to be morally wrong, and since our situation is analogous to Bob's in relevant respects (i.e., choosing to have luxury items for ourselves rather than saving the lives of dying children), then our actions of purchasing luxury items for ourselves must be morally wrong for the same reason.

One way of arguing against the conclusion of this argument is by trying to argue that there are relevant disanalogies between Bob's situation and our own. For example, one might claim that in Bob's situation, there was something much more immediate he could do to save the child's life right then and there. In contrast, our own situation is not one in which a child that is physically proximate to us is in imminent danger of death, where there is something we can immediately do about it. One might argue that this disanalogy is enough to show that the two situations are not analogous and that, therefore, the conclusion does not follow.

So, we've seen that an argument from analogy is strong only if the following **two conditions** are met:

1. The characteristics of the two things being compared must be similar in relevant respects to the characteristic cited in the conclusion.

2. There must not be any relevant disanalogies between the two things being compared. Arguments from analogy that meet these two conditions will tend to be stronger inductive arguments.

**Exercise 3** : Evaluate the following arguments from analogy as either strong or weak. If the argument is weak, cite what you think would be a relevant disanalogy.

1. Every painting by Rembrandt contains dark colors and illuminated faces, therefore the original painting that hangs in my high school is probably by Rembrandt, since it contains dark colors and illuminated faces.

**Answer:** Weak: if the painting is hanging in your high school, it probably isn't a Rembrandt. That is the disanalogy: even if the colors are very similar, almost all Rembrandts hang in galleries, not in high schools.

2. I was once bitten by a poodle. Therefore, this poodle will probably bite me too.

3. Every poodle I've ever met has bitten me (and I've met over 300 poodles). Therefore this poodle will probably bite me too.

4. My friend took Dr. Van Cleave's logic class last semester and got an A. Since Dr. Van Cleave's class is essentially the same this semester and since my friend is no better a student than I am, I will probably get an A as well.

5. Bill Cosby used his power and position to seduce and rape women. Therefore, Bill Cosby probably also used his power to rob banks.

6. Every car I've ever owned had seats, wheels and brakes and was also safe to drive. This used car that I am contemplating buying has seats, wheels and brakes. Therefore, this used car is probably safe to drive.

### **Causal Reasoning**

When I strike a match it will produce a flame. It is natural to take the striking of the match as the cause that produces the effect of a flame. But what if the matchbook is wet? Or what if I happen to be in a vacuum in which there is no oxygen (such as in outer space)? If either of those things is the case, then the striking of the match will not produce a flame. So, it isn't simply the striking of the match that produces the flame, but a combination of the striking of the match together with a number of other conditions that must be in place in order for the striking of the match to create a flame. Which of those conditions we call the "cause" depends in part on the context. Suppose that I'm in outer space striking a match (suppose I'm wearing a space suit that supplies me with oxygen but that I'm striking the match in space, where there is no oxygen). I continuously strike it but no flame appears (of course). But then someone (also in a space suit) brings out a can of compressed oxygen that they spray on the match while I strike it. All of a sudden

a flame is produced. In this context, it looks like it is the spraying of oxygen that causes flame, not the striking of the match. Just as in the case of the striking of the match, any cause is more complex than just a simple event that produces some other event. Rather, there are always multiple conditions that must be in place for any cause to occur. These conditions are called background conditions. That said, we often take for granted the background conditions in normal contexts and just refer to one particular event as the cause. Thus, we call the striking of the match the cause of the flame. We don't go on to specify all the other conditions that conspired to create the flame (such as the presence of oxygen and the absence of water). But this is more for convenience than correctness. For just about any cause, there are a number of conditions that must be in place in order for the effect to occur. These are called necessary conditions. For example, a necessary condition of the match lighting is that there is oxygen present. A necessary condition of a car running is that there is gas in the tank. We can use necessary conditions to diagnose what has gone wrong in cases of malfunction. That is, we can consider each condition in turn in order to determine what caused the malfunction. **For example**, if the match doesn't light, we can check to see whether the matches are wet. If we find that the matches are wet then we can explain the lack of the flame by saying something like, "dropping the matches in the water caused the matches not to light." In contrast, a sufficient condition is one which if present will always bring about the effect. For example, a person being fed through an operating wood chipper is sufficient for causing that person's death (as was the fate of Steve Buscemi's character in the movie Fargo).

Being able to determine when causal generalizations are true is an important part of becoming a critical thinker. Since in both scientific and every day contexts we rely on causal generalizations in explaining and understanding our world, the ability to assess when a causal generalization is true is an important skill. **For example**, suppose that we are trying to figure out what causes our dog, Charlie, to have seizures. To simplify, let's suppose that we have a set of potential candidates for what causes his seizures. It could be either:

- A) eating human food,
- B) the shampoo we use to wash him,
- C) his flea treatment,
- D) not eating at regular intervals, or some combination of these things.

## **READINGS AND VIDEOS (Please see the digital copies of the materials.)**

**Reading 1** Van Cleave, M. (2016). Introduction to Logic and Critical Thinking. Retrieved from <https://open.umn.edu/opentextbooks/textbooks/introduction-to-logic-and-critical-thinking>

**Reading 2** Copi, I., Cohen, C & McMahon, K. (2014). Introduction to Logic Fourteenth Edition. London: Pearson Education Limited

**Video 1** What is inductive reasoning? In <https://www.youtube.com/watch?v=4ZKa1S1wPy4>

**Video 2** Deductive and Inductive Reasoning in <https://www.youtube.com/watch?v=WAdpPABoTzE>

**Video 3** Inductive Arguments in <https://www.youtube.com/watch?v=kUeqO90agT8>

## **ACTIVITY AND ASSESSMENT**

Answer Exercise 1 to 3 (Write your answer in a separate sheet of paper)

### **REFERENCES:**

**Introduction to Logic and Critical Thinking**  
Matthew J. Van Cleave

**Introduction to Logic**  
Irving Copi  
Carl Cohen  
Kenneth McMahon  
14th edition, Pearson Education Limited, 2014

**Logic for Filipinos 3<sup>rd</sup> Edition**  
Prisciliano Bauzon, National Bookstore 2013