

Inductive Reasoning

Chapter Objectives

Enumerative Induction

You will be able to

- define *enumerative induction* and explain how it's used.
- define the terms *target population*, *sample*, and *relevant property*.
- understand the two ways in which an enumerative induction can fail to be strong.
- understand the error known as hasty generalization and know how to avoid it.
- understand the basics of opinion polls and know the definitions of *random sampling*, *self-selecting sample*, *margin of error*, and *confidence level*.

Statistical Syllogism

You will be able to

- explain what a statistical syllogism is.
- define *individual*, *group*, *characteristic*, and *proportion*.
- understand three ways in which statistical syllogisms can fail to be strong.

Analogical Induction

You will be able to

- formulate and evaluate an argument by analogy.
- use the following criteria to evaluate arguments by analogy: relevant similarities, relevant dissimilarities, the number of instances compared, and diversity among cases.

Causal Arguments

You will be able to

- define *causal claims* and *arguments*.
- apply Mill's methods to the evaluation of causal arguments.
- recognize the ways in which people can make errors in causal reasoning.

- recognize and know how to avoid the post hoc fallacy.
- define necessary and sufficient conditions.
- distinguish between necessary and sufficient conditions in everyday contexts.

Mixed Arguments

You will be able to

- explain what a “mixed argument” is and what its key components are.
- evaluate a mixed argument.

Chapter Summary

An inductive argument is intended to provide only probable support for its conclusion, being considered strong if it succeeds in providing such support and weak if it does not.

Inductive arguments come in several forms, including enumerative, statistical, analogical, and causal. In **enumerative induction**, we argue from premises about some members of a group to a generalization about the entire group. The entire group is called the **target group**; the observed members of the group make up the **sample**; and the group characteristics we’re interested in are the **relevant property**. An enumerative induction can fail to be strong by having a sample that is too small or not representative. When we draw a conclusion about a target group based on an inadequate sample size, we commit the error of **hasty generalization**. Opinion polls are enumerative inductive arguments, or the basis of enumerative inductive arguments, and must be judged by the same general criteria used to judge any other enumerative induction.

Statistical syllogisms begin with a statistical generalization about some group or category and reach a conclusion about some specific member of that group or category. We evaluate a statistical syllogism by examining (1) whether the statistical generalization it begins with is well-founded, (2) the strength of the statistical claim (is it a near-universal generalization or a weaker claim about “a majority” of members of the group?), and (3) whether the individual about whom a conclusion is being reached is in fact likely to be typical of the group as a whole.

In **analogical induction**, or argument by **analogy**, we reason that since two or more things are similar in several respects, they must be similar in some further respect. We evaluate arguments by analogy according to several criteria: (1) the number of relevant similarities between things being compared, (2) the number of relevant dissimilarities, (3) the number of instances (or cases) of similarities or dissimilarities, and (4) the diversity among the cases.

A **causal argument** is an inductive argument whose conclusion contains a causal claim. There are several inductive patterns of reasoning used to assess causal connections. These include the Method of Agreement, the Method of Difference, the Method of Agreement and Difference, and the Method of Concomitant Variation. Errors in cause-and-effect reasoning are common. They include misidentifying relevant factors in a causal process, overlooking relevant factors, confusing cause with coincidence, confusing cause with temporal order, ignoring a common causal factor, and mixing up cause and effect.

Crucial to an understanding of cause-and-effect relationships are the notions of necessary and sufficient conditions. A **necessary condition** for the occurrence of an event is one without which the event cannot occur. A **sufficient condition** for the occurrence of an event is one that guarantees that the event occurs.

Answers to Select Textbook Exercises

Please note: These answers are for some of the questions that were not answered in Appendix B of *The Power of Critical Thinking*, Fifth Canadian Edition.

Exercise 8.1

2. Target group: people in general; Sample: several people at PETA Canada's office; Relevant property: Thinking that injecting hormones into livestock is a bad idea.
The argument is weak; the sample is not representative and is also probably too small.
5. Target group: people in Canada; Sample: an unknown number of adults in Toronto and Montreal; Relevant property: favouring banning construction of new oil pipelines.
The argument is weak; the sample is not representative.

Exercise 8.2

2. *Weak.* To ensure a strong argument, poll a truly representative sample of subjects, say, 1200 (if the poll is to be national in scope) or far fewer if the argument concerns a smaller subgroup (perhaps people who live in a particular neighbourhood).
5. *Weak.* To ensure a strong argument, discard the very unrepresentative sample of people from big cities and conduct a random poll of people from across the country.

Exercise 8.3

4. The poll does not support the conclusion. The sample is not representative of the target group. It is at best representative of people—from Winnipeg or elsewhere—who visited the newspaper's website that day.
5. The survey does not adequately support the magazine's conclusion. The sample has not been randomly selected; it has been self-selected. The magazine's readers—including the 20,000 respondents—may not be representative of the target group.

Exercise 8.4

2. C
5. D

Exercise 8.5

4. Very slightly more likely to be true. A larger sample is better, but it is still not guaranteed to be representative.
5. The conclusion is not more likely to be true because the sample, though larger, is still self-selected and not representative of the target group.

Exercise 8.6

2. Individual: Jessica; Group: people in Canada; Characteristic: earning more than \$191,000 per year; Proportion: 1 in 100.

Exercise 8.7

3. Unacceptable premise (most people know that the success rate among new restaurants is very low)

Exercise 8.8

6. Argument by analogy. One instance compared: A bully and a dictator; Relevant similarities: Tolerating a bully or a dictator leads to further abuse; Conclusion: The best course of action for people oppressed by a dictator is to resist and attack.

The argument is weak because dictators rarely surrender simply because there is violent resistance to their rule.

Exercise 8.9

2. Things being compared: degree of success on various exams; Relevant similarities: very little time dedicated to studying; Diversity among multiple cases: a somewhat significant factor because the exams referred to are on very different topics; Conclusion: I am likely to do badly on my Philosophy exam.

The argument is strong, although the sample could be larger. The arguer presents three relatively diverse cases which nevertheless exhibit two highly relevant similarities, and no relevant dissimilarities. Since the fourth case possesses the first relevant similarity, it is convincingly argued that it is also likely to possess the second.

Exercise 8.10

4. Conclusion: Something to do with the ownership of the plants is responsible for the *E. coli* contamination. Method of agreement. *The argument is strong.*
18. Conclusion: Lather-Up is better at killing germs. Joint method of agreement and difference. *The argument is strong.*
20. Conclusion: Barry's criminal behaviour is caused by high outdoor temperatures. Correlation. *The argument is weak.*

Exercise 8.11

4. (a) Misidentifying or overlooking relevant factors; (b) being misled by coincidence.
14. (a) Misidentifying or overlooking relevant factors; (b) being misled by coincidence;
18. (a) Misidentifying or overlooking relevant factors; (c) falling for the post hoc fallacy.

Exercise 8.12

2. (b) Neither a necessary nor a sufficient condition
5. (b) A sufficient condition
10. (c) A necessary and sufficient condition

Study Questions

1. What is enumerative induction?
2. What is a target population? A sample? A relevant property?
3. In what ways can an enumerative induction fail to be strong?
4. What is a hasty generalization?
5. What is the difference between a representative sample and a biased sample?
6. What two characteristics must a representative sample have?

7. What two characteristics must a credible opinion poll have?
8. What is the purpose of random sampling?
9. What is a common margin of error for national polls?
10. What is the usual confidence level in a national opinion poll?
11. What is a statistical syllogism? What makes a statistical syllogism strong or weak?
12. What is an analogy?
13. What is the argument pattern of an analogical induction? How might an analogical induction be used in medical science? Law?
14. What are the four criteria for evaluating an argument by analogy?
15. What is a causal argument?
16. What are Mill's methods?
17. How can you use the method of agreement or the method of difference to evaluate a causal argument?
18. How can someone be misled by coincidence?
19. Describe the method of concomitant variation. How does it differ from the method of agreement?
20. What is the difference between a statistical syllogism and an enumerative induction? Provide examples to illustrate.
21. What does it mean to confuse cause and effect? Provide an example to illustrate.
22. What does it mean to confuse coincidence with cause? Provide an example to illustrate.
23. What does it mean to ignore the common causal factor? Provide an example to illustrate.
24. What does it mean to confused cause with temporal order? Provide an example to illustrate.
25. What is the difference between a necessary and a sufficient condition? Provide examples to illustrate.

Self-Assessment Quiz

Scroll down for answers.

Inductive Arguments

For each argument below, (a) determine whether the argument is an enumerative induction, a statistical syllogism, or an analogical induction; (b) identify the conclusion of the argument; (c) identify the principal components of the argument (for enumerative induction, identify the target population, sample, and relevant property; for statistical syllogism, identify the individual being examined, the group to which the individual is said to belong, the characteristic being attributed, and the proportion that the characteristic is represented in the group; for analogical induction, identify the individuals being compared and the stated or implied similarities); and, finally, (d) briefly assess the strength of the argument.

1. Cats are like dogs. They are mammals, can be domesticated, eat meat, and can be very cute. Therefore, cats would also make good guide animals.
2. A student wants to learn about the relationship between positions on the legalization of marijuana and gender at her college. So she puts an advertisement in the student newspaper inviting students to complete an online questionnaire. She gets 273 completed responses. Of the 145 who identified as male, 67 per cent are in support of marijuana legalization. Respondents who are female (112) were 65 per cent in favour of marijuana legalization. The 16 who identified their gender as “other” were 75 per cent in favour of legalization. So the student researcher concludes that there is probably no significant difference between genders with respect to opinions on marijuana legalization.
3. Nearly all devout Muslims abstain from pork consumption. Therefore, Fatima, who is a devout Muslim, probably does not eat pork.
4. A geologist is interested in the concentration of copper in an area that is $2\text{km} \times 3\text{km}$. She examines samples from 20 randomly selected drill sites taken in the area and discovers high amounts of copper in all of the samples. She concludes that there are high concentrations of copper throughout the area.
5. About half of all Biology students at the University of Guelph are interested in getting into medical school after completing their degrees. Therefore, about half of all Biology students at the University of Waterloo, are interested in getting into medical school.
6. 29 per cent of Saskatchewan residents support Trudeau’s carbon tax plan. Kevin Hoffman, of North Battleford, is a Saskatchewan resident. So, Kevin Hoffman likely supports Trudeau’s carbon tax plan.
7. Bill, Shawn, and Sandra all like country music. Since they are all university students, it follows that most other university students like country music too.

8. Milk is rich in calcium, which is known to promote bone and dental health, as well as to help prevent cancer, diabetes, and high-blood pressure. It is a healthy part of any balanced diet. Yogourt, like milk, is rich in calcium. So it is probably a healthy part of any balanced diet too.
9. 83 per cent of Chemong Lake residents enjoy fishing. Aaron Martin is a resident of Chemong Lake, so he likely enjoys fishing also.
10. A recent study revealed that 93 per cent of university graduates enjoy bowling. To reach this startling conclusion, the pollsters visited hundreds of bowling alleys all over the country, and interviewed the patrons there regarding their education levels and leisure habits.

Causal Arguments

For each of the following arguments, (a) identify the conclusion; (b) identify which of Mill's Methods is/are being employed; and (c) briefly evaluate the argument.

1. I took a large dose of vitamin C and two days later my cold was gone! Vitamin C really does help you recover from a cold.
2. A philosophy professor wanted to know whether her "beer and talk" sessions were helping her students. There were 20 students who regularly joined her in the campus pub on Friday afternoons and 35 students who did not attend the sessions. So she asked the students to submit their papers without their names attached, using a numerical code known only to the student and the departmental secretary. She graded the papers anonymously. She found that, on average, the students who attended the beer and talk sessions scored about 10 per cent higher than those who did not. So she concluded that her sessions were making a difference in the quality of the students' work.
3. It's strange, but I've noticed that the last three students who got an A+ in Logic class have tattoos. Three years ago it was a 35-year-old woman with a tattoo of a snake on her forearm. Last year, there was an 18-year-old boy from a Bosnian refugee family. He had a tattoo of a star on the back of his neck. This year, it was a 40-year-old ex-con from Newfoundland with a tattoo of a dragon on his chest. I think it must be that having a tattoo causes you to be good at logic. I'm going to get one now.
4. Professor Jean-Denis Rouillon, of Besancon University, spent 15 years studying the anatomy of 330 women before concluding that bras are a "false necessity."
 Using a slide rule and a caliper, he found a seven-millimetre difference in the height of busts, with those who went without the support of a bra faring best against gravity.
 The research found that breasts were firmer and sagged less in the women studied who did not wear a bra and that those women were no more likely than others to suffer from back pain.
 "Medically, physiologically, anatomically—breasts gain no benefit from being denied gravity," he said. (Reported in the *Vancouver Sun*, April 13, 2013.)
5. Many studies have shown that children who play musical instruments show increased verbal ability, mathematical ability, memory, and cognitive flexibility, as compared to children who do

not play musical instruments. So it is reasonable to infer that learning musical instruments is likely to lead to many intellectual benefits.

6. A recent longitudinal study confirmed that life-threatening diseases actually cause human beings to age. The scientists found that participants over the age of 70, were far more likely to have a life-threatening disease than those in any other age group. On the other hand, participants under the age of 40 were far less likely to have a life threatening disease.
7. A recent study demonstrated that if you want to become a successful trial lawyer, you should try to develop as large of a vocabulary as possible. The pollsters found that literally 100 per cent of trial lawyers with a success rate over 90 per cent had a larger vocabulary than the national average.
8. Data from the US Census Bureau, and National Science Foundation shows that an increase in computer science doctorates awarded in the US since the year 2000, has led to a corresponding increase in total revenue generated by arcades. Though they might seem unrelated at first sight, there exists an undeniably and remarkably close correlation between these two seemingly distinct phenomena. (<http://tylervigen.com/spurious-correlations>)
9. Everyone at the party who ended up getting food poisoning had some of the cake and also some of the popcorn. Those are the only two items that all of them consumed. But no one who only ate the popcorn and not the cake got sick, so I guess the cake must be the source of the food poisoning.
10. Studies have shown that adults over 60 tend to be more likely to be diagnosed with common skin cancers, the more frequently they have experienced sun burn. This suggests that skin damage due to exposure to the sun, may be a cause of many common skin cancers.

Answers to Self-Assessment Quiz

Inductive Arguments

- (a) Cats will make good guide animals.
 - (b) Analogical induction.
 - (c) Cats are compared to dogs; they are alike in that they both can be domesticated, eat meat, and can be cute.
 - (d) There are important differences between cats and dogs, including the general independent quality of most cats.
- (a) There is probably no significant difference between genders with respect to opinions on marijuana legalization.
 - (b) Enumerative induction.
 - (c) There are really three studies here; all three are concerned with the property of approving of marijuana legalization. The first targets male students and has a sample size of 145; 67 per cent support legalization. The second targets female students, with a sample size of 112; 65 per cent support legalization. The third targets students who identify as “other” with respect to gender. The size of the third group is 16, and 75 per cent support legalization.
 - (d) There are two problems here: the samples are all too small, and, because they are self-selecting, they are also unrepresentative.
- (a) Fatima probably does not eat pork.
 - (b) Individual: Fatima; Group: Devout Muslims; Characteristic: Not eating pork; Percentage: “most.”
 - (c) Probably a good argument, unless there are reasons to believe that Fatima is atypical.
- (a) There are high concentrations of copper in the area.
 - (b) Enumerative induction.
 - (c) Target: Rock throughout the given area; Sample: 20 samples of core randomly selected with the area; Property: having high concentrations of copper; Percentage: “all.”
 - (d) The sample might seem small, but if one is getting uniform results, then it is reasonable to infer that the entire area will be similar to the samples taken—but of course one could nevertheless be unlucky in one’s random selection.
- (a) About half of all students at the University of Waterloo are interested in getting into medical school.
 - (b) Analogical induction.
 - (c) Biology students at the University of Guelph are being compared to Biology students at the University of Waterloo. The property in question is “wanting to get into Medical school.”
 - (d) Unless we know that the universities and their students are very similar, we should say that this is a weak argument. Too few similarities between the groups are established.
- (a) Statistical syllogism
 - (b) Kevin Hoffman likely supports Trudeau’s carbon tax plan
 - (c) Individual: Kevin Hoffman, Group: Saskatchewan residents, Characteristic: supports Trudeau’s carbon tax plan, Percentage: 23 per cent

- (d) This inductive argument is weak; the problem is a lack of statistical strength, given that only 23 per cent of Saskatchewan residents support Trudeau’s carbon tax plan, it is actually more likely that Kevin Hoffman does not support it than that he does. Even if the premises are acceptable, they do not render the conclusion probable or likely.
7. (a) enumerative induction
 (b) most university students like country music
 (c) Target population: University students; Sample: Bill, Shawn, and Sandra; Relevant property: likes country music
 (d) This inductive argument is weak; the sample are three students is too small to justify the generalization to “most” university students. This is a hasty generalization.
8. (a) analogical induction
 (b) Yogurt is a healthy part of any balanced diet
 (c) In this argument by analogy, Yogurt and Milk are being compared with respect to their health benefits. The stated similarity is that both are rich in calcium, which is known to promote bone and dental health, and to ward off cancer, diabetes, and high blood pressure.
 (d) This inductive argument is strong. The similarity identified is relevant, and there are no obvious relevant dissimilarities. The premises are acceptable.
9. (a) Statistical syllogism
 (b) Aaron Martin likely enjoys fishing
 (c) Individual: Aaron Martin, Group: Chemong Lake residents, Characteristic: enjoys fishing, Percentage: 83%
 (d) This inductive argument is strong; assuming the premises are acceptable, which seems likely since the community where Aaron lives is named after a lake, the sort of location where fishers are likely to congregate, the relatively high percentage of Chemong lake residents who enjoy fishing makes it likely that Aaron Martin is among them. The syllogism is statistically strong.
10. (a) enumerative induction.
 (b) 93% of university graduates like bowling
 (c) Target population: University graduates; Sample: hundreds of bowling alley patrons all over the country; Relevant property: likes bowling
 (d) This inductive argument is weak. The sample is biased. Only people actually at bowling alleys were polled, meaning they were already likely to prefer bowling over other recreational activities.

Causal Arguments

1. (a) Vitamin C helps you recover from a cold.
 (b) Hard to diagnose due to a very small sample (1), but it is best construed as “method of agreement.”
 (c) Poor argument; commits the fallacy of *post hoc, ergo propter hoc*
2. (a) The professor’s sessions are making a difference in the quality of the students’ work
 (b) Both agreement and difference
 (c) There are too many factors not accounted for here. Perhaps, for example, the students who attend the extra sessions are the keenest students; they would succeed anyway. Also, despite

the efforts to anonymize the marking, the professor might recognize ideas or language that reflect discussions at the beer drinking sessions.

3. (a) Having a tattoo causes people to be good at logic.
(b) Method of agreement
(c) Weak argument; the common factor is probably just a coincidence
4. (a) Bras are not necessary to maintain breast firmness, prevent sagging, and reduce back pain.
(b) Both agreement and difference. (This is a controlled study but it is obviously not double-blind—the women would know which group they are in!)
(c) The argument is limited due to the small group sizes. It would be useful to know more about the study in order to assess group representativeness and other factors (such as how the investigator confirmed that the subjects were reporting their behaviour accurately)
5. (a) Learning to play a musical instrument increases intellectual ability in children.
(b) The passage reports the results of several studies, but these will mostly be the method of concomitant variation; as musical instrument playing increases, so do these intellectual benefits.
(c) The chief trouble with such studies is ruling out other causes, including the possible common cause of relatively wealthy parents who devote time and money to their children's development.
6. (a) Life-threatening diseases causes human beings to age
(b) Method of concomitant variation
(c) Weak argument; the study confuses cause with effect.
7. (a) Large vocabularies cause trial lawyers to be inordinately successful.
(b) Method of agreement
(c) Weak argument; the study ignores a common causal factor: education. Obtaining the level of education required to be a successful trial lawyer is also likely to lead one to possess a vocabulary well-above the national average.
8. (a) Increases in Computer Science doctorates awarded causes increases in total revenue generated by arcades.
(b) Method of concomitant variation
(c) Weak argument; confuses correlation with causation. The arguer is misled by a by mere coincidence or "spurious correlation."
9. (a) The cake was the source of the food poisoning at the party.
(b) Method of agreement and disagreement
(c) Strong argument. In every instance where a party goer got food poisoning, they consumed both cake and popcorn. But in all other instances, where a party goer consumed popcorn but not cake, that person did not get food poisoning. Using the method of agreement and disagreement, we can isolate the cake as the source of the food poisoning.
10. (a) Increased sun exposure is the cause of many common skin cancers.
(b) Method of concomitant variation.
(c) Strong argument. In this case, the correlation exhibits a strong dose-response relationship. There is also a plausible mechanism linking the suspected causal agent to the observed effect: skin cell damage due to exposure to harmful solar radiation.