



Judging Scientific Theories

Chapter Objectives

Science and Not Science

You will be able to

- understand why science is not the same thing as technology, ideology, or scientism.

The Scientific Method

You will be able to

- list the five steps of the scientific method.
- understand the logic of scientific testing.
- understand why no scientific hypothesis can be conclusively confirmed or conclusively confuted.

Testing Scientific Theories

You will be able to

- use the steps of the scientific method, and be able to explain how a scientist would go about testing a simple hypothesis in medical science.
- understand why scientists use control groups, make studies double-blind, include placebos in testing, and seek replication of their work.

Judging Scientific Theories

You will be able to

- list the five criteria of adequacy and explain what they mean.
- understand how to apply the criteria of adequacy to the theories of evolution and creationism and why the text says that evolution is the better theory.

Science and Weird Theories

You will be able to

- explain why evaluating weird claims might be worthwhile.

Making Weird Mistakes

You will be able to

- understand why it can be so easy to make mistakes when trying to evaluate weird theories.
- explain three major errors that people often make when they are trying to assess extraordinary experiences and theories.
- explain the distinction between logical possibility and physical possibility.

Judging Weird Theories

You will be able to

- use the TEST formula to evaluate extraordinary theories.
- understand why eyewitness testimony is often unreliable.

Chapter Summary

Science seeks knowledge and an understanding of reality; it does so through the formulation, testing, and evaluation of theories. Science is a way of searching for truth. Technology, though, is the production of products. Science is not a world view, and we can't identify it with a particular ideology. A particular world view may predominate in the scientific community, but this doesn't mean that the world view is what science is all about. Science is not scientism—it is not the only way to acquire knowledge. It is, however, our most reliable way of acquiring knowledge of empirical facts.

The scientific method cannot be identified with any particular set of experimental or observational procedures. But it does involve several general steps: (1) identifying the problem, (2) devising a hypothesis, (3) deriving a test implication, (4) performing the test, and (5) accepting or rejecting the hypothesis. This kind of theory-testing is part of a broader effort to evaluate a theory against its competitors. This kind of evaluation always involves, implicitly or explicitly, the criteria of adequacy. Inference to the best explanation can be used to assess weird theories as well as more commonplace explanations in science and everyday life. However, when people try to evaluate extraordinary theories, they often make certain typical mistakes. They may believe that, because they can't think of a natural explanation, a paranormal explanation must be correct. They may mistake what *seems to be* for what *is*, forgetting that we shouldn't accept the evidence provided by personal experience if we have good reason to doubt it. And they may not fully understand the concepts of logical and physical possibility. In both science and everyday life, the TEST formula enables us to fairly appraise the worth of all sorts of weird theories, including those about crop circles and communication with the dead—the two cases examined in this chapter.

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 10.1

Answers are not provided for this exercise.

Exercise 10.2

7. Hypothesis: B vitamins can lower the incidence of headaches.
Test implication: If B vitamins really lower the incidence of headaches, then a double-blind controlled trial (testing B vitamins against a placebo in people prone to headaches) should reveal fewer headaches in the experimental group.

Exercise 10.3

Answers are not provided for this exercise.

Exercise 10.4

4. Test implication: If the BMW 325i is a more reliable car than the Ford Focus, then that could be shown using some criteria of reliability (such as the rate at which both cars need to be repaired). The test will likely confirm the theory.

Exercise 10.5

Answers are not provided for this exercise.

Exercise 10.6

Answers are not provided for this exercise.

Exercise 10.7

1. It is unreasonable to accept an extraordinary claim solely because of its weirdness because “weirdness” is not proof of legitimacy.
8. No. Some things are logically impossible (such as the same claim being both true and false) and some things are physically impossible (such as a baby lifting a truck).

Exercise 10.8

4. *Theory 1:* A real person rendered aid and then left.
Theory 2: A real person rendered aid, gave his name, and stayed for a while—but the person needing help couldn’t recall these explanatory details later.
Theory 3: The stranger was a real guardian angel.

Exercise 10.9

Answers are not provided for this exercise.

Study Questions

1. What is the difference between science and technology?
2. Why can’t science be considered an ideology?
3. What is scientism?
4. Why is science a reliable way of acquiring knowledge?
5. What are the five steps involved in the scientific method?

6. How do scientists construct hypotheses to test theories?
7. What is a test implication?
8. What are the two conditional arguments used as models for scientific testing?
9. Why can't scientific hypotheses be conclusively confuted?
10. What does double-blind mean? Why are double-blind methods used in scientific testing?
11. Why is replication of a scientific study important?
12. What are the five criteria of adequacy?
13. What is the TEST formula and how is it used to evaluate theories?
14. Can the TEST formula be used to evaluate extraordinary theories? Explain your answer.
15. What is the error referred to as "leaping to the weirdest theory"? Why is this line of thinking fallacious?
16. Are most paranormal phenomena logically possible? What does it mean for something to be logically possible?
17. What is "cold reading" and how is it used by psychic readers to make it appear as if they have paranormal abilities?
18. In evaluating extraordinary theories, explain the common error of believing that just because you can't think of a natural explanation, a phenomenon must be paranormal. Provide an example to illustrate.
19. What is the difference between logical and physical possibility? If a state of affairs is logically possible, must it be physically possible? Must it be actual?
20. If a state of affairs is physically possible, must it be logically possible? If something is actual, must it be logically possible?

Self-Assessment Quiz

Scroll down for answers.

Explanation Identification

Devise a hypothesis to explain each of the following phenomena, and derive a test implication to test the hypothesis.

1. The rates of obesity are higher among low-income individuals than they are among middle- or upper-income individuals.
2. Recent research confirms a link between diets high in saturated fat and a higher risk of coronary heart disease.
3. Corporations are less likely to hire female managers.
4. The rates of hearing loss are higher among construction workers than the average across all occupations.
5. In the Greater Toronto Area, 73 per cent of days this year have been overcast.

Alternate Theory Assessment

Using your background knowledge and any other information you may have about the subject, devise an alternative theory to explain each of the following and then apply the criteria of adequacy to both of them—that is, ascertain how well each theory does in relation to its competitor on the criteria of testability, fruitfulness, scope, simplicity, and conservatism.

1. *Phenomenon:* Twenty patients with severe arthritis pain were prayed for by 50 people, and 14 out of those 20 reported a significant lessening of pain.
Theory: Prayer heals.
2. *Phenomenon:* Players in the National Hockey League (NHL) are more likely to have been born in the first half of the calendar year.
Theory: The astrological sign of a person affects his or her athletic abilities.
3. *Phenomenon:* Residents of northern Canada are more likely to suffer from Vitamin D deficiency than residents of southern Florida.
Theory: People in northern Canada are less likely to eat salmon than people in southern Florida.

Test Implications

For each of the following theories, derive a test implication and indicate whether you believe that such a test would likely confirm or disconfirm the theory.

1. The Ultra-Sonic 2000 pest control device can rid a house of roaches by emitting a particular sound frequency that humans can't hear.
2. Attending religious services regularly will prevent depression.
3. Taking multivitamins leads to less colds and flus over the winter months.
4. Smoking marijuana prevents cancer.

5. Drinking diet soda leads to type II diabetes.
6. Drinking coffee causes anxiety disorders.
7. Exposure to cold weather leads to flu symptoms.

Theory Assessment

Read the passage below and answer the following questions:

- a) What is the phenomenon being explained?
- b) What theories are advanced to explain the phenomenon? (Some theories may be unstated.)
- c) Which theory seems the most plausible and why? (Use the criteria of adequacy.)
- d) Regarding the most credible theory, is there a test implication mentioned? If so, what is it? If not, what would be a good test implication for the theory?
- e) What test results would persuade you to change your mind about your preferred theory?

Cancer has been known and dreaded by physicians since ancient times. Despite decades of trying and despite billions of dollars spent on research, no cure for cancer has yet been found. Many drugs are available to treat various forms of cancer, but there is nothing that could really be called a “cure” for cancer. Why is that? For years now a theory has circulated that there is an international conspiracy to prevent the discovery and sale of a cure for cancer. After all, treating cancer is highly profitable. Drug companies make hundreds of millions of dollars each year producing drugs that treat—but do not cure—cancer. Thus, according to this conspiracy theory, drug companies make no effort to conduct research that would lead to a genuine cure, and they act quickly to silence any doctor or scientist who strays too close to the dangerous truth.

Weird Theories

In each of the following examples, a state of affairs is described. Devise three theories to explain each one. Include two plausible theories that are natural explanations and one competing theory that is paranormal.

1. Jason spent the night in a hotel that has a reputation for being haunted. He slept in the very room (number 666) in which a horrible murder had been committed in the 1930s. He fell asleep thinking about the crime. At 3:00 a.m. he awoke to see the apparition of a man sitting at the foot of his bed.
2. I believe that alien abductions are real. I once knew a guy who lived in my university dorm. He was completely normal and fit in with other students quite well. One day, he just seemed to disappear. No one knew where he was, and then three days later he returned. He was in the same clothes as when we last saw him, but he was dirty and confused. He didn't have any clear memory of where he had been. After that, he always seemed a little peculiar.

3. Ella ate at a Chinese restaurant and got a fortune cookie. On the back of the fortune there was a list of six suggested lottery numbers. She played those numbers and won over a million dollars!
4. After taking a homeopathic remedy for his upset stomach, Amir felt a lot better.
5. At a party, Aaron declared that he could read minds—that just by asking someone a few questions he could uncover all kinds of accurate information about the person. Sure enough, he asked Susan a few simple questions and then proceeded to divulge all kinds of personal information about her that she swore was accurate.
6. Several Canadian Forces planes took off from their base to conduct training exercises off the northern coast of Labrador. They departed during daylight, but it was evening by the time they completed training and turned homeward. Sometime after their last transmission to the airbase, all the planes vanished without a trace. No wreckage was ever found, and to this day no one knows what happened to the planes or the pilots.
7. On a talk show, self-professed psychic John Edward was able to correctly predict that someone in the audience would be attending a wedding that July. He could not have known that in advance, since the audience was composed entirely of people he had never met before.
8. Televangelist Peter Popoff correctly stated that an elderly lady in the audience had been diagnosed with rheumatoid arthritis.
9. A teenager named Natasha claims she has x-ray vision, and used it to correctly determine that one of her subjects had previously had an operation to remove part of her lung.

Answers to Self-Assessment Quiz

Explanation Identification

- Hypothesis:* Low income is a causal factor in the incidence of obesity.
Test Implication: If poverty is a causal factor in the incidence of obesity, then there will be a higher proportion of low income people (as compared with people in the middle- to high-income range) who present with obesity.
- Hypothesis:* Diets high in saturated fat increase the risk of coronary heart disease.
Test implication: If a diet high in saturated fat increases the risk of coronary heart disease, then we would expect that, as the amount of saturated fat in a population's diet increases, there will be a higher incidence of coronary heart disease.
- Hypothesis:* Corporations are influenced by implicit bias against women, when recruiting managers.
Test implication: If corporations are influenced by implicit bias against women when recruiting managers, then, of any pair of resumes for an open management position which are otherwise identical, we would expect them to be more likely to select for an interview, the candidate whose resume had a male sounding name on it (e.g., John Doe), as opposed to a female sounding name (e.g., Jane Doe).
- Hypothesis:* Construction workers experience higher rates of hearing loss than average, due to increased exposure to loud noise created by equipment used on construction sites.
Test implication: If the higher than average rates of hearing loss among construction workers is due to increased exposure to loud noise created by equipment used on construction sites, then the more often individuals are exposed to noise, and the louder the noise is, the more likely they will be to develop hearing loss.
- Hypothesis:* More frequent and increased cloud cover in the Greater Toronto Area is due to global warming.
Test implication: If more frequent and increased cloud cover in the Greater Toronto Area is caused by global warming, then one would expect there to be more overcast days per year in the GTA, the higher the average global temperature is.

Alternate Theory Assessment

- Alternate theory:* The placebo effect causes the decrease in pain.
Assessment: Both theories are testable, but the prayer theory is clearly less simple. The placebo theory also has greater scope than the prayer theory.
- Alternate theory:* Players born in the first half of the year will likely be more developed in the early years of play than players born in the latter half of the year. (In youth leagues, players often play according to birth year, giving the early-born children a greater chance to succeed and get access to better coaches and other benefits.)
Assessment: Both theories are testable, but the astrological theory is less conservative and certainly less simple.
- Alternate theory:* People in northern Canada are generally exposed to less sunlight than those in southern Florida.
Assessment: Both theories are testable, but the sunlight theory is more conservative, as the likelihood that there is more salmon eaten in southern Florida than in northern Canada (per capita) is

unlikely to be supported by investigation. Sunlight is known to be relevant to Vitamin D production, and there are fewer hours of sunlight (for much of the year) in northern Canada.

Test Implications

1. *Test implication:* If a house is infested with roaches, then activating the Ultra-Sonic 2000 will eliminate the pests. → It is unlikely that a test would confirm this hypothesis.
2. *Test implication:* If a person attends religious services regularly, then he/she will be less likely to suffer from depression. → It is unlikely that a test would confirm this hypothesis.
3. *Test implication:* If a person takes multivitamins, then he/she will suffer fewer incidents of catching a cold over the winter months. → It is unlikely that a test would confirm this hypothesis.
4. *Test implication:* The more Marijuana a person smokes, the less likely he/she will be to be diagnosed with cancer. → It is unlikely that a test would confirm this hypothesis.
5. *Test Implication:* The more diet soda a person consumes, the more likely they are to be diagnosed with Diabetes type II. → It is unlikely that a test would confirm this hypothesis.
6. *Test implication:* The more coffee someone consumes, the more likely they would be to be diagnosed with an anxiety disorder. → It is unlikely that a test would confirm this hypothesis.
7. *Test Implication:* The more frequently one is exposed to cold weather, and the colder it is, the more likely one would be to experience flu symptoms. → It is unlikely that a test would confirm this hypothesis.

Theory Assessment

- a) *Phenomenon:* No cure for cancer has been discovered.
- b) *Theory suggested:* There is an international conspiracy that quashes promising leads in order to maintain the lucrative cancer treatment industry.
Unstated alternative: Cancer is very difficult to cure.
- c) The conspiracy theory is less plausible than the alternative. It is certainly less simple, and it is less conservative, as it makes unnecessary assumptions (an international conspiracy), and we know that cancer is complex and difficult to cure.
- d) If the conspiracy hypothesis were true, then we would expect scientists to report the silencing of their research. Without evidence of a conspiracy we should maintain the simpler, more conservative theory.
- e) Genuine evidence of a conspiracy would cause one to reject the “difficult to cure” hypothesis.

Weird Theories

1. *Natural theory 1:* The apparition is a delusion caused by the power of suggestion—Jason’s expectation—that the room is haunted.
Natural theory 2: The apparition is caused by projectors set up to promulgate the haunted reputation in an effort to gain publicity for the hotel.
Paranormal theory: The apparition is caused by the spirit of the murdered man.
2. *Natural theory 1:* The guy was drinking heavily and stayed away from the dorm for a few days.
Natural theory 2: The guy suffered an acute head injury or episode of mental illness, causing him to be away for a few days.

- Paranormal theory:* The guy was abducted by aliens, leading to long-lasting mental challenges.
3. *Natural theory 1:* Ella was very fortunate; the win was mere coincidence.
Natural theory 2: The lottery was fixed in her favour.
Paranormal theory: The fortune cookie foretold the future.
 4. *Natural theory 1:* Amir would have recovered anyway, without any medication.
Natural theory 2: The placebo effect contributed to Amir's recovery.
Paranormal theory: The homeopathic treatment caused Amir to recover.
 5. *Natural theory 1:* Aaron and Susan conspired to fool others at the party.
Natural theory 2: Aaron used "cold reading" techniques.
Paranormal theory: Aaron has the ability to read minds.
 6. *Natural theory 1:* The planes were shot down by terrorists or other enemies.
Natural theory 2: The planes landed safely at a secret location, but a rumour was begun by people who only knew part of the story.
Paranormal theory: The planes and crew were abducted by aliens.
 7. *Natural theory 1:* John Edward used cold reading in order to get the correct answer.
Natural theory 2: John Edward made an educated guess that happened to be correct.
Paranormal theory: John Edward possesses a supernatural ability to predict the future.
 8. *Natural theory 1:* Popoff used cold reading in order to surreptitiously acquire this information from the elderly lady herself.
Natural theory 2: The elderly lady wrote down that she had rheumatoid arthritis on a card on her way into the event, and gave the card to Popoff's assistant. Popoff is wearing an earpiece that allows his assistant to communicate this information to him.
Paranormal theory: Peter Popoff has supernatural powers which allow him to diagnose illnesses without undertaking medical examinations.
 9. *Natural theory 1:* Natasha used cold reading in order to make this determination.
Natural theory 2: Natasha made an educated guess based on the woman's appearance, behaviour, and habits.
Paranormal theory: Natasha actually has x-ray vision, and used it to perceive that the woman had previously undergone surgery on her lung.