Title: Hypothetical Reasoning: Characteristic Features, Use in Arguments, and Associated Fallacies

Author: M. FitzGerald

Introduction:

Hypothetical reasoning is fundamental to thinking critically. In one of its most important applications, it's a method for proposing and testing a theory, so it's very useful in the social and natural sciences. Below, you'll find a brief overview of hypothetical reasoning, including its some of its formal features, its use in argumentative prose, and several fallacies associated with its misuse.

Formal Characteristics of Hypothetical Reasoning:

- **Use of Conditional Statements:** Hypothetical reasoning almost always involves conditional statements, where an assertion is made about what would be true IF certain conditions were met. These statements often take the form "if…then," but they can also use cognates – words that function the same as "if-then."
    a. **Examples:** If it rains, then the streets are wet.
    The streets are wet if it rains.
    The streets are wet whenever it rains.
    That it is raining implies that the streets are wet.
    Wet streets are a consequence of rain.
- **Antecedent and Consequent:** In a conditional statement, the antecedent is the "if" clause, which specifies the condition, while the consequent is the "then" clause, which specifies the result or consequence. Note that "if" is not part of the antecedent, and "then" is not part of the consequent.

The Truth or Falsity of Conditional Statements:

- As noted above, a conditional statement is one in which "an assertion is made about what would be true IF certain conditions were met." But what are those conditions? Simply put, they depend on the respective truth and falsity (the so-

called “truth-values”) of the antecedent and consequent, for which there are only four possibilities:

a. If the antecedent is true and the consequent is true, then “If X then Y” is true.
b. If the antecedent is true and the consequent is false, the “If X then Y” is false.
c. If the antecedent is false and the consequent is true, then “If X then Y” is true.
d. If the antecedent is false and the consequent is false, then “If X then Y” is true.

- **Note that the ONLY time that a conditional statement is false is when the antecedent is true and the consequent is false.** In all other cases, conditional statements are true, even when both the antecedent and consequent are both false. This can be counterintuitive, so let’s explain it with an example. Suppose I say, “If it’s raining, then the streets are wet.” This is a conditional statement, so it has an antecedent (“it’s raining”) and a consequent (“the streets are wet”). But suppose that it’s sunny and the streets are dry – that would mean that both the antecedent and consequent (respectively,“it’s raining”/”the streets are wet”) are false. Nonetheless, our conditional would still be true – namely, that IF it’s raining THEN the streets are wet. The ONLY time that this statement is false is if it were raining and the streets were not wet, that is, when the antecedent is true and the consequent is false.

Application to Scientific Reasoning

Scientific inquiry often starts with a research question. Can we edit human genes to forestall certain cancers? Is a tax on carbon an effective way to lower greenhouse gases? Will increasing use of AI lead to a net loss of human jobs in the IT industry?

To answer questions such as these, we must formulate testable hypotheses:

- **Question**: Can we edit human genes to forestall certain cancers?
- **Hypothesis**: **If** gene-editing is a useful tool against certain cancers, **then** we should find a reduced cancer rate among individuals with a family history of those cancers who undergo gene-editing, compared to control groups without gene editing.

- **Question**: Is a federally mandated carbon tax an effective way to mitigate greenhouse gases?
- **Hypothesis**: **If** enacting a mandated carbon tax is an effective approach to mitigating greenhouse gases, **then** we should find a significant reduction in greenhouse gases after the tax is enacted as longitudinally measured by standard tools, such as non-dispersive infrared (NDIR) analyzers.

- **Question**: Will increasing use of AI lead to a net loss of human jobs in the IT industry?
- **Hypothesis**: **If** widely implemented AI technologies cause job-loss in the IT industry, **then** we should find an inverse correlation between the degree of adoption of AI technologies in IT and corresponding losses in IT employment levels – according to our hypothesis, as AI adoption increases, IT jobs will decrease.

As you can see, **if-then statements are used to structure hypotheses**. The antecedent expresses the presumptive causal mechanism or prediction; the consequent expresses the expected outcome or result. Together, they constitute a scientific theory.

Two Argument Forms[1] Frequently Used in Hypothetical Reasoning:
When reasoning hypothetically, it's essential to use proper logical form. Here are two valid forms that you should know:

1. **Modus Ponens** (MP -- Latin for "in the mode of affirming"):
   Proper (valid) logical form:
   Premise 1: If A then B
   Premise 2: A
   Conclusion: Therefore, B

   Example:
   Let A = "you are a mother" (antecedent)
   Let B = "you are female" (consequent)
   Premise 1: If you are a mother, then you are female
   Premise 2: You are a mother
   Conclusion: Therefore, you are female

2. **Modus Tollens** (MT -- Latin for "in the mode of denying"):
   Proper (valid) logical form:
   Premise 1: If A then B
   Premise 2: not B
   Conclusion: Therefore, not A

   Example:
   Let A = "you are a mother" (antecedent)
   Let B = "you are female" (consequent)
   Premise 1: If you are a mother, then you are female
   Premise 2: You are not female
   Conclusion: Therefore, you are not a mother

[1] While there is an additional form of hypothetical reasoning (called "hypothetical syllogism") that is useful in scientific reasoning, we'll stick with **MP** and **MT** for now.

The Application of MP to Hypothetical Reasoning in the Sciences
MP can be used in scientific reasoning to draw valid conclusions from evidence. For instance, if researchers conjecture that a particular drug (known as donepezil) can be used to treat Alzheimer's disease, they might hypothesize that, when donepezil is administered, memory loss is diminished.

Let's use MP (if X then Y; X; therefore Y) to structure our reasoning:
Premise 1 (if x then y): **If** donepezil is administered to treat Alzheimer's disease, **then** memory loss will be diminished as measured by standard cognitive tests.
Premise 2 (X, logically known as "affirmation of the antecedent"): Donepezil was administered to treat Alzheimer's disease.
Conclusion (therefore Y): Memory loss was diminished as measured by standard cognitive tests.

In essence, MP is a method in scientific reasoning for the confirmation of hypotheses based on empirical results. However, if its premises are based on incorrect or misleading information, then the conclusions drawn from MP may be faulty. If we suspect this, we should either reject or significantly revise the hypothesis.

The Application of MT to Hypothetical Reasoning in the Sciences
Sir Karl Popper, one of the 20th century's most ingenious thinkers, proposed a theory of scientific discovery based upon the notion of **falsifiability**. According to Popper, a scientific hypothesis must be framed in such a way that it can be **proven false** through empirical observation. The key to falsifiability is **modus tollens** (MT).

Remember how MT works? Starting with a hypothetical statement as premise one (**if X then Y**), we then negate the consequent in the second premise (**not Y**) and conclude by negating the antecedent in the conclusion (**therefore not X**).

To put this another way, MT can be applied when a scientific theory (if x then y) makes a prediction (X) but the empirical evidence does not lead to the expected result (not Y). According to MT, the prediction must be rejected (not X).

Here's our previous example, now structured using MT. Note that the first premise is identical in both instances:
Premise 1 (if x then y): **If** donepezil is administered to treat Alzheimer's disease, **then** memory loss will be diminished as measured by standard cognitive tests.
Premise 2 (not Y, logically known as "denial of the consequent"): Memory loss was not diminished.
Conclusion (therefore not X): Therefore, the administration of donepezil cannot be used to treat Alzheimer's disease.

We have disconfirmed, or **falsified**, the hypothesis.

The use of MT in hypothetical reasoning emphasizes the value of falsification. Again, if its premises are based on incorrect or misleading information, then the conclusions drawn from MT, just as with MP, may be faulty. If we suspect this, we should either reject or significantly revise the hypothesis.

Use of Hypothetical Reasoning in Argumentative Prose

Hypothetical reasoning also can be effectively used in argumentative prose. Because it allows writers to frame conjectures, explore alternatives, and test assumptions, it is a mainstay of research papers. Here are a few tips for its use:

- Since hypotheses often originate in research questions, **start by stating the question or problem your paper will address**, which will provide the context for your hypothesis. For example, if you were writing a research paper for an economics course, you might ask "Do tariffs on imported garments lead to increased consumption of clothing that is domestically produced?" This question might be a good opening for your paper.

- **Clearly state the hypothesis related to your research question and ensure that it's testable.** For the question above, you might hypothesize the following: "**If** tariffs are imposed on imported garments to encourage the consumption of domestically produced clothing, **then** sales of similar garments produced in the USA will increase." There's enough data available to confirm or refute the hypothesis, so it's testable.

- **Frame the logic of your hypothetical reasoning: Using either MP or MT,** state the logical structure for either confirming or disconfirming (falsifying) your hypothesis. Here, you'll want to make clear the valid pattern for your inference.

    - Modus Ponens:
        - Premise 1: **If** tariffs on imported garments lead to increased consumption of clothing that is domestically produced, **then** sales of similar garments produced in the USA will increase (if X then Y).
        - Premise 2: Sales of similar garments produced in the USA increased (X).
        - Conclusion: Therefore, tariffs on imported garments lead to increased consumption of clothing that is domestically produced (Therefore, Y).
    - Modus Tollens:
        - Premise 1: **If** tariffs on imported garments lead to increased consumption of clothing that is domestically produced, **then** sales of similar garments produced in the USA will increase (if X then Y – note the use of the same first premise in both MP and MT).

    - Premise 2: Sales of similar garments produced in the USA did not increase (not Y).
    - Conclusion: Therefore, tariffs on imported garments do not lead to increased consumption of clothing that is domestically produced (Therefore, not X).

- **Enrich your research by imagining a hypothetical variant that explores from a different angle the question you're discussing.** You can use **"but what if"** statements to introduce these scenarios. In the example we're using, such a variant might be, "But what if the imported garments provide better protection from hazardous materials in specialized industries?" or "But what if the imported garments are from high-end Italian clothiers?" These variants will allow you to accomplish several ends simultaneously, specifically (a) address specific objections (known as rebuttals) to your hypothesis and (2) make your hypothesis more comprehensive. Acknowledging rebuttals shows that you've considered opposing viewpoints. It bolsters your argument.

- **Validate the credibility and strength of your evidence.** Any hypothesis will ultimately stand or fall on the evidence that used to support it. Practically speaking, this requires that you inspect each of the premises you use to frame your hypothesis. Is the evidence you will use to confirm or disconfirm your hypothesis clearly identified? Is it sufficiently credible to either affirm or deny your conclusion?

Fallacies Associated with Hypothetical Reasoning
A fallacy is a mistake in reasoning. Fallacies associated with hypothetical reasoning invalidate it. Here are two that you should recognize and avoid:

- **Affirmation of the consequent** occurs when a reasoner wrongly assumes that if the consequent of a conditional statement is true, then the antecedent must also be true. Example:

    If it is raining, then the streets are wet. (If R then W)
    The streets are wet. (W)
    Therefore, it is raining. (Therefore R)

    Why is this reasoning fallacious? There could be reasons other than rain that cause the streets to be wet, such as an open fire hydrant. It's a clear case of affirmation of the consequent.

- **Denial of the antecedent** occurs when a reasoner incorrectly concludes that if the antecedent is false, then the consequent must also be false. Example:

    If it is raining, then the streets are wet. (If R then W)
    It is not raining. (not R)

Therefore, the streets are not wet. (Therefore, not W)

This inference also is incorrect. There could be reasons for the streets to be wet other than rain, such as street washer. It's a clear case of denial of the antecedent.

Being able to spot these two fallacies -- affirmation of the consequent and denial of the antecedent -- will help ensure that the hypothetical reasoning we employ is logically sound.

Conclusion

Hypothetical reasoning is a powerful tool for anyone seeking to reason critically. By understanding its formal features, its use in argumentative prose (particularly research papers), and some fallacies associated with its misuse, we can become better thinkers.