Confirmation, Falsification, and Fallibility

Clicker Question

What form does this argument have?

The color will not turn blue because the temperature did not rise and we know that if the color turns blue the temperature rises.

A. Modus ponens
B. Affirming the consequent
C. Modus tollens
D. Denying the antecedent

Clicker Question

What form does this argument have?

Deficits increase only if unemployment increases. Unemployment is increasing. Thus, the deficit is increasing.

A. Modus ponens
B. Affirming the consequent
C. Modus tollens
D. Denying the antecedent

Clicker Question

What form does this argument have?

When it rains in San Diego, it snows in Julian. It is not snowing in Julian, so it is not raining in San Diego.

A. Modus ponens
B. Affirming the consequent
C. Modus tollens
D. Denying the antecedent

The simple model of falsifying a hypothesis

The basic idea that false predictions count against the truth of a hypothesis is captured in the following argument schema

If the hypothesis is true, then the prediction will be true
The prediction is not true
∴The hypothesis is not true

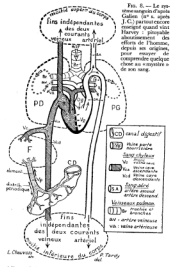
This argument form is *modus tollens*. It is valid.

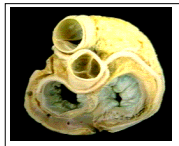
- The question is whether the premises are true.

Galen's (129-216) two bloods

According to Galenic physiology, arteries and veins each carried different types of blood away from the heart

- Venous blood carried nutrients from the liver (where it is made) through the right side of the heart to the body. This blood is sucked in by the heart
- Arterial blood is created in the heart, vivified by the lungs, and carried from the left side of the heart to the body
- Both types of blood were consumed by the body's tissues





William Harvey's (1578-1657) evidence against Galen

Determined that the valves in the veins would only permit flow into the heart, not out

But the Galenic theory predicted that blood could flow away from the heart in the veins

If the Galenic theory were true, valves should permit outward flow from the heart into the veins
Valves do not permit outward flow from the heart
∴The Galenic theory is wrong

William Harvey's evidence against Galen- 2

An assumption of the Galenic theory is that all the contents of arterial and venous blood originate in food and are dispersed

- Prediction: the mass of food and drink must equal the mass of the material in the arterial and venous blood
- Harvey measured the amount of blood in the heart at a time (approx. 2 ounces) and multiplied by number of heart beats an hour (2,000)
  - He estimated that 40 pounds of blood was sent out per hour
- This exceeded the amount of food and liquid a person consumes —and where does it all go?

If Galenic theory is true, people need to replenish the stuff of blood from food and drink
People do not eat or drink enough to replenish the stuff of blood
∴Galenic theory is false

Clicker Question

What form of inference is Harvey using in this argument?

If Galen's theory is right, people need to replenish the stuff of blood from food and drink
People do not eat or drink enough to replenish the stuff of blood
∴Galen's theory is wrong

A. Modus ponens
B. Affirming the consequent
C. Modus tollens
D. Denying the antecedent

Clicker Question

If you want to challenge the conclusion of the argument

If Galen's theory is right, people need to replenish the stuff of blood from food and drink
People do not eat or drink enough to replenish the stuff of blood
∴ Galen's theory is false

your best strategy is to

A. Challenge its validity
B. Simply assert that Galen's theory could not be false
C. Suspect that people eat or drink much, much more than they admit
D. Question the correctness of the first premise

Holding on to hypotheses despite falsification

- It is infrequent that a scientist will give up a hypothesis as soon as a prediction fails. Why?
  - An accepted hypothesis often has lots of evidence in its favor—things it does explain
  - Even a flawed hypothesis is better than no hypothesis
    - Without an alternative theory, stay with what has worked so far
  - There are also other factors involved in deriving a prediction from a hypothesis that can be blamed for a failed prediction...

The Gap Between Hypothesis and Predictions

- Other factors often involved in deriving a prediction from a hypothesis:
  - Auxiliary assumptions/hypotheses that are assumed to be true and required to make the prediction
  - Features of the observational or experimental design that affect the prediction

Option: Reject the auxiliary assumptions or the experimental procedure

If the hypothesis is true AND all auxiliary hypotheses needed to make the prediction are true AND if the experimental setup is adequate, then the prediction will be true
The prediction is not true
∴The hypothesis is false, OR an auxiliary hypothesis is false, OR the experimental setup is not adequate.

Challenge: When to reject one of the auxiliary hypotheses or the experiment, and when to reject the main hypothesis?

This requires thoughtful deliberation, not just following a rule

Clicker Question

What is an auxiliary assumption?

A. An alternative hypothesis to the one being tested
B. An additional hypothesis required to derive a prediction from the main hypothesis being tested
C. A hypothesis put forward so as to be rejected if possible
D. A hypothesis which has not yet been adequately confirmed and so requires more testing

Clicker Question

Consider now what happens when a prediction turns out to be true. Does this argument show how one should reason?

If the hypothesis is true, then the prediction is true
The prediction is true
∴The hypothesis is true

A. Yes, it shows why the hypothesis is true
B. No, the argument has a false premise
C. No, the argument is MT
D. No, the argument affirms the consequence

The fallacious version of confirming a hypothesis

If the hypothesis is true, then the prediction is true
The prediction is true
∴The hypothesis is true.

XXXXXX

This is the form affirming the consequent, and is invalid

Clicker Question

What premise needs to be added to make this argument valid:

?
The prediction is true
∴The hypothesis is true

A. All the predictions are true
B. If the hypothesis is true, the prediction is true
C. If the prediction is not true, the hypothesis is not true
D. If the hypothesis is not true, the prediction is not true

Using a prediction not otherwise expected to be true

If the hypothesis were **not** true, then the prediction would **not** be true
The prediction is true
∴The hypothesis is true

- This argument is valid, but is it sound?
  - We now have to be sure that the first premise is true
- Problem—typically there will be alternative hypotheses (some slight variants of the one under consideration) that make the same prediction

Refining the Argument for Confirmation

If the hypothesis under investigation were not approximately true and there is not a plausible alternative hypothesis that is true, then this prediction would be very unlikely to be true

The prediction is true

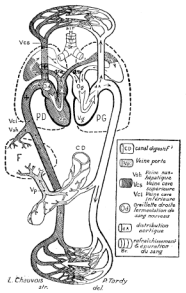
∴The hypothesis is approximately true or a plausible alternative hypothesis is true

– If there are no plausible alternatives, then we can conclude our hypothesis is approximately true
  But what if an alternative is discovered next month?

Harvey's Alternative Hypothesis

Rejecting Galen's hypothesis, Harvey proposed that

- there is only one kind of blood
- it circulates out from the heart in the arteries and returns to the heart in the veins



Harvey's proposal

Since all things, both argument and ocular demonstration, show that the blood passes through the lungs and heart by the force of the ventricles, and is sent for distribution to all parts of the body, where it makes its way into the veins and porosities of the flesh, and then flows by the veins from the circumference on every side to the centre, from the lesser to the greater veins, and is by them finally discharged into the vena cava and right auricle of the heart, and this in such a quantity or in such a flux and reflux thither by the arteries, hither by the veins, as cannot possibly be supplied by the ingesta, and is much greater than can be required for mere purposes of nutrition; it is absolutely necessary to conclude that the blood in the animal body is impelled in a circle, and is in a state of ceaseless motion. (Harvey, 1628, *On the movement of the heart and blood in animals*)

How to secure positive evidence?

Harvey could not see the connecting capillaries. What kind of prediction could he make on the basis of his hypothesis that would be specific to it (i.e., not expected on other grounds)?

What would happen if Harvey is right and you permit blood to flow through arteries in your arm but not through the veins?

- Harvey predicted and demonstrated swelling of the limbs
  - This is a prediction one would not make without Harvey's hypothesis

Harvey's argument

If the blood does not circulate, then leaving the arteries into the arm open but blocking the veins would not generate swelling
Leaving the arteries into the arm open but blocking the veins does generate swelling
∴The blood circulates

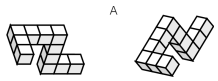
The first premises asserts the fact that whereas on Harvey's hypothesis swelling is expected, it would not have been on any of his competitors, especially Galen's

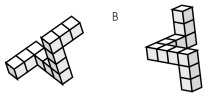
It helps to have friends in high places!

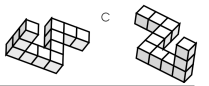
Harvey was severely ridiculed for his radical ideas and lost lots of patients

But he has one who mattered—Harvey is here demonstrating the heart to King Charles, to whom he was personal physician

Confirming a mental rotation hypothesis







Hypothesis: People use mental images and operate on them in problem solving

Prediction: If asked whether two rotated figures match, response times will vary with degree of rotation.

If an image is not being rotated, reaction times should not correspond to degree of rotation
Reaction times do correspond to degree of rotation
∴An image is being rotated mentally

Hypothesis: Perception affected by one's beliefs

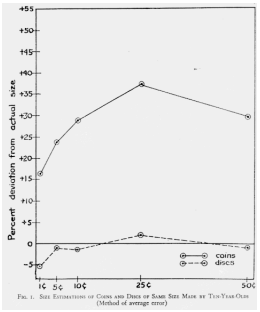
Traditional view: perceiving is independent of one's beliefs and relies on what is there to be seen

Jerome Bruner suspected that this was false and considered the alternative: beliefs affect perception

Prediction: judgments of the sizes of cardboard circles will be quite accurate

But judgments of the size of coins will be affected by their value

Bruner's Results



Size of coins significantly overestimated

Up through quarter, overestimate larger for larger valued coins

Further prediction: poor children will overestimate more than rich

Bruner's results - 2

Poor children overestimated the sizes of coins more than rich children

If value did not influence perception, then there should be no overestimates of coin sizes
There are overestimates of coin sizes
∴Value does influence perception

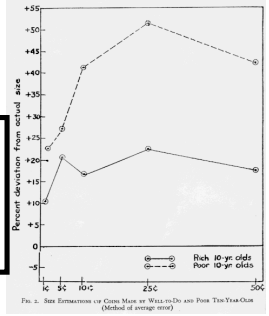


Fig. 2. Size Estimations of Coins Made by Well-to-Do and Poor Ten-Year-Olds (Method of average error)

Evaluating Hypothesis: The Simple and the Subtle

- In principle the logical evaluation of a hypothesis given evidence is simple:
  - If a hypothesis predicts something not otherwise expected, that counts in favor of its truth
  - If a hypothesis makes a false prediction, that counts against its truth
- But most interesting hypotheses in science both make new, unexpected predictions that turn out to be true and make predictions that turn out to be false
- No simple recipe for deciding whether to reject a hypothesis once it has made a false prediction or to hold onto it because of its record of true predictions

Fallibility

- Issues in science are seldom resolved by decisive experiments that once and for all falsify or confirm a hypothesis
- Hypotheses often take a long period to become established
  - And once established, a long period is often required to overthrow them
- All judgments in science are *fallible*—subject to revision with more evidence
- Yet, making the best judgment about our hypotheses is important and by focusing on the forms of argument that are used and then considering the premises it is possible to improve our judgments.