Confirmation, Falsification, and Fallibility

Review

- Valid argument:
  - An argument in which, if the premises are true, the conclusion **must** also be true

- Sound argument:
  - An argument which is valid and has true premises

- Sound arguments provide justification since they *compel* belief in the conclusion

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Review - 2

- Conditional statements are true **except** when
  - The antecedent is true and the consequent is false
    - If you attend class, you will pass the course.

True	True	True
True	False	False
False	True	True
False	False	True

  - Note: conditional statements are **not** arguments

- A *only if* B says the same thing as
  - *If* A, *then* B

- A *unless* B says the same thing as
  - *If* not B, *then* A   or
  - *If* not A, *then* B

Clicker Question

The statement:
    Unless Congress acts, taxes will increase
is equivalent to
- A. If Congress acts, taxes will increase
- B. If Congress acts, taxes will not increase
- C. If Congress does not act, taxes will increase
- D. If Congress does not act, taxes will not increase

Clicker Question

Which statement is not equivalent to the others?

- A. There are no fires unless there are Santa Ana winds
- B. If there are Santa Ana winds, there are fires
- C. If there are fires, there are Santa Ana winds
- D. There are fires only if there are Santa Ana winds

Clicker Question

Assume:
The dogs are barking = T   The storm is violent = F

What is the truth value of the following statement?
    Unless the dogs are barking the storm is not violent.

A. True
B. False

Clicker Question

Assume:

The dogs are barking = T   The storm is violent = F

What is the truth value of the following statement?
   Only if the storm is violent are the dogs barking.

   A. True
   B. False

Review - 3

- **Valid argument forms:**

If A, then B	If A, then B
A_____	Not B_____
∴B	∴Not A
– *Modus ponens*	– *Modus tollens*

- **Invalid argument forms**

If A, then B	If A, then B
Not A	B
∴Not B	∴A
– Denying the antecedent	– Affirming the consequent

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.

A compelling simple example of falsification

Where do plants get their body mass from?

Natural hypothesis: from the soil

In 1649 Jan Baptista van Helmont grew a willow tree for five years in a measured amount of soil, adding only water.
   Prediction: The soil should diminish proportionate to the tree's mass
   Result: The tree increased in weight by 164 pounds while the soil diminished by **only two ounces**.

> If soil is the source of the mass of trees, then the weight of the soil should diminish as the tree grows
> The weight of the soil does not diminish as the tree grows
> ∴The soil is not the source of the mass of trees

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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
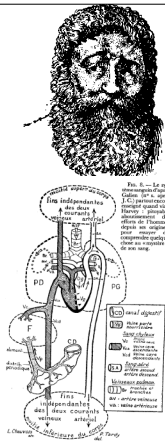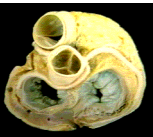

William Harvey's (1578-1657) evidence against Galen

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), estimated that 40 pounds of blood 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...

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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

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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

The endurance of the caloric theory of heat

- The ability to heat a cold body by placing it next to a warm one suggested the hypothesis that heat is a fluid

- In the 18th century heat (caloric) was treated like other newly discovered fluids such as electricity.
- Suggests that heat can be conserved

- Complexity: different substances warmed differently by same source of heat:
  - 1 liter of 100° C. water will warm a liter of
    - 0° C. water to 50° C.
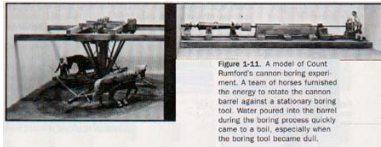   - 0° C. mercury to approx. 97° C.

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Count Rumford's (aka Benjamin Thompson's) experiment

Friction from boring out a cannon heats the metal, but there is no source from which caloric is transferred

Maybe the caloric is contained in pockets within the metal

But slow boring with a dull knife produced more heat than rapid boring, which would unseal more pockets.

Figure 1-11. A model of Count Rumford's cannon-boring experiment. A team of horses furnished the energy to rotate the cannon barrel against a stationary boring tool. Water poured into the barrel during the boring process quickly came to a boil, especially when the boring tool became dull.

Rumford's reasoning

If caloric (a fluid) is responsible for heat, drilling a cannon with a bit should not produce heat
Drilling a cannon with a bit did produce heat (lots of it)
∴Caloric is not responsible for heat

Endurance of caloric theory

Caloric had been named by Lavoisier after he rejected phlogiston. After Lavoisier was executed, Rumford married Mme. Lavoisier

I think I shall live to drive caloric off the stage as the late Lavoisier drove away [phlogiston]. What a singular destiny for the wife of two Philosophers!

But caloric survived Rumford
and Mme. Lavoisier divorced him

Caloric theory had a great deal of explanatory power such as the ability to explain the movement of heat through a vacuum.
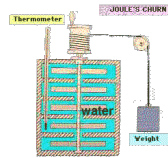
The final demise of caloric

James Joule discovered in 1840 that the an electric current (I) flowing through a resistance (R) generated a rate of heating I^2R

Joule calculated the mechanical energy needed to produce one BTU of heat

Relating heat to mechanical energy provided an alternative conception of heat

With the development of an alternative theory linking heat to mechanical energy, the caloric theory was finally displaced

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.

XXXXX

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?
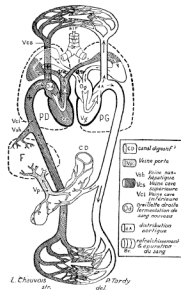
Harvey's Alternative Hypothesis

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