Valid Arguments (cont.);
Confirmation, Falsification, and Fallibility

Phil 12: Logic and Decision Making
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Review

• Conditional statements
  - False when antecedent true, consequent false
  - Otherwise true
Review

• Rules for translating between equivalent conditional statements:
  
  - Reverse antecedent and consequent:
    
    \[
    \text{If } A \text{ then } B = \text{If not } B, \text{ then not } A
    \]

  - **Only if** indicates the consequent
    
    \[
    A \text{ only if } B = \text{If } A, \text{ then } B
    \]

  - **Unless** = **If not**
    
    \[
    A \text{ unless } B = \text{If not } B, \text{ then } A = \text{If not } A, \text{ then } B
    \]
Review

• Necessary & sufficient conditions in terms of conditionals:
  
  - antecedent suffices for consequent
  
    \[
    \text{If } A \text{ then } B = A \text{ suffices for } B
    \]

  - consequent is necessary for the antecedent

    \[
    \text{If } A \text{ then } B = B \text{ is necessary for } A
    \]
Consider the statement:

Unless you go to medical school, your parents won't be happy.

You go to medical school is:

A. a necessary condition for your parents' being happy
B. a sufficient condition for your parents' being happy
C. neither necessary nor sufficient for your parents' being happy
D. both necessary and sufficient condition for your parents' being happy
Arguments using conditionals
Review

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

If A, then B
A
\[
\therefore B
\]

If A, then B
Not B
\[
\therefore \text{Not } A
\]

*Modus ponens*  
*Modus tollens*
Uses of conditional arguments in scientific reasoning

• **Modus ponens** is most commonly invoked to make predictions from a hypothesis

  *If malaria is transmitted by mosquitoes and we eliminate the mosquitoes, then malaria will decline.*

  *Malaria is transmitted by mosquitoes and we are eliminating the mosquitoes.*

  ∴ *Malaria will decline.*

• **Modus tollens** is most commonly invoked to confirm or falsify a hypothesis based on the truth of falsity of a prediction
Invalid conditional arguments

If A, then B
Not A
Not B

Denying the Antecedent
INVALID

- If we assume the premises are true, **must** the conclusion be true?

  - No! Both B and *not B* are compatible with the premises
Invalid conditional arguments

If A, then B
B
A

Affirming the Consequent
INVALID

• If the premises were true, must the conclusion be true in this case?
  - No. Both A and Not A are compatible with these premises
  - There is no valid argument here either!
Summary: Conditional Arguments

• Valid argument forms:

  If A, then B
  A ________
  ∴ B

  Modus ponens

  If A, then B
  Not B _____
  ∴ Not A

  Modus tollens

• Invalid argument forms:

  If A, then B
  Not A _____
  ∴ Not B

  Denying the antecedent

  If A, then B
  B _________
  ∴ A

  Affirming the consequent

Thursday, April 7, 2011
What form does this argument have?

I know I passed the test since I took the test, and if I passed the test, I took the test.

A. Modus ponens
B. Affirming the consequent
C. Modus tollens
D. Denying the antecedent
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
Falsification & Confirmation of Hypotheses
Falsification

• The initial intuition: a hypothesis is false if a prediction derived from it is false:

   If the hypothesis is true, then the prediction is true.
   The prediction is not true.
   ∴ The hypothesis is not true.

• Argument form? Valid or invalid?
  - Modus tollens -- valid
A compelling simple example of falsification

• Question: Where do plants get their body mass from?
  - Natural assumption: 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.
  - The tree increased in weight by 164 pounds
  - 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.

∴ The soil is not the source of the mass of trees.
Galen (129-216): Two bloods

- According to Galenic physiology, arteries and veins each carried different types of blood away from the heart
  - **Venous blood** carries nutrients from the liver (where it was made) through the right side of the heart to the body
  - **Arterial blood** created in the heart, vivified by the lungs and carried from the left side of the heart to the body
  - Heart operates to suck blood in from the veins (and ultimately from the liver)
  - Both types of blood are 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 right, 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 is dispersed
  
  Prediction: the mass of food and drink must equal the mass of the material in the arterial and venous blood

- Harvey did some measurements and calculations:

  2 oz blood in heart × 2000 heart beats per hour = 40 pounds of blood sent out per hour
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.
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 it its favor—things it explains
  - 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 prediction

- 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
How to handle false predictions

If the hypothesis is true AND all auxiliary hypotheses needed to make the prediction are true AND 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?
The case of parallax

- Copernicus’ heliocentric theory of the solar system predicts \textit{parallax}: at different times of year a planet ought to appear at a different position against the fixed stars.

- But no one observed parallax for centuries. Does this falsify the heliocentric theory?

- Not necessary. A mistaken \textit{auxiliary assumption} could be to blame.
  - mistaken auxiliary assumption: distance to the planets is relatively short.
The case of parallax

- Modified auxiliary assumption (large distance to planets/stars) helps yield new prediction of very small parallax
- Still couldn’t detect parallax. Does this mean heliocentric theory is false?
- Not necessarily. The observational/experimental procedure might be to blame
Difficulty in observing parallax

- Failure to observe parallax due to inadequacies of observational/experimental procedure
- Parallax finally detected in 1838
Lesson of the parallax case

- Heliocentric theory predicts parallax
- But failure to observe parallax didn’t necessarily falsify heliocentric theory
- Other factors at play in generating a prediction:
  - auxiliary assumptions
  - observational/experimental procedure

If the earth is revolving around the sun and if all other auxiliary assumptions are true and the experimental procedure is adequate, then parallax should be observed.

Parallax is not observed.

∴ Either the earth is not revolving around the sun or one of the other assumptions is false or the experimental procedure is inadequate.
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 that should be rejected if possible

D. A hypothesis which has not yet been adequately confirmed and so requires more testing
The challenge of confirmation

• A seemingly obvious model for confirming hypotheses:

\[ \text{If the hypothesis is true, then the prediction is true.} \]
\[ \text{The prediction is true.} \]
\[ \therefore \text{The hypothesis is true.} \]

• But there is a serious problem with this argument...
Clicker question

What is the problem with the following simple argument for confirmation?

\[
\text{If the hypothesis is true, then the prediction is true.}
\]

\[
\text{The prediction is true.}
\]

\[
\therefore \text{ The hypothesis is true.}
\]

A. The second premise is false

B. It is valid because it an instance of modus tollens

C. It is invalid because it is an instance of modus ponens

D. It is invalid because it is an instance of affirming the consequent

E. I’m not sure
The challenge of confirmation

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

• This is of the form affirming the consequent, and is invalid

• We can also see what is intuitively wrong with it
  - Make up a theory (a really bad one) from which you predict that sunlight feels warm.
  - Check the prediction. Sure enough, it is true
  - That doesn’t make your bad theory true
Confirming with unlikely predictions

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 have to be sure that the first premise is true

  - Problem: typically there will be alternative hypotheses (major or slight variants of the one under consideration) that make the same prediction
If the hypothesis 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.