Valid Arguments

Brief Preview

- Decision making (whether in science or elsewhere) involves reasoning based on evidence
- Question: when does some piece of information count as (good) evidence for or against a conclusion?
  - When does some piece of information (evidence) serve to support (confirm) or count against (disconfirm) a hypothesis or theory
- To answer these questions we need to discuss arguments

Brief Review

- **Statements** are sentences that have a **truth value**—are either true or false
- **Arguments** are sets of statements, some of which serve as **premises** for others, which are **conclusions**
- **Valid arguments** are arguments in which, if the premises are true, the conclusion ***must*** also be true
- Sound arguments are ***valid*** arguments with ***true*** premises

Review continued

- True or False:
  - A valid argument cannot have a false conclusion.
  - A sound argument cannot have a false conclusion.
  - An argument with a true conclusion is sound.
  - The conclusion of a valid argument with false premises is false.

Conditional Statements

- Conditional statements consist of two component statements linked by the logical connective IF, THEN
- *If* and *then* are not indicator words—they are not marking premises and conclusions of an argument
  - *If it rains today there will be no picnic* is not an argument!
    - It simply asserts a conditional relationship between two statements
  - Compare: *On account of the fact that it is raining today, there will be no picnic.*

Conditional Statements - 2

IF, THEN is a *truth functional* connective: the truth of a compound statement depends only on the truth values of the component statements

If A, then B **is false**
when the antecedent is true and the consequent is false. Otherwise, it is true.

If you trespass, then you will be arrested

is false if you trespass and are not arrested
is true if you trespass and are arrested
is true if you do not trespass and are not arrested
is true if you do not trespass and are arrested

The last case may seem surprising, but of course there are other reasons you might be arrested

Conditional Statements - 3

IF A, THEN B is **NOT** equivalent to *IF B, THEN A*
IF A, THEN B is false when A is true and B is false
IF B, THEN A is false when B is true and A is false

IF A, THEN B **is equivalent to** *IF <u>not</u> B, THEN <u>not</u> A.*

If you trespass, then you will be arrested
is equivalent to
If you are <u>not</u> arrested, then you did <u>not</u> trespass

Conditional Statements - 4

IF, THEN versus ***ONLY IF***

Compare:
If you trespass, then you will be arrested
False if you trespass and are not arrested
Only if you trespass will you be arrested
False if you don't trespass and are arrested

B ONLY IF A is equivalent to If B, then A

If you were arrested, then you trespassed

THERE IS NO IF IN *ONLY IF*

Conditional statements - 5

UNLESS can also be used to assert conditional relations

Unless you complete the assignment, you will not get promoted
says the same thing as
If you do not complete the assignment, you will not get promoted
or
If you get promoted, then you completed the assignment.

Sufficient Conditions

When a conditional statement uses general terms (e.g., *dog*, *mammal*) it expresses relations between categories of things that satisfy those terms

If something is a dog, then it is a mammal

Presents a relation between ***being a dog*** and ***being a mammal***

It asserts that meeting the first condition (being a dog) *suffices* for meeting the second condition (being a mammal)

If __________, then___________

suffices for

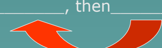
Necessary Conditions

Since a true conditional statement cannot have a true antecedent and a false consequent, the consequent of a conditional expresses something that is *necessary* if the antecedent is true

If something is a dog, then it is a mammal

Asserts that meeting the second condition (being a mammal) is necessary for meeting the first condition (being a dog)

If __________, then___________



is necessary for

If versus *Only if* again

What follows the *if* of a conditional is a sufficient condition

What follows *only if* is a necessary condition

You can vote only if you are at least 18 years old

Being 18 is a necessary condition for voting

If you are able to vote, then you are at least 18 years old

Being able to vote is sufficient (evidence) that you are at least 18 years old

Practice with conditionals

Assume:

Sales are increasing = T *Our sales force is less effective* = F
We need to build a new plant = F *We have excess production capacity* = T

Whenever sales are increasing, we need to build a new plant
T F = F

If we do not need to build a new plant, then our sales are not increasing
T F = F

Only if sales are increasing do we need to build a new plant
T F = T

We do not need to build a new plant only if we have excess production capacity
T T = T

Unless we have excess production capacity, we need to build a new plant
T F = T

Only if our sales force is less effective are our sales not increasing
F F = T

Unless sales are increasing we need to build a new plant
T F = T

Using conditionals in inference

There are two ways to use a conditional statement in a valid inference, one obvious, one less so:

The obvious way:
From *IF A, THEN B*, affirm A
From this it follows that B

Why?
If *B* weren't true, and A is true
If A, then B would be rendered false

So, the following form is VALID:

If A, then B
A
∴B ***Modus ponens***

Using conditionals in inference - 2

The less obvious way:

From *IF A, THEN B*, what happens if B is denied?

If *B* is false and *A* is true, then what is the truth value of IF A, THEN B?

It is false. Thus A cannot be true when the whole conditional is true. Thus:

If A, then B
Not B
∴Not A
is VALID *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, 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

Not all arguments that start with conditional statements are valid

What can you conclude (validly) from:

If A, then B
Not A
?

Denying the Antecedent
INVALID

Remember, to be valid, it must be that *if the premises were true, the conclusion would also have to be true*

What conclusion has to be true in this case?
Both *B* and *not B* are compatible with the premises
There is no valid argument here!

Invalid conditional arguments - 2

What about if we start with:

If A, then B
B
?

Affirming the consequent
INVALID

What conclusion has to be true in this case?
Both *A* and *Not A* are compatible with these premises
There is no valid argument here either!

Practice with Argument Forms

- I know I passed since I took the test, and if I took the test, I passed.
  - Modus ponens, valid
- Only if the dog is white is the ball blue. Indeed, the dog is white. So, the ball is blue
  - Affirming the consequent, invalid
- Whenever the computer is broken, I have to calculate the result by hand. Today I had to calculate the result by hand. Thus, the computer must have been broken.
  - Affirming the consequent, invalid

Reasoning with *And*, *Or* and *Not*

A very commonly used valid argument form is the following:

Either A or B
Not A [or Not B]
∴ B [or A] *Alternative Syllogism Valid*

Common reasoning strategy:

- start with an *exhaustive* set of alternatives
- eliminate all but one
- conclude that the remaining one is true

Reasoning with *And*, *Or* and *Not* - 2

An important but somewhat confusing type of inference involves negations operating on disjuncts (or) or conjuncts (and)

Consider the statement:
You cannot enlist in both the Army and the Navy

This is not the same as:
You cannot enlist in either the Army or the Navy

If you want to make the statement using or you must divide the negation:
Either you do not enlist in the Army or you do not enlist in the Navy

Reasoning with *And*, *Or* and *Not* - 3

Likewise, consider the statement

Neither San Diego nor Los Angeles will win the World Series this year

Which is equivalent to

It is not the case that either San Diego or Los Angeles will win the World Series this year

You cannot simply move the *not* to be with the two parts:

Either San Diego will not win the World Series this year or Los Angeles will not win

But must switch to an *and*

San Diego will not win the World Series this year and Los Angeles also will not win.

The *apparent* simplicity of showing a hypothesis to be false

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

If the hypothesis is true, then the prediction is true
<u>The prediction is not true</u>
∴The hypothesis is not true

Apply this to Halley
If Halley's comet hypothesis is correct, his comet will reappear in December, 1758

Had his comet not appeared, people would have concluded that his hypothesis was wrong.

The challenge of confirmation

What seems to be the obvious way to confirm a hypothesis faces a serious problem:

If the hypothesis is true, then the prediction is true
<u>The prediction is true</u>
∴The hypothesis is true.

XXXXX

This is 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

The strategy for overcoming the problem of confirmation

Focus not on any prediction of a theory, but one that, ***if one did not accept the hypothesis, one would not expect to be true***

That is, one connected to the hypothesis in the following conditional:

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

Now you can invoke *modus tollens* in the confirmation:

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