Critical Reasoning:
A Romp Through the Foothills of Logic

Lecture Three: Deduction and Induction

Marianne Talbot
Department for Continuing Education
University of Oxford
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Last week we learned how to:

- **set out arguments logic book style**
- **deal with ambiguities**
- **identify conclusions and premises**
- **eliminate irrelevancies**
- **identify suppressed premises**
- **make terms consistent**

So now we:

- **know what arguments are;**
- **can distinguish arguments from other sets of sentences;**
- **can analyse arguments and set them out logic book style.**

We haven't yet started on how to evaluate arguments

We won't be starting that this week

This week we are going to look at:

- the normativity of critical reasoning
- the relation of 'following from'
- the two main types of argument
- how to distinguish deductive arguments from inductive arguments

In critical reasoning we are concerned with…

… whether or not an argument is *good…*

…it is not, therefore, a purely descriptive discipline…

…it is *normative*, i.e. it lays down standards for us to follow

In studying critical reasoning we are interested in…

… when a conclusion *follows from* a set of premises (and is good)…

…and when it doesn't *follow from* a set of premises (and is bad)

But there are broadly two varieties of 'following from'…

…today we are going to learn how to distinguish them from each other

Both deduction and induction are varieties of 'following from'…

…so a conclusion may follow *deductively* from a set of premises…

…or it may follow *inductively* from a set of premises

There are three questions we can ask to determine whether an argument is deductive or inductive:

1. **Does the argument preserve truth?**

2. **Is the matter of whether the conclusion follows from the premises an either/or matter or a matter of degree?**

3. **Can we evaluate the argument a priori?**

Let's look at each in turn

The first property that distinguishes…

…deduction from induction is…

…the fact that a *good deductive argument* is truth-preserving…

…whilst neither *bad* deductive arguments…

…or *inductive* arguments…

… are truth-preserving

An argument is truth-preserving if and only if (iff)…

… it is not logically possible…

… for its premises to be true…

… whilst its conclusion is false

To understand this you must…

… be able to distinguish…

… *logical impossibility*…

…and *physical impossibility*

Something is *physically* impossible if it is inconsistent with the laws of nature

Something is *logically* impossible if it is inconsistent with the laws of logic

It is physically impossible…

… for a human being to swim three miles underwater without breathing apparatus…

…or for a cat to talk intelligently about Kant…

…but both these things are logically possible

It is logically impossible…

… for a square to be a circle…

…or for a man to be a married bachelor…

…or for a person to have exactly three *and* exactly four children

Exercise One:

1. **Give two example of states of affairs (other than those in the presentation) that are logically possible but not physically possible?**

2. **Give two examples of states of affairs (other than those in the presentation) that are logically impossible**

3. **Are the following physically impossible, logically impossible or such that we can't tell?**

    1. **By means of genetic manipulation we can produce pigs that are able to fly**
    2. **John has exactly twice as many siblings as Janet: He has Susan and the twins**
    3. **Muon neutrinos can travel faster than the speed of light in a vacuum**
    4. **Physicists have succeeded in building a time machine**

So an argument is truth-preserving if and only if (iff)…

… it is not logically possible…

… for its premises to be true…

… whilst its conclusion is false

It is important to notice that the *actual* truth value…

… of the premises and conclusion of an argument…

… are irrelevant to determining whether…

… an argument preserves truth

This argument is truth-preserving:

All heavenly bodies revolve around the earth.

The sun is a heavenly body

Therefore the sun revolves around the earth

Yet its conclusion is false, as is at least one of its premises

We can be certain…

…of an argument that preserves truth…

…that it is a *good deductive argument*

We can be just as certain…

…that if an argument *doesn't* preserve truth…

…it is either a bad deductive argument…

… *or* an inductive argument

Exercise Two:

Which of the following arguments is truth-preserving (i.e. is a good deductive argument):

1. **Tom is a banker. All bankers are rich. Therefore Tom is rich.**

2. **Sue and Tom lead similar lives but Sue smokes and Tom doesn't. Therefore Sue is more likely to die from heart disease than Tom.**

3. **All dogs are mortal. Lucy is mortal. Therefore Lucy is a dog.**

4. **Killing is wrong. Therapeutic cloning involves killing. Therefore therapeutic cloning is wrong.**

5. **Every person with Huntington's Disease who has been examined, has had the HD gene on chromosome 4. Therefore everyone with HD has the HD gene on chromosome 4.**

6. **If this liquid is acidic it will turn litmus paper blue. This liquid does not turn litmus paper blue. Therefore this liquid is not acidic.**

(An argument is truth-preserving iff it is logically impossible for all its premises to be true yet its conclusion false)

You might reasonably ask ‘why is deduction useful’?

After all if we believe the premises of a good deductive argument…

… and it is logically impossible for the premises to be true and the conclusion false…

… then to believe the premises *is* to believe the conclusion

The conclusion of a good deductive argument doesn't tell us anything we don't already know

If human beings were perfectly rational….

…and believed the logical consequences of all their beliefs…

…then deduction *wouldn't* be useful…

…but human beings, sadly, are not perfectly rational…

The utility of deduction is a monument to human frailty

This phrase originated in a similar claim by Mark Sainsbury (see Logical Forms: An Introduction of Philosophical Logic, Blackwell 1991, page 25)

The second question we ask to distinguish deductive arguments from inductive arguments is:

is the matter of whether the conclusion follows from the premises *an either/or matter* or a *matter of degree*?

If it is an either/or matter the argument is deductive (good or bad)

If it is a matter of degree the argument is inductive

We know that the conclusion of a *deductive* argument follows from its premises…

… iff the argument is truth-preserving…

… so if a deductive argument is *not* truth-preserving…

… its conclusion *doesn't* follow from its premises

So the evaluation of a deductive argument is an either or matter…

…either the conclusion follows from its premises or it doesn't…

…there is no 'maybe', no *degrees* of 'following from'…

…when we are talking about deduction

The argument on the LHS is a good deductive argument, the one on the RHS a bad deductive argument

All bankers are rich.

Deepak is a banker.

Therefore Deepak is rich.

All bankers are rich.

Deepak is rich.

Therefore Deepak is a banker.

When a deductive argument is good…

…i.e. when it is truth preserving…

…when its conclusion follows deductively from its premises…

…its premises are *conclusive* reason for believing its conclusion

The conclusion follows conclusively from the premises in a good deductive argument…

… because deductively valid arguments are *monotonic*…

… we can add *anything we like* to a good deductive argument without making it bad…

… there is *nothing* we can learn that would change it from a good argument to a bad argument

This is a good deductive argument:

All bankers are rich.

Deepak is a banker.

Therefore Deepak is rich

Is there any premise we could add that would change it from a good deductive argument into a bad one?

Does the addition of these premises change the argument from being deductively good to being deductively bad?

All bankers are rich

Deepak is a banker

It's not the case that Deepak is a banker

Therefore Deepak is rich

All bankers are rich

Deepak is a banker

No banker is rich

Therefore Deepak is rich

This is a bad deductive argument:

If it is Monday Marianne will be wearing jeans

Marianne is wearing jeans

It is Monday

But its conclusion is true – something we know on grounds *other* than our belief in the premises of the argument

So either a deductive argument is good because its premises are *conclusive* reason to believe its conclusion…

…or a deductive argument is bad because its premises are *no reason at all* to believe its conclusion…

…with deduction it is always an either/ or matter

But *no* inductive argument preserves truth…

…so we cannot evaluate inductive arguments…

…by appeal to whether or not they preserve truth…

…instead we evaluate them according to how *strong* they are

An inductive argument is *strong* iff the truth of its premises make its conclusion significantly more likely to be true

An inductive argument is a *weak* iff the truth of its premises make its conclusion only slightly more likely to be true

Which argument is inductively strong and which inductively weak?

The sun has risen every day in the history of the universe

The sun will rise tomorrow

Every time I have ever seen Marianne she has been wearing earrings.

Next time I see Marianne she will be wearing earrings

We can see that inductive strength is a matter of degree…

…because whether the premises of an argument…

… make the conclusion more or less likely…

…is itself a matter of degree

Inductive strength is not monotonic…

… the addition of a new premise to…

… an inductively strong argument…

… might make it inductively weak…

…and the addition of a new premise to an inductively weak argument…

… might make it inductively strong

So take the relatively strong inductive argument:

Jones confessed, therefore Jones is guilty of the crime

and add the extra premise:

Ten independent witnesses testify to Jones being 100 miles away from the scene of the crime at the time it was committed.

Suddenly a strong argument looks very much weaker

Example adapted from one used by Mark Sainsbury in Logical Forms: An Introduction to Philosophical Logic (Blackwell, 1991)

And take the relatively weak inductive argument:

> **Jones was present at the crime scene, therefore Jones is guilty of the crime**

and add the extra premise:

> **Smith, the policeman who tried to stop Jones kill the man, saw Jones plunge the dagger into his heart**

Suddenly a weak argument looks very much stronger

Example adapted from one used by Mark Sainsbury in Logical Forms: An Introduction to Philosophical Logic (Blackwell, 1991)

Exercise Three:

Which of these arguments is such that its being good or bad is an either/or matter, and which a matter of degree?

1. **Tom is a banker. All bankers are rich. Therefore Tom is rich.**

2. **Sue and Tom lead similar lives but Sue smokes and Tom doesn't. Therefore Sue is more likely to die from heart disease than Tom.**

3. **All dogs are mortal. Lucy is mortal. Therefore Lucy is a dog.**

4. **Killing is wrong. Therapeutic cloning involves killing. Therefore therapeutic cloning is wrong.**

5. **Every person with Huntington's Disease who has been examined, has had the HD gene on chromosome 4. Therefore everyone with HD has the HD gene on chromosome 4.**

6. **If this liquid is acidic it will turn litmus paper blue. This liquid does not turn litmus paper blue. Therefore this liquid is not acidic.**

So we now know that:

1. **If an argument preserves the truth it is a good deductive argument**

2. **If an argument doesn't preserve the truth it is either a bad deductive argument or an inductive argument**

3. **If the argument is either good or bad, with no possibility of 'maybe' it is a deductive argument**

4. **If an argument's being good or bad is a matter of degree it is an inductive argument**

The third question we ask to distinguish deductive arguments from inductive arguments is:

Can we evaluate the argument a priori?

To be able to evaluate an argument a priori …

….is to be able to tell whether the argument is good or bad…

…by appeal only to the structure of the argument…

… and the logical words used in it…

…without need of any information about the world

These are logical words:

- **‘and’**
- **‘if/then’**
- **‘not’**
- **‘or’**
- **‘if and only if’**

This gives you an indication of what is meant by the *structure* of an argument:

If it is snowing the mail will be late

It is snowing

Therefore the mail will be late

If P then Q

P

Therefore Q

Is this a good argument?

If widgets are pomol then widgets are havena

Widgets are pomol

Therefore widgets are havena

If we can tell the argument is deductive, if not it is inductive

Is this a good argument?

If widgets are pomol then widgets are havena

Widgets are havena

Therefore widgets are pomol

If we can tell, the argument is deductive, if not it is inductive

It is interesting to note that…

… the fact that deduction is a priori …

…means that it is 'topic neutral'…

…which is why it is such a useful transferable skill

These arguments have the same form but their content is quite different:

If it is snowing the mail is late.

It is snowing.

Therefore the mail is late

If the act produces the greatest happiness of the greatest number it is right.

The act does produce the greatest happiness of the greatest number.

Therefore the act is right.

Finally is this a good argument?

All widgets I ever seen have been havena

Therefore all widgets are havena

If we can tell, the argument is deductive, if not it is inductive

Inductive arguments can be evaluated only *a posteriori*…

…in the light of an understanding of the content of the argument…

…and by bringing to bear background information about the world

Exercise Four: Can we evaluate these arguments a priori or not?

1. **Jennifer is tall. Jennifer is the bank manager. Therefore the bank manager is tall.**

2. **Crocodiles are dangerous. James's dog is dangerous. Therefore James's pet is a crocodile.**

3. **It is wrong to tell a lie. Jane's telling her mum her hair looked good was a lie. Therefore Jane's telling her Mum her hair looked good was wrong.**

4. **Tomato plants that have been fed well, kept warm and watered frequently usually thrive. This tomato plant has been fed well and watered frequently but it is dead. Therefore this tomato plant hasn't been fed properly.**

5. **If this liquid is acidic it will turn litmus paper blue. This liquid turns litmus paper blue. Therefore this liquid is acidic.**

6. **The last two springs were hot and sunny, but the summers were awful. This spring was hot and sunny. Therefore this summer will be awful.**

Exercise to do at home: Are the following arguments deductive or inductive? Are they good or bad?

1. **All serial relations are transitive, aliorelative and connected. The relation 'greater than' is a serial relation. Therefore the relation 'greater than' is transitive, aliorelative and connected.**

2. **The 'games-makers' at the Olympic Stadium were all marvellous. Therefore all British people are marvellous.**

3. **The Coalition has become steadily more unpopular as the recession has deepened. Therefore the Coalition will be dissolved before the next election.**

4. **If you are a nurse you would know how to give an injection. You are not a nurse. Therefore you don't know how to give an injection.**

5. **The jet stream is to the north of us again. So next week is going to be wet, cold and grey.**

This week we have learned:

- **that critical reasoning is normative not descriptive**
- **that there are two types of 'following from'**
- **that deductive arguments are:**
  - **truth preserving (when good)**
  - **such that their being good is an either/or matter**
  - **such that we can determine a priori whether they are good or not**
- **that inductive arguments are:**
  - **not truth preserving**
  - **such that their being good is a matter of degree**
  - **such that we can determine whether they are good or not only a posteriori**

To go with this lecture series, which I gave at the Department For Continuing Education, The University of Oxford (OUDCE) in Michaelmas Term 2012, there is an e-book and a short (ten week) online course run by OUDCE.

Both are entitled: *Critical Reasoning: A Romp Through the Foothills of Logic*

- **The book, by Marianne Talbot will soon be available from all good e-book providers (follow me on Twitter @oxphil_marianne to find out when it will be released)**

- **Further details of the course can be accessed here: http://www.conted.ox.ac.uk/courses/online/short/subject.php?course_subject=Philosophy**

Marianne Talbot
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That's it folks…

…next week we'll learn how…

… to evaluate deductive arguments