INTRODUCTION TO LOGICAL THINKING

Lecture 6: Two types of argument and their role in science: Deduction and induction

1. Deductive arguments

Arguments that claim to provide logically conclusive grounds for their conclusion are **deductive arguments** (here the conclusion is claimed to lead down from the premises). Where the premises do indeed guarantee the conclusion, the argument is held to be ***deductively valid***.

1.1 Deductive validity

Where the premises guarantee with certainty the conclusion, the relation between premises and conclusion is referred to as ***deductive validity.*** Consider this argument:

All jumblies have two moggs
Sam is a jumblie
So Sam has two moggs

Notice the conclusion follows logically from (i.e., to be entailed by) the premises here.

1.2 The different forms of deductive argument

Typically, a deductive argument comes in the form of a syllogism (an argument with two premises and a conclusion, and there is a single term which appears in both premises (as in all the examples we have used so far):

All A are B
X is A
Therefore X is B

One common type of syllogism is the ***hypothetical syllogisms***. This includes a hypothetical or conditional statement in one of the premises "If ... then ...".
They are not asserting two statements – they are only asserting a single statement. The proposition which follows the "*If*" is called the "*antecedent*", and the proposition which follows the "*then*" is called the "*consequent*".

There are two common forms of **deductively valid conditional** argument: ***modus ponens*** and ***modus tollens***.

Modus ***p****onens ("****p****utting or asserting the antecedent")*

Premise 1:	If A then B	If you are a mother, then you are female
Premise 2:	**A**	You are a mother
Conclusion:	Therefore B	Therefore you are female

"antecedent" = A = "you are a mother"
"consequent" = B = "you are female"

Modus ***t****ollens ("****t****aking away or denying the consequent"):*

If A then B	If you are a mother then you are female
Not B	You are not female
Therefore not A	Therefore you are not a mother

"antecedent" = A = "you are a mother"
"consequent" = B = "you are female"

However, if you ***assert the consequent*** or ***deny the antecedent***, your argument will be not valid. We have an **error or fallacy** in the argument:

Fallacy of asserting the consequent

If A then B	If you are a mother then you are female
B	You are female
Therefore A	Therefore you are a mother

<u>Fallacy of denying the antecedent:</u>

If A then B	If you are a mother then you are female
Not A	You are not a mother
Therefore not B	Therefore you are not female

Another common type of syllogism is what is called "***argument by elimination***". Here the syllogism involves a *disjunctive statement* in the premises. A disjunctive statement is an "Either ... or ..." statement:

Either A or B	Either he is sleeping or he is watching TV
Not A	He is not sleeping
Therefore B	Therefore he is watching TV

We can also have deductively valid forms in which the premises are a mixture of hypothetical and disjunctive statements:

Either A or B	Either he's sleeping or he's watching TV
If A then C	If he's sleeping then he's breathing
If B then C	If he's watching TV then he's breathing
Therefore C	Therefore he's breathing

2. Inductive arguments

"Inductive" means "to bring forward". In inductive arguments, the premises support the conclusion to a greater or less extent, so we are looking at degrees of likeliness or probability. For example:

Many smokers die of lung cancer.
John is a smoker.
Therefore John will die of lung cancer.

Here, even if the premises are true, the conclusion is not guaranteed, because the first premise, by saying "many", allows that some smokers won't die of lung cancer. John could be one of those. There may be something about John which puts him in the "low-risk" category, such that it is not even probable that he will die of lung cancer. Now consider this argument:

I have 1000 balls in this bag. 999 are red and 1 is black. Therefore, when I put my hand in and draw out one ball, it will be red

Here, the relationship between premises and conclusion is very strong indeed, meaning that the conclusion is very likely. However, it is still not guaranteed, because there is an outside chance that I'll draw out the single black ball.

With inductive arguments, we never have logical validity in the deductive sense; the conclusion is never entailed by the premises. So all inductive arguments are logically **invalid**. Instead, what we have is degrees of strength or plausibility.

Varieties of inductive argument

Inductive arguments come in different forms, but they all involve stating the premises and then moving beyond them.

- *<u>Predictive argument:</u>* we make a prediction based on the past or present (e.g., "The logic exam has always been 2 hours long. Therefore, it will be 2 hours long next year").
- *<u>Causal reasoning:</u>* we infer a causal relation from past experience (e.g., "I can't log on. Therefore, the network must be down").
- *<u>Statistical generalisation:</u>* we observe statistical trends in a sample and then project these onto the population. Eg: if 70% of our sample first year students are female, then we might conclude inductively that 70% of all first years are female.
- *<u>Argument from analogy</u>*: we conclude something based on a comparison/similarity between two things. Eg: "John and Mary are registered psychologists, and they both practice. Lee also a registered psychologist. Therefore, Lee is likely to be in practice.

3. Deduction and induction: advantages and disadvantages

3.1 Deduction

+ The advantage of valid deductive arguments is: If the premises are true, the conclusion follows "truth preserving".
- This same benefit, however, is bought at a high price—the price of *emptiness*. They do not give us any new knowledge that isn't already in the premises.

3.2 Induction

+ It does give new information in the conclusion which is not already contained in the premises.
- But this advantage is bought at a price, the price of *fallibility*. The disadvantage of induction is that the truth of the premises does not guarantee the truth of the conclusion.

4. The role of induction and deduction in science

The word "science" means “knowledge”. Science is the careful and systematic search for knowledge. In this search for knowledge, we need to find evidence for or against our hypotheses about the world. Here is a view of science from Cohen and Nagel, the authors of one of the most famous texts on logic and scientific method:

> If we look at all the sciences … we find that the constant and universal feature of science is its general method, which consists in the persistent search for truth, constantly asking: Is it so? To what extent is it so? Why is it so? … And this can be seen on reflection to be the demand for the best available evidence, the determination of which we call logic. Scientific method is thus the persistent application of logic as the common feature of all reasoned knowledge. From this point of view scientific method is simply the way in which we test impressions, opinions or surmises by examining the best available evidence for and against them ... in essence scientific method is simply the pursuit of truth as determined by logical considerations (emphasis added). (Cohen & Nagel, 1957, p. 192)

It is worth bearing in mind that, science is amongst the most open of methods, provided that it is properly conducted (i.e., in the true spirit of *critical inquiry*). Cohen and Nagel examine non-scientific methods like dogma, relying on authority, intuition, etc. and they say that these methods:

> … are all inflexible, that is, none of them can admit that it will lead us into error. Hence none of them can make provision for correcting its own results. What is called scientific method differs radically from these by encouraging and developing the utmost possible doubt, so that what is left after such doubt is always supported by the best available evidence. As new evidence or new doubts arise it is the essence of scientific method to incorporate them ... Its method, then, makes science progressive because it is never too certain about its results. (Cohen & Nagel, 1957, p. 195)

This is what is meant by identifying science as *critical inquiry*. Science is *self-critical*, in that it accepts that we are *fallible*, and attempts to employ the best error-detection mechanisms that we have.

Now, in scientific inquiry, we meet both kinds of argument—inductive and deductive. How we evaluate an argument depends to some extent on what kind of argument it is.

4.1 Induction in science

Science is generally an *inductive* process of *searching for knowledge, a process of discovery*. In science, all forms of induction are used: inductive generalisation, predictive argument, etc. The conclusions of scientific arguments are expressed as *contingent statements* (i.e., statements which may be either true or false, such as: "Smoking causes lung cancer"). Science proposes theories and attempts to *support these theories via evidence*. However, the theories are themselves the result of experience and observations—i.e., the result of *inductive* processes. Therefore, scientific reasoning cannot yield certainty. This is what is meant by saying that science does not *prove* theories.

Evidence plays the role of the *premises* in an *inductive* argument. For example, if we find that, the % of people contracting lung cancer is consistently and significantly higher in smokers than in non-smokers, we use those observations as evidence for our inductive conclusion. If we want to be cautious, we conclude not that smoking *causes* lung cancer, but that smoking increases the risk of contracting lung cancer and simply make a statement about the observed correlation.

4.2 Deduction in science

Evidence will also play a role in the way deductive arguments are used in science. Here, we need to know about background events in the history of science. Early last century, philosophers of science were arguing that science proceeds inductively by verification (i.e., showing that the theory is true). That is, we propose a theory, and then find instances and evidence which support that theory.

But Karl Popper, said that this method is flawed, because no matter how many supporting instances we find, we can never prove true a general theory. For example, imagine that our theory is: "All crows are black". This theory is based on our past *observations*. Instead, according to Popper, we attempt to falsify the theory, because we can falsify a general theory. A single observation of a non-black crow would falsify our theory. So Popper introduced falsificationism as a scientific approach, and falsifiability (instead of verifiability) as the criterion for a scientific theory. According to Popper, whatever your theory is, you must be able to specify what observation would in principle make it false. If your theory is consistent with any actual or possible state of affairs, then your theory is unfalsifiable, and so it is not *scientific*.

This is where deduction comes in, because falsification is done via a deductive argument. It uses the familiar form of *modus tollens* (denying the consequent):

If A then B	If the theory is true, we shall observe X (e.g., If all crows are black, then the crow around the corner will be black)
Not B	We do not observe X (The crow around the corner is not black)
Therefore not A	Therefore the theory is not true (Therefore, not all crows are black)

But notice that the first premise in the above crow argument is itself a deduction.

All crows are black.
There is a crow around the corner.
The crow around the corner will be black

In other words, our hypothesis, the observation which we propose to make to support the theory is logically entailed by the theory. This is part of the *hypothetico-deductive method*, and is essential to *sound* theory testing.

In Step 1 we begin with our theory (e.g., “All crows are black”) and in Step 2 we logically/deductively derive a hypothesis from the theory (e.g., “The crow around the corner will be black”). It is this hypothesis that we empirically test in Step 3. Because of the logical validity of modus tollens, disconfirming evidence is stronger than confirming evidence (just as Popper argued).

Obviously, if a theory is true, it will never be falsified. But Popper was not claiming that we should actually falsify our scientific theory. He was insisting that we make clear what observation would falsify our theory if our theory were false. A common problem is that it’s not clear sometimes how the researcher's hypothesis is derived from the theory that is supposedly being “tested”. Also, when we put a hypothesis to empirical test in psychology, we typically use a sample drawn from a larger population of interest. Therefore, we deal with probabilities in our statistical test, and these probabilities are included in our argument’s premises. So even if we use modus tollens, our conditional first premise has reference to likeliness in the consequent. As we’ll see, this means that we never actually falsify the hypothesis that we are testing. (These issues are crucial for the way in which we go about doing scientific psychology, and we are just flagging them here; we’ll return to them later)

Conclusion

In conclusion, evidence can be used to either *support* (via induction) or *disconfirm* (via deduction) a theory. And we use deduction to derive a testable hypothesis from our theory. In the next lecture, we begin to look at this process of evaluating arguments.

References Cohen, M. R. & Nagel, E. (1957). An introduction to logic and scientific method. London: Routledge & Kegan Paul.