Deductive, Inductive, and Abductive Inference

I. Lesson

"A *deduction* is a discourse in which, certain things having been supposed, something different from the things supposed results of necessity because these things are so. By 'because these thing are so', I mean 'resulting through them', and by 'resulting through them', I mean 'needing no further terms from outside in order for the necessity to come about.'"
(Aristotle, *Prior Analytics*, transl. Robin Smith, 1989)

In this lesson, we will turn to three forms of inference – *deductive, inductive,* and *abductive*. We will look at the differences in the usages of 'deduction' and 'induction' during Aristotle's time and their usages in our contemporary era. We will also examine the practical aims of each type of inference.

1) Deductive Inference

- **(Aristotelian) Deductive Inference:** A type of inference in which the truth of the propositions in the premises logically guarantees the truth of the conclusion, which is different from the premises.

We have already seen what it means to *deduce* a conclusion from a set of premises. The types of arguments which we have examined up until now have all been *deductive inferences,* often in the form of syllogisms. For Aristotle, a deduction was any inference which satisfied the following three conditions: (1) certain propositions, namely the premises, are presupposed (i.e. taken as a logical starting point for the argument); (2) on their basis, a result which is *different* from the premises is obtained, namely the conclusion; and (3) this result follows out "of necessity". The important point lies in condition (3): Aristotle considered deductions to be *only* those syllogisms where the conclusion *must* follow from the premises. In other words, he considered deductions only those inferences which we would now label *valid* syllogisms. With this in mind, we can note that all deductions (in Aristotle's sense) are syllogisms (in our sense), but not all syllogisms (in our sense) are deductions (in Aristotle's sense).

2) Inductive Inference

Induction is a new type of inference that begins with premises concerning particular objects of a certain type and concludes with a universal proposition about all the items of that type. For example, if we would like to infer that all ravens are black, we make the inference from compiling a great many observations of actual black ravens. From observing many ravens that are black -- it would be practically impossible to observe *every* raven -- we arrive at the conclusion that *all* ravens are black, although we do not exactly have evidence for *all* ravens, only *many* of them. This kind of inference is most often used in empirical science – we *induct* on large sets of evidence in order to establish general scientific principles and results. In terms of the *scope* of such inferential

patterns, modern conventions are in agreement with Aristotle. However, there is a meaningful difference between how Aristotle defined the method of induction and how we define it today.

- **(Aristotelian) Inductive Inference:** A type of inference from the particular to the universal that has a certain logical form (see below).

For Aristotle, an inductive inference must still respect the guidelines of the syllogistic form. Suppose some term, B, is the middle term for two others, A and C, where C is a particular term and A is universal. Aristotle claims that inductive arguments allow us to predicate B of A *using* C, as follows. (1) All observed C's are A's. (2) All observed C's are also B's. (3) All A's are observed C's. Thus, all A's are B's. The crux of this inductive argument lies in the *standard of evidence* demanded by (3). Put differently, (3) expresses that the Cs observed according to (1) are *the entire extension* of A. Every object we observe having property C has property A and property B; We conclude that all A's are B's. We will look at a practical example of this pattern shortly.

- **(Modern) Inductive Inference**: A type of inference in which the truth of some conclusion follows from the truth of the premises and some *generalization* about certain items in those premises

The modern form of inductive arguments lets us conclude the same thing, but under weaker evidentiary demands. We compress (1) – (3) in the following inference: All observed Cs are As. Thus, the next C we shall observe will also be A. Under the modern conception of induction, we no longer need to establish that the Cs we have observed are the entire extension of A, nor do we need a middle term. Aristotle's demand, especially (3), is simply too strong to be widely applicable. It is often the case that we cannot establish the entire extension of A to be composed of the observed Cs. As a rough illustration of the problem with Aristotle's conception, consider the earlier example about black ravens. For the inductive argument to go through according to his definition, we would have to establish that the entire extension of 'ravens' is composed of those ravens that we have observed to be black (we would also require a third property distinct from 'ravens' and 'observed to be black' as a middle term, but ignore that for now). In other words, we need to document the properties of *every single raven* in order to conclude that they are all black. Therefore, we lower the evidential bar in the way described above.

Modern inductive arguments can thus be characterized as inferences from *frequent occurrences* of a *particular* property or behaviour to the conclusion that such a property or behaviour is *general*. In this sense, we say that inductive arguments *do* extend logically beyond the data available in the premises: even though we do not introduce any new concept or property in the conclusion. Inferences in which we "reach" beyond what our starting point establishes are called *ampliative.* Note that, as opposed to valid deductive inferences, inductive inferences can sometimes go wrong even if their premises were generally true.

3) Abductive Inference

- **<u>Abductive Inference</u>**: A type of inference in which the truth of the conclusion is reached through assuming the 'best explanation' about a set of premises.

Abductive inferences are a markedly modern notion. In fact, you might have heard of them already: a commonly-used name for abductive inference is *inference to the best explanation*. The idea behind them is simple. Sometimes, we have a broad set of premises or evidence that do not point to a single conclusion. In such cases, we opt for the conclusion which *best explains* the evidence we have observed so far. Consider the following example. You walk into your bedroom and find all the papers on your desk lying on the floor and all your books open. Your window is ajar and right above the desk. You look through your things and notice that nothing at all is missing. With this evidence in mind, you might conclude that a thief entered your room, went through the papers and books on your desk *only*, took nothing, and left. You might conclude that a malicious entity cast a spell and threw all the things on your desk in disarray. These are possible, but not very persuasive explanations. The *best explanation* for the evidence available is quite simple: a strong gust of wind blew through your open window and made a mess of the things on your desk.

Abductive inferences do extend logically beyond the premises or evidence available – as such, they are *ampliative*. This kind of inference is perhaps the one we use most in our day-to-day life, but it is also commonly employed in empirical science where, for example, a researcher comes up with some testable hypothesis that best explains a set of data that they had previously gathered. Abductive inferences lead to provisional conclusions that can be disconfirmed by future evidence, just like induction.

II. Examples

Here are two deductive inferences we might come across:

(P1): All snakes are trees.

(P2): All trees are plants.

(C): All snakes are plants.

and

(P1): All snakes are trees.

(P2): All trees are plants.

(C): No snake is a plant.

As we have seen before, the first of these is a *valid syllogism* and the second is an *invalid syllogism*. In Aristotle's sense, only the *first* will count as a deduction. The second falls short of condition (3) – the conclusion does not follow "of necessity" from the premises; quite the opposite.

Now look at the following example of Aristotelian induction, adapted directly from Aristotle. Consider A to mean 'my classmates', B to mean 'a person who is late', and C to stand for 'people in my one and only class'. We want to conclude that all my classmates are late. First, we note that each particular person in my one and only class that I observe is one of my classmates (all observed Cs are As). Then, we note that each particular person in my one and only class that I observe is late (all observed Cs are Bs). Then, we note that all my classmates are people in my one and only class (all of A is Cs). Thus, we conclude that all my classmates are late (all As are Bs).

III. Exercises

1. Explain the differences between (i) deduction and the two uses of (ii) induction in your own words.
2. Define abduction in your own words.
3. Come up with your own examples of an Aristotelian deductive inference, an Aristotelian inductive inference (use A: 'coffee strains', B: 'bitter thing' and C: a particular strain of coffee), an inductive inference in the modern sense, and an abductive inference.
4. What kind of evidence would disconfirm an inductive inference (in the modern sense)? As a test case to help you formulate a more general answer, take the following infamous case: Every particular swan observed thus far is white. Therefore, all swans are white.
5. Which of the three types of inference is weakest? Which is strongest?
6. (Optional) Generally, we take what other people tell us at face value. In other words, we rely on other people's testimony about all sorts of things. Why do you think we do this? Why do we have reason to believe what other people tell us? (What types of inference do we often rely upon in hearing testimony from others?)

IV. Conclusion

Deduction, induction, and abduction are the three main types of inferences which we commonly employ. Induction and abduction are perhaps the two most employed ones, both in day-to-day life, and in empirical science. Induction is now used differently than in Aristotle's time, but both types of usage attempt to define the same basic inferential process: in the one case, going from a set of premises to a conclusion which rests on the content of the premises, but does not logically go beyond them; in the other, going from a set of particular observations of a behavior to a general conclusion about that behavior. Sometimes, we do not have enough data to establish either type of inference. That is when we look for best explanations for the data we do have – we abduct on a set of data.

V. Lesson Goals

At the end of this lesson, students will be able to:

- define the three main types of inference: deduction, induction, abduction
- understand the differences between the Aristotelian and modern uses of induction
- provide examples of deductions and inductions under each definition

- provide examples of abductive reasoning
- understand the scope of each type of inference
- understand and rank the strength of each type of inference
- construct counterexamples for induction
- define the domains of practical utility for each type of inference

Answer Key:

Exercise 1

Deduction is used by Aristotle to only pick out what we call valid syllogisms (and there are deductions that allow us to move from the general to the particular). Induction is used by Aristotle to pick out a particular syllogistic form which allows us to move from the particular to the general. In the modern sense, we lower the evidential bar on such inferences, considering that sufficiently frequent occurrences of a particular behavior can be used to infer that such behavior generally holds.

Exercise 2

Abduction is a process inference which takes us from a set of premises or evidence to the best explanation for their being so.

Exercise 3

Answers may vary. For Aristotelian induction, the answer can be as follows: All observed strains of coffee belong by definition to the class of 'coffee strains'. All observed strains of coffee are also bitter. All the particular strains of coffee we have observed form the entire extension of 'coffee strains'. We conclude that all coffee strains are bitter.

Exercise 4

For the test case, our inductive conclusion would be disconfirmed by the first observation of a black swan. For the general case, any observation of an object which exhibits the contradictory of our conclusion disconfirms our inductive inference.

Exercise 5

Abductive inferences are generally the weakest. Deductive inferences are strongest.

Exercise 6

This is an instance of abductive reasoning. The best explanation for people expressing something to us is that they believe what they say for justifiable and responsible reasons and, consequently, they also want us to believe what they do. Therefore, we abduct that we are justified in relying on other people's testimony.

Alternatively, students might answer that we inductively conclude that if someone tells us something, then they are telling us the truth. This is because we come to this conclusion on the basis of confirming that people have been truthful with us in the past.