



HANDBOOK
of
THE HISTORY
OF LOGIC

VOLUME 10

INDUCTIVE LOGIC

Edited by

Dov M. Gabbay, Stephan Hartmann
and John Woods

NORTH-HOLLAND

Inductive Logic

Handbook of the History of Logic

General Editors

Dov Gabbay
John Woods



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INTRODUCTION

While the more narrow research program of inductive logic is an invention of the 20th century, philosophical reflection about induction as a mode of inference is as old as philosophical reflection about deductive inference. Aristotle was concerned with what he calls *epagoge* and he studied it, with the same systematic intent with which he approached the logic of syllogisms. However, it turned out that inductive inferences are much harder to evaluate, and it took another 2300 years to make substantial progress on these issues. Along the way, a number of philosophical and scientific turning points were achieved, and we can now look back on the excitingly rich history that this handbook covers in considerable detail.

After Aristotle, our history took off in the 18th century with the ingenious insights and contributions of two philosophers: David Hume famously formulated the problem of induction with tremendous clarity. This problem (also called *Hume's Problem*) kept philosophers busy ever since; many responses have been put forward and, in turn, criticized and variants of a major philosophical claim ("scepticism") have been defended on its basis. At around the same time, Blaise Pascal and the philosophers of the School of Port Royal developed probability theory and laid the groundwork for decision theory. Both developments eventually lead to a much better understanding of inductive inferences, and it would be difficult to see how their impact on philosophy and science could be overestimated.

The strong bond between developments in science and philosophy (as far as they can be separated) can also be observed in the later course of this history. Think, for example, of the work by Carnap, Hintikka, Ramsey and de Finetti and the contemporary endeavours in learning theory and Bayesian inference. The close interaction between science and philosophy is obvious here, which makes the field of inductive logic rather special. While there are many examples where a science split from philosophy and became autonomous (such as physics with Newton and biology with Darwin), and while there are, perhaps, topics that are of exclusively philosophical interest, inductive logic — as this handbook attests — is a research field where philosophers and scientists fruitfully and constructively interact.

A final development should be noted: While much of deductive logic has been developed in an anti-psychologistic spirit (an exception is van Lambalgen and Stenning's *Human Reasoning and Cognitive Science*, MIT Press 2008), inductive logic profits considerably from empirical studies. And so it is no wonder that contemporary cognitive psychologists pay much attention to inductive reasoning and set out to study it empirically. In the course of this work philosophical accounts (such as Bayesianism) can be critically evaluated, and alternatives might be inspired.

It is to be hoped that philosophers and psychologists will interact on these issues more closely in the future, and that the new trend in experimental philosophy will prove a beneficial good.

It was our intention to include a chapter on the Port Royal contributions to probability theory and decision theory. For reasons of space, we decided to avoid duplication with Russell Wahl's excellent chapter, "Port Royal: The Stirrings of Modernity", which appears in volume two of the Handbook, Mediaeval and Renaissance Logic.

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INDUCTION BEFORE HUME

J. R. Milton

The word ‘Induction’ and its cognates in other languages, of which for present purposes the most important is Latin ‘*inductio*’, have a complex semantic history, as does the Greek *ἐπαγωγή* from which they were derived. Though some of these uses — electromagnetic induction, or the induction of a clergyman into a new benefice — are manifestly irrelevant, others that still diverge significantly from any of the uses current among present-day philosophers and logicians are not. As will soon become apparent, any attempt to write a history that focused solely on the direct ancestors of modern usage would be arduous if not impossible to execute, and deeply unsatisfactory if it could be brought to a conclusion. The net must, at least initially, be cast more widely.

Another potential problem is that there may have been philosophers who discussed problems of inductive inference without using the word ‘induction’ (or its equivalents) at all. The most conspicuous suspect here is David Hume, who has been widely seen — in the twentieth century at least¹ — as an inductive sceptic, even though it is notorious that he rarely used the word, and never in the passages where his inductive scepticism has been located. Whether or not this interpretation of Hume is correct lies outside the scope of this chapter, but it is at least entirely clear that the issue cannot be decided simply from an analysis of Hume’s vocabulary. In the Hellenistic era discussions of non-deductive inference were centred on what became known as inference from signs (*semeiosis*). This was concerned with arguments from the apparent to the non-apparent — either the temporarily and provisionally non-apparent (for example something at a distance), or to the permanently and intrinsically non-apparent (for example invisible bodies such as atoms). How useful it is for modern historians to employ the terminology of induction when dealing with this material is disputed: some do so quite freely, e.g. [Asmis, 1984], while others reject it altogether [Barnes, 1988]. In the present study no attempt will be made to discuss this material in any detail; for some modern accounts see [Burnyeat, 1982; Sedley, 1982; Allen, 2001].

1 THE ANCIENT WORLD

Human beings have been making generalisations since time immemorial, and certainly long before any logicians arrived on the scene to analyse what they were doing. Techniques could sometimes go well beyond induction by simple enumeration, as the following remarkable passage from the Old Testament shows:

¹[Stove, 1973; Winkler, 1999; Howson, 2000; Okasha, 2001].

And Gideon said unto God, If thou wilt save Israel by mine hand, as thou hast said, Behold I will put a fleece of wool in the floor; and if the dew be on the fleece only, and it be dry upon all the earth beside, then shall I know that thou wilt save Israel by mine hand, as thou hast said. And it was so: for he rose up early on the morrow, and thrust the fleece together, and wringed the dew out of the fleece, a bowl full of water. And Gideon said unto God, Let not thine anger be hot against me, and I will speak but this once: let me prove, I pray thee, but this once with the fleece; let it now be dry only upon the fleece, and upon all the ground let there be dew. And God did so that night: for it was dry upon the fleece only, and there was dew on all the ground. (Judges, vi. 36–40).

Neither the writer of this passage nor his readers had ever read Mill, or heard of the Method of Agreement or Method of Difference, but few could have found Gideon's procedures difficult to comprehend. As Locke was to comment sardonically, 'God has not been so sparing to Men to make them barely two-legged Creatures, and left it to *Aristotle* to make them Rational' (*Essay*, IV. xvii. 4; [Locke, 1975, p. 671]).

It was, nevertheless, Aristotle who was the first philosopher to give inductive reasoning a name and to provide an account, albeit a brief and imperfect one, of what it was and how it worked. The name chosen was ἐπαγωγὴ (*epagoge*), derived from the verb ἐπάγειν, variously translated, according to context, as to bring or lead in, or on. Like 'induction' in modern English, *epagoge* had (and continued to have) a variety of other, irrelevant meanings: Plato had used it for an incantation (*Republic* 364c), and Aristotle himself employed it for the ingestion of food (*De Respiratione* 483a9).

1.1 *Socrates and Plato*

Although none of Aristotle's predecessors had anticipated him in using the term *epagoge* for inductive arguments, he had himself picked out Socrates for his use of what Aristotle called ἐπαγωγικούς λόγους (*Metaphysics* 1078b28). Though Aristotle would have had testimony about Socrates' activities that has since been lost, there can be little doubt that his main source of information was Plato. In the early dialogues, Socrates was often portrayed as using modes of argument that Aristotle would certainly have classed as *epagoge*, for example in *Protagoras* 332c, where Socrates is reporting his interrogation of Protagoras:

Once more, I said, is there anything beautiful?
 Yes.
 To which the only opposite is the ugly?
 There is no other.
 And is there anything good?
 There is.

To which the only opposite is the evil?
 There is no other.
 And there is the acute in sound?
 True.
 To which the only opposite is the grave?
 There is no other, he said, but that.
 Then every opposite has one opposite only and no more?
 He [Protagoras] assented. [Plato, 1953, vol. I, p. 158]

Here and elsewhere (e.g. *Charmides* 159–160; *Ion* 540) the conclusion is a philosophical one that could have been grasped directly by someone intelligent and clear-sighted enough. Plato was concerned with truths such as these, not with empirical generalisations involving white swans or other sensory particulars [Robinson, 1953, pp. 33–48; McPherran, 2007].

1.2 Aristotle

Aristotle's theory of induction — or to put it more neutrally, of *epagoge*, since there is disagreement even about the most appropriate translation of that term — has long been a matter of controversy. It is widely regarded as incomplete and in various respects imperfect: one modern commentator has referred to 'the common belief [that] Aristotle's concept of induction is incomplete, ill-conceived, unsystematic and generally unsatisfactory', at least in comparison with his theory of deduction [Upton, 1981, p. 172]. Though not everyone might agree with this, it is clear that there is no consensus either about what exactly Aristotle was trying to do, or about how successful he was.²

When Aristotle used the word *epagoge* to characterise his own arguments, his employment of the term is thoroughly Socratic, or at least Platonic; the arguments were seldom empirical generalisations, or anything like them. The following passage from *Metaphysics* I is in this respect entirely typical:

That contrariety is the greatest difference is made clear by induction [ἐκ τῆς ἐπαγωγῆς]. For things which differ in genus have no way to one another, but are too far distant and are not comparable; and for things that differ in species the extremes from which generation takes place are the contraries, and the distance between extremes — and therefore that between the contraries — is greatest. (1055a5–10).

Similar remarks can be found elsewhere in the same book, e.g. in 1055b17 and 1058b9.

Aristotle discussed *epagoge* in three passages, none of them very long. The earliest is in *Topics* A12, where dialectical arguments are divided into two kinds,

²A selection of diverse views can be found in [Kosman, 1973; Hamlyn, 1976; Engberg-Pedersen, 1979; Upton, 1981; Caujolle-Zaslavsky, 1990; McKirahan, 1992, pp. 250–7; De Rijk, 2002, pp. 140–8].

sylogismos and *epagoge*. The meaning of the former term is certainly broader than ‘syllogism’ as now generally understood, and as the word is used in Aristotle’s later writings; it can probably best be translated as ‘deduction’. *Epagoge* is characterised quite briefly:

Induction is the progress from particulars to universals; for example, ‘If the skilled pilot is the best pilot, and the skilled charioteer the best charioteer, then in general the skilled man is the best man in any particular sphere.’ Induction is more convincing and more clear and more easily grasped by sense perception and is shared by the majority of people, but reasoning [*sylogismos*] is more cogent and more efficacious against argumentative opponents (105a12–19).

The first part of this subsequently became the standard definition of induction in the Middle Ages and Renaissance. It is natural for a modern reader to interpret it as meaning that induction is the mode of inference that proceeds from particular to universal propositions, but the Greek does not quite say this. Induction is merely the passage (ἐφοδος) from individuals to universals, τὰ καθόλου, and in other places (notably *Posterior Analytics* B19) these universals would seem to be, or at least to include, universal concepts. It should also not be automatically assumed that ‘ἐφοδος’ means inference in any technical sense [De Rijk, 2002, pp. 141–4].

Aristotle’s longest account of *epagoge* is in *Prior Analytics* B23:

Now induction, or rather the syllogism which springs out of induction [ὁ ἐξ ἐπαγωγῆς συλλογισμὸς], consists in establishing syllogistically a relation between one extreme and the middle by means of the other extreme, e.g. if *B* is the middle term between *A* and *C*, it consists in proving through *C* that *A* belongs to *B*. For this is the manner in which we make inductions. For example let *A* stand for long-lived, *B* for bileless, and *C* for the particular long-lived animals, e.g. man, horse, mule. *A* then belongs to the whole of *C*: *for whatever is bileless is long-lived*.³ But *B* also (‘not possessing bile’) belongs to all *C*. If then *C* is convertible with *B*, and the middle term is not wider in extension, it is necessary that *A* should belong to *B*. For it has already been proved that if two things belong to the same thing, and the extreme is convertible with one of them, then the other predicate will belong to the predicate that is converted. But we must apprehend *C* as made up of all the particulars. For induction proceeds through an enumeration of all the cases. (68b15–29).

This is not an easy passage to understand, and has been the subject of much discussion. Aristotle appears to be applying his method of conversion, devised as

³The phrase given here in italics makes no sense here; it may be an interpolation and if so should be excised [Aristotle, 1973, p. 514], even though there is no manuscript support for doing this [Ross, 1949, p. 486].

part of his account of syllogisms, to a case where it is not obviously applicable: hence the mention of middle terms. The crucial step in the argument is that *B* belongs to all *C*, i.e. that every long-lived animal is bileless. This could mean that every individual long-lived animal is bileless, or it could mean that every species of such animals is bileless. The latter seems to be indicated by the examples given — man, horse, mule, rather than (say) Socrates, Bucephelas etc. If so, then Aristotle appears to have been giving an example of what has subsequently come to be termed perfect (i.e. complete) induction: an inference from a finite sample that is sufficiently small for all the particular cases to be examined. This might seem to be what is indicated by the final remark, that ‘induction proceeds through an enumeration of all the cases’, but here (as often) the Oxford translation supplies words not present in the Greek, which merely says ‘for induction [is] through all’, ἡ γὰρ ἐπαγωγὴ διὰ πάντων.

It is perhaps significant here that the proposition being proved — that all bileless animals are long-lived — is a generalisation about the natural world, and therefore very unlike the propositions argued for by Socrates in the early Platonic dialogues. It is manifestly not something that could in principle be grasped immediately by intuition. The same is true of another proposition described as having been derived by induction: in *Posterior Analytics* A13 (78a30–b4) Aristotle gave a celebrated example of a scientific demonstration:

- (1) The planets do not twinkle.
 - (2) Whatever does not twinkle is near.
- Therefore (3) The planets are near.

This counts as a demonstration, as distinct from a merely valid syllogism, because it states the cause: it is *because* the planets are near (i.e. nearer than the fixed stars) that they do not twinkle. Premise (2) is described as having been reached ‘by induction or through sense-perception’ (78a34–5), though the same must in fact be true also of premise (1). For (1) the argument is straightforward and unproblematic — Mercury does not twinkle, Venus does not twinkle, etc. — but for (2) it is not. There is clearly no difficulty in assembling a long list of particular non-twinkling objects that are also nearby, but how could the general proposition that *all* such objects are nearby be established? If it is supposed to be the conclusion of an inductive argument, then the enumeration is manifestly incomplete, and the inference correspondingly fallible.

The demonstrations analysed in the *Posterior Analytics* are syllogistic arguments (here ‘syllogism’ is being used in the strict sense) which proceed from premises that are ‘true, primary, immediate, better known than, prior to, and causative of their conclusion’ (71b20–2). All these premises are universal in form, and this raises an obvious question: if the primary premises from which demonstrations proceed cannot themselves be demonstrated, how are they to be known? It was an issue that Aristotle deferred until the final chapter of the second book. The problem is stated quite clearly at the beginning of the chapter, but the discussion that follows at first sight seems rather puzzling: rather than discussing

inductive arguments, Aristotle appears to be trying to account for the acquisition of universal concepts — from the perception of several individual men to the species *man*, and then to the genus *animal* (100a3–b3). He then commented (this is the only place in which the word *epagoge* occurs in the whole chapter): ‘Thus it is clear that it is necessary for us to come to know the first principles by induction, because this is also the way in which universals are put into us by sense perception’ (100b3–5).

The whole passage is undeniably difficult, and has been diversely interpreted, as the two main English commentaries on the *Posterior Analytics* show. Sir David Ross took it that Aristotle was concerned with both concept formation and induction, and treated them together because ‘the formation of general concepts and the grasping of universal propositions are inseparably interwoven’ [Ross, 1949, p. 675]. Jonathan Barnes, on the other hand, held that ‘Here “induction” is used in a weak sense, to refer to any cognitive progress from the less to the more general . . . Thus construed, 100b3–5 says no more than that concept acquisition proceeds from the less to the more general.’ [Barnes, 1975, p. 256]. On Barnes’s reading, the passage is not concerned with the inference from singular to universal propositions at all.

This is not a dispute that can easily be resolved: the relevant texts are quite short, and all the participants in the debate are thoroughly familiar with them. My own inclination is to side with Ross. Aristotle’s position here is very different from that found in a later empiricist like Locke. Locke had an account of how humans — unlike the other animals that he called ‘brutes’ — had a capacity to frame abstract general ideas from the ideas of particular things given in perception [Locke, 1975, pp. 159–60], but this process had nothing to do with an inductive ascent from particular to universal propositions, about which Locke said virtually nothing. For Aristotle what comes to rest in the soul (more specifically, in the intellect) is not a mere Lockean abstract general idea, a particular entity that has the capacity to function as a universal sign, but rather a real universal thing, a form freed from matter and thereby de-individuated. This is why the same psychological process can be used to explain both the acquisition of universal concepts and the knowledge of first principles. In the *Posterior Analytics* the account of this is little more than a sketch, but it was subsequently fully worked out by Aristotle’s followers in late antiquity and in the Middle Ages.

There is no hint whatever in Aristotle that *epagoge* is merely one of several ways by which we can gain knowledge of first principles. The view found in many modern empiricists that while some universal truths are known — or at least receive some degree of evidential support — a posteriori, by induction, others (for example Euclid’s axiom that all right angles are equal) are known a priori, is entirely foreign to his way of thinking. For Aristotle it is impossible to view ($\theta\epsilon\omega\rho\eta\sigma\alpha\iota$) universals except through induction (*Posterior Analytics* 81b2).

In all the passages mentioned so far, *epagoge* is treated as a process leading to universals, whether concepts, or propositions, or both. This is explicit in the definition in the *Topics*, but it can also be seen in the *Prior* and the *Posterior Analytics*. Often, however, and especially in the practical affairs of life, we are

concerned with reasoning from particulars to other particulars — whether the sun will rise tomorrow, whether this loaf of bread will nourish me, and so on. Aristotle was, of course, well aware that we do this, and classified such inferences as ‘examples’ (*paradeigmata*). What is less clear is whether *paradeigma* is a type of induction, or whether it is a different kind of argument, resembling induction in various ways, but not a sub-variety of it.

In *Prior Analytics* B24, the chapter immediately after the chapter on induction, there is an account of *paradeigmata*. To give one specimen of such an argument, Athens against Thebes and Thebes against Phocis are both cases of wars against neighbours; the war against Phocis was bad for Thebes, so a war against Thebes would be bad for Athens (68b41–69a13). The inference might appear to proceed via a more general principal that war against neighbours is always bad (69a4, 6), which would make it an application of induction: a two-part argument involving an inductive ascent to a generalisation followed by a deductive descent to a particular case. Aristotle, however, insisted that the two kinds of inference were distinct: example is not reasoning from part to whole or from whole to part, but from part to part (69a14–15). Induction proceeds by an examination of all the individual cases (ἐξ ἀπάντων τῶν ἀτόμων), while example does not (69a16–19).

In Aristotle’s *Rhetoric*, however, induction and example seem much closer, if not identical:

just as in dialectic there is induction on the one hand and syllogism or apparent syllogism on the other, so it is in rhetoric. The example is an induction, the enthymeme⁴ is a syllogism, and the apparent enthymeme is an apparent syllogism. I call the enthymeme a rhetorical syllogism and the example a rhetorical induction. Every one who effects persuasion through proof does in fact use either enthymemes or examples: there is no other way. And since every one who proves anything at all is bound to use either syllogisms or inductions (and this is clear to us from the *Analytics*), it must follow that enthymemes are syllogisms and examples are inductions (1356b1–10).

The exhaustive division of all arguments into either *syllogismos* or *epagoge* is not peculiar to the *Rhetoric*: it can be found in both parts of the *Analytics* (68b13–14, 71a5–6), as can the identification of enthymeme and example as their rhetorical counterparts (71a9–11). One very plausible way of interpreting this is that enthymeme and example are not sub-varieties of *syllogismos* and *epagoge*, still less entirely different types of argument, but rather instances of *syllogismos* and *epagoge* ‘when these occur in a rhetorical speech rather than in a dialectical argument’ [Burnyeat, 1994, p. 16]. If this is done, however, the notion of *epagoge* must be broadened to include most if not all non-deductive argument, since one thing that is absolutely certain about *paradeigma* is that it concerns arguments from particulars to particulars.

⁴Aristotle’s account of enthymeme is complex and has often been misunderstood, but lies outside the scope of this chapter; for a penetrating modern analysis, see [Burnyeat, 1994].

None of Aristotle's surviving works contains a detailed and systematic account of induction, and there is no evidence that one was ever produced. Why this should have been the case is not obvious, given the potential importance of such reasoning in his theory of knowledge, but one explanation may be that the separation of form and content, which had been central to his analysis of the syllogism, was (and still remains) more difficult to achieve in the case of induction. At all events, Aristotle did not bequeath to his successors an account of induction that was in any way comparable to his treatment of the syllogism.

1.3 *Hellenistic and later Greek accounts*

In the three centuries that followed Aristotle's death, his technical writings were not much studied outside the (declining) Peripatetic school, and the terms that he had devised were replaced by others. The problems involved in inference from particular to universal propositions were raised occasionally, but they seem not to have become the central issue of discussion, unlike the problems of inference from signs.

Alcinous

The lack of any serious interest in induction among the Platonists is indicated by the extremely brief treatment in one of the few philosophical textbooks to survive, the *Handbook of Platonism* (*Didaskalikos*) attributed to a certain Alcinous, often identified with the Middle Platonist Albinus (2nd century AD):

Induction is any logical procedure which passes from like to like, or from the particular to the general. Induction is particularly useful for activating the natural concepts (*Didaskalikos*, 6.7; [Dillon, 1993, p. 10]).

The last remark may allude to the well-known passage in the *Meno* where the slave boy is being led to reveal his innate knowledge of geometry [Dillon, 1993, p. 77]. One finds here a characteristic blend of Platonism and Aristotelianism: the role of induction is to provide particular examples that can bring to full consciousness the concepts implanted in us by nature.

Diogenes Laertius

Two other Greek writers from the Roman period had rather more to say about induction: the biographer Diogenes Laertius (early 3rd century?), and the Pyrrhonian sceptic, Sextus Empiricus (late 2nd or early 3rd century?). Neither was an original thinker, and indeed Diogenes was barely a thinker at all, but rather a scissors-and-paste compiler whose labours would have been ignored by posterity had they not resulted in the only extensive compendium of philosophical biographies to have survived from antiquity.

Diogenes' remarks on induction are in his life of Plato (III. 53–55). *Epagoge* is defined as an argument in which we infer from some true premises a conclusion resembling them. There are two varieties: from opposites (κατ' ἐναντίωσιν), and from implication (ἐκ τῆς ἀκολουθίας). The former is a mode of argument that bears little resemblance to any modern notion of induction:

If man is not an animal he will be either a stick or a stone. But he is not a stick or a stone, for he is animate and self-moved. Therefore he is an animal. But if he is an animal, and if a dog or an ox is also an animal, then man by being an animal will be a dog and an ox as well.

The first part of this is clear enough — it seems that either Diogenes or his source was using an ancient version of the question ‘Animal, Vegetable or Mineral?’ — but the last part is considerably more obscure. The second kind of induction is much more familiar. There are two sub-varieties: one, described as belonging to rhetoric, in which the argument is from particulars to other particulars, and the other, belonging to dialectic, in which it is from particulars to universals. The former is clearly the Aristotelian *paradeigma*, though that term was not used. An instance of the latter is the argument that the soul is immortal:

And this is proved in the dialogue on the soul [presumably the *Phaedo*] by means of a certain general proposition, that opposites proceed from opposites. And the general proposition is established by means of some propositions which are particular, as that sleep comes from waking and vice-versa, and the greater from the less and vice-versa.

These are not examples of empirical generalisations.

Sextus Empiricus

Among the immense range of sceptical arguments preserved and deployed by Sextus Empiricus, inductive scepticism is inconspicuous, though not wholly absent. In the *Outlines of Pyrrhonism* II. 204 inductive arguments were dismissed in a very cursory, almost contemptuous, manner:

It is also easy, I consider, to set aside the method of induction [τὸν περὶ ἐπαγωγῆς τρόπον]. For, when they propose to establish the universal from the particulars by means of induction, they will effect this by a review either of all or of some of the particular instances. But if they review some, the induction will be insecure, since some of the particulars omitted in the induction may contravene the universal; while if they are to review all, they will be toiling at the impossible, since the particulars are infinite and indefinite. Thus on both grounds, as I think, the consequence is that induction is invalidated.⁵ [Sextus, 1967, p. 283].

⁵Literally, ‘shaken’, or ‘made to totter’.

Another passage a few pages earlier (II. 195) supplies a little more detail:

Well then, the premiss ‘Every man is an animal’ is established by induction from particular instances; for from the fact that Socrates, who is a man, is also an animal, and Plato likewise, and Dion and each one of the particular instances, they think it is possible to assert that every man is an animal. . . [Sextus, 1967, p. 277].

Sextus was not persuaded: if even a single counter-example can be found, the universal conclusion is not sound (ὕγιής, i.e. healthy), ‘thus, for example, when most animals move the lower jaw, and only the crocodile the upper, the premiss “Every animal moves the lower jaw” is not true.’ [Sextus, 1967, p. 277]. At first sight this differs from the familiar modern textbook example of ‘All swans are white’ being falsified by the observation of a single individual black swan, but in fact the differences are small. In the case of the swans, what makes the falsification effective is that it was a *species* of black swans that was discovered. Logically speaking, a single negative instance can falsify a universal proposition; in practice it usually would not, as a variety of what Imre Lakatos called ‘monster-barring’ stratagems would come into play.

It is very unlikely that the generalisation about how animals move their jaws, with the crocodile as an exception, was original to Sextus: the same example can be found in Apuleius’ *Peri Hermeneias* [Apuleius, 1987, p. 95]. It had probably long been a stock example, repeated from author to author.

Alexander of Aphrodisias

The view that conclusions drawn from inductive arguments are not conclusively established was not peculiar to the sceptics — indeed it can be found among the Aristotelians themselves, notably the late second-century commentator Alexander of Aphrodisias. On the passage in *Topics* 105a10ff quoted above, Alexander observed:

So induction has the quality of persuasiveness; but it does not have that of necessity. For the universal does not follow by necessity from the particulars once these have been conceded, because we cannot get something through induction by going over all the particular cases, since the particular cases are impossible to go through [Alexander, 2001, p. 93].

As this and other remarks to be quoted in what follows show quite clearly, it is utterly mistaken to suppose that Hume was the first person to notice that inductive arguments are not deductively valid, and that any universal generalisation which covers a field that is either infinite or too large to survey completely is vulnerable to counter-examples. To suppose this would be unfair both to Hume, who was certainly doing something more radical and much less banal, and to his predecessors, who had taken the fallibility of such inferences for granted.

1.4 Roman philosophy

Cicero and the rhetorical tradition

The Romans, unlike their medieval successors, had little interest in logic as a technical discipline,⁶ but rhetoric was a central — perhaps *the* central — element of their educational curriculum.

When philosophy began to be written in Latin, a new technical vocabulary needed to be devised. Who introduced the term ‘inductio’ for *epagoge* is not now known, but in the surviving corpus of Latin literature the word first appears with this sense in a youthful work by Cicero, *De Inventione*. Here it is described as a form of argument in which the speaker first gets his opponent to agree on some undisputed propositions, and then leads him to assent to others resembling them. In the example Cicero gave, Pericles’ sharp-witted mistress Aspasia is interrogating the wife of a certain Xenophon (not the historian):

‘Please tell me, if your neighbour had a better gold ornament than you have, would you prefer that one, or your own?’ ‘That one’, she said. ‘And if she had clothes or other finery more expensive than you have, would you prefer yours or hers?’ ‘Hers, of course’, she replied. ‘Well then, if she had a better husband than you have, would you prefer yours or hers?’ At this, the woman blushed. (I. 55).

Clearly this is not a specimen of inductive generalisation, but rather of what Aristotle called *paradeigma*. Cicero had little interest in the kinds of generalisation that might be made by a natural philosopher: his concern, here as elsewhere, was with the strategies that can be used in public speaking or in a court of law. In a later rhetorical treatise, the *Topics*, induction is mentioned very briefly as merely one variety of a more extensive class of arguments from similarity. The example Cicero gave — that if honesty is required of a guardian, a partner, a bailee and a trustee, it is required of an agent (*Topics*, 42) — is described as an *epagoge* (the Greek term was used), but it is clearly a case of what Aristotle had called *paradeigma*. In the rhetorical tradition, it was the analysis and employment of arguments of this type that attracted most interest.

Cicero’s account of induction was followed by the writers of rhetorical treatises and textbooks, notably Quintilian’s *Institutio Oratoria*, V. x. 73, xi. 2 [Quintilian, 1921, vol. II, pp. 241, 273], though the treatment is fairly cursory: induction was merely one rather unimportant variety of reasoning, less deserving of extended analysis than either arguments from signs or examples. This subsumption of induction into the theory of rhetoric had the unwelcome result (for analytically minded historians of philosophy) that what they have thought of as the Problem of Induction — the enquiry into how (if at all) universal propositions can be proved, or

⁶Though the aversion was by no means universal: see [Barnes, 1997, ch. 1].

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