Aristotle and Gautama on Logic and Physics

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Introduction

Physics as part of natural science and philosophy explicitly or implicitly uses logic, and from this point of view all cultures that studied nature [e.g. 1-4] must have had logic. But the question of the origins of logic as a formal discipline is of special interest to the historian of physics since it represents a turning inward to examine the very nature of reasoning and the relationship between thought and reality. In the West, Aristotle (384-322 BCE) is generally credited with the formalization of the tradition of logic and also with the development of early physics. In India, the Ṛgveda itself in the hymn 10.129 suggests the beginnings of the representation of reality in terms of various logical divisions that were later represented formally as the four circles of catuskoti: “A”, “not A”, “A and not A”, and “not A and not not A” [5]. Causality as the basis of change was enshrined in the early philosophical system of the Sāṃkhya. According to Purāṇic accounts, Medhātithi Gautama and Aksapāda Gautama (or Gotama), which are perhaps two variant names for the same author of the early formal text on Indian logic, belonged to about 550 BCE.

The Greek and the Indian traditions seem to provide the earliest formal representations of logic, and in this article we ask if they influenced each other. We are also interested in the scope of early logic, since this gives an idea to us of the way early thinkers thought about nature and change. We will show that Greek and Indian logical traditions have much that is distinctive and unique.
Philosophy and physics were considered part of the same intellectual enterprise until comparatively recent times. Thomas McEvilley’s *The Shape of Ancient Thought* does an excellent comparative analysis of Greek and Indian philosophy [6], stressing how there existed much interaction between the two cultural areas in very early times, but he argued that they evolved independently. Some scholars believe that the five part syllogism of Indian logic was derived from the three-part Aristotelian logic. On the other hand, there is an old tradition preserved by the Greeks and the Persians which presents the opposite view. According to it, Alexander was the intermediary who brought Indian logic to the Greeks and it was under this influence that the later Greek tradition emerged.

In this article, I review the evidence afresh and conclude that although the Greeks may have been aware of Indian logic, there is no reason to suppose that it influenced their own development of the subject in any fundamental way. I argue that the five-part Indian syllogism is likely to have been an earlier invention than Aristotle’s work. These conclusions can assist us in finding the chronological framework for the development of logic within India.

**Background**

My interest in the question of the connections between Indian and Greek logic was triggered several years ago by a letter from Andrei Heilper of the IBM Research Laboratory in Haifa, Israel. Heilper felt that Western logic might be indebted to Indian logic but this feeling was based on secondary evidence, and he wanted to know if I could help him reach a more definitive conclusion.

Heilper’s interest in Indian logic was born out of a passage in the book *The World as Will and Representation* [7] by the German philosopher Arthur Schopenhauer (1788-1860), who was commenting on the reference by the Indologist William Jones (1746-1794) on this matter.¹

William Jones has the following account on the question of the relationship between Indian and Greek logic (it appears in the 11th discourse):²

> Here I cannot refrain from introducing a singular tradition, which prevailed, according to the well-informed author of the "Dabistan", in the Panjab and in several Persian provinces, that, “among other Indian curiosities, which CALLISTHENES transmitted to
his uncle, was a technical system of logick, which the Brahmens had communicated to the inquisitive Greek,” and which the Mohammedan writer supposes to have been the groundwork of the famous Aristotelean method: if this be true, it is one of the most interesting facts, that I have met with in Asia; and if it be false, it is very extraordinary, that such a story should have been fabricated either by the candid MOHSANI Fani; or by the simple Parsis Pundits, with whom he had conversed; but, not having had leisure to study the Nyaya Sastra, I can only assure you, that I have frequently seen perfect syllogisms in the philosophical writings of the Brahmens, and have often heard them used in their verbal controversies. ...

Kallisthenes (370-327 BCE), a relative of the philosopher Aristotle, was the court historian to Alexander who was a member of the campaign. He was executed by Alexander in 327 BCE. There exists credible evidence that Kallisthenes was asked by Aristotle to bring texts to Greece. Since his bringing back of the astronomical observations of the Babylonians is attested by several sources, it is reasonable to assume that the story about his having brought back Indian logic is also credible. But this cannot be taken to mean that the texts of Indian logic directly or indirectly influenced Aristotle.

The relevant passage from the *Dabistan-i Madhahib* (School of Sects), a 17th century text by Mohsan Fani, a Kashmiri scholar of Persian ancestry who lived during 1615 - 1670 (?) [8, pages 270-273]:

*Tark sastra* is the science of dialectics; ... These are the sixteen parts of the Tarka. The followers of this doctrine judge and affirm that, as this world is created, there must be a Creator; the *mukt*, or “emancipation,” in their opinion means striving to approach the origin of beings, not uniting like the warp and the web, the threads of which, although near, are nevertheless separate from each other. This was related to me by the Imam Arastu [Aristotle], who was a chief of the learned and said to me that he had derived it from an old treatise upon logic, the precepts of which were without explanation, and to have bestowed on it that arrangement under which it now exists among the learned: he meant, probably, that the maxims are the same as those extracted from the Tarka. The same doctrine was taught in Greece;
in confirmation of this, the Persians say, that the science of logic
which was diffused among them was, with other sciences, trans-
lated into the language of Yonia and Rumi, by order of king
Secander [Alexander], the worshiper of science, in the time of his
conquest, and sent to Rumi.

The similarity in the reasoning of pre-Christian Greece and India was
noted repeatedly by al-Biruni (1030 CE) in his book on India [9]. The Indian
system takes the material processes to be governed by laws in the ancient
philosophical framework of Sāmkhya, which takes the evolution and change
in the world to be entirely materialistic while acknowledging the existence of
consciousness as a separate category.

Aristotle’s logic

In the West, Aristotle’s theory of the syllogism has had enormous influence.
At one time in Greece, Stoic logic was more influential until Aristotles ideas
became dominant, and they were subsequently adopted by the Arabic and
the Latin medieval traditions. The commentators grouped Aristotle’s works
on logic under the title Organon (Instrument), which comprised of:

1. Categories
2. On Interpretation
3. Prior Analytics
4. Posterior Analytics
5. Topics
6. On Sophistical Refutations

The central notion in Aristotle’s logic is that of deduction involving
premise of the argument, and the conclusion. It also recognizes induction,
which is an argument from the particular to the universal.

In Aristotle’s syllogism, the primary premise is always universal, and it
may be positive or negative. The secondary premise may also be universal

or particular so that from these premises it is possible to deduce a valid conclusion. An example is: “All men are mortal; Socrates is a man; therefore, Socrates is mortal.” Another:

- Everything that lives, moves (primary premise)
- No mountain moves (secondary premise)
- No mountain lives (conclusion)

Aristotle supposed that this scheme accurately represents the true nature of thought. If we take thought, language, and reality to be isomorphic, consideration of our reasoning will help us understand reality.

In Categories, Aristotle makes a distinction among three ways in which the meaning of different uses of a predicate may be related to each other: homonymy, synonymy, and paronymy (“equivocal,” “univocal,” and “derivative”). For any such use, he proposed descriptions in ten attributes: substance, quantity, quality, relative, where, when, being in a position, having, acting on, and being affected by. The most important of these is substance, which is the individual thing itself; secondary substances include the species and genera to which the individual thing belongs. The other categories distinguish this individual substance from others of the same kind.

In Interpretation, Aristotle considers the use of predicates in combination with subjects to form propositions or assertions, each of which is either true or false. But he recognizes that certain difficulties arise when speaking of the future. He suggests that it is necessary that either tomorrow’s event will occur or it will not, but it is neither necessary that it will occur nor necessary that it will not occur.

In Prior Analytics, Aristotle used mathematics as a model to show that knowledge must be derived from what is already known. The process of reasoning by syllogism formalizes the the deduction of new truths from established principles. He offered a distinction between the non-living and the living in terms of things that move only when moved by something else and those that are capable of moving themselves. He also distinguished between the basic material and the form and purpose which jointly define the individual thing.

He suggested four different explanatory principles or causes in his Physics: (i) the material cause is the basic substance out of which the thing is made
(like the building materials for a house); (ii) the formal cause is the pattern in conformity with which these materials are assembled (like the builder’s plan of the house); (iii) the efficient cause is the agent or force immediately responsible for the production of the thing (builders of the house); and (iv) the final cause is the end purpose for which a thing exists (shelter to the resident of the house). Aristotle believed that the four causes are essential in the existence and nature of all things.

The four causes apply clearly to machines built by man. As for things that appear to arise by pure chance, Aristotle believed that there must likewise be four causes of which we may not be unaware.

Aristotle’s logic has been the basis of theology in the West. Modern science rejects the notion of final causes. Creationism and theories of Intelligent Design are an attempt to bring in final causes into biology.

The Indian tradition

Logic (ānvikṣikī, nyāya, or tarka in Sanskrit) is one of the six classical schools of Indian philosophy. These six schools are the different complementary perspectives on reality, that may be visualized as the views from the windows in the six walls of a cube within which the subject is enclosed. The base is the system of the traditional rites and ceremonies (Pūrva Mīmāṃsā), and the ceiling is reality that includes the objective world and the subject (Uttara Mīmāṃsā or Vedānta); one side is analysis of linguistic particles (Nyāya), with the opposite side being the analysis of material particles (Vaiśeṣika); another side is enumerative categories in evolution at the cosmic and individual levels (Sāṁkhya), with the opposite side representing the synthesis of the material and cognitive systems in the experiencing individual (Yoga). Clearly, the use of systematic view of nature had been taken to a very advanced level.

Logic is described in Kauṭilya’s Arthaśāstra (c. 350 BCE) as an independent field of inquiry ānvikṣikī [10]. The epic Mahābhārata, which is most likely prior to 500 BCE because it is not aware of Buddhism in its long descriptions of religion [11], declares (Mahābhārata 12.173.45) that ānvikṣikī is equivalent to the discipline of tarka. Clearly, there were several equivalent terms in use in India for logic in 500 BCE.

The canonical text on the Nyāya is the Nyāya Sūtra of Aksapāda Gautama. The most important early commentary on this text is the Nyāya
Bhāṣya of Vātsyāyana which is estimated to belong to 5th century CE. Satisa Chandra Vidyabhusana, the well-regarded authority on Indian logic, assigned Akṣapāda Gautama the date of approximately 550 BCE. He based this on the reference in the Kāṇya recension of the Śatapatha Brāhmaṇa, in which Gautama (or Gotama) is shown to be contemporary of Jātukarṇya Vyāsa, who was a student of Āsurāyaṇa. This and other evidence from the Gṛhya Sūtras, the Vāyu Purāṇa, and the Buddhist Sanskrit text the Divyāvadāna is summarized in the introduction of Vidyabhusana’s edition of the Nyāya Sūtra [12].

In his “History of Indian Logic”, Vidyabhusana modified his views [13] under the influence of the then current ideas of history of science and the now-discredited Aryan invasion theory. He now argued that the texts speak of two Gautamas who are both associated with logic. He declared that Medhātithi Gautama (was) the founder of ānvikṣikī (circa 550 BCE), and Aksapāda Gautama came much later, perhaps 150 CE or so.

Indian science and chronology has come in for a major revision in recent years. Archaeologists have found no evidence for any large migration into India subsequent to 4500 BCE, and found that Indian art, iconography, social organization, and cultural motifs can be traced to a tradition that began in 7000 BCE [14-17]. There is also new textual analysis that pushes back the origins of Indian astronomy and mathematics considerably [18-21]. We see Indian scientific ideas develop in a systematic manner over a period of several centuries going back to the second millennium BCE, if not earlier [22-29]. This development is an enlargement in different fields of the recursive system of Vedic cosmology [5]. We also know that ancient India and West Asia had considerable interaction much before the time of Alexander [30].

Parenthetically, we note that genetic evidence related to mitochondrial DNA and the Y chromosome has allowed the reconstruction of the movements of ancient peoples. According to the highly regarded synthesis of this evidence by Stephen Oppenheimer [31], India was populated by people who left Africa about 90,000 years ago, and that in India over the next tens of thousands of years, both the Mongoloid and the Caucasoid types evolved, migrating to the northeast and northwest regions about 50,000 years ago.

The earlier chronology of Indian texts was coloured first by the then popular Biblical chronology that took the origin of mankind to go back to only 4004 BCE, and later by the theory of Aryan invasions for which archaeologists have found no support [15-17]. According to Stephen Oppenheimer,
genetic evidence also goes counter to the Aryan invasion theory. One must, therefore, question Vidyabhusana’s revision of the chronology of Indian logic, especially in light of the new understanding of the literary tradition and the evidence related to the presence of Indian kingdoms in West Asia in the second millennium BCE that provides a late material basis for the cultural continuity between India and the West.

**Gautama’s Nyāya Sūtra**

The Nyāya also calls itself *pramāṇa śāstra*, or the science of correct knowledge. Knowing is based on four conditions: (i) The subject or the *pramatra*; (ii) The object or the *prameya* to which the process of cognition is directed; (iii) The cognition or the *pramiti*; and (iv) the nature of knowledge, or the *pramāṇa*. The four pramāṇas through which correct knowledge is acquired are: *pratyakṣa* or direct perception, *anumāna* or inference, *upamāna* or analogy, and *śabda* or verbal testimony.

The function of definition in the Nyāya is to state essential nature (*svārūpa*) that distinguishes the object from others. Three fallacies of definition are described: *ativyāpti*, or the definition being too broad as in defining a cow as a horned animal; *avyāpti*, or too narrow; and *asambhava*, or impossible.

Gautama mentions that four factors are involved in direct perception: the senses (*indriyas*), their objects (*artha*), the contact of the senses and the objects (*sannikarśa*), and the cognition produced by this contact (*jñāna*). The five sense organs, eye, ear, nose, tongue, and skin have the five elements light, ether, earth, water, and air as their field, with corresponding qualities of color, sound, smell, taste and touch.

*Manas* or mind mediates between the self and the senses. When the manas is in contact with one sense-organ, it cannot be so with another. It is therefore said to be atomic in dimension. It is due to the nature of the mind that our experiences are essentially linear, although quick succession of impressions may give the appearance of simultaneity.

Objects have qualities which do not have existence of their own. The color and class associated with an object are secondary to the substance. According to Gautama, direct perception is inexpressible. Things are not perceived as bearing a name. The conception of an object on hearing a name is not direct perception but verbal cognition.
Not all perceptions are valid. Normal perception is subject to the existence of (i) the object of perception, (ii) the external medium such as light in the case of seeing, (iii) the sense-organ, (iv) the mind, without which the sense-organs cannot come in conjunction with their objects, and (v) the self. If any of these should function improperly, the perception would be erroneous. The causes of illusion may be *doṣa* (defect in the sense-organ), *samprayoga* (presentation of only part of an object), or *saṃskāra* (habit based on irrelevant recollection).

*Anumāna* (inference) is knowledge from the perceived about the unperceived. The relation between the two may be of three kind: the element to be inferred may be the cause or the effect of the element perceived, or the two may be the joint effects of something else.

The Nyāya syllogism is expressed in five parts:

1. *pratijñā*, or the proposition: the house is on fire;
2. *hetu*, or the reason: the smoke;
3. *drṣṭānta* the example: fire is accompanied by smoke, as in the kitchen;
4. *upanaya*, the application: as in kitchen so for the house;
5. *nigamana*, the conclusion: therefore, the house is on fire.

This recognizes that the inference derives from the knowledge of the universal relation (*vyāpti*) and its application to the specific case (*pākṣadharmaṭā*). There can be no inference unless there is expectation (*ākārikṣa*) about the hypothesis which is expressed in terms of the proposition.

The minor premise (*pākṣadharmaṭā*) is a consequence of perception, whereas the major premise (*vyāpti*) results from induction. But the universal proposition cannot be arrived at by reasoning alone. Frequency of the observation increases the probability of the universal, but does not make it certain. Gangeśa, a later logician, suggested that the apprehension of the universal requires *alaukika pratyakṣa* (or nonsensory apprehension).

The Nyāya system lays stress on antecedence in its view of causality. But both cause and effect are viewed as passing events. Cause has no meaning apart from change; when analyzed, it leads to a chain that continues without end. Causality is useful within the limits of experience, but it cannot be regarded as of absolute validity. Causality is only a form of experience.
The advancement of knowledge is from *upamāna*, or comparison, with something else already well-known. The leads us back to induction through *alaukika pratyakṣa* as the basis of the understanding.

*Śabda*, or verbal testimony, is a chief source of knowledge. The meaning of words is by convention. The word might mean an individual, a form, or a type, or all three. A sentence, as a collection of words, is cognized from the trace (*saṃskāra*) left at the end of the sentence. Knowledge is divided into cognitions which are not reproductions of former states of consciousness (*anubhava*) and those which are recollections (*smṛti*).

The Nyāya speaks of errors and fallacies arising by interfering with the process of correct reasoning. The Nyāya attacks the Buddhist idea that no knowledge is certain by pointing out that this statement itself contradicts the claim by its certainty. Whether cognitions apply to reality must be checked by determining if they lead to successful action. *Pramā*, or valid knowledge, leads to successful action unlike erroneous knowledge (*viparyaya*).

### More on Gautama’s logic and physics

Gautama’s propositions assume a dichotomy between object and subject. The objective world is open to logical analysis since it maps to linguistic categories; the subjective world can suffer from invalid perception for a variety of reasons. This is consistent with the Vedic view that although the inner world maps the outer, the mind can be clouded by habits or wrong deductions owing to incorrect assumptions.

The Sāṃkhya, attributed to the legendary rishi Kapila, is the first philosophy of science that arose centuries before the Buddha and it is the background to be considered when speaking of Indian logic. In Sāṃkhya, evolution occurs due to changing balance and proportion both in the objective and the subjective worlds. The three *guṇas* or fundamental modalities are *sattva*, *tamas* and *rajas*, and they operate both at the large scale as well as in quick transformation. The normative “thing” behind this ceaseless change is the witness, or self, who is viewed in the singular for the entire universe.

At the objective level, *tamas* is inertia, *rajas* is action or transformation and *sattva* is the relative balance or equilibrium between *tamas* and *rajas*. The interplay between the three sets up oscillations in the objective and the mental levels. In Yoga, the objective is to achieve the cessation of the fluctuations of the mind.
Consciousness or pure awareness is by definition not an object and therefore it does not have attributes. It must for the same reason be beyond the categories of the living or dead. It must be beyond inertia, or change or fluctuations. It is extraordinary that in this analysis the qualities that are associated with objects become describable by an internal order.

The gunās do not admit of any further breakdown. This defines a position that is deeper and different from that of Aristotelian physics. The three gunās are present in all objects and we can isolate one only in terms of the momentary strength of one in relation to the other in a process. Their fluctuations mark the universal “internal clock” of worldly processes.

In the Śaṅkhyā, the effect is the cause in a new form, and this is why the system is also called pariṇāmavāda, or theory of transformation. Between the cause and effect is a relation of identity-and-difference, that is identity of stuff but difference of form (bhedābheda). The method at the basis of the Śaṅkhyā and the Nyāya Sūtra may be seen in the Yoga Sūtra as well. In the Yoga Sūtra 3.13 three aspects of change are identified: transformation of a thing (dharmī) into a property (dharma), transformation of a property into a mark (laksāṇa), and the transformation of a mark into a condition (avasthā). This is then the basis of the “unreasonable effectiveness” of mathematics in the description of the world.

The form of the Nyāya syllogism

The five parts of the Nyāya syllogism spring from the idea of bandhu that is fundamental to Vedic thought. The bandhu is the equivalence between two different systems, which ordinarily are the microworld, the macroworld, and the individual’s cognitive system.

The Nyāya syllogism first sets up the propositional system with its two components (two parts) and then identifies another well known system to which the first is supposed to have a bandhu-like relationship (third and fourth parts). The conclusion (fifth part) can be made only after the preliminaries have been formally defined. As we see, this takes five steps.

The appeal to the bandhu in the syllogism is to acknowledge the agency of the subject who can be, without such knowledge, open to invalid perception. One can see how in systems that do not accept transcendental reality (such as Aristotle’s or Buddhist), a simplification from the five-part to the three-part syllogism would be most natural.
It was pointed out in a 1930 article by the French Indologist Rene Guénón [32-33], that some later Indian texts on logic present two abridged forms of the five-membered syllogism of the Nyāya Sūtra, in which either the first three or the last three parts appear alone. The first version is similar to the 6th century Nyāyapraveśa of India (which had much influence on Chinese Buddhism and on Jain thought), and the latter version resembles the syllogism of Aristotle.

It appears then that the Nyāya Sūtra syllogism was only the most comprehensive way of establishing the chain of reasoning consistent with Vedic ideas of bandhu, and since two different simplifications arose out of it, it is likely to have been the older tradition.

Concluding remarks

We find that as ānvikṣiki Indian logic goes back to at least the 6th century BCE based on the textual evidence that has been universally accepted. The syllogism used in the Nyāya Sūtra has five parts, as against the three-part syllogism of Aristotle’s logic. But we know that simplification of the five-part logic into one similar to Aristotle’s was also known in India.

It seems that although the Greek and Persian stories related to Callisthenes having brought Indian logic to Greece may have a historical basis, they are not to be taken as the literal truth. At best, Indian logic provided inspiration in the sense of the need for a formal text on the subject by the Greeks. The focus in the two logical traditions is quite different, and either one is unlikely to have borrowed from the other.

Regarding the transmission of the Indian texts, this could have occurred only at the tail-end of Alexander’s campaign of conquest. It is quite likely that Aristotle’s logical texts were already in place by that time. It is more likely that the Greek and Persian traditions merely acknowledge a different system of logic in a civilization that existed far away.

The Nyāya Sūtra and Aristotle’s texts are two different perspectives that tie in with the cosmologies of the two civilizations. The Nyāya Sūtra, like other Indian philosophical texts, maintains the centrality of the subject, whereas in Aristotle’s logic the emphasis is on the design of the world as a machine. This also corresponds to the difference in the Indian system which considers the universe to be composed of five elements, as against the four of Aristotle. The fifth element (ākāśa) of the Indian system concerns
the field of sentience.

Diogenes Laertius in his *Lives of the Eminent Philosophers* [34] says this of Democritus: “According to Demetrius in his book on Men of the Same Name and Antisthenes in his Successions of Philosophers, he [Democritus] traveled into Egypt to learn geometry from the priests, and he also went into Persia to visit the Chaldaeans as well as to the Red Sea. Some say that he associated with the Gymnosophists in India and went to Aethiopia” [page 445]. Judging from the rest of the biographical material in Diogenes’ account, a visit to India is not entirely implausible. Diogenes represents Democritus as a “student of the Magi” from boyhood, and an enthusiastic and well funded traveler. This is evidence of the interaction between India and Greece that goes back much before Aristotle. The legend that Indian logic was taken by Alexander to Greece is just the acknowledgement that Indians had a fully flowered system of logic before the time of Aristotle, who himself perhaps only reworked an earlier Greek tradition.

**Acknowledgement**

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**Notes**

1. “Aristotle collected, arranged, and corrected all that had been discovered before his time, and brought it to an incomparably greater state of perfection. If we thus observe how the course of Greek culture had prepared the way for, and led up to the work of Aristotle, we shall be little inclined to believe the assertion of the Persian author, quoted by Sir William Jones with much approval, that Callisthenes found a complete system of logic among the Indians, and sent it to his uncle Aristotle” [7].

2. Quoted in the note by Heilper.

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