

Introduction

Human beings, despite their differences, have been practicing logical thinking since they first began using language and constructing speech. Man is a logical thinker by nature, and he alone unlike other living beings is capable of making judgments, distinguishing right from wrong, and deriving conclusions from given premises through mental processes that have no equivalent in the rest of the animal kingdom.

If we were to define the human being in contrast to other species, we might say that he is the creature who thinks logically and applies logical reasoning to acquire knowledge across various disciplines, manage daily life, and assess behaviors and interactions.

Although logical studies are often attributed primarily to the philosopher Aristotle, this does not mean that logical thinking did not exist before him. Elements of logical reasoning can be found in earlier civilizations. In Indian philosophy, for example, we encounter logical contributions in Buddhist thought, the Nyāya school, Gautama's works, and the writings of Dharmakīrti. Likewise, in Greek civilization, logical thinking appeared before Aristotle.

Socrates employed implicit rules of logic in his efforts to expose the contradictions of the Sophists, relying on principles of reason. Plato inherited and developed this method, laying the early groundwork for formal logic. However, the conclusions he reached did not carry the necessity required for valid inference.

Aristotle corrected this by introducing the concept of the middle term, through which necessary conclusions could be reached. His defining contribution was the development of syllogistic theory (theory of the syllogism) and its rules, which had a lasting impact on the evolution of logic.

1. Logic in Ancient Greece Before Aristotle

While Alexander Macfarlane discussed Indian logic and the main schools that engaged with it, Blanché focuses on its development in ancient Greece before presenting Aristotle's theory of logic.

The use of logical principles does not necessarily mean an awareness or formal understanding of them just as a person may speak grammatically without knowing the rules of grammar. If asked to explain the rules, such a person may be unable to do so. The same is true for logic before Aristotle.

Blanché argues that the early Greek logicians used logical principles in their thinking, but they did not yet formulate them as an independent and organized discipline.

1.1 Early Logical Practice Before Aristotle

The early thinkers before Aristotle were content with using logic in their discussions and writings without possessing the ability to define its principles or organize them systematically. Aristotle himself acknowledged this after completing his study of logical [1] matters, stating: "On this subject, nothing had been prepared at all indeed, nothing existed whatsoever." (Blanché, *Logic and Its History from Aristotle to Russell*, 2004, p. 7)

Despite this, the implicit use of logic in earlier periods remains highly significant. It laid the groundwork and offered the first signs from which formal logic would later emerge. The debates practiced before Aristotle brought to light many problems related to thinking. These challenges inspired and hastened the development of logical theory.

We can say that the evolution of logic passed through three stages. The first stage was marked by a kind of debate that took the form of recommendations. These were not expressed explicitly or systematically but appeared within dialogue [2], The Second and Third Stages of Logic's Development

The second stage relates to the rules and foundations that were used implicitly. This is the work that Aristotle undertook and organized in a book titled *Topics*.

The third stage marks the shift from the study of dialectical argument to the study of forms of formal reasoning. This development is found in his works *Analytics* and *On Interpretation* (Blanché, *Logic and Its History from Aristotle to Russell*, 2004, p. 8).

Aristotle's contribution can be seen as a transition from spontaneous practice to the conscious understanding of rules. It reflects a move toward systematic thinking. For this reason, Blanché states: "The *Prior Analytics* marks a systematic break—not only with all earlier forms of logical practice among the Eleatics, Sophists, and Plato, but also with Aristotle's own earlier logical writings." (Ali, 2013, p. 199) Although the early implicit phase of logic was necessary, it can be outlined in the following way:

1.2 Dialectic in the Eleatic School

The Eleatics' style of thinking was characterized by [3] *Using Logical Arguments*. This approach stems from the school's close relationship with mathematical thinking and its fundamental concepts. This influence reached a significant level. Among the key ideas that shaped their contribution to logic were the notions of the infinite and binary division.

Although some have attributed the founding of the Eleatic school to Xenophanes, its true founder is Parmenides. It is said that the young Socrates met him and was influenced by his ideas and positions. Parmenides himself was initially influenced by the Pythagorean school. However, he later chose a different path and developed a method of his own. This method centered on rejecting the Heraclitean principle of change and replacing it with a principle of unity and stillness. As Heraclitus (535–470 BCE) believed that things are in constant motion and that opposites come together to form harmony within multiplicity, Parmenides took a completely opposite view. He stood in clear opposition to these ideas (Ryan, 2014, p. 731).

Parmenides expressed his philosophy in a poem made up of two parts. The first part addresses truth, and the second presents popular opinions. In the first section, he starts with the central idea of his doctrine: what exists is, and what does not exist is not. In this way, he formulated the principle of identity in logic, which affirms the preservation of the nature and essence of things.

Zeno of Elea (490–430 BCE) was a student of Parmenides. According to Tricot (1992, p. 29), he was "the first conscious dialectician to use dialectic in the sense later defined by Aristotle." His role was to respond to critics and opponents of the Eleatic doctrine. He defended the ideas of unity and stillness and rejected the concepts of movement and plurality. His main criticism was directed toward the Pythagorean school, which believed that the universe consists of numbers. From their perspective, the world is characterized by change, not stability.

Zeno is also credited with articulating the principle of contradiction. As Makovelsky (1987, p. 52) points out, "Zeno was the first to expose contradictions within prevailing concepts." Aristotle also links the development of dialectic to Zeno and considers him one of its first contributors. Zeno presented precise arguments and inferences aimed at challenging the theories of his opponents and revealing the contradictions within them. He did this by using the method of *reductio ad absurdum*.

Zeno's work focused on refuting opposing arguments. He did not, however, establish a formal set of rules to govern the type of reasoning he used to reject the principles of the Pythagorean school, especially their belief in motion and plurality. Nonetheless, he was highly skilled in demonstrating the impossibility of motion, as shown in examples such as "Achilles and the Tortoise" (Copleston, 2002, p. 70).

What sets Eleatic dialectic apart is its ontological character. It is rooted in a metaphysics of being and built on the idea that the world is intelligible and can be explained in a comprehensive way. This idea later appeared in Aristotle's thought as well, where he continued to maintain a realistic and grounded approach to logic.

1.2. The Controversy of the Sophists

The Sophists [4] Dialectic for Its Own Sake. Among the Sophists, dialectic reached its peak. They practiced argumentation for its own sake. Socrates strongly opposed them, using reason and evidence to expose the flaws and contradictions in their views. The Sophists used arguments to pursue specific goals and personal interests, often following a highly pragmatic and utilitarian approach. Their central claim was that "man is the measure of all things, of what is, that it is, and of what is not, that it is not" (Plato, p. 152). This statement became the foundation of Sophist philosophy, especially in the works of Protagoras (485–411 BCE), Gorgias (480–375 BCE), Hippias (443–400 BCE), and Prodicus (465–396 BCE). These thinkers moved beyond cosmological inquiries and turned to the study of humans in political and ethical contexts. They laid the groundwork for rhetoric and oratory and showed a strong interest in language studies.

The Sophists rejected traditional claims of acquiring knowledge in an objective way. They embraced a relativist view inspired by Heraclitus' philosophy, which held that everything is in flux. They concluded that all opinions, however diverse or contradictory, could be equally valid. Each individual expresses their view according to their own perspective. The Sophists articulated this theory of relativism in *Dissoi Logoi* (Double Arguments), a text by an unknown author that presents the idea of absolute relativity regarding human concepts such as good and evil, beauty and ugliness, justice and injustice, and truth and falsehood (Makovelsky, 1987, p. 57).

Based on these concepts, the Sophists often paired contradictory notions or treated them as distinct. A single case, for example, could be viewed by a judge as either just or unjust. Things could simultaneously be seen as real or unreal, good or bad—depending on how they relate to other things and within specific contexts.

The Sophists began engaging with logic when they started defending their views in realistic ways. Their public debates attracted large audiences. Protagoras even wrote a book on this skill titled *The Art of Persuasion*. In it, he analyzed deductive reasoning, using the same method Aristotle would later develop in his work on inference in *Topics*.

The Sophistic school was not a unified movement. Its thinkers held different intellectual and political views. While Protagoras strongly defended democracy, Lycophron opposed social inequality and the privileges of the aristocracy. Antiphon (480–411 BCE) advocated for equality without distinction. Some Sophists also promoted the idea of natural rights, though their views varied. Certain philosophers linked natural rights to the power of the strong and believed that the role of the state was to protect these rights. Others, however, defended morality, human values, and religion, and associated natural rights with these ethical foundations.

In contrast to the Sophists, Democritus was one of their most vocal critics. He adopted the atomist doctrine of Leucippus (460–370 BCE) and built upon it a comprehensive theory that extended into knowledge, logic, ethics, and other areas. In epistemology, he believed that reason and the senses are distinct but interconnected. Reason reflects the external world through what the senses convey. In logic, he wrote a treatise composed of three books.

The Sophists were also able to distinguish between various types of propositions. In his book *Good Speech*, Protagoras outlines several forms of predication. These included seven modes of speech: declarative, interrogative, imperative, vocative, narrative, and optative. They also explored modal propositions, such as those involving possibility and probability. Moreover, they paid closer attention to doubtful or uncertain propositions than to those regarded as absolutely true. This approach later appeared in the work of mid-twentieth-century logicians and contributed to important developments in fields such as computer science and artificial intelligence.

1.3. Dialectic in Socrates (Socrates 470–399 BCE)

The importance of Socrates in the history of logic becomes clear through the dialogues and discussions he held with the Sophists. These took the form of questions and answers. In these exchanges, he used the methods of irony and maieutics. Georges Tricot considered him the founder of the philosophy of concepts, which focuses on the essence of things and their basic characteristics. This approach laid the foundation for Plato's theory of Forms, which is based on fixed essences and absolute truths (Tricot, 1992, p. 31).

1.4. Dialectic in Plato (Plato 427–347 BCE)

Blanche devoted a special section to Plato, in which he discussed his various works and the techniques he used in his dialogues. These techniques are seen as early forms of logic.

There is no doubt that Plato's dialogues show great intellectual skill. However, they also contain logical flaws that any trained logician can notice. Plato's reasoning was not always sound. For instance, when he states: "If a soul is wise, it is a good soul. Therefore, a soul that is the opposite of a wise one is a bad soul" (Blanche, *Logic and Its History from Aristotle to Russell*, 2004, p. 11), he commits a logical fallacy. The conclusion here suggests that from the negation of (A), we can infer the negation of (B). In fact, valid reasoning should move in the opposite direction: from not (B), we conclude not (A).

It is important to highlight Plato's major role in the emergence of logic as a system of rules. Blanche believed that Plato's contribution lies in discovering the laws that govern the movement of phenomena. These same laws also apply to reasoning. While the laws of nature are fixed, humans tend to impose their own views. As a result, reasoning often appears distorted. For this reason, we must learn to use logical rules to avoid errors in reasoning.

In *Timaeus*, Plato says: "If a god has offered us the freedom to reflect, it is so that we may use it. We must align the cycles of our divine reason with the cycles of thought that occur within us. These cycles are of the same nature, but the divine ones are constant, whereas ours are always changing. Through this study, we can contribute to correct natural calculations. By imitating the perfect, error-free movements of the divine, we may offer guidance to the confusion within us." (Plato, 1970, p. 42)

Thus, the general principles we follow in pursuit of the Forms allow us to gain proper understanding of the nature of knowledge.

Plato used the five universals in what he called the ascending and descending dialectic. The ascending dialectic, also called the upward process, begins with the particular and moves toward the abstract universal or ultimate idea. This process resembles induction, where we move from judgments about parts to judgments about the whole. This is known as material logic (R. Kaltszer, 1982, p. 47).

The descending dialectic, or downward process, moves from the universal to the particular. It is the reverse: from the broadest genus, to the next-level genus, to the species, and finally to the specific differentia (Blanche, *Logic and Its History from Aristotle to Russell*, 2004, pp. 13–14).

Blanche explains that the method proposed by Plato was later corrected by Aristotle. Plato's method does not lead to necessary conclusions. That is why Aristotle replaced Platonic division with the syllogism, which does produce necessary results. The syllogism includes a middle term that links the major and minor premises and must meet certain conditions. This makes the conclusion valid.

In Platonic division, we cannot always determine whether one term truly belongs to another in the second premise. Instead, the method offers only a choice between two possibilities: (B) or (not B). In contrast, the minor premise in Aristotle's syllogism clearly defines the relationship between two terms. Blanche provided a chart to show the key differences between Platonic division and Aristotelian syllogism, as follows:

Platonic division:

Q is (L)

It is not divided into (B) nor (B)

So Q is it?

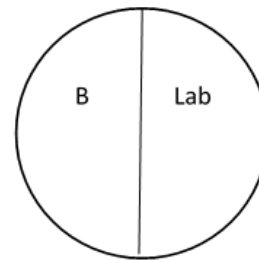


Figure 1 Platonic division

Aristotelian Analogy : (x) is (a)

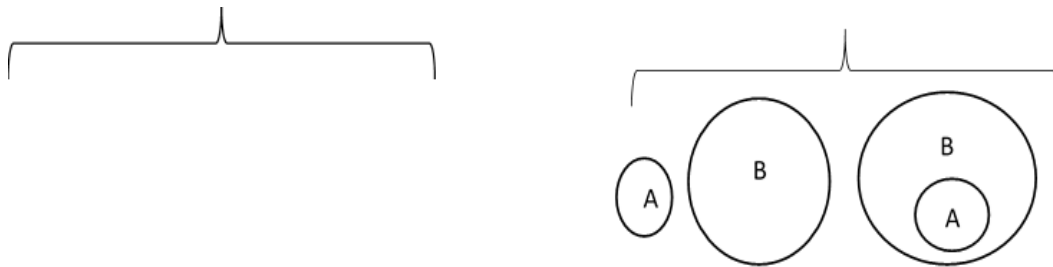


Figure 2 Aristotelian Analogy

(a) is (b) (a) is (lab)

2. Logic in Aristotle (Aristotle, 384–322 BCE)

Blanche begins his historical account of Aristotle's work by discussing a range of logical topics. These include opposition, conversion, syllogism and its interpretation, modal logic, induction, and demonstration. When referring to Aristotle's logical works, Blanche notes that they appear as an organized set of treatises, which might suggest that Aristotle himself arranged them. However, Blanche disagrees with this view.

He explains that the credit for compiling these texts goes to Aristotle's eleventh student, who assembled them in the first century BCE. Blanche also points out that not all of the logical works attributed to Aristotle are necessarily his. Some are genuinely authored by him, while others were only attributed to him. For instance, the *De Interpretatione* is not directly referenced in his other writings, which casts doubt on its attribution. Similarly, the *Categories* has also raised questions. Scholars believe that the final chapters of the *Categories* (Κατηγορίαι / *Katēgoriāi*) are not consistent with the rest of the text. These later sections are thought to have been added in a questionable way, as they seem disconnected from the original topic of the treatise.

2.1. Aristotle's Logical Works and Their Chronological Order

Blanche affirms that the term "Organon" was adopted [5] The term Organon was one of the names given by Aristotle's students to the collection of his logical works. The word means "instrument" or "tool." The number of works attributed to him in this domain has been counted as sixteen. This number is confirmed by both Makovelsky and Georges Tricot in their book *Formal Logic*.

Porphyry wrote an introduction to these works, known as the *Isagoge*. This became one of the most well-known texts among Arab scholars (Saliba & Kamal 'Ayyad, *Logic and the General Methods of Science*, 1942, p. 62). The *Isagoge* includes the five predicables: genus, species, specific difference, property, and common accident. It is usually followed by Aristotle's *Categories* (*Categoriae* or *Catégories*), which presents ten fundamental categories. Aristotle considered these to be primary genera that are self-evident and do not require definition or proof. They are: substance, quantity, quality, relation, place, time, position, possession, action, and passion. Blanche did not discuss them in detail, believing that their content was already well known. He did, however, mention five additional categories, which he believed were later additions by Aristotle's students.

The second book in order is *On Interpretation*, also known as the *Book of the Proposition*. It deals with logical operations such as opposition and conversion, as well as modal propositions, including those that are probable and necessary.

Blanche provides an overview of the third book, *Analytics*, also referred to as the *Analytica*. It is divided into two parts. The *First Analytics* contains two books that present the formal rules of syllogistic theory. The *Second Analytics*, also in two books, deals with syllogisms based on necessary premises, which is what Aristotle called demonstration.

Finally, we find the *Topics*, a work composed of eight books. However, the most important texts for logicians have been *On Interpretation* and the *First Analytics* (Blanche, *Logic and Its History from Aristotle to Russell*, 2004, p. 20). In addition, there are references to logical themes in other works, including Aristotle's formulation of the principle of non-contradiction in *Metaphysics*.

Blanche also notes that certain books—or parts of them—were likely not written by Aristotle himself but were later attributed to him. For example, the last five chapters of the *Categories* do not align with the introductory material at the beginning of that work.

2.2. Blanchet's Commentary on Aristotle's Logical Works

Blanchet interprets the sequence of Aristotle's works—as presented by his students—as methodical and coherent. He explains that the *Categories* comes first because it introduces concepts, which serve as the initial step in logic and are necessary for defining terms. It is followed by *On Interpretation*, which discusses the proposition. A proposition is a composition of two concepts. Then comes the *Prior Analytics*, which deals with combining propositions in what is known as syllogism. Syllogism, as Blanchet notes, is one form of reasoning. This arrangement, according to him, reflects a progression from the simple to the more complex.

When examining the concept itself, Aristotle did not formulate an elaborate theory. He simply referred to general concepts, as found in the *Categories*. As for the theory of syllogism, Blanchet argues that Aristotle developed it at a relatively late stage. He even suggests the possibility that Aristotle had not yet discovered the syllogism when he composed the *Categories* and *On Interpretation*, as there is no evidence in either text that prepares for such a theory. The absence of a clear logical foundation in these earlier works raises questions. This inconsistency led Blanchet to doubt the authenticity of the received sequence of Aristotle's writings.

Blanchet proposes an alternative ordering of Aristotle's logical corpus. He bases this reordering on internal content and conceptual maturity. In his view, the *Analytics*—both the first and second books—reflect a degree of logical development that makes it unlikely they were written before the *Categories* or *On Interpretation*, which contain less advanced theories.

He also believes that Aristotle only arrived at the idea of syllogism in a later phase of his logical studies. Thus, it is probable that Aristotle was not yet familiar with syllogistic reasoning when composing the *Categories*. Consequently, Blanchet rejects the traditional order of the works and suggests another sequence that he finds more plausible. He considers the *Categories* as the starting point, followed by the *Topics*, and then *Sophistical Refutations*. He places the *Prior Analytics* next, beginning from the first part through to the

seventh. After that, he includes the first book of the Posterior Analytics, then returns to complete the Prior Analytics from chapter eight to twenty-two. These chapters address modal propositions. Finally, he refers to the second book of the Prior Analytics, which contains refined analyses of syllogistic theory and introduces logical expressions that serve as keys for understanding more advanced logical operations (Blanchet, *Logic and Its History from Aristotle to Russell*, 2004, p. 21).

Among the criticisms directed at Blanchet is his omission of any discussion concerning the chronological priority of the later parts of the Prior Analytics. Although he suggests that some of these parts were composed concurrently with the second book of the Prior Analytics, he does not explain their internal sequencing. Moreover, he neglects to address the arrangement of the second book of the Posterior Analytics. Additionally, his claim that modal logic represents the highest stage of logical thought carries some risk. It is entirely possible that modal logic predates syllogistic reasoning.

Despite Blanchet's efforts to establish a chronological order for Aristotle's logical works, he overlooks the later chapters of the Prior Analytics and does not attempt to organize the second part of the Posterior Analytics. Therefore, the true chronological order remains unknown—not only to Blanchet but to all others. Aristotle alone knew the actual sequence in which his logical system developed.

2.3 The Proposition and Immediate Inference

Blanché, in his discussion of concept, definition, and logical propositions, did not merely cite Aristotle's main ideas. He began by examining Aristotle's view of the proposition as a declarative statement that can be either true or false. In such propositions, the subject is either affirmed or denied of the predicate. A proposition, according to Aristotle, is "any speech that is meaningful not in the way of a tool but by convention, and not every speech is assertoric; only that which can be true or false is assertoric, and this is not the case with all statements" (Aristotle, *De Interpretatione*, 1948, p. 63). What Aristotle calls an assertoric statement is precisely what logic aims to study. Therefore, the grammatical sentence differs from the logical proposition.

This distinction is also emphasized by Avicenna (Ibn Sīnā), who states: "This class of composition that we are about to mention is the declarative composition. It is the one for which we can say of its speaker that he is either telling the truth or lying. As for interrogatives, requests, wishes, hopes, and exclamations, we do not say of their speaker that he is truthful or lying" (Ibn Sīnā, *Al-Ishārāt wa al-Tanbīhāt*, 1960, pp. 267–268). From this, we understand that every proposition is a sentence, but not every sentence is a proposition.

Blanché views propositions through two main lenses: quantity and quality. In terms of quality (qualité), propositions are either affirmative or negative. In terms of quantity, they are either universal or particular. Quality is not determined by the subject or predicate, but rather by the copula that connects or separates them. Considering both quantity and quality together yields four types of propositions: two affirmative and two negative.

The distinction between universal and particular propositions depends on the nature of the terms. If the subject is a proper name, the proposition is singular. If the subject is a general term, the proposition is universal. Blanché notes that Aristotle paid little attention to singular propositions. This, he argues, is due to their unsuitability for conversion, which requires propositions of the same type, allowing the subject and predicate to switch places. Singular propositions lack referents in the way universals do. As for indefinite propositions, Aristotle treated them as equivalent to particular ones.

Blanché distinguishes between two types of universal propositions: essential universals and existential universals. In his *Topics*, Aristotle also divides particular propositions into definite and indefinite types.

Propositions can be approached in two ways: conceptually or extensionally. If interpreted extensionally, the subject falls under the predicate. If interpreted conceptually, the predicate is included in the subject. Blanché raises the question of which interpretation Aristotle preferred. After reviewing various interpretations, he

notes that philosophers have generally explained Aristotle's syllogistic theory conceptually, where the relation between terms is one of necessity. In contrast, logicians and mathematicians tend to offer an extensional or formal interpretation, where the relationship is one of inclusion.

Yet Aristotle, according to Blanché, employed both interpretations. He did not limit himself to an extensional view but also adopted a conceptual perspective. Nevertheless, Blanché argues that Aristotle favored the conceptual interpretation. This is evident in categorical propositions, especially when the subject is general. In such cases, the predicate necessarily follows from the subject. However, when it comes to syllogistic reasoning, the extensional interpretation becomes more dominant, particularly in discussions of formal validity (Blanché, *La Logique et son histoire d'Aristote à Russell*, 2004, pp. 30–31).

Blanché's analysis of Aristotle's syllogism reveals his own preference for the conceptual view, a position he maintains in his critique of formal logic in *La Raison et le discours*, where he criticizes the purely extensional interpretation. In contrast, Marie-Louise Roure interprets Aristotle's logic as leaning toward an extensional reading, even though Aristotle himself believed that conceptual understanding grounds the referents of terms (Roure, M., 2014, p. 18).

Blanché identifies three key relationships between the four standard categorical propositions: inclusion, expressed by the universal affirmative when the subject is included in the predicate; exclusion, expressed by the universal negative when the subject is denied of the predicate; and intersection, represented by the particular affirmative and particular negative propositions.

2.4 Opposition and Conversion

Blanché's discussion of propositions does not stop at their classification. He also examines a basic mental operation—reasoning which results from the combination of propositions. Reasoning is divided into two types. Immediate inference involves two propositions, where the conclusion is drawn directly from a single premise. Mediate inference, on the other hand, involves three propositions: two premises and a conclusion.

Focusing on immediate inference, the conclusion (i.e., the second proposition) is obtained by altering the quantity, quality, or both of the first proposition. The resulting proposition is the conclusion. This kind of inference is called opposition. The second type of immediate inference is conversion, where the subject and predicate exchange places.

A. Opposition

The concept of opposition in Aristotle has been previously noted, defined as follows: "One thing opposes another in four ways: either by relation, or by contrariety, or by privation, or by affirmation and negation" (Aristotle, *De Interpretatione*, 1948, pp. 38–39). Aristotle's types of opposition do not exhibit homogeneity or strict ordering. The first three kinds of opposition occur between concepts, while only the fourth kind exists between propositions.

Blanché points out that the theory of opposition and conversion is fully present throughout Aristotle's logic because dialectic and debate require it, even though Aristotle himself does not explicitly present this classification in exactly the same terms.

In his *De Interpretatione*, Aristotle discusses opposition between propositions, highlighting key differences between universal and particular propositions, as well as their interrelations. Opposition is fundamental in argumentation and necessary for refuting opponents and dismantling their arguments.

Regarding the negation of propositions, Aristotle distinguishes two types: contradiction and contrariety. The latter does not represent absolute opposition, whereas contradiction involves total opposition. In

contradiction, two propositions cannot both be true nor both be false. From the contradiction relation, one can infer the truth of one proposition from the falsehood of the other, and vice versa.

In contrariety, however, the truth of one proposition implies the falsehood of the other, but the falsehood of one does not necessarily imply the truth of the other. Blanché notes that Aristotle initially did not differentiate sharply between contradiction and contrariety, treating contradictory propositions similarly to contrary ones (Blanché, *Logic and Its History from Aristotle to Russell*, 2004, p. 35).

Contradiction occurs between the universal affirmative and the particular negative, and between the universal negative and the particular affirmative. Contrariety, on the other hand, exists only between the universal affirmative and the universal negative. The contrary propositions can both be false when the corresponding particular propositions are true simultaneously.

Aristotle did not explicitly include this relationship between particulars; this extension was added later by logicians. This omission does not mean Aristotle was unaware of the law, as he alludes to it in *De Interpretatione*. As for subalternation (implication from universal to particular), Aristotle does not explicitly address it, but it was later completed by Apollonius of Perga to render the square of opposition more coherent.

B. Conversion

Another form of immediate inference is called conversion, in which the subject and predicate of a proposition are exchanged. Both subject and predicate must be concepts. Blanché notes that the predicate of a proposition varies; it may denote essence, making the proposition a conceptual definition, or a property particular to the subject, or a genus, or even an accident.

Aristotle encountered no problem converting propositions when the predicate expresses essence or a particular property, since in such cases the truth-values coincide for subject and predicate. Thus, only propositions containing essence or particular property are convertible.

Conversion of the universal negative proposition is straightforward because quantity and quality are preserved. However, conversion of the universal affirmative differs. In the original proposition, the species is included under the genus, but the reverse—placing the genus under the species—is invalid. Therefore, the converse must be particular; a part of the genus is included in the species. The particular negative proposition cannot be converted.

2.5 Syllogism

Aristotle discusses various types of inference in his *Topics*. Alongside inductive reasoning, he presents deductive reasoning, which moves from universal judgments to particular ones. Deductive reasoning is itself divided into demonstrative, dialectical, and sophistical types. The classification depends on the nature of the premises: demonstration involves necessary premises (or those derived from necessary principles), whereas dialectical syllogisms rely on generally accepted premises, which may be refuted as errors if falsely presented as commonly accepted (Blanché, *Inference*, 2003, p. 127).

Aristotle defines syllogism as follows: “It is a discourse in which, given certain things, something different from the things given necessarily follows of necessity because of their being given” (*Prior Analytics*, 1980, p. 142).

He acknowledges that syllogism is the most expressive form of inference. However, he admits that some valid inferences may not appear in syllogistic form.

A syllogism consists of three terms and three propositions. Each term appears twice. One term serves as the middle term, connecting the other two in the premises, which leads to the conclusion uniting the two remaining terms. The terms differ in extension: the term with the broadest extension is called the major term, the narrowest is the minor term, and the intermediate term is the middle term.

The well-known example “All humans are mortal; Socrates is a human; therefore, Socrates is mortal” was never used by Aristotle himself. He did not employ singular propositions and instead used literal variables such as (S), (P), and (M) to represent terms. The first to formulate Aristotle’s syllogism with such variables was Alexander of Aphrodisias, aiming to demonstrate deductively how conclusions follow from premises (Łukasiewicz, 1961, p. 21).

Blanché criticizes the view that these symbols were central to Aristotle’s late works, asserting that Aristotle’s use of variables was more a matter of convenience than systematic formalization.

Some scholars, including Bocheński and other contemporary logicians, consider Aristotle the true originator of formal logic. In contrast, Hamblin argues that Aristotle’s logic is overly described as formal and that it lacks the rigor found in modern formal systems [6] Stoic logic was influential, but Łukasiewicz believes that Aristotle’s brief mention of it marks the initial step toward formal logic (Blanché, *Logic and Its History from Aristotle to Russell*, 2004).

Blanché raises the issue of using variables and symbols instead of words in logic and links this to how we perceive the discipline. If logic is viewed as a theoretical science, comparable to mathematics, the use of symbols becomes necessary. However, if logic is considered a normative science, akin to ethics or aesthetics, words are preferred. Aristotle, however, was not sufficiently aware of these possible perspectives on logic.

Returning to syllogism, Aristotle classified syllogisms into three types according to the role of the middle term. He then examined the possible combinations, known as figures. In Leach figure, he identified a set of valid moods based on formal criteria, without delving into the content of the propositions. The three syllogistic figures Aristotle described are as follows:

First Figure: Here, the minor term is predicated of the middle term, and the middle term is predicated of the major term. Aristotle states: “The last term is universal of the middle, and the middle is universal of the first” (Prior Analytics, 1980, p. 113). This figure produces four valid moods:

- If all S is included in all M, and M is predicated of all P, then S is predicated of all P.
- If S is excluded from all M, and all M is included in all P, then S is excluded from all P.
- If S is included in all M, and M is predicated of some P, then S is predicated of some P.
- If S is excluded from all M, and M is predicated of some P, then S is excluded from some P.

Second Figure: In this figure, the middle term is the predicate in both premises. Aristotle explains: “If a single thing is predicated universally of one thing and not at all of another, or predicated of both” (Prior Analytics, 1980, p. 118). This figure also yields four valid moods:

- If M is not included in all S, while it is predicated of all P, then S is excluded from all P.
- If M is included in all S and excluded from all P, then S is excluded from all P.
- If M is excluded from all S and predicated of some P, then S is excluded from some P.
- If M is included in all S and excluded from some P, then S is excluded from some P.

Third Figure: Here, the middle term serves as the subject in both premises. Aristotle describes it as: “If both premises are predicated of the same thing, one universally and the other partially, or both universally, or neither universally” (Prior Analytics, 1980, p. 124). This figure produces six valid moods:

- When both S and P are included in all M, then S must be included in some M.
- If some M is included in P and all M in S, then some S is not P.
- If some M is included in all P and all M in S, then some S is included in P.
- If all M is P and some M is S, then some S is P.
- If no M is P and some M is S, then some S is P.
- If some M is P and all M is S, then some S is not P (Tricot, 1992, p. 274)

The fourteen moods mentioned earlier include both valid (complete) and invalid (incomplete) syllogisms. The complete syllogisms belong to the first figure. Several reasons support the greater completeness of this figure. First, it is widely used in sciences and mathematics. Second, the conclusions derived from this figure express the essence of things, whereas the conclusions of the second and third figures tend to be either negative or partial. Third, the first figure is self-sufficient; it compensates for the shortcomings found in the second and third figures.

Beyond these three reasons, another important factor favors the first figure: the middle term occupies an intermediate position between the major and minor terms, both in location and in terms of its scope of reference.

Regarding the second and third figures, although they are productive, they appear somewhat unnatural, particularly the second figure, where the middle term has the widest and most inclusive scope.

The proof of the validity of the second and third figures can only be achieved through the first figure. Here, “proof” does not mean direct proof but rather reduction of syllogisms to the first figure. Aristotle believed that the moods of the second and third figures are defective because the relationships of inclusion between the middle term and the major and minor terms are not harmonious, which makes the resulting conclusion unclear (Blanché, *Logic and Its History from Aristotle to Russell*, 2004, p. 50).

The syllogisms of the first figure, which Aristotle considers complete and legitimate, were challenged by nineteenth-century logicians. They started from different assumptions than Aristotle's. His preference for the first figure and rejection of the others stemmed from his belief that the figure is fundamental. The first figure was the original one Aristotle discovered, or in a narrower sense, the first mood of the first figure.

Blanché points out that the names Aristotle gave to the three terms can cause some confusion. In the second figure, where the middle term is predicate in both premises, it becomes, from a validity perspective, the major term. In the third figure, where the middle term is subject in both premises, it becomes, from a validity standpoint, the minor term.

The identification of a syllogistic figure depends on the position of the middle term within it. This aligns clearly with the aims of formalism. From this modern perspective, it is necessary to acknowledge the existence of a fourth figure. This figure considers the case where the middle term is predicate in the major premise and subject in the minor premise. Therefore, logicians who align with formalism emphasize the importance of including a fourth figure [7] This figure also produces four valid and legitimate moods. Some may question whether Aristotle was aware of these valid moods. The answer lies in the fact that we find five such valid moods discussed by Aristotle in Book I, Chapter 7, and Book II, Chapter 1 of the *Prior Analytics*. These moods closely resemble those of the fourth figure. Both Łukasiewicz and Bocheński argue that these two chapters were added later, after Aristotle had already presented the three figures and their types in Chapters 4 and 6 of Book I (Łukasiewicz, 1961, pp. 16–17).

2.6 Interpretation of Aristotelian Syllogism

Aristotelian logic can be seen as somewhat distorted. For example, the terms we use like “Socrates” or “human” were not explicitly mentioned by Aristotle. Łukasiewicz observes that Aristotle employed only symbols such as (A, B), representing universal terms. Essentially, Aristotle presented all propositions as

conditional syllogisms with a necessary relation between the two statements. The first statement acts as the premise, while the second serves as the conclusion.

Therefore, the debate over whether Aristotle's syllogistic theory belongs to the class theory (Théorie des classes) or the theory of predicates is somewhat futile. Aristotle's theory stands on its own, with its own issues and axioms. Łukasiewicz explains that Aristotle's syllogistic system represents an initial conception of what mathematical logic later developed as the theory of "classes" (Łukasiewicz, 1961, pp. 16–17).

Aristotle's proof of the syllogistic moods involves reducing them to the first figure, specifically to two moods: BARBARA and CELARENT. However, Aristotle later recognized the possibility of conversion and reduction. The syllogisms of the first figure can be reduced to some moods of the third figure. Likewise, the negative syllogisms of the first figure can be reduced to those of the second figure.

Aristotelian logic, as Łukasiewicz noted, is formal but not purely symbolic. Blanché agrees with this view. Although Aristotle used variables, he did not explicitly represent them symbolically. This raises Blanché's question: if Aristotle's logic is not symbolic, can it still be considered formal?

Bocheński and Łukasiewicz raise this question and attempt to answer it through several inquiries. They ask, for example, if Aristotle used symbols instead of terms or propositions, why did he not provide a clear explanation for this usage? He employed the same symbols both for terms and propositions. Additionally, Aristotle sometimes uses the word "statement" to refer both to a single proposition and to a syllogism (a set of propositions). Another issue concerns the nature of the predicate and subject of propositions: are they concepts or specific terms?

To verify the legitimacy and validity of moods, Aristotle employed concrete examples. Initially, the logical form served merely as a tool to achieve the essential goal of logic: truth. Over time, this idea evolved until emphasis shifted to the structural forms of syllogisms rather than their concrete applications.

Blanché raises another concern regarding the classification of Aristotelian logic. According to Łukasiewicz, Aristotle's logical theory is purely scientific, free from any philosophical implications. This view is supported by the fact that Prior Analytics can be understood without prior knowledge of Aristotle's Metaphysics. However, Blanché argues that this view oversimplifies the issue, especially from a historian's perspective who considers the interconnectedness of Aristotle's work. Aristotle's logic fits perfectly within his philosophical system, as does Stoic logic.

The categorical form Aristotle uses aligns with his metaphysical concept of substance. The middle term corresponds to the principle of causality; it acts as the cause of the syllogism (Blanché, *Logic and Its History from Aristotle to Russell*, 2004, p. 59). Therefore, Aristotle's logic is somewhat narrow, reflecting only the inclusion relation while excluding others. This can only be properly understood by linking it to Aristotle's metaphysics.

Łukasiewicz accepts the idea of defining syllogistic figures based on the position of the middle term, without relying on inclusion relations between terms. This implies he does not consider Aristotelian logic as symbolic logic. Otherwise, Aristotle could have abandoned defining syllogisms by the position of the middle term and moved to a validity-based interpretation, which is closer to the truth, rather than blaming Aristotle for rejecting the fourth figure (Blanché, *Logic and Its History from Aristotle to Russell*, 2004, p. 63).

2.7 Induction and Demonstration

Induction and demonstration are not solely related to logic in its strict sense. They are also connected to epistemology and methodology. While syllogism, according to Aristotle, is a hypothetical science and serves as a tool for knowledge, it cannot be regarded as the sole instrument of science. This is because syllogism

requires the truth of its premises to be established. Such truth demands proof in two possible ways: either by infinite regression or by circular demonstration.

Initially, knowledge derives from sensation, but sensation alone is insufficient for its formation, as it applies only to particulars, whereas knowledge is universal. Therefore, induction is necessary. Through induction, we move from judgment about particulars to judgment about universals. Following this, demonstration allows us to reach conclusions. Learning occurs only through induction and demonstration. If induction starts from particular cases, demonstration begins with universal cases. Moreover, universal judgments are made only through induction, and induction itself ultimately rests upon sensation. As Aristotle states, "Demonstration proceeds from universal premises, induction from particulars, and we cannot know the universal except through induction" (Posterior Analytics, 1980, p. 385).

The distinction between induction and syllogism does not negate the relationship between them. This connection exists only in material terms, not formal ones. Syllogistic reasoning is based on the interrelation of concepts, which requires a middle term linking the premises. In induction, however, there is no middle term; instead, it concerns a collection of observed instances. Lachelier (1832–1918) argues that induction is a form of the DARAPTI syllogism, which yields a particular affirmative conclusion. He also notes that this is a syllogism of the third figure. Regarding the results each method produces, they differ greatly: induction's results are probabilistic, whereas syllogistic results are absolutely certain.

Jules Tricot views induction in its syllogistic form as drawing the major premise from comparing the minor premise and the conclusion. Hence, induction in this form is reversed compared to Aristotle's view, where the conclusion should be the major premise and the middle term becomes the minor premise. Therefore, the middle and minor terms should share the same extension, which contradicts the normal arrangement (Tricot, 1992, pp. 370–373).

Aristotle accepts induction temporarily because he sees knowledge as fundamentally deductive, favoring syllogism. His goal is to eliminate induction, which does not rely on the principle of identity. For Aristotle, particular induction is foreign to formal logic since it is synthetic, not analytic.

Demonstration, on the other hand, represents the ultimate goal of science. Aristotle's mistake was his belief that science could be addressed purely deductively through analysis of forms. However, modern science recognizes the necessity of returning to experience as a crucial means to achieve deductive reasoning, the highest aim of science. John Stuart Mill confirms this when he says, "Syllogism is originally connected with a theory of meaning... but the universal major premise 'all men are mortal' corresponds, according to empiricists, to a known number of particular experiences" (Briand, 1987).

3. Conclusion

From the foregoing discussion, we can draw several key conclusions:

Logic is as ancient as humanity itself. In ancient Greece, many early signs and logical inquiries were closely linked to dialectical debates among the Sophists, Socrates, and Plato. However, the logical works produced in ancient Greece did not develop into a fully established scientific theory that could serve as a crucial reference for contemporary logical studies.

Aristotle's work is distinguished by its richness, diversity, and originality. It is also characterized by clear organization and coherence among its parts.

Aristotle's theory of syllogism stands as his most significant contribution to logic. It exerted a considerable influence on later logicians, particularly through the work of Lukasiewicz, who authored *Aristotelian Syllogistic from the Perspective of Modern Logic*.

Aristotle's syllogism centers on a single relation—subsumption. However, this relation alone proved insufficient because logic also encompasses other relations, such as equality, inclusion, and logical product, among others.

Aristotle showed interest in possible and future contingencies. This focus became the starting point for modern logicians who sought to establish three-valued logic.

Aristotle gave equal attention to both the conceptual and the truth-relational aspects of logic. In contrast, contemporary formal logic tends to emphasize formal structure at the expense of conceptual interpretation. This divergence distances modern logical studies from the familiar philosophical approach—a positive aspect credited to Aristotle.

4. References and Explanations:

[1] Logicians: We use this term to refer collectively to those engaged in logic. Dr. Mahmoud Yaacoubi has employed this word frequently in his works, including *Logic and Its History* and *Introduction to Contemporary Logic*. He finds this term particularly suitable, especially given the need for Arabic terminology that parallels logical terms in other languages.

[2] Dialogue: To say "he dialogued," "he argued," or "engaged in dialogue" means to debate or discuss. Dialogue refers to the exchange or review of speech in conversation between a speaker and an interlocutor. The purpose of dialogue is to generate new ideas. (Sleeba, *Philosophical Dictionary*, 1982, p. 501)

[3] The Eleatic School: This school is named after Elea (ELEA) in southern Italy. It is said that its founder was Xenophanes. Although he never visited Elea itself, Xenophanes is considered its founder because he rejected the idea of gods having bodies. He agreed with the school's leaders—Parmenides, Zeno, and Melissus—in affirming the unity of all things. This static unity is called "the divine." Aristotle reported that Xenophanes stated that "the One is God," who in no way resembles humans either in body or thought. (Kamel & Jalal Al-Ashri, p. 70)

[4] Sophist: The term originally meant a skilled person in a particular art, especially teachers of philosophy and rhetoric. Sophists first appeared in the mid-fifth century BCE. Before that, young Greeks received initial education from language scholars. Sophists were the first higher education teachers and were itinerant, giving lessons in each city they visited. Their lectures were costly, with Protagoras earning, according to Plato, more than a sculptor. (Pierre Degennebié, 2014, p. 15)

[5] The Organon: This is the collection of Aristotle's logical works, including *Categories*, *On Interpretation*, *Analytics* (First and Second), *Topics* (Dialectic), *Sophistical Refutations*, and *Introductory Topics* (Isagoge). (Lalande, 1996, p. 724). The collection consists of six books, though some add *Rhetoric* and *Poetics*, increasing the total to eight.

[6] System (Nasq): In philosophy and theoretical sciences, this refers to a set of coherent and interconnected ideas that support each other, such as Aristotle's system. (Madkour, 1983, p. 201)

[7] The Fourth Figure of the Syllogism: The syllogistic form where the middle term is the subject in the major premise and the predicate in the minor premise is traditionally attributed to Galen. In fact, Galen discussed compound syllogisms made of four terms. However, the specific fourth figure involving three terms was not discovered until the sixth century CE. It is important to note that Aristotle was not unaware of the five valid forms generated by this syllogistic figure.

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Conflict of Interest

The author declares no conflict of interest. This research was conducted independently, without any financial or personal relationships that could inappropriately influence the findings or interpretations presented in this article.

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