Note on Formal Logic

Samena Bahleri

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Chapter I

Introduction

1 Etymology and Terminology

Normally, in the study of logic, the first thing we need to understand is the question: what is logic in terms of its definition? Etymologically, the word logic comes from the Greek word (logos). The word logos carries various meanings, including "word," "speech," "reason," "explanation," and "principle." Over time, this term was adopted into Latin as *logica*, which means the art or science of reasoning. On the other hand, in terms of terminology, logic is the systematic study of valid inference and correct reasoning. Therefore, it can be understood that when we study logic, what we are learning is how to evaluate things rationally and systematically to reach a solid understanding and draw a sound conclusion. One striking statement about logic comes from the philosopher John Locke, who said that "logic is the anatomy of thought." In this metaphorical statement, we can also understand that by studying logic, we are essentially learning about the structure of thought itself.

2 Logic in History

2.1 Philosophical revolution

In this era, humans began to think not only about how to live in their environment, but also about themselves, truth, and ideas. One figure whose statement represents this revolution is Socrates, with his famous quote: "The unexamined life is not worth living.". To understand the systematic development of logic, we can follow the stages of history below:

2.1.1. Pre-Aristotelian Era

In this era, humans tried to understand the world through myth, narratives shaped by imagination and traditional constructions. Thinkers of this era include:

1. Thales

   He believed the world originated from water. This was considered rational at the time and reflected the knowledge of that era. Thales is often regarded as the first philosopher and the first to consider the problem of the one and the many.

2. Anaximander

   He questioned Thales' idea: If everything comes from water, then where does water come from? He introduced the idea of the *Apeiron* (the indefinite/infinite), beginning the philosophical search for a first principle (*archê*).

3. Xenophanes

   As humans began to question truth and divinity, Xenophanes criticized anthropomorphic portrayals of gods. Monotheistic ideas began to appear.

4. Heraclitus

   Famous for the quote: "You cannot step into the same river twice." He believed everything is in constant flux, reality is constant change. He introduced the concept of Logos as the rational structure behind the universe, implying that nature can be understood through patterns.

5. Parmenides

   Opposing Heraclitus, Parmenides argued that opinions do not necessarily reflect truth. In his view: What is, is; what is not, is not. Truth lies in existence, while change is an illusion.

6. Zeno

   He raised questions about the relationship between logic and sensory data. One of his most famous arguments is the Achilles and the Tortoise paradox.

2.1.2. Aristotelian era

Aristotle is regarded as the Father of Logic. He developed a system of categories, e.g., Substance, Quantity, Quality, Relation, Place, Time, Position, State, Action, Passion. He also developed syllogistic reasoning: *All men are mortal. Socrates is a man. Therefore, Socrates is mortal.* This illustrates the basics of formal logic.

2.2 Modern era

In the modern era, logic evolved in three main phases:

1. Enlightenment

   During the Enlightenment, philosophy grew in popularity, especially in terms of rationality, scientific methods, and freedom of thought. Philosophers and mathematicians like René Descartes, Gottfried Wilhelm Leibniz, and Immanuel Kant began developing more systematic and reflective approaches to logic, emphasizing reason as the means to acquire knowledge.

2. 19 Century

   "Logic" experienced a revolution. Thinkers such as George Boole, Augustus De Morgan, and Gottlob Frege developed symbolic and mathematical logic, which was far more precise than traditional Aristotelian logic. Frege introduced predicate logic, leading to non-classical logic.Georg Cantor founded set theory, now a foundation of modern mathematics. The dominant school of thought: Logicism, which holds that mathematics can be reduced to logic.

3. 20 Century

"Logic" continued to grow and was applied in mathematics, linguistics, and computer science. This era saw the emergence of modal logic and its branches, such as:

(a) Alethic logic
(b) Deontic logic
(c) Epistemic logic
(d) Doxastic logic
(e) Temporal logic
(f) Dynamic logic
(g) Action logic
(h) Intuitionistic logic
(i) Multi-modal logic
(j) Provability logic

Meanwhile, mathematics faced a foundational crisis, initiated by Kurt Gödel. Where the 19th century saw Logicism, the 20th century saw new "isms":

(a) Formalism: Logic is symbol manipulation based on formal rules.
(b) Intuitionism: Mathematical truths are mental constructions.

Chapter II

Arguments

1 Definition of Arguments