INTRODUCTION TO LOGICAL REASONING

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Reasoning is an art that can be acquired through study and practice. As with other arts, there is no formula or set of rules that can be employed to assure a successful outcome; but there are fundamental principles that can guide thinking in order to promote cogency, precision, and depth. This short introduction to logical reasoning outlines some of those principles.

I. THE PRINCIPLE OF NON-CONTRADICTION

This universal principle is a necessary condition for all logical reasoning. Here is Aristotle's formulation:

> **It is impossible for the same thing at the same time to belong and not belong to the same thing and in the same respect . . . No one can believe the same thing to be and not to be.**[1]

Consistency alone is not sufficient, but when the principle of non-contradiction is violated, logical reasoning is impossible.

II. SOME OTHER PRINCIPLES OF LOGICAL REASONING

A. THE NATURE OF ARGUMENT

One important goal of reasoning is to distinguish good arguments from bad ones. An argument is a logical relationship between a set of premises and a conclusion in which the conclusion is affirmed on the basis of the premises; the conclusion is **inferred from or follows from the premises**. In a formal argument, premises and conclusions are stated explicitly in the form of propositions.

Logical reasoning seeks to determine (a) which arguments are **valid** and (b) which arguments are **sound**. A valid argument is defined as one in which it is impossible for the premises to be true and the conclusion to be false. It is possible for a valid argument to have one or more false premises. A sound argument is a valid argument in which all the premises are true.

One way to distinguish between valid and invalid arguments is to apply a negative test by identifying fallacious forms of argument. Lists of common fallacies have been developed over several centuries. No list can tell which arguments are valid, but any argument that commits one or more of these fallacies is known to be invalid. In an invalid argument, the conclusion is not based upon relevant premises.

B. SOME COMMON FALLACIES

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[1] Aristotle, *Metaphysics*, trans. Richard Hope (New York: Columbia University Press, 1952), 1005b.

1. **Appeal to force:** Frequently one person tries to persuade another by appealing to dire consequences or punishment if a suggested conclusion is not accepted. This approach may influence behavior, but it is not a logical justification.

2. **Argument directed to the person (*ad hominem*):** Usually this fallacy is committed by trying to establish a conclusion either by attacking the character of a person or by appealing to irrelevant circumstances (rather than to the truth).

3. **Argument from ignorance:** In this case one claims that because we do not *know* whether something is true, it is not true. To conclude that since we have no proof that something is false it is not false is another instance of this fallacy.

4. **Argument from universal agreement:** This is an attempt to prove the truth of a proposition on the basis of widespread acceptance.

5. **Appeal to authority:** It is fallacious to say that a proposition is true merely because some authority says it is true.

6. **Appeal to pity:** This fallacy tries to establish a conclusion on the basis of sympathy or by arousing the feeling of compassion.

7. **Begging the question:** In this case one assumes as a premise what one is trying to prove as a conclusion.

8. **Fallacy of many questions:** In this fallacy, more than one question is contained in what appears to be a single question with a single answer. Several questions need to be answered, not just one:

9. **Fallacy of composition:** This pattern of fallacious reasoning involves a movement from the properties of parts to the properties of the wholes they constitute.

10. **Fallacy of division:** This is the converse of the fallacy of composition. It is an error to say that if the whole has a certain property then the part must have that same property.

11. **Equivocation:** In this fallacy the conclusion is inferred on the basis of two separate meanings in the premises. Since many words have more than one literal meaning, it is easy to fall prey to this error.

C. ANALOGICAL REASONING

Much of our reasoning is **analogical**. In employing an analogy, we relate one or more elements in one domain to elements in another domain, drawing upon inferences from domains with which we are familiar and applying them to those with which we are not familiar. **Inductive reasoning**, which is the basis of much scientific thinking, extrapolates from a set of examples or instances to a generalization about the behavior or nature of a whole set or class. When we infer that all crows are black from the vast number of instances of black crows people have actually seen, we are reasoning by induction. Such reasoning produces only probable conclusions, not certainty. The unfamiliar domain of crows yet to be seen leaves open the possibility that white crows might yet await future observers. To say that it is **likely** or **probable** that all future observations will yield only black crows does not settle the matter. Critical thinking about the nature of scientific reasoning itself alerts us to a problem.

When we confine our attention to argument forms, not actual instances, analogical reasoning has greater cogency. One effective way of showing that a **formal argument** is invalid is to construct another argument that has the same form and is obviously invalid. Consider this argument:

> If Jesus rose from the dead, then he was the Son of God.
> Jesus was the Son of God.
> Therefore, Jesus rose from the dead.

The invalidity of this argument is clear if we consider an analogous argument where the premises are true and the conclusion is false (a relationship that always characterizes an invalid argument). The following argument has the same **form** as the one above:

> If Socrates was murdered, then he is dead.
> Socrates is dead.
> Therefore, Socrates was murdered.

In this case the premises are true and the conclusion is false, a clear indication that we have an invalid argument form. By use of analogy, we are able to demonstrate the invalidity of the first argument, where there is disagreement about the truth of the conclusion, by comparison with the second. Validity or invalidity of arguments is a formal property related to the structure of the reasoning process; truth or falsehood of propositions is a function of their relationship to actual domains.

Not all forms of logical reasoning are negative, designed only to show unsound or fallacious reasoning. We can see that a certain argument is valid by showing that its form or structure is the same as that of another argument known to be valid. We must take care with respect to arguments by analogy. The following argument by analogy, which compares natural phenomena to social phenomena, ignores crucial differences between the two domains.

> Nature's forces know no pity. Just so in sociology. The forces know no pity. Nature's remedies against vice are terrible. She removes the victims without pity. A drunkard in the gutter is just where he ought to be, according to the fitness and tendency of things. Nature has set upon him the processes of decline and dissolution by which she removes

> things that have survived their usefulness. The punishments of society are just like those of Nature—they are warnings to the wrongdoer.[2]

Reasoning by analogy fails when the domains being compared are not similar or because elements of the domains seem to be common but are not.

III. SYMBOLIC LOGIC

In the twentieth century, logical reasoning took a giant step in the direction of formalization. Symbolic logic has contributed significantly to the development of computer languages, resulting in both great speed and accuracy in data analysis and word processing. Formal logic is much more difficult to apply to ordinary language than are the informal fallacies listed above. Whenever propositions are formulated so that they may be expressed symbolically, it is necessary to **abstract** from ordinary language or to create a new language that seeks to avoid the vagueness and ambiguity that characterize natural languages (English, German, Japanese, Hebrew, Swahili, etc.).

Alfred North Whitehead, who helped develop the new logical symbolism, put it this way: "By relieving the brain of all unnecessary work, a good notation sets it free to concentrate on more advanced problems, and in effect increases the mental power of the race."[3] Through the use of formal logic we can identify various forms of argument and test their validity. Even Whitehead could not envision the degree to which this symbolic formulation would take over so much of our mental life as computer technology developed.[4] Symbolic logic made modern computer technology possible.

Here are some basic forms of valid inference that serve as models of formal reasoning. To understand these argument forms, some symbols must be defined.

1. Definitions

p = a proposition
q, r = other propositions
• = and
v = either/or
˜ = not
> if . . . then

The law of non-contradiction is expressed as: ~(p • ~p)

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[2]William Graham Sumner, *What Social Classes Owe to Each Other*.

[3]Alfred North Whitehead, *An Introduction to Mathematics* in Irving M. Copi and James A. Gould, *Readings on Logic* (New York: The Macmillan Company, 1964 [1948]), p. 211.

[4]At the same time, the limitations of computers have also become clearer. In his book *What Computers Can't Do,* first published in 1972, Herbert Dreyfus explored some of those limitations. In a revised version of that book he is even more vehement about those limitations: "The book now offers not a controversial position in an ongoing debate but a view of a bygone period of history. For now that the twentieth century is drawing to a close, it is becoming clear that one of the great dreams of the century is ending too. Almost half a century ago computer pioneer Alan Turing suggested that a high-speed digital computer, programmed with rules and facts, might exhibit intelligent behavior. Thus was born the field later called artificial intelligence (AI). After fifty years of effort, however, it is clear to all but a few diehards that this attempt to produce general intelligence has failed" (Herbert L. Dreyfus, *What Computers Still Can't Do: A Critique of Artificial Reason* [Cambridge, MA: MIT Press, 1992], p. ix).

2. Some **Valid** Argument Forms

a. *Modus Ponens*

p > q (if p, then q)
p
Therefore, q

EXAMPLE: If this metal is gold, then it is heavier than water.
This metal is gold.
Therefore, this metal is heavier than water.

b. *Modus Tollens*

p > q
~ q (not q)
Therefore, ~ p

EXAMPLE: If this metal is gold, then it is heavier than water.
This metal is not heavier than water.
Therefore, this metal is not gold.

c. Disjunctive Syllogism

p v q (p or q)
~p
Therefore, q

EXAMPLE: Either this metal is heavier than water,
or it is not gold
This metal is not heavier than water.
Therefore, this metal is not gold.

d. Hypothetical Syllogism

p > q
q > r
Therefore, p > r

EXAMPLE: If this metal is gold, then it is heavier than water.
If this metal is heavier than water, then it will not float.
Therefore, if this metal is gold, then it will not float.

3. Some **Invalid** Argument Forms (note their resemblance to valid forms presented above):

a. Fallacy of Affirming the Consequent

p > q
q
Therefore, p

EXAMPLE: If this metal is gold, then it is heavier than water.
This metal is heavier than water.
Therefore, this metal is gold.

b. Fallacy of Denying the Antecedent

$p > q$
$\sim p$
Therefore, not q

EXAMPLE: If this metal is gold, then it is heavier than water.
This metal is not gold.
Therefore, this metal is not heavier than water.

IV. DIALECTIC

For modern culture and the scientific imagination, the attraction of formalizing thought and action lay in part in its promise of clarity, certainty, efficiency, and a greater measure of control over nature. Indeed, writing in the seventeenth century at the fountainhead of the modern world, Descartes argued that establishing an analytical method based on certainty would ultimately yield an intimate knowledge of nature's mechanisms, resulting in the amelioration of human ills and making us "the lords and masters of nature."[5] And even before Descartes, Aristotle praised demonstrative reasoning as the sole method capable of yielding genuine philosophical knowledge.[6] Unlike Descartes, who conceived nature mechanistically, Aristotle thought of nature as a living organism, whose ends and actions lay before humans as objects of contemplation, not as objects of scientific knowledge and control. For Aristotle, much in nature outstrips human efforts to grasp it scientifically. The domain of what can be known with certainty is far narrower than the domain of human action.

When people are confronted with making the kinds of judgments and decisions essential to practical affairs, formal systems are of little direct help. But if there can be no certainty about human affairs, what method remains whereby we may come to a measure of clarity about fundamental values and principles of action? For both Aristotle and his teacher, Plato, the answer is dialectic.

The word "dialectic" means "to talk or reason (something) *through*." Thus, dialectic may be characterized informally as an "art of reasoning." Dialectic is never casual but depends upon a discipline, a practical familiarity with the tools of discourse. Among the essential dialectical tools are those aspects of logic discussed above: the laws of thought; facility at recognizing logical fallacies; analogical reasoning; and formal analysis. Without providing certainty, such tools enable the practitioner of dialectic to avoid poor reasoning and, at the same time, to exhibit sound reasoning about contingent human affairs. Ideally, dialectic is a cooperative activity practiced for the sake of wisdom; but it also provides a shield from the verbal assaults of unscrupulous people seeking mastery over others. Dialectic, then, has a clear function in the ethical and political domain, being essentially a method for evaluating opinions and the principles that ground those opinions. No opinion in this domain is inviolable. All opinions must

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[5]Cf. René Descartes, *Discourse on the Method*, in *The Philosophical Writings of Descartes*, Vol. I, trans. John Cottingham, et al (New York: Cambridge UP, 1985), 142-143.

[6]Cf. Aristotle, *Posterior Analytics*, trans. Hugh Tredennick (Cambridge, MA: Harvard UP, 1960), 71b.

be subjected to dialectical scrutiny to identify what is clearly false or contradictory. Dialectic is inherently anti-dogmatic.

In Plato's dialogues, we see dialectic's role in ethical and political inquiry. Often associated with the "Socratic method," in Plato's hands dialectic becomes, both a tool to uncover wisdom about human affairs and a means to reveal the ethical nature of his characters. Socrates questions others about the true nature of justice, virtue, beauty, and goodness. Often the result of Socratic inquiry is *aporia,* a condition of perplexity, in which we lack resources to complete the task at hand. For Socrates, the ethical imperative is to keep the dialectic inquiry moving forward, hence resisting the human tendency to allow opinions to sink into dogmatism. One's ability to withstand the rigors of the inquiry becomes, in part, a measure of one's ethical standing. The coward retreats from the battle; the courageous person endures. While *producing* nothing concrete, the pursuit of wisdom can foster clear aims and strong character. Dialectic enables us to (1) distinguish sound from unsound reasoning; (2) identify and differentiate the various senses of central terms; (3) recognize at a glance both the premises that underlay an opinion and the logical consequences of those premises; and (4) learn how to ask questions effectively so as to reveal ignorance or error and thereby contribute to wisdom. Plato's dialogues provide a good introduction to dialectical reasoning; they frequently reflect on the nature of the process and show it in action.