
Casual Notes on Fallacies, Validity, and Truth

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INTRODUCTION

Eventually, these notes will mention antennas. Initially, however, I want to meander through some subjects that I taught for 30 years before retiring. Since I have donated my personal library in these fields to various universities and colleges, I must rely on memory. I have been warned against the dangers of academic senility, but have forgotten what those warnings are.

The intimate relationship among language, logic, and mathematics has intrigued good minds since ancient times. Aristotle did not invent logic or even its syllogistic form. Rather, he is the most ancient figure who codified what was known and whose works survive today. As the self-destructive urges of the Roman Empire plunged Europe into the so-called Dark Ages, the rising and thriving Arabic culture had scholars who preserved the works of the Greeks and made advances upon them. In this same period, they developed the Arabic numerals on which we so much depend in arithmetic and mensuration tasks. Through southern Spain, the Islamic culture spread their efforts into Europe. Aristotle supplanted the remnant off springs of Plato as the dominant framework for European thought from Aquinas onward. With Aquinas, syllogistic logic flourished until the 20th century.

In the 19th century, logicians embellished the syllogism virtually to its logical limit trying to find a way to fold together the language in which we expressed it components, the structure of logical relationships, and an undoubted but seemingly inexpressible relationship to mathematics. Every school child had a course in logic—actually a mixture of Aristotle’s syllogistic logic and his rhetoric. Hence, most children thought that the list of fallacies—with Latin (not Greek) names—might be the key to a good grade. Indeed, many an article made light of day in journals solely by identifying a new fallacy. We shall bypass the obvious *ad hominem*s and *ad baculum*s in favor of an example of a syllogistic fallacy that has as many variations as a couturiere has color names. A syllogism in its pure form has three statements: two premises and a conclusion. The statements must be either universals (such as “all apples are red”) or particulars (such as “some apples are yellow”). Individual statements (such as “that man is green”) were a special form. Each statement must contain two and only two terms (we might call them classes or sets today), and the entire syllogism could contain only 3 terms. If the concluding statement did not violate any of the rules of logic, the syllogism was valid.

Now compare:

Apples are red.	African elephants are disappearing.
That object is an apple.	That animal is an African elephant.
That object is red.	That animal is disappearing.

Both syllogisms have the same form and ought to be equally valid. Alas, language turns out to have more subtleties than the syllogistic form can handle. Indeed, the fading elephant case is not even very subtle, but fallacious arguments like it have been the source of great humor from time to time.

Two important items—one terminological and one historical—emerge from the syllogism. One is an understanding of deductive systems. The key to any such system is the concept of validity as used by logicians. The concluding statement of an argument is true if the argument has the

correct form and uses language correctly and if the premises are true. Within the confines of an argument, the factual truth of the conclusion is never in question. Outside of the realm of logic and mathematics, we carelessly interchange the terms *truth* and *validity*, much to the chagrin of those who seriously engage in the study of these subjects.

Historically, the turn into the 20th century brought about the first reasonably successful attempt to reformulate logic into what we today call mathematical, formal, or symbolic logic. The work of two diverse thinkers, Russell and Whitehead, resulted in the multiple heavy volumes that only a few scholars read any more: *Principia Mathematica*. Nevertheless, they revolutionized the manner in which we formulate logical relationships and the search for the fundamentals of mathematics.

For Russell and Whitehead, the syllogism was only a special case of more fundamental relationships among statements. Their system rested on 5 relationships, later boiled down to 4, and later by others reduced to an absolute minimum of 2. From these relationships and a few basic axioms, they developed the system of modern logic still taught a century later in essentially the same form. What we often fail to appreciate is how far reaching the influence of *Principia* has been. Students forced to take the modern college course in symbolic logic are familiar with deductive argumentation in its extended form and with the construction of proofs. These former students do not quake in the face of conjunctions, disjunctions, conditionals, and bi-conditionals. They may even be familiar (although only in a memory as dim as being born) with the quantified versions of logical deductions and the axiomatic foundations on which it rests (and on which many a scholarly debate may also rest).

One of the bases on which Russell and Whitehead rested their formulations was the binary nature of the terms *true* and *false*. Every statement must be one or the other (or it was not a “real” statement) and no statement could be both simultaneously. (Inventive logicians and mathematicians have developed alternative systems in which a. the values are not mutually exclusive and/or b. the assignable values for a statement might be other than binary. One result of these efforts has been n-valued logics.) If we change the names of the value assignments—perhaps to *plus* and to *minus*, we obtain the logic of binary chips as taught in tech schools. The rules are identical. Moreover, we can build a complete set of logical operations with no more than 2 relationships. One is usually an inverter (logical negation) and the other is usually either an AND or an OR (logical conjunction or disjunction). NAND and NOR simply reflect how transistor inputs relate to transistor outputs, not to the basic logical rules.

We also often fail to appreciate how far Russell and Whitehead carried their efforts. The basic unit of the logical argument is the statement. Not just any statement will do. We cannot simply take a statement like “All apples are red” at face value as a simple statement. It is anything but simple. A syllogistic universal translates into a complex expression of the order “For all X (where X is anything), if X is an apple, then X is red.” The statement “That is an apple” becomes “X is an apple.” Therefore, we can conclude that “X (or that) is red.” (There are more elements to the analysis, but these will do for the present.) Note that we have converted our original valid syllogism into an argument of more general form with a specific logical relationship between something being an apple and its being red. The *if-then* form of relationship is the conditional. It is not bi-conditional. We cannot correctly argue that because something is red, it is an apple on the basis of the fact that (for the sake of argument), all apples are red.

Of course, our modern analysis is ruinous to humor. We would spot our safari problem instantly if we tried to analyze the first statement of the jocular syllogism by claiming that “for all X, if X is

an Africa elephant, then X is disappearing.” The confusion between collective and distributed properties would be instantly apparent, and mere confusion is rarely very funny in itself.

Nevertheless, there is a connection between the modern analysis of syllogistic statements into complex logical relationships and mathematics. To say that “X is an apple” is to say that X falls into the class or set of things properly labeled as “apples.” To say that “X is red” is to say that X belongs to the class or set of red things. To assert that “all apples are red” is alternatively to say that the class or set of things properly labeled as apples is a subclass or subset of the class or set of things properly labeled as red. The subset relationship is identical to the conditional relationship, except that the domain of each differs. One applies to statements, which normally appear in words, while the other applies to classes or sets, that is, collections.

Set or classes deeply interested Russell and Whitehead. In them, they thought they had discovered the foundation of mathematics. They proposed to define numbers as classes, more specifically classes of classes with certain properties. Their proposal has risen and fallen like the waves on the Atlantic, rarely placid and often in stormy conflict—as storms go among academics. But it persists today, if for no other reason than its place in history as a significant attempt to unify language, logic, and mathematics.

We may illustrate the formal parallelisms among logic, sets, and arithmetic by a set of symbolic formulations.

Logic	disjunction $p \vee q$ (where p and q are propositions)	conjunction $p \cdot q$	conditional $p \supset q$	bi-conditional $p \equiv q$	negation $\sim p$
Sets	union $A \cup B$ (where A and B are sets or classes)	junction $A \cap B$	subset $A \subseteq B$	identity $A = B$	complement $-A$
Arith	addition $X + Y$ (where X and Y are numbers)	multiplication $X \times Y$		equation $X = Y$	negation $-X$

For the relationships shown, the same “truth conditions” apply, reformulated for the system involved. For example, if p is false, then its negation is true. If x is not a member of A, then x is a member of $-A$. Of course, each basic system has extensions. Mathematics is capable of a large number of operations unique to its axiom set, and set or class logic introduces the interesting concepts of the universal and the null set. Logic has quantification in terms of particulars and universals.

A number of theorists of formal systems view classes or sets as perhaps the most important formulation of axiomatic systems. The reason behind their judgment involves the two basic ways in which we may formulate a set. One way to formulate a set is to specify the properties that anything must have to be a member of the set. If we let “apple” be a name for a certain set of properties, then to say that X is a member of A is to say that x has the requisite properties. This formulation lies at the heart of Aristotelian classes, if we treat each term in a syllogism as a class term. What we obtain is a deductive formal system.

Alternatively, we may specify the membership of a class simply by counting up a collection. In this formulation, $A = \{a, b, c, d, e, f\}$, where A is the class designator and a through e are member objects. The interesting feature of this method of formulating sets is that we may count the members. Hence, $nA = 6$. (In the other formulations of classes, we cannot specify a value

of nA.) From the alternative form of classes and the basic class or set relationships, we may derive the rudiments of probability and statistics.

In a standard deck of 52 cards, we know that there are 4 aces and 4 twos. Let's give 2 draws, replacing the card after each draw. What is the probability of drawing either an ace or a two (a union relationship)? $4/52 + 4/52 = 0.3077$. What is the probability of drawing an ace and a 2 (a junction relationship)? $4/52 \times 4/52 = 0.00592$. All basic probability values must be greater than zero but less than 1. If we examine closely the language of weather forecasters, they make two technical errors, one when they claim that the probability of rain (or snow, etc.) is 100% and the other when they claim that the probability of rain is zero. However, in those circumstances, we may excuse their rounding upward or downward as needed for a statistically uninformed audience. In contrast to the values of a probability system, the binary mutually exclusive specifications for the values assignments of *true* and *false* in a deductive system are equivalent to assigning values of 1 and zero to the terms, with no possible intermediate ground.

The foundation of probability and statistics, especially in its contrast to deductive formal systems, is very interesting to the theory of mensuration or measurements. However, our interest here lies in deductive systems, to which we may return. Remembering Aristotelian formulations of classes or set, our syllogistic universal was "All apples are red."

But all apples are not red. Our syllogism and its modern revisions are all valid. But one premise is patently false. Some apples are yellow, some are green, and who knows what designer colors geneticists may come up for apples in the future. The universal claim that apples are red is not factual, since we need only one non-red apple to falsify it. Does that make the conclusion false? Not if we understand the concepts of truth and validity.

To say that a statement is true is to say that it has an acceptable body of substantiating evidence for its correctness or to say that it follows from a set of statements, all of which are true by the same standard. To say that a statement is a valid conclusion to an argument (or a valid deduction) is only to say that it follows by the rules of the logical system (which might be a mathematical system) from its premises, without inquiry into the ultimate evidential correctness of the premises.

If the conclusion of an argument results from either a fallacious argument or from a premise set in which one or more of the premises are false, then that conclusion does not have a known truth-value. Arguments are in fact extended forms of conditionals such that the conjunction of premises implies the conclusion. If they fail to imply the conclusion, as in a fallacious argument form, then we simply do not know the evidential truth of the conclusion. If the form is correct but one of the premises is false, then we again do not know the evidential truth of the conclusion, since the argument is conditional, not bi-conditional.

All mathematical models, whatever the complexity or simplicity, are essentially deductive arguments based upon setting into the model a number of elements. One obvious set of elements is the data on the basis of which we may make our calculations. We shall assume accurate data, perhaps a series of measurements or a set of specifications. Another set of elements includes all of the calculation formulations for manipulating the data. These entries constitute the rules of deduction for the modeled system. The formulations are subject to at least two limitations. One critical question is the accuracy and precision of the formulation. In the field of climatological studies, the mathematical formulations of the complex interactions among terrestrial and atmospheric are so complex that we are uncertain still that we have included all of them, let alone correctly formulated their inter-relationships. A second critical

question involves the calculation medium and its practical ability to handle complex mathematical deductions within a reasonable time frame. The average weather station at the television facility has a forecasting program for the local area. This program uses simplified algorithms relative to the sets employed in models that run on the so-called super computers.

In a parallel fashion, all of the antenna modeling programs—including NEC, MININEC, and the collection of hybrids—are subject to the same set of critical questions: the adequacy of the input data, the accuracy and precision of the basic calculation formulations, and the approximations used within the program designed to produce results in a finite time that a customer will accept. Nevertheless, mathematical models remain deductive systems with premises and rules of deduction. If the binary calculating machinery is sound, then the model yields valid conclusions. The results are true with respect to the premises and the rules of deduction used within the model.

The deductive nature of all mathematical models limits the types of questions that are sensible to raise about them. Those who dismiss modeling in a blanket fashion do not realize that they are also dismissing the scratchpad calculations they rely upon, since both are parts of the same deductive formal system. Sensible questions always interrogate the particular elements within the models, whether the element involves the input data, basic formulations of the deductive or calculation rules, or the specific approximations used within a program.

Being a “good” model has at least two meanings. Functionally, an informed user expects the program to yield reliable outputs or results within the limitations of its formulation. In other words, if the premises are true relative to the portion of the universe covered by the model, then a good program produces results that are also true of that portion of the universe—again, within the limits of the model. Structurally, a good program enumerates the basis of its formulation so as to list the limitations—a list that informed users may extend based on applications not initially tested by the program’s developers. A given program may be good in both senses, but that does not mean that it cannot be better.

There are meta-arguments (arguments on a different logical level) that we may apply both to models and to deductive systems in general. One very old and traditional argument claims in one or another form that a model can never be complete in the sense of never needing or accepting further refinements of its formulations. Goedel produced a meta-theorem in the 1930s showing that the quantified version of logic was incomplete in the sense of never being able to produce a final theorem from its axioms and rules that would close the system. Theorists challenge the idea from time to time, but his work persists. Likewise, we find individuals who argue—usually on far less firm grounds than Goedel—that climatological models intrinsically involve so many variables that they can never be complete. While interesting and challenging, such arguments do not count against the use, testing, and improvement of the models in question. Challenges to modeling are not challenges to models. The inference from “all models are incomplete” to “no individual models are any good” is not only invalid, it is limited in scope. Either—like Goedel’s proof of deductive incompleteness—it records a note on the nature of the deductive system in question, or it simply registers an attitude that falls outside of any technical enterprise.

In any technical enterprise, we owe a further debt to Russell, who in his own day thought of himself as a “logical atomist.” In any “serious” attempt to arrive at the truth of any subject, there needs to be a very close (if not perfect) correlation between the basic terms and the entities under study. Moreover, there needs to be a tight correlation between the terms of relationship that we use and the actual relationships that exist among the entities under study. We need to

make the language of science as precise as its mathematics—and even more so, since mathematical relationships ultimately rest upon the logical relationship that govern language when we are speaking seriously. The outgrowth of Russell’s position became known in the 1930s as logical positivism. The ultimate abuse of that overview to dismiss ethical concerns in various quarters has become part of the history of the recently ended century. Nevertheless, the view has served scientific enterprises well.

A paradigm attempt to formulate a rigorous relationship between logic and language appeared in the 1920s: Wittgenstein’s *Tractatus*. It began, “The world is all that is the case,” although in German. (Modern editions print the German and the English on facing pages, since Wittgenstein wrote the work in Germany but published it after moving to England.) It closes, “Whereof one cannot speak, one must be silent” (although the German term appears to have an active sense, more akin to “shut up”). In the 1940s, Wittgenstein reversed his field and published *Philosophical Investigations*, a foray into what many have come to call “ordinary language” analysis. In that volume, he set aside the idea that one might formulate the relationship between words and things independently of human activity and the myriad of ways in which language is a social or human-inter-active enterprise. Language is not solely a matter of what we say, but more significantly, of what we do. First, second, and third persons are not mere artifacts convenient to teaching grammar, pronouns, and verb forms. Very often, they represent very different enterprises that we conduct with words in lieu of other things.

“John loves Mary”—a typical third person report—states a relationship (apart from all questions of the required evidence for the fact asserted) between two parties. However, “You love me”—a second person sentence—may be as much an accusation as anything else. The first person form, “I love you,” makes a commitment—or re-affirms one, if one is bright in his or her marriage. It is not a report by some objective observer, although it may report a surprising self-realization. Much overlooked in the morass engendered by this different direction that seemed unpromising to the logical positivists has been a plethora of patient works, one of which bore the title, *How to Do Things with Words*. Words can be binding, although often only in complex ways. A contract is a vehicle of words that converts a breakable promise into a legally binding agreement for which—upon breakage—there is legal recourse. (The understanding of how contracts relate to promises goes back at least to the beginning of the 19th century in the writings of the German thinker Hegel, but took on renewed significance in the context of language analysis.) We need not here go down a road that leads to certain linkages with existential thinkers that Americans especially seem determined to misunderstand.

The students of ordinary language also began investigations into enterprises that rely upon narrative exposition. The concept of evidence in historical contexts became central to their concerns. R. G. Collingwood was somewhat before his time in this interest. Logic countenanced only the categories of possibility and necessity (where the opposite of necessity is impossibility). Now we began to study the conditions of plausibility as a foundation for writing history and much else. As well, we began to re-appreciate conceptual logic. If we have firm evidence that Caesar was one day in Gaul and some days later in Rome, we may assert without further evidence that Caesar journeyed to Rome, since journeying is simply how humans change geographically significant positions over time. Teleportation and Star Trek transporters are not plausible alternatives. However, to use a more specific concept or concept set—such as Caesar rode by horseback to Rome or Caesar was carried by his men to Rome—requires more specific evidence. However, given knowledge of Caesar’s typical method of journeying with his army, along with the military procedures of the day, we might make a plausible claim that Caesar rode by horseback to Rome. Of the possibilities, journeying by horseback is the most probable, even though we cannot quantify the probability.

Equally—and restricting ourselves to this narrow time frame—there are many things that we cannot correctly say of Caesar. Given the data points, we cannot assert that Caesar traveled from Rome to Gaul. For reasons of understanding how things work, we cannot say that the Rubicon crossed Caesar (although Brutus would eventually cross Caesar). In short, there are logical canons within the use of ordinary language—language that shows no parallels to the formal systems that end up in mathematics—that enable us to determine sense from non-sense, and justifiable claims from those which lack evidence or sufficient evidence.

One popular tactic—that virtually everyone should be able to see through—is the attempt to defeat a claim simply by showing that something else is a possibility. Smith claims to have seen a UFO and provides a detailed account of what he saw. Smith is a very credible observer, perhaps even a police officer or a member of the military. Jones does not believe in UFOs and notes that it is possible that Smith saw something else or that his memory is slipping since it has been many years since he saw whatever forms the basis for his report. Those who wish to think like Jones tend to accept the possibility as sufficient evidence that Smith did not see a UFO. Those who understand evidence know that the Jones' claim establishes nothing at all, since Jones does not site evidence that the possibility actually occurred. The failure of evidence does not establish the veridicalness of Smith's report. One eyewitness report is insufficient to do that. But understanding the canons of evidence in various situations does not let us cast doubts on Smith's veracity either.

Those who experiment with and study antennas are thoroughly familiar with the multi-faceted nature of evidence in general. Anecdotal claims about the performance capabilities of antennas in operation automatically discount such claims (whatever their force in advertising) until and unless they receive additional confirmation via fair comparisons or appropriate measurements. We do not dismiss the reporter as speaking falsely in any of the ways in which we might intentionally or unintentionally speak falsely. Rather, we hold such claims to need a more exacting foundation. Indeed, a goodly amount of space in *antenneX* over time is devoted to refining the comparisons and measurements made on a number of experimental antenna designs. In many instances, no single treatment of an experimental antenna suffices to justify or deny acceptance of an antenna technique. Moreover, the summary judgment on a design is not solely a function of applying formal logic and mathematics to the proposal, but instead is a matter of a complex combination of both formal and narrative logics. Unlike a strictly deductive problem, in which a valid form necessitates a conclusion, our conclusions about experimental antennas rest on *warrant*. What conclusion, if any, does the evidence warrant? Warranting evidential conclusions is a summary event. As such, it generally affirms a very high probability or a very low one relative to appropriately good performance and its basis in the foundational statements made about the antenna in question by its inventor or developer.

Unlike a court of law, insufficient evidence does not proclaim the subject antenna innocent—whatever that term might mean in electronics. Rather, insufficient evidence simply means that a conclusion is not yet warranted. Measurement sets (assuming confirmed standards for making them) may conflict with each other or simply be too sparse to be accounted reliable. Theoretical derivations of basic concepts may be absent—but without any formal proof that (as Ogden Nash once titled a book of verse) “You Can't Get There from Here.” Any number of factors may enter into a judgment of insufficient evidence that leaves one with an unknown. Unknowns are as important as—if not more important than—what we already know, since they set us challenges for future effort.

These notes have meandered over a large spread of analytical thought, mostly in this century, but with roots in antiquity. Everything said in this highly compressed venue requires expansion, more precise expression, more detailed exemplification, and correction of memory errors that have crept into the notes. As well, I have painted in very broad strokes, less Rembrandt or Reubens than Van Gogh (or even abstract expressionism). Nevertheless, perhaps the notes provide something of a context for some of the commonplace things that we take for granted in technical enterprises, such as designing, analyzing, and understanding antennas. For example, understanding the general place of mathematics as a deductive system in both the general framework of such systems and as a tool at the service of any number of exercises might be useful to someone. Then again, these might simply be the rambling pathways of a brain grown dry with time.

But to see if you have followed me down the (garden) path, consider the following syllogism.

Ivory-billed woodpeckers are extinct.	(from a text on bird species)
That bird is an ivory-billed woodpecker.	(from a report of a naturalist about a year ago)
That bird is extinct.	(conclusion)

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