What Is Reason?

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To assert a belief is simple; defending it is far more difficult. Yet if a belief is not defended adequately, why accept it?

Saying something is true does not make it true. Suppose Smith says that both Charles Darwin, who developed the theory of evolution, and Abraham Lincoln were born on February 12, 1809. Jones denies this claim. If saying something is true proves it true, then what Smith says is true and what Jones says is also true—which is impossible, because one of them denies exactly what the other affirms. Their statements are contradictory, and asserting both of them amounts to saying nothing at all. (Incidentally, Smith is correct.)

To reason effectively, we need to avoid contradiction and accept beliefs that are adequately defended. But what are the appropriate standards by which we can determine if our beliefs are consistent with each other and well-confirmed by the available evidence? Logic is the subject that offers answers to these questions, and the scope of logic is explained in the following essay by Patricia Kitcher, Professor of Philosophy at Columbia University; George Sher, Professor of Philosophy at Rice University, and myself. At one time we were colleagues in the Department of Philosophy at the University of Vermont.

We reason every day of our lives. All of us argue for our own points of view, whether the topic be politics, the value or burden of religion, the best route to drive between Boston and New York, or any of a myriad of other subjects. We are constantly barraged by the arguments of others, seeking to convince us that they know how to build a better computer, or how to prevent a serious illness, or whatever.

ARGUMENTS

In ordinary parlance, an argument is a verbal dispute carried out with greater or less ferocity. The technical, philosophical notion is quite different. An argument is a collection of sentences consisting of one or more *premises* and a *conclusion.*

It is sometimes said that a true philosopher never assumes anything; every claim must be proved. Taken literally, this cannot be right. For if you are going to construct an argument at all, you must take some claim (or claims) as your premise(s). It would obviously be backwards to assume the truth of a very controversial claim in order to argue for something that is obvious to everyone. The direction of argumentation must always be, as above, from the more obvious to the less obvious. Ideally a reasoner will assume, as premises, claims that are very un-controversial and argue that a much more controversial, perhaps even surprising, conclusion follows from those unproblematic assumptions.

A chain of argumentation is exactly as solid as the arguments it contains. If any link is weak, then the entire chain will break down. From a logical point of view, the crucial aspect of arguments is the relationship between the premises and the conclusion. Logic is the branch of philosophy that studies the inferential relations between premises and conclusion. The task of logic is to establish rules or guidelines about which claims can be inferred from other claims. This task has been carried out with great success for *deductive inference.*

DEDUCTIVE ARGUMENTS

The central concept of deductive logic is *validity.* An argument is valid if and only if the following relation holds between its premises and its conclusion: *It is impossible for the conclusion to be false if the premises are true.* Alternatively, in a valid argument, if the premises are true, this guarantees that the conclusion is also true. It is important to realize that logicians are not concerned with truth itself. Logicians will certify an argument as valid whether or not the premises are true. Their concern is only with the relation between the premises and the conclusion. Regardless of whether the premises are true, an argument is valid if, *if* the premises *happen* to be true, then the conclusion *must* be true. If all the arguments in a chain of argumentation are valid, then the entire chain will also be valid. Valid arguments are ideal, because if you start from true premises, true conclusions are guaranteed. Like a trolley car that is bound to follow the tracks, if you start with the truth and make only valid inferences, you will never veer away from the truth.

It is somewhat unfortunate that, in ordinary (English, "valid" and "true" are often used as synonyms. Their technical, philosophical meanings are quite distinct. In the primary philosophical use of "valid," it makes no sense to say that a statement is "valid," for validity is a *relation among statements.* Statements can be true, but not valid; arguments can be valid, but not true. "True" and "valid" have distinct meanings, and truth and validity are independent properties; that is, each property can occur without the other. Arguments whose premises are all true can still be invalid and valid arguments can have false premises. Thus, a valid argument can have (a) true premises and a true conclusion, as in (1) below; (b) one or more false premises and a false conclusion, as in (2); or (c) one or more false premises and a true conclusion, as in (3). The only possibility ruled out by validity is that the argument have true premises and a false conclusion.

(1) P_1 Wombats belong to the order of marsupials.
P_2 Koalas belong to the order of marsupials.
C Wombats and koalas belong to the same order.

(2) P_1 All philosophers lived in Ancient Greece. (false)
P_2 Bertrand Russell was a philosopher.
C Bertrand Russell lived in Ancient Greece. (false)

(3) P_1 All canaries are polar bears. (false)
P_2 All polar bears have feathers. (false)
C All canaries have feathers.

Finally, an argument can have true premises and a true conclusion and still be invalid, as in (4).

(4) P_1 Some roses are red.
P_2 Some violets are blue.
C Some flowers give some people hay fever.

The problem with argument (4) is that, while all the claims are true, the fact that P_1 and P_2 are true gives us no reason whatsoever to believe that C is true.

So far, we have been assuming that the reader can simply "see" when an argument is valid or invalid. But how can we actually test for deductive validity? In one sense, the test for validity comes right out of the definition of validity: A valid argument is one whose conclusion cannot be false if its premises are true. To test for validity,

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try negating the conclusion while assuming the truth of the premises.

(5) P_1 All Englishmen love the Queen. (false)
P_2 Henry is English.
C Henry loves the Queen.

In (5) we would negate the conclusion, yielding "Henry does not love the Queen." Now the question is, can we still maintain the truth of the premises? Obviously not, for if we try to claim that Henry does *not* love the Queen, while holding to the truth of P_2, "Henry is English," then we shall have to give up the truth of P_1, "All Englishmen love the Queen." Conversely, if we claim that Henry does not love the Queen and try to maintain P_1 as well, then we will have to give up P_2. Since we cannot maintain the truth of both (or all) premises while negating the conclusion, this argument is valid. If it is possible to preserve the truth of the premises, while denying the conclusion, as in (6), then the argument is invalid.

(6) P_1 Only U.S. citizens vote in American elections.
P_2 Jones is a U.S. citizen.
C Jones votes in American elections.

Even though P_1 and P_2 are true, C could be false, if Jones is one of the citizens who does not bother to vote. . . .

A compelling deductive argument should be valid. Otherwise, the premises should not lead us to accept the conclusion. However, validity is not enough. Even if the truth of a conclusion may be validly inferred from the truth of certain premises, that gives us no reason at all to accept the conclusion, unless we have good reason to believe that the premises are, in fact, true. Unfortunately, there is no magical device we can use to determine truth. For philosophers, as for anyone else, establishing the truth of claims is often a complex, difficult, and uncertain project. Still, through their explicit study of argumentation, philosophers have recognized that there is a general method that can be used to assess the worth of premises, even in the absence of a test of truth.

In analyzing arguments, philosophers noticed that the key terms in some premises were either so vague or so ambiguous that the premise ought to be rejected out of hand. For example,

(7) P_1 The Constitution requires that public education be theologically neutral.
P_2 The theory of evolution is really just a religious doctrine.
C Therefore, since evolution is taught in schools, the biblical account of creation should also be taught in order to ensure theological neutrality.

While P_2 is also highly questionable, we will just consider the terminology employed in P_1 and the conclusion. What is the key expression "theologically neutral" supposed to mean? Given a standard interpretation of the Constitutional doctrine of the separation of Church and State, if P_1 is to be true, then "theologically neutral" must be read as something like "devoid of theology." Notice, however, that this cannot be the intended reading of "theologically neutral" in the conclusion, or the conclusion would be self-contradictory, asserting that the way to make public education devoid of theology is to start teaching the biblical account of creation. There, "theologically neutral" must be interpreted to mean something like "theologically balanced." In this example, the ambiguous terminology completely vitiates the argument. The only reason the premises even appear to support the conclusion is that the same phrase occurs in both P_1 and C. That connection is illusory, however, because the phrase is used ambiguously. In cases like this, the arguments may be dismissed without trying to determine the *truth* of the premises. In fact, when a key term in a premise is either ambiguous or vague, there is no way to figure out whether the premise is true or not. For if we are unsure about what the premise asserts, we are in no position to find out whether what the premise asserts is true. . . .

NONDEDUCTIVE ARGUMENTS

We have looked briefly at one type of inferential relation between premises and conclusions—the relation of deductive validity. . . . [W]e must try to deal with nondeductive reasoning, because there are many good, but nondeductive inferences that we encounter in everyday and scientific discussions. Suppose, for example, that a particular drug is given a hundred thousand trials across a wide variety of people and it never produces serious side effects. Even the most scrupulous researcher would conclude that the drug is safe. Still, this conclusion cannot be validly inferred from the data.

(8) P_1 In 100,000 trials, drug X produced no serious side effects.
C Drug X does not have any serious side effects.

We can use our regular method of testing validity to show that this argument is invalid. Assuming the negation of the conclusion—drug X *has* a serious side effect—can we preserve the truth of premise P_1? It could turn out that a serious side effect only shows up on the 100,001st trial. Thus the premise, P_1, could be true, even though C is false, so the argument is invalid.

There are many more good, but invalid arguments. Here is a mundane example.

(9) P_1 The dining room window is shattered.
P_2 There is a baseball lying in the middle of the glass on the dining room floor.
P_3 There is a baseball bat lying on the ground in the yard outside the dining room.
C The dining room window was shattered by being hit with a baseball. . . .

If we cling to the standard of deductive validity, then . . . the previous arguments—and all other arguments like these—will have to be dismissed as bad reasoning. That constraint on argumentation is unacceptable for three reasons. First, these arguments appear to be perfectly reasonable, at least at first glance. Second, it is hard to see how we could get by without engaging in the sorts of reasoning represented by these examples. Finally, and perhaps most critically, it seems unreasonable to demand that the truth of the premises must *guarantee* the truth of the conclusion. Very often it is reasonable to believe something that is merely very probable, given the evidence. To take a different example, given the number of traffic lights in Manhattan, it is reasonable to believe that, if you drive the entire length of the island in normal traffic, you will have to stop at some traffic light or other (and probably at several). At least, we would be willing to make a small wager on this point.

Logic has, therefore, a second task. It needs to provide criteria for evaluating good, but nondeductive, inferences. . . .

INDUCTION

Without any detailed knowledge of combustion, we know that if we place a dry piece of paper into the flame of a candle, the paper will burn. We know this because we have witnessed or heard about many similar events in the past. In the past, the paper has always burned, so we infer that the paper will burn in the present case. This common type of reasoning is called ***induction***. In induction, one relies on similar, observed cases, to infer that the same event or property will recur in as yet unobserved cases. We reason that since paper has always burned when placed in a flame, the same thing will happen in the present case. . . .

For different cases, we will have different amounts of evidence, on which to draw. If only ten instances of a disease have been observed, then we will have much less confidence in predicting the course of the disease than if we had observed ten thousand occurrences. Philosophers usually describe our "confidence" in a claim as our "strength of belief" in that claim. The obvious suggestion is that our strength of belief in a claim should vary with the amount of evidence supporting the claim. More precisely, our strength of belief should increase with the number of positive instances of the claim. In other words, the degree of *rational* belief *does* increase as positive instances increase. So, for example, if you arrive in a new town and notice that all the buses you see on your first day are green, then as the days pass and you continue to observe nothing but green buses, the degree of your rational belief in the claim that all the buses in town are green will continually go up. Each new instance of a green bus is said to "confirm" the generalization that all the buses are green. Another way to state this relationship is that the degree of rational belief in an inductive generalization should vary with the amount of confirmation that the generalization has received.

Positive instances gradually confirm an inductive generalization, making it more and more reasonable to accept the generalization. By contrast, a negative instance defeats the generalization in a single stroke. To take a dramatic twentieth-century example, with the splitting of the first atom, the long-standing claim that atoms are indivisible particles of matter had to be given up. Besides the sheer number of positive instances, another criterion for good inductive reasoning is that the evidence be varied. If you have observed buses in many different parts of town, then you are more justified in claiming that the town's buses are all green than if you only considered the buses on your street.

HYPOTHESIS TESTING

It is a commonplace that people—most notably scientists and detectives—test hypotheses and accept those hypotheses that pass the tests they have devised. The process of ***hypothesis testing*** (with consequent acceptance or rejection) is very similar to the process of inductive reasoning. For example, imagine that a problem has developed in a small rural town. Residents are falling sick, complaining of severe nausea, abdominal pains, and other symptoms. The local doctor hypothesizes that the trouble has been caused by the opening of a new chemical plant that is emptying waste within a mile of one of the lakes that yield the town's supply of drinking water. The hypothesis can be tested in a number of different ways. The residents might check the consequences of only drinking water from lakes that are not close to the chemical plant. Or they might examine the effects on laboratory animals of drinking water obtained shortly after large amounts of waste had been ejected from the plant. It is relatively easy to see how the doctor's hypothesis might fail such tests. The residents might find that using water from different lakes achieved nothing, and that the sickness continued to spread. Equally, it is evident how the hypothesis could pass the tests. One might discover, for example, that the health of laboratory animals was dramatically affected by providing them with water obtained shortly after an episode of waste disposal.

The case just described indicates the general way in which a hypothesis might be tested. Frequently we advance a claim—a hypothesis—whose truth or falsity we are unable to ascertain by relatively direct observation. We cannot just look and see what causes the sickness in the rural town (or what causes various forms of cancer); we cannot just look and see if the earth moves, or if the continents were once part of a single land mass, or if the butler committed the crime. In evaluating such hypotheses, we consider what things we would expect to observe if the hypothesis were true. Then we investigate to see if these expectations are or are not borne out. If they are, then the hypothesis passes the test, and its success counts in its favor. If they are not, then the failure counts against the hypothesis. . . .

INFERENCE TO THE BEST EXPLANATION

Another common and indispensable type of non-deductive inference should be familiar to readers of both scientific essays and detective stories. Sherlock Holmes uses this type of reasoning in his first encounter with Dr. Watson in *A Study in Scarlet:*

> "*I knew* you came from Afghanistan. From long habit the train of thoughts ran so swiftly through my mind that I arrived at the conclusion without being conscious of intermediate steps. There were such steps, however. The train of reasoning ran, 'Here is a gentleman of a medical type, but with the air of a military man. Clearly an army doctor, then. He has just come from the tropics, for his face is dark, and that is not the natural tint of his skin, for his wrists are fair. He has undergone hardship and sickness, as his haggard face says clearly. His left arm has been injured. He holds it in a stiff and unnatural manner. Where in the tropics could an English army doctor have seen much hardship and got his arm wounded? Clearly in Afghanistan.' The whole train of thought did not occupy a second. I then remarked that you came from Afghanistan, and you were astonished."[1]

It is no help to students of reasoning that Sir Arthur Conan Doyle consistently misdescribes Holmes' reasoning as "deduction." Holmes' argument is obviously invalid. Even though Watson has a deep tan and a wounded arm, it is still entirely possible that he has never been in Afghanistan. He could have obtained the tan in Florida and the wound in a knife fight in Peru. Still, Holmes's argument does provide considerable support for his claim that Watson had been in Afghanistan. This is the way Holmes' reasoning (here and in most other places) actually works. He lists a number of facts: the military bearing, the medical bag, the tan, the wounded arm. Then he uses those facts to infer a conclusion, ***on the grounds that the claim made by the conclusion would explain all the facts presented.*** In this case, if Watson is, in fact, a military doctor who has just returned from active service in Afghanistan, that would explain why he has a medical bag, a tan, and so forth. The correct, if clumsy, name for this type of reasoning is ***argument by inference to the best explanation.***

Inference to the best explanation is related to hypothesis testing. In hypothesis testing, a hypothesis is supported when observations which can be deduced from that hypothesis are borne out by observation. In inference to the best explanation, the relation between the conclusion—the explanation—and the observed facts is looser. For example, the fact that Watson was in Afghanistan does not deductively imply that his face was tanned. (He could have worn a large hat to protect his face from the sun.) Still, the conclusion, that he was in Afghanistan, makes it likely that, other things being equal, he would be deeply tanned. So, in argument by inference to the best explanation, the premises support the conclusion because, if the conclusions were true, that would give us good reason to expect that the premises would be true, and the premises are true. . . .

ARGUMENT ANALYSIS

We have examined various types of inference. Now we will consider how this information may be used in analyzing reasoning. The basic task of argument analysis is to provide a clear formulation of the chain of argumentation presented in a piece of prose. It is important to realize that arguments do not come neatly packaged, with labels clearly identifying the premises and the conclusion. A critic needs to be careful and sympathetic. The best critic works hard at finding the optimal version of the argumentation contained in a passage before evaluating it.

While it may seem surprising, the first step in evaluating a piece of reasoning is to find the conclusion. The conclusion may occur at the beginning, or at the end, or in the middle of the passage. Often the conclusion will not be stated at all! To find the conclusion, you need to ask yourself, What is the author trying to get us to believe?

After locating the conclusion, the next step in analyzing an argument is to list the stated premises. To find the stated premises of an argument, you need to ask about the author's starting place. What claims is the author assuming, without argument? Once you have found the conclusion and found the stated premises (and eliminated any other apparent claims as rhetorical fluff), then you are ready to move to the most difficult stage in argument analysis. You need to trace a plausible route from the premises to the conclusion. This stage is frequently the most difficult. Authors do not tell us what kinds of arguments they are making, nor (obviously) do they tell us their unstated assumptions. Often it will be necessary to try several alternative reconstructions before you are satisfied that you have found the argument buried in the prose. Besides adding needed unstated assumptions and deleting any unnecessary rhetorical flourishes, you will often have to clarify the meanings of key terms, as we noted above.

Once you have reconstructed the argument, so that you know how it is supposed to work, then you can appraise its success or failure. This step employs the criteria for evaluating different types of inferences, some of which are presented above.

Evaluating reasoning is a complex task, because human language is rich and fluid, and because we are able to see a large number of subtle connections among the facts we confront. While the task is difficult, the alternative is unacceptable. For if we give up trying to understand reasoning, then we must either naively accept the arguments of others, as if we were children, or play the cynic, and forswear the possibility of learning from the insights of others.

NOTE

1. "A Study in Scarlet," in Arthur Conan Doyle, *The Complete Sherlock Holmes* (Garden City, N.Y.: Doubleday, n.d.), p. 24.

Study Questions

1. Can a valid deductive argument have true premises and a false conclusion?
2. Can a valid deductive argument have false premises and a true conclusion?
3. Give your own example of hypothesis testing.
4. Give your own example of arguing by inference to the best explanation.

Scientific Inquiry

CARL G. HEMPEL

The scientific method of explanation involves formulating a hypothesis and testing it, then accepting, rejecting, or modifying it in light of the experimental results. But how do we test a hypothesis? That is the subject of the following selection by Carl G. Hempel (1905–1997), who was Professor of Philosophy at Princeton University.

As you read about hypothesis testing, you may wonder how hypotheses are developed. What is their source? No mechanical procedures are available; the answer lies in creative imagination. While giving free rein to ingenuity, however, scientific method requires that our intuitions be accepted only if they pass the rigors of careful testing.

1. A CASE HISTORY AS AN EXAMPLE

As a simple illustration of some important aspects of scientific inquiry let us consider Semmelweis' work on childbed fever. Ignaz Semmelweis, a physician of Hungarian birth, did this work during the years from 1844 to 1848 at the Vienna General Hospital. As a member of the medical staff of the First Maternity Division in the hospital, Semmelweis was distressed to find that a large proportion of the women who were delivered of their babies in that division contracted a serious and often fatal illness known as puerperal fever or childbed fever. In 1844, as many as 260 out of 3,157 mothers in the First Division, or 8.2 per cent, died of the disease; for 1845, the death rate was 6.8 per cent, and for 1846, it was 11.4 per cent. These figures were all the more alarming because in the adjacent Second Maternity Division of the same hospital, which accommodated almost as many women as the First, the death toll from childbed fever was much lower: 2.3, 2.0, and 2.7 per cent for the same years. In a book that he wrote later on the causation and the prevention of childbed fever, Semmelweis describes his efforts to resolve the dreadful puzzle.[1]

He began by considering various explanations that were current at the time; some of these he rejected out of hand as incompatible with well-established facts; others he subjected to specific tests.

One widely accepted view attributed the ravages of puerperal fever to "epidemic influences," which were vaguely described as "atmospheric-cosmic-telluric changes" spreading over whole districts and causing childbed fever in women in confinement. But how, Semmelweis reasons, could such influences have plagued the First Division for years and yet spared the Second? And how could this view be reconciled with the fact that while the fever was raging in the hospital, hardly a case occurred in the city of Vienna or in its surroundings: a genuine epidemic, such as cholera, would not be so selective. Finally, Semmelweis notes that some of the women admitted to the First Division, living far from the hospital, had been overcome by labor on their way and had given birth in the street: yet despite these adverse conditions, the death rate from childbed fever among these cases of "street birth" was lower than the average for the First Division.

On another view, overcrowding was a cause of mortality in the First Division. But Semmelweis points out that in fact the crowding was heavier in the Second Division, partly as a result of the desperate efforts of patients to avoid assignment to the notorious First Division. He also rejects two similar conjectures that were current, by noting that there were no differences between the two Divisions in regard to diet or general care of the patients.

In 1846, a commission that had been appointed to investigate the matter attributed the prevalence of illness in the First Division to injuries resulting from rough examination by the medical students, all of whom received their obstetrical training in the First Division. Semmelweis notes in refutation of this view that (*a*) the injuries resulting naturally from the process of birth are much more extensive than those that might be caused by rough examination; (*b*) the midwives who received their training in the Second Division examined their patients in much the same manner but without the same ill effects; (*c*) when, in response to the commission's report, the number of medical students was halved and their examinations of the women were reduced to a minimum, the mortality, after a brief decline, rose to higher levels than ever before.

Various psychological explanations were attempted. One of them noted that the First Division was so arranged that a priest bearing the last sacrament to a dying woman had to pass through five wards before reaching the sickroom beyond: the appearance of the priest, preceded by an attendant ringing a bell, was held to have a terrifying and debilitating effect upon the patients in the wards and thus to make them more likely victims of childbed fever. In the Second Division, this adverse factor was absent, since the priest had direct access to the sickroom. Semmelweis decided to test this conjecture. He persuaded the priest to come by a roundabout route and without ringing of the bell, in order to reach the sick chamber silently and unobserved. But the mortality in the First Division did not decrease.

A new idea was suggested to Semmelweis by the observation that in the First Division the women were delivered lying on their backs; in the Second Division, on their sides. Though he thought it unlikely, he decided "like a drowning man clutching at a straw," to test whether this difference in procedure was significant. He introduced the use of the lateral position in the