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# 1 Logic

Logic is about good and bad reasoning. In order to talk clearly about reasoning, logicians have given precise meanings to some ordinary words. This chapter is a review of their language.

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## ARGUMENTS

Logicians attach a special sense to the word *argument*. In ordinary language, it usually takes two to argue. One dictionary defines an argument as:

- 1 A quarrel.
- 2 A discussion in which reasons are put forward in support of and against a proposition, proposal, or case.
- 3 A point or series of reasons presented to support a proposition which is the conclusion of the argument.

Definition (3) is what logicians mean by an argument.

Reasoning is stated or written out in arguments. So logicians study arguments (in sense 3).

An argument thus divides up into:

A point or series of reasons which are called *premises*, and a *conclusion*.

Premises and conclusion are *propositions*, statements that can be either true or false. Propositions are "true-or-false."

## GOING WRONG

The premises are supposed to be reasons for the conclusion. Logic tries to understand the idea of a good reason.

We find arguments convincing when we know that the premises are true, and when we see that they give a good reason for the conclusion.

So two things can go wrong with an argument:

- the premises may be false.
- the premises may not provide a good reason for the conclusion.

Here is an argument:

(\*) If James wants a job, then he will get a haircut tomorrow.

James will get a haircut tomorrow.

So:

James wants a job.

The first two propositions are the premises. The third proposition is the conclusion.

Someone might offer this argument, thinking the premises give a conclusive reason for the conclusion. They do not. The premises could be true and the conclusion false, for any number of reasons. For example:

James has a date with a girl who likes tidy men, and his hair is a mess.  
He has to go home to his family, who would be disgusted by how he looks.  
It is the third Monday of the month, and he always gets a haircut then.  
No way does he want a job! Of course, if he did want a job, he'd get a haircut tomorrow.

Argument (\*J), if offered as a conclusive argument, commits an error—a common error. That is why we labeled it with a "star" in front, as a warning that it is a bad argument.

Argument (\*J) commits a *fallacy*. A fallacy is an error in reasoning that is so common that logicians have noted it. Sometimes they give it a name. Argument (\*J) commits the fallacy called "affirming the consequent." The first premise in the argument is of the form:

If A, then C.

A is called the *antecedent* of this "if-then" proposition, and C is called the *consequent*.

The second premise of (\*J) is of the form "C." So in stating this premise, we "affirm the consequent."

The conclusion is of the form "A." It is a fallacy to infer the antecedent A from the consequent C. That is the fallacy of affirming the consequent.

## TWO WAYS TO CRITICIZE

Here is a conclusive argument that only looks a little like (\*J):

(J) If James wants a job, then he will get a haircut tomorrow.

James wants a job.

So:

James will get a haircut tomorrow.

Here the premises do provide a conclusive reason for the conclusion. If the premises are true, then the conclusion must be true too.

But you might question the premises.

You might question the first premise if you knew that James wants a job as a rock musician. The last thing he wants is a haircut.

You might also question the second premise. Does James really want a job?

There are two basic ways to criticize an argument:

- Challenge the premises—show that at least one is false.
- Challenge the reasoning—show that the premises are not a good reason for the conclusion.

The two basic types of criticism apply to any kind of argument whatsoever. But logic is concerned only with reasoning. It cannot in general tell whether premises are true or false. It can only tell whether the reasoning is good or bad.

## VALIDITY

Here is another conclusive argument:

(K) Every automobile sold by Queen Street Motors is rust-proofed.

Barbara's car was sold by Queen Street Motors.

Therefore:

Barbara's car is rust-proofed.

If the two premises of (K) are true, then the conclusion must be true too. The same goes for (J) above. But not for (\*J)!

This idea defines a valid argument. It is logically impossible for the conclusion to be false given that the premises are true.

Validity is best explained in terms of logical form. The logical form of arguments (J) and (K) is:

- |                  |                  |
|------------------|------------------|
| 1. If A, then C. | 4. Every F is G. |
| 2. A.            | 5. b is F.       |
| So:              | Therefore:       |
| 3. C.            | 6. b is G.       |

Whenever an argument of one of these forms has true premises, then the conclusion is also true. That is a definition of a valid argument form.

*Valid* is a technical term of deductive logic. The opposite of *valid* is *invalid*. In ordinary life, we talk about a valid driver's license. We say someone is making a

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valid point if there is a basis for it, or even if it is true. But we will stick to the special, logicians' meaning of the word. Arguments are valid or invalid.

Argument (\*) above was invalid. Here is another invalid argument:

(\*K) Every automobile sold by Queen Street Motors is rust-proofed.  
Barbara's car is rust-proofed.

Therefore:

Barbara's car was sold by Queen Street Motors.

This is invalid because the conclusion could be false, even when the premises are true. Many companies sell rust-proofed cars, so Barbara need not have bought hers at Queen Street Motors.

**TRUE VERSUS VALID**

Be careful about *true* and *valid*. In logic:

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Propositions are true or false.  
Arguments are valid or invalid.

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You should also distinguish the argument (K) about Barbara's car from an "if-then" or conditional proposition like this:

If Barbara's car was sold by Queen Street Motors, and if every automobile sold by Queen Street Motors is rust-proofed, then Barbara's car is rust-proofed.

This is a true proposition of the form,

If  $p$  and if  $q$ , then  $r$ .

Or, in finer detail,

If  $b$  is  $F$ , and if every  $F$  is  $G$ , then  $b$  is  $G$ .

Argument (K), on the other hand, is of the form:

- |          |                      |                       |
|----------|----------------------|-----------------------|
| 4. $p$ . | Or, in finer detail, | 4. Every $F$ is $G$ . |
| 5. $q$ . |                      | 5. $b$ is $F$ .       |
| So:      |                      | Therefore:            |
| 6. $r$ . |                      | 6. $b$ is $G$ .       |

To every argument there is a corresponding conditional proposition "if-then." An argument is valid if and only if the corresponding conditional proposition is a truth of logic.

**METAPHORS**

There are many ways to suggest the idea of validity:

- The conclusion follows from the premises.
- Whenever the premises are true, the conclusion *must* be true too.
- The conclusion is a logical consequence of the premises.
- The conclusion is implicitly contained in the premises.
- Valid argument forms are truth-preserving.

"Truth-preserving" means that whenever you start out with true premises, you will end up with a true conclusion.

When you reason from true premises using a valid argument, you never risk drawing a false conclusion. When your premises are true, there is no risk that the conclusion will be false.

Textbooks on deductive logic make precise sense of these metaphors. For the purposes of this book, one metaphor says best what matters for validity:

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Valid arguments are risk-free arguments.

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**SOUND**

A *valid* argument never takes you from true premises to a false conclusion.

But, of course, the argument might have a false premise.

We say an argument is *sound* when:

- all the premises are true, and
- the argument is valid.

Thus an argument may be unsound because:

- A premise is false.
- The argument is invalid.

*Validity* has to do with the logical connection between premises and conclusion, and *not* with the truth of the premises or the conclusion.

*Soundness* for deductive logic has to do with *both* validity *and* the truth of the premises.

**LIKE BUILDING A HOUSE**

Making a deductive argument is like building a house.

- It may be built on sand, and so fall down, because the foundations are not solid. That is like having a false premise.

- Or it may be badly built. That is like having an invalid argument.
- And, of course, a house built on sand with bad design may still stay up. That is like an invalid argument with false premises and a true conclusion.

There are two ways to criticize a contractor who built a house. "The foundations are no good!" Or, "The house is badly built!" Likewise, if someone shows you a deduction you can make two kinds of criticism. "One of your premises is false." Or, "The argument is invalid." Or both, of course.

### VALIDITY IS NOT TRUTH!

A valid argument can have a *false premise* but a *true conclusion*. Example:

(R) Every famous philosopher who lived to be over ninety was a mathematical logician.

Bertrand Russell was a famous philosopher who lived to be over ninety.

So:  
Bertrand Russell was a mathematical logician.

This argument is valid. The conclusion is true.

But the first premise is false. Thomas Hobbes, the famous political philosopher, lived to be over ninety, but he was not a mathematical logician.

Likewise an argument with *false premises* and a *false conclusion* could be valid. Validity is about the connection between premises and conclusion, not about truth or falsehood.

### INVALIDITY IS NOT FALSEHOOD!

An invalid argument can have *true premises* and a *true conclusion*. Example:

(\*R) Some philosophers now dead were witty and wrote many books.  
Bertrand Russell was a philosopher, now dead.

So:  
Bertrand Russell was witty and wrote many books.

Both premises are true. The conclusion is true. But the argument is invalid.

### TWO WAYS TO CRITICIZE A DEDUCTION

Both (R) and (\*R) are unsound, but for quite different reasons.

You can tell that (\*R) is unsound because it is invalid. You can tell it is invalid without knowing *anything* about Bertrand Russell (except that "Bertrand Russell" was someone's name).

Likewise, you can tell that (R) is valid without knowing anything about Bertrand Russell.

But to know whether the premises are true, you have to know something

about the world, about history, about philosophers, about Bertrand Russell and others.

Maybe you did not know that Bertrand Russell was witty or that Thomas Hobbes was a famous political philosopher who lived to be over ninety. Now you do.

You need not know anything special about the world to know whether an argument is valid or invalid. But you need to know some facts to know whether a premise is true or false.

There are two ways to criticize a deduction:

- A premise is false.
- The argument is invalid.

So there is a *division of labor*.

Who is an expert on the truth of premises?

Detectives, nurses, surgeons, pollsters, historians, astrologers, zoologists, investigative reporters, you and me.

Who is an expert on validity?

A logician.

Logicians study the relations between premises and conclusions, but, as logicians, are not especially qualified to tell whether the premises are true or false.

### EXERCISES

- 1 *Propositions*. The premises and conclusion of an argument are propositions. Propositions are expressed by statements that can be either true or false. For brevity, we say that propositions are true-or-false.

The headline of a newspaper story is:

SEIZED SERPENTS MAKE STRANGE OFFICE-FELLOWS  
SHIPPING ERROR LANDS OFFICIAL WITH PYTHONS

There was a bizarre mix-up. A man who runs a tropical fish store in Windsor, Ontario, was delivered a box of ball pythons from a dealer in California. The newspaper tells us that:

The ball python is a central African ground dweller that can grow to more than a meter on a diet of small mammals.

- (a) Is that true-or-false?
- (b) Do you know whether it is true?
- (c) Is it what logicians call a proposition? [You should give the same answer to (c) as to (a).]

The newspaper goes on to tell us that:

The ball python is named for its tendency to curl up into a ball.

- (d) Is that true-or-false?  
 (e) Do you know whether it is true?

The story continues:

The shipment of tropical fish intended for Windsor went to a snake dealer in Ohio.

- (f) Is that a proposition?

In logic, propositions express matters of fact that can be either true or false. Judgments of personal taste, such as "avocados are delicious," are not strictly matters of fact. Avocados taste good to some people and taste slimy and disgusting to others. The proposition that avocados are delicious is not strictly speaking true-or-false. But if I say "avocados taste delicious to me," I am stating something about me, which happens to be true.

Joe, the man who owns the fish store, is quoted as saying:

Ball pythons are very attractive animals.

- (g) Is that true-or-false? Is it a proposition?

Suppose that he had said,

I think ball pythons are very attractive animals.

- (h) Is that true-or-false? Is it a proposition?

The newspaper begins the story by saying "It is not so nice to share your office with a box of snakes for two months." Then it adds, as a full paragraph:

Especially when it was all a result of being soft-hearted.

- (i) Is that a proposition?

Joe has to feed the snakes a lot of live mice. According to the reporter, Joe said,

I'm not really too thrilled to hear baby mice squeaking and screaming behind me while I'm on the telephone.

- (j) Is that a proposition?

Then Joe said,

Thank God they don't eat every day!

- (k) Is that a proposition?

He next asked,

Do you know any zoos or schools who might want these snakes?

- (l) Is that a proposition?

Joe phoned Federal Express, the shipper who had mixed up the deliveries, saying:

You owe me for my expenses, my trouble, and your mistake.

- (m) Is that a proposition?

The story ended happily:

On Wednesday Federal Express bargained a \$1000 payment to Joe.

- (n) Is that a proposition?

- 2 *False all over.* State two arguments—they can be silly ones—in which the premises and conclusion are all false, and such that one argument is (a) valid and the other is (b) invalid.
- 3 *Unsound.* Is either of your answers to question 2 a sound argument?
- 4 *Combinations.* Only one of the following eight combinations is impossible. Which one?  
 (a) All premises true. Conclusion true. Valid.  
 (b) All premises true. Conclusion false. Valid.  
 (c) One premise false. Conclusion true. Valid.  
 (d) One premise false. Conclusion false. Valid.  
 (e) All premises true. Conclusion true. Invalid.  
 (f) All premises true. Conclusion false. Invalid.  
 (g) One premise false. Conclusion true. Invalid.  
 (h) One premise false. Conclusion false. Invalid.
- 5 *Soundness.* Which of the combinations just listed are sound arguments?
- 6 *Conditional propositions.* Which of the following is true-or-false? Which is valid-or-invalid? Which is an argument? Which is a conditional proposition?  
 (a) Tom, Dick, and Harry died.  
 So:  
 All men are mortal.  
 (b) If Tom, Dick, and Harry died, then all men are mortal.
- 7 *Chewing tobacco.* Which of these arguments are valid?  
 (a) I follow three major league teams. Most of their top hitters chew tobacco at the plate.  
 So:  
 Chewing tobacco improves batting average.  
 (b) The top six hitters in the National League chew tobacco at the plate.  
 So:  
 Chewing tobacco improves batting average.  
 (c) A study, by the American Dental Association, of 158 players on seven major league teams during the 1988 season, showed that the mean batting average for chewers was .238, compared to .248 for non users. Abstainers also had a higher fielding average.  
 So:  
 Chewing tobacco does not improve batting average.  
 (d) In 1921, every major league pitcher who chewed tobacco when up to bat had a higher batting average than any major league pitcher who did not.  
 So:  
 Chewing tobacco improves the batting average of pitchers.
- 8 *Inductive baseball.* None of the arguments (7a)–(7d) is valid. Invalid arguments are not conclusive. But some non-conclusive arguments are better than others. They are risky arguments. Each of the arguments (a)–(d) is risky. We have not

done any inductive logic yet, but you probably think some of (7a)-(7d) are better arguments than others. Which is best? Which is worst?

**KEY WORDS FOR REVIEW**

Argument	Conclusion
Proposition	Valid
True-or-false	Sound
Premise	Conditional

## 2 What Is Inductive Logic?

Inductive logic is about risky arguments. It analyses inductive arguments using probability. There are other kinds of risky arguments. There is inference to the best explanation, and there are arguments based on testimony.

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Valid arguments are risk-free. Inductive logic studies risky arguments. A risky argument can be a very good one, and yet its conclusion can be false, even when the premises are true. Most of our arguments are risky.

Begin with the big picture. The Big Bang theory of the origin of our universe is well supported by present evidence, but it could be wrong. That is a risk.

We now have very strong evidence that smoking causes lung cancer. But the reasoning from all that evidence to the conclusion "smoking causes lung cancer" is still risky. It might just turn out that people predisposed to nicotine addiction are also predisposed to lung cancer, in which case our inference, that smoking causes lung cancer, would be in question after all.

After a lot of research, a company concludes that it can make a profit by marketing a special left-handed mouse for personal computers. It is taking a risk.

You want to be in the same class as your friend Jan. You reason that Jan likes mathematics, and so will take another logic class. You sign up for inductive logic. You have made a risky argument.

**ORANGES**

Here are some everyday examples of risky arguments.

A small grocer sells her old fruit at half-price. I want a box of oranges, cheap. But I want them to be good, sweet, and not rotten. The grocer takes an orange from the top of a box, cuts it open, and shows it to me. Her argument is: