1   Fundamentals

1   Conditionals

"Iffy" thinking is one of the characteristic resources of the sorts of creatures we humans have become. For in intellectual regards, the *Homo sapien* is an amphibian who lives and functions in two very different realms—the domain of existing reality that we can investigate in observational inquiry, and the domain of suppositional projection that we can explore in creative imagination. And this second ability becomes crucially important for the first as well, when once one presses beyond the level of a mere *description* of the real to concern oneself also with its rational *explanation*, which involves providing an account of why things are as they are rather than otherwise. In the history of Western thought this transition was apparently first made by the Greek nature-philosophers of pre-Socratic times, who, as best we can now tell, invented "thought experimentation" as a cognitive procedure and—as will be seen—practiced it with great dedication and versatility.

A thought experiment is an attempt to draw instruction from a process of hypothetical reasoning that proceeds by eliciting the consequences of a hypothesis which, for aught that one actually knows to the contrary, may well be false. It consists in reasoning from a supposition that is not (or not as yet) accepted as true—and perhaps is even known to be false—but is assumed provisionally in the interests of making a point or establishing a conclusion.[1]

In natural science, thought experiments are commonplace. One classic instance is Albert Einstein's pondering the question of what the world would look like if one were to travel along a ray of light. Think too of the physicists' assumption of a frictionlessly rolling body or the economists' assumption of a perfectly efficient market and similar devices for

establishing the laws of descent or the principles of exchange. Indeed, thought experiments are far more common in science than one may think. More than a century ago, Ernst Mach made the sound point that any sensibly designed *real* experiment should be preceded by a *thought* experiment that anticipates at any rate the possibility of its outcome.[2] The conclusion of *such* a thought experiment will clearly be hypothetical: "If the experiment turns out *X*-wise, we shall be in a position to conclude. . . ." There is good reason to see such thought experimentation as an indispensably useful accompaniment to actual experimentation.[3]

To us moderns, brought up on imaginative children's nursery rhymes ("If wishes were horses, then beggars would ride") and accustomed to obvious adult fictions, this sort of belief-suspensive thinking seems altogether natural. It takes a logician to appreciate how complex and sophisticated thought experimentation truly is. For what it involves is *not* simply the drawing of an appropriate conclusion from a given true fact, but also the higher-level consideration that a particular thesis (be it fact or mere supposition) carries a certain conclusion in its wake. Thought experimentation thus takes us from mere inference to hypothetical thinking at large.

Hypotheses open up a gateway to conditional reasoning, and conditionality covers a vast range. There are not just conditional assertions but also conditional questions ("If winter comes, can spring be far behind?"), conditional commands ("If he comes late, give him hell!"), conditional directions ("If you just keep going straight, you'll find the town hall"), conditional promises ("If you do the work, you will be well paid for it"), conditional advice ("If ever in doubt, ask for directions"), and more. However, the conditionals that will primarily concern us here are assertoric: they are statement-connective statements that are explicitly or implicitly of "if-then" form, for ordinarily the consequent of the conditional spells out what follows (in one of the many senses of this term) from the acceptance or supposition of the antecedent. "If he comes, then I shall leave" is a typical example.

As regards nomenclature, with an assertorically consequential conditional of the format "If *p*, then *q*" (symbolically $p \Rightarrow q$) the first, "iffy" part (*p*) is called the *antecedent* (protasis), and the second, thenny part (*q*) is call the *consequent* (apodosis). To be sure, it must be granted that not every if-then statement is genuinely conditional. For example, some such statements convey a mere expression of politeness:

If I may offer a suggestion, then do *X*.

What we have here is simply a more tentative—and thereby more polite—way of making the suggestion at issue. Analogously,

If you need money, there is plenty in your account

is not really a proper conditional, although it could be reformulated as something like "If you need to obtain money, then you can succeed in doing so by taking it from your account (where there is plenty of it)."[4] Such statements are cast in conditional form but do not, as they stand, involve the consequential idea that one thing follows from or upon another. Assertorically consequential conditionals, by contrast, spell out a result of projecting a certain assumption or supposition. In taking the form "If p, then q," they set out the claim that (though, of course not *how*) q is a consequence that somehow follows in the wake of the hypothesis p. The present book will be concerned only with such consequential statements.

The range of assertorically conditional discourse is surprisingly extensive. Of course, there are the obvious "if-then" propositions. But conditionals can wear a disguise in this regard. "Should he come, I'm out of here" comes sufficiently close to count as a variantly formulated conditional. And "This button operates that light" is effectively equivalent with "If you push this button, that light will switch its on/off state." "Whenever it rains, it pours" comes to: "If it rains, it also pours" and "Wherever he goes, they follow him" comes to: "If he goes someplace, they follow him." "Membership in the club requires a fee" comes to "If someone is to join the club, then this individual must pay a membership fee." Again, "Doing X successfully requires a great effort" in effect comes to "If one is to succeed at doing X, one will have to exert a great effort." Even merely descriptive statements can carry an essentially conditional message. "Dogs are mammals" to all intents and purposes comes to "If a creature is a dog, then it is a mammal." Thus the aspect of conditionalization is often concealed. Consider: "No American adult, even the least well uninformed, can fail to realize that George Washington was the first president," which amounts to the doubly conditionalized statement:

If someone is an American, then even if he is among the least informed he will (nevertheless) realize that George Washington was the first president.

The language of provisos also provides examples of obliquely formulated conditionals, with "provided" as *if* or possibly *iff*. Again, "Barring

unforeseen developments he will be joining us'' comes to ''If unforeseen developments do not arise, he will be joining us.'' And ''Should they invite him, he'll of course accept'' is a further example of conditionals that sidestep the standard if-then formulation. Then too, in American usage conditionals can assume an if-then-lacking format of the structure:

Present tense + and + future tense

For example:

You do that, and I'll never speak to you again.

He comes in wearing those clothes, and they'll throw him out.

More generally, the construction ''when + future tense'' is sometimes used for ''if'':

When you look into it, you'll find that this can also be done in other ways.

Here there is no predictive claim that you actually are going to look into it in the future. However, there are also contexts where ''when'' is strictly time-indicative and is something very different from ''if'' because there is no intention to assert anything iffy or uncertain. A passenger would be dismayed at an iffy reformulation of ''When we land, the pilot will turn off the 'Fasten Seat Belt' sign.'' And a patient would not be happy to have his doctor substitute ''if'' for ''when'' in the otherwise reassuring ''When you recover from this ailment you'll be good as new.''

The long and short of it is that assertoric conditionality is not so much a grammatically taxonomic category as a functional category in the domain of information management. ''Had he but known they would abandon him, he would not have trusted them'' is every bit as much of a conditional statement as ''If he had known they would abandon him, then he would not have trusted them.''

What has been called ''Geach's thesis'' is the contention that only a completed proposition can function as the antecedent of a meaningful conditional.[5] This contention may seem problematic in the face of such conditionals as

If not now, then never.

If awake, he will not have failed to notice.

But this reservation could be countered that such statements are merely elliptical, and that what is really at issue is a rather different conditional:

If we do not do the deed now, then we shall never do so.

If he was awake at the time, then he will not have failed to notice.

However, a graver problem for Geach's thesis arises with the subjectivity exhibited by such subjunctive conditionals as:

If Jones were here, this mess could not have arisen.

Here the antecedent scarcely qualifies as a completed statement, for while "Jones was here" indeed qualifies, "Jones were here" does not, seeing that it fails to state. More damaging yet for Geach's thesis are conditionals involving propositional functions rather than propositions. Take

If an integer is greater than 5, then it is greater than 4,

or, symbolically, $(\forall x)(x > 5 \Rightarrow x > 4)$. There is simply no way to recast this conditional into the format $p \Rightarrow q$, with p as a "completed proposition."

2 Supposition, Hypothesis, Assumption

Informatively consequential conditionals are answers to "what-if" questions: "What if it rains tomorrow?," "What if dinosaurs had never evolved?," "What if a number equals twice its square root?" The object of such conditional assertions is to let our thought and discourse move above and beyond the range of categorical actuality. They enable us to say something about what must, will, or can be in circumstances that we merely assume rather than believe. Without conditionals our thought would be restricted to reality—constrained to the decidedly limited, factual range of what is actually so. Speculation, planning, and conjecture would be aborted.

We can, to be sure, inquire into the reality of things, but we also have at our disposal an imagination that affords the resources of assumption, supposition, hypothesis, and conjecture. And the main reason for preoccupation with the theory of conditionals is their role in broadening the range of reason. The crucial fact of it is that we can reason equally well both from fact and from supposition. We can say:

Since he is here, we can give the book to him.

But we can also—and no less appropriately—say:

If he were not here, we could send the book to him.

Thus the antecedent of a conditional need not be known; it can merely be supposed. Conditionalization is intimately intertwined with hypothetical reasoning. Since, by definition, one does not propose to assert the premises of a hypothetical inference as true, its status within the framework of our "knowledge" will be that of a *supposition*. And this term will here be used in a very broad sense, to apply to any informative statement put forward within what may be called a *supposition-context*, illustrated by such qualifying phrases as:

Let us suppose that . . .

Let us assume that . . .

Let it, for the sake of argument, be agreed that . . .

Let it, for the sake of discussion, be accepted that . . .

Let the hypothesis be made that . . .

Let . . . be so

The close relationship between conditional assumption and hypothetical inference lies at the heart of the present deliberations. For whenever we obtain a conclusion by drawing an inference from a supposition—no matter how elaborate the course of reasoning may be—then we can summarize the overall result by if-then conditionalizations. As the ensuing discussion will show, assertoric conditionals are always, in effect, reports on what in some suitable sense follows by inference from the substance of such an assumption or supposition.

Speculatively fact-dismissive conditionals are not limited to saying what *would* happen when or if but can just as readily deal with merely speculative possibility, with what *could or might* happen: "If you have a license, then you can drive." Then too they can deal with normative or evaluative issues, with "what ought to happen if," or "what it would be nice to happen if." The conditional

If (only!) you had spoken up, you might have prevented it

is every bit as authentic a conditional as

If you had spoken up, this would have prevented it.

Such conditional possibilities and necessities are often both informative and useful. For example, the conditionals

If you take an umbrella, then you can keep yourself dry with it

If they took the 6 AM train, then they must be home by now

convey potentially helpful information.

If-then thinking of the sort involved in imaginative wondering, planning, promising, and various other activities is a pervasive and characteristic mode of human endeavor. We live the whole of our physical existence in the realm of what is. But much of our mental existence is lived in the realm of what might be.

3 Enthymematic Bases

"If you open that box, you'll find a gold ring in it" actually says little more than "There is a gold ring in that box." In general, when a conditional that claims "If p then q" is appropriate, there lies in the background some categorical (unconditional) facts in virtue of which this conditional obtains—facts that must obtain for the conditional to hold. This body of fact is not, however, something that the conditional explicitly asserts. It is the tacit, *enthymematic basis* on which the appropriateness of the conditional rests, although the conditional itself usually does no more than hint at what this basis of underlying fact actually is. When one asserts a conditional this enthymematic basis must belong to the manifold of one's beliefs: it must be accepted or at any rate supposed to be true. Were it to be regarded otherwise—as a merely speculative possibility, say—then that conditional is not in order. And likewise in the case of the counterfactual conditional, in particular, however much the antecedent may be regarded as fanciful and false, the enthymematic basis of the conditional must be deemed true. Consider, for example:

If Queen Elizabeth I had married, she would have had a husband.

The marriage of Elizabeth I is clearly something fanciful and unreal. But the background presence of something on the order of the consideration that a married woman takes on a husband in the process—at least for a time, however brief—has to be seen as a fixed fact for this conditional to hold water.

The bonding of a conditional to its enthymematic basis is such that one of the effective ways of classifying such conditionals is by the subject matter at issue. Thus consider:

If an integer is prime, then it will not be divisible by 4.

The enthymematic basis of this conditional is simply the definition of a "prime number" as an integer divisible by no other apart from 1. And of

course any number divisible by 4 will also have 2 as divisor. This circumstance makes the conditional at issue an *arithmetic* one.

It is worth noting in this regard that a conditional can provide the enthymematic basis for others. Thus consider the conditional:

Only if switches no. 1 and no. 2 are both thrown will the engine start.

Clearly this conditional itself can serve as enthymematic basis for the following conditional:

If switch no. 1 is not thrown, then the engine will not start.

For the initial conditional has the format:

(1) $\sim$(no. 1 & no. 2) $\Rightarrow$ $\sim$*Start*

or equivalently:

Start $\Rightarrow$ (no. 1 & no. 2)

But now consider the hypothesis:

(2) $\sim$no. 1, by assumption

Then clearly:

(3) $\sim$*Start*, from (1) and (2).

Since (3) is deducible from (1) and (2), we can obtain the conditional (2) $\Rightarrow$ (3), with (1) hovering in the background as its enthymematic basis. Accordingly, that original conditional here serves as enthymematic basis for: "If switch no. 1 is not thrown, the engine will not start."

4 Iffy Variations

Conditionals are often disguised so that any explicit mention of "if-then" is absent. Thus "He would have been a fool to do that" is to all intents and purposes equivalent to:

If he did that, he was a fool.

And even with explicitly iffy statements there can be many variations.

Even If
What role does "even" play in the conditional: "Even if *p*, then *q*" (e.g., even if he had sworn it on the Bible, I would [still] not have believed

him)? It is an indication of counterexpectation, operative in a context where one would normally expect that if *p*, then not *q*. An even-qualified conditional counterindicates an otherwise natural expectation in the case at hand. Thus consider: "Even if they paid him a lot more, he would (still) be disaffected." Normally one would expect: "If they pay him a lot more, he will not be disaffected." Or again consider:

Even if you were the last man on earth, I (still) wouldn't marry you.

Ordinarily one would expect a healthy young female to show some interest in partnering with the only available young male, but our conditional indicates a personal antipathy that demolishes this general expectation in the present case. (Note the role of "still" as a further reinforcement.)

On this basis, when there is an auxiliary power generator in place, it would be appropriate to say:

Even if the main cable breaks, electric power will still be available.

And an analogous situation arises in all cases of redundant causality and of fail-safe or backup provision, as per:

Even if the gunshot had not killed him that morning, the poison he had ingested at breakfast would have.

Even if assassin no. 1 had failed, assassin no. 2 would have done him in.

On the other hand, consider a counterfactual conditional on the order of:

Even if Caesar had not crossed the Rubicon, Washington might still have crossed the Delaware.

Here we have a counterfactual conditional whose consequent is a possibility and whose antecedent concerns a fact that is substantially independent of it. Such conditionals are invariably tenable—albeit not very informative, since the antecedent does little real work.

Only If

"Only if *p* then *q*" generally implies "If *q* then *p*." Thus

Only if one is in New England will one be in Vermont

will imply

If one is in Vermont, then one will be in New England.

However, there are exceptions to this rule. Thus,

Only if he swears to it will she believe what he says

does not unproblematically imply

If she believes what he says then he swears to it.[6]

For it is a tacit aspect of that original conditional that its "only if" clause bears the unspoken qualifier "among the things she does not otherwise accept but regarding what relies entirely on his say-so." But this tacit qualification does not automatically accompany the second conditional.

If Only
An if-only conditional on the order of

If only he had known that the assassins were lying in wait, he would have avoided going there

comes to much the same thing without the "only," whose sole role here is one of stylistic emphasis on the positive aspect of the consequent. Thus consider a statement on the order of:

If only he had explained, she would have forgiven him.

This conjoins an ordinary if-then conditional with an evaluative indication that realization of the consequent is a good thing. A paradigm instance of this sort of thing is:

If only he would give up drinking, he would be a far happier person.

This example shows that if-only conditionals need not be counterfactual. They can be anticipatory with an aura of qualified hopefulness.

If and Only If (IFF)
A conditional of the format "Iff p, then q," comes to: If p then q, and if q then p. This is generally called a *biconditional* because its conditionality runs both ways. What is generally at issue is the formulation of a necessary and sufficient condition as per:

If and only if he studies will he pass the examination.

In ordinary usage, "if" is often employed to mean "if and only if" (iff). When the gatekeeper says "You may enter if you have a ticket," his stipulation is meant to convey not just an if but also an only if.[7]

As If

Consider the conditional: *p* as if *q* ("He greeted her cordially [*p*] as if—or 'just as if' or 'as though'—they had not quarreled [*q*]"). This is a close cousin of the "even if" locution. We effectively have a combination of an ordinary conditional with an index of present-case violation:

Ordinarily: If *p*, then *q* (and thereby: If not *q*, then not *p*).

In the present case: *p*, despite not *q*.

Thus the case at hand runs against the general rule, by way of exception. Consider, for instance: "He threw his weight about, as if he were the top dog," combines

If he were not the top dog, then (ordinarily) he would not throw his weight about

with

In the present case: he threw his weight about even though he was not the top dog.

The as-if locution marks the present case as an exception to the situation usually prevailing with the conditional relationship at issue.[8]

Provided That and Unless

Some theorists maintain that "provided that" encodes not just a conditional but a biconditional.[9] This seems doubtful. Thus suppose that Tuesdays and Thursdays are market days. You and I now discuss whether the market is open today, being in agreement that it is either Thursday or Friday, but disagreeing as to which. In the circumstances you would unproblematically say: "The market is open, provided it is Thursday." But if you were to say "The market is open if, but only if it is Thursday" your statement would seem to deny (erroneously) that Tuesday is also a market day. Here the two assertions are not equivalent.

And the same goes for "unless," theorists to the contrary not withstanding.[10] In saying

You won't pass the exam unless you study,

I am effectively claiming

If you don't study, then you won't pass.

But I am offering no definite assurance that if you do study you will pass. It is a necessary but not necessarily sufficient condition that is at issue.

In general, it should be remarked that accepting "If p, then q" is something very different from accepting "q on condition that p" or accepting "q provided that p." Conditional or provisional acceptance is a matter of

(1) $p \Rightarrow$ to accept q (here "$\ldots \Rightarrow \underline{\quad}$" is to be read as "If $\ldots$, then $\underline{\quad}$")

and not

(2)   to accept $(p \Rightarrow q)$.

For with (2) we do actually accept something here and now, namely, that a certain implicative relationship ($\Rightarrow$) holds between p and q. With (1) by contrast we do no more than to indicate the acceptability of something (viz., q) if and when a certain condition (viz., p) is realized—which may well never occur.

These considerations do not, however, gainsay the fact that "unless" and "provided that" are frequently used in the sense of "if and only if." The long and short of it is that "unless" and "provided that" admit of different constructions in different situations.[11]

5   Uses of Conditionals

Often conditionals are used even for straightforwardly factual reportage. Thus to say that the town hall is three blocks ahead and one to the left one could offer the conditional:

If you go three blocks ahead and one to the left you will be at the town hall.

The fact is that whatever information can be conveyed in a declarative statement can be formulated in conditional form as well. Thus consider a statement p—or equivalently "p is true." Observe that precisely the same information is conveyed by the conditional:

If you answer "yes," then you are [or: *will be*] giving the correct reply to the question: "Is p true or not?"

There is no difference in informative content here: what difference there is is purely stylistic. Of course, this very fact shows that the aspect of conditionality is quite inessential in this particular case and provides merely a stylistic variation.

Disposition statements are always tantamount to conditional if-thens. ("Glass is fragile" amounts to "If glass is subjected to a shock, it will break"; "Wood is combustible" comes to "If wood is exposed to fire, it will burn"; and so on.) And many statements have conditional implications and involvements. "I must meet him lest he complain" implies "If I don't greet him, then he will complain." All sorts of capacities and capabilities are conveyed by if-then statements. "He knows how to do that sum" comes to "If you ask him to do that sum, he will provide the correct answers." "If one plays chess with him he will acquit himself ably" comes to "He plays chess well." Moreover, all sorts of conditional implications are inherent in the fact that qualifying as something of a given kind inheres in keeping true to type. If it does not look like a duck, waddle like a duck, and quack like a duck, we would be reluctant to call it one.

Conditionals are especially prominent in causal contexts, and conditional and causal talk are often interconnected. However, it is important to note in this connection that "p because q" admits of two constructions: the rationalizing and the causal. Some examples help to clarify this.

Rationalizing (Rational Explanation)

He is in France because he is in Paris.

$X > 3$ because $X > 4$.

In such a case it is not that being in Paris *causes* being in France or that being greater than four *causes* being greater than 3. It is rather that our entitlement to say the one thing provides for an intellect to say the other.

The stipulative use of conditionalization proceeds on the order of "If you do the work, I'll pay you" or "If he goes, we shall join him." The causal type has such instances as "If the match is struck, it will light." The performatory type involves performance conditions and includes conditional orders, promises, intentions, and the like. ("I'll do it, if he orders me to.") The inferential type maintains implicational consequences. ("If people are in Paris, then they are in France.") Evidential conditionals have such instances as "If that's what he said, then he must have been thinking about her."

In sum, conditional statements are ubiquitous and serve a wide variety of communicative functions:

Conjecture   If there were life on other planets, it might be scientifically more advanced than we.

Explanation   If he left, she must have been arguing with him.

Causality   If cancer could be cured, life expectancy would increase enormously.

Process description   When that switch is closed, the light goes on.

Planning   If tomorrow is a nice day, we'll go on a picnic.

Intention avowal   If I remember it, I will greet him by name.

Habits and dispositions   If addressed in the early morning, he was curt.

Instruction   If you want to start the engine, just turn the key.

Control   If that handle is turned clockwise, water will flow from the spigot.

Promises   If you require the money, I'll pay it back to you.

Contracts   I'll do *A* if (and only if) you'll do *B*.

Excuses   If only I had known how sensitive he is, I would never have said that.

Restrictive requirements   "If a child attends, it must be accompanied by a parent" reformulates "Children who attend must be accompanied by parents"; "If a building has not passed inspection, then it cannot be insured" comes to "Only buildings that have passed inspection can be insured."

Threats   If you do that, we'll make sure that you do no more business in this town.[12]

Negotiation   Only if you do *A* will we do *B*.

As even so brief and incomplete a survey indicates, conditionals are an enormously versatile resource.

What would be lost by doing without conditionals—and so without hypothetical reasoning at large? The very question is an exercise in self-illustration. We would be unable to speculate, to plan, to make inference, and in general to achieve a vast variety of communicative functions. The limits of our thought would contract to the limits of our factual knowledge, confined to what we accept as matters of real truth. Speculation, conjecture, fiction would all be outside our repertoire. Even science itself, which standardly proceeds by way of hypotheses and thought experiments, would become incapacitated. Without the use of conditionals speculative thought would be infeasible: we could not deal efficiently with questions of "what-when?" if the resources of "what-if?" were not at our disposal.