Part II

SYMBOLIC LOGIC AND ORDINARY LANGUAGE

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Language, Logic, and Form

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Despite their diversity, natural languages have many fundamental features in common. From the perspective of Universal Grammar (see, e.g., Chomsky 1986), such languages as English, Navajo, Japanese, Swahili, and Turkish are far more similar to one another than they are to the formal languages of logic. Most obviously, natural language expressions fall into lexical categories (parts of speech) that do not correspond to the categories of logical notation, and some of them have affixes, including prefixes, suffixes, and markings for tense, aspect, number, gender, and case. Moreover, logical formalisms have features that languages lack, such as the overt presence of variables and the use of parentheses to set off constituents. The conditions on well-formed formulas in logic (WFFs) are far simpler than those on well-formed (grammatical) sentences of natural languages, and the rules for interpreting WFFs are far simpler than those for interpreting grammatical sentences. Compare any book on syntax and any book on formal logic and you will find many further differences between natural languages and formal languages. There are too many approaches to the syntax of natural languages to document these differences in detail. Fortunately, we will be able to discuss particular examples and some general issues without assuming any particular syntactic framework.

We will focus mainly on logically significant expressions (in English), such as 'and,' 'or,' 'if,' 'some,' and 'all' and consider to what extent their semantics is captured by the logical behavior of their formal counterparts, '&' (or '$\wedge$'), '$\vee$,' '$\supset$' (or '$\rightarrow$'), '$\exists$,' and '$\forall$.' Rendering 'if' as the material conditional '$\supset$' is notoriously problematic, but, as we shall see, there are problems with the others as well. In many cases, however, the problems are more apparent than real. To see this, we will need to take into account the fact that there is a pragmatic dimension to natural language.

Sentences of English, as opposed to (interpreted) formulas of logic, not only have semantic contents but also are produced and perceived by speakers (or writers) and listeners (or readers) in concrete communicative contexts. To be sure, logical formulas are also produced and perceived by particular people, but nothing hangs on the fact that they are so produced and perceived. In ordinary speech (or writing), it is not just what a sentence means but the fact that someone utters (or writes) it plays a role in determining what its utterance conveys (Bach 1999a). So, for example, there is a difference between what is likely to be conveyed by utterances of (1) and (2),

(1) Abe felt lousy and ate some chicken soup.
(2) Abe ate some chicken soup and felt lousy.

and the difference is due to the order of the conjuncts. Yet 'and' is standardly symbolized by the conjunction '&,' and in logic the order of conjuncts doesn't matter. However, it is arguable that (1) and (2) have the same semantic content and that it is the fact that the conjuncts are *uttered* in a certain order, not the meaning of 'and,' that explains the difference in how the utterances are likely to be taken.

One recurrent question in our discussion is to what extent rendering natural language sentences into logical notation exhibits the logical forms of those sentences. In addressing this question, we will need to observe a distinction that is often overlooked. It is one thing for a sentence to be rendered into a logical formula and quite another for the sentence itself to have a certain logical form. When philosophers refer to the logical form of a sentence, often all they mean is the form of the (interpreted) logical or semi-logical formula used to paraphrase it, often for some ulterior philosophical purpose, for example to avoid any undesirable ontological commitments (see Quine 1960) or to reveal the supposedly true structure of the proposition it expresses. A logical paraphrase of a natural language sentence does not necessarily reveal inherent properties of the sentence itself. However, as linguists construe logical form, it is a level of syntactic structure, the level that provides the input to semantic interpretation. The logical form of a sentence is a property of the sentence itself, not just of the proposition it expresses or of the formula used to symbolize it.

The difference is evident if we consider a couple of simple sentences and how they are standardly symbolized:

(3) There are quarks.
(4) Some quarks are strange.

In first-order predicate logic (3) and (4) would be symbolized as (3_{PL}) and (4_{PL}):

(3_{PL}) $(\exists x)\ Qx$
(4_{PL}) $(\exists x)\ (Qx\ \&\ Sx)$

Whereas (3) expresses an existential proposition and (4) apparently does not, both sentences are symbolized by means of formulas containing an existential quantifier. Not only that, there appears to be nothing in (4) corresponding to the conjunction ('&') in (4_{PL}). These discrepancies do not, however, deter many philosophers and logic texts from proclaiming that a formula like (4_{PL}) captures the logical form of a sentence like (3). Obviously they are not referring to logical form as a level of syntactic structure.

1 Sentential Connectives

In the propositional calculus, the words 'and' and 'or' are commonly rendered as truth-functional, binary sentential connectives. 'S_1 and S_2' is symbolized as 'p & q,' true iff 'p' is true and 'q' is true, and 'S_1 or S_2' as '$p \vee q$,' true iff 'p' is true or 'q' is true. There are two obvious difficulties with these renderings. For one thing, there is no limit to the number of clauses that 'and' and 'or' can connect (not that their usual truth-functional analysis cannot be extended accordingly). Moreover, 'and' and 'or' do not function exclusively as sentential connectives, for example as in (5) and (6):

(5) Laurel and Hardy lifted a piano.
(6) Abe wants lamb or halibut.

Clearly those sentences are not elliptical versions of these:

(5+) Laurel lifted a piano and Hardy lifted a piano.
(6+) Abe wants lamb or Abe wants halibut.

So the use of 'and' and 'or' as subsentential connectives cannot be reduced to their use as sentential connectives. It could be replied that this difficulty poses no problem for the standard truth-functional analysis of 'and' and 'or' when used as sentential connectives. However, such a reply implausibly suggests that these terms are ambiguous, with one meaning when functioning as sentential connectives and another meaning when connecting words or phrases. These connectives seem to have unitary meanings regardless of what they connect.

A further difficulty, perhaps of marginal significance, is that the truth-functional analysis of 'and' and 'or' does not seem to handle sentences like 'Give me your money and I won't hurt you' and 'Your money or your life,' or, more domestically:

(7) Mow the lawn and I'll double your allowance.
(8) Mow the lawn or you won't get your allowance.

It might seem that these sentences involve a promissory use of 'and' and a threatening use of 'or.' But that's not accurate, because there are similar cases that do not involve promises or threats:

(9) George Jr. mows the lawn and George Sr. will double his allowance.
(10) George Jr. mows the lawn or he won't get his allowance.

Here the speaker is just a bystander. The 'and' in (9) seems to have the force of a conditional, that is 'If George Jr. mows the lawn, George Sr. will double his allowance.' This makes the 'and' in (9) weaker than the ordinary 'and.' And the 'or' in (10) has the force of a conditional with the antecedent negated, that is 'if George Jr. does not mow the lawn, he won't get his allowance.'

If we can put these difficulties aside, although they may not be as superficial as they seem, the standard truth-functional analysis of 'and' and 'or' does seem plausible. Grice's (1989: ch. 2) theory of conversational implicature inspires the hypothesis that any counterintuitive features of this analysis can be explained away pragmatically.

'And'

As observed by Strawson (1952: 81) and many others since, the order of conjuncts seems to matter, even though the logical '&' is commutative: (p&q) ≡ (q&p). Although there is no significant difference between (11a) and (11b),

(11) a. Uzbekistan is in Asia and Uruguay is in South America.
b. Uruguay is in South America and Uzbekistan is in Asia.

there does seem to be a difference between (12a) and (12b):

(12) a. Carly got married and got pregnant.
b. Carly got pregnant and got married.

and between (13a) and (13b):

(13) a. Henry had sex and got infected.
b. Henry got infected and had sex.

However, it is arguable that any suggestion of temporal order or even causal connection, as in (13a), is not a part of the literal content of the sentence but is merely implicit in its utterance (Levinson 2000: 122–7). One strong indication of this is that such a suggestion may be explicitly canceled (Grice 1989: 39). One could utter any of the sentences in (12) or (13) and continue, 'but not in that order' without contradicting or taking back what one has just said. One would be merely canceling any suggestion, due to the order of presentation, that the two events occurred in that order.

However, it has been argued that passing Grice's cancelability test does not suffice to show the differences between the (a) and (b) sentences above is a not a matter of linguistic meaning. Cohen (1971) appealed to the fact that the difference is preserved when the conjunctions are embedded in the antecedent of a conditional:

(14) a. If Carly got married and got pregnant, her mother was thrilled.
b. If Carly got pregnant and got married, her mother was relieved.

(15) a. If Henry had sex and got infected, he needs a doctor.
b. If Henry got infected and had sex, he needs a lawyer.

Also, the difference is apparent when the two conjunctions are combined, as here:

(16) I'd rather get married and get pregnant than get pregnant and get married.

(17) It's better to have sex and get infected than to get infected and have sex.

However, these examples do not show that the relevant differences are a matter of linguistic meaning. A simpler hypothesis, one that does not ascribe multiple meanings to 'and,' is that these examples, like the simpler ones in (12) and (13), are instances of the widespread phenomenon of conversational impliciture (Bach 1994), as opposed to Grice's implic-a-ture, in which what the speaker means is an implicitly qualified version of what he says. Here are versions of (14a) and (16) with the implicit 'then' made explicit:

(14a+) If Carly got married and *then* got pregnant, her mother was thrilled.
(16+) I'd rather get married and *then* get pregnant than get pregnant and *then* get married.

(14a) and (16) are likely to be uttered as if they included an implicit 'then,' and are likely to be taken as such. The speaker is exploiting Grice's (1989: 28) maxim of manner. Notice that if the contrasts in the pairs of conjunctions were a matter of linguistic meaning, then 'and' (and sentences containing it) would be semantically ambiguous. There would be a sequential 'and,' a causal 'and,' and a merely truth-functional 'and,' as in (11). Each of our examples would be multiply ambiguous and would require disambiguation. (13b), for example, would have a causal reading, even if that is not the one likely to be intended. An additional meaning of 'and' would have to be posited to account for cases like (18):

(18) He was five minutes late and he got fired?

where what is questioned is only the second conjunct. The pragmatic approach, which assimilates these cases to the general phenomenon of meaning something more specific than what one's words mean, treats 'and' as unambiguously truth-functional and supposes that speakers intend, and hearers take them to intend, an implicit 'then' or 'as a result' or something else, as the case may be, to be understood along with what is said explicitly.

'Or'

Even though it is often supposed that there is both an inclusive 'or' and an exclusive 'or' in English, in the propositional calculus 'or' is symbolized as the inclusive '∨.' A disjunction is true just in case at least one of its disjuncts is true. Of course, if there were an exclusive 'or' in English, it would also be truth-functional – an exclusive disjunction is true just in case exactly one of its disjuncts is true – but the simpler hypothesis is that the English 'or' is unambiguously inclusive, like '∨.' But does this comport with the following examples?

(19) Sam is in Cincinnati or he's is Toledo.
(20) Sam is in Cincinnati or Sally (his wife) will hire a lawyer.

An utterance of (19) is likely to be taken as exclusive. However, this is not a consequence of the presence of an exclusive 'or' but of the fact that one can't be in two places at once. Also, it might seem that there is an epistemic aspect to 'or,' for in uttering (19), the speaker is implying that she doesn't know whether Sam is in Cincinnati or Toledo. Surely, though, this implication is not due to the meaning of the word 'or' but rather to the presumption that the speaker is supplying as much relevant and reliable information as she has (see Grice 1989: ch. 2). The speaker wouldn't be contradicting herself if, preferring not to reveal Sam's exact whereabouts, she added, "I know where he is, but I can't tell you."

The case of (20) requires a different story. Here the order of the disjuncts matters, since an utterance of "Sally will hire a lawyer or Sam is in Cincinnati" would not be taken in the way that (20) is likely to be. Because the disjuncts in (20) are ostensibly unrelated, its utterance would be hard to explain unless they are actually connected somehow. In a suitable context, an utterance of (20) would likely be taken as if it contained 'else' after 'or,' that is as a conditional of sorts. That is, the speaker means that if Sam is *not* in Cincinnati, Sally will hire a lawyer, and might be implicating further that the reason Sally will hire a lawyer is that she suspects Sam is really seeing his girlfriend in Toledo. The reason that order matters in this case is not that 'or' does not mean inclusive disjunction but that in (20) it is intended as elliptical for 'or else,' which is not symmetrical.

One indication that 'or' is univocally inclusive is that it is never contradictory to add 'but not both' to the utterance of a disjunction, as in (21),

(21) You can have cake or cookies but not both.

However, it might be argued that 'or' cannot be inclusive, or at least not exclusively so, since there seems to be nothing redundant in saying,

(22) Max went to the store or the library, or perhaps both.

The obvious reply is that adding 'or perhaps both' serves to cancel any implication on the part of the speaker that only one of the disjuncts holds and to raise to salience the possibility that both hold.

'If'

Since the literature on conditionals is huge, they cannot be discussed in detail here. But we must reckon with the fact – nothing is more puzzling to beginning logic students than this – that on the rendering of 'if S_1, then S_2' as '$p \supset q$,' a conditional is true just in case its antecedent is false or its consequent is true. This means that if the antecedent is false, it doesn't matter whether the consequent is true or false, and if the consequent is true, it doesn't matter whether the antecedent is true or false. Thus, both (23) and (24) count as true,

(23) If Madonna is a virgin, she has no children.
(24) If Madonna is a virgin, she has children.

and so do both (25) and (26),

(25) If Madonna is married, she has children.
(26) If Madonna is not married, she has children.

Apparently the basic problem with the material conditional analysis of 'if' sentences is that it imposes no constraint on the relationship between the proposition expressed by the antecedent and the one expressed by the consequent. On this analysis (27)–(30) are as true as (23)–(26),

(27) If Madonna is a virgin, she is a multi-millionaire.
(28) If Madonna is a virgin, she is not a multi-millionaire.
(29) If Madonna is married, she is a pop singer.
(30) If Madonna is not married, she is a pop singer.

This might suggest that 'if' sentences are not truth-functional (indeed, Edgington (1991) has argued that they are not even truth-valued).

However, it is arguable that the connection (what Strawson (1986) calls a "ground-consequent relation") between antecedent and consequent is not part of the conventional meaning of an 'if' sentence. Perhaps the implication of such a connection can be explained pragmatically. So suppose that an 'if' sentence is equivalent to a material conditional, '$p \supset q$,' true just in case either its antecedent is false or its consequent is true. It is thus equivalent to '$\neg p \vee q$.' Now as Strawson sketches the story, one would not utter a conditional if one could categorically assert the consequent or the negation of the antecedent. That would violate the presumption, to put it roughly, that a speaker makes as strong a relevantly informative statement as he has a basis for making. As we saw above, it would be misleading to assert a disjunction if you are in a position to assert a disjunct, unless you have independent reason for withholding it. In the present case, you wouldn't assert the equivalent of '$\neg p \vee q$' if you could either assert '$\neg p$' or assert 'q.' But then why assert the equivalent of '$\neg p \vee q$'? The only evident reason for this is that you're in a position to deny '$(p \& \neg q)$' – '$\neg(p \& \neg q)$' is equivalent to '$\neg p \vee q$' – on grounds that are independent of reasons for either asserting '$\neg p$' or asserting 'q.' And such grounds would involve a ground-consequent relation. So, for example, you wouldn't utter (23) if you could assert that Madonna is not a virgin or that she has no children. However, in the case of (31),

(31) If Madonna has many more children, she will retire by 2005.

where you're not in a position to deny the antecedent or categorically assert the consequent, you would assert it to indicate a ground-consequent relation between them.

Although Strawson's account is plausible so far as it goes, sometimes we have occasion for asserting a conditional without implicating any ground-consequent relation between its antecedent and consequent. Indeed, we may implicate the absence of such a relation. This happens, for example, when one conditional is asserted and then another is asserted with a contrary antecedent and the same consequent, as in the following dialogue:

Guest: The TV isn't working.
Host: If the TV isn't plugged in, it doesn't work.
Guest: The TV *is* plugged in.
Host: If the TV is plugged in, it doesn't work.

Clearly the host's second utterance does not implicate any ground-consequent relation. As the propositional calculus predicts, the host's two statements together entail that the TV doesn't work, period.

One last bit of support for the truth-functional account of conditionals comes from cases like "If you can lift that, I'm a monkey's uncle" or (32),

(32) If Saddam Hussein wins the Albert Schweitzer Humanitarian Award, Dr. Dre will win the Nobel Prize for medicine.

In such cases, the antecedent is obviously false, and the speaker is exploiting this fact. There is no entailment of a ground-consequent connection between the antecedent and consequent, and the speaker is not implicating any. Rather, he is implicating that the consequent is false, indeed preposterous.

One last point about conditionals is that sometimes they are used as if they were biconditionals (symbolized by '≡' rather than '⊃'). For example, it might be argued that 'if' can sometimes mean 'if and only if,' as in (33),

(33) If Harry works hard, he'll get promoted.

where there seems to be an implication that if Harry doesn't work hard, he won't get promoted, that is that he'll get promoted only if he works hard.

We have not addressed the case of so-called subjunctive or counterfactual conditionals (I say 'so-called' because, as Dudman (e.g. 1991) has repeatedly pointed out, they need not be either subjunctive or counterfactual). The conditions on their truth is a complex and controversial question (see the relevant essays in Jackson 1991), but clearly the following conditionals differ in content:

(34) a. If Oswald didn't shoot Kennedy, someone else did.
b. If Oswald hadn't shot Kennedy, someone else would have.

Whatever the explanation of the difference, presumably it is not due to any ambiguity in 'if' but to something else.

There are a great many sentential connectives that we will not consider, such as 'after,' 'although,' 'because,' 'before,' 'but,' 'consequently,' 'despite the fact that,' 'even though,' 'however,' 'inasmuch as,' 'nevertheless,' 'provided that,' 'since,' 'so,' 'therefore,' 'unless,' and 'until.' We cannot take them up here, but it is interesting to consider which ones are truth-functional and which are not.

2 Quantifiers and Quantified Noun Phrases

Only the existential and universal quantifiers are included in standard first-order predicate logic. The existential quantifier is commonly used to capture the logical properties of 'some' and 'a' and the universal quantifier those of 'every,' 'each,' and 'all' ('any' is a tricky case because it seems to function sometimes as a universal and sometimes as an existential quantifier). But there are differences between 'some' and 'a' and between 'every,' 'each,' and 'all' that are not captured by their formal symbolizations. For example, only 'some' and 'all' can combine with plural nouns. Also, 'some' but not 'a' can be used with mass terms, as in 'Max drank some milk' as opposed to 'Max drank a milk' ('Max drank a beer' is all right, but only because the mass term 'beer' is used here as a count noun, as in 'Max drank three beers'). But these differences are superficial as compared with two deeper difficulties with the symbolization of quantifiers in first-order predicate logic.

One difficulty was mentioned at the outset. A simple sentence like (4) is standardly symbolized with existential quantification, as in (4_{PL}):

(4) Some quarks are strange.
(4_{PL}) $(\exists x)(Qx \,\&\, Sx)$

The difficulty is that there is nothing in (4) corresponding to the connnective '&' in (4_{PL}) or to the two open sentences it conjoins. There is no constituent of (4_{PL}) that corresponds to the quantified noun phrase 'some quarks' in (4). The situation with universal quantification is similar, illustrated by the symbolization of a sentence like (35) as (35_{PL}):

(35) All fish are garish.
(35_{PL}) $(\forall x)(Fx \supset Gx)$

In fact, not only is there is nothing in (35) that corresponds to the connective '$\supset$' in (35_{PL}), but (35_{PL}) is true if there are no Fs, as with (36),

(36) All four-legged fish are gymnasts.

This is not a difficulty only if (36) is equivalent to (37),

(37) Anything that is a four-legged fish is a gymnast.

and intuitions differ on that. In standard predicate logic, universal sentences of the form 'All Fs are G' are true if there are no Fs, and, according to Russell's theory of descriptions, sentences of the form 'The F is G' are true if there is no unique F. Of course, one would not assert such a sentence if one believed there to be no F or no unique F, but logic need not concern itself with that. In any case, clearly the forms of (4_{PL}) and (35_{PL}) do not correspond to the grammatical forms of the sentences they symbolize.

These discrepancies might be thought to reveal a problem with English rather than with predicate logic. Indeed, Russell regarded it as a virtue of his theory of descriptions that the structure of the formal rendering of a description sentence does not mirror that of the sentence it symbolizes. A sentence like (38),

(38) The director of *Star Wars* is rich.

should not be symbolized with 'Rd,' where 'R' stands for 'is rich' and 'd' stands for 'the director of *Star Wars*,' but with the more complex but logically revealing (38_{PL}):

(38_{PL}) $(\exists x)(Dx \,\&\, (y)(Dy \supset (y = x) \,\&\, Rx)$

(This is not Russell's notation but one of several ways in modern predicate logic to render his analysis.) Whereas (38) has 'the director of *Star Wars*' as its grammatical subject and 'is rich' as its grammatical predicate, it is revealed by logical analysis not to be of subject-predicate logical form. Hence the grammatical form of a sentence like (38) is "misleading as to logical form," as Russell was paraphrased by Strawson (1952: 51). The definite description 'the director of *Star Wars*' does not correspond to any constituent of the proposition expressed by (38). Definite descriptions "disappear on analysis." The contribution they make to the propositions in which they occur is a complex quantificational structure of the sort contained in (38_{PL}).

Although Russell's theory of descriptions is often taken as the paradigm of how grammatical form can be misleading as to logical form, as we have seen, sentences like (4) and (35), when symbolized in the standard ways, seem to be examples of the same thing. However, it is arguable that this alleged misleadingness is entirely an artifact of the notation being used. Indeed, as Barwise and Cooper (1981) have shown, the notation of first-order logic is not adequate for symbolizing such quantificational expressions as 'most,' 'many,' 'several,' 'few.' And there are numerical quantifiers to contend with, like 'eleven' and 'a dozen,' and more complex quantificational expressions, such as 'all but one,' 'three or four,' 'fewer than ten,' 'between ten and twenty,' 'at most ninety-nine,' and 'infinitely many.' The notation of restricted quantification can uniformly handle this rich diversity of locutions (see Neale (1990: 41ff.) for a clear explanation of how restricted quantification works). Not only that, it does so in a way that respects the structural integrity of the quantified noun phrases that it symbolizes. So, for example, the sentences in (39) may be symbolized by the corresponding formulas in (39_{RQ}), where for simplicity the predicates are symbolized with predicate letters:

(39) a. Most baseball players like golf.
b. Many philosophers like wine.
c. Few pro-lifers support gun control.
d. Eleven jurors voted guilty.

(39_{RQ}) a. [Most x: Bx] Gx
b. [Many x: Px] Wx
c. [Few x: Lx] Cx
d. [Eleven x: Jx] Gx

Restricted quantification notation thus avoids first-order logic's "notorious mismatch between the syntax of noun phrases of natural languages like English and their usual representations in traditional predicate logic" (Barwise and Cooper 1981: 165), and instead symbolizes constituents with constituents, thus facilitating a more straightforward compositional semantics. In particular, it does not separate quantifiers from their nominal complements. As a result, it removes any suggestion that grammatical form is misleading as to logical form. This holds even for definite descriptions, which do not disappear on the restricted quantification analysis.

The terms 'only' and 'even' pose some special problems. What propositions are expressed by (40) and (41)?

(40) Only Ernie eats turnips.
(41) Even Ernie eats turnips.

(41) seems to entail that Ernie is not the sole individual who eats turnips, even though there is no explicit indication who the other people are, much less an explicit quantification over the group in question. (41) seems to say, in effect, that Ernie eats turnips and that, of an unspecified group of people who eat turnips, Ernie is the least likely to do so. Exactly what it says is a matter of some debate (see, e.g., Kay 1990, and Francescotti 1995), but even if the paraphrase is correct, it is not obvious how to render that into the notation of first-order logic or even restricted quantification. Even if it could be so rendered, such a symbolization would have to contain structure that is not present, or at least not evident, in (41) itself.

Let us focus on the somewhat simpler case of 'only.' Offhand, (40) seems to express the proposition that Ernie and no one (in the contextually relevant group) other than Ernie eats turnips. In first-order predicate logic, this can be rendered as (40_{PL}):

(40_{PL}) $Te \ \& \ (\forall x)(x \neq e \supset \neg Tx)$

Like (40), (40_{PL}) entails both that Ernie eats turnips and that no one else does. A logically equivalent but distinct rendering of (40) is ($40'_{PL}$),

($40'_{PL}$) $Te \ \& \ (\forall x)(Tx \supset x = e)$

which says that Ernie eats turnips and anyone who does is Ernie. There has been a debate in the literature about whether this is entirely accurate (see Horn (1996) and references there), but the relevant question here concerns the relationship between (40) and the first-order formula used to symbolize it. Both (40_{PL}) and ($40'_{PL}$) contain elements of structure that are not present, at least not obviously so, in (40). This can be avoided somewhat if we render the second conjuncts of (40_{PL}) and ($40'_{PL}$) in restricted quantificational notation. Then (40_{PL}) becomes (40_{RQ}) and ($40'_{PL}$) becomes ($40'_{RQ}$).

(40_{RQ}) $Te \ \& \ [\text{every } x: x \neq e] \ \neg Tx$
($40'_{RQ}$) $Te \ \& \ [\text{every } x: Tx] \ x = e$

But still there are elements not ostensibly present in (40): conjunction, a universal quantifier, an identity sign, and, in the case of (40_{RQ}), a negation sign. We can eliminate most of these elements and the structure they require if we treat 'only' as itself a quantifier,

($40''_{RQ}$) $[\text{Only } x: x = e] \ Tx$

Here the proper name 'Ernie' is treated as a nominal that combines (together with a variable and an identity sign) with a quantifier to yield a quantified noun phrase.

There is a further problem posed by 'only.' Consider (42):

(42) Only Bernie loves his mother.

What is the property that no one else (in the contextually relevant group) possesses? On one reading of (42), it is the property of loving Bernie's mother; on another, it is the property of loving some contextually relevant male's mother). These two readings may be represented with the help of indices.

(42) a. Only Bernie$_1$ loves his$_1$ mother.
b. Only Bernie$_1$ loves his$_2$ mother.

But there is a third, reflexive reading of (42), on which the property in question is that of loving one's own mother (for discussion of different approaches to reflexivity, see Salmon 1992). There is no obvious way to use indices to reflect that (the indices in (42) cover the options), but restricted quantificational notation can do the trick:

(42) c. [Only x: x = b] (x loves x's mother).

Notice that, as in ($40_{RQ''}$) above, 'only' is treated here as a quantifier and the proper name as a nominal that combines with the quantifier to yield a quantified noun phrase.

3 Proper Names and Individual Constants

It is customary in logic to use individual constants to symbolize proper names, and to assign only one such constant to a given individual. Doing so obliterates semantic differences between co-referring proper names. It implicitly treats names as essentially Millian, as contributing only their bearers to the semantic contents of sentences in which they occur. From a logical point of view there is no difference between the propositions expressed by (43) and (44),

(43) Queen Noor skis.
(44) Lisa Halaby skis.

since Queen Noor is Lisa Halaby. They could be symbolized as 'Sn' and 'Sh' respectively, but this would not exhibit any semantic difference, given that n = h. It might seem that there is no such difference, insofar as co-referring names may be substituted for one another without affecting truth value, but such substitution does seem to affect propositional content. As Frege (1892) pointed out, a sentence like (45) seems to be informative in a way that (46) is not:

(45) Queen Noor is Lisa Halaby.
(46) Queen Noor is Queen Noor.

Millianism, which provides the rationale for symbolizing proper names as individual constants, must deny that there is any difference in propositional content between (45) and (46), even if it concedes a cognitive, but non-semantic, difference between them, or between (43) and (44). However, replacing a name with a co-referring one does seem to affect both truth value and propositional content in the context of attitude ascriptions:

(47) Prince Rainier believes that Queen Noor skis.
(48) Prince Rainier believes that Lisa Halaby skis.

It seems that (47) might be true while (48) is false and that they have different contents, since they ascribe to Prince Rainier belief in two different things. Millians must reject this, and explain away the appearance of substitution failure as based on some sort of pragmatic or psychological confusion (see Salmon 1986; Braun 1998; Soames 2001), but many philosophers find such explanations, however ingenious, to be implausible (see Bach 2000).

A further problem for Millianism is posed by existential sentences containing proper names. If the contribution that a proper name makes to sentences in which it occurs is its referent (if it has one) and nothing else, then how are sentences like the following to be understood or symbolized?

(49) Bigfoot does not exist.
(50) Sting exists.

As first remarked by Kant, existence is not a property and 'exists' is not a predicate. Bigfoot is not a creature which lacks a property, existence, that Sting possesses. That is why sentences like (49) and (50) are ordinarily not symbolized as '¬Eb' and 'Ep.' But what is the alternative? In first-order predicate logic, there is no straightforward way to symbolize such sentences, since 'exists' is symbolized by the existential quantifier, not by a predicate, and combines with open sentences, not individual constants. A common trick for symbolizing sentences like (49) and (50) is with identity, as in (49_{PL}) and (50_{PL}):

(49_{PL}) $\neg(\exists x)\ x = b$
(50_{PL}) $(\exists x)\ x = s$

However, (49) and (50) do not seem to contain anything corresponding to the variable-binding existential quantifier '∃x' or to the identity sign '='. It is not evident from their grammatical form that (49) says that nothing is identical to Bigfoot and that (50) says that something is identical to Sting.

In any case, in claiming that the meaning of a proper name is its referent, Millianism has the unfortunate implication that a sentence like (49), which contains a name that lacks a referent, is not fully meaningful but is nevertheless true. And if the meaning of a proper name is its referent, then (50) presupposes the very proposition it asserts; indeed, its meaningfulness depends on its truth.

The case of non-referring names has an important consequence for logic. In standard first-order logic, individual constants are assumed to refer, so that, by existential generalization, 'Fa' entails '(∃x)Fx.' This assumption conflicts with the fact that some proper names do not refer. So-called free logics, which do not take existential generalization as axiomatic, have been devised to accommodate empty names. However, adopting a free logic does not help explain how different empty names, like 'Bigfoot' and 'Pegasus,' can differ semantically. It provides no explanation for the difference in content between (49) and (51),

(51) Pegasus does not exist.

Leaving aside the common controversies about proper names, consider uses of proper names that tend to be overlooked by philosophers and logicians. For example, names can be used as predicates (Lockwood 1975). Also, they can be pluralized and combined with quantifiers as in (52),

(52) Many Kennedys have died tragically.

This conflicts the treatment of proper names as individual constants or logically singular terms, and suggests that proper names are more like other nominals than is commonly supposed. In syntax, it is common to treat nominals as constituents of noun phrases, which included a position for a determiner as well, as in 'a man,' 'few tigers,' 'all reptiles,' and 'some water.' And note that in some languages, such as Italian and German, names are often used with definite articles.

A further complication is that proper names seem to function as variable binders. To see this, notice that in the following two sentences,

(53) Marvin$_1$ hates his$_1$ supervisor.
(54) Every employee$_1$ hates his$_1$ supervisor.

the relation between the pronoun and the noun phrase that syntactically binds it appears to be the same. It is sometimes suggested that the pronoun 'his$_1$' is an anaphor when bound by a singular referring expression, such as a proper name, and is a variable when bound by a quantificational phrase. However, it is difficult to see what the relevant difference here could be. Notice further that there are readings of (55) and (56) in which the pronoun functions as a bound variable:

(55) Marvin and every other employee hates his supervisor
(56) Only Marvin hates his supervisor.

Against the suggestion that a proper name is a variable binder it could be argued, I suppose, that in (55) and (56) it is the phrase in which the proper name occurs that binds the pronoun, but consider the following example, involving ellipsis:

(57) Marvin hates his supervisor, and so does every other employee.

If the pronoun is not a bound variable, then (57) could only mean that every other employee hates Marvin's supervisor. It could not have a reading on which it says that every other employee hates his respective supervisor.

4 Adjectives

When a noun is modified by a adjective, it is customary to symbolize this by means of conjunction. A sentence like (58) is standardly symbolized by (58_{PL}) or in restricted quantifier notation by (58_{RQ}):

(58) Enzo has a red car.
(58_{PL}) (∃x)(Hex & (Rx & Cx)
(58_{RQ}) [an x: Rx & Cx] Hex

Leaving aside the difference between (58_{PL}) and (58_{RQ}), notice that they both render the modification as predicate conjunction. In effect, something is a red car just in case it is a car and it is red. Intuitively, however, it seems that the modification restricts the sort of thing in question. That is, just as 'car' applies to cars, so 'red car' applies to those cars that are red. (58_{PL}) and (58_{RQ}) do not quite capture this.

Even so, using conjunction to adjectival modification does seem to explain why (59) entails (60),

(59) Garfield is a fat cat.
(60) Garfield is a cat.

where 'Garfield' is the name of a child's pet. As (59_{PL}) and (60_{PL}) represent these sentences,

(59_{PL}) Fg & Cg
(60_{PL}) Cg

the entailment is from conjunction to conjunct, and that is a formal entailment. However, there is a problem here, as illustrated by (61) and (62),

(61) Springfield is a plastic cat.
(62) Springfield is a cat.

where 'Springfield' is the name of a child's toy. (61) does not entail (62), since plastic cats aren't cats. Whether or not (59_{PL}) is the best way to symbolize (59), surely (61_{PL}),

(61_{PL}) Ps & Cs

is not even a good way to symbolize (61). Plastic cats are not cats that are plastic (just as counterfeit money is not money). Notice, however, that when 'plastic' modifies, say, 'hat,' the resulting phrase applies to a subcategory of hats. So sometimes the entailment from 'x is a plastic K' to 'x is a K' holds, and sometimes it does not. This shows that when the entailment does hold, it is not a formal entailment, and not explained by logic alone. (For further discussion of these and other issues involving adjectives, see Partee 1995.)

5 Adverbs and Events

Consider the fact that (63) entails (64) and (65):

(63) Jack is touching Jill gently with a feather.
(64) Jack is touching Jill gently.
(65) Jack is touching Jill.

Standard symbolizations of these sentences make these entailments problematic, because 'touch gently' is treated is a distinct predicate from 'touch' and whereas in (63) the predicate is treated as three-place predicate, in (64) and (65) it represented as two-place. Then these sentences come out (semi-formalized) as:

(63′) Touch gently (Jack, Jill, a feather)
(64′) Touch gently (Jack, Jill)
(65′) Touch (Jack, Jill)

Special meaning postulates are needed to account for the entailments. It needs to be assumed that to touch someone with something is to touch someone and that to touch someone gently is to touch someone. Davidson (1967) suggested that such entailments can best be explained on the supposition that sentences containing action verbs (or other verbs implying change) involve implicit quantification to events. Then these sentences can be symbolized as:

(63_e) $\exists e$(Touching(Jack, Jill, e) & Gentle(e) & With(a feather, e).
(64_e) $\exists e$(Touching(Jack, Jill, e) & Gentle(e)).
(65_e) $\exists e$(Touching(Jack, Jill, e).

Given these symbolizations, (64) and (65) are formal entailments of (63).

Implicit event quantification also helps handle what Lewis (1975) calls adverbs of quantification, such as 'always,' 'never,' 'often,' 'rarely,' 'sometimes,' and 'usually.' For example, (66) can be symbolized as (66_e):

(66) Jack always touches Jill gently.
(66_e) $\forall e$(Touching(Jack, Jill, e) & Gentle(e)).

Despite the perspicuousness of this symbolization and the explanatory value of the previous ones, they all seem to suffer from a familiar problem: they introduce structure that does not seem to be present in the sentences they purport to symbolize. However, Parsons (1990) and Higginbotham (2000) have offered various reasons for supposing that this problem is not genuine.

6 Utterance Modifiers

There are certain expressions that do not contribute to the propositional contents of the sentences in which they occur and thus fall outside the scope of logical symbolization. I don't mean interjections like 'Oh' and 'Ah' but a wide range of expressions that may be called 'utterance modifiers.' These locutions, like 'moreover,' 'in other words,' and 'now that you mention it,' are used to comment on the main part of the utterance in which they occur, as in:

(67) *Moreover*, Bill is honest.
(68) *In other words*, Bill is a liar.
(69) New York is, *now that you mention it*, a great place to visit.

Such locutions are vehicles for the performance of second-order speech acts. Thus, for example, 'moreover' is used to indicate that the rest of the utterance adds to what was previously said, and 'in other words' indicates that the balance of the utterance will reformulate something just said.

Because of the second-order function of an utterance modifier, it is not semantically coordinate, though syntactically coordinate, with the rest of the sentence. If it is a connective, it is a *discourse* as opposed to a *content* connective. To appreciate the difference, compare the uses of 'although' in the following two utterances:

(70) *Although* he didn't do it, my client will plead guilty.
(71) *Although* I shouldn't tell you, my client will plead guilty.

In (70), the content of the main clause contrasts with the content of the subordinate clause. The use of 'although' indicates that there is some sort of clash between the two. In (71), on the other hand, there is no suggestion of any contrast between the client's pleading guilty and his lawyer's divulging it. Here the speaker (the lawyer) is using the 'although' clause to perform the second-order speech act of indicating that he shouldn't be performing the first-order speech act of revealing that his client will plead guilty.

There are a great many utterance modifiers, and I have catalogued and classified them elsewhere (Bach 1999b: sec. 5). They can pertain to the topic of conversation, the point of the utterance or its relation to what preceded, the manner of expression, or various other features of the utterance. To illustrate their diversity, here are a few more examples of them:

by the way, to sum up, in a nutshell, figuratively speaking, in a word, frankly, off the record, to be specific, by the same token, be that as it may

It should be understood that these locutions do not function exclusively as utterance modifiers. They function as such only when they occur at the beginning of a sentence or are otherwise set off. But when they do so function, they do not contribute to the primary propositional content of the sentence that contains them and therefore fall outside the scope of logical symbolization.

7 Logical Form as Grammatical Form

Ever since Frege, Russell, and the early Wittgenstein, many philosophers have thought that the structures of sentences of natural languages do not mirror the structures of the propositions they express. Whether their goal is to develop a language adequate to science, to avoid unwanted ontological commitments, to provide a framework for the analysis of propositions, or merely to adopt a notation that makes the logical powers (formal entailment relations) of sentences explicit and perspicuous, philosophers have generally not supposed that logical forms are intrinsic to natural language sentences themselves. They have supposed, as Russell did in the case of sentences containing definite descriptions, that grammatical form is often misleading as to logical form. From a linguistic point of view, however, logical form is a level of syntactic structure. The logical form of a sentence is a property of the sentence itself, not just of the proposition it expresses or of the formula used to symbolize it. From this perspective, it makes no sense to say that grammatical form is misleading as to logical form.

If logical form is a property of sentences themselves and not merely of the propositions they express or of the formulas used to symbolize them, it must be a level of grammatical form. It is that level which provides the input to semantic interpretation, the output of which consists of interpreted logical forms. This is on the supposition that natural language semantics is compositional, and that the semantics of a sentence is a projection of its syntax. Anything short of that puts the notion of logical form in a different light. If it is essentially a property of propositions, not sentences, or merely a property of logical formulas, then two structurally different sentences, or a sentence and a formula, can express the same proposition, in which case to say that a sentence has a certain logical form is just to say that it expresses a proposition of that form or can be symbolized by a formula with that form. If logical form is not a property of sentences themselves, any reference to the logical form of a sentence is just an elliptical way of talking about a property of the proposition it expresses or of the logical formula used to symbolize it.

There are various sorts of linguistic evidence for a syntactic level of logical form. Consider first the case of scope ambiguity, as in (72),

(72) Most boys love some girl.

Its two readings are captured in semi-English restricted quantifiers as follows,

(73) a. [most x: boy x] ([some y: girl y] (x loves y))
b. [some y: girl y] ([most x: boy x] (x loves y))

where the order of the quantifiers determines relative scope. Here it might be objected that this notation does not respect syntax because it moves the quantificational phrases to the front, leaving variables in the argument positions of the verb. However, as May (1985) explains, working within the syntactic framework of GB theory, such movement of quantificational phrases parallels the overt movement of wh-phrases in question formation, as in (74),

(74) [which x: girl x] (does Marvin love x)?

The transitive verb 'love' requires an object, and the variable marks the position from which the wh-phrase 'which girl' has moved. There are constraints on wh-movement, and these, in conjunction with other syntactic constraints, explain why, for example, (75a) and (75b) are grammatical and (75c) is not,

(75) a. Who does Jack believe helped Jill?
b. Who does Jack believe that Jill helped?
c. *Who does Jack believe that helped Jill?

why (76a) is ambiguous and (76b) is not,

(76) a. What did everyone see?
b. Who saw everything?

and why (77a) but not (77b) is possible with a co-referential interpretation,

(77) a. Who_1 saw his_1 dog?
b. *Who_1 did his_1 dog see?

May (1985) presents compelling arguments to show that what he calls "quantifier raising" (QR) can explain not only scope ambiguities but a variety of other phenomena. Of course, QR differs from wh-movement in that it is not overt, occurring only at the level of logical form (LF). Positing QR at LF explains the bound-variable interpretation of VP-ellipsis, as in (78),

(78) Cal loves his mother, and so do Hal and Sal.

on which Hal and Sal are being said to love their own mothers, not Cal's. It also explains the phenomenon of antecedent-contained deletion, illustrated by (79),

(79) Clara visited every town that Carla visited.

(79) would be subject to an interpretive regress unless it has, at the level of LF, something like the following form,

(80) [every x: (town that Carla visited) x] (Clara visited x)

which is clearly interpretable. The linguistic arguments based on data like these cannot be presented here, but suffice it to say that they all appeal to independently motivated principles to explain the phenomena in question. The syntactic level of logical form is supported by the same sorts of empirical and theoretical considerations that support other levels of grammatical representation.

8 Summary

There are many topics we haven't even touched on here (see Further reading), including negation, modalities, mass terms, plural quantifiers, quantificational adverbs, higher-order quantification, quantifier domain restriction, implicit arguments, pronouns and anaphora, prepositions, tense and aspect, context-dependence, vagueness, and semantic underdetermination (sentences that do not express complete propositions, even with context-sensitive references fixed). We have not examined the linguistic arguments for a syntactic level of logical form. Moreover, there are many different syntactic frameworks and, as later chapters explain, many different types of logic and various approaches to each. In short, there is an open-ended range of linguistic phenomena for a diversity of syntactic frameworks and logical theories to take into account. Even so, as suggested by the limited range of phenomena we have discussed, apparent divergences between the behavior of logically important expressions or constructions in natural languages and their logical counterparts are often much narrower than they seem. And where grammatical form appears misleading as to logical form, this appearance is often the result of limiting consideration to standard logic systems, such as first-order predicate logic, and failing to appreciate that insofar as logical form is a property of natural language sentences and not just a property of artificial forms used to symbolize them, logical form is a level of grammatical form.

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