ADVERBS AND MODAL OPERATORS*

George Lakoff

Phonetics Laboratory
University of Michigan

Second draft - December, 1970
Based on first draft of
August, 1970

*This work was partially supported by Grant NSF-2939 from the National Science Foundation to the University of Michigan. The author would like to thank Robert Stalnaker and Richmond Thomason for their comments.

A number of logicians, especially Montague, Parsons, and Thomason, have done linguists a considerable service in raising the question of the logical status of adverbs and in making concrete proposals. The most detailed claims have been made by Richmond Thomason in his "A Semantic Theory of Adverbs". I find Thomason's work extremely stimulating, and would like to make some comments on it.

Thomason's basic claim is that operators that map propositional functions into propositional functions are fundamentally different from modal operators and that they correspond roughly to surface structure adverbs in English. I say "roughly", since Thomason, by his own criteria, relegates adverbs such as reluctantly to the category of modal operators. Most likely, he and most others would agree that probably, possibly, certainly, necessarily, allegedly, admittedly, and many other so-called (by linguists) "sentence adverbs" are also modal operators. What Thomason has in mind are adverbs like slowly, rapidly, in the yard, with a hammer, at 10 o'clock, etc. Such a claim is of particular interest to me, since I have turned up grammatical evidence bearing on the question. [See Lakoff, 1965, 1970a, 1968, 1970b.] The small amount of grammatical evidence that we have, provided mostly by pronominalization evidence and selectional regularities, indicates that adverbs of manner, time, place, instrument, and comparison derive from underlying syntactic structures (i.e., logical forms) containing predicates that take complement constructions (i.e., modal operators in a second-order logic -- permitting variables over propositions and propositional functions). Thomason's paper is of particular interest to linguists, since it claims to provide logical criteria to distinguish adverbs (more precisely, nonsentence adverbs) from modal operators. In addition, Thomason claims that adverbs on the whole form a natural logical category -- operators that map propositional functions into propositional functions. If true, this would be very nice.

What follows are the results of a quick check of Thomason's criteria. I have made the following general findings:

I. Thomason, like Montague, Parsons, and others, is correct in claiming that natural language contains operators that map propositional functions into propositional functions. Let us call these "predicate modifiers".

II. Predicate modifiers (which are members of a logical category) sometimes show up in surface structures as what grammarians call "adverbs" (which are members of a surface grammatical category).

III. Predicate modifiers may also show up in surface structure as members of the surface grammatical categories "verb" and "adjective".

IV. Surface structure "adverbs" are often not members of the logical category of predicate modifiers, and are sometimes operators that map propositions into propositions, that is, modal operators.

V. Thomason uses the term "adverb" throughout his paper to mean "predicate modifier", which is confusing in the light of III and IV above. Thomason's claims as to the properties of "adverbs" are, I assume, to be taken either as claims as to the properties of all predicate modifiers, or at least those that show up in surface structure as adverbs.

VI. None of Thomason's proposed criteria characterize either (a) all and only the predicate modifiers or (b) all and only the predicate modifiers that show up in surface structure as adverbs.

VII. One of Thomason's criteria does, however, provide a one-way test. Those items that obey criterion F (see below) seem to be predicate modifiers that may show up in surface structure as surface adverbs.

VIII. With the exception of F, Thomason's criteria seem to characterize interesting subcategories of both modal operators and predicate modifiers. That is, there are predicate modifiers for which his criteria do not hold and modal operators for which they do hold. Such facts are deserving of much greater attention than I have been able to pay to them.

Thomason's criteria are as follows:

A. Adverbs [predicate modifiers do not take embedded negatives.
*John slowly didn't run.

B. Adverbs [predicate modifiers do not form referentially opaque contexts.

C. $f(p \wedge q) = f(p) \wedge f(q)$

D. $f(p \vee q) = f(p) \vee f(q)$

E. if $f(p)(d)(\alpha) = T$, then $p(d)(\alpha) = T$
if John walks slowly, then John walks.

F. $fg(p) = gf(p)$
John hit Harry in the yard with a hammer = John hit Harry with a hammer in the yard.

A. Many adverbs do not take embedded negatives, but this is a special case of a more general fact about those adverbs. Adverbs of manner, means, instrument, and some others may not modify stative predicates, but require nonstative (action or event) predicates. [See Lakoff, 1966.] Negatives act like stative predicates. Therefore, it follows that adverbs of manner, means, and instrument do not take negatives. However, the failure to take statives (and therefore negatives) is not unique to adverbs, but is also true of a large class of predicates that take sentential complements.

(1)*Sam kept not trying to leave.

(2)*Sam kept knowing that the earth was round.

Unfortunately, it is harder to check out this constraint for negatives than for other statives, since surface structure not in English may not only be a reflex of a simple negative, but in infinitival and gerundive complements, not may also be a reflex of the nonstative predicates refuse, avoid, and fail.

(3) a. Sam tried not to hit Harry.

b. Sam tried to avoid hitting Harry.

(4) a. Sam managed not to hit Harry.

b. Sam managed to fail to hit Harry.

(5) a. I forced Sam not to marry Sheila.

b. I forced Sam to refuse to marry Sheila.

In each case, the not in the (a) sentence is a surface structure reflex of the corresponding verb in the (b) sentence. Verbs like try and force generally do not take statives.

(6)*John tried to know that the earth is round.

(7)*I forced Irving to contain DNA molecules.

Nor do they take simple negatives -- when surface not occurs with such verbs, it can only be understood as a reflex of refuse, avoid, or fail.

While some adverbs do not occur with statives (and hence, negatives), others do.

(8) a.*With this hammer, Sam contained DNA molecules.

b.*With this hammer, Maxwell didn't hit Sam.

(9) a. Usually, Sam contains DNA molecules.

b. Usually, Sam doesn't wear a tie.

(10) a. In his garden, Irving is happy.

b. In his garden, Irving doesn't do any work.

(11) a. Because he ate shredded wheat all his life, Irving is now fat.

b. Because he is a hunchback, Irving didn't win the 60-yard dash.

Unlike manner, means, and instrumental adverbs, adverbs of time, place, and reason do permit statives and negatives. Thus we see that the ability to take statives and negatives does not distinguish adverbs from predicates that take sentential complements (modal operators).

B. Thomason is right in that many adverbs do not create referentially opaque contexts. However, there are many adverbs that do -- in particular, those adverbs that indicate someone's attitude toward clause being modified. Take the following contexts:

(1) a. Oedipus _____ married Jocasta.

b. Oedipus _____ married his mother.

If the following manner adverbs expressing the subject's attitude are substituted for the blank in (1), we get referential opacity, that is, one of the above sentences can be false and the other true: resignedly, calmly, nonchalantly, dejectedly, willingly, earnestly, glumly, readily, gladly, enthusiastically, disinterestedly, and dozens of others. Similarly, there are adverbs that express someone else's attitude toward an event. Suppose we have a situation where a king fights and kills gladiators to the delight of his subjects. One day the prince (his only son) dresses up as a gladiator.

(2) a. The king _____ killed the gladiator.

b. The king _____ killed the prince.

Substituting in the following adverbs, we create opaque contexts: charmingly, engagingly, amusingly, appealingly, appalingly, bewilderingly, shockingly, cheeringly, and many others. Adverbs like often and seldom, carefully and carelessly (what is careful for a plumber may not be careful for a brain surgeon), and a very large number of other adverbs work in the same way. Thomason's claim holds only for adverbs that are independent of anyone's attitude, judgement, or expectations. Thus, some adverbs create opaque contexts, while other do not -- just like modal operators. ("It is true that" is a modal operator that does not create opaque contexts.)

C. Consider the following cases:

(1) a. In a short time, John ate a hotdog, drank a beer, and smoked a joint.

b. In a short time John ate a hotdog, and in a short time John drank a beer, and in a short time John smoked a joint.

If (1a) is true, then (1b) is true, but not vice versa. If each of the things John did took a short time, it does not follow that all of them together did. Thus, if f = in a short time, it is not true that $f(p \wedge q) = f(p) \wedge f(q)$. It is, however, the case that $f(p \wedge q) \supset f(p) \wedge f(q)$. Now consider (2).

(2) a. John slowly ate a hotdog, drank a beer, and smoked a joint.

b. John slowly ate a hotdog, slowly drank a beer, and slowly smoked a joint.

If (2b) is true, then (2a) is, but not vice versa. He may have done each of them quickly, but may have been slow in doing all of them together. If f = slowly, it is again not true that $f(p \wedge q) = f(p) \wedge f(q)$, though it is true that $f(p) \wedge f(q) \supset f(p \wedge q)$.

There are still other cases where the implication does not work in either direction. Take easily, for example.

(3) a. John easily ate 100 pretzels and drank a gallon of beer.

b. John easily ate 100 pretzels and John easily drank a gallon of beer.

(3a) does not entail (3b); for example, in the event that John can only drink a lot of beer easily if he is also eating pretzels and if he can only eat a lot of pretzels easily if he is also drinking beer. Similarly, (3b) does not entail (3a), as when John can easily eat a lot of pretzels when he's not drinking, and can easily drink a lot of beer when he's not eating. Such cases should make it clear that C does not in general characterize the class of adverbs.

It should be noted that the same is true of modal operators. Take want, for example.

(4) a. Sally wants to live in a big house and have a lot of servants.

b. Sally wants to live in a big house and she wants to have a lot of servants.

(4a) does not entail (4b), since she might want to live in a big house only if

she has enough servants to take care of it and she might want a lot of servants only if they don't crowd her in. Similarly, she might want a big house only if she could be completely alone in it, or she might want a lot of servants only if they could be crowded in with her.

D. Take the following cases:

(1) a. John continuously danced or sang.

b. John continuously danced or John continuously sang.

If f = continuously, then it is clear that $f(p \vee q) = f(p) \vee f(q)$ is false, although $f(p) \vee f(q) \supset f(p \vee q)$. The same is true for the verb keep.

(2) a. John kept dancing or singing.

b. John kept dancing or John kept singing.

On the other hand, consider an adverb like seldom.

(3) a. John seldom sang or danced.

b. John seldom sang or John seldom danced.

If f = seldom, then $f(p \vee q) \supset f(p) \vee f(q)$, but not vice versa. The same is true of verbs like refuse.

(4) a. John refused to dance or sing.

b. John refused to dance or John refused to sing.

It should be clear that $f(p \vee q) = f(p) \vee f(q)$ is not a criterion for adverbhood.

E. It is usually taken to be particularly characteristic of predicate-modifier adverbs that a sentence containing an adverb entails the sentence minus the adverb. Thus, John kicked Harry at 10 o'clock entails John kicked Harry. However, not all adverbs have this characteristic. Thomason noticed one class of counterexamples: almost, symbolically, nearly, etc. Sam almost hit Harry does not entail Sam hit Harry. The other class of counterexamples has, to my knowledge, not been previously noticed. Let us first consider two classes of adverbials. I: adverbs of time, place, and circumstance. II: adverbs of manner, means, instrument, and reason. In simple cases, both classes meet Thomason's criterion E.

(1) a. Irving ate the bagel at 10 o'clock.
b. Irving ate the bagel in the kitchen.
c. Irving ate the bagel under strange circumstances.
(2) a. Irving ate the bagel cautiously.
b. Irving ate the bagel with chopsticks.
c. Irving ate the bagel because it was there.

Each of these sentences entails that Irving ate the bagel. Now consider the following:

(1') a. At no time did Irving eat the bagel.
b. Nowhere did Irving eat the bagel.
c. Under no circumstances did Irving eat the bagel.
(2') a. Irving ate the bagel in no particular manner.
b. Irving ate the bagel with no instrument.
c. Irving ate the bagel for no reason.

When the adverbs are quantified by a negative existential, they split into two classes. The sentences of (1') do not entail that Irving ate the bagel, while those of (2') do. Thus, adverbs of time, place, and circumstance, when quantified by a negative existential, are exceptions to Thomason's criterion E. I have no idea why this should be so.

As a grammatical aside, it should be observed that there are syntactic correlates of these adverb classes. When quantified by a negative existential, the adverbs of class I must obligatorily move to the front of the clause, while those in class II may optionally do so. These facts obtain in my speech, though there is considerable dialect variation, as might be expected.

(3) a. *Irving ate the bagel at no time.
b. *Irving ate the bagel nowhere.
c. *Irving ate the bagel under no circumstances.
(4) a. In no particular manner, Irving ate the bagel.
b. With no instrument, Irving ate the bagel.
c. For no reason, Irving ate the bagel.

Moreover, when in initial position and quantified by a negative existential, adverbs of class I require auxiliary inversion, while adverbs of class II forbid it.

(5) a. *At no time, Irving ate the bagel.

b. *Nowhere Irving ate the bagel.

c. *Under no circumstances, Irving ate the bagel.

Compare (5) with (1').

(6) a. *In no particular manner did Irving eat the bagel.

b. *With no instrument did Irving eat the bagel.

c. *For no reason did Irving eat the bagel.

Compare (6) with (4). For many speakers, (6) is grammatical.

It should be noted, incidentally, that there are a great many verbs that take complements (modal operators) that meet Thomason's criterion E, for example, force, manage, cause, and many others. For instance, Sam forced Sheila to leave entails Sheila left. Thus, to the extent that criterion E works, it does not distinguish adverbs from modal operators.

F. Thomason himself gives an exception to commutativity.

(1) a. He ran from Marathon to Athens as fast as he could.

b. He ran as fast as he could from Marathon to Athens.

Another example is:

(2) a. Sam worked for his mother harder than Sue did.

b. Sam worked harder than Sue did for his mother.

Another:

(3) a. Sam worked at full capacity for his wife's sake.

b. Sam worked for his wife's sake at full capacity.

To my knowledge, only adverbs of extent, such as the comparatives in (1) and (2) and "at full capacity" in (3) are exceptions to commutativity. Of all of Thomason's criteria, commutativity seems to come closest to distinguishing those things which turn up in English as surface structure adverbs from predicates that take complements. To my knowledge, commutativity never holds for verbs, adjectives, or nouns that take complements.

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Let us consider what all of this means. Thomason wants to characterize a distinction between modal operators and adverbs. He characterizes the latter as operators that map propositional functions into propositional functions. He doesn't say so specifically, but presumably he accepts Scott's characterization

of modal operators as mapping propositions into propositions. Propositions, for Thomason as for most people, are functions from possible worlds into truth values. Propositional functions are functions from individuals into propositions. Suppose we let K be a set of possible worlds, V a set of virtual individuals, V^n an n-tuple of members of V, and $2 = \{T,F\}$. Adverbs A and modal operators M would then be characterized as:

$M \in (2^K)^{2^K}$ — Propositions are members of 2^K. Modal operators map propositions into propositions.

$A \in \left((2^K)^{V^n}\right)^{\left((2^K)^{V^n}\right)}$ — Propositions are functions from the set of worlds, K, to the set of truth values, 2, and hence are members of 2^K. Propositional functions are functions from the set of n-tuples of virtual individuals, V^n, to the set of propositions, 2^K. Hence propositional functions are members of $\left((2^K)^{V^n}\right)$. Predicate modifiers map propositional functions into propositional functions.

Such definitions, taken literally, are slightly misleading, but can be fixed easily enough. To see the difficulty, consider the account of referential opacity given in Thomason and Stalnaker, "Modality and Reference", where the notion of abstraction is employed, and is pressed into service to distinguish, for example, between (1) and (2).

(1) $\Box\hat{x}P(x)(a)$ $[=\Box Pa]$

(2) $\hat{x}\,\Box P(x)(a)$

(2) might be used, for example, to say that a has the property of being necessarily tall. What is important here is that in (1), $\Box$ is mapping a proposition into a proposition, that is, it maps P_a into $\Box Pa$. In (2) on the other hand, $\Box$ is mapping a propositional function into a propositional function, that is, it maps P(x) into $\Box P(x)$, which is then bound by the abstraction operator. According to a literal reading of the account in his paper on adverbs, Thomason would have $\Box$ in (1) be a modal operator, but $\Box$ in (2) be an adverb. I am sure that he does not intend to have $\Box$ be a member of two different categories, and there is an easy way out. Let propositional

functions be functions from $K \times V^n$ into 2, where $n \geqslant 0$. That is, let propositional functions be functions from ordered pairs of worlds and n-tuples of virtual individuals into truth values. Let propositions be zero-place propositional functions. In the limiting case, where $n = 0$, we will have functions from worlds into truth values. Let modal operators map propositional functions (in this sense of the term) into propositional functions. That is,

$M \in \left(2^{K \times V^n}\right)^{\left(2^{K \times V^n}\right)}$

Propositional functions are members of $2^{K \times V^n}$. Modal operators map propositional functions into propositional functions. When $n = 0$, M will be a member of $\left(2^K\right)^{\left(2^K\right)}$.

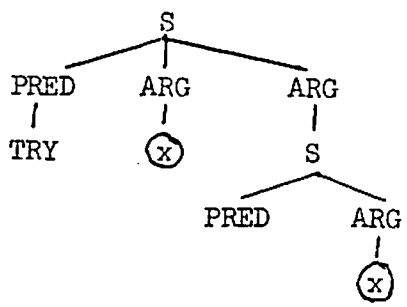
From this point of view, predicate-modifiers will be special kinds of modal operators, those for which $n \geqslant 1$.

Let us now turn to the question of what correlation there is between logical properties and surface grammatical properties such as whether an item is a surface adverb in a given language (or an idiolect of a language). Certain limited generalizations will be possible. For example, modal operators that are commutative will turn out to be surface structure adverbs in English, though there will be other types of adverbs as well. I doubt that there can be a completely general semantic characterization of what can be a surface structure adverb in English, which I think is a correct result. In the first place, surface structure adverbs in English do not, in general, have correlates in other languages, though the same concepts can be expressed in those languages. For example, many languages have no surface instrumental adverbs. Instrumental adverbs are translated into such languages in sentences containing the verb meaning "use". I am told (though I have not checked it out myself) that in Javanese there are no surface locative adverbs, and that instead, expressions with a verb meaning "be located at" are used to communicate concepts that in English require surface locative adverbs. What sort of concepts turn out to be surface structure adverbs is a highly language-dependent matter. In fact, among speakers of a language one finds considerable idiolectal variation, especially in cases where adverbs are derivationally related to adjectives or other lexical items. A quick look through a dictionary or thesaurus will confirm this. Dictionaries compile words which are used with

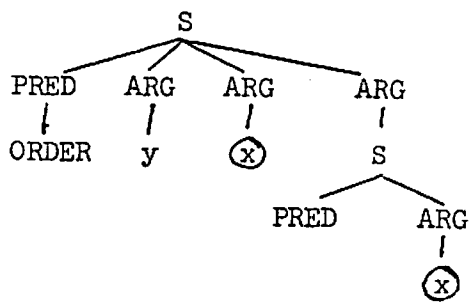
reasonable frequency by some educated speakers or others -- the ones who happen to write for the periodicals that the dictionary-makers clip. In dictionaries one finds words that are in the vocabularies of some speakers, but not others. For example, here are a number of adverbs that I recently turned up that are not in my speech, but presumably occur in the speech of some educated speakers or other: dissatisfiedly, drolly, dully, misgivingly, sanguinely, harebrainedly, finickily, uncomelily, showily, truckingly, contumeliously, sillily, musefully, assumptively, suppositionally, conjecturably, evidentially. Such lexical irregularity is, of course, the usual case. Just which modal operators will turn up as surface structure adverbs in a given idiolect of a given language cannot be completely predicted by logical characteristics. The best one can hope for is to provide either necessary or sufficient conditions. In English, commutativity seems to be a sufficient condition.

It should be borne in mind that what I have proposed is lacking in explanatory power, especially in the case of opacity phenomena. Given that adverbs that involve an attitude or judgment on the part of an individual create opaque contexts, why should it be the case that other adverbs do not? Is there any relationship between commutativity and the lack of opacity? My guess is that there is. Are there any modal operators (as I've redefined them) that (i) can only map propositions into propositions or (ii) can only map one-or-more-place propositional functions into propositional functions, but are not surface adverbs? Cases like (i) would be modal operators that cannot be quantified into, and I know of no such cases in natural language. Cases like (ii) do occur. Recall that certain verbs, such as try and order require activity predicates. Verbs of this sort have an additional peculiarity.

(3)



(4)



In (3) and (4), the encircled variables are required to be the same. For example, Someone tried to leave has a logical form essentially like (5).

(5) (Ex)(TRY(x,LEAVE(x)))

The variable representing the subject of the embedded clause must be identical to the variable representing the subject of TRY. In English (though not in all languages), the embedded subject variable is deleted by a rule called EQUI-NP-DELETION, which deletes the lower of two identical variables in configurations like those in (3) and (4). If the variable which is the subject of the embedded sentence is not identical to the subject of TRY, the result is an ill-formed logical form. For example, (6) is impossible.

(6) $(\forall x)(\exists y)(TRY(x,LEAVE(y)))$

This is not a language-particular fact; (6) would be ill-formed in any natural language. Operators like TRY and ORDER, since they require the EQUI-SUBJECT-CONSTRAINT (as shown in (3) and (4), therefore require one-or-more-place propositional functions, but never appear as surface adverbs. For some unknown reason, predicates that require the EQUI-SUBJECT-CONSTRAINT all require active predicates. This is no accident and cries out for an explanation.

Here are some residual problems that have been wrinkling the brows of linguists for years:

(7) a. John left in an obnoxious manner.

b. *John left in a manner.

(8) *John left in that manner and Bill left in it too.

Why are the starred sentences ungrammatical? What is the logical form of John left in that manner? What are the reflexes in logical form of nouns such as manner, way, circumstances, reason, means, etc., which characterize categories of adverbs? What is the logical form of: Somehow it must be possible to figure out how adverbs work?

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