COGNITIVE SCIENCE. 2, 17-26 (1978)

The Meaning of Modality*

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This paper describes a semantics for modal terms such as *can* and *may* that is intended to model the *mental* representation of their meaning. The basic assumption of the theory is that the evaluation of a modal assertion involves an attempted mental construction of a specified alternative to a given situation rather than the separate evaluation of each member of a set of possible alternatives as would be required by a "possible worlds" semantics. The theory leads to the conclusion that, contrary to what is often assumed, modal auxiliary verbs are unambiguous.

An influential account of the meaning of modality derives from the "possible worlds" semantics developed for modal logics by Kripke (1963) and Hintikka (1963). The central assumption in interpreting such models of modality is the Leibnizian idea that a proposition which is *necessarily* true is true in all possible worlds including the real world, whereas a proposition which is *possibly* true is true in some possible world(s). To make sense of certain modal logics, however, one need consider only certain possible worlds, namely, those that are "accessible" to a given world. This notion may be taken to mean that there are only certain possible worlds that can be conceived of in a particular world, and hence for that world a necessary proposition is one that is true in all the worlds conceivable from within it, i.e., true in all the possible worlds that are accessible to it. The importance of the accessibility relation is simply that depending upon the assumptions made about its logic (whether it is deemed to be transitive, reflexive, etc.) so the resulting model captures the semantics of different modal logics.

A number of theorists have used a "possible worlds" semantics in attempting to formalize the semantics of natural language (see, e.g., Montague, 1974; Partee, 1975). However, such formal models bear only a remote relation to the *mental* representation of meaning. Human beings show little aptitude in considering the complete set of alternatives to a given situation, even where the set is small (see Wason & Johnson-Laird, 1972, Chapters 13-15), and for many states of affairs the set of possible alternatives is vast. Moreover, before an individual can evaluate the truth of a proposition in a possible world, it is first necessary for

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him or her to construct a representation of that world: there is no magical access to the set of possible worlds. A theory of the mental representation of meaning must be compatible with the abstract logical template provided by a "possible worlds" semantics, just as, for example, a theory of mental arithmetic must be compatible with a semantical model of Peano's axioms of arithmetic. But the formal model places few constraints on the psychological theory. The aim of the present paper is to develop an approach to modal semantics that concerns the constructive nature of psychological processes rather than the formal aspect of logical structures; it is in the tradition of the procedural accounts of modality developed by Isard and Longuet-Higgins (1973), Isard (1975), Miller (1977, 1978), and Steedman (1977). The focus of the exercise will be the English modal auxiliary verbs.

It is a commonplace of the linguistic literature from Jespersen (1924) to Jackendoff (1972) that modal auxiliaries are systematically ambiguous. A sentence such as, *John may leave*, can be interpreted to mean either that John has permission to leave—its deontic sense, or that he is possibly leaving—its epistemic sense. There is a similar ambiguity in the sentence, *John can leave*. Moreover, as Boyd and Thorne (1969) have pointed out, *can* is also used to express an ability (*He can swim*), a progressive sense for verbs of achievement (*He can see the mountain*), and a sort of sporadic aspect (*Welshmen can be tall*). The multiplication of meanings in these and other modals is alarming, but almost certainly rests on a false assumption.

The hypothesis to be advanced in this paper is that the major modal auxiliaries are unambiguous: *can* has a single sense, *may* has a single sense, and so on. The distinctions between deontic, epistemic, ability, progressive, and aspectual interpretations are real, but they do not reflect ambiguities in modals. In the case of *ought*, such a view has been urged by Wertheimer (1972), who argues that this auxiliary is univocal: its differences in interpretation depend on whether its use relates to a system of factual laws or to a system of moral laws. A similar argument will be advanced here in order to elucidate the mental representations of the meaning of modals.

The first step of the argument is straightforward. The two main interpretations of modals, epistemic and deontic, can be captured using one or other of two general sorts of sentence:

(1) *It is possible that* John will leave.

(2) *It is possible for* John *to* leave.

A natural extension of the arguments in the literature would be to claim that *possible* must be ambiguous, too, because it is capable of bearing the different interpretations of the modal auxiliaries. This argument is, of course, a twofold fallacy. First, it has yet to be established that modal sentences are ambiguous; the fact that they can be understood in different ways is a necessary, but not suffi-

cient, condition for their ambiguity (see Zwicky & Sadock, 1973). Second, the fact that a word occurs in an ambiguous sentence does not establish that the ambiguity resides in that word; it is also necessary to consider the contributions of other words in the sentence and the circumstances of its use.

An obvious difference between the two sorts of basic sentence is the nature of their complements: *possible* is combined with a *that*-complement in Sentence (1), but with an infinitival complement in Sentence (2). In general, a *that*-complement refers to a proposition, and indeed the matrix may specify the truth value of the proposition, as in the case of a "factive" such as, *He knows that John has left* (Kiparsky & Kiparsky, 1970). Hence, Sentence (1) can only be interpreted epistemically: one cannot give permission to a proposition. In general, an infinitival complement refers, not to a proposition, but to an event, action, or state of affairs (see Miller & Johnson-Laird, 1976, Section 7.3.1; Vendler, 1968). Here, the matrix may specify that the event occurred (*He happened to leave*), that it was a potential one (*He wanted to leave*), or that it did not occur (*He didn't happen to leave*). The contrast between the two sorts of complement is perhaps best illustrated by considering a specific example. There is a subtle distinction in meaning between:

(3) He wishes that he was the pilot.

and its close relative:

(4) He wishes to be the pilot.

Sentence (3) claims that among his wishes is to be found one that has the propositional content of *I am the pilot*. Sentence (4) is more direct: he has an actual achievement in mind and the sentence accordingly refers to a state of affairs. Hence, the first sentence reports the sort of remark that a passenger might make to an air hostess, whereas the second sentence reports the remark of a potential hijacker.

Since an infinitival complement can refer to a potential event, its combination with *possible* is interpretable either epistemically or deontically: an event can be possible or permissible. Here, the role of circumstances is crucial. In some contexts, a sentence such as, *It is possible for John to leave*, will be interpreted deontically, and in other contexts it will be interpreted epistemically. The difference hinges on the body of knowledge that is available for evaluating the function, POSSIBLE. The basic distinction between bodies of general knowledge is, as Wertheimer (1972) points out, that a counterexample renders an epistemic law false, whereas it is the counterexample itself that is rendered wrong by a deontic law. The naïve physics and psychology of everyday life, as well as their sophisticated scientific counterparts, are typical examples of bodies of epistemic knowledge; the rules of games, the conventions of society, and the laws of the land are typical examples of bodies of deontic knowledge. Where the relevant general knowledge is deontic, a sentence is interpreted deontically;

where the relevant general knowledge is epistemic, the sentence is interpreted epistemically. Strong support for this argument is to be found when both sorts of general knowledge are relevant. Thus, for example, the question:

(5) Is it possible for us to have lunch now?

may concern both permissibility and possibility. Such answers as:

(6) Yes, we are allowed to.

or else

(7) Yes, there is a table available.

could be equally appropriate, and there is no sense in which one of them necessarily reflects a misinterpretation of the question. Indeed, they could be combined together in a single reply.

It comes as no surprise to discover that conjunction reduction, one of Zwicky and Sadock's (1973) diagnostic tests for identity of sense, can occur with clauses bearing deontic and epistemic interpretations, e.g., *It is possible for us to dine* (because we are allowed to) *and to get a table* (because there is one available). It would seem that the word *possible* is deictic rather than ambiguous: its interpretation depends upon context. The results of such tests of ambiguity are hardly decisive, as Zwicky and Sadock point out, but they will be confirmed here by developing a single unambiguous semantics for *possible*.

In order to establish whether a given state of affairs is *possible*, human beings do not ordinarily have access to the complete set of "possible worlds," that is to say, they do not search through the entire set of possible states of affairs in order to ascertain whether it contains the relevant situation. They lack both the machinery and the time for so exhaustive a search. Hence, it is plausible to assume a more "constructive" approach.

The evaluation of a modal sentence containing an infinitival complement, such as:

(8) It is possible for John to leave.

involves determining the situation that it concerns—the *reference* situation—and then attempting mentally to construct a sequel to it that leads to the event of John leaving. If this procedure fails, then alternatively one attempts to establish that the event cannot be ruled out as occurring in some sequel to the reference situation. Logically speaking, these two conditions would seem to be equivalent. Psychologically speaking, however, it is one thing to construct a path to the required event, and quite another merely to establish that there is no reason to suppose that such a path cannot be constructed. More formally, the function POSSIBLE takes an argument, e, and seeks to establish *either* a sequel to the reference situation that contains e, or, failing that, that its presence cannot be

ruled out in some sequel. This process utilizes any relevant general knowledge, either deontic or epistemic. Mechanisms for the retrieval of relevant knowledge have been explored both in terms of PLANNER-like languages (e.g., Hewitt, 1971) and in the theory of "scripts" (see Schank & Abelson, 1975); their exact nature need not detain us since although they are vital to the actual evaluation of modals, they have no direct bearing on their meaning.

In order to evaluate a sentence containing a *that*-complement, such as:

(9) It is possible that John will leave.

it is first necessary to evaluate *John will leave*. The function WILL takes one argument, e, and seeks to establish *both* that there is a sequel to the reference situation in which e occurs *and* that there can be no sequel in which e does not occur. This process takes into account not merely general knowledge but also specific knowledge about the particular individuals participating in the event, i.e., information about them that cannot be inferred from general knowledge. It is important to distinguish such specific knowledge from general knowledge: it may be true that an individual will do something without being true that he must do it. Likewise, in a situation in which there is no general reason that would prevent John from leaving, there may be some reason that ensures that he will not leave. In this case, it would be entirely appropriate to assert, *It is possible for John to leave but he will not leave*, but it would be most odd to assert, *It is possible that John will leave but he will not leave*.

If the function, $F(e)$, is introduced in order to represent finding an event, e, in the sequelae of a reference situation, then NOT(F(NOT(e))) represents not finding that e is not in the sequelae, i.e., e cannot be ruled out as occuring in them. The two functions can be represented as follows:

(10) POSSIBLE(e): $F(e)$ OR NOT(F(NOT(e))) where F takes into account general knowledge

(11) WILL(e): $F'(e)$ AND NOT(F'(NOT(e))) where F' takes into account both general and specific knowledge.

There is a straightforward evaluation for the basic sentence with the infinitival complement:

(12) It is possible for x to V: POSSIBLE($V(x)$).

In a search that takes no account of x's dispositions, POSSIBLE looks for a sequel in which x achieves V, or, failing that, it establishes that $V(x)$ cannot be ruled out as among the sequelae.

The evaluation of the basic sentence with the *that*-complement is slightly more complex:

(13) It is possible that x will V: POSSIBLE[WILL($V(x)$)]

where the square parentheses are used to indicate that an argument denotes an assertion rather than an event. This expression is equivalent to:

(14) $F(F'(e)$ AND NOT$(F'($NOT$(e))))$ OR
NOT$(F($NOT$(F'(e)$ AND NOT$(F'($NOT$(e))))))$.

Because in computational terms, finding that you find something is equivalent to finding it, not finding that you don't find it is equivalent to finding it, etc., this disjunction can be simplified first to:

(15) $(F'(e)$ AND NOT$(F'($NOT$(e))))$ OR
NOT$(F($NOT$(F'(e))$ OR $F'($NOT$(e))))$

and then to:

(16) $(F'(e)$ and NOT$(F'($NOT$(e))))$ OR $F'(e)$ OR NOT$(F'($NOT$(e)))$.

But, here, the initial conjunction is redundant because either of its constituents suffices to satisfy the expression as a whole. Hence, we obtain the following:

(17) POSSIBLE[WILL$(V(x))]$ = $F'(V(x))$ OR NOT$(F'($NOT$(V(x))))$.

At this point, it might seem that WILL plays no part in the proceedings. Yet, while it is true that it has no effect on the logic of the expression, it plays the decisive role of ensuring that the evaluation of the expression takes into account specific knowledge about individuals referred to in the sentence. An answer to the question:

(18) Is it possible that John will leave?

will accordingly take into account what is known about John's specific dispositions.

Although Wertheimer (1972) invokes the notion of bodies of knowledge in his theory of modality, his interpretations of the major auxiliaries are open to doubt. The gist of his argument is that a sentence such as, *John* must *leave*, means that John has some property which, according to the relevant body of knowledge, implies that *John leaves* is true. It is unclear how he proposes to distinguish this analysis from the one required for *John* will *leave*. He claims that *John* may *leave* is stronger than *It is possible that John will leave*: it implies that there is some (unspecified) probability that John will leave. This distinction is somewhat obscure since, if something is possible, it presumably has some (unspecified) probability. An alternative conception of the meanings of the modals emerges from the present account of POSSIBLE, WILL, and the two sorts of basic sentence:

1. *May*. A sentence such as, *John may leave*, is interpretable with respect to either epistemic or deontic knowledge. When it is evaluated according to epistemic knowledge, it receives an interpretation equivalent to:

(19) It is possible that John will leave: POSSIBLE[WILL($V(x)$)], which takes into account both general and specific knowledge.

When it is evaluated according to deontic knowledge, it receives an interpretation equivalent to:

(20) It is possible for John to leave: POSSIBLE($V(x)$), which takes into account general knowledge.

The two different interpretations arise not from an ambiguity in *may*, whose meaning corresponds to POSSIBLE, but from the nature of the complements that it modifies. Certain complements are unequivocal and possess a temporal schema that can be interpreted in only one way, e.g., *John may have left* (see Steedman, 1977). In other cases, a sentence is unequivocal because there is only one relevant body of knowledge, e.g. *The substance may act as a catalyst*. The two different sorts of complement are processed in the same way by POSSIBLE: the only difference is in the body of knowledge that it uses.

II. *Can*. A sentence such as, *John can leave*, receives the same deontic interpretation as (20) or an epistemic interpretation equivalent to:

(21) It is possible for John to leave: POSSIBLE($V(x)$), evaluated with respect to general knowledge.

The two interpretations again arise solely from the nature of the complements, and differ only with respect to the relevant body of knowledge. The sense of ability that occurs in:

(22) He can swim.

is a direct reflection of the interpretation of:

(23) *It is possible for* him *to* swim: POSSIBLE($V(x)$).

where the reference situation is the present state of affairs, i.e., the habitual situation, and the procedure looks for the appropriate sequel. The normal epistemic interpretation of *can* occurs where the reference situation is the present moment, i.e., *now*. The distinction is deictically based and, indeed, is often clarified by the use of deictic adverbs:

(24) It is possible for John to swim (because he knows how) but it is impossible for him to swim *now* (because he is asleep).

The two alternative reference situations are also relevant to the interpretation of the ordinary present tense:

(25) He swims.

which may refer to what he is doing at the moment or to what he does habitually. The progressive interpretation that occurs with achievement verbs:

(26) It is possible for John to see the mountain.

is like the aspectual interpretation of such sentences as:

(27) It is possible for Welshmen to be tall.

Both hinge on a special feature of POSSIBLE when its argument denotes a state rather than an event. In this case, the function looks, not among the temporal sequelae, but among the inferential consequences of the reference situation for the relevant state of affairs. This feature is shared by the function, WILL.

III. *Must*. A sentence such as *John must leave*, corresponds to, *It is not the case that John can not leave*, and receives an interpretation equivalent to:

(28) NOT(POSSIBLE[(NOT($V(x)$))]), evaluated with respect to general deontic or epistemic knowledge.

The difference between:

(29) You must be the plumber.

and

(30) You will be the plumber.

as Steedman (1977) has pointed out, depends on whether your model of the world includes the prediction of a plumber's arrival. Only where you possess this *specific* knowledge can you properly greet the plumber's arrival with Sentence (30).

There are, of course, some putative counterexamples to the present analysis, but I believe that they can all be resolved in terms of the pragmatics of discourse and in particular the conventions governing conversation. Let us consider two test cases.

First, imagine a situation in which there is no reason to prevent John from leaving, but he is nevertheless compulsively disposed to stay. Would one be prepared to assert, *It is possible for John to leave*? It is sometimes suggested that the utterance would be inappropriate or untrue, yet it seems entirely natural to say, *It is possible for John to leave but he has some inner compulsion that prevents him from so doing*. In other words, the claim that it is *not* possible for John to leave is taken to concern general knowledge unless reference is made to specific dispositions. An entirely analogous case can be made for the deontic interpretation of modals. If a speaker asserts, *John can vote in the election*, his remarks will be deontically interpreted with respect to the rules governing the election, but this interpretation does not preclude the addition of some rider concerning John's specific status.

Second, consider the case where a speaker grants permission in an actual utterance: *You may leave*, *You can leave*. These utterances are treated as synonymous in the present theory: they can both be paraphrased by "It is possi-

ble for you to leave'' in relation to deontic knowledge. But this analysis is glaringly inadequate: it fails to capture the notion that the speaker is granting permission in his speech act. However, this problem is by no means peculiar to modal verbs. It occurs with all performative utterances. There is an exactly parallel distinction, for example, between *The Queen named the ship H.M.S. Victoria*, and *I name this ship H.M.S. Victoria*, uttered felicitously as the Queen breaks a bottle of champagne over the bows of the vessel at a launching ceremony. The exact nature of the distinction between performatives and descriptions of them is a controversial matter; my only claim here is that the mechanism that accounts for the performative interpretation will be one that adds the necessary causal component to the present analysis of modals.

In conclusion, it seems that modal auxiliaries are unambiguous, and that modal sentences take on different interpretations as a function of the complements they contain. The notion of possibility is deictic rather than ambiguous, and its interpretation hinges on knowledge. This view was anticipated by Frege (cited by Karttunen, 1973), who argued that modality is a pragmatic matter and hence should be excluded from logic proper. In most cases, the mental processes involved in evaluating modal assertions are likely to consist in the construction of specified alternatives to a given situation rather than the evaluation of the complete set of possible worlds.

ACKNOWLEDGMENTS

Many of the ideas in this paper were developed in collaboration with George A. Miller to whom I am greatly indebted; he should not, however, be held responsible for any errors it may contain. I am grateful to Eugene Charniak, Stephen Isard, Judi Kornfeld, John Lyons, and Mark Steedman, for critical readings of an earlier draft. The research was supported by the Social Science Research Council (U.K.).

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