MODELS FOR MORALITY: TEMPORAL SEMANTICS
FOR DEONTIC LOGIC

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A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

MASTER OF ARTS

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Houston, Texas
May, 1985
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ABSTRACT

This work addresses several topics in the semantics of deontic logic. In Chapter One I introduce a standard branching temporal model to serve as the basis for deontic logics and I define three tense operators. I argue that none of the three corresponds to a popular view of the 'will' operator, that the 'will' operator cannot be defined on the model provided, and finally, that the truth conditions for 'will' are exactly those of 'must.' In Chapter Two I introduce the monadic and dyadic operators 'O' and '0(−−)' and review arguments for taking the dyadic as primitive. I show that those arguments do not prove that a dyadic operator is necessary, and that the considerations which led to its introduction are better served by defining conditional obligations with a tense operator 'will always' and the standard truth-functional connectives. I also argue that the 'set of morally acceptable worlds' which deontic semantics use should be construed as a set in which some particular agent fulfills all her obligations. In the third chapter I demonstrate how temporal semantics enable deontic logicians to choose among several formulations of the principles that what is necessary is obligatory and that what is obligatory is possible. I review arguments for rejecting the former as a principle of logic and note a problem which arises when it is rejected. In Chapter Four I demonstrate that an attempt by Richmond Thomason to relate 'dutiful' choices to morally perfect worlds on the temporal model cannot succeed. Finally, I conclude the thesis by investigating the broader implications of the results from the first four chapters.
Acknowledgements

I wish to thank my committee members Dr. Baruch A. Brody and Dr. Christine Sistare for accommodating my writing schedule and for providing helpful comments on very short notice. In addition, comments from Susanna Goodin and Jay Jones were of great help during the writing of this paper. I am especially indebted to Dr. Richard E. Grandy. My two years as a student of his were challenging and enjoyable, and his support and guidance as my thesis director encouraged me to finish.

On a more personal level, I am grateful to my parents Mary Lou and Phil, whose curiosity at my studying philosophy never affected their unending support for my endeavor.
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INTRODUCTION

A system of formal logic has syntactic features and semantic features. Generally, syntactic features are those related to the ways in which strings of symbols are put together to form well-formed formulas and the ways in which the rules of the system allow formulas to be listed and manipulated to arrive at (derive) other formulas. Statementhood, derivability, and theoremhood are all syntactic notions. Semantic features are those related to the ways in which the symbols and formulas of the formal language are interpreted. Truth and falsehood, validity, consequence, and entailment are all semantic notions.

In the following five chapters I will discuss a variety of topics in the semantics of deontic logic. In recent years philosophers have become increasingly aware of the assets of using a temporal models as the basis for models of deontic logic. My investigations focus primarily on the way intensional operators can be defined on that model. In addition, I consider an attempt by Richmond Thomason to utilize the deontic model to relate deontic logic to moral philosophy.

The first half of Chapter One introduces the reader to the temporal model used throughout the work. I summarize the ways in which an intensional operator can be defined on the simple model at hand and identify those operators which are most commonly used in tense logic today. In truth-functional logic a compound sentence like 'Av(B&C)' is given a truth value by an assignment. An assignment is a
function which assigns truth values to atomic sentences of the language, and then assigns truth values to compound sentences based on the truth values of atomic sentences. For example, let 'V' be an assignment of either 'T' or 'F' to each atomic formula A, B, C, ... of the language. We write 'V(A) = F' to say A is false on the assignment.

We then define the truth assignments to compound sentences as follows:

- $V(\neg A) = T$ iff $V(A) = F$
- $V(A \lor B) = T$ iff $V(A) = T$ or $V(B) = T$
- $V(A \land B) = T$ iff $V(A) = T$ and $V(B) = T$
- $V(A \rightarrow B) = T$ iff $V(A) = F$ or $V(B) = T$.

An intensional operator 'I' operates on a sentence A in the sense that 'IA' is assigned a truth value not based simply on the assignment to A, but rather, 'IA' depends for its truth value on the way A is given truth values by many assignments.

An example of an intensional operator is the 'necessity' operator from modal logic. The sentence '[]A,' which is read 'necessarily, A' is true on a valuation just in case every relevant truth value assignment gives A the value 'T.' For conceptual clarity, we will talk about 'states of affairs' and 'world-times' instead of truth value assignments even although formally they are equivalent notions. Instead of saying that '[]A' is true just in case every relevant truth value assignment assigns 'T' to A, we will say '[]A' is true just in case A is true in every relevant state of affairs or world-time. We get different intensional operators by varying the 'relevance' relation or by changing the requirements of how truth values of A are given by assignments. For example, the sentence 'possibly, A' or '◊ A' is true, in our terms, just in case A is true in some relevant state of affairs.
After I summarize the temporal model and introduce the tense operators, I discuss the English tense operator 'will'. I begin by noticing that none of the formal operators defined earlier seems to correspond to 'will' as the latter is used in everyday language. A popular view among ordinary people and philosophers alike is that the sentence

(2) Ronald Reagan will win the 1984 Presidential election on November 6,

is true now just in case Reagan eventually does win the election on November 6. I argue that the popular view is incorrect, and that in any case it is impossible to define a 'will' operator on our model which is consistent with the popular view. Furthermore, I claim that the truth conditions for the 'will' operator in English are exactly those of the 'must' operator. In partial defense of my view, I argue that the linguistic phenomenon which people usually cite in support of the popular view is not really evidence for that position. I show that the phenomenon can be explained satisfactorily in a way consistent with my candidate for the 'will' operator.

In the second chapter I identify the 'obligation' operator which is the subject of later discussion throughout this work. I am concerned with English sentences which report personal, all-things-considered (as opposed to prima facie) obligations. Two candidates for the 'obligation' operator are defined: some logicians use the monadic (one-place) operator 'O-' which is read 'it is obligatory that _____.' Other accounts use the dyadic (two-place) operator 'O(-/-)' which is read 'it is obligatory that _____, given that _____.'
A few logicians have argued that the dyadic operator must be used to translate properly and define formally conditional obligation reports such as "John is obligated to pay Ellen, given that Ellen conveys her car over to John." I review the arguments they offer in support of the dyadic operator; those arguments amount to showing that truth-functional connectives and the monadic operator are insufficient to capture the meaning of conditional obligations. While I conclude that those arguments do establish the insufficiency of the monadic operator, I show that our temporal model and the appropriate tense operator can be used to translate conditional obligations without using the dyadic operator. Furthermore, I point out that the philosophical considerations which motivate the dyadic operator are better served by my translation.

I end the second chapter with a brief discussion of the morally perfect world-times which play an important role in the definition of the deontic operator. Those world-times can be construed either as states in which each person fulfills all her obligations or else as states in which some particular agent fulfills all her obligations. I argue there that deontic logic should specify that the relevant world-times are the latter, that is, those in which a particular agent fulfills all her obligations. When the world-times are construed in the former sense, counterintuitive results ensue.

Chapter Three focuses on the relationship between definitions of the obligation operator 'O' and formalizations of the principles that 'ought' implies 'can' and that 'necessary' implies 'obligatory.' After discussing several formulations of the Kantian maxim in our
logic, I demonstrate how our model can be enriched to provide a better formulation. The richer model borrows from Keith Lehrer the idea that 'can' is analyzable on a temporal model. Previous deontic models permit only a limited range of definitions or characterizations of 'can' which may not satisfy a moral philosopher's interpretation of that verb as it appears in "'ought' implies 'can'."

The second principle which I discuss is the principle that what is necessary is obligatory. While some philosophers are uncomfortable in supporting a formal principle equivalent to "'necessary' implies 'obligatory'," it is an unfortunate fact of deontic logic that all standard definitions of the obligation operator insure that some version of that principle comes out valid. As a result, some logicians have introduced complications in the definition of the 'O' operator in order to weaken the formal principle which comes out valid. I argue that while their reasons for weakening the principle are legitimate, the weaker formal principle which their accounts validate is just as counterintuitive as the stronger principle which they seek to replace.

I then consider a way to make sure that no formal counterpart to "'necessary' implies 'obligatory'" comes out valid: by requiring of obligatory states that they be contingent states. Four ways of interpreting 'contingent' are listed as well as four formulas of increasing strength which capture the belief that obligatory states must be contingent. Any account which tries to validate such a principle of reasonable strength, however, runs into a very serious formal problem. I close the chapter by identifying and discussing
briefly that problem.

In the fourth chapter I consider an attempt by Richmond Thomason to utilize the deontic model in relating moral choices to obligations. Thomason introduces the notion of a "choice set" -- the set of possible future world-times which a person strives to make actual. For example, a person who has political ambitions would have among his 'choice' set states in which he is elected to Congress. Thomason then suggests that a person acts dutifully just in case his choice set includes only states in which he fulfills all his obligations.

While Thomason's idea is interesting and deontic logic clearly needs to be shown to have some relation to moral philosophy, I argue that Thomason's account fails. I show that the states of affairs which need to be included in the choice set are not always states which are causally possible, given the present. In simpler language, people often try to actualize situations which in fact could not arise given the present state of the world and our laws of physics. Since our models include only causally possible states of affairs, our models are incapable of representing choice sets. Furthermore, it is very likely that choice sets include situations which are not even logically possible; so neither a modification of our models nor a modification of his account in any apparent way will enable Thomason's account to succeed.

In each of the four chapters which constitute the main body of this essay I focus my attention on the narrow issues at hand. In the concluding chapter, I step back from the previous investigations to
assess their importance and relevance to broader issues in deontic logic and philosophy of logic.
CHAPTER ONE

We can think of the complete history of the world -- past, present and future -- as a succession of states of affairs. Each moment of history constitutes one state of affairs, and the present moment is among those states. Philosophers use a variety of terms for these states of affairs: 'possible worlds,' 'world-times,' 'maximal consistent sets of propositions,' etc. In the discussion below, I will use 'world-time' and 'state of affairs' as synonyms, and talk of sentences being true at a world-time or in a state of affairs.¹

How do we conceive of history in these terms? Most people agree that the past is fixed or determined up through the present moment. George Washington was the first President of the United States, and nothing that you or I could do now or twenty years from now could change that fact. In our 'states of affairs' language, the past is a chain of states of affairs: where 't₀' denotes the present world, we represent this chain with a straight line:

[Diagram: A straight line with arrows pointing to the right and left, labeled 't₀'.]

The future, we believe, is not determined. There are infinitely many states of affairs which could succeed the present state. In some of those possible futures, the Astros win the National League pennant; in others, the Cubs win. Our conception of the future, then is of a
variety of states being possible at any given point in the future. Schematically:

The broken lines represent two of the many possible strings of world-times which could succeed the present. The worlds at \( t \) are supposed to be 'simultaneous.' They represent possible October 15ths, for example. In the world at the top, the Astros win and the Cubs lose; on the bottom, vice versa.

We can treat tense and time more formally with the use of models such as the one above. Our primitive notion will be of the truth of an atomic sentence \( A \) at a possible world \( w \). We suppose that the truth-values of all atomic sentences are given by a valuation \( V \). \( V \) is a function from sentence-world pairs to truth values. Formally, we will write \( 'V(A,w) = T' \) to say that \( A \) is true at \( w \). The truth values of non-atomic sentences are defined recursively as follows:

\[
\begin{align*}
V(-A,w) &= T \text{ if and only if } V(A,w) = F, \\
V(A \lor B,w) &= T \text{ if and only if } V(A,w) = T \text{ or } V(B,w) = F, \\
V(A \land B,w) &= T \text{ if and only if } V(A,w) = T \text{ and } V(B,w) = T, \\
V(A \rightarrow B,w) &= T \text{ if and only if } V(A,w) = F \text{ or } V(B,w) = T.
\end{align*}
\]

So far we have the tools needed to talk about the truth and falsity of many compound sentences at possible world-times, but that alone is not sufficient to serve as a basis for more complicated, intensional sentences. We need (we will see why shortly) a formal
characterization of a single, complete possible history of the world. Intuitively, we will want to be able to talk about a specific chain of events which includes the past, present, and exactly one possible succession of future states of affairs. For example:

In the model above, we are considering only the world in which things happen in a certain way at each of $t_0 - t_3$. Of course, specifying just four world-times does not pick out a unique branch, but the idea should be clear from this example.

We will call each possible chain of events a 'history,' use 'h' to label histories, and 'H' to denote the set of all possible histories. In other words, each $h_n$ is a maximal chain in the set of world-times, or a way to draw a line from the past through the future. These chains are sets of world-times, and we will talk of world-times and states of affairs as being included in or as being elements of histories. Thus, we write $w \in h_n$ to say that $w$ belongs to history $h_n$. Finally, the worlds in the branching model are ordered in two ways. First, each history is ordered by the 'earlier than' relation. Second, the set of all world-times is ordered by the 'same
time as' relation. The first ordering is motivated by the belief that we are talking about a progression of states of affairs. The motivation for the second ordering is less obvious: when we say that it might rain tomorrow and that it might not rain tomorrow, we seem to be talking about different states of affairs, one in which it rains and one in which it does not. Nonetheless, we are talking about the 'same' tomorrow. We will put this differently: we are talking about different, but 'simultaneous' states of affairs.

Having established a basis for temporal operators, where do we go? The standard approach is to jump right into a discussion of tensed locutions in English, but that approach ignores some tricky questions as we shall see below. For now, I will define a few tense operators formally, and will follow that with a detailed discussion of the English tense operator 'will.'

For the sake of simplicity, we suppose that the present moment \( t_0 \) is given and define the following operators as being true at \( t_0 \):

\[
V(HA) = T \quad \text{iff} \quad V(A, w) = T \text{ for all } w \text{ such that } w \text{ is before } t_0.
\]

\[
V(PA) = T \quad \text{iff} \quad V(A, w) = T \text{ for some } w \text{ such that } w \text{ is before } t_0.
\]

Roughly, the operators are read:

\( HA = \) It has always been the case that \( A \).

\( PA = \) It was (at least) once the case that \( A \).

The operators for the future are not quite so simple. We begin by defining operators which are indexed to histories. In other words, the operators below only consider one forward-looking chain, just as the backward-looking operators above were only concerned with one
chain. The superscript 'h' will remind us of this indexing; and it is important to keep it straight.

\[ V(G^hA) = T \text{ iff } V(A, w) = T \text{ for all } w \text{ such that } w \text{ is after } t_0 \text{ and } w \in h. \]

\[ V(F^hA) = T \text{ iff } V(A, w) = T \text{ for some } w \text{ such that } w \text{ is after } t_0 \text{ and } w \in h. \]

Keeping in mind that we are talking about a single, linear future, the operators above are read:

- \( G^hA \) = it will always be the case in \( h \) that \( A \).
- \( F^hA \) = it will at some (at least one) time during \( h \) be the case that \( A \).

In defining the four operators above we have considered, in effect, the single time line,

\[ \begin{array}{c}
\rightarrow \\
| \\
| \\
t_0
\end{array} \]

"GA" and "FA" are straight-forward analogs to "HA" and "PA," respectively. What we have ignored so far in our definition of future operators is that the future of \( t_0 \) is not a single line, but rather a branching set of lines. More intuitively, we think of the future as being non-determined: a single set of possible world-times forming one chain does not capture that intuition.

To understand how we will have to go about taking care of this problem, let us return briefly to the simpler past tense operators. Consider the two sentences,

1. Abraham Lincoln was President of the United States,
and

(2) The world has always been round.

Using the operators from above, those sentences receive the following translations:

(1*) \( P(\text{Lincoln is the President of the United States}) \),

and

(2*) \( H(\text{the world is round}) \).

(1*) and (2*) are cast in their respective forms to emphasize that the past tense operators act just like quantifiers over past states of affairs: "P" and "H" amount to "at some past time" and "at every past time."

We have cut up the future, however, not only into world-times or states of affairs, but we have further grouped those states into particular sets of world-times, or histories. We can quantify not only over world-times, then, but also over the branches which contain the world-times. In familiar (but somewhat shoddy) notation, the following are ways in which we can quantify over both branches and worlds:

\[
(3) (\forall h) F^h A
\]

\[
(4) (\exists h) F^h A
\]

\[
(5) (\forall h) G^h A
\]

\[
(6) (\exists h) G^h A
\]

Reading these back into English, we get:

(3*) On every future branch there is an A-world.

(4*) On some future branch there is an A-world.

(5*) On every future branch, every world is an A-world.
On some future branch, every world is an A-world. The problem is to find idiomatic English translations of the four sentences above. The following, I believe, capture the essence of (3*) through (6*):

(3**) It is inevitable that A.

(4**) It might be the case that A.

(5**) It will always be the case that A.

(6**) It might always be the case that A.

Richmond Thomason uses equivalents of the first three above when he introduces three future tense operators with the following truth conditions:

$$(4T) \quad V(FA) = T \text{ iff } V(A,w) = T \text{ for some } w \text{ after } t_0 \text{ such that } w \in h, \text{ for some } h \in H.$$  

$$(3T) \quad V(SA) = T \text{ iff } V^h(FA) \text{ is true for all } h \in H.$$  

$$(5T) \quad V(LA) = T \text{ iff } V(A,w) = T \text{ for all } w \text{ after } t_0 \text{ in every } h \in H.$$  

These represent:

\[ FA = \text{A might happen} \]
\[ SA = \text{A is inevitable (or A is Settled)} \]
\[ LA = \text{A is necessary}. \]

The operators above, taken with the operators for the past introduced earlier, will enable us to talk about almost any way the truth values for an atomic sentence are distributed among the world-times on the branching model. The problem is in matching English tense operators with those possible distributions, and then finding the appropriate operator or combination of operators to characterize that distribution.

The easiest case to use to see how this was done is for 'might':
we ordinarily think it true that A might happen just in case there is a possible future in which it does happen. And very conveniently (though certainly not by accident) we have the operator "F" which corresponds to 'truth-in-some-future.'

Interestingly enough, we seem to have carried out a good deal of tense logic semantics without mentioning what appears to be the most obvious candidate for an English tense operator: 'will.' I will consider three possibilities for defining a 'will' operator. We begin by remembering that there are four ways of quantifying over branches and times as listed in (3*) through (6*). (5*) and (6*) are not suitable for defining the 'will' operator as the following counterexample (to both) shows:

(7) I will eat this apple.

(7) can be true; however, there is not any way in which "I am eating this apple" can be true at every world time on a branch, hence it cannot be true on every branch.

Two of the candidates for translating 'will' come from our stock of operators which we discussed earlier: the 'F' and the 'S' operators. After those two are discussed, a third alternative will be suggested.

(A) 'A will occur' is true just in case some future world on some branch is an A-world.

(B) 'A will occur' is true just in case every future branch contains some A-world.

The view expressed in (A)—that 'A will occur' is equivalent to 'FA'—is on its face absurd. One of its results is that both of the
following come out true:

(8) Reagan will win the 1984 election.
(9) Reagan will not win the 1984 election.

Those two appear contradictory, or at the very least, inconsistent. If we believe that there are some futures in which Reagan wins and some in which he does not win, however, then both (8) and (9) are reckoned to be true by (A).

Why even consider (a), then? I think that English speakers often use 'will' as if they mean something very close to what is expressed by (A). Two people in a bar may agree that the Presidency of the United States for 1985 is not yet decided, but that either the speaker of (8) or the speaker of (9) utters a true sentence before the election. The claim might be that Reagan's eventually losing makes (9) true, and true now.

The phrase "one will turn out to be right" seems appropriate here, and that suggests that we are dealing with what the speakers believe:

(8*) George believes that Reagan will win the 1984 election.
(9*) Geraldine believes that Reagan will not win the 1984 election.

Those two are not inconsistent, but neither can they be what the speaker (suppose it is Geraldine) claims she is right about. Being right in that case just amounts to honestly having believed that Reagan would lose. The question is: what makes the belief expressed by (8*) or (9*) a true belief? If we grant that "x believes that A" reports a true belief just in case A is true, we are back where we started.
(A) does, nonetheless, have one asset: it explains how the following two sentences can be true at the same time:

(10) Reagan will win the 1984 election.
(11) Reagan might not win the 1984 election.

The cost of that asset is too high, however. While it makes (10) and (11) consistent, it still leaves (8) and (9) consistent. Furthermore, it makes 'will A' and 'might A' true under exactly the same circumstances.

(B), on the other hand, has an initial advantage over (A) in that it makes (8) and (9) inconsistent. It cannot be true both that Reagan wins the 1984 election in every future state of affairs and that Reagan loses the 1984 election in every future state of affairs. The problem here is that "wins in every world" under (B) amounts to "Must win," and it certainly is not clear that 'will' and 'must' are the same operator in English. As a result, (B) makes (10) and (11) inconsistent: if Reagan might lose, then Reagan loses at some future world-time, hence it is not the case that Reagan wins at every future time, hence "Reagan will win" is false.

This puts us on uncomfortable ground. Our initial judgments were that (8) and (9) are inconsistent, while (10) and (11) are consistent. But (A) and (B) make both pairs consistent or inconsistent, respectively. Thus we must look outside the apparati we have provided so far for an accurate definition of 'will' or else reconsider our consistency judgments above. I will consider now what appears to me to be the only alternative for defining 'will' above while using the temporal model under investigation.
The motivation for the third alternative can be put something like this:

There is a man who is now correctly described as the 41st U.S. President, despite the fact that the American voters will only decide the matter in 1984. For a unique man will no doubt be selected and of that man it is undoubtedly true to say now that he is the 41st of U.S. Presidents.

The idea expressed there is that either (8) is true now or that (9) is true now; which is true depends on how the future turns out, but one of them will have turned out to be true. Oddie and Tichy do not go much beyond the passage above to convince the reader that they are right, and their lack of an argument on the point is not hidden by the underlining. We will see below that their position is not as tenable as may seem at first blush.

In any case, we are trying to figure out the third candidate for representing the 'will' operator on a branching tree of futures. What Oddie and Tichy have in mind is something like this: "A will be the case at t_1" is true at t_0 just in case A is true at t_1. More formally, let \( \psi \) be the function which picks out the 'actual' course of the world—past, present, and future. \( \psi \) assigns to world-times all the atomic sentences true at those world-times. Then

\[
(C) \quad A \text{ will occur at } t_n \text{ is true at } t_0 \text{ iff } \psi(t_n) \subseteq A \quad \text{(where } t_n \text{ is after } t_0\).
\]

(C) is very tidy and, I am afraid, what many people believe to be the case. While I do not see any great positive arguments for (B) above, I think the arguments for (C) are at very best inconclusive. Let us start with what I think is an indisputably true sentence:

\[
(12) \quad \text{It was true in 1978 that Reagan would eventually win the 1980 Presidential election.}
\]
Why is (12) true? Consider the world as it is now represented by our branching model:

![Branching Model Diagram]

We are evaluating the truth value at $t_0$ of a sentence of the form "it was the case at $t_n$ that A would happen at $t_m$" where $t_m$ is after $t_n$. Now on the model above, at $t_0$ the past is determined; no matter how far back you go and look forward, the world line is straight up through the present moment and branching thereafter. In other words, 1984's history is settled. (12) is true because starting with the 1984 world and looking back to 1978, there was exactly one way the world turned out in 1980, and that way included Reagan's winning the Presidency.

That much is the backbone of Oddie and Tichy's conceptualization of the issue: we can look back now and see that in 1978 it was true that a particular course of events would happen. But I do not see at all why one should infer from the truth of (12) that the following is true:

(14) "Reagan will win the 1980 election" was true in 1978.

I emphasize here that we are discussing 'will' and not 'would'; 'would' is not simply the past tense of 'will.' When we evaluate
truth values of tensed statements, we begin by structuring our model on the present time. That is, we select the point $t_0$ and construct a branching future and linear past. Now to talk about the truth value of "A will occur" at $t_0$, we construct the following model:

On this model, the world at $t_0$, the 1978 world, does not necessarily include an 'actual' 1980 world. The claim that there is a real function which picks out the actual 1980 world in 1978 is just a way to rephrase the claim that in 1978, there was an actual 1980 world. The passage cited above makes the following inference, which seems to presuppose that we can talk coherently about the existence of the function: it will be the case that some man is elected, therefore there is some man such that he will be elected. And that inference is simply not valid in any obvious way.\(^9\)

Their argument continues along similar lines:

(i) ...it is as yet undecided which of the possible continuations of the up-to-now history of the universe will eventually materialize.

(ii) But one of them undoubtedly will materialize, and that one, whichever it is, is truly said to be the actual future already.\(^10\)
First we must notice that in (ii) Oddie and Tichy make exactly the quantifier exchange mistake that was pointed out above. Their position falls apart, I believe, when we consider (i). What does it mean to say that the future is 'undecided' except to say that the mythical $\psi$ function is undefined after the present moment?! They seem to want to talk about the actual 1980 from 1978's viewpoint while maintaining that there is no world in 1978 which can rightly be called the actual 1980. In short, (i) just seems to be a denial of one of the presuppositions of (ii)!

The view that Oddie and Tichy express is a very popular view. Nearly everyone whom I asked to choose between (B) and (C) chose (C) and offered reasons very similar to the reasons offered above. But their arguments just do not support (C) as far as I can tell, and it is not clear that the indeterminist can coherently assert the thesis that the future is not determined while also asserting that of some future possible state of affairs it is true to say that it is the actual future now.

Nonetheless, I still need to explain why, if (C) is incorrect or incoherent, we make judgments like:

(15) Harvey said to me two years ago, "Wait and see, Mondale will be nominated by the Democratic Party in 1984," and sure enough, he was right.

My discussion of 'would' above contains the seed of my answer. First, we need to ask the question: does "Harvey was right" just mean that what Harvey said in 1982 was true? I do not think so. We ordinarily would say that Harvey's prediction eventually 'turned out' to be right, that Mondale was nominated by the Democratic Party.
In so saying, we use language which indicates our looking backward in time from 1984, or in other words, the tense operators we employ take 1984 as the 'present' of the model. When we judge that Harvey was right about Mondale, what we are saying is that it is true now that in 1982 Walter Mondale was the man who would become the Democratic nominee. And when we model sentences like "it was true at \( t_0 \) that A would be the case at \( t_1 \)," we do not need to make the sentence "A will be the case at \( t_1 \)" true at \( t_0 \).

As difficult as it may be to accept (B), the reasons most people offer for (C) do not support (C). And until more convincing arguments for (C) are given, (B) appears to be the more acceptable choice.
In the previous chapter we saw how a particular temporal model could be used in providing the semantics for tense logic. We began with a broad characterization of our intuitions about how the history and future of the world could be structured with the use of possible world-times and then on that basis we defined certain tense operators.

This chapter is concerned with a different sort of logic: deontic logic. Generally speaking, deontic logic investigates the formal relations between sentences which contain the deontic operators "ought" and "may", that is, sentences which report what is obligatory and what is permissible. Before we begin our discussion of deontic logic, however, we need to point out two problems in the language of obligations which some authors have noticed and others have not.

The first problem is that English contains a variety of deontic locutions such as "You ought to do A," "It is obligatory that A," "John has an obligation to do A," "Americans should not let the people of Ethiopia starve," and so on. And to make matters worse, there is no univocal sense of "ought," as Baron and Grandy have pointed out. Following those two, I will restrict my attention to personal, all-things-considered obligations, usually reported in the form "agent x has an obligation to A." Unfortunately, that phrase gets tiresome rather quickly, so I will often use other idiomatic expressions. In all cases, I use other expressions as shorthand for "x has an obligation to A."
What is an all-things-considered obligation? Philosophers sometimes distinguish between *prima-facie* and *actual* obligations. A prima-facie obligation is a moral presumption to act in a certain way. For example, "Thou shalt not lie" reports a prima facie obligation. We can imagine cases in which that obligation is overridden. I may know that a thief who has a gun at my stomach will kill me if he believes that I have a lot of money in my wallet, but let me go otherwise. If I have $12,000 in my wallet, I do not think we would say that I ought not to lie about that fact. An actual obligation, on the other hand, is the morally best way to act in a particular situation; it is the way a person is morally required to act, all things considered. In the case above, I might have some moral obligation to get the $12,000 somewhere which overrides my obligation not to lie (although I think my keeping myself alive is enough to override the prima-facie obligation). In that case, I have a prima-facie obligation not to lie and an actual obligation to lie. When I talk of obligations below, I will be talking only about actual obligations.2

The second problem we must face is that the obligation operator 'O' operates on infinitival verb phrases, whereas we usually want to use indicative sentences in describing states of affairs or world-times in which obligations are met. For example, we might say that

John has an obligation to pay Nathan $50 on Friday.

We translate this into our formal language as 'OA' where 'A' represents the verb phrase "to pay Nathan $50 on Friday." As we
characterize states of affairs, however, we will want to distinguish those in which John pays the money (those in which A holds) from those in which he does not repay the money. But does it make sense to say that "to pay Nathan $50 on Friday" is true at; or holds in a state of affairs? I assume here that the reader is facile enough at translating between moods to understand this grammatical point, work through the examples despite the problem, and not to be too much bothered by it. So long as we remember that we are dealing with actual, personal obligations we should not have much trouble keeping the discussion straight.

That takes care of the introductory remarks, and it is time to take a look at deontic logic. We begin our study with the basic temporal model used in the previous chapter:

As in the last chapter, we are going to define deontic sentences in terms of their truth values at the present moment $t_0$; although we will leave reference to $t_0$ implicit. For the purposes of deontic logic, we need to partition the set of future world-times into two subsets: the subset $M$ of morally perfect world-times, and $M$'s complement $\overline{M}$, the set of world-times which are not morally perfect. In the discussion of tense operators earlier we; in essence,
quantified over all the branches and worlds in $t_0$'s future. In deontic logic, however, we will be concerned almost solely with the world-times in $M$. The temporal operators 'consult' causally accessible states of affairs; deontic operators are concerned with morally accessible states of affairs.

The basic deontic operator 'O' is defined as follows:

$$V(OA) = T \iff V(A,w) = T \text{ for all } w \in M.$$ 

In English, A is obligatory just in case A occurs in every morally perfect state of affairs. The reader may have noticed that there is a great deal of similarity between the obligation operator of deontic logic and the necessity operator 'L' of tense logic, as introduced in the previous chapter. The reason behind the similarity is quite simple: "LA" and "OA" are each true just in case A occurs throughout a particular set of world-times; the only difference is the set over which each quantifies. The necessity operator quantifies over all possible futures; the obligation operator quantifies over all the morally perfect futures.

Going back to the tense operators now, to say that A might happen is to say that it is not necessary that $\neg A$ happen, and vice versa. In fact, the 'F' and 'L' operators are interdefinable:

$$FA =df \neg L\neg A,$$
$$LA =df \neg F\neg A.$$ 

We should not be surprised to find a deontic analog to these, and indeed we do find an analog:

$$p^eA =df \neg O\neg A,$$
$$OA =df \neg p^e\neg A.$$
The truth conditions of the 'P' operator are given by the biconditional,
\[ V(P^eA) = T \iff V(A, w) = T \text{ for some } w \in M. \]

'P^e' is the permission operator of English. A is permitted, then, just in case A occurs in some morally perfect state of affairs. (The superscript 'e' is used above to remind the reader that we have introduced a deontic operator and are not now discussing the tense operator 'P.' Since we will have no further occasion to talk about the tense operator, I will drop the superscript below and use 'P' solely for the permission operator.) We have our two basic operators, then, 'O' and 'P.' The goal of deontic logic, as mentioned earlier, is to characterize formally the logical relations among deontic sentences. With the model and the definitions above, the logician proceeds to investigate what formal sentences always come out true on (are validated by) the semantics. She then considers the appeal of those consequences and makes adjustments where necessary. We will see where some adjustments have been thought necessary to make 'O' more reasonable as we consider the semantics more closely in the next chapter.

For now, consider a typical deontic sentence which is a theorem of almost all deontic logics:
\[ O(A&B) \leftrightarrow OA \& OB. \]

It is easy to show that the formula is always true given the model and definition of 'O' above. The left side is true just in case every morally perfect state of affairs contains (A&B), which by the definition earlier holds just in case each of A and B holds in every
perfect state, which is true just in case OA, OB, and thereby (OA & OB) are all true.

In many cases, the debate over the 'proper' deontic logic turns on which formulas the semantics validate. There is another debate, however, and it centers on the proper nature of the obligation operator. The approach above takes the 'O' operator to be a monadic (one-place) operator. As I put the sentences above in my example, the operator operates on an infinitival verb phrase: "$x$ has an obligation to do____." The blank can be filled in with logically complex phrases, but the main 'O' operator just takes one argument, simple or complex.

Some logicians have argued that obligations are inherently complex in a different sort of way and that they are best translated using a dyadic (two-place) operator. The basic form those logicians see in obligation reports is "$x$ has an obligation to ______ given that condition ______ obtains." In the formal language they employ, such sentences are translated 'O(A/C).' Their arguments that obligations are logically complex are persuasive; that the complexity indicates a need for a dyadic operator, less so. I will discuss the monadic-dyadic dispute shortly.

Just as we noticed that obligation reports like 'OA' and statements of an obligation's being fulfilled are in different grammatical moods, we must point out that 'C' and 'A' represent phrases of different moods within the single formula 'O(A/C).'</p>

For example, we have

Todd has an obligation to send Hickory Farms a check, given that Hickory Farms sent Todd the salami he ordered.
The condition is in the form of a present tense sentence, while the obligation report is an infinitival verb phrase. We need to be especially careful to keep this in mind, because we will see sentences in which the same letter is used in both argument places, such as $O(-A/A)$.

We are ready to look at the analysis of the 'O' operator and its companion 'P.' Our semantics for the dyadic operator start with a branching temporal model, and the future states are partitioned into the sets $M$ and $\overline{M}$ of morally perfect and morally imperfect world-times. In addition, the set of futures gets divided into two sets in another way: the set of those futures in which the condition $C$ is fulfilled, and the set of futures in which $C$ is not fulfilled. Schematically:

We will not worry here about where on each branch $C$ is true; the branches are marked only as to whether $C$ occurs at some point along the branch at the relevant time, and the set $M$ is indicated likewise.

The basic operator 'O' then has the following truth condition:
\[ V(O(A/C)) = T \text{ iff } V(A,w) = T \text{ for every C-world w which belongs to M.} \]

A is obligatory, given C, just in case A occurs in every morally perfect state of affairs in which C occurs (including, of course, the C-world at the San Diego Zoo). Again, the 'O' operator is analogous to the necessity operator 'L' of tense logic. Instead of quantifying over all the world-times, however, the 'O' operator essentially quantifies over morally perfect C-worlds.

The permission operator is also dyadic and can be introduced by definition in terms of the obligation operator,

\[ P(A/C) = df -O(-A/C) \]

or else given its own truth clause in the definitions of truth:

\[ V(P(A/C)) = T \text{ iff } V(A,w) = T \text{ for some C-world in M.} \]

In English, A is permissible given that C occurs just in case there is a morally perfect state in which both C and A occur.

Finally, consider the case in which the condition C always occurs. For example, suppose that C is any tautologous state of affairs T. The O(A/C) is true just in case A is true in every morally perfect T-world, which ex hypothesi is every morally perfect state of affairs, so A is true in every morally perfect state and 'OA' is thereby true. In other words, when C is any necessary or inevitable state of affairs, the truth condition for 'O(A/C)' reduces to that for 'OA.' Thus in a logic which utilizes the dyadic operator, the monadic can be defined by,

\[ OA = df O(A/T). \]

Given that the monadic operator can be defined in terms of the dyadic, one may wonder why anyone would prefer using a logic in which
the monadic operator is primitive. I will ask the question the other way around—why favor the dyadic operator?—but will pause for a brief overview of our endeavor.

The use of temporal models is a fairly recent innovation in the short history of deontic logic. Early logicians began the study of deontic logic with a syntactical approach and did not devote much attention to the semantics of their logics. Their method was to formulate sentences in the formal language of deontic logic, posit some of them as axioms, use a few reasonable inference rules to derive theorems and then judge the quality of the resulting logic by the intuitiveness or lack thereof of the theorems. When semantic investigations were added to the endeavor, the models provided at first were simple set-theoretic constructs without much basis in the 'real' world (some may argue that no change in that has come about). As deontic logic developed—and it is still young—logicians became more concerned with semantics and introduced morally perfect states of affairs and more sophisticated ordering relations among the sets of world-times in the models.

Explicit use of temporal models and accompanying tense operators was suggested independently by Baron and Grandy in one paper and Richmond Thomason in another. Why introduce temporal models? In the discussion earlier, we were led into considering obligations in terms of what happens in a certain subset of world-times which are causally accessible from the present world; that is, we are concerned with some of the situations which could arise given our present state of affairs and our laws of physics. The causally accessible world-times
are exactly those in our temporal model; the morally perfect states are a subset of those.

The authors above were motivated by a different and more important concern, however: obligations change as time passes, and since any correct account of obligations must consider these changes, any correct account must include reference to the temporal base of obligations. Specifically, the authors wanted to show that some of the paradoxes of deontic logic could be resolved when time and tense were taken into account properly. I mentioned earlier that part of the motivation behind the introduction of the dyadic operator was that obligations are logically complex and dyadicity is 'necessary' to treat that complexity, and thereby resolve numerous paradoxes of deontic logic. Baron and Grandy acknowledged the complexity of some obligations, but argued that the complications were due to problems with the conditional aspect of the obligations, and that the obligation operator need not be complicated to solve those problems.

Azizah al-Hibri, one of the most important writers on deontic logic, seems to get caught in the twilight zone between temporal models and a dyadic operator. On one hand, she recognizes that the relevant worlds in defining truth conditions for the deontic operators are worlds causally accessible to the present; but on the other hand she still insists that a dyadic operator is necessary. A discussion of her argument will help explain our approach as well as help to see what the monadic/dyadic dispute turns on.

al-Hibri's most extended discussion of assertion that a dyadic operator is necessary is in reference to the sentence
Some writers had claimed that sentences whose form was like that of (1) above could never be true, and al-Hibri wants to show how (1) can be interpreted such that some of its substitution instances are true. Consider, she asks, the following sentence:

(2) It is obligatory that the door be closed, given that it is open.

(2) reports and obligation 'to close the door' given that 'the door is open.' We can imagine, she says, a store manager uttering (2) to her clerks.

As we consider her argument below concerning 'O(-A/A),' we must remember that 'O' is the only intensional operator in her deontic language. While she uses some sort of temporal base for her logic, she does not utilize either modal or temporal operators. In any case, we read

...there is an extra meaning in O(-A/A) which is not captured by any combination of our usual connectives. This is why a new primitive, O(/) was introduced. In English such a notion of conditionality is different from that of material implication in that while 'A 0-A' is read "if A, then 0-A," the statement of obligation 'O(-A/A)' is read as "given that A, 0-A." The latter reading stresses the fact that 0-A is conditional upon A, that A is the ground for 0-A. The relation suggested in this reading cannot be replaced by a conjunction.

The final word in that passage is not a misprint; there and a little later in her discussion she just does not separate clearly two candidates for translating conditional obligations with truth-functional connectives. We will address these translations separately.
First, one might try to translate (2) as

(3) A & O-A.

(2) fails miserably, because the door may in fact be closed as the manager utters (2). Furthermore, as al-Hibri points out, the conjunction does not capture the 'ground for' connection implicit in (2): The manager desires that the door get shut whenever it is open; (3) says only that the door is open and that it ought to be shut.

This leads to a more natural attempt which tries to capture the 'whenever' in the phrasing above:

(4) A → O-A.

al-Hibri seems to argue against (4) in the passage above, but whatever her argument is, it is occluded by her use of such phrases as "extra meaning in O(-A/A);" "such a notion of conditionality;" and "O-A is conditional upon A."

Nonetheless, a little digging will uncover the good point that al-Hibri buries in that language. Suppose that at t₀ the door is in fact closed and the manager says nothing--she does not care whether or not the door is open or closed. We would say, in this case, that (2) is false: there is no obligation for the clerks to shut the door when it is opened. But since the door is closed, the antecedent of (4) is false and hence (4) is true.

How is this related to her objection? The way I read it is something like this: material implication is often faulted for not capturing the intended 'necessary' connection which is implicit (allegedly) in many English "if____, then ____" sentences. What we need to express that connection, it is argued, is strict implication.
Similarly, one might argue, (2) expresses something like a conditional: one which expresses a 'necessary' connection between the antecedent condition and the consequent obligation. That the obligation 'results' from the occurrence of the condition, or that the condition is the 'ground for' the obligation, is not expressed by the material conditional.

If that is the argument, it still needs to be fleshed out to go beyond then rejection of (4) to provide a reason for accepting the dyadic operator and (1). Let us continue the analogy between the problem with (4) and the strict-material implication problem. Strict implication holds between between A and B ( [ ](A → B) is true) just in case B is true at every possible world-time at which A is true. The material conditional 'A → B', on the other hand, holds at a particular world-time just in case either A does not obtain or B does. As al-Hibri points out—quite correctly—we do not want to base the truth of (2) solely on what happens in the present, actual world: we want all of a certain set of world-times to be such that they are either ¬A-worlds or else O-A-worlds. And we need, therefore, an operator whose purpose is to 'consult' all of those other world-times beyond the present one. Which world-times do we want to be considered? In this case, every future world-time. We want it to be the case that the obligation holds in every state of affairs in which the condition holds, or in other words, whenever the condition holds.

So far we have seen only that conditional obligations cannot be translated using the truth functional connectives and 'OA.' To show at least that much was necessary for al-Hibri in supporting her use of
the dyadic operator. But we do not need to use a dyadic operator if we have the temporal operator 'L.' We want a sentence which is true just in case 'O-A' holds at every A-world, and the following will do fine:

(5) \[ L(A \supset O-A). \]

(5) is true just in case every state of affairs in \( t_0 \)'s future is an 'A+O-A' state, hence either a -A-world or an O-A-world. Then every A-world is an O-A-world, and \( O(-A/A) \) is true. Now suppose that

(6) \[ O(-A/A) \]

is true. Then every A-world is an O-A-world; hence either a -A-world or an O-A world, hence an A+O-A world, hence \( L(A \ 0-A) \) is true. (5) and (6) do exactly the same things on their respective accounts.⁹

Al-Hibri's argument is effective only insofar as it shows that an account of deontic logic must utilize some intensional operator other than the monadic 'O.' But how we are to enrichen our logic is not thereby a closed matter: we can do it using either temporal operators and the monadic 'O' or by using the dyadic 'O.' Finally, the use of (5) instead of (6) satisfies Baron and Grandy's wish that we put the burden of the complexity of conditional obligations where it belongs: on the conditional and not on the obligation operator.¹⁰

We have up to this point paid no attention to what might constitute a world's being a morally perfect world. It is time now to address a problem which limits the scope of the whole endeavor of doing deontic logic.¹¹

The problem can best be seen as follows. The set \( M \) as used above is the set of morally perfect worlds in the future of the present
state of affairs. One of the following must be true:

(7) For every world, every obligation is satisfied in that world.

or else

(8) For some world in \( M \), there is some obligation which is not satisfied.

Suppose (8) is the case, and let \( A \) be whatever obligation goes unfulfilled in some world. By the truth conditions given for \( OA \) above, \( OA \) is false: \(-A\) occurs in some morally perfect. But our assumption was that \( A \) is obligatory. Hence either our truth conditions for 'OA' are wrong, or else (8) is false and (7) is true.

Defining 'OA' as 'A is true in every morally perfect world' has the support of a long tradition in the literature of deontic logic. Even those accounts which alter the standard definition do not avoid the problem just cited. In keeping with the tradition, we keep our basic definition of the deontic operator and conclude that (7) is true.

But then another problem arises. We have just defined the truth conditions for obligation reports in terms of what happens in morally perfect worlds. Those worlds, in turn, are worlds in which all of everyone's obligations are satisfied. Hence we have more than a hint of circularity in the project at hand.

That shows, I think, that deontic logic can neither claim nor even hope to analyze "x has an obligation to do A" with the apparati so far available. Whatever else deontic logic does, it does not tell us what it means for us to have an obligation. Rather, the use of our tools in doing deontic logic presupposes some account of obligations.

That result is not too discouraging so long as we remember that
the purpose of deontic logic is not to analyze the meaning of "obligation," but to determine what logical relations hold among deontic sentences. We do that by supposing there is a set of worlds in which all obligations are fulfilled, defining an 'obligation' operator in terms of that set, and then working out the appropriate deontic calculus. And this limited project is not crippled by the circularity inherent in trying to give an analysis of 'obligation' in terms of morally perfect states of affairs.

After acknowledging this limitation in the scope of our endeavor, there is nonetheless something to be gained by scrutinizing 'morally perfect states of affairs.' Almost all deontic logicians have avoided discussing the nature of these states in detail; in fact, all of deontic logic could be done in some sense with sets of numbers instead of sets of world-times, thereby avoiding any questions about the content of those world-times. But that is no reason why we should do deontic logic with domains of numbers any more than the Lowenheim-Skolem Theorem is a reason to do first-order logic without discussing domains of human beings or the fatherhood relation.

Returning to M, then, it is a set of world-times in which all obligations are satisfied. That there are two ways of construing that set, however, is not recognized by deontic logicians. In our discussions earlier in this chapter and in the previous chapter, we spoke of personal obligations as the objects of our study, Nathan's obligations or Paula's obligations, etc. If we consider the union of Nathan's obligations with Paula's, with John's...and so on. We are ready now to distinguish between two sets of morally perfect
world-times:

$M^e = \text{the set of world-times in which each person fulfills all his obligations,}$

$M^a = \text{the set of worlds in which agent } a \text{ satisfies all of his obligations.}$

We have not made it clear which set is the proper set to be used in our deontic logic investigations. First, we note that $M^e$ is a proper subset of $M^a$ (suppose $a$ is Alan). If everyone fulfills all his obligations, then Alan surely fulfills all of his, hence any world-time in $M^e$ is in $M^a$. Furthermore, there are world-times at which Alan fulfills all his obligations but some other people are negligent and do not fulfill all of their obligations. Thus there are $M^a$ worlds which are not $M^e$ worlds. We return to our stock model and label $M^a$ and $M^e$ accordingly:

Consider the sentence "Alan has an obligation to be in Boston on Friday," where $t_0$ is Thursday and $t_1$ is Friday. That sentence is true just in case Alan is in Boston on Friday in every morally perfect state of affairs.

Suppose we choose $M^e$ as our set of morally perfect states. That is, we consider a state of affairs morally perfect just in case every
person fulfills all his obligations in that world. I think it is a very real possibility that the present state of affairs is loaded in such a way that it is now causally impossible that each person fulfills all his obligations on Friday. And if that possibility is in fact the truth, then \( M^e \) is empty. But when \( M^e \) is empty, any sentence 'A' whatsoever satisfies the condition that "A holds at every element of \( M^e \);" hence OA is true for every sentence A. On our semantics, then, if there is a very good chance that \( M^e \) is empty, then there is also a very good chance that every state of affairs is obligatory.

One way a logician may think of retaining \( M^e \) but avoiding the counterintuitive result above is to add a codicil to the right side of the definition of the 'O' operator:

\[
\text{OA is true iff } A \text{ in every morally perfect state of affairs (element of } M^e \text{ ), and there is at least one morally perfect state of affairs—} M^e \text{ is not empty.}
\]

The addition of the conjunct "\( M \) is not empty" would take care of the problem that arises when there are no morally perfect states: it would not follow that everything is obligatory, because the right hand side would be false for any A.

Is that any better a result? Since the right side is never satisfied when \( M^e \) is empty, OA is false and -OA is true for any A whatsoever, and by our schema from earlier, P-A is true for any A whatsoever. Hence if there are no morally perfect worlds—which is not out of the question—then every state of affairs is permissible. That, I think, is no less disturbing than the case in which everything is obligatory. The trouble here is not something which can be solved by tinkering with the definition of the truth conditions for the
obligation operator.

The way out of the problem is to reconsider what we are taking as the set of morally perfect states of affairs, and the arguments above should lead us to use $M^a$ as that set in our truth definitions. This is how it should be, after all, since we are concerned with how Alan's obligation to do $A$ is related to his obligation to do $(A \lor B)$, $(A \land B)$, etc., and there is no a priori reason for us to restrict our attention to $M^e$. Whether or not everyone else satisfies all of their obligations is not immediately (or perhaps even remotely) relevant to the logic of Alan's satisfying his.

In what follows, therefore, I will take $M$ to be the set $M^a$, the set of worlds in which the agent at hand satisfies all of his obligations. From a purely formal standpoint, remember, it does not matter whether by $M$ we mean the set $M^e$, the set $M^a$, or even the set $M^m$ of worlds in which there are fewer females than males: exactly the same logics are validated regardless of what $M$ is. But if there is any point in talking about sets of morally perfect states of affairs instead of sets of male-dominant states, the point also favors using $M$ as the set of morally perfect states of affairs.13
In this chapter I extend the use of temporal semantics for deontic logic to discuss two principles which one often meets in the study of deontic logic. The two sets of formal principles which I discuss below try to capture the intuitions that what is obligatory is possible and that what is necessary is obligatory. I will begin by considering what the semantic account developed in the first two chapters has to contribute to previous discussions, and will then consider a different intuitive approach to the problems which the formal principles address.

Our tools so far include the definitions of operators for 'obligation' as found in both the monadic and the dyadic accounts:

(M1) OA is true iff A is true in every w ∈ M,

and,

(D1) O(A/C) is true iff A is true in every C-world w such that w ∈ M.

The first group of formulas under consideration are those which correspond roughly to the principle that 'ought' implies 'can,' or that a person cannot be obligated to do what he cannot do.

(1) \(-O(A \& -A)\)
(2) \(-O(A \& -A/C)\)
(3) OA \rightarrow FA
(4) O(A/C) \rightarrow P(A/C)

Among other things, we want to see how choosing truth conditions for the monadic and dyadic operators affects the resulting deontic logic,
so we must pay particular attention to the truth conditions for the formal principles under scrutiny.

(1) and (2) say, respectively, that no contradiction is obligatory and that no contradiction is obligatory under any circumstances. Using (M1) and (D1), consider the possible truth values for (1) and (2). Either there are morally perfect states of affairs (C-worlds) or there are not any morally perfect states of affairs. Suppose that there are morally perfect states. In those worlds, \((A \& \sim A)\) is always false, hence \(\Box(A \& \sim A)\) is false as is \(\Box(A \& \sim A/C)\). And thus if there are any elements in \(M\), then (1) and (2) come out true. On the other hand, suppose that there are no morally perfect states of affairs, and therefore no morally perfect C-worlds. In that case, the right hand sides of (M1) and (D1) are satisfied regardless of what 'A' is. So the right hand side is satisfied when 'A' is replaced by '(A \& \sim A)', and both \(\Box(A \& \sim A)\) and \(\Box(A \& \sim A/C)\) are true, hence (1) and (2) are false when \(M\) is empty. (M1) and (D1), therefore, do not validate (1) and (2), respectively.

If one believes that 'ought' implies 'can,' the result above shows that (M1) and (D1) must be modified in some way. After all, nobody can do the contradictory, hence contradictory states of affairs cannot be obligatory states of affairs. (1) and (2) can be validated by replacing the definitions above with the following:

\[(M2) \quad \Box A \text{ is true iff } A \text{ is true in every } w \in M, \text{ and there is some } w \in M.\]

\[(D2) \quad \Box(A/C) \text{ is true iff } A \text{ is true in every C-world } w \in M, \text{ and there is some C-world } w \in M.\]

By adding the codicil that there are morally perfect states in \(M\), (M2)
and (D2) avoid the problem that arises when M is empty. For if M is empty, then the right hand side of each is false regardless of which 'A' we choose, hence false when we choose '(A&-A).' Since the right hand side of the biconditional in the definition is false, so is the left, and (1) and (2) are thereby always true, that is, valid. In the case where the set of morally perfect states of affairs contains at least one element, the right hand side of (M2) and (D2) are always false when 'A' is replaced with '(A&-A)' so in that case too (1) and (2) come out true.

Furthermore, (M2) and (D2) validate the stronger principles (3) and (4). The latter two say respectively that what is obligatory occurs in some causally accessible future state and that what is obligatory, given C, occurs in some morally perfect C-world. It is important to note that these principles are stronger than those expressed in (1) and (2); the effect of validating (3) or (4) is to strengthen the interpretation of 'A can occur' from 'A is non-contradictory' to 'A is causally possible.'

This difference arises in part from our having chosen carefully to model deontic sentences with temporal models and having defined temporal operators for our language. Not all authors (few, in fact) have done so. Many of the early deontic logicians took the possible world-times of their models to be the logically possible world-times and defined M to be a subset of that set of logically possible world-times such that M included exactly all the logically possible and morally perfect states. Hence $M^1$ (their M, as I will it) included states which our M does not. What is the difference?
Suppose Penelope is in Austin at noon on Thursday. We want to consider whether or not she can be obligated to be in Paris, France at one o'clock in the afternoon on Thursday. On the model we proposed and utilizing (M2) as the definition of the obligation operator, it is not possible that she is obligated to be in Paris at one o'clock. Given our means of transportation there is no way to go from Austin to Paris in one hour, so if the noon world includes Penelope's being in Austin there is no causally accessible state of affairs; hence no element of M, in which Penelope is in Paris at one. (This, of course, does not entail that she cannot be blamed for not being in Paris at one, it just means that at twelve o'clock it is false that she has an actual obligation to be in Paris an hour later.)

When the world-times of the model are logically possible world-times, however, and M^1 is the subset of those which are morally perfect, then M^1 contains world-times which M does not. After all, it is logically possible that there is a morally perfect state of affairs in which Penelope is in Paris at one o'clock after having been in Austin at noon. Now if we replace 'M' with 'M^1' in the definition of the obligation operator, then there is a morally perfect state which includes Penelope's being in Paris even there is no causally accessible state like that. Hence when M is used,

(3) OA + FA

is false in some instances; hence it is not valid. The principle corresponding to 'ought' implies 'can' which the modal account we are discussing does validate is the principle,

(4) OA + [-[]]-A.
It says that what is obligatory is logically possible. We note here that whatever is causally possible is logically possible, so (M2) as it stands--and using our version of M (causally accessible; morally perfect states)--also validates (4). Looking at (M2), we suppose that 'OA' is true; then every morally acceptable, causally accessible world-time contains And there is such a world-time; hence there is a causally possible world-time at which A occurs; hence there is a logically possible world-time at which A occurs, hence '-[A]' is true.

Let us review what we have seen so far. Using (M1) or (D1) with our temporal model will not validate either (1) or (2); that is, it does not always come out true that contradictory states of affairs are not obligatory states of affairs. Many people believe that 'ought' implies 'can,' and are thereby led to reject (M1) and (D1). On our model, one way to make (1) and (2) valid is to use as our definitions (M2) and (D2) so as to require that obligations occur at some causally accessible world-time. And at those world-times contradictions never occur, and thus contradictions are never obligations.

We noticed further that there is a stronger formula validated by (M2) and (D2) than (1) or (2); that formula says that whatever is obligatory occurs in a morally perfect; causally accessible state of affairs. However, in going from 'non-contradictory' to 'causally accessible,' we skipped over a different interpretation of 'A can occur': the interpretation which reads that phrase as 'A occurs in some logically possible state of affairs.' The modal interpretation of that 'can' operator was used by earlier logicians who did not have the tools (or did not use them) to strengthen the formulation of
"'ought' implies 'can'."

This is not merely an academic point. What is at question is how close our logic can come to representing and validating the Kantian principle in question. There is probably not unanimous agreement as to what 'can' means in that maxim, and our logic should not limit us as to what it might mean. Yet we have seen how earlier accounts have only been able to formulate fairly weak interpretations of the Kantian principle.

Our approximation of that principle as (3) and (4) is still not the strongest, and we will see later in this chapter how our semantic account can be enriched to enable us to formalize and validate a formula even stronger than (3) or (4). Before we take up that task, however, we turn to a different set of formal principles: principles which express the belief that 'necessary' implies 'obligatory.'

To refresh the reader's memory, look again at the original 'standard' definitions of the obligation operator with which we began:

(M1) OA is true iff A is true in every w ∈ M,

and

(D1) O(A/C) is true iff A is true at every C-world w such that w ∈ M.

The principle that what is necessary is obligatory finds its way into every extant deontic logic through one or another of the following theorems or rules:

(5) []A → OA

(6) from ⊨ A, infer ⊨ OA

(7) O(T/T)

(8) OB + ([]A → OA)
(9) \( O(B/C) \rightarrow O(T/C) \).

While there are shades of difference between (5), (6) and (7), I will not detail those differences since they are not important to the discussion here. (5) says that what is necessary is obligatory, (6) says that what is valid is obligatory, and (7) says that tautologous states of affairs are obligatory under any condition (except the impossible condition). If we look at the right hand sides of (Ml) and (Dl), respectively, and note that \( M \) is a subset of the set of causally possible futures, then we see that whatever is true in every causally possible future is an obligation on our account. (Av-A) is true in every causally possible future, so the following are also true:

\[(5^*) \quad [](Av-A)\]
\[(6^*) \quad \models (Av-A)\]
\[(7^*) \quad O(Av-A/T)\]

Those, taken with (5) through (7) above, each yields 'O(Av-A)' as shown below:

\[(5^{**}) \quad O(Av-A) \text{ follows from } [](Av-A) \text{ and (5) my modus ponens.}\]
\[(6^{**}) \quad \models O(Av-A) \text{ follows from (6*) and the rule (6).}\]
\[(7^{**}) \quad O(Av-A) \text{ follows from (7*) and the definition } OA =df (A/T).\]

In short, whenever (Ml) or (Dl) is used, we get the result that every tautologous state of affairs is an obligatory state of affairs.

al-Hibri uses that result to argue against (Ml) and (Dl), and her method is to argue that 'O(Av-A)' should not be valid in deontic logic. She provides two arguments against positing the validity of 'O(Av-A)."
First, she points out, if we take 'O(Av-A)' to be valid and make sure that our semantics validates that formula, then we end up being committed to the existence of obligations. On any model of ours, 'O(Av-A)' will come out true, and thus (Av-A) will be an obligation. So in using (M1) or (D1) we make it a principle of our logic that obligations exist.

Second, she argues, we are supposed to be talking about moral obligations. And it is not clear that it makes any sense to say that one is morally obligated to insure that (Av-A) occurs; after all, it occurs at every world-time. From that consideration and the one above, she concurs with von-Wright's judgment that the most plausible course seems to be to regard O(Av-A) as expressing [a] contingent proposition which can be either true or false.3 Baron and Grandy say nothing along the lines of al-Hibri's second objection, but they too want to avoid being committed to the existence of obligations as a matter of logic.4 And since (M1) and (D1) so commit one, they join al-Hibri in dropping (M1) and (D1) in favor of (M2) and (D2), which we introduced earlier:

(M2)  OA is true iff A is true in every w ∈ M, and there is some w ∈ M.

(D2)  O(A/C) is true iff A is true in some C-world w ∈ M, and there is some C-world w ∈ M.

We saw earlier how adopting (M2) and (D2) resulted in validating stronger principles expressing "'ought' implies 'can':" In this case, however, (M2) and (D2) validate principles expressing "what is necessary is obligatory" which are weaker than (5) through (7). The formulas which come out valid are:
(8) \( O\beta \to ([\Box]A \to OA) \)

and

(9) \( O(B/C) \to O(T/C). \)

(8) and (9) say, respectively, that if there is some obligation \( B \) then whatever is necessary is obligatory, and that if some \( B \) is obligatory under some condition \( C \), then whatever is tautologous is also obligatory under \( C \). When (M2) and (D2) are used, the authors get the desired result: if there are no obligations, then what is tautologous is not obligatory, hence (5) and (7) are not valid and the rule (6) is not sound.

But at what cost have they avoided validating (5), (6) and (7)? As we review the justification for using (M2) and (D2) in the first place, we will see that little has been gained by the switch.

al-Hibri's first argument against (M1) and (D1) is that it is strange to say of a tautologous state of affairs that it is morally obligatory. (9) is valid on her account; however, so suppose that there are some non-tautologous obligations in the world. The sentence \( O(B/C) \) is true, then, and from that and (9) it follows that whatever is tautologous is obligatory. Even on her account, then, the plausible assumption that there are non-trivial obligations forces us to say of the state \( (Av-A) \) that it is a morally obligatory state. And thus her first justification may be correct insofar as it show that we need to dump (M1) and (D1); but for the every same reason it also shows that we ought to reject (M2) and (D2)!

The second argument she gives against (M1) and (D1); and the position which Baron and Grandy take, is that those two definitions
make the existence of obligations a principle of our deontic logic. The reason is simple: everyone will always have an obligation to do (Av-A), hence have some obligation.

As al-Hibri notes, (Av-A) sometimes comes out obligatory on her account and sometimes it does not. In which cases is O(Av-A) true? As on Baron and Grandy's account, O(Av-A) is true exactly when there are other, non-trivial obligations. In other words, (Av-A) is an obligation if and only if there is some non-necessary state of affairs B such that B is obligatory. But that leads to a strange consequence: a person is obligated to (Av-A) when he has some other obligations, but not so obliged when he has no other obligations. And his having other obligations does not seem even remotely related to whether or not (Av-A) is a moral obligation of his.

We might accept (M2) or (D2) on the grounds provided earlier in the discussion of "'ought' implies 'can':" But the debate over (5) through (9), while giving us a reason to reject (M1) and (D1), gives us no independent reasons for accepting (M2) and (D2) as the definition of the obligation operator. We will address the question of what can be done to avoid validating (5) through (7) at the end of this chapter.

For now, we return to our discussion of "'ought' implies 'can'," where we saw three ways in which our logic formalized 'can A': as "A is non-contradictory," as "A is logically possible," and as "A is causally possible." In 1976 Keith Lehrer introduced a possible worlds analysis of the 'can' operator, and since then Graham Oddie and Pavel Tichy have refined the analysis and developed a Byzantine logic to
accommodate the analysis. The approach of those philosophers is quite similar to our approach, and while the logic of the 'can' operator is itself a subject worthy of detailed study, we will use only the most basic of previous logicians' findings.

As usual, we start with a branching temporal model with a present time $t$ and a valuation function $V$ which assigns truth values to sentence-world pairs. In our definition of the obligation operator, we partitioned the set of causally possible futures into two subsets: the set $M$ of morally perfect world-times and the set $\overline{M}$, $M$'s complement. Our definition then used the set $M$ in introducing the deontic operator:

$$V(OA) = T \text{ iff } V(A,w) = T \text{ for all } w \in M.$$ 

We will want to do roughly the same thing for the 'can' operator, but before we get to it we should consider the motivation for complicating our logic.

We saw that the strongest principle which our logic validates concerning the Kantian maxim that 'ought' implies 'can' is the formula

$$(3) \quad OA \supset FA,$$

which says that what is obligatory happens in some future world causally accessible to our world. Now we ask the question: does 'Jennifer can A' just mean that Jennifer does A in some causally accessible world? In some sense of "can" it might mean that, but does it in the sense that a person cannot be obligated to do what she in fact 'cannot' do?

That it does not is shown, allegedly, by the following counterexample. Suppose two gunmen enter a bank and tie Jennifer to
her chair while they try to break into the safe. In the tree below, $t$ is the state of affairs immediately after the robbers bind Jennifer:

Should we say now at $t_0$ that Jennifer has an obligation to trip the silent alarm at $t_2$? In other words, is the following true at $t_0$:

(10) Jennifer has an obligation to trip the alarm at $t_2$?

(10), I think, is obviously false. Jennifer cannot trip the alarm at $t_2$ in any reasonable sense of the word "can," and by the principle that 'ought' implies 'can,' she cannot be obligated to trip the alarm.

However, the sentence 'FA' comes out true at $t_0$ on our account. Suppose that at $t_1$ one of the robbers gets soft-hearted and unties Jennifer. Then at $t_2$ she is free and in one of the $t_2$ states is pushing the alarm button. Thus there is a $t_2$ state in which Jennifer trips the alarm, hence a causally possible state in which she does so, and thus 'FA' is true at $t_0$. Since 'FA' is true, however, we cannot use (3) above and the claim that at $t_0$ "Jennifer cannot A at $t_2"$ to infer that 'OA' is false at $t_0$. And in order to replace (3) as a translation of "'ought' implies 'can'" with a stronger formula which will allow us to make that inference, we need a stronger interpretation of 'can.'
The relevant feature of the example above which made "Jennifer can A" false at $t_0$ but 'FA' true at $t_0$ was that the world in which A is true at $t_2$ included Jennifer's having been freed from her chair. In other words, she gained an advantage over her situation at $t_0$. There are other ways in which she may have gained an advantage: a passerby might have come in and untied her, the robbers may have returned and pushed her up against the wall where she could reach the alarm with her foot, etc. We can divide the set of world-times causally possible from $t_0$ into two subsets accordingly: the set $B$ of world-times in which Jennifer's situation improves, and the set $\overline{B}$ of world-times in which she does not gain an advantage over her situation at $t$. And we can now define the 'can' operator in terms of $\overline{B}$:

$$V(CA) = T \text{ iff } V(A,w) = T \text{ for some } w \in \overline{B}.$$ 

In English, "Jennifer can A" is true at $t_0$ just in case there is some causally accessible world to $t_0$ in which Jennifer does A without gaining an advantage over her position at $t_0$.

We are eventually going to have to refine our partitioning of world-times into the sets $B$ and $\overline{B}$. Suppose, for example, that the robbers are careless and tie Jennifer's hands very loosely. She could improve her situation very easily by wriggling around a little and freeing herself from the rope. In that case, I think we would want to say at $t_0$ that she is obligated to trip the alarm at $t_2$. But as we have chosen $B$, 'CA' is false since that world in which she frees herself includes her gaining an advantage over her $t_0$ state. The way to avoid this sort of counterexample is to play around with $\overline{B}$ so that it does not include states in which Jennifer gains the advantage by
her own doing.

While redefining B in the way suggested would avoid that counterexample, there are other counterexamples to the resulting definition of the 'can' operator, all of which involve the way in which B is chosen. Oddie and Tichy's goal is to investigate the ways of characterizing B to avoid those counterexamples and to provide an analysis of 'can.' This is not the place to go into fine details about the 'can' operator, and I will assume that there is some reasonable account of 'can' and that it is given in the same form as the definition above.

If Graham and Oddie are right that it is so done, then we have a new principle which our logic validates:

\[(11) \quad OA \rightarrow CA.\]

By defining B and adding a 'can' operator 'C' in terms of B to our account, we increase the variety of ways in which "'ought' implies 'can'" might be translated into our language, and thus allow us to better approximate (some think) the Kantian maxim. We have the four following candidates for translating "'ought' implies 'can'":

\[(1) \quad \neg O(A \& \neg A)\]
\[(4) \quad OA \rightarrow [\square]A\]
\[(3) \quad OA \rightarrow FA\]
\[(11) \quad OA \rightarrow CA.\]

As I mentioned earlier, some people find that the 'can' operator as defined above is too strong to capture the 'can' of the Kantian maxim. That need not bother us here; our semantics can be adjusted in various ways so that only a weaker principle is validated.
The 'strengths' of the formulas (3), (4) and (11) are determined by the set each uses in the interpretation of the 'can' operator; that is, the set associated with the truth conditions for the intensional operator in the consequent of the formula. The relevant sets are ordered by inclusion as follows (where "[w:P(w)]" is read "the set of world-times w such that P"): 

\[
\begin{align*}
&[w : w \text{ is logically possible }] \supset \\
&[w : w \text{ is causally possible }] \supset \\
&[w : w \in E].
\end{align*}
\]

As a result, any semantics which validates one of the four formulas above also validates the others preceding it.

Philosophers writing about deontic logic, on the other hand, have been seeking ways in which to weaken the formal analog of "'necessary' implies 'obligatory'," as we saw above. There has been only one suggestion along those lines so far, namely that a necessary state's being obligatory be conditioned on the existence of non-tautological obligations.

One of the observations which led to the suggestion was that it does not make a lot of sense to talk about a person's being obligated morally to do (Av-A) since it is something she must do. Some moral philosophers, thinking along those lines, believe that the moral sense of a person's being obligated to do A presupposes that his doing A is not determined. In other words, 'OA' cannot be true at t₀ if the question of whether or not the person will do A is decided at t₀.

I have left the notion of an agent's being 'determined' to do A—or it being decided that he will do A—somewhat open; we will see
that there are various ways in which we can capture that notion in our logic, and that a philosopher can adjust her semantics to validate the formulas she feels appropriate. So far we have seen that the formula

\[(12) \quad O(A \lor -A)\]

is valid on our semantics when we define the obligation operator as follows:

\[V(OA) = T \text{ iff } V(A, w) \text{ is true for all } w \in M.\]

As pointed out earlier, whatever is true at all world-times is true in all elements of \(M\), so \((A \lor -A)\) is true throughout \(M\) and \((12)\) is always true. I argued against the move that al-Hibri and Baron and Grandy made to weaken \((12)\) to a conditionalized version thereof on the grounds that if it does not make sense to talk about \((A \lor -A)'\)'s being obligatory, it does not help to make it obligatory only when some other, non-trivial obligations exist. The simplest way to avoid validating \((12)\) while keeping the assets of \((M2)\) (one asset was that \((M2)\) validates \(-O(A \& -A)\), as we saw above) is to adopt

\[(M3) \quad V(OA) = T \iff \begin{array}{l}
i) \quad V(A, w) = T \text{ for all } w \in M; \\
ii) \quad \text{for some } w, w \in M, \\
& \text{and } iii) \quad V(A, w) = F \text{ for some } w \text{ after } t_0. \\
\end{array}\]

The third clause on the right hand side guarantees of obligations that they are not causally necessary states of affairs. Since \((A \lor -A)\) always holds, clause (iii) fails for \((A \lor -A)\) and thus \('O(A \lor -A)'\) is false.

By using \((M3)\) we thus avoid the problems of trying to make sense of a necessary state of affairs being obligatory, and with our new definition we are not committed to the existence of any obligations. For suppose \(M\) is empty: (ii) is false, hence \('OA'\) is false for any
'A,' hence for the troublesome '(Av-A).' 

(iii), however, is a fairly weak condition which some may find too weak: it only says that what is obligatory cannot be tautologous. If a moral philosopher believes that the very concept of 'obligatory that A' presupposes that A has not been determined, she can vary (iii) to accommodate stronger versions of 'decided.' These possible interpretations correspond nicely to interpretations of 'can.' The versions are as follows: "it is not decided that A" is true if and only if:

(14) A and -A are each logically possible,
or (15) A and -A are each causally possible,
or (16) 'can A' and 'can -A' are both true.

(M3) above uses what amounts to (15). The logician can alter clause (iii) of (M3) to accommodate (14) or (16) by changing it to read

(14*) (iii) -A in some logically possible state of affairs,
or
(16*) (iii) A in some w B, and -A in some w B.

By adding one of those clauses to (M2) and obtaining some version of (M3), one thereby validates some of the following formulas:

(17) ¬O(Av-A)
(18) OA→([-]A & [-]-A)
(19) OA→(FA & F-A)
(20) OA→(CA & C-A).

Any account which validates one of the four above also validates those which precede it. 8

By introducing operators for tenses and for 'can', and by enr
ichening our models by partitioning the set of future world-times in a variety of ways, we have obtained a logic more versatile than we had before; that versatility lies in its ability to better translate, validate, and thereby model English sentences.

One may get the impression that on the semantic basis provided above, choosing the proper deontic logic is a simple matter. After all, we need only pick out the formulas above which are most appealing intuitively and choose the definitions of the operators which validate those formulas. Unfortunately, the matter is not so simple. I will present an argument which shows that the cost of validating some of those formulas is very high. The argument presupposes that our logic has been extended to include quantification theory, however, so I will begin by considering why we should want to extend our logic.

There are two reasons why we might want to include some sort of quantification theory. The first and most obvious reason is that our logic is much more powerful when we include quantificational logic. All of the assets I claimed for our semantic in the paragraph preceding the last would hold for the extended logic. It is a brute fact that we use "some," "all," "any," etc., in our everyday language, and the inability of our logic to translate and model quantified sentences is clearly a deficiency.

The second reason is more sophisticated. I have assumed throughout this essay that the 'present' moment of time in the temporal models and that the agent of the obligation reports were specified in advance (see above, pp. 4, 15-17). When I defined the tense and deontic operators, I noted that the operators were 'indexed'
implicitly to the time or the agent, respectively. I did so for the sake of simplicity, but in doing so I paid the price with a loss of generality. I might instead have complicated the logic by introducing apparatus so that the respective operators could take into account all agents or times.

This is not an easy point to understand (or to explain, for that matter), so let us look at a simpler example. We could if we wished take an English sentence like "All logicians are clever" and explain it thus: take any object \( o \) you want, the following is true of \( o \):

\[(21) \quad L \cdot C.\]

We then continue: "the sentence letters are interpreted '\( o \) is a logician' and '\( o \) is clever,' and we assume that \( o \) is given in advance." We almost never see such an account: quantificational logic puts the quantifiers right into the formal language so we do not mess around with all the 'take any \( o \)' phrases:

\[(22) \quad (x)(Lx \cdot Cx).\]

The point here is that our logic should, ideally, do the same. Some philosophers argue that we in fact must include quantifiers to generalize on obligatory acts or states of affairs if we really want to model English deontic sentences. The debate over the necessity and proper role of quantification in our language is by no means closed. While I will not discuss the debate here, it is important to notice this possible shortcoming in the account at hand. It is reasonable, at least, to think that we will eventually want to include quantification theory in our logic.

When we do extend our logic to include quantification theory,
however, we run into a serious problem. (The problem and its proof was pointed out to me by Richard Grandy.) Suppose we want our semantics to validate (18) above— that we do not want valid states of affairs to be obligatory states of affairs.

Now consider the following sentence where 'C' is any sentence letter and 'A' is any formula not containing 'C' as one of its subformulas:

(23) \( \vdash OC \rightarrow O(CvA) \) iff A is not valid.

(23) is false and will be proven so by reductio. Suppose (23) is in fact true. The theorems of a language can be listed mechanically, and we can generate two lists: the first list will include only the theorems of quantification theory, the second will include only theorems of our deontic language. If (23) is true, then whenever a formula A is not valid, 'OC→O(CvA)' will appear somewhere on the second list. But then we have a mechanical test for validity: every formula A will appear either on the first list (as a theorem of quantification theory) or on the second list (as a subformula of a deontic theorem). By checking back and forth between the lists, we sooner or later will find either 'A' or 'OC→O(CvA)', and from (23) be able to tell whether A is valid. Unfortunately, Alonzo Church proved (Church's Undecidability Theorem) that quantification theory is undecidable, that there can be no mechanical test for determining whether a formula in a language including quantification theory is valid. Therefore, (23) must be false!

Why should that cause us to pale? We assume that our logic is sound— that all of its theorems are valid. As long as that is so,
whenever \(OC \rightarrow O(CvA)\)' can be proven from our axioms and rules, \(A\) is not valid (that is how we want it). The conditional going from left to right, therefore, is true under the assumption. So the conditional going from left to right is false. That means for some \(A\) which is not valid, we cannot prove \(OC \rightarrow O(CvA)\)' even though the latter is a valid formula?

We see, then, that the versatility which we bring to deontic logic is helpful in allowing us more choices among formulas which we can validate. But by increasing the versatility of our logic to include quantification theory, we may be presented with a choice between two alternatives, either of which causes more trouble than we had before we were allowed to make the choice.
Richmond Thomason uses the deontic model in an interesting attempt to relate morally 'right' choices to obligations.\(^1\) He begins with the standard temporal model and the 'ought set' M—the set of futures in which the agent fulfills all her obligations—and then introduces what he calls the 'choice set C.' In his words, the choice set

\[
\text{...is the set you will (ceteris paribus) adjust your actions so that some member of the set should be realized—you devote yourself to realizing some member or other of the set.}\quad 2
\]

For example, I may plan to go to Montana during Christmas this year and adjust my actions accordingly so that I end up in Montana. My choice set C, then, is some subset of possible futures in which I am in Montana at Christmas.

The choice set might be narrower if I put more constraints on my Christmas: that it be one in which I give my brother a toy train set, for example. It can be narrowed in a different way, too. If my choice set for October includes my being in Colorado, then my choice set for Christmas includes at most those worlds in which at Christmas my past includes having been in Colorado during October. We need to keep this implicit temporal indexing of choice sets in mind and remember that future choice sets can affect what belongs to their successors.

Ignoring this complication for now, we are ready to see what use Thomason makes of his 'choice sets.' There are, Thomason says, various ways in which C can be related to the 'ought' set M. Consider
the temporal model below, with Cl, C2, and C3 representing different possible choice sets, and M representing the ought set:

Remember that M is the set of states of affairs in which the agent fulfills all of her obligations, and each choice set represents a set of futures which the agent could devote herself to actualizing. Now, says Thomason, we can characterize the agent's dutifulness as follows:

- **Cl**: The agent acts dutifully; she chooses to act so as to fulfill all her obligations.

- **C3**: The agent transgresses; she chooses to act so as not to fulfill all her obligations.

- **C2**: The agent neglects her duty; she does not choose to act so as to fulfill her obligations, but neither does she transgress her duty.

That all seems fairly reasonable from an intuitive standpoint. Suppose Alexandra has borrowed a watch from Paul and promises to return it on Friday. She may plan to do so when she borrows it (Cl); on the other hand, she may plan to leave the country forever and keep the watch (C2); finally, she may hock it and use the money for a poker game, in which case she knows she may lose and not be able to buy the watch back on Friday to return it (C3).

In the previous three chapters I have tried to show how temporal
semantics can be used to define various operators and thereby translate English sentences and investigate the logic thereof. In the case at hand, however, I will argue that there are serious problems with Thomason's approach to using temporal semantics and choice sets to characterize moral decisions.

Every time one of us acts in any way, we in some minimal way determine what the future is going to be like. When I choose to go bowling this evening and then eventually do so, I determine that every future will include my having gone bowling tonight. In some sense, I 'choose' not only certain actions, but also all of the world-times which have that action in their pasts. We can generalize this for sets of world-times and their futures, too. Let us call the result set, \( R(C) \) the set of futures in the model of all the states of affairs in my choice set. On the picture below, \( t_0 \) is the afternoon during which I decide to go bowling and \( t_1 \) is the evening of that day:

![Diagram](image)

At \( t \) my choice set includes B-worlds only. The set \( R(C) \) is the set of all those B-worlds' futures, or the various ways the world could turn out after I go bowling:

The choice sets, as mentioned above, must be indexed to times since my choosing to "be in Colorado in October" and my choice to "be
in Montana at Christmas" pick out different subsets of world-times. And, of course, R is indexed to a particular choice set since it just picks out the futures of those choice set states. Bear with me, then, when I write 'Ct_n' to denote the individual's choice set for the future world at t_n, and 'R(Ct_n)' to denote the result set of the choice set Ct_n. In the picture immediately above, Ct_n consists of those two worlds at which B is true, and R(Ct_n) is the set of those B-worlds' futures.

Now the following situation might arise:

I decide at t_0 that I will go bowling at t_1, so my choice set Ct_1 contains only the B-world at the top of the tree. Suppose I also decide at t_0 that I am going to visit Francine later, at t_3. However, R(Ct_1) and Ct_3 do not intersect. The way the world is set up causally, there is no future from t_0 in which I both go bowling at t_1 and visit Francine later at t_3. My plans are not realizable.

It might not seem that there is anything troubling about the case above; it just looks like a complicated way to express the intuitively simple idea that it is not always possible to fulfill all our goals. But as we shall see, that is exactly the problem with Thomason's
account.

Let us take a case which is similar to the one above, except that it includes obligations as one of its relevant features. Edgar is the manager of a restaurant and at closing time he can decide to go out the back door and drive to the bank to deposit the day's receipts, or he can decide to go out the front door on the way to the bank. He decides while sitting at his desk that he will go out the back door. He does not know, however, that a gunman lies in wait to rob Edgar of the money. Edgar is very duty conscious, so naturally he plans to drive to the bank to deposit the money. His situation looks like this while he sits behind his desk:

His choice set $C_{t_1}$ includes only back-door worlds, but then $R(C_{t_1})$ contains no worlds in which he deposits the money. His choice set $C_2$, which looks originally like it could contain two world-times at $t_2$ cannot in fact include any since there are no world--times in which he goes through the back door and ends up at the bank with the money. If we were to look at the choice sets apart from each other, we would see that their predecessors (the worlds in their pasts) only intersect before $t_1$, so Edgar has made choices which cannot be realized.
simultaneously. (The idea is that in order for choice sets to be realizable simultaneously, \(R(C_{t_n})\) must be a subset of \(C_{t_n}\) where \(t_n\) is later than or at the same time as \(t_m\). Another way to state that requirement is to say that their predecessors must intersect at or before \(t_m\).)

The problem this creates is that Thomason wants to talk about a choice set's being a subset of the set of causally possible futures. And then, he thinks, can he talk about the choice set's relation to the ought set \(M\), and then characterize dutiful action by the nature of that relationship. But in cases like Edgar's above in which the agent's choice set does not contain world-times causally accessible from the present, those sets have no place on the model and we cannot talk about their relation to \(M\).

On a slightly more normal level, his suggestion amounts to this: let \(C\) be the choice set of some agent and \(M\) the set of all worlds in which the agent fulfills all her obligations (ignore the indexing of choice sets to times for now). Then an agent acts dutifully when \(C\) is a subset of \(M\), she transgresses when \(C\) is a subset of \(\bar{M}\), and she neglects her duty when some element of \(C\) is in \(M\) and some element is in \(\bar{M}\). When as in Edgar's case the choice set is empty, both the first two definitions are satisfied and on Thomason's account she is both acting dutifully and transgressing.

There is a more general problem with his account. We first must see what constitutes 'gambling' on the account under consideration. A person who neglects her duty, on this account, is one whose choice set contains some states in \(M\) and some in \(\bar{M}\). Strictly speaking, however,
when we talk about the gambler it is not the choice set whose elements fall in or outside \( M \), but rather the consequences of her choice set (the result set \( R(C) \)) which is related to \( M \) in the appropriate way.

Consider the model below:

\[
\begin{array}{c}
\text{P} \\
\text{G} \\
\text{P} \\
\text{t}_0 \\
\text{t}_1 \\
\text{t}_2 \\
\text{-P} \\
\end{array}
\]

At \( t \) Allyson must choose between playing poker at \( t \) (\( G \) for gambling) or else not playing poker (\(-G\)). She is obligated to repay a loan at \( t_2 \) which she may not be able to do if she plays poorly. The characteristic of a gambler, then, is that \( R(C_{t_1}) \) -- when she chooses to gamble -- includes states in which she repays her loan (\( P \)) and states in which she does not (\( -P \)) at \( t_2 \).

Given that account of gambling, then, consider a slightly different story along those lines. In 1979 the Pennsylvania State Lottery was fixed so that the three-digit number drawn would be some combination of 4s and 6s. (The crooks weighted the other ping-pong balls with white paint. The number that evening came up 6-6-6, which raised grave conversations among the state's fundamentalists.) Now suppose that \( t_0 \) was right before the lottery, and Allyson spent her loan money on tickets. By happy coincidence, her favorite numbers were four and six, so she divided the money evenly and bet on all and
only the combinations thereof. When at $t_0$ Allyson had to choose between buying the tickets and paying the loan back, her futures looked like this:

Since $R(Ct)$ included only states in which she won with one of her lottery tickets and paid back the loan from the proceeds, her choice to gamble was in fact a choice to act dutifully on Thomason's account. After all, her choice set is entirely within $M$, so she could not have been gambling.

The problem with this case and Edgar's case which hurts Thomason's attempt is that our ignorance of the world can mislead us. What we envision when we make plans—what we devote ourselves to actualizing—may not be a subset of the set of causally possible states of affairs. And when we endeavor to explain moral choices or acting dutifully as a relation between 'choice' sets' and 'ought' sets, we need to ensure that our model is ontologically rich enough to represent those sets. As we have seen, our temporal models are quite poor in that respect.

I mentioned in the earlier example of Edgar's choice set (which included his going out the back door and to the bank) that while it
contained causally impossible states, its states might nonetheless be logically possible. It may seem, then, that Thomason's idea just needs a bigger set of worlds to make it work, namely the set of all logically possible worlds.

But I do not see that there is any way to do what he wants, even with the set of all possible worlds. I might know that I have six dollars in one pocket and eleven in the other, and believe that six plus eleven equals twenty. So when my choice set includes states in which I reach to take all the money from both pockets and hand you twenty dollars, it includes a logically impossible state of affairs. Thomason's attempt to use choice sets and ought sets to characterize dutiful choices is interesting. Unfortunately, the temporal model which he uses is inappropriate for his project, and there is no apparent way to modify either the model or his account to make the project work.
CONCLUSION

In Chapter One I introduced the temporal model to be used as the basis for the semantics of deontic logic. The model is designed to reflect our conception of the history and future of the world. As we believe that the past is now settled, the model contains exactly one point corresponding to each past moment of time. Intuitively, these points represent the ways the world used to be. On the other hand we generally believe that the world is indeterministic—that the future is not settled. To reflect that belief, our model includes many points corresponding to each future moment of time. Intuitively, each of these points represents one of the many ways the world could turn out at that moment.

I discussed briefly the formal operators which can be defined with that temporal model, and then went on to argue the central result of the first chapter: that there is in principle no formal operator which can be defined on our model which captures the belief that

(1) "A will occur at \( t_1 \) " is true at \( t_0 \) if and only if A occurs at \( t_1 \) in the actual future of \( t_0 \).

My own view is that the truth conditions for "A will occur" are exactly those of "A is settled" or "A is inevitable." I then argued that the reasons people usually give for accepting (1) do not in fact support that acceptance: the linguistic phenomenon which they think can be explained only by (1) can in fact be explained by our account of the 'will' operator. Nonetheless, I recognize that (1) is very
popular and that its proponents would sooner give up some other part of my account than to do what I have done, which is to equate 'will' with 'must' when it comes to giving truth conditions.

But now we need to step back a little and ask what part of the account may be given up so as to save (1). A quick review of tense logic will help. The principle objectives of providing temporal semantics are: first, to model accurately our conception of time; second, to model accurately the use of temporal operators in natural (English, e.g.) languages. One assumption that is made in this endeavor is that our use of temporal operators reflects our conception of time. If our tense operators do not have a basis in our conception of time, then there is no reason to think that a temporal model will serve well to define tense operators. In arguing that the 'will' operator cannot be defined as most people would want, I assumed implicitly that the model at hand reflects accurately our conception of time.

It looks, therefore, like there are two ways in which the defender of (1) can respond: she can challenge the assumption that the tree model used throughout this work accurately models our conception of time, or she can challenge the assumption that our tense operators in English reflect our conception of time. Neither alternative is appealing. To begin with, both of those challenges—if successful—would require some new model: in the first case, a model for time unlike our branching model; in the second case, a model for temporal operators unlike our temporal model. So far as I know, there is not a model yet which would satisfy (1). That there is no model is
certainly not an argument that there should not or cannot be a model. Nonetheless, anyone who wishes to support (1) needs to show that it can in fact be supported, and that will not be an easy endeavor. I believe that the search for support of (1) is bound to be futile. For the reasons outlined earlier, I do not see how any sense can be made of (1) which does not make the introduction of 'will' into our formal language impossible. Even if we agree that (1) is incorrect, however, there is still much explaining to be done. For example, we still need to explain why the following two sentences seem to be consistent:

(2) Reagan will win the 1984 Presidential election;

and

(3) Reagan might lose the 1984 Presidential election.

After all, uttering a sentence like "Reagan will win; he could lose, but he will in fact win," does not make the speaker sound like a babbling idiot. On my account, though, he is making inconsistent claims.

If I had a good explanation of why our non-idiot speaker seems to be making perfectly coherent conversation, I would have offered it. Unfortunately, I do not have such an explanation and that is a difficulty which I must concede. A solution may be found eventually, I think, by distinguishing between the appropriateness of an utterance and the truth value of the sentence uttered. For example, suppose I had just parked my car outside Lovett Hall and on my way to class Nat asks if he can borrow it. I tell him where it is and hand him my keys, and he says, "Look, I'm in a hurry...are you sure your car is behind Lovett?" I might respond, "Don't worry, I know it is there, I
just parked it." Now suppose that as soon as I had left the car a 
thief drove it off. Then my claim that "I know the car is there" is 
in fact false. Nonetheless, my use of that locution is appropriate.

Similarly, we might try to explain that while "Reagan will win the 
election in 1984" is in fact false, the utterance of that sentence 
might nonetheless be appropriate. (2) and (3) appear consistent; we 
continue, only because they can be both uttered by one person at the 
same time and be appropriate remarks. In any case, the result of the 
first chapter indicates that whichever side we support in the debate 
over 'will,' there is still much work to be done.

The second chapter began by introducing the reader to the 
semantics of deontic logic. I described briefly the two candidates 
for translating obligation reports: the monadic operator '0-' read 'it 
is obligatory that _____' and the dyadic operator '0(~/~),,' read -it is 
obligatory that _____, given that ____.' I then discussed the 
alleged necessity of the dyadic operator to formalize conditional 
obligations.

Several authors before me had suggested that a dyadic operator was 
unnecessary and undesirable. For example, in Baron and Grandy's paper 
we find the charge that

...the conflation of problems about obligation and 
the subsequent treatment of '0' as a dyadic operator 
often lead to incorrect results. '0' should not be 
blamed for the sins (of non-extensionality) of the 
conditionals.1

The authors had suggested that by utilizing a temporal model, one 
could separate properly the problems of the conditional from the 
problems of obligation. Unfortunately, they did not present any
general way in which that could be done.

In addition, they display but do not solve a problem with using the material conditional in translating conditional obligations. Suppose we translate "If John is robbing the store than you have an obligation to shoot him" as

\[(4) \quad J \Rightarrow OK.\]

To deny that obligation report by denying (4) is to assert 'J & -OK,' which is silly since John may not be robbing the store. Yet we still think the obligation report is false, hence (4) won't do as its translation.

Baron and Grandy attribute the identification of that problem to von Wright, who in turn gave that argument as showing the necessity of the dyadic 'O' operator. Curiously, however, von Wright seems to have changed his mind and jumped out of the proverbial pan into the proverbial fire:

it now seems to me possible to build a satisfactory theory of conditional norms using simpler and more conventional logical tools. I think that the notion of material implication will actually serve the purpose. The norm to the effect that, when it is the case that p, it ought to be the case that q may be rendered 'p \Rightarrow q.'

He then argues that he can defend that view against the 'standard' objection, which interestingly is not the objection which Baron and Grandy cite. He is just wrong in the passage above, and the counterexample given shows that convincingly.

My contribution to this debate was two-fold. First, using al-Hibri's rough argument as a base, I showed exactly where the problem of the non-extensionality of the conditional in "given C, it
is obligatory that A" lies. Conditional obligations amount to "Whenever C, OA" and in that occurrence, 'whenever' functions as a temporal (and intensional) operator. Second, I completed the argument for Baron and Grandy's claim that a dyadic operator is not necessary by demonstrating how our semantic basis enables us to translate 'O(A/C)' without complicating the obligation operator by making it a dyadic operator.

Is that finding important? From a purely technical viewpoint, it is interesting but not all that important. al-Hibri had already shown how the monadic operator could be defined in terms of the dyadic, so the result above only evened the score.

From an intuitive viewpoint, however, the result is important. In many cases in logic the choice of primitive operators is as much a matter of taste as a matter of anything else. We often see schemas like:

(5) \( (x)Fx = \text{df} \neg (3x)-Fx \),

and

(6) \( \Diamond A = \text{df} \neg [-A] \),

where we could have easily and reasonably reversed the definiendum and the definiens.

The work of theorists like Baron and Grandy and Thomason has shown, however, that choosing a primitive deontic operator between the two now available to us is not just a matter of whim. There are serious philosophical objections to taking the dyadic operator as primitive. My finding that there is no need for a dyadic operator, paired with the objections to the dyadic operator, leads us to the
proper choice of 'O- as primitive.

I acknowledged near the conclusion of Chapter Two a problem identified by Baruch Brody (a similar problem was pointed out to me by Christine Sistare): the 'morally perfect' worlds of our model must be worlds in which all our obligations are met. I pointed out that the effect of this problem is to limit what deontic logic is capable of doing; namely, it cannot provide an analysis of "it is obligatory that A," with its present apparati.

Finally, I concluded that there is nonetheless an important distinction which needs to be drawn concerning 'worlds in which all our obligations are satisfied.' We can construe that phrase as meaning that all of everyone's obligations are fulfilled or as meaning that all of some particular person's obligations are fulfilled. The argument I gave to the end that we should construe M as the latter is of more intuitive than technical importance. Since we are purporting to characterize the formal relations which hold between one agent's obligation reports, to construe M as the set of states of affairs in which all of everyone's obligations are fulfilled would lead to strongly counterintuitive results.

In Chapter Three we saw two principles which helped to highlight some weaknesses of deontic logic. To begin with, one of the fundamental principles which any deontic logic ought to be able to formalize is the Kantian principle that 'ought' implies 'can.' In my consideration of that principle, I appropriated from Keith Lehrer the idea that a temporal model like our model can serve as the basis for providing an analysis of the 'can' operator. I grafted his apparati
onto my model, then showed how to strengthen the relevant formal principle to better approximate Kant's axiom.

I believe that this sort of project—increasing the stock of tools in the shed of the deontic logician—is quite important. The biggest problem with deontic logic today is that we must grant that it has not been shown to have any important applications in moral philosophy. It is a young field, perhaps two thousand years younger than the field of ethics; and it has some catching up to do. One of its troubles is that it has not attracted many moral philosophers, and if one looks at the limited range of sentences which our logic can translate it is not surprising. I do not see my results concerning "'ought' implies 'can'" as being very important in their own right. Rather, they are important for the place they have in the larger project of better modeling English sentences.

The second principle I considered was the principle that what is necessary must be obligatory. The principle, as we saw, is eventually going to end up as an embarrassment to our logic by being valid, or absent its validity and the resulting embarrassment, our logic is going to have a serious formal and intuitive problem. We are stuck whether or not we accept the principle's formal counterpart as valid.

First, if we accept its validity then we end up having, apparently, morally obligatory necessary states of affairs. Many people have difficulty in understanding how necessary states of affairs can meaningfully be said to be morally obligatory states of affairs; and we have no answer for them. About the best we can do is to explain our predicament and ask for their sympathy, or ask them to
join us in recognizing that some of our formal 'OA' sentences do not really report moral obligations. In either case our endeavor is open to the objection that our formal obligation reports cannot be counted on to be reporting obligations of the proper (moral) variety to us. And that is a clear weakness.

On the other hand, if we eventually extend our logic to include quantification theory—as I argued that we should—and then try to validate the axioms which say that necessary states are not obligatory states, we run into a different problem. We will not be able to provide a set of axioms and rules from which we can derive all of the valid sentences of our logic.

I mentioned above that one of the weaknesses of deontic logic is its apparent irrelevance to moral philosophy. Richmond Thomason took a bold step in trying to bridge the gap between logic and moral philosophy (no offense intended) and at the beginning of his paper wrote:

> What I will do is rough and very tentative, but maybe it suggests that deontic logic can be related to some interesting questions in moral philosophy. *§*

I am all for progress, but in my fourth chapter I argued that Thomason's noble attempt failed. And the difficulty which any approach like his faces is, I believe, insurmountable.

Thomason tries to deal with sets of obligations and sets of choices. Now I hope that prior chapters indicate that we can talk about the morally perfect worlds well enough to utilize our models in formalizing relations between them and various other sets. The problem, as I suggested, is with the choice sets.
I want to generalize that result from earlier to indicate how our deontic logic is limited in an important respect. Choices often involve beliefs which cannot be associated in any apparent way with possible states of affairs. My belief that Santa Claus comes every Christmas, that eight times nine is seventy-four, or that all aspirin are alike just cannot be represented on our models of worlds causally accessible from our world. Since our beliefs are intimately related to our choices, we are at a loss to include sets of choices on the model.

In general, epistemic operators and their ilk do not fare well in possible world semantics. People often have inconsistent beliefs, desires, and intentions, and that they are inconsistent just amounts to their not being simultaneously satisfiable. Here is the rub: "not simultaneously satisfiable" means, on our semantics, that not all of the beliefs (intentions, desires) can come out true (satisfied, fulfilled) in any possible state of affairs.

The more startling and important effect of the main result of Chapter Four is this: to whatever extent a full account of moral obligations depends on the set or some subset of our beliefs, desires, and intentions, it is to that extent that our logic is inherently unable to make any contribution to moral philosophy.
Chapter One

1. While 'possible worlds' is the most commonly used label, it is also ambiguous in that it sometimes used to label chains or complete histories of worlds and sometimes to label particular moments; or world-times. At the cost of some awkwardness in language, I do not use 'possible worlds.'

2. In fact, a branch contains uncountably many world-times between any two states on the branch.

3. The 'settled' operator found its way into tense logic through the work of Richmond Thomason and Bas van Fraassen.

4. Notice that 'SA' is true when A is true at some (not necessarily every) time on every branch.

5. My own feeling is that (10) and (11) are inconsistent, but I suspect that most people would disagree with me.

6. Of course, perhaps the whole approach is mistaken; which I consider in the final chapter.


8. 'Actual' is a dangerous label here. We are merely supposing that a unique line through the future is being considered, and that we happily choose exactly the line whose points represent the world as it eventually turns out.

9. While I stand by my objection to the standard position, I must admit that my own position is not as strong as I thought originally.
Baruch Brody has pointed out to me that throughout this chapter I assume we can talk meaningfully about the 'actual' past as though it is unproblematic. But such a notion, if investigated more closely, leads to pretty much the same troubles as the position I criticize.


11. My discussion was greatly aided by Grandy's discussion of tense logic in Richard E. Grandy, *Notes on Intensional Logic*, unpublished manuscript.

Chapter Two

1. Marcia Baron and Richard Grandy, "Simplifying the Story of 'O'," unpublished manuscript.

2. I do not mean to imply here that a person could not find herself in a moral dilemma, i.e., in a position in which she had conflicting actual obligations.


4. Baron and Grandy, "Simplifying the Story of 'O'."


6. Her most extensive work on the subject is the book cited in note 1 to this Chapter.


9. \(L(A \rightarrow O-A)\) is slightly different, one might argue, in that it can be true even if \((A \rightarrow O-A)\) is false at the present moment. Since the obligation report being considered concerns future times, this is not an important objection. In any case, the two sentences can be conjoined to get \('L(A \rightarrow O-A) \& A \rightarrow O-A,'\) the exact equivalent of \(O(A/-A)\).

10. Baron and Grandy, "Simplifying the Story of 'O'," unpublished manuscript.

11. This potential difficulty was pointed out in different ways by both Baruch Brody and Christine Sistare.

12. Many advances in deontic logic have been made doing exactly that. When considering the purely formal properties of various deontic logics it is usually unhelpful and inefficient to do more.

Chapter Three

1. Strictly speaking, the rule appears in the form 'from \(\vdash A,\)
   infer \(\vdash OA.'\ My retranslation of the rule into semantic terms is for the sake of clarity in the discussion below, and the retranslation makes no substantive difference so long as the logic embodying this rule is sound.


3. Baron and Grandy, "Simplifying the Story of 'O'."

4. Ibid.

5. Keith Lehrer, "'Can' in Theory and Practice: A Possible Worlds


7. The following type of counterexample and a variety of others are found in Oddie and Tichy's work cited above.

8. Naturally, one may wish to choose a definition and corresponding formula somewhere in between those given. Suppose I believe that a person can be obligated to do that which he can do even if he cannot do otherwise. I may believe that the opposite only be causally possible. By substituting 

(iii) A in some w and -A in some w after to, into (M3) the following is valid:

(19.5) \( OA \rightarrow (CA & F-A) \).

(17 through (19) remain valid but (20) is no longer valid. By maintaining that intermediate formula, remember, one must also hold that 'can A' does not imply 'can -A.'

Chapter Four


2. Ibid., p. 177.
Conclusion

1. Marcia Baron and Richard Grandy, "Simplifying the Story of 'O'," unpublished manuscript.


Baron, Marcia and Grandy, Richard E. "Simplifying the Story of 'O'." Unpublished manuscript.


Grandy, Richard E. "Time and Tense Logic." Chapter 8 of Notes on Intensional Logic. Unpublished manuscript.


