The Flexible Use of Deontic Mental Models

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Abstract
Deontic mental model theory proposes that social norms are the basic concept underlying deontic inferences. Norms impose constraints on individual actions under certain conditions. Two assumptions are made: First, people’s representations of norms follow a closed world principle. Second, they interpret the relation between a behavioral constraint and its conditions as equivalence. Both principles allow them to draw definite deontic inferences very flexibly. An experiment provides first empirical evidence that the assumptions are justified.

Introduction
Deontic reasoning refers to thinking about which actions people may or must perform with respect to social norms. According to Deontic Mental Model theory (DMM; Beller, 2001), people build normative mental models that represent social restrictions on actions, and they use these models flexibly to determine their implications for the behavior of individuals. Two principles, illustrated by the following examples, are at the heart of the DMM representation of norms.

Imagine a person whose job is to control entry into a pop concert. The promoter pointed out two conditions for admitting somebody into the concert:

(a) The person has a ticket.
(b) The person has no weapons.

Suppose Peter is waiting at the entrance with a ticket. May he enter? The answer is: “It depends.” If Peter has not yet been checked for weapons, it cannot be decided whether he may enter or must stay outside. If Peter does not have a weapon he may enter. Giving these answers requires integrating the admission conditions: both are necessary, and together they are exhaustive. DMM theory assumes that people’s representations of norms follow such a closed world principle. Let us consider another case. Suppose that Tom may enter. Does he have a ticket? DMM theory claims that people treat the relation between the permission to enter and its preconditions as equivalence. They would thus conclude that Tom fulfills the conditions: he has a ticket and no weapons. Together, both principles enable people to draw definite inferences and to do this flexibly in both directions, from facts to deontic statements and vice versa.

What evidence is there to support the claims of DMM theory? Until now, DMM theory has only been applied to various deontic versions of Wason’s (1966) selection task. Deontic selection tasks (for an overview see, e.g., Newstead, 1988, and Newstead & Evans, 1995) ask participants to identify people violating a deontic conditional such as “If a person is drinking beer, then he or she must be over 19.” All central findings from such tasks were able to be successfully traced back to deontic mental models or to particular features of the domain (Beller, 2001): the high proportion of correct violation detections compared with the classical abstract task (for an overview see Dominowski, 1995), as well as the effects of instructional modifications (e.g., Noveck & O’Brien, 1996), of syntactical changes of the rule (e.g., Cosmides, 1989), and of the way in which negation is expressed (e.g., Jackson & Griggs, 1990). This indicates that DMM theory provides an adequate account for the understanding of deontic conditionals and rule violations – but its core assumptions are supported only indirectly. By using a combination of different tasks, this paper aims to prove the assumptions more directly and to demonstrate people’s competence and flexibility in reasoning about social rules.

Deontic Mental Models
DMM theory (Beller, 2001) distinguishes two types of models: normative and factual. Factual models describe whether or not an action is performed (symbolized as Action vs. ¬Action) or whether or not a precondition is fulfilled (C vs. ¬C). Normative models represent restrictions on actions imposed by social rules, that is, they describe the conditions under which an action is forbidden or obligatory. Bans are used as a basic representational concept and are represented as forbidden (Action). Obligations can be derived from bans since they prohibit the omission of an action.

As explained in the introductory section, DMM theory makes two assumptions with regard to the relation between a ban and the conditions under which it comes into force: People represent each relevant ban together with all its conditions (closed world), and they treat the relation between a banned action and the conditions as an equivalence: The action is forbidden if the conditions are met; otherwise it is allowed. Accordingly, the basic schema of a norm takes the following form:

\[
\text{(1) Normative} \\
\text{[forbidden(Action)] Conditions} \\
\text{[¬forbidden(Action)] ¬Conditions} \\
\ldots
\]
Each line denotes a separate model. Since, according to the closed world principle, all conditions concerning the ban are subsumed under the condition side, the action side is represented exhaustively (indicated by the square brackets). The condition side is not necessarily exhaustive because there may be other bans under the same conditions (indicated by the three dots). A weak definition of permission can be associated with this representation— all actions not explicitly forbidden are allowed—so that models of the second type need not be represented explicitly and are omitted below.

Often, conditions have to be combined. Conditions that are additionally necessary are integrated conjunctively, while alternative conditions cause a disjunction of models. In the introductory example, people without a ticket or with weapons are not admitted to the concert. The models thus represent two disjunctive conditions:

(2) Normal

\[
\begin{align*}
&[\text{forbidden(entering)}] \quad [\neg \text{ticket}] \\
&[\text{forbidden(entering)}] \quad [\neg \text{ticket}] [\neg \text{weapon}] \\
&[\text{forbidden (ticket)}] \quad [\text{ticket}] [\text{weapon}]
\end{align*}
\]

Leaving aside the condition of checking persons for weapons, let us consider musicians who are allowed to enter the concert hall without a ticket. In this case, entry is forbidden if somebody has no ticket and is not a musician. Thus, two conditions are combined conjunctively:

(3) Normal

\[
[\text{forbidden(entering)}] \quad [\neg \text{ticket}] [\neg \text{musician}]
\]

What inferences are implied by a given set of normative models? Modal inferences about what must or may be the case can be derived by connecting norms with facts about actions or conditions. If the conditions Cs of a ban apply to a person, then two statements can be asserted: the action must not be taken and, according to the axiom of definitional equivalence in modal logic (e.g., Chellas, 1980), the action must be omitted:

(4) Normal

\[
\begin{align*}
&[\text{forbidden (Action)}] \quad \text{Cs} \\
&\ldots.
&. \text{must-not Action} \\
&. \text{must } \neg \text{Action}
\end{align*}
\]

Taking a forbidden action implies that the conditions Cs must not apply; otherwise the norm would be violated. Equivalently, it must be the case that the conditions do not apply:

(5) Normal

\[
\begin{align*}
&[\text{forbidden (Action)}] \quad \text{Cs} \\
&[\text{Action}] \\
&\ldots.
&. \text{must-not Cs} \\
&. \text{must } \neg \text{Cs}
\end{align*}
\]

The modal terms must not and must directly correspond to the notion of ban and obligation. What about the complementary concepts of permission and release from obligation? In the deontic square of opposition (e.g., Anderson, 1956), ban and permission, and obligation and release are pairs of contradictionary. Only one of each pair is true. Thus, one can infer that something may be the case if it is not forbidden, and it need not be the case if it is not obligatory.

The inferences considered so far are derived by combining a factual model with a normative model. DMM theory predicts that people can flexibly switch between the modals must and must-not, as well as between may and need-not. In addition to this, people’s reasoning should be even more flexible, making use of the inference schemas in reversed direction. By relating deontic statements and norms, inferences about facts can be derived. Given a normative model (4) and the deontic statement “Paul must not take the action”, for example, one can infer that the conditions of the ban apply. The conditions do not apply when a banned action may be taken. Analogous inferences can be drawn from deontic statements with the modals must and need-not.

DMM theory integrates and expands on former psychological contributions to human deontic reasoning (for a detailed discussion see Beller, 2001). Johnson-Laird (1978) proposed that the modal terms gain their deontic meaning by referring to deontic norms. Such norms should, in turn, represent permissible and impermissible situations (Johnson-Laird & Byrne, 1992). DMM theory goes beyond these ideas by providing an elaborated approach to norms and deontic inferences. The idea of a domain-specific representation is adopted from the theory of pragmatic reasoning schemas (PRS, Cheng & Holyoak, 1985) while its conceptual weaknesses are avoided (Beller, 2001; cf. Mankelow & Over, 1995). In addition, DMM theory covers a broader range of deontic decisions than PRS theory, which postulated two schemas only, one for permission and one for obligation. The permission schema, for example, is defined by the following rules:

P1: If the action is to be taken, then the precondition must be satisfied.

P2: If the action is not to be taken, then the precondition need not be satisfied.

P3: If the precondition is satisfied, then the action may be taken.

P4: If the precondition is not satisfied, then the action must not be taken.

A rule is applicable when the schema is activated by appropriate content and the antecedent of the rule is fulfilled. Consider the statement: “If a person has no ticket, then this person must not enter.” Since it matches rule P4, the permission schema is activated with “having a ticket” as the only admission condition. The fact “Carla has a ticket” matches the antecedent of rule P3 supporting the inference “Carla may enter.” But does anything follow from the fact that a person may enter? The closed world principle and the equivalence principle justify the conclusion that the precondition is satisfied. The person has a ticket since he or she would not have been allowed
to enter without one. However, this inference is not covered by the current PRS schemas. Suppose Lisa has no ticket. This fact matches the antecedent of rule P4, so we can assert that “Lisa must not enter”. But what if we were to ask, “must Lisa stay out?” According to the relations between the deontic operators (cf. model 4) Lisa must stay out. Again there is no inference rule within the permission schema supporting this conclusion.

In addition to the basic representational assumptions, it is this broader range of deontic inferences that is scrutinized in the following experiment.

**Experiment**

The experiment used a modified version of Ruth Byrne’s (1989) suppression paradigm. Participants received one of three deontic scenarios similar to that in the introductory example. All scenarios mentioned the same primary condition $p$ (“having a ticket”), which has to be fulfilled for admission to an event. In one scenario, $p$ was the only relevant condition ($p_{only}$). In the other two scenarios a second condition was introduced, either “being a musician” or “no weapons”. The first of these two scenarios supplements an alternative admission condition ($p_{add}$), the second an additional one ($p_{alt}$). Participants were expected to consider the conditions as exhaustive and integrate them into the respective normative model (cf. model 2 and 3) according to the closed world and the equivalence principle. The effects of the experimental manipulation were checked with three types of tasks. An evaluation task asked for the necessity of the primary condition, inference tasks types of tasks. An evaluation task asked for the necessity of the primary condition, inference tasks for each participant. The inference block was followed by a new random sequence of the groups. In both groups, tasks (1) and (2) required participants to draw a deontic inference about the action from information about the condition (i.e., whether or not the person has a ticket). Tasks (3) and (4) called for a reversed inference. This time, a deontic statement about the action is given (e.g., that the person may enter) and participants were asked to decide whether or not the condition is fulfilled. Finally, task (5) and task (6) demanded a deontic inference about the condition.

The tasks of the first group are related to PRS theory (at least in parts). Note that the basic situation mentions *preconditions* that have to be fulfilled in order to be *allowed* to perform an action in correspondence with PRS rule P3 “If the precondition is fulfilled then the action may be taken.” If people’s deontic knowledge is organized according to the two postulated PRS schemas, then the permission schema should be activated but not the obligation schema. Four tasks of the first group can be solved by applying the permission schema. The “deontic-to-fact” inferences (tasks 3 and 4) are not covered since its inference rules are not conceived to be used in both directions. Each task of the second group,

**Table 1: Inference tasks and applicable PRS rules.**

<table>
<thead>
<tr>
<th>Given</th>
<th>Question</th>
<th>PRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A.1</td>
<td>X has a ticket</td>
<td>May X enter?</td>
</tr>
<tr>
<td>2</td>
<td>X has no ticket</td>
<td>May X enter?</td>
</tr>
<tr>
<td>3</td>
<td>X may enter</td>
<td>Does X have a ticket?</td>
</tr>
<tr>
<td>4</td>
<td>X may not enter</td>
<td>Does X have a ticket?</td>
</tr>
<tr>
<td>5</td>
<td>X enters</td>
<td>Must X have a ticket?</td>
</tr>
<tr>
<td>6</td>
<td>X stays out</td>
<td>Must X have a ticket?</td>
</tr>
<tr>
<td>B.1</td>
<td>X has a ticket</td>
<td>Must X stay out?</td>
</tr>
<tr>
<td>2</td>
<td>X has no ticket</td>
<td>Must X stay out?</td>
</tr>
<tr>
<td>3</td>
<td>X need not stay out</td>
<td>Does X have a ticket?</td>
</tr>
<tr>
<td>4</td>
<td>X must stay out</td>
<td>Does X have a ticket?</td>
</tr>
<tr>
<td>5</td>
<td>X enters</td>
<td>May X have no ticket?</td>
</tr>
<tr>
<td>6</td>
<td>X stays out</td>
<td>May X have no ticket?</td>
</tr>
</tbody>
</table>
corresponds to a respective task in the first group but uses the complementary deontic operator according to the logical relations between must and may. These relations are not considered in PRS theory. According to DMM theory, people should be able to switch flexibly between both modal versions and to reason backwards (“deontic-to-fact”) equally well.

Evaluation task: Following the inference tasks, participants were required to work on an evaluation task. This first repeated the basic situation and the condition(s) and then required participants to evaluate the necessity and sufficiency of the primary condition (“having a ticket”), either alone (p_only) or in the context of the second condition (p_alt or p_add). Two questions were posed (each to be answered with Yes or No):

Is having a ticket sufficient for permission to enter?
Is having a ticket necessary for permission to enter?

Reformulation task: The final task required participants to choose the best reformulation for describing the complete deontic norm. Again, the basic situation and the condition(s) were repeated first. Next, several reformulations were given in a multi-choice format, together with the instruction: Which statement best represents the admission regulation as you understood it? Please choose one statement. In the p_only scenario, participants had to choose between a conditional and a biconditional reformulation:

“If a person has a ticket, then this person may enter; otherwise you don’t know whether this person may enter or must stay out.” (conditional)

“If a person has a ticket, then this person may enter; otherwise this person must stay out.” (biconditional)

In the p_alt and p_add scenarios with two conditions for the deontic norm, four rules were given from which to choose. The rules were constructed by combining the conditions either conjunctively (e.g., “If a person has a ticket and is one of the musicians, then ...”) or disjunctively (e.g., “If a person has a ticket or is one of the musicians, then ...”) and completing them in either the conditional or biconditional format explained above.

Participants: 33 students from the University of Freiburg participated in the experiment. They came from various disciplines (excluding psychology, mathematics, and philosophy). 17 students were male and 16 female, and the mean age was M = 21.1 years (range: 18-28). Each student received € 5 for participating.

Procedure: The experiment was conducted in conjunction with another study on a different topic running in the Psychology Department. Each participant received a booklet that presented the basic situation and the relevant conditions of the social norm on the first page. In addition, it was explained that several possible answers were given, which were mutually exclusive, and that no other answers were possible. Participants were instructed to choose the answer that they considered to be correct and to work on all tasks in the given order.

Results
In order to determine whether the experimental manipulation had the expected effect, the evaluation task is analyzed first.

Evaluation task: The three deontic scenarios (p_only, p_alt, and p_add) differed with respect to the conditions for admission. The primary condition of “having a ticket” was either the only condition, or combined with an alternative versus an additional condition – its sufficiency and necessity should change accordingly.

Participants’ evaluations of the primary condition are shown in Table 2. Necessity and sufficiency ratings varied as expected. In the p_only group, “having a ticket” was interpreted quite uniformly as sufficient and necessary (81.8 %). The interpretation changed in the other groups depending on the second condition. The introduction of an alternative condition p_alt reduced the necessity: when musicians are allowed to enter as well, having a ticket is still sufficient but not necessary (81.8 %). Mentioning an additional condition p_add instead had the opposite effect of reducing the sufficiency: when people have to be checked for weapons as well, having a ticket is a necessary but not a sufficient condition (100 %).

Inference tasks: Six different tasks were distinguished and each was formulated in two analogous modal versions (cf. Table 1). Two predictions were derived from DMM theory: first, people’s inferences should change across the three deontic versions according to the sufficiency and necessity ratings they made in the evaluation task, and second, participants should solve both analogous modal versions consistently.

To test the latter hypothesis, a log-linear analysis (Kennedy, 1992) was performed for each deontic scenario (p_only, p_alt, and p_add). Two independent variables entered into the analyses: the type of task (1-6) and the modal version (A and B). The dependent variable “answer” was coded in three categories (affirmative, negated, or undecidable), as shown in Table 3. All analyses revealed that the modal version did not significantly contribute to the data. This factor could be removed from the analyses without loosing the fit of the resulting log-linear model (for each of the three analyses: G² < 16.3, df = 12, p > 0.18). This confirms the prediction that people answer both modal versions consistently.

Table 2: Sufficiency (suff.) and necessity (nec.) ratings of primary condition p (n = 11 in each group; predicted ratings bold-faced).

<table>
<thead>
<tr>
<th>p evaluated as</th>
<th>p_only</th>
<th>p_alt</th>
<th>p_add</th>
</tr>
</thead>
<tbody>
<tr>
<td>suff. and nec.</td>
<td>9</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>suff. but not nec.</td>
<td>2</td>
<td>9</td>
<td>–</td>
</tr>
<tr>
<td>not suff. but nec.</td>
<td>–</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>not suff. and not nec.</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
consistently, making it justifiable to aggregate the data. The aggregated results are shown in Table 3.

As predicted by DMM theory, people reasoned from the condition to the permission (tasks 1 and 2) and in reversed direction (tasks 3 and 4) equally well. In the $p_{\text{only}}$ scenario, 92.0% of the participants’ inferences reflected a biconditional interpretation of the norm: a person is permitted to enter if and only if he or she has a ticket. Introducing the alternative condition “musician” (+$p_{\text{alt}}$) reduced the necessity of a ticket. Consequently, it could not be decided whether a person is permitted to enter the concert when he or she has no ticket (task 2: 59.1% undecidable), nor was it clear whether a person has a ticket when he or she is admitted (task 3: 86.4% undecidable). Complementarily, the sufficiency of the ticket was reduced by introducing the additive condition “no weapons” (+$p_{\text{add}}$): this time, having a ticket is not sufficient to decide whether a person is permitted to enter (task 1: 90.9% undecidable), and analogously the reason for not having the permission to enter is unclear – the person may have no ticket or may have a weapon (task 4: 86.4% undecidable).

Let us now turn to the inference tasks (5) and (6). In order to enter the concert (task 5) a ticket should be necessary in two scenarios ($p_{\text{only}}$ and +$p_{\text{add}}$ “no weapons”), while in the third (+$p_{\text{alt}}$) necessity should depend on whether the person is a member of the musicians (ticket not necessary) or of the audience (ticket necessary). Nearly all participants identified when a ticket is necessary (88.6%), and necessity decreased as predicted in the +$p_{\text{add}}$ musician groups (91.1%; $\chi^2(2, N = 66) = 40.3; p < 0.001$). In this latter case, 45.4% of the participants inferred that the necessity of having a ticket is in question. For task (6), DMM theory predicts that people staying outside do not need a ticket. The data confirm this prediction: “ticket not necessary” was the most frequent answer (54.5% on average) – independent of the scenario ($\chi^2(2, N = 66) = 4.4; p = 0.111$). 34.8% of the participants could not decide whether a ticket is needed. This uncertainty was presumably due to a lack of information about the intention: people who want to attend the concert need a ticket, while people who stay outside for other reasons need none.

Reformulation task: In all previous tasks, the equivalence principle could be checked directly only in the $p_{\text{only}}$ scenario. The reformulation task makes it possible to check this principle in all three scenarios. Choosing an adequate reformulation for the complete deontic norm requires participants to consider two aspects at the same time. In all scenarios, they must determine the relation between the conditions of the norm and the permission as either conditional or biconditional. The scenarios with two conditions (+$p_{\text{alt}}$ vs. +$p_{\text{add}}$) required participants to decide additionally which relation holds between the conditions, that is, whether they are to combine disjunctively or conjunctively.

### Table 3: Proportions of the various answers in the six inference tasks aggregated over the modal versions (number of inferences in each task = 22; predicted inferences bold-faced).

<table>
<thead>
<tr>
<th></th>
<th>Person X has a ticket</th>
<th>Permission to enter</th>
<th>Person X stays out</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>answer</td>
<td>answer</td>
<td>answer</td>
</tr>
<tr>
<td></td>
<td>yes</td>
<td>no</td>
<td>yes</td>
</tr>
<tr>
<td>$p_{\text{only}}$</td>
<td>0.95</td>
<td>0.00</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>0.95</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>0.00</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td>+$p_{\text{alt}}$</td>
<td>0.82</td>
<td>0.14</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>0.27</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>0.14</td>
<td>0.59</td>
<td>0.14</td>
</tr>
<tr>
<td>+$p_{\text{add}}$</td>
<td>0.05</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>0.14</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>0.91</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

### Table 4: The number of selected reformulations ($n = 11$ in each group; predicted choices bold-faced).

<table>
<thead>
<tr>
<th></th>
<th>$p_{\text{only}}$</th>
<th>+$p_{\text{alt}}$</th>
<th>+$p_{\text{add}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>biconditional</td>
<td>9</td>
<td>8</td>
<td>–</td>
</tr>
<tr>
<td>conditional</td>
<td>2</td>
<td>10</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td>or 2</td>
<td>or 1</td>
<td>–</td>
</tr>
</tbody>
</table>

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As indicated in Table 4, participants were very sensitive to both aspects. Across all groups, 87.9 % preferred a biconditional reformulation and only 12.1 % used a conditional statement ($\chi^2(1, N = 33) = 18.9; p < 0.001$). The second precondition was considered in accordance with the evaluation and inference results: the alternative condition was integrated by using a disjunction ($+p_{alt}$: 81.8 % or vs. 18.2 % and) and the additive condition by using a conjunction ($+p_{add}$: 0 % or vs. 100 % and; $\chi^2(1, n = 22) = 15.2; p < 0.001$).

**Discussion**

The experimental results confirm DMM theory in two different ways. First, they provide clear evidence for the basic representational assumptions. Across all tasks, the data of the $p_{only}$ scenario directly reflect the equivalence principle: if the conditions of a ban are fulfilled, then the action is forbidden; otherwise it is allowed. And the data of all three scenarios suggest that people consider the condition(s) mentioned in the respective scenario in correspondence with the closed world principle and integrate them into their deontic mental models according to their background knowledge.

Second, people are very accurate in determining the implications of a social norm. As predicted by DMM theory, they use modal operators flexibly and in accordance with principles of modal logic. It was further demonstrated that deontic reasoning also includes inferences from modal premises to facts. This finding has not yet been predicted by any other theory. PRS theory (Cheng & Holyoak, 1985) lacks corresponding inference rules. Acknowledging that this problem may be solved by supplementing further rules, the DMM approach nevertheless appears to be more promising: It uses a unified representation for social rules instead of different schemas and considers relations known from deontic logic. Current evolutionary approaches (e.g., Cosmides, 1989; Cummins, 1996) have not predicted deontic inferences on the same fine-grained level as DMM theory either. Apart from that, they are intended to answer a different question: What is the ultimate origin of domain-specificity – learning or evolutionary adaptation? DMM theory does not attempt to answer this question, but suggests to approach it with respect to people’s general capability to build and use mental representations of real world situations for particular purposes.

Independent of the answer to the origin question, however, it seems unquestionable that social rules in general and deontic concepts in particular are core concepts of social life. By indicating what is forbidden and what is allowed, they guide individual behavior in favor of group interests and thus constitute an essential part of what defines the identity of the group or culture. The particular content of social rules as well as their linguistic expression may vary considerably; the underlying concepts, however, as they are described by DMM theory, seem to be comparable even across cultures (e.g., Bender & Beller, 2003).

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**References**


