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 & 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:

```
(1) Normative
 [forbidden(Action)]     Conditions
[¬forbidden(Action)]    ¬Conditions
                    ...
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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) Normative		
[forbidden(entering)]	[¬ticket]	[weapon]
[forbidden(entering)]	[¬ticket]	[¬weapon]
[forbidden(entering)]	[ticket]	[weapon]

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) Normative		
[forbidden(entering)]	[¬ticket]	[¬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) Normative		Factual
[forbidden(Action)]	Cs	[Cs]
...		∴ must-not Action
		∴ must ¬Action

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) Normative		Factual
[forbidden(Action)]	[Cs]	[Action]
		∴ must-not Cs
		∴ must ¬Cs

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 *contradictories*. 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. Manktelow & 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 ($+p_{alt}$), the second an additional one ($+p_{add}$). 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 and sufficiency of the primary condition, inference tasks were used to assess people's inferential flexibility, and a reformulation task required to rephrase the complete norm. Each type of task allows conclusions to be made about both representational principles.

Method

Design: Participants were randomly assigned to one of three groups (n = 11), which were defined by the scenarios described above (p_{only}, $+p_{alt}$ vs. $+p_{add}$). Participants in all of the groups were required to work on 14 tasks. 12 inference tasks were given in one block to ensure that participants make their inferences on the basis of their spontaneous interpretation of the norm. These tasks were arranged in a new random sequence for each participant. The inference block was followed by the evaluation task and the reformulation task.

Materials: All scenarios started with a description of the *basic situation*:

> *Imagine you are on the staff of an open-air concert. Your job is to control the admission at the entrance. The promoter has given you the following condition[s] as the only one[s] you have to pay attention to in order to admit somebody into the concert:*

The primary condition *p* for the admission was simply:

> *The person has a ticket.*

This was the only prerequisite in the p_{only} scenario. A second one was added in the other two scenarios introducing either an alternative or an additional condition:

> *The person is one of the musicians.* ($+p_{alt}$)
> *The person has no weapons.* ($+p_{add}$)

Inference tasks: The basic situation was followed by 12 inference tasks. Each task repeated the deontic context (*Condition/s to admit somebody into the concert:* ...) and the condition(s). Information about a person was then given together with a specific question. Three answers were proposed: *yes*, *no*, and *cannot be decided*.

The tasks are listed in Table 1. They are divided into two 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.

	Given	*Question*	*PRS*
A.1	X *has* a ticket	*May* X enter?	P3
2	X has *no* ticket	*May* X enter?	P4
3	X *may* enter	Does X *have* a ticket?	–
4	X *may not* enter	Does X *have* a ticket?	–
5	X *enters*	*Must* X have a ticket?	P1
6	X *stays out*	*Must* X have a ticket?	P2
B.1	X *has* a ticket	*Must* X stay out?	–
2	X has *no* ticket	*Must* X stay out?	–
3	X *need not* stay out	Does X *have* a ticket?	–
4	X *must* stay out	Does X *have* a ticket?	–
5	X *enters*	*May* X have no ticket?	–
6	X *stays out*	*May* X have no ticket?	–

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: $G^2 < 16.3$, $df = 12$, $p > 0.18$). This confirms the prediction that people answer both modal versions

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

p evaluated as	p_{only}	$+p_{alt}$	$+p_{add}$
suff. and nec.	**9**	–	–
suff. but not nec.	2	**9**	–
not suff. but nec.	–	2	**11**
not suff. and not nec.	–	–	–

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).

		1	2		3	4		5	6
		Person X has ...			Permission to enter			Person X ...	
	answer	a ticket	no ticket	*answer*	yes	no	*answer*	enters	stays out
p_{only}	permission	**.95**	.00	has a ticket	**.86**	.00	ticket is necessary	**.82**	.05
	no permission	.05	**.95**	has no ticket	.00	**.91**	ticket is not nec.	.00	**.64**
	undecidable	.00	.05	undecidable	.14	.09	undecidable	.18	.32
$+p_{alt}$	permission	**.82**	.14	has a ticket	.14	.00	ticket is necessary	.09	.14
	no permission	.05	.27	has no ticket	.00	**.82**	ticket is not nec.	.45	**.36**
	undecidable	.14	**.59**	undecidable	**.86**	.18	undecidable	**.45**	.50
$+p_{add}$	permission	.05	.00	has a ticket	**1.00**	.00	ticket is necessary	**.95**	.14
	no permission	.05	**1.00**	has no ticket	.00	.14	ticket is not nec.	.00	**.64**
	undecidable	**.91**	.00	undecidable	.00	**.86**	undecidable	.05	.23

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_{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" ($+p_{alt}$) 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" ($+p_{add}$): 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_{only} and $+p_{add}$ "no weapons"), while in the third ($+p_{alt}$) 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 $+p_{alt}$ musician groups (9.1 %; $\chi^2(2, N = 66) = 40.3$; $p < 0.001$). 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_{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 ($+p_{alt}$ vs. $+p_{add}$) required participants to decide additionally which relation holds between the conditions, that is, whether they are to combine disjunctively or conjunctively.

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

	p_{only}		$+p_{alt}$	$+p_{add}$
biconditional	**9**	or	**8**	–
		and	2	**10**
conditional	2	or	1	–
		and	–	1

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).

Acknowledgements This research was supported in part by a grant from the Deutsche Forschungsgemeinschaft to Hans Spada (project *Content effects in propositional reasoning*; contract Sp 251/15-1). I am grateful to Stefan Kleinbeck and Gregory Kuhnmünch for conducting the experiment, and to Andrea Bender for her valuable comments on earlier versions of this paper.

References

Anderson, A. R. (1956). The formal analysis of normative systems. In N. Rescher (Ed.), *The logic of decision and action*. Pittsburgh: University of Pittsburgh Press.

Beller, S. (2001). A model theory of deontic reasoning about social norms. In J. D. Moore, & K. Stenning (Eds.), *Proceedings of the Twenty-Third Annual Conference of the Cognitive Science Society* (pp. 63-68). Mahwah, NJ: Lawrence Erlbaum.

Bender, A., & Beller, S. (2003). Polynesian *tapu* in the "deontic square": A cognitive concept, its linguistic expression and cultural context. To appear in *Proceedings of the 25th Conference of the Cognitive Science Society.* Mahwah, NJ: Lawrence Erlbaum.

Byrne, R. M. J. (1989). Suppressing valid inferences with conditionals. *Cognition, 31*, 61-83.

Chellas, B. F. (1980). *Modal logic: An introduction*. Cambridge: Cambridge University Press.

Cheng, P. W., & Holyoak, K. J. (1985). Pragmatic reasoning schemas. *Cognitive Psychology, 17*, 391-416.

Cosmides, L. (1989). The logic of social exchange: Has natural selection shaped how humans reason? Studies with the Wason selection task. *Cognition, 31*, 187-276.

Cummins, D. D. (1996). Evidence for the innateness of deontic reasoning. *Mind & Language, 11*, 160-190.

Dominowski, R. L. (1995). Content effects in Wason's selection task. In S. Newstead, & J. St. B. T. Evans (Eds.), *Perspectives on thinking and reasoning*. Hove: Erlbaum.

Jackson, S. L., & Griggs, R. A. (1990). The elusive pragmatic reasoning schemas effect. *Quarterly Journal of Experimental Psychology, 42A*, 353-373.

Johnson-Laird, P. N. (1978). The meaning of modality. *Cognitive Science, 2*, 17-26.

Johnson-Laird, P. N., & Byrne, R. M. J. (1992). Modal reasoning, models, and Manktelow and Over. *Cognition, 43*, 173-182.

Kennedy, J. J. (1992). *Analyzing qualitative data*. New York: Praeger.

Manktelow, K. I., & Over, D. E. (1995). Deontic reasoning. In S. Newstead, & J. St. B. T. Evans (Eds.), *Perspectives on thinking and reasoning*. Hove: Erlbaum.

Newstead, S., & Evans, J. St. B. T. (Eds.) (1995). *Perspectives on thinking and reasoning*. Hove: Erlbaum.

Noveck, I. A., & O'Brien, D. P. (1996). To what extent do pragmatic reasoning schemas affect performance on Wason's selection task? *The Quarterly Journal of Experimental Psychology, 49A*, 463-489.

Wason, P. C. (1966). Reasoning. In B. M. Foss (Ed.), *New horizons in psychology.* Harmondsworth: Penguin.