

## **Evoking the Permission Schema: The Impact of Explicit Negation and a Violation-checking Context**

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Cheng and Holyoak (1985) proposed that realistic reasoning in deontic contexts is based on pragmatic schemas such as those for assessing compliance with or violation of permission and obligation rules, and that the evocation of these schemas can facilitate performance in Wason's (1966) selection task. The inferential rules in such schemas are intermediate in generality between the content-independent rules proposed by logicians and specific cases stored in memory. In one test of their theory, Cheng and Holyoak demonstrated that facilitation could be obtained even for an abstract permission rule that is devoid of concrete thematic content. Jackson and Griggs (1990) argued on the basis of several experiments that such facilitation is not due to evocation of a permission schema, but, rather, results from a combination of presentation factors: the presence of explicit negatives in the statement of cases and the presence of a violation-checking context. Their conclusion calls into question both the generality of content effects in reasoning and the explanation of these effects. We note that Jackson and Griggs did not test whether the same combination of presentation factors would produce facilitation for an arbitrary rule that does not involve deontic concepts, as their proposal would predict. The present study tested this prediction. Moreover, we extended Jackson and Griggs' comparisons between performance with an abstract permission rule versus an arbitrary rule, introducing clarifications in the statement of each. No facilitation was observed for an arbitrary rule even when explicit negatives and a violation-checking context were used, whereas strong facilitation was found for the abstract permission rule under the same conditions. Performance on the arbitrary rule was not improved even when the instructions indicated that the rule was conditional rather than biconditional. In contrast, a small but reliable degree of facilitation was obtained for the abstract permission rule, with violation-checking content even in the absence of explicit negatives. The theory of pragmatic reasoning

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schemas can account for both the present findings and those reported by Jackson and Griggs.

A longstanding puzzle for theories of human reasoning concerns the fact that patterns of reasoning performance differ enormously as a function of the thematic content of premises. Much of the evidence for content effects on reasoning has been obtained in studies using variations of Wason's (1966) selection task (e.g. Johnson-Laird, Legrenzi, & Legrenzi, 1972; Wason & Shapiro, 1971; for reviews see Evans, 1983; Wason, 1983). The selection task involves giving subjects a conditional rule in the form *If p then q*. Subjects are then shown one side of each of four cards, which, respectively, show the cases corresponding to *p*, *not-p*, *q*, and *not-q*. They are told that each card shows the value of *p* on one side and the value of *q* on the other. Their task is to decide which of the cards must be turned over to determine whether the rule is false.

The "correct" choice, according to standard propositional and modal logics, is to select the *p* card (which might have *not-q* on its back) and the *not-q* card (which might have *p* on its back), because these are the only two cards that could falsify the rule. Subjects seldom make the correct choice when the conditional rule has arbitrary content (e.g. "*If a card has an 'A' on one side, then it must have a '4' on the other*"). Rather, they tend to make various errors, of which the most common is to select the cards corresponding to *p* and *q* (i.e. "A" and "4"). In contrast, for certain formally equivalent rules that can be interpreted as expressing deontic relations of permission or obligation, such as "*If a person is to drink alcohol, then they must be at least 21 years old*", the correct *p* and *not-q* cases are selected much more frequently (e.g. D'Andrade, 1982; Griggs & Cox, 1982; Cheng & Holyoak, 1985; Girotto, Gilly, Blaye, & Light, 1989; Light, Girotto, & Legrenzi, 1990; Manktelow & Over, 1991; Politzer & Nguyen-Xuan, 1992; for a brief review see Holyoak & Spellman, 1993).

To explain this influence of content on reasoning in the selection paradigm and other tasks (such as linguistic rephrasing) involving inference with conditionals, Cheng and Holyoak (1985) suggested that certain thematic content evokes a *pragmatic reasoning schema*: a set of rules that address a recurring class of goals and relationships relevant to these goals. Pragmatic reasoning schemas fall into broad categories, such as those dealing with causal inference (Cheng & Nisbett, 1993) and those dealing with regulations. Cheng and Holyoak (1985; Cheng, Holyoak, Nisbett, & Oliver, 1986) suggested that conditional regulations are often understood in terms of "permission" and "obligation" schemas, which are based on deontic relations.

The theory of pragmatic reasoning schemas predicts that performance on the selection task will be facilitated when the stated rule has content

that evokes a schema, and the correspondence between the stated rule and the schema rules is such that the latter map onto rules of standard logic. For example, the "drinking-age" rule just mentioned will tend to evoke a permission schema, which includes the following schematic production rules (Cheng & Holyoak, 1985, p. 397):

*Rule 1:* If the action is to be taken, then the precondition must be satisfied.

*Rule 2:* If the action is not to be taken, then the precondition need not be satisfied.

*Rule 3:* If the precondition is satisfied, then the action may be taken.

*Rule 4:* If the precondition is not satisfied, then the action must not be taken.

Note that the above "drinking age" rule is in the form of Rule 1. In this case the antecedent of Rule 1 matches the *p* case. As the consequent of this rule makes a definite prediction, it indicates that someone who drinks alcohol should be checked to be sure the age precondition has been met. The antecedent of Rule 4 matches the *not-q* case. The consequent of Rule 4 also makes a definite prediction, indicating that someone who is under age should be checked to be sure they are not drinking alcohol. The antecedents of Rules 2 and 3, respectively, match the *not-p* and *q* cases. Because the consequents of these rules do not make any definite predictions, they indicate that no violation is possible given the *not-p* and *q* cases, therefore blocking the errors that correspond to the selection of these cases.

In addition to explaining patterns of facilitation for rules with concrete thematic content, Cheng and Holyoak (1985) demonstrated that facilitation could be obtained even for an abstract permission rule, "*If one is to take action 'A', then one must first satisfy precondition 'P'.*" Similarly, Cheng and Holyoak (1989) found that selection performance was significantly better for an abstract statement of a conditional precaution (a form of permission in which the precondition for engaging in a hazardous activity is to take a prudent precautionary measure) than for an arbitrary rule. Although devoid of specific thematic content, such abstract rules appear to evoke regulation schemas that guide reasoning. These demonstrations of selective facilitation for non-arbitrary but abstract rules are theoretically important because the results are not readily explicable either by accounts of human reasoning based on memory for specific counterexamples (e.g. Griggs & Cox, 1982), by current proposals involving content-free proof-theoretic inference rules (e.g. Braine & O'Brien, 1991), or by current proposals involving content-free model-theoretic procedures (e.g. Johnson-Laird & Byrne, 1991).

Recently, Jackson and Griggs (1990) argued that Cheng and Holyoak's (1985) demonstration of facilitation for the abstract permission rule was

not due to evocation of a permission schema, but, rather, resulted from a combination of two "presentation factors": (a) providing explicit negatives in the statement of cases, and (b) providing a violation-checking context. For the rule, "*If one is to take action 'A', then one must first satisfy precondition 'P'*", Jackson and Griggs (Experiment 2) compared performance in a condition that employed the cases used by Cheng and Holyoak, which included explicit negatives for the *not-p* and *not-q* cases—"has not taken action A" and "has not fulfilled precondition P", respectively—to performance in a condition for which these two explicitly negative cases were replaced by "has taken action B" and "has fulfilled precondition Q", respectively. Jackson and Griggs found that facilitation was eliminated when the latter wording, which did not include explicit negatives, was used. Similarly, these investigators also found (Experiment 4) that facilitation was eliminated when the instructions did not orient subjects to check whether the rule was violated, but, rather, "to find out whether a certain regulation is being followed". On the basis of these results, Jackson and Griggs argued that performance on the abstract permission rule can be explained by these two presentation factors, without postulating any role for pragmatic schemas. More specifically, they suggested that the overall pattern is consistent with Evans' (1984) general two-stage model of reasoning.

Their conclusion raises the issue of the level of abstraction of inferential rules. If Jackson and Griggs (1990) were correct, then the content effects demonstrated for abstract situations would not be due to people's knowledge about types of situations such as permissions and obligations. Instead, content effects would be attributable to general heuristics for assessing relevance and for checking violations, heuristics that are not tied specifically to deontic content.

The role played by explicit negatives in assessing relevance in the context of deductive reasoning tasks was first noted by Evans (1983, 1984). Given a conditional such as "*If the letter is not K, then the number is 3*", the statement "*The letter is not K and the number is 5*" should be judged false, as it represents a "*p* and *not-q*" counterexample. Evans found that for conditionals with a negative antecedent, "false" responses were less frequent when the negative introduced in the statement was implicit, as in the above example ("... the number is 3") than when it was explicit, as in "*The letter is not K, and the number is not 3*" (66% vs. 83% "false" responses). Evans suggested that the deficit observed for implicit negatives was due to a "matching bias", which disposed subjects to consider a statement as irrelevant if there was no nominal match between the term stated in the rule (e.g. "5"), and the term expressing the cases to be judged (e.g. "3"). In Evans' two-stage theory of reasoning, this kind of relevance judge-

ment is a *heuristic* process (stage one), serving to select relevant information that is then subjected to *analytic* processing (stage two). The latter involves the application of content-independent rules. Thus in Evans' (1983) study, when the counterexample included an explicit ("not 3") rather than an implicit ("5") negative, the effect of the matching bias was alleviated, and performance improved. In terms of his theory, the improvement results from the nominal match between the "topic" of the rule ("3") and the explicit negative ("not 3"). The match leads to analytic processing.

Jackson and Griggs (1990) argued that similar factors operate when the *not-p* and *not-q* cases are presented as explicitly negative cases in the selection task for an abstract permission rule. In the heuristic stage, the use of explicit negatives prevents subjects from treating the *not-p* and *not-q* cards as irrelevant, ensuring that all four cards are attended to. In the analytic stage, according to Jackson and Griggs, the presence of a violation-checking context is necessary to cue subjects to search for "violators" of the rule, allowing them to select the correct cards.

As Girotto, Mazzocco, and Cherubini (1992) have noted, the data and conclusions of Jackson and Griggs (1990) have figured prominently in several recent critical discussions of the theory of pragmatic reasoning schemas (Eysenck & Keane, 1990; Johnson-Laird & Byrne, 1991; Rips, 1990). We argue, however, that the observed impact of the two presentation factors on facilitation for the abstract permission rule, rather than contradicting the theory of pragmatic schemas, is actually explained by it. Moreover, not only does the evidence presented by Jackson and Griggs fail to distinguish between the theory of pragmatic schemas and Jackson and Griggs' adaptation of the two-stage model, but a key prediction that can distinguish between the alternative explanations remains untested.

Consider the role of a context that encourages checking for rule violations in the theory of pragmatic schemas. This kind of context constitutes a major cue for evocation of the deontic concepts of permission and obligation that underlie the regulation schemas, as Cheng and Holyoak pointed out: "The core of the permission schema, as well as of similar schemas for other types of regulations, indeed consists of procedural knowledge for assessing whether a type of rule is being followed or violated" (1985, p. 410). The alternative context tested by Jackson and Griggs (a hypothesis-testing context) will presumably lead subjects to interpret the conditional not as an established rule against which compliance is to be assessed, but, rather, as a hypothesized rule that requires confirmation. As Yachanin and Tweney (1982) and Cheng and Holyoak (1989) have shown, a hypothesis-testing context tends to elicit a very different pattern of choices in the selection task than does a deontic context.

The basis for the impact of explicit negatives in evoking the permission



schema is similarly clear. Rule 4 above, which is required to cue selection of the crucial *not-q* case, has an explicitly negative antecedent, "*If the precondition is not satisfied. . .*" Suppose the precondition of an abstract permission rule is stated as "*must fulfil requirement X*". An implicit negation of the precondition might be "*fulfilled requirement Y*", whereas an explicit negation might be "*did not fulfil requirement X*". A subject presented with the explicit negation can determine directly by comparison of the precondition of the rule with the negative case that requirement X was not satisfied, and therefore the required precondition was not fulfilled. The explicit negation thus matches directly with the antecedent of Rule 4, permitting correct selection of this case. In contrast, a subject presented with the implicit negation must first infer that having fulfilled requirement Y implies that the person has *not* fulfilled requirement X before they can match the negation to the antecedent of Rule 4 so as to determine that the precondition has not been fulfilled. It should be noted that this inference requires a presumption that only X or Y, and not both, is fulfilled. If for any reason the necessary inference is not reliably made, the probability that Rule 4 will be matched will be reduced when explicit negatives are eliminated from the cases. Indeed, this consideration guided the construction of materials in Cheng and Holyoak's (1985) original study of performance with the abstract permission rule.

There is, however, a key prediction that distinguishes between the theory of pragmatic schemas and Jackson and Griggs' adaptation of the two-stage model: If a combination of the presentation factors is itself sufficient to determine reasoning performance, without involving evocation of a permission schema, then a violation-checking context coupled with explicit negatives should facilitate performance for arbitrary rules just as well as for the abstract permission rule. In contrast, ". . . the schema approach predicts that violation checking will only lead to accurate performance if the problem evokes a schema specifying those situations that in fact constitute violations. Asking subjects to check for violations in an otherwise arbitrary problem would not suffice . . ." (Cheng & Holyoak, 1985, p. 410).

Jackson and Griggs did not test whether the combination of the two proposed presentation factors benefit arbitrary rules as much as they benefit permission rules. In particular, the instructions in the "violation" conditions did not clearly establish a violation-checking context for the subjects in the arbitrary condition, because Jackson and Griggs' instructions asked subjects to check whether the rule was "being followed". For the permission materials, because subjects were asked to assume the role of an authority ensuring that people obey the rule, subjects might have understood the task to imply checking for violations. For the arbitrary materials, however, no analogous cue was given. Given that neither

Jackson and Griggs (1990) nor any other study has found evidence that the two proposed presentation factors benefit arbitrary rules, their claim that their results eliminated any need to attribute facilitation to evocation of pragmatic reasoning schemas seems premature.

Jackson and Griggs also failed to note that several studies have demonstrated reliable facilitation in the selection task with concrete regulation problems that did not present cases with explicit negatives (e.g. the airport problem in Cheng & Holyoak, 1985; the Sears problem in D'Andrade, 1982; and the drinking-age problem in Griggs & Cox, 1982). An account of facilitation that depends on provision of explicit negatives clearly cannot account for these findings, whereas the pragmatic schemas theory can readily explain the observed facilitation. Note that in such concrete problems, the interpretation of an implicitly negative alternative is typically unambiguous. For example, in checking possible violations of the drinking-age rule, the case of a person who is less than 18 is readily interpretable as one that fails to satisfy the precondition of being 21 years of age (i.e. as a *not-q* case). In such concrete rules, the inference required to match the antecedent of Rule 4 will be reliably made, yielding strong facilitation even when the negative is implicit rather than explicit.

In contrast, an implicitly negative case for an abstract regulation, devoid of concrete semantic content, is likely to be much more difficult to interpret unambiguously. A methodological problem with some of Jackson and Griggs' (1990) experiments, which they themselves noted (as did Girotto et al., 1992), is that the cases they presented to subjects with explicit negatives removed were not, in fact, logically equivalent to the cases they replaced. The rule presented in their Experiment 2 was, "*If one is to take action 'A', then one must first satisfy precondition 'P'*". The *not-q* case was "*has not fulfilled precondition P*", whereas the supposedly equivalent form without an explicit negative was "*has fulfilled precondition Q*". However, without additional information that preconditions P and Q are mutually exclusive, there is no logical basis for relating "*has fulfilled precondition Q*" to the precondition stated in the rule; accordingly, the correct response would be to refrain from checking it, just as Jackson and Griggs' subjects did. In a replication of Experiment 2, Jackson and Griggs added the statement, "Each person has taken one action and fulfilled one precondition" in an attempt to eliminate any misconception that both preconditions could have been satisfied simultaneously. However, this sentence appeared in a separate paragraph from the presentation of the rule, possibly leading to subjects being confused or forgetting to consider this additional constraint when choosing cards. As Girotto et al. (1992) have observed, Jackson and Griggs' subjects, when given permission or obligation rules without explicit negatives, tended to make the apparent error of selecting only the *p* case, whereas when given arbitrary rules they tended to make the error of

selecting both  $p$  and  $q$ . In fact, selection of  $p$  alone would be the logically correct response if the so-called *not-q* case were not actually interpreted by subjects as a denial of  $q$ .

There is evidence that when the interpretation of the *not-q* case is made unambiguous to subjects, even without an explicit negative, facilitation for the abstract permission rule can in fact be obtained. Girotto et al. (1992) have shown that when several possible preconditions are explicitly listed on the response page, along with marks indicating which subset of these had been fulfilled, and the precondition corresponding to  $q$  is not marked, then subjects correctly select this *not-q* case for the abstract permission rule. In addition, Girotto et al. found substantial facilitation using Jackson and Griggs' non-negative cases when the permission rule was rephrased into an "only if" form, "*One can take action 'A' only if one has first satisfied precondition 'P'*". This result is consistent with Cheng and Holyoak's (1985) finding that subjects can readily rephrase permission rules (but not arbitrary rules) from "if" to "only if" form, where the latter form serves to emphasize the necessity of the consequent and hence eliminates the logical possibility that some precondition other than  $P$  might also allow action  $A$  (Evans, 1977).

Although Girotto et al. found facilitation without explicit negatives for an "only if" permission rule, their experiments with the "if" form always used presentations of the *not-q* case that mentioned the  $q$  case (as an unmarked precondition). Mentioning the  $q$  case could be interpreted as a factor focusing attention on the *not-q* case in an initial heuristic stage of processing. The present experiments were designed to provide a direct comparison of the effects of a violation-checking context and explicit negatives for arbitrary and abstract permission rules stated in "if" form, with instructions that clarified the logical status of the *not-q* case in conditions in which explicit negatives were not used. The form of the non-negative cases was identical to that employed in the experiments of Jackson and Griggs.

The theory of pragmatic reasoning schemas predicts that a violation-checking context provides an important cue to evoke deontic schemas, and that explicit negatives will make it easier to match the *not-q* case to Rule 4 of the permission schema. Accordingly, removing either of these two factors should diminish facilitation for the abstract permission rule. However, if the mutual exclusivity of the complementary cases is clearly conveyed to subjects, some facilitation may be observed for the permission rule, relative to an arbitrary rule, even when explicit negatives are removed. In contrast, even inclusion of both of the favourable presentation factors should provide no facilitation for an arbitrary rule, which will not evoke a deontic schema under any of the presentation conditions.



## EXPERIMENT 1A

## Method

*Subjects.* Subjects were 235 undergraduate students, who participated in the study as part of the requirements for the introductory psychology course at the University of California, Los Angeles (UCLA) (198 subjects) or the University of Washington (37 subjects). Approximately equal numbers of subjects served in each of the six conditions. None of the subjects had previously encountered the Wason selection task.

*Design and Materials.* Six versions of the Wason selection task were used, which formed a  $2 \times 3$  design involving (a) two rules (abstract permission rule or an arbitrary rule) and (b) three combinations of presentation factors, involving either both or just one of the two favourable factors identified by Jackson and Griggs (1990) (both explicit negatives and a violation-checking context, explicit negatives without a violation-checking context, or a violation-checking context without explicit negatives).

The abstract permission rule with explicit negatives and a violation-checking context was stated as follows:

Suppose people wish to engage in activity A. You know that before one can engage in this activity, one must fulfil requirement X. Your task is to make sure that people follow the regulation: "If one is to engage in activity A, then one must fulfil requirement X."

There are four cards below, one each for four people. Each card gives information on a single person. One side of each card shows whether this person engaged in activity A. The other side shows whether he or she fulfilled requirement X.

You want to see if any person violated the regulation. Which of the cards below would you have to turn over to check? Turn over as many cards as you think appropriate, but do not turn over a card unless what is on the other side can potentially tell you that the person violated the regulation.

The four cards displayed the cases "*engaged in activity A*" (*p*), "*did not engage in activity A*" (*not-p*), "*fulfilled requirement X*" (*q*), and "*did not fulfil requirement X*" (*not-q*).

For the abstract permission rule with violation-checking context but without explicit negatives, the wording of the first and third paragraphs was identical to that of the condition above. The second paragraph was changed to the following:

There are four cards below, one each for four people. Each card gives information on a single person. One side of each card shows whether this person engaged in activity A or B. The other side shows whether he or she fulfilled requirement X or Y. Assume that a person fulfils one and only one requirement, and engages in one and only one activity.

The final sentence above was intended to clarify to subjects that activities A and B, and requirements X and Y, were each to be treated as mutually exclusive. The two positive cases among the four cards were the same as for the explicit-negatives condition, but the negative cases were changed to "*engaged in activity B*" (*not-p*) and "*fulfilled requirement Y*" (*not-q*).

For the abstract permission rule with explicit negatives but without a violation-checking context, we presented the rule as a hypothesis to be tested:

Suppose people wish to engage in activity A. You know that before one can engage in this activity, one must fulfil a requirement. After watching others, you guess the regulation is: "If one is to engage in activity A, then one must fulfil requirement X."

There are four cards below, one each for four people. Each card gives information on someone who has not violated the regulation concerning activity A (whatever that regulation may be). One side of each card shows whether this person engaged in activity A. The other side shows whether he or she fulfilled requirement X.

You want to see whether your guess about the regulation is correct or not. Which of the cards below would you have to turn over to check? Turn over as many cards as you think appropriate, but do not turn over a card unless what is on the other side can potentially tell you that your guess is incorrect.

The four cards were identical to those used in the violation-checking condition with explicit negatives.

The three arbitrary conditions were matched as closely as possible to the corresponding permission conditions. The arbitrary condition with explicit negatives and violation-checking context was stated as follows:

Below are four cards. One side of each card has written on it either "A" or "not A". The other side has written either "X" or "not X". Your task is to make sure that the cards conform to the rule: "If a card says 'A' on one side, then the other side must say 'X'."

You want to see if any of the cards violates the rule. Which of

the cards below would you have to turn over to check? Turn over as many cards as you think appropriate, but do not turn over a card unless what is on the other side can potentially tell you that the card violates the rule.

The four cards, respectively, showed "A" ( $p$ ), "not A" ( $\text{not } p$ ), "X" ( $q$ ), and "not X" ( $\text{not } q$ ).

For the arbitrary condition without explicit negatives, the first paragraph was modified to read:

Below are four cards. One side of each card has written on it either "A" or "B". The other side has written either "X" or "Y". Your task is to make sure that the cards conform to the rule: "If a card says 'A' on one side, then the other side must say 'X'."

The *not-p* and *not-q* cases were "B" and "Y", respectively.

Finally, the arbitrary condition with explicit negatives but without a violation-checking context introduced the rule as a hypothesis, as follows:

Below are four cards. One side of each card has written on it either "A" or "not A". The other side has written either "X" or "not X". You guess the cards conform to the rule: "If a card says 'A' on one side, then the other side must say 'X'."

You want to see whether your guess about the rule is correct or not. Which of the cards below would you have to turn over to check? Turn over as many cards as you think appropriate, but do not turn over a card unless what is on the other side can potentially tell you that your guess is incorrect.

For each of the six conditions, the instructions and conditional rule were presented on one page, together with diagrams of the four cards. In each condition, the cases were ordered as follows: *not-q*,  $p$ ,  $q$ , *not-p*.

*Procedure.* The subjects at UCLA, who were run in groups of up to ten, performed the experiment as a filler task in a memory experiment. Each subject received one selection task in a booklet that also contained materials for other experiments. They were told to perform the tasks in their booklet, and that the instructions for each task would be self-explanatory. They were allowed about five minutes to perform the selection task, after which materials were collected. The subjects at the University of Washington performed this experiment in groups of up to 30, as one of several experiments administered together in a booklet.

## Results and Discussion

Table 1 presents the percentages of subjects selecting individual cards and selecting the correct combination in each condition, along with the number of subjects in each. Responses were scored as correct if the *p* and *not-q* cases were the only cards selected. As the theory of pragmatic schemas predicted, the presentation factors had no impact at all on performance for the arbitrary rule, which yielded less than 10% correct responses in all three conditions. When the permission rule was embedded in a violation-checking context with explicit negatives, performance was substantially more accurate (47% correct) than in the matched arbitrary condition (5% correct),  $\chi^2(1) = 18.35, p < 0.001$ . Facilitation for the permission rule was reduced to just 18% when explicit negatives were removed, and to 16% when the context was changed to hypothesis testing. Neither of the latter permission conditions yielded significantly greater accuracy than the corresponding arbitrary conditions, with corrected  $\chi^2(1) < 1.30$  for both comparisons.

As in previous studies such as those of Jackson and Griggs (1990) and Girotto et al. (1992), the predominant error for all the arbitrary conditions was choosing *p* and *q* (39% of all responses), with a much lower frequency of choosing *p* only (12% of all responses). This pattern did not vary significantly across the three arbitrary conditions. For the permission rule, the *p*-and-*q* error also dominated when the context involved hypothesis testing rather than violation checking (22% *p*-and-*q* vs. 8% *p* responses). In contrast, the *p*-and-*q* error was less prevalent than the *p*-only error for the permission rule with violation-checking context, both for the condition with explicit negatives (8% *p*-and-*q* responses versus 24% *p* responses) and for the condition that lacked explicit negatives (9% versus 27%). The difference in this aspect of the error pattern for the former versus the latter

TABLE 1  
Percentages of Subjects Choosing Individual Cases and the Correct Combination<sup>a</sup> in Experiment 1A

	Permission						Arbitrary					
	<i>N</i>	<i>p</i>	<i>q</i>	$\bar{p}$	$\bar{q}$	correct	<i>N</i>	<i>p</i>	<i>q</i>	$\bar{p}$	$\bar{q}$	correct
Violation-checking, explicit negatives	38	84	18	16	57	47	40	75	60	30	40	5
Violation-checking, no explicit negatives	45	78	31	36	47	18	40	73	55	33	43	8
Hypothesis-testing, explicit negatives	36	56	53	28	44	16	36	75	61	28	25	6

<sup>a</sup>The *p* and *not-q* cases for the rule *if-p-then-q*.

two permission conditions was significant,  $\chi^2(1) = 7.6$ ,  $p < 0.01$ . This difference in error pattern between the permission and arbitrary counterparts of the violation-checking-context but no-explicit-negatives conditions was also significant,  $\chi^2(1) = 10.2$ ,  $p < 0.005$ . There were 33% *p*-and-*q* responses and 8% *p* responses in this arbitrary condition. The fact that the permission condition that included explicit negatives yielded an error pattern similar to that of the permission condition that included explicit negatives suggests that despite the lower percentage of correct responses in the former condition, a violation-checking context is sufficient to cause subjects to process the abstract permission rule differently from the arbitrary rule. We will explore this possibility further in Experiment 2.

## EXPERIMENT 1B

Contrary to the hypothesis proposed by Jackson and Griggs (1990), Experiment 1A yielded no evidence that the two presentation factors, either singly or in combination, produce any facilitation for an arbitrary rule, which could not evoke the permission schema. However, one might argue that the arbitrary rule is more likely to be given a biconditional interpretation by subjects than is the permission rule. A biconditional assumption might plausibly encourage the erroneous selection of the *q* case, as evidenced by the high frequency of *p*-and-*q* errors observed for the arbitrary conditions in Experiment 1A. A biconditional assumption might have counteracted facilitation that would otherwise have been observed for the arbitrary rule with violation-checking context and explicit negatives.

It follows that if the arbitrary rule is clarified to exclude the biconditional assumption, then the high percentage of correct responses that Jackson and Griggs would predict for the arbitrary condition with explicit negatives and the violation-checking context should be obtained. In contrast, if evocation of a pragmatic reasoning schema is necessary for improved accuracy, performance should again be poor for both the new conditions. Experiment 1B was designed to test these opposing predictions.

## Method

*Subjects.* A total of 95 undergraduate students (81 at UCLA and 14 at the University of Washington) participated in the study as part of the requirements for an introductory psychology course. As in Experiment 1A, none of the subjects had previously encountered the Wason selection task.

*Design, Materials, and Procedure.* Two modified versions of the arbitrary conditions with violation-checking context were created, one with and one without explicit negatives. Each of these versions was identical to the



corresponding condition of Experiment 1A, except that the following sentence was added at the end of the first paragraph: "The rule does *not* imply that if a card does not say 'A' on one side, then the other side must not say 'X'." This addition was intended to prevent subjects interpreting the rule as an "*if and only if*" biconditional.

The procedure was identical to that of Experiment 1A.

## Results and Discussion

Table 2 displays the results of Experiment 1B. In both of the new conditions, the percentage of subjects who chose the correct cards was in the same range as in the arbitrary conditions in Experiment 1A: 5% for the condition with explicit negatives, 14% for the condition that lacked them. Neither the difference between these two conditions, nor either of the comparisons between each condition and the corresponding arbitrary condition of Experiment 1A, approached significance (corrected  $\chi^2 < 1$  for all comparisons). Thus Experiment 1B provided no evidence that a modification of wording designed to block an erroneous biconditional assumption is sufficient to yield facilitation of selection-task performance for an arbitrary rule by a violation-checking context and explicit negatives.

## EXPERIMENT 2

Experiment 1A revealed a non-significant trend toward facilitation for the permission rule (relative to the arbitrary rule) in the violation-checking condition, even in the absence of explicit negatives on the cards. As we noted earlier, the theory of pragmatic schemas predicts that removing explicit negatives will reduce facilitation of the permission rule because the match to Rule 4 of the schema will be rendered less direct. However, assuming some subjects will at least occasionally make the required

TABLE 2  
Percentages of Subjects Choosing Individual Cases and the  
Correct Combination<sup>a</sup> in Experiment 1B<sup>b</sup>

	<i>N</i>	<i>p</i>	<i>q</i>	$\bar{p}$	$\bar{q}$	correct
Arbitrary, explicit negatives	39	77	51	36	41	5
Arbitrary, no explicit negatives	56	68	50	32	55	14

<sup>a</sup>The *p* and *not-q* cases for the rule *if-p-then-q*.

<sup>b</sup>With violation-checking context in both conditions.

bridging inference, we might expect that some facilitation could be obtained for the permission rule even without explicit negatives. In Experiment 1A, the pattern of errors for the permission rule in the violation-checking context did not differ as a function of the explicitness of the negation, providing suggestive evidence that the permission rule and the arbitrary rule were processed differently even in the absence of explicit negatives.

As Girotto et al. (1992) have noted, subjects may be confused about whether the alternative to fulfilling requirement X might not itself be a different way to fulfil the precondition. If subjects were unsure about how to interpret the alternative case, it would not be treated as the logical equivalent to a negation of X, and hence would not be selected. Experiment 2 was performed to test the possibility that some facilitation can be obtained for an abstract permission rule in the absence of explicitly negative cases, once the interpretation of the case corresponding to *not-q* is clarified.

## Method

*Subjects.* A total of 131 UCLA undergraduates participated in the study as part of the requirements for an introductory psychology course. None of the subjects had previously encountered the Wason selection task.

*Design, Materials, and Procedure.* Three conditions were tested, all involving a violation-checking context without explicit negatives on the cards. One condition used the abstract permission rule. The other two conditions used the arbitrary rule, either with (as in Experiment 1B) or without (as in Experiment 1A) a clarification intended to block a biconditional interpretation.

The wording of the permission rule was altered slightly from Experiment 1A in order to further clarify that doing Y was not an alternative way of fulfilling the requirement for A. The precise wording used in the permission condition was as follows:

Suppose people wish to engage in activity A. You know that before one can engage in this activity, one must fulfil requirement X. Your task is to make sure that people follow the regulation: "If one is to engage in activity A, then one must fulfil requirement X."

Suppose each of several people has engaged in one of two activities, activity A or activity B. In addition, each person has either fulfilled requirement X, or else done Y instead, where Y does *not* fulfil the requirement for activity A. There are four cards below, one each for four people. Each card gives information on a single person. One side of each card shows whether this person engaged in activity

A or B. The other side shows whether the person fulfilled requirement X or did Y instead.

You want to see if any person violated the regulation. Which of the cards below would you have to turn over to check? Turn over as many cards as you think appropriate, but do not turn over a card unless what is on the other side can potentially tell you that the person violated the regulation.

Note that the clarification involved stating that Y does not fulfil the requirement for activity A. Subjects were not explicitly told that Y is equivalent to "not X", and none of the four cards contained negatives.

The arbitrary rule, with the clarification to block a biconditional interpretation, read as follows:

Below are four cards. One side of each card has written on it either "A" or "B". The other side has written either "X", or else "Y" instead. The cards are supposed to be constructed so that if any card has an "A" on one side, it has an "X" on the other. Your task is to make sure that the cards conform to the rule: "If a card says 'A' on one side, then the other side must say 'X'." The rule does *not* imply that if a card does not say "A" on one side, then the other side must not say "X".

You want to see if any of the cards violates the rule. Which of the cards below would you have to turn over to check? Turn over as many cards as you think appropriate, but do not turn over a card unless what is on the other side can potentially tell you that the card violates the rule.

The wording of the arbitrary rule without the clarification was identical to the above, except that the last sentence of the first paragraph was deleted.

A total of 65 subjects received the permission rule, 31 received the arbitrary rule with the clarification, and 35 received the arbitrary rule without the clarification. Within each condition, about half the subjects saw the cards in the order "Y", "A", "B", "X", and half saw them in the reverse order. The procedure was essentially identical to that of the earlier experiments.

## Results and Discussion

The percentages of subjects who selected individual cards and the correct combination (i.e. the "A" and "Y" cards) in the three conditions, along with the number of subjects in each, are presented in Table 3. As in Experiment 1B, the pattern of selections did not differ significantly across the two versions of the arbitrary rule, indicating that ruling out the possible

TABLE 3  
Percentages of Subjects Choosing Individual Cases and the  
Correct Combination<sup>a</sup> in Experiment 2<sup>b</sup>

	<i>N</i>	<i>p</i>	<i>q</i>	$\bar{p}$	$\bar{q}$	<i>correct</i>
Permission	65	75	29	34	48	22
Arbitrary clarified	31	55	61	48	55	6
Arbitrary unclarified	35	74	60	34	37	5

<sup>a</sup>The *p* and *not-q* cases for the rule *if-p-then-q*.

<sup>b</sup>With violation-checking context and no explicit negatives in all conditions.

biconditional interpretation was not sufficient to produce facilitation with the arbitrary rule. Accordingly, data from these two conditions were combined and compared to the results produced in the permission condition. A small but highly significant advantage was obtained for the permission rule (22% correct) relative to the arbitrary rule (6%),  $\chi^2(1) = 8.37$ ,  $p < 0.005$ .<sup>1</sup> Thus, as the theory of pragmatic reasoning predicts, it is possible to obtain limited but reliable facilitation of violation-checking performance for an abstract permission rule even when the cards lack explicit negatives for the *not-p* and *not-q* cases, so that an inference is required to match Rule 4 of the permission schema.

## GENERAL DISCUSSION

The present findings disconfirm Jackson and Griggs' (1990) interpretation of facilitation in the selection task. Contrary to the implication of their proposal, the presentation factors to which they assigned credit for facilitation of the abstract permission rule proved completely ineffective in enhancing accuracy for an arbitrary rule.

Even when the arbitrary rule was clarified to rule out a possible biconditional interpretation, performance was not improved. In contrast, the results of Experiment 2 demonstrated that even when the cards presented to subjects do not include explicit negatives for the *not-p* and *not-q* cases, a small but reliable facilitation effect can still be obtained for an abstract statement of the permission rule, as long as the statement of the problem

<sup>1</sup>As a partial replication of Experiment 2, an additional 124 UCLA undergraduates received either the permission rule ( $n = 71$ ) or the arbitrary rule with the clarification ( $n = 53$ ), again using a violation-checking context in the absence of explicit negatives. The procedure was identical to that of Experiment 2, except that the problem was presented immediately after an initial selection problem based on a concrete conditional regulation. The percentage correct in this replication was 32% for the permission rule and 8% for the arbitrary rule.  $\chi^2(1) = 11.00$ ,  $p < 0.001$ .

clearly implies that the implicit version of the *not-q* case is in fact logically equivalent to that case.

There might appear to be some discrepancy between the findings of Evans (1983), who found facilitation on an abstract truth-table task by explicit negatives, and the lack of any such facilitation for arbitrary rules in the selection task, both in the present study and in that of Jackson and Griggs (1990, Experiment 4). The discrepancy is actually more apparent than real, since the selection-task studies have exclusively used affirmative conditional rules. Evans (1983) did not find any facilitation for such rules except in evaluating the case in which both the antecedent and consequent are false (i.e. the case of "*not-p* and *not-q*"). Facilitation in processing this case should not improve selection-task performance, regardless of whether subjects interpret the task as involving falsification or verification. If subjects interpret the task as involving falsification, then as the appropriate response for this case is "true", it cannot falsify the rule and hence should not affect selection-task performance. Otherwise (i.e. if subjects interpret the task as involving verification), facilitation due to explicit negatives would predict that subjects should choose *not-p* and *not-q* more often, in addition to choosing *p* and *q*. Again, selection performance would not be facilitated. Moreover, there is no evidence that subjects chose *not-p* and *not-q* more frequently in explicit than implicit conditions (see the percentages of subjects selecting these two cases individually in Tables 1–3). It follows that Evans' (1983) findings provide no empirical justification for Jackson and Griggs' (1990) extrapolation of the two-stage model to the selection task.

Evans found the most pronounced facilitation effects for conditional rules in which the conditional itself contained a negative; however, to the best of our knowledge such rules have never been used in selection task. It would be interesting to examine whether or not explicit negatives facilitate selection-task performance for negative conditional rules.<sup>2</sup>

There is certainly a difference, however, between subjects' processing of the *not-q* alternative in the abstract truth-table task and the arbitrary selection task. In Evans' (1983) truth-table task, more than 90% of subjects correctly identified the "*p* and *not-q*" case as falsifying the affirmative conditional rule "If *p* then *q*", regardless of the presence or absence of explicit negatives. In contrast, although most subjects choose the *p* card on the selection task, the great majority fail to choose the *not-q* card for arbitrary rules. Subjects thus appear to have difficulty choosing both cards corresponding to the falsifying case, despite the ease with which they correctly classify that case as "false" in the truth-table task.

It may be that the two tasks involving an arbitrary rule differ in the kind of reasoning demands they place on subjects. In the truth-table task sub-

<sup>2</sup>We thank Jonathan Evans for making this suggestion.



jects are shown cases for each possible conjunction of the truth and falsity of  $p$  and  $q$ , whereas in the selection task subjects must construct the possible conjunctions. Moreover, in the truth-table task there is no need to remember to restrict the task to falsification, excluding verification; subjects are asked to assess the truth or falsity of each case. In contrast, in the selection task verification needs to be excluded. The greater task demands may increase the difficulty of evaluating the  $q$  and *not-q* cases in the selection task. In any event, evidence of a matching bias for arbitrary conditionals on the truth-table task is not inconsistent with the role of explicit negatives in the evocation of pragmatic schemas for rules with abstract deontic content.

More generally, the influence of the two presentation factors identified by Jackson and Griggs—provision of explicitly negative cases and a violation-checking context—on selection-task performance is entirely consistent with the theory of pragmatic reasoning schemas. This theory predicts that (a) the favourable presentation factors will be useless for facilitating performance with an arbitrary rule; (b) a violation-checking context is a key cue for evoking deontic schemas and is therefore required to obtain facilitation of an abstract permission rule; (c) explicit negatives provide a more direct match with the negative antecedent of Rule 4 of the permission schema and hence maximize facilitation for the permission rule; and (d) limited facilitation can be obtained for a permission rule even in the absence of explicit negatives, as long as the logical status of the implicit version of the *not-q* case is made clear to subjects. Thus the theory is able to account for both the present findings and those of Jackson and Griggs (1990).

The results of the present study complement those obtained by Girotto et al. (1992). Together, these studies support the view that the content effects consistently observed for conditional regulations in the selection task are due to the selective evocation of pragmatic schemas. At present no viable alternative theory has been offered to account for the influence of deontic content on selection-task performance. As noted earlier, no theory based on content-free inference procedures, whether formulated in terms of inference rules or mental models, provides a mechanism by which an abstract deontic context can influence reasoning. It has nonetheless been claimed that the mental-models approach can actually explain content effects in the selection task (Johnson-Laird & Byrne, 1991, 1992). A number of empirical problems with this proposal have been noted by others (Manktelow & Over, 1992; Politzer & Nguyen-Xuan, 1992). In fact, Johnson-Laird and Byrne have not specified any mechanism by which an abstract or unfamiliar deontic rule might produce facilitation. Their explanation of contextual variations is simply that, "The model theory assumes that reasoners use their knowledge, however it is represented, in

constructing models of premises" (Johnson-Laird & Byrne, 1991, p. 79). Their most specific suggestions as to *how* knowledge might be used are that the content of the rule may trigger "memories for violations" or "memories for analogous events". They assert that "General knowledge need not be represented by pragmatic reasoning schemas"; instead, it might be represented by "general assertions" (see Johnson-Laird & Byrne, 1991, pp. 79–81). No details are provided as to what these "general assertions" might be. In the absence of any attempt to specify a theory of memory organization or retrieval processes (which would clearly require assumptions that go beyond the scope of any available formulation of mental-models theory), this effort to explain content effects in reasoning does not go beyond Griggs and Cox's (1982) explanation in terms of memory for counterexamples.

We do not mean to imply, however, that the theory of pragmatic schemas offers a complete account of content effects in reasoning. The theory has only been developed in two domains: the deontic relations of permission (Cheng & Holyoak, 1985) and obligation (Cheng et al., 1986), and causal relations (Cheng & Nisbett, 1993). Even in the deontic domain, where the theory has been developed in greatest detail, basic questions concerning the psychological representation of deontic concepts remain open (Manktelow & Over, 1991). Nonetheless, the evidence that even an abstract deontic context is capable of facilitating reasoning suggests that relatively abstract knowledge structures in long-term memory play an important role in reasoning.

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