

## Pragmatic Reasoning With a Point of View

Keith J. Holyoak and Patricia W. Cheng

*University of California, Los Angeles, USA*

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. A number of investigators have since obtained evidence that the dominant pattern of selections for deontic rules can be reversed from the so-called "logical" pattern,  $p \ \& \ not-q$ , to  $not-p \ \& \ q$ , by manipulating subjects' perspective. We show that such selection reversals can be derived from the theory of pragmatic schemas given an analysis of the complementarity of rights (which underlie the permission schema) and duties (which underlie the obligation schema). The theory predicts that the  $not-p \ \& \ q$  combination will be obtained equally often for two superficially different conditions: an ambiguous rule, nominally stated in the form *if p then q*, presented within a context that encourages mapping to a particular rule of the permission schema; and an unambiguous rule with the logical form *if q then p* that is mapped to a different rule of the same schema. In contrast, the  $p \ \& \ not-q$  combination will be generated when the context encourages a mapping to a particular rule of the obligation schema. These predictions were confirmed in an experimental test. The status of alternative theoretical approaches is considered in light of the present findings and other relevant research.

### INTRODUCTION

One of the most distinctive aspects of human intelligence is the ability to reason about the consequences of actions taken by oneself and others. Not only do people anticipate the immediate consequences of actions (for example, whether an action is likely to achieve a desired goal), but also more indirect consequences related to social roles and regulations. For a person acting within a social context, the evaluation of actions is guided in part by a complex web of contract-like regulations. Some of these regulations are

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Requests for reprints should be sent to Keith J. Holyoak, Dept. of Psychology, Franz Hall, UCLA, Los Angeles, CA 90095-1563, USA.

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codified as laws, imposed by the authority of state or religion; others are based on looser regulations that arise from expectations about behaviours appropriate for members of particular social groups (for example, a scout troop, an urban gang, or a family), from informal agreements between individuals, or from self-imposed codes of conduct. People are able to assess whether or not actions conform with or violate applicable regulations, and make use of this assessment in selecting actions. Of course, people often select actions that violate regulations. For this reason it is important to be able to assess whether the actions of others conform to regulations in which one has an interest.

Research on reasoning about regulations has played a central role in the development of theories of conditional reasoning. There is now considerable evidence that people employ content-specific inference procedures specialised to deal with the deontic concepts that underlie regulations. One paradigm in which such content effects have been studied extensively is Wason's (1966) "selection task". (See Evans, 1989, and Wason, 1983, for reviews.) The selection task involves giving subjects a conditional rule in the form *if p then q*. Subjects are 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 the cards show 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 true or false. The "correct" choice, according to standard propositional logic, 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 possibilities that would 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 *p* and *not-q* cases are selected much more frequently (see, for example, Cheng & Holyoak, 1985; Cosmides, 1989; D'Andrade, 1982; Girotto, Gilly, Blaye, & Light, 1989; Griggs & Cox, 1982; Johnson-Laird, Legrenzi, & Legrenzi, 1972; Light, Girotto, & Legrenzi, 1990; Manktelow & Over, 1991; Politzer & Nguyen-Xuan, 1992). Moreover, it appears that the ability to reason about regulations emerges at an early age. Work by Girotto and his colleagues has demonstrated that children as young as 6 years old can solve simplified versions of the selection task when the rule is interpreted deontically (Girotto, Light, & Colburn, 1988; Light, Blaye, Gilly, & Girotto, 1990), and children as young as 9 years old can solve the full selection task given deontic content (Girotto et al., 1989). Indeed, an earlier study suggests that 6-7-year-old children can

solve a complete selection task based on a rule interpretable as an obligation (Legrenzi & Murino, 1974).

To explain this type of content-based influence on reasoning in the selection paradigm and other tasks (such as linguistic rephrasing) involving inference with conditionals, 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 pragmatic reasoning schemas based on deontic relations. Such schemas represent knowledge about the types of regulations typically constructed by those in authority to constrain human voluntary action in a manner consistent with their goals. The theory of pragmatic reasoning schemas (PRS) predicts that performance on the selection task will be facilitated (i.e. be in accord with standard logic) 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 will tend to evoke a permission schema, the core of which can be represented in terms of the following rules, P1-P4 (Cheng & Holyoak, 1985, p.397):

- 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.

We will refer to schema rules such as P1 and P4 as "deterministic" conditionals because they contain the modal *must* in their consequent, and hence make definite predictions. Note that the "drinking age" rule is in the form of Rule P1, the antecedent of which is matched by the *p* case. As P1 is deterministic, it indicates that someone who drinks alcohol should be checked to be sure the age precondition has been met. The antecedent of Rule P4 matches the *not-q* case. The consequent of P4 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 P2 and P3 respectively match the *not-p* and *q* cases. Because the consequents of these rules do not make any definite predictions (they contain the modal *may* rather than *must*), they indicate that no violation is possible given the *not-p* and *q* cases, thereby 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 pre-

cautionary measure) than for an arbitrary rule. (See also Girotto, Mazzocco, & Cherubini, 1992; Kroger, Cheng, & Holyoak, 1993.) 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 not readily explicable either by alternative 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).

### Perspective Effects in Deontic Reasoning

An aspect of deontic content effects that has recently been a focus of attention in evaluating alternative theories has been the influence of subjects' perspectives on performance on the selection task. Conditional regulations typically involve interactions between two parties who have distinct points of view. Manktelow and Over (1991) investigated selection performance using a conditional permission statement said to be made by a mother to her young son, "If you tidy your room then you may go out to play", which pragmatically corresponds to the deterministic conditional "If you go out to play then you must have tidied your room." Here "going out to play" is the  $p$  case and "tidying the room" is the  $q$  case. The mother plays the role of the permittor who grants conditional permission, and the boy plays the role of the corresponding permittee. As Manktelow and Over observed, the goals of the two parties are likely to differ. The mother's goal is to have the boy tidy his room; thus she is likely to be concerned with the possibility that the boy "cheats" by violating his side of the implicit contract, going out to play without tidying his room. In a selection task, someone taking the mother's point of view would therefore tend to select the  $p$  and *not- $q$*  cases (i.e. a card indicating the boy went out to play and one indicating he did not tidy his room). This is the so-called "logical" pattern often observed for selection problems with deontic content.

It is possible, however, to consider instead the situation from the perspective of the son. He also has an interest in the actions regulated by the contract. In particular, his goal is to go out to play; thus his interests would be ill-served if he tidied up his room but was nonetheless prevented from playing. From the son's point of view, then, it would be sensible to examine the *not- $p$*  and  $q$  cases (i.e. a card indicating the boy did not get an opportunity to play and a card indicating he did tidy his room). In fact, Manktelow and Over (1991) found that the dominant response pattern could be reversed by instructions that manipulated the subjects' point of view concerning the regulation. Subjects who were led to take the mother's (permittor's) perspective tended to select the  $p$

and *not-q* cases, whereas those led to take the son's (permittee's) perspective tended to select the *not-p* and *q* cases.

Similar perspective effects in selection tasks have been reported by Light et al. (1990) for children, and by Politzer and Nguyen-Xuan (1992) and Gigerenzer and Hug (1992) for adults. For example, the latter investigators gave subjects the "day off" (D) rule:

(D) If an employee works on the weekend, then that person gets a day off during the week.

Two context stories were used, one of which cued subjects into the employee's perspective, and one that cued the employer's perspective. Those subjects who were encouraged to take the employee's perspective tended to select the *p* and *not-q* cases ("worked on the weekend" and "did not get a day off"). In contrast, subjects who were led to take the employer's perspective tended to select the opposite cases; *not-p* and *q* ("did not work on the weekend" and "did get a day off").

Gigerenzer and Hug's (1992) results, like those of Manktelow and Over (1991), reveal that the dominant selection pattern for a deontic rule can systematically deviate from that supported by the standard logic of the material conditional. But as Cheng and Holyoak (1985) noted, evocation of a pragmatic schema will not necessarily lead to selection of the "logically correct" cases, both because different schemas will suggest different relevant inferences, and because the inferences based on any particular schema will vary depending on the mapping between the stated rule and those associated with the schema. For example, PRS theory predicts that a stated rule that can be interpreted as a permission will lead to selection of the "logically correct" cases only if it maps directly onto Rule P1 of the permission schema. Politzer and Nguyen-Xuan (1992), who also obtained perspective effects in a selection paradigm, have shown that an analysis in terms of an integrated combination of schemas for permission and obligation can account for the pattern observed in their own study and those of Manktelow and Over (1991) and Gigerenzer and Hug (1992). In the present paper we will generalise Politzer and Nguyen-Xuan's analysis by relating it more explicitly to the concepts of *rights* and *duties* as they have been used in legal theory. We use this analysis to derive a novel prediction from PRS theory, and report an experiment that tests this prediction.

### The Complementarity of Permission and Obligation

As already noted, the PRS theory postulates that deontic inferences, which concern what *ought* to be done, are governed by schemas specialised for situations involving permission and obligation. In its original formulation (Cheng & Holyoak, 1985), the permission schema was defined in terms of Rules P1–



P4, but without reference to the concepts of rights and duties. Furthermore, the permission rules used in experimental tests of the theory were selected so as to map most directly onto Rule P1, rather than any other schema rule. Here we will define both permissions and obligations in terms of rights and duties, thereby clarifying the relationships among these concepts.

For both permissions and obligations, four possible situations can be defined in terms of whether or not the precondition is satisfied, and whether or not the action is to be taken. Corresponding to Rules P1–P4 for the permission schema are Rules O1–O4 for the obligation schema (adapted from Politzer & Nguyen-Xuan, 1992):

- O1: If the precondition is satisfied, then the action must be taken.
- O2: If the precondition is not satisfied, then the action need not be taken.
- O3: If the action is to be taken, then the precondition may have been satisfied.
- O4: If the action is not to be taken, then the precondition must not have been satisfied.

Typically both permissions and obligations involve preconditions that serve to trigger the regulation of voluntary action. In a conditional permission, satisfaction of the precondition bestows a *right* to take a regulated action, typically conveyed by the modal *may*:

If <precondition> then <may take action>.

For example, the regulation “If a person is over 21 years of age, then they may drink alcohol” is a conditional permission rule. Note that in this canonical form the stated permission rule maps most directly to schema rule P3 (rather than P1). In a conditional obligation, on the other hand, satisfaction of the precondition imposes a *duty* to take the relevant action, as conveyed by the modal *must*:

If <precondition> then <must take action>.

For example, the regulation “If a person is over 18 years of age, then they must register for the military draft” is a conditional obligation rule. Note that in this canonical form the stated obligation rule maps most directly to schema rule O1.

Although these regulations are stated as conditionals, in many contexts they can be interpreted as being pragmatically biconditional at the deontic level. That is, unless the context suggests some alternative precondition that would also trigger the right or duty, conditional regulations are likely to be interpreted as if the precondition is necessary as well as sufficient to establish the right or duty introduced in the consequent. It is important to distinguish the deontic level (rights and duties) from the level of overt action. A rule that is

pragmatically biconditional at the deontic level can nonetheless be conditional at the level of action, because in a conditional permission the action need not be taken even if the precondition is satisfied, and in a conditional obligation the action may be taken even if the precondition is *not* satisfied. Furthermore, in no case of a permission or obligation is it certain that the regulated action will in fact be taken. It is the nature of voluntary action that rules can be violated: people can take actions they have no right to take, while failing to perform their duties. Deontic regulations fundamentally govern the creation of rights and duties, and only indirectly influence the actions taken by those subject to the regulations.

The explanation provided for perspective effects by PRS theory hinges on the recognition that rights and duties are complementary and interdefinable concepts. This complementarity, noted by Politzer and Nguyen-Xuan (1992), corresponds to fundamental legal conceptions of rights and duties. A thorough treatment of rights and duties from a legal perspective was provided by Hohfeld (1919), who referred to these concepts as "jural correlates". Hohfeld quotes (1919, p.38) from a 1894 legal decision in the case of *Lake Shore & M.S.R. Co. v. Kurtz*: "'Duty' and 'right' are correlative terms. When a right is invaded, a duty is violated." Hohfeld then gives the illustration, "... if X has a right against Y that he shall stay off the former's land, the correlative (and equivalent) is that Y is under a duty toward X to stay off of the place".

We can formalise the equivalence noted by Hohfeld by stating the relations of "right" and "duty" as predicate-argument structures. Each relation has three arguments, corresponding to the two parties to a regulatory agreement and the action that is regulated. A right has the general form:

right (of X, against Y, re A)

that is, X has a right against Y with respect to action A (e.g. if X is a property owner, X has the right that Y should remain off X's land). Similarly, a duty has the form:

duty (of Y, toward X, re A)

that is, Y has a duty towards X regarding action A (e.g. Y has a duty to X to stay off X's land). It should be noted that this type of complementarity is by no means specific to rights and duties. Many pairs of converse relations, such as "left of" versus "right of", and "parent of" versus "child of", have a similar semantic structure, in which the meaning of the paired relations is equivalent (except for pragmatic focus) when their argument fillers are interchanged. For example:

parent-of (Mary, Sam)

is equivalent to:

child-of (Sam, Mary).

The general complementarity of rights and duties gives rise to special cases in which the schemas for permission and obligation are interdefined. These special cases involve conditional *contractual* permissions and obligations, based on regulatory agreements between two parties. Not all permissions and obligations are contractual in this sense; for example, neither the drinking age rule (permission) nor the draft age rule (obligation) involve bilateral contracts. The contractual cases correspond to the prototypical type of social contract discussed by Cosmides (1989). For such cases, the interdefinability hinges on the fact that the "precondition" either to X's right against Y (a permission) or to Y's duty toward X (an obligation) may be the fulfillment of a duty of X to Y. Thus we can state a specific version of Rule P3 of the permission schema, in which the precondition is a fulfilled duty, as:

P3': If duty (of X, towards Y, re A1) is fulfilled, then right (of X, against Y, re A2) is acquired

where A1 and A2 are regulated actions. Similarly, we can state a specific version of Rule O1 of the obligation schema as:

O1': If duty (of X, towards Y, re A1) is fulfilled, then duty (of Y, towards X, re A2) is incurred.

Note that the antecedents of P3' and O1' are identical, and the consequents of these rules express complementary rights and duties.<sup>1</sup> Conditional contractual permissions and obligations are thus interdefinable.

This analysis of the relationship between the permission and obligation schemas provides a straightforward explanation of the perspective effects observed by Manktelow and Over (1991) and others. We need only assume that people focus on whichever interpretation of the stated rule yields a definite conclusion about their *own* rights and the duties of others (rather than their own duties and the rights of others). That is, people's selections will be primarily focused on the cases related most directly to their own goals. For example, the rule used by Gigerenzer and Hug (1992):

(D) If an employee works on the weekend, then that person gets a day off during the week

<sup>1</sup>Alternatively, the precondition to either a permission or an obligation may be the exercise of a right of Y against X.



is, from the perspective of the employee, a conditional obligation imposed on the employer (i.e. a description of a regulation of the employer's duty toward the employee). The employee's goal is to have a day off during the week. A subject taking the employee's perspective would therefore represent this "day off" rule as something like:

(D-O1) If an employee works on the weekend, then the employer must grant a day off during the week.

Under this interpretation, the stated rule thus matches Rule O1 of the obligation schema. Once the schema is evoked, the entire set of obligation rules will apply. The deterministic rules, O1 and O4, will encourage selection of the  $p$  ("worked on the weekend") and  $not-q$  ("did not get a day off") cases.

The employer, on the other hand, has the goal of getting employees to work on weekends. Therefore from the employer's perspective the rule is likely to be interpreted as a conditional permission, equivalent to:

(D-P3) If an employee works on the weekend, then that person may take a day off during the week

a form that matches Rule P3 of the permission schema. Once the permission schema is evoked, the stated rule can be recast in the form of Rule P1, which provides a definite consequent:

(D-P1) If an employee takes a day off during the week, then that person must have worked on the weekend.

That is, the rule is interpreted as regulating a duty of the employee towards the employer. Once the stated rule has been mapped into the permission schema, all the schema rules become available, and the deterministic rules, P1 and P4, will determine the selected cards. If we consistently notate "worked on the weekend" as  $p$  and "did get a day off" as  $q$  (as in the stated rule), the result will be a preference for selection of the  $not-p$  ("did not work on the weekend") and  $q$  ("did get a day off") cases, just as Gigerenzer and Hug observed. In effect, the mapping to the permission schema causes the stated rule to be internally represented in the logical form *if  $q$  then  $p$* . The difference in perspective thus triggers complementary schematic interpretations, reversing the selection preference.

In addition to providing an explanation of previous demonstrations of perspective effects, the analysis of schema complementarity given here makes a prediction that has not been previously tested. A regulation such as Gigerenzer and Hug's "day off" rule is ambiguous in its pragmatic focus, which is why the context story can guide subjects to a particular point of view. The form of the stated rule was such that the obligation interpretation (employee version) would match Rule O1 of the obligation schema; and hence tend to promote selection

of the  $p$  and  $not-q$  cases. In contrast, the permission interpretation (employer version) would match Rule P3 of the permission schema, and hence would tend to promote selection of the  $not-p$  and  $q$  cases. From the employer perspective, the permission schema will thus apply in a manner that supports selection of the two cases ( $not-p$  and  $q$ ) opposite to those licensed by the material conditional.

But if the schema-complementarity account is correct, subjects' internal representation of the ambiguous rule in the employer context will in fact be equivalent to the representation of an unambiguous deontic rule presented in a form that matches P1, i.e. the form stated earlier as (D-P1). As this version explicitly has the logical form *if  $q$  then  $p$* , selection of the  $not-p$  and  $q$  cases for this rule is in accord with the logic of the material conditional. The present experiment tests whether subjects' performance in the selection task is in fact comparable for pragmatically ambiguous rules in a context that supports selection of the  $not-p$  and  $q$  cases, as compared to unambiguous rules in the form *if  $q$  then  $p$* .

### SELECTION PERFORMANCE FOR DEONTIC RULES VARYING IN PRAGMATIC FOCUS

Using the selection task, we varied the form and context of conditional rules concerning the regulation of voluntary human action. Each subject received a single selection task, with a rule presented in one of three conditions. In two conditions, subjects received a rule in the form *if  $p$  then  $q$*  that in isolation would be ambiguous between a conditional contractual obligation and a conditional contractual permission. The rule was presented along with a context intended to favour one of these two interpretations. Under the obligation interpretation the stated rule would match Rule O1 of the obligation schema, and hence tend to promote selection of the  $p$  and  $not-q$  cases. In contrast, under the permission interpretation the stated rule would match Rule P3 of the permission schema, and hence would tend to promote selection of the  $not-p$  and  $q$  cases. Subjects in the third condition received an unambiguous version of the rule in a form matching Rule P1 of the permission schema (in the form *if  $q$  then  $p$* ), with a minimal context. PRS theory predicts that selection performance should be the same for the ambiguous rule in the permission context as for the unambiguous form of the rule.

### Method

*Subjects.* Subjects were 143 undergraduate students, who participated in the study as part of the requirements for the introductory psychology course at the University of California, Los Angeles. Approximately equal numbers of subjects served in each of the six conditions (two basic rules crossed with three

presentation conditions varying the context and form of the rule). 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 basic rules and (b) three presentation conditions. The two rules and the context manipulations were adapted from problems used by Gigerenzer and Hug (1992) to investigate perspective effects.<sup>2</sup> The complete materials are provided in the Appendix. Each subject received one selection problem, which was presented on a single page. One rule was the "day off" rule, which in its ambiguous form (without a modal) was as stated earlier in (D). In the "employee-O1" condition, the rule was embedded in a context designed to encourage subjects to take the perspective of the employee, which would lead to a match to Rule O1 of the obligation schema. The story indicated that an employee was considering working on the weekend, but was concerned because of rumours that the rule had been violated. In the "employer-P3" condition, the context instead oriented subjects to the perspective of the employer, which would lead to a match to Rule P3 of the permission schema. In this version it was the employer who was described as being concerned that the rule was being violated. Finally, in the "employer-P1" condition the context was more neutral in that the violation-checker was not explicitly specified, and the rule was restated as:

(D-P1') An employee must have worked on the weekend if the person takes a day off during the week.

The statement (D-P1') is identical to (D-P1), except for a syntactic inversion from the form *if q then p* to the form *p if q* (given that we consistently denote "works on the weekend" as *p* and "gets a day off" as *q*), thus equating the surface order of *p* and *q* across versions (D) and (D-P1') of the stated rule, and hence across all three presentation conditions. In the (D-P1') form the modal *must* should facilitate matching the stated rule to Rule P1 of the permission schema. In all conditions subjects were asked to select the cases that might reveal violations of the rule from among cards representing four alternatives: "worked on the weekend" (*p*), "did not work on the weekend" (*not-p*), "got a day off" (*q*), and "did not get a day off" (*not-q*). Within each condition, about half the subjects received the cards in each of two orders: *not-p, q, p, not-q*; or else *p, not-q, not-p, q*.

PRS theory predicts that the employee-O1 condition should favour selection of the *p* and *not-q* alternatives, whereas both the employer-P3 and the employer-P1 conditions should favour selection of the *not-p* and *q* alternatives. The

<sup>2</sup>As Gigerenzer and Hug (1992) did not report the precise wording of the materials they used to manipulate subjects' perspectives, it was necessary to develop our own versions.

latter two conditions are predicted to yield identical response patterns because both should trigger matches to a core rule of the permission schema (P3 or P1, respectively), either of which will enable access to the entire set of schematic inferences. Importantly, although selection of the *not-p* and *q* alternatives is opposite to the so-called "logical" answer for the employer-P3 condition (given that the ambiguous rule is nominally in the form *if p then q*), this same selection is in accord with the material conditional for the employer-P1 condition (as the unambiguous rule has the logical form *if q then p*). If these two conditions in fact yield comparable patterns of selections, such a result would support a central claim of PRS theory: people's reasoning about deontic relations is not in fact based on the syntactic rules of the material conditional, but rather on domain-specific rules sensitive to people's goals.

Three parallel conditions were generated on the basis of a second problem, in order to provide greater generality for testing the predictions of PRS theory. The basic rule for the second set of materials was the "subsidy" (S) rule:

(S) If a car owner installs a new catalytic converter, then that person gets a subsidy.

The general rationale for this rule was that the Greater Los Angeles Air Quality Management District is concerned about the pollution caused by the car exhaust generated by older cars. (This rule was adapted from a similar subsidy rule used by Gigerenzer & Hug, 1992, involving a corrective action to prevent pollution from outdated heating systems in the former East Germany. Car exhaust provided an analogous issue that could be related to realistic concerns of subjects in Los Angeles.) In the "owner-P1" condition subjects were encouraged to take the perspective of the owner of an older car, who was considering installing a catalytic converter, but was concerned by rumours that the rule had been violated. In the "officer-P3" condition subjects were instead encouraged to take the perspective of an officer working for the Air Quality Management District, who was concerned that the rule was being abused. Finally, the "officer-P1" condition used a more neutral context in which the violation-checker was not specified, and restated the rule as:

(S-P1') A car owner must have installed a new catalytic converter if the person receives a subsidy.

The logical form of (S-P1') was thus parallel to that of the equivalent day-off rule (D-P1'), i.e. *q if p*. The design and predictions for the subsidy conditions were in all respects the same as those for the day-off conditions.

*Procedure.* Subjects were run in two large groups. Subjects each received one selection task in a booklet that also contained materials for other experi-

ments. 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.

### Results

The frequency of selecting each individual alternative was scored, as was the frequency of selecting the two critical combinations:  $p$  &  $not-q$ , and  $not-p$  &  $q$ . As the response pattern did not differ across the two orders of the cards, all results will be reported after collapsing across card order.

Table 1 presents the frequencies with which each individual card was selected as well as the frequencies with which the two critical combinations were selected. PRS theory predicts that the individual  $p$  and  $not-q$  responses, as well as the  $p$  &  $not-q$  combination, will tend to be selected more often in the O1 conditions (the employee condition for the day-off problem and the owner condition for the subsidy problem) than in the corresponding P3 or P1 conditions. In contrast, the individual  $not-p$  and  $q$  responses, as well as the  $not-p$  &  $q$  combination, were predicted to be selected more frequently in the P3 and P1 conditions (the employer conditions for the day-off rule and the officer conditions for the subsidy rule) than in the corresponding O1 condition. Within each problem the response patterns for the P3 and P1 conditions were predicted to be the same as each other, as both involve mappings to the permission schema that indirectly (via P3) or directly (via P1) impose the logical form *if  $q$  then  $p$*  on the stated rule.

To test these predictions, log-likelihood chi-square analyses using the  $G^2$  statistic (Wickens, 1989) were performed on the frequency data for each basic problem, first comparing the P3 and P1 conditions, and then comparing these two conditions combined to the O1 condition. The results were fully in accord

TABLE 1  
Frequencies of Individual Responses and Critical Combinations for Each condition

	Individual Responses				Combinations		N
	$p$	$not-q$	$not-p$	$q$	$p$ & $not-q$	$not-p$ & $q$	
Day-Off Problem							
employee-O1	0.77	0.59	0.27	0.59	0.23	0.14	22
employer-P3	0.24	0.14	0.81	0.81	0.00	0.57	21
employer-P1	0.15	0.22	0.70	0.89	0.04	0.56	27
Subsidy Problem							
owner-O1	0.83	0.63	0.33	0.38	0.46	0.08	24
officer-P3	0.36	0.23	0.68	0.86	0.00	0.41	22
officer-P1	0.22	0.26	0.59	0.67	0.00	0.44	27



with the predictions of PRS theory. For the day-off problem the employer-P3 and employer-P1 conditions did not differ significantly from each other for any individual response or either combination,  $G^2(1) < 1$  for all tests. Tests comparing the O1 condition to the combined P3 and P1 conditions also confirmed the predictions of the theory. The frequencies of the *p* and *not-q* alternatives were each greater for the employee-O1 than for the employer conditions,  $G^2(1) = 19.7$  and  $9.60$ , respectively,  $P < 0.005$  in both cases. The same pattern of differences was obtained for the *p* & *not-q* combination,  $G^2(1) = 5.78$ ,  $P < 0.025$ . Conversely, the frequencies of the *not-p* and *q* alternatives were each greater for the combined employer conditions than for the employee-O1 condition,  $G^2(1) = 12.4$ ,  $P < 0.001$ , and  $G^2(1) = 4.53$ ,  $P < 0.05$ , respectively. The same pattern of differences was obtained for the frequency of the *not-p* & *q* combination,  $G^2(1) = 9.51$ ,  $P < 0.005$ . The response that was predicted to be dominant was in each case the majority response, with the exception of the *p* & *not-q* combination for the employee-O1 condition, which was produced less frequently than expected because a substantial percentage of subjects (27%) selected *q* in addition to *p* & *not-q*.

For the subsidy problem, the pattern of results for the three conditions were qualitatively identical to that observed for the day-off problem. The officer-P3 and officer-P1 conditions did not differ significantly on any measure, with the largest difference occurring for the choice of *q*,  $G^2(1) = 1.59$ ,  $P > 0.10$ . The frequencies of the *p* and *not-q* alternatives were each greater for the owner-O1 than for the officer conditions,  $G^2(1) = 17.3$  and  $8.42$ , respectively,  $P < 0.005$  in both cases, as was the frequency of the *p* & *not-q* combination,  $G^2(1) = 23.0$ ,  $P < 0.001$ . Conversely, the frequencies of the *not-p* and *q* alternatives were each greater for the combined officer conditions than for the owner-O1 condition,  $G^2(1) = 4.66$ ,  $P < 0.05$ , and  $G^2(1) = 8.42$ ,  $P < 0.01$ , respectively, as was the frequency of the *not-p* & *q* combination,  $G^2(1) = 7.37$ ,  $P < 0.01$ . Each predicted individual response was produced by at least 59% of subjects, and each predicted combination was produced by at least 41% of subjects.

## GENERAL DISCUSSION

### Perspective Effects from the Perspective of PRS Theory

The present results provide clear support for predictions derived from the theory of pragmatic reasoning schemas, as proposed by Cheng and Holyoak (1985) and elaborated by Politzer and Nguyen-Xuan (1992) with an analysis of schema complementarity. The present paper extends the complementarity analysis by relating it more explicitly to the concepts of rights and duties. In everyday reasoning about regulations governing human voluntary action, as in the interpretation of more formal legal codes (Hohfeld, 1919), rights and duties

are interdefinable: the right of X against Y with respect to Action A entails a correlative duty of Y towards X with respect to Action A, and vice versa. In the special cases of the permission and obligation schemas in which the "precondition" is fulfillment of a duty of X to Y (i.e. contractual regulations), the two schemas are interconnected by a relation of complementarity. In such situations a context that establishes a particular perspective on an ambiguous rule can trigger a match either to Rule O1 of the obligation schema or Rule P3 of the permission schema. While a match to Rule O1 favours selection of the so-called "logical" alternatives,  $p \ \& \ not-q$ , a match to Rule P3 favours selection of the opposite alternatives,  $not-p \ \& \ q$ . However, in neither case is the selection process actually governed by formal rules of a mental logic equivalent to the material conditional. Rather, a match to Rule P3 implicitly leads subjects to represent the ambiguous stated rule in the logical form *if q then p*. The complementarity analysis predicted that the same pattern of selections,  $not-p \ \& \ q$ , would also be obtained in a more neutral context when the stated rule unambiguously matched Rule P1 of the permission schema, with the explicit logical form *if q then p*. The experimental results reported here confirmed these predictions for two different problems.

The present analysis and empirical results support Cheng and Holyoak's claim (1985, p.397) that the permission schema is *not* equivalent to the material conditional in standard propositional logic. Rather, the deontic schemas are context-sensitive, and the inferences they will generate will necessarily depend on the specific mapping between the stated rule and the rules of a relevant schema. If a stated rule is matched to Rule P1 of the permission schema or to Rule O1 of the obligation schema, then the so-called "logical" selection of  $p \ \& \ not-q$  will indeed be facilitated. But precisely the opposite selection pattern will be encouraged if the stated rule is instead mapped onto Rule P3 of the permission schema. More generally, of course, other schemas that apply to non-deontic situations, such as causal hypothesis testing, will favour different selection patterns.

PRS theory was originally supported by experiments that demonstrated the importance of goals and context in the evocation of deontic schemas. For example, Cheng and Holyoak (1985, Experiment 1) found that the identical stated rule either would or would not yield facilitation depending on whether the context made it clear that the rule was an established regulation for which it was necessary to check for possible violations. A number of investigators have nonetheless ignored the fundamental importance of context in PRS theory, instead assuming that a stated rule can be classified as a permission rule without consideration of its context. For example, Gigerenzer and Hug (1992) had subjects perform a selection task with a rule presented in one of two contexts: a context that involved checking for violations of an established rule, and a context that involved testing the correctness of an hypothesised rule.

They observed a greater frequency of selecting the *p* & *not-q* combination in the violation-checking than the hypothesis-testing context, thereby replicating similar findings reported by Yachanin and Tweney (1982) and Cheng and Holyoak (1989). This difference between the two conditions follows directly from PRS theory, as a violation-checking context constitutes a major cue for evocation of the deontic concepts of permission and obligation that underlie the regulation schemas, as Cheng and Holyoak (1985, p.410) 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.

Nonetheless, Gigerenzer and Hug (1992, p.143) asserted without explanation that "PRS theory . . . predicts no difference between the two versions because the rule is in both cases a permission rule . . .". The analysis and results provided in the present paper will, we hope, serve to correct such misconceptions of the basic principles of PRS theory.

### Alternative Explanations of Reasoning about Deontic Concepts

We will now briefly consider the implications of the present findings and related previous evidence for alternative theoretical approaches that have been advanced as possible explanations of human reasoning about deontic concepts. We will consider three such approaches: possible models based on variants of formal logic, the social contract theory of Cosmides (1989), and models based on subjective utilities.

*Logic-based Models.* Content effects of the sort observed in research on reasoning about regulations clearly lie beyond the scope of existing psychological models of reasoning based on variants of formal logic (e.g. Braine & O'Brien, 1991). In general, proponents of the logic-based approach have conceded that domain-general natural inference procedures must be supplemented by pragmatic extensions of the sort proposed by PRS theory.<sup>3</sup> However, it has occasionally been suggested that the logic-based approach could account for findings concerning human deontic reasoning by incorporating some extended

<sup>3</sup>The mental-models theory of Johnson-Laird (1983; Johnson-Laird & Byrne, 1991), like logic-based accounts, is based on content-independent reasoning procedures that do not provide a direct explanation of the distinctive patterns of reasoning observed for deontic regulations and other content domains (Holyoak & Spellman, 1993, but see Johnson-Laird & Byrne, 1991, 1992). Manktelow and Over (1992) and Politzer and Nguyen-Xuan (1992) have pointed out a number of empirical problems with the mental-models approach as it might apply to perspective effects.

modal or deontic logic, which would have formal rules specific to sentences containing terms such as *must* and *may* (e.g. Gigerenzer & Hug, 1992; Rips, 1990). In practice, however, no serious treatment of content effects based on an extended logic has ever been offered. Here we consider the problems that would confront an attempt to provide such a treatment.

A basic point that is often ignored by advocates of a modal-logic approach is that such logics are *extensions* of propositional logic, not replacements for it. In particular, all standard modal logics allow the derivation of *modus tollens* from their axioms. Accordingly, such logics fail to account for why people act as if they use *modus tollens* in certain contexts (e.g. permissions) but not others (e.g. reasoning about arbitrary conditionals). One could presumably construct a deontic "mental logic" that excludes *modus tollens*, as do the propositional mental logics that have actually been proposed as psychological theories (e.g. Braine & O'Brien, 1991; Rips, 1983). However, the empirical problem raised by content effects would then be left unsolved. Just as non-deontic mental logics fail to provide any explanation for the context-specificity with which people make inferences that would be licensed by *modus tollens*, a deontic mental logic that excluded *modus tollens* would exhibit precisely the same deficiency. Moreover, standard deontic logics, such as *deontic S5*, are distinctly non-psychological in other respects. For example, a basic theorem precludes the possibility that obligations might conflict with one another, whereas people often find themselves struggling to reason about moral dilemmas (Chellas, 1980).

It should also be noted that empirical evidence has already established that the mere presence of a modal term in a rule is not sufficient to predict reasoning performance. For example, in all three experiments reported by Cheng and Holyoak (1985), the modal terms in the materials were matched across permission and arbitrary rules; hence the content effects obtained in that study could not have been due to differences in modal terms. Sentences with *must* and *may* can be used to describe a wide range of arbitrary situations, in addition to meaningful regulations. Thus an explanation of human reasoning with modals requires more than simply postulating specialised formal rules for drawing inferences based on sentences containing modals.

A remaining possibility is to hypothesise a mental logic in which *modus tollens* is restricted to apply only to those sentences for which the context supports the kind of deontic interpretation associated with regulations. Although to a first approximation such an account could indeed handle deontic content effects, it would do so by essentially assuming the principles of PRS theory. In particular, a rich theory of contextual cues would have to be somehow incorporated into the deontic logic. Even so, a logic-based account would differ from PRS theory in that all proposed deontic logics support only exceptionless inferences, whereas the rules hypothesised by PRS theory capture default expectations (i.e. plausible but defeasible inferences) rather than strict

deductions. Thus although it remains possible that a logic-based theory of human deontic reasoning may be developed, the difficulties confronting such a project are more formidable than has apparently been recognised by psychologists who have advocated such an approach.

*Social Contract Theory.* Cosmides (1989) proposed that facilitation in the selection task is obtained only for rules that fit a "social contract" schema, in which a cost is incurred by one party in exchange for a rationed benefit provided by another. As Cheng and Holyoak (1989) pointed out, social contracts are special cases of the permission and obligation schemas. For example, the social contract schema:

If <cost paid> then <may take benefit>

is a special case of the permission schema:

If <precondition> then <may take action>

where the "precondition" is a cost paid and the "action" is taking a benefit. As we noted in the Introduction, the rules used in the present study represent the kind of special cases of regulations that are in fact social contracts. Accordingly, the present results are fully compatible with social contract theory, given that theory's assumption that people check cases that might reveal cheating contrary to their interests.

More generally, however, the fact that social contract theory predicts distinctive selection patterns *only* for the special cases of deontic regulations that have a cost-benefit structure has allowed the theory to be conclusively disconfirmed, as facilitation has been observed for many rules that do not involve social exchanges (e.g. Cheng & Holyoak, 1989; Girotto, Blaye, & Farioli, 1989; Manktelow & Over, 1990; Politzer & Nguyen-Xuan, 1992). For example, Manktelow and Over (1990) found facilitation in the selection task for the conditional precaution "If you clean up spilt blood, then you must wear rubber gloves", where there was no suggestion that cleaning up spilt blood was a rationed benefit for which one must pay a cost. Although Cosmides (1989) reported failing to obtain facilitation with some conditional rules, none of them was cast unambiguously to subjects as a permission or obligation situation (Cheng & Holyoak, 1989; Pollard, 1990). Thus the successful predictions of social contract theory lie entirely in the area where it is equivalent to a restricted form of PRS theory.<sup>4</sup> PRS theory, by contrast, can explain patterns of performance with both social contracts and other types of deontic regulations (as well as with additional classes of schema-based rules, such as causal regularities; see Cheng & Nisbett, 1993).



Although the rules used in the present study involved social contracts, it should be noted that rights and duties are more general concepts than benefits and costs as conceptualised within social contract theory. Regulated rights often involve rationed benefits obtained in exchange for costs, and regulated duties often involve costs incurred in exchange for benefits. However, these concepts are not equivalent. The following exceptions should be noted:

1. Rights are not always benefits. For example, a person may have the right to eat as many anchovies as they like, but this will provide no benefit if the person happens to hate anchovies.
2. Duties are not always costs. The best man at a wedding may have the "pleasant duty" to offer a toast to the bride, and expect to enjoy doing so. It remains the case that he will have failed in his duty should he negligently forget to make the toast.
3. Duties are not always incurred in exchange for benefits. That is, the precondition to a conditional duty (i.e. obligation) need not be a benefit. Many a hapless motorist has confronted a law such as "If your car is towed away, then you must pay a fine to get it back".
4. Rights are not always acquired in exchange for costs. That is, the precondition to a conditional right (i.e. permission) need not be a cost. The well-known "drinking age" rule, which states that a person must be above a certain age before they are permitted to drink alcoholic beverages, is an example of this sort (as one's age is simply a condition, not a cost paid to someone).

The analysis of permissions and obligations based on the complementarity of rights and duties thus provides a more general framework for understanding reasoning about regulations than does social contract theory.

*Subjective Utilities.* A basic tenet of PRS theory is that pragmatic schemas are closely tied to the recurring inferential goals of human reasoners. We argued earlier that, in selection tasks based on deontic regulations, people's selections will be primarily focused on the cases related most directly to their own goals. That is, they will tend to check cases that might reveal violations of their own rights or of the duties owed them by others. In one way or another, all accounts of perspective effects incorporate some version of the

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<sup>4</sup>The fact that social contract theory is logically a restricted special case of PRS theory, so that the two theories make equivalent predictions for cost-benefit rules, has not deterred some investigators from interpreting results obtained with such rules as somehow favouring social contract theory over PRS theory. For example, Platt and Griggs (1993) found that removing the cost-benefit context from social-contract rules reduced facilitation, and concluded (p.185) that this result "cannot be accounted for by pragmatic reasoning schema theory". In fact, a cost-benefit context is simply a special case of the kind of rationale that Cheng and Holyoak (1985) showed to be important in leading subjects to interpret an unfamiliar rule as a regulation.

idea that people select cases that have high subjective utility to the reasoner. Manktelow and Over (1991, 1992, 1995) have laid particular stress on the role of perceived utilities in reasoning. Cosmides (1989) emphasised the pragmatic importance of detecting cheating by the other party in a contractual agreement. Oaksford and Chater (1994) have developed a Bayesian analysis of selection-task performance with both arbitrary and realistic materials. In their analysis, choice probability is assumed to be directly related to subjective utility, expressed as the product of the utility of the information that might be gained and the probability that checking will obtain the information.

There is no inherent conflict between the subjective-utility approach and PRS theory. As Oaksford and Chater (1994) have noted, a theory of domain-specific knowledge can provide information for setting parameters in a subjective-utility model. For example, the complementarity of the permission and obligation schemas makes it possible to infer the rights of one party from the duties of another, information that feeds into calculation of the different utilities associated with each perspective.

Given that deontic concepts and subjective utilities are clearly interconnected, it is worth exploring the nature of their relationship. Manktelow and Over (1995) suggest that deontic concepts can be defined in terms of the preferences of an authority who lays down a rule. In particular, they argue that a party "ought" to perform an action A (obligation situation) if and only if the authority prefers their performing A to their refraining from performing A; and that a party "may" perform A (permission situation) if and only if the authority is indifferent between them performing versus not performing A (or perhaps prefers that they perform A). These relationships indeed provide reasonable default expectations; however, exceptions can be found. In the case of obligation, it is possible to construct sensible scenarios in which an authority may impose a duty but hopes the subject will fail to perform it. For example, it is a cynical truism in Los Angeles that it would be disastrous for civic finances if motorists faithfully fed their parking meters with coins, as the city depends on the revenue generated by the parking tickets issued for expired meters. Here the authority imposes a duty on motorists to put coins in meters, but gleefully anticipates multitudinous lapses. In the case of permission, there are counterexamples to the claim that permission necessarily implies indifference or a positive preference. For example, the law may permit abortion, but the government may nonetheless wish to minimise the number of abortions performed (as evidenced by prohibitions against the use of public funds to pay for abortions). In such cases the authority makes a right available, even though that same authority may also prefer that the right not be exercised.

The parking-meter and abortion examples illustrate that, from the perspective of the enforcer of a regulation, provision of rights and imposition of duties cannot be equated with preferences about actions. Analogous counterexamples

can be found if we examine utilities from the perspective of the subject of a regulation. In general, one's rights tend to have positive utility and one's duties tend to have negative utility. But in the previous section we raised examples of worthless rights (eating anchovies) and pleasant duties (toasting the bride). It is also important to recognise that regulations do not simply reflect pre-existing utilities; in addition, they create new utilities. A pragmatically well-formed regulation carries with it the possibility of enforcement: a lapse in fulfilment of a duty, or the abridgment of a right, can result in coerced compliance or imposition of a compensatory penalty. People's preferences among courses of action are therefore routinely modified by the very existence of relevant regulations.

Just as rights and duties are not reducible in a direct way to utilities regarding actions, it seems that utilities are by no means reducible to deontic concepts. A nice illustration of the independent role of utilities is provided by a study of selection performance reported by Kirby (1994). Using a variation of the "drinking age" problem Kirby provided subjects with multiple *not-q* alternatives (i.e. customers under age 21): a customer who was 19 years of age, one of 12 years, and one of 4 years. Kirby found that the probability of selecting a *not-q* alternative declined with the indicated age, presumably reflecting people's knowledge that very young children are less likely to be drinking alcoholic beverages than are older children or teenagers. Thus although all *not-q* cases present potential violations of the rule, the probability of finding an actual violation—and hence the utility of checking—can systematically vary.

Both empirical evidence and conceptual analysis therefore suggest that the relationship between deontic concepts and subjective utilities is quite complex. It seems that a complete theory of human deontic reasoning will likely require an integration of models of contractual schemas with models of utility assessment.

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## APPENDIX

### Day-off Problem

*Ambiguous rule, employee perspective (matches Rule O1 of the obligation schema).*

Suppose you are an employee at a manufacturing company. Your employer has decided that it is useful to have employees work on the weekend, because the firm can get more flexible and efficient use of its machines that way. However, although employees such as yourself certainly like to have days off during the week, they do not like to work on weekends. Taking days off during the week ordinarily is not allowed. Accordingly, your employer has established the following regulation:

If an employee works on the weekend, then that person gets a day off during the week.

As an employee at this firm, you have never worked on the weekend before, but are now considering working Saturdays from time to time, as having a day off during the week is a benefit that outweighs the costs of working on Saturday. There are rumours going around that the regulation has been violated. You want to check whether there is any substance to the rumours.

*Ambiguous rule, employer perspective (matches Rule P3 of the permission schema).*

Suppose you are an employer at a manufacturing company. You have decided that it is useful to have employees work on the weekend, because the firm can get more flexible and efficient use of its machines that way. However, although employees certainly like to have days off during the



week, they do not like to work on weekends. Taking days off during the week ordinarily is not allowed. Accordingly, you have established the following regulation:

If an employee works on the weekend, then that person gets a day off during the week.

As the employer, you must ensure that the rule is not being abused. There are rumours going around that the regulation is being violated. You want to check whether there is any substance to the rumours.

*Unambiguous rule, employer perspective (matches Rule P1 of the permission schema).*

A manufacturing company has decided that it is useful to have employees work on the weekend, because the firm can get more flexible and efficient use of its machines that way. However, although employees certainly like to have days off during the week, they do not like to work on weekends. Taking days off during the week ordinarily is not allowed. The following regulation has been established:

An employee must have worked on the weekend if the person takes a day off during the week.

*Question (all conditions)*

Below are four cards, one each for four workers. Each card gives information on a single person. One side of each card shows whether or not this person worked on the weekend. The other side shows whether or not the person got a day off during the week.

You want to see if the regulation has been violated for these cases. 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 regulation has been violated.

*Cards (presented in one of two orders):*

"worked on the weekend" ( $p$ ), "did not work on the weekend" ( $\text{not-}p$ ), "got a day off" ( $q$ ), "did not get a day off" ( $\text{not-}q$ ).

## Subsidy Problem

*Ambiguous rule, owner perspective (matches Rule O1 of the obligation schema).*

Suppose you are the owner of an old car with a malfunctioning catalytic converter. The Greater Los Angeles Air Quality Management District is concerned about the pollution caused by cars such as yours. In order to diminish pollution from car exhaust, AQMD offers monetary subsidies to car owners who are willing to instal new catalytic converters in their vehicles. These subsidies cover about half the cost of a new catalytic converter. Accordingly, the agency has established the following regulation:

If a car owner installs a new catalytic converter, then that person gets a subsidy.

As the owner of an old car, you are considering whether you should replace its catalytic converter, thinking it may be worth it to take advantage of the subsidy. However, there are rumours going around that the regulation has been violated. You want to check whether there is any substance to the rumours.

*Ambiguous rule, officer perspective (matches Rule P3 of the permission schema).*

Suppose you are environmental officer working for the Greater Los Angeles Air Quality Management District. There is concern about the pollution caused by ageing automobiles with malfunctioning catalytic converters. In order to diminish pollution from car exhaust, AQMD offers

monetary subsidies to car owners who are willing to instal new catalytic converters in their vehicles. These subsidies cover about half the cost of a new catalytic converter. Accordingly, the agency has established the following regulation:

If a car owner instals a new catalytic converter, then that person gets a subsidy.

As an official of AQMD, you must ensure that the rule is not being abused. There are rumours going around that the regulation has been violated. You want to check whether there is any substance to the rumours.

*Unambiguous rule, officer perspective (matches Rule P1 of the permission schema).*

The Greater Los Angeles Air Quality Management District is concerned about the pollution caused by cars such as yours. In order to diminish pollution from car exhaust, AQMD decided to offer monetary subsidies to car owners who are willing to instal new catalytic converters in their vehicles. These subsidies cover about half the cost of a new catalytic converter. The agency has established the following regulation:

A car owner must have installed a new catalytic converter if the person receives a subsidy.

*Question (all conditions):*

Below are four cards, one each for four car owners. Each card gives information on a single person. One side of each card shows whether or not this car owner installed a new catalytic converter. The other side shows whether or not the car owner got a subsidy from the AQMD.

You want to see if the regulation has been violated for these cases. 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 regulation has been violated.

*Cards (presented in one of two orders):*

"installed a catalytic converter" ( $p$ ), "did not instal a catalytic converter" ( $not-p$ ), "owner gets a subsidy" ( $q$ ), "owner does not get a subsidy" ( $not-q$ ).