

## Pragmatic Reasoning Schemas

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We propose that people typically reason about realistic situations using neither content-free syntactic inference rules nor representations of specific experiences. Rather, people reason using knowledge structures that we term *pragmatic reasoning schemas*, which are generalized sets of rules defined in relation to classes of goals. Three experiments examined the impact of a "permission schema" on deductive reasoning. Experiment 1 demonstrated that by evoking the permission schema it is possible to facilitate performance in Wason's selection paradigm for subjects who have had no experience with the specific content of the problems. Experiment 2 showed that a selection problem worded in terms of an abstract permission elicited better performance than one worded in terms of a concrete but arbitrary situation, providing evidence for an abstract permission schema that is free of domain-specific content. Experiment 3 provided evidence that evocation of a permission schema affects not only tasks requiring procedural knowledge, but also a linguistic rephrasing task requiring declarative knowledge. In particular, statements in the form *if p then q* were rephrased into the form *p only if q* with greater frequency for permission than for arbitrary statements, and rephrasings of permission statements produced a pattern of introduction of modals (*must*, *can*) totally unlike that observed for arbitrary conditional statements. Other pragmatic schemas, such as "causal" and "evidence" schemas can account for both linguistic and reasoning phenomena that alternative hypotheses fail to explain. © 1985 Academic Press, Inc.

Reasoning fallacies are apparent in discourse and behavior. Their causes, however, have been as mysterious and elusive as the fallacies

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themselves are evident. A classic debate among both philosophers and psychologists concerns whether apparent fallacies directly reflect errors in the deductive process or indirectly reflect changes in the interpretation of the material from which one reasons. According to the latter view, "fallacies" in fact stem from interpretational changes such as the addition or omission of premises. It has been claimed that if such changes are taken into account, adults in fact reason in accord with formal logic (Henle, 1962). The above view assumes two components in the reasoning process: a deductive component that has context-free, syntactic rules comparable to those in formal logic and an interpretative component that maps statements in natural language onto syntactic rules in the deductive component.

Despite abundant evidence for such interpretational changes (e.g., Filenbaum, 1975, 1976; Geis & Zwicky, 1971), they in fact cannot fully account for typical patterns of errors produced by college students in deductive reasoning tasks (see Evans, 1982, for a review). Some of these patterns are inconsistent with any logical interpretation of the materials. One such line of evidence is based on Wason's (1966) selection task. In this task subjects are informed that they will be shown cards that have numbers on one side and letters on the other, and are given a rule such as, "If a card has a vowel on one side, then it has an even number on the other." Subjects are then presented with four cards, which might show an "A," a "B," a "4," and a "7" and are asked to indicate all and only those cards that must be turned over to determine whether the rule is true or false. The correct answer in this example is to turn over the cards showing "A" and "7." More generally, the rule used in such problems is a conditional, *if p then q*, and the relevant cases are *p* and *not-q*. When presented in an "abstract" form, such as in the above example, typically less than 10% of college students produce the above answer. Subjects also rarely select in accord with a biconditional interpretation of the rule (i.e., *p if and only if q*), which requires that all four cards be turned over. Instead they often select patterns that are irreconcilable with any logical interpretation, such as "A" and "4" (i.e., *p* and *q*). One of the errors in the above answer is omission of the card showing "7," indicating a failure to see the equivalence of a conditional statement and its contrapositive (i.e., "If a card does not have an even number on one side, then it does not have a vowel on the other"). Such systematic errors suggest that typical college students do commit fallacies due to errors in the deductive process, at least with "abstract" materials.

Although subjects typically fail to reason correctly with "abstract" materials, they nonetheless seem capable of doing so with materials that have been characterized as "concrete," "realistic," or "thematic" (e.g., Johnson-Laird, Legrenzi, & Legrenzi, 1972; Wason & Shapiro, 1971).

Reasoning performance has sometimes been shown to dramatically improve when the selection task is recast in such contexts (see Evans, 1982, Griggs, 1983, and Wason, 1983, for reviews). Johnson-Laird et al., for example, asked their subjects to pretend that they were postal workers sorting letters, and had to determine whether rules such as, "If a letter is sealed, then it has a 5d stamp on it," were violated. The problem was cast in the frame of a selection task. The percentage of correct responses for this version was 81. In sharp contrast, only 15% of the same subjects produced the correct response when given the "card" version mentioned earlier.

Despite these and other positive results, however, the search for thematic facilitation has also been fraught with failures to replicate. To illustrate, although the postal rule problem mentioned above produced facilitation for British subjects in the 1972 study by Johnson-Laird et al., it produced no facilitation at all for American subjects studied by Griggs and Cox (1982). Golding (1981) found that the postal rule problem produced facilitation for older British subjects who were familiar with a similar but now defunct postal regulation imposed by the British post office, but not for younger British subjects who were not as familiar with this rule. The pattern of replications suggested to some that the source of facilitation was prior experience with a rule, particularly prior experience with counterexamples to the rule. It has been argued that subjects familiar with the postal rule do well because the falsifying instance—a sealed but understamped envelope—would be available immediately in the subjects' memory, prompting them to inspect the sealed envelope (*p*) and the understamped envelope (*not-q*). Faced with the mass of evidence indicating illogical reasoning, several psychologists have recently hypothesized that people typically are not able to use rules of inference to reason, but instead use their memory of domain-specific experiences (e.g., Griggs & Cox, 1982; Manktelow & Evans, 1979; Reich & Ruth, 1982).

The syntactic view has not been abandoned by all, however. Various theorists have proposed *natural logics* which specify repertoires of inferential rules that people untutored in formal logic naturally use (Braine, 1978; Braine, Reiser, & Rumin, 1984; Johnson-Laird, 1975; Osherson, 1975; Rips, 1983). With respect to the connective *if-then*, every one of these repertoires proposed include modus ponens. Only one includes modus tollens (Osherson, 1975); however, others include reductio ad absurdum (an inference method which can be used to derive indirectly the same conclusion as follows from tollens) for some or all people (Braine, 1978; Braine et al., 1984; Johnson-Laird, 1975; Rips, 1983).

A different approach, which can be viewed as an attempt to merge the extreme positions represented by specific knowledge and abstract syntactic rules, has been taken by Johnson-Laird (1982, 1983). He proposed



that people possess a set of procedures for "modeling" the relations in deductive reasoning problems so as to reach conclusions about possible states of affairs given the current model of relations among elements. In Johnson-Laird's theory, mental models are constructed using both general linguistic strategies for interpreting logical terms such as quantifiers and specific knowledge retrieved from memory. The modeling procedures themselves are formal and domain independent. Although Johnson-Laird's theory differs from other accounts of reasoning in its performance aspects, it does not introduce novel types of knowledge structures.

### *Critique of Two Current Theories*

To recapitulate, the view that people typically reason in accord with formal logic has been overwhelmingly refuted by evidence based on experiments in conditional reasoning. In its place two major views have been proposed: the specific-experience view and the natural-logic view. We find neither of these views entirely convincing. The inadequacies of each are discussed in turn.

The specific-experience view faces two difficulties. First, remembered counterexamples do not always facilitate performance. In a series of four experiments, Manktelow and Evans (1979) failed to observe facilitation with conditional rules for which subjects were likely to have experienced counterexamples. The rules were arbitrary combinations of foods and drinks, such as, "If I eat haddock, then I drink gin." It should be noted that although the particular combinations used were arbitrary, the general idea of selecting drinks based on the selection of food would presumably be familiar to most people, as would the foods and drinks themselves. A further problem with the above hypothesis is that prior experience does not seem to be required for facilitation. A version of the selection problem developed by D'Andrade (1982) involves an assistant at a department store who has to check sales receipts to ensure that receipts exceeding a certain value were initialed at the back by a section manager. Few subjects would be expected to have a counterexample to this rule readily available in memory. Yet the problem has reliably produced facilitation. Thus experience with a specific rule appears to be neither necessary nor sufficient to yield facilitation.

A further problem with the specific memory approach is that subjects are prone to different types of errors on different types of problems. Reich and Ruth (1982) reported that with "symbolic" problems subjects tended to match the terms mentioned in the rule with those provided in the cards (disregarding negatives associated with those terms), whereas with "realistic" problems they tended to verify the rule (i.e., selecting  $p$  and  $q$ ). These two patterns of errors can be explained by neither the specific-experience approach nor the natural-logic approach.

The natural-logic view (as well as the syntactic view in general) assumes that when the invitation to infer the converse is taken into account, rules associated with the connective *if-then* are general across contexts. This assumption implies that any variation in performance that is logically unrelated to the invitation to infer the converse, such as the different patterns of errors just mentioned, either falls outside the scope of the theory, or contradicts it. Another type of variation in performance that is logically unrelated to the invitation to infer the converse is variation in the frequency of selecting the *not-q* case in a selection task. The natural logic view, by positing that some subjects do not have *reductio* or *modus tollens* available, can explain some subjects' failure to select *not-q*. This view cannot, however, explain why the same subjects who fail to select *not-q* in one context do select it in other contexts.

These problems, and others that are raised in the General Discussion, beset any theory of conditional reasoning that assumes context-free inference rules associated with *if-then*. Therefore, a different approach seems warranted.

### *Pragmatic Reasoning Schemas*

Our own approach is based on a type of knowledge structure qualitatively different from those postulated by other theories of deductive reasoning. We propose that people often reason using neither syntactic, context-free rules of inference, nor memory of specific experiences. Rather, they reason using abstract knowledge structures induced from ordinary life experiences, such as "permissions," "obligations," and "causations." Such knowledge structures are termed *pragmatic reasoning schemas*. A pragmatic reasoning schema consists of a set of generalized, context-sensitive rules which, unlike purely syntactic rules, are defined in terms of classes of goals (such as taking desirable actions or making predictions about possible future events) and relationships to these goals (such as cause and effect or precondition and allowable action). Although context-sensitive, the rules that comprise pragmatic schemas may extend beyond the scope of purely syntactic rules of logic, because they will serve to interpret "nonlogical" terms such as *cause* and *predict* as well as terms treated by formal logic, such as *if-then* and *only-if*.

Although a syntactically based reasoning system tells us which inferences are valid, it does not tell us which inferences are useful among the potentially many that are valid. Consider, for example, the contrapositive transformation of the material conditional. Given the statement, "If two particles have like electrical charges, then they repel each other," a logic-based reasoning system lets us infer the potentially useful conclusion, "If two particles do not repel each other, then they don't have like electrical charges." In contrast, given the statement, "If I have a headache,



then I should take some aspirin," the same rule will produce the inference, "If it's not the case that I should take some aspirin, then I don't have a headache," which is hardly ever a useful inference to make. More generally, the fact that a problem exists creates the goal of finding a remedy for it; however, the absence of the need for a remedy does not create the goal of inferring the absence of a problem. Since people do not seem to make this type of useless inference, it seems that pragmatic goals must guide the process of inference.

Our theoretical framework assumes that the role of prior experience in facilitation is in the induction and evocation of certain types of schemas. Not all schemas are facilitating, as becomes clear below. Some schemas lead to responses that correspond more closely than others with those that follow from the material conditional in formal logic. Performance as evaluated by the standard of formal logic depends on what type of schema is evoked, or whether any schema is evoked at all.

An arbitrary rule, being unrelated to typical life experiences, will not reliably evoke any reasoning schemas. Subjects confronted with such a rule may attempt to interpret it in terms of a reasoning schema. Failing that, they would have to draw upon their knowledge of formal reasoning to arrive at a correct solution. Only a small percentage of college students apparently know the material conditional or can derive the contrapositive or modus tollens using *reductio ad absurdum*. Failing either, some might draw on some nonlogical strategy such as matching, as observed by Reich and Ruth (1982) and Manktelow and Evans (1979), among others.

In contrast, some rules evoke schemas with structures that yield the same solutions as the material conditional (under circumstances explicated below). In particular, most of the thematic problems that have yielded facilitation fit a *permission* schema. The permission schema describes a type of regulation in which taking a particular action requires satisfaction of a certain precondition.

In standard propositional logic the deductive rules pertaining to *if-then* specify syntactic patterns based on the components *if*, *then*, *not*, and *only if*. For example, one rule states that *if p then q* is equivalent to *if not-q then not-p*, where the symbols *p* and *q* represent any statements. The permission schema, in contrast, contains no context-free symbols such as *p* and *q* above. Instead, the inference patterns include as components the concepts of possibility, necessity, an action to be taken, and a precondition to be satisfied. (The deontic concepts of possibility and necessity are typically expressed in English by the modals *can* and *must*, respectively, and various synonyms, such as *may* and *is required to*.)

The core of the permission schema can be succinctly summarized in four production rules, each of which specifies one of the four possible antecedent situations, assuming the occurrence or nonoccurrence of the action and the precondition:

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.

To understand when and why the permission schema facilitates selection performance, compare the above rules to the four possible inference patterns of the material conditional. When a situation or problem evokes a permission schema, the entire set of rules comprising the schema becomes available. Suppose the conditional rule in a given selection problem is in the form of Rule 1, such as "If one is to drink alcohol, then one must be over eighteen." Rule 1 has the same effect as *modus ponens*. Rule 2, because it indicates that the precondition is irrelevant if the action is not taken (the precondition need not be satisfied, but may be anyway), effectively blocks the fallacy of Denying the Antecedent. Similarly, Rule 3 indicates that if the precondition is satisfied, then the action is allowed but not dictated, thus blocking the fallacy of Affirming the Consequent. Finally, Rule 4 explicitly states that failure to satisfy the precondition precludes taking the action, an inference pattern corresponding to the contrapositive. A rule corresponding to the contrapositive is thus available directly, rather than requiring an indirect derivation by means of *reductio ad absurdum*. In sum, when a conditional statement in the form of Rule 1 evokes a permission schema, the solution derivable from the permission schema matches that required by the material conditional. Hence, the permission schema should be facilitative.

This does not imply that the permission schema is equivalent to the material conditional in standard propositional logic. The permission schema is context-sensitive. In addition, as is discussed further in Experiment 3, the permission schema is directly related to deontic concepts such as *must* and *may* that cannot be expressed in standard propositional logic. Furthermore, the rules attached to reasoning schemas are often useful heuristics rather than strictly valid inferences. For example, Rule 3 above does not logically follow from Rule 1, since it could yield a false conclusion if the precondition is necessary but not sufficient to render the action permissible (e.g., if a drinking law required drinkers to be both over 18 and free of recent drunk driving violations, then the inference "If a person is over eighteen, then he or she may drink alcohol" would not hold). Because reasoning schemas are not restricted to strictly valid rules, our approach is not equivalent to any proposed formal or natural logic of the conditional.

Not all conditional reasoning schemas suggest the same solution to selection problems as does formal logic. A *causal* schema, for example,



will sometimes invite an assumption of the converse of a given conditional statement. (Assumption of the converse is to be distinguished here from the biconditional, which includes assumption of both the converse and its contrapositive.) A conditional, *if p then q*, interpreted in the context of a causal schema may be represented as "If (cause), then (effect)." To the degree that only a single cause is perceived, the effect may be treated as evidence for concluding the presence or prior existence of the cause, yielding an inference in the opposite direction, "If (evidence), then (conclusion)." Since events are sometimes perceived as having a single cause, problems evoking a causal schema are more likely to lead to the fallacy of Affirming the Consequent than problems evoking a permission schema.

Alternative reasoning schemas may account for reported variations in performance on the selection task. As noted earlier, Reich and Ruth (1982) found that "realistic" sentences such as, "If a fruit is yellow, then it is ripe," tended to lead to verification (selecting *p* and *q*), whereas arbitrary "symbolic" problems tended to lead to a matching strategy (also Manktelow & Evans, 1979). It seems that there may be a general "covariation" schema, which can be applied to any situation in which two situations or events are for some reason expected to co-occur, as in Reich and Ruth's "realistic" sentences. The covariation schema, like the causal schema, can be expected to invite an assumption of the converse of a given conditional statement and would lead to selection of *p* and *q*, the pattern observed for Reich and Ruth's "realistic" sentences. Arbitrary rules, being unrelated to real-life experiences, may fail to evoke even a covariation schema for some subjects, so that these subjects must resort to an entirely nonlogical strategy. It is therefore possible that evocation of different reasoning schemas can account for variations in performance even among problems in which none of the dominant response patterns are consistent with formal logic.

To summarize, we suggest that many inference schemas are pragmatic in nature, with the purposes of the set of rules being salient features of each schema. Because these purposes differ between schemas, they may serve to discriminate between types of schemas at the interpretative stage. Regulations such as permissions and obligations are imposed typically by an authority to achieve some social purpose. In contrast, causal rules are not imposed by an authority, but simply serve to generate useful predictions about transitions between environmental states. Thus the purposes of the schemas are of different natures. As we see in Experiment 1, provision of the purpose of a regulation constitutes a major cue for evocation of the permission schema.

We propose that people typically make inferences based on pragmatic reasoning schemas. Whereas the logic approach assumes that an interpretative component maps statements onto particular context-free syn-

tactic inference rules comprising the deductive component, the schema approach assumes that the interpretative component maps statements onto a particular set of context-sensitive rules attached to the relevant schema. Such schemas vary in their degree of correspondence with the material conditional. The experiments reported below were designed to provide direct tests of the schema hypothesis.

## EXPERIMENT 1

According to the schema hypothesis, failure on selection problems is due to failure to evoke a schema that corresponds well with the conditional in formal logic. A possible explanation for the conflicting results obtained with the envelope problem (discussed earlier) is that subjects who have had experience with the postal rule (or one that is highly similar to it) understand the rule in terms of a permission—one is permitted to seal an envelope only if it carries a certain amount of postage. In contrast, subjects who have not had any experience with such rules perceive it as being arbitrary. If people in fact reason using pragmatic reasoning schemas, then it may be possible to improve performance by evoking a facilitating schema, such as the permission schema, without providing subjects with experience on specific rules.

In the present experiment we attempted to evoke a permission schema by providing a rationale for conditional rules that may otherwise appear arbitrary. Two versions of each of two thematic problems were administered to groups of college students: a version with a rationale and a version without it. If provision of a rationale succeeds in evoking a permission schema, then performance should generally be better in the rationale than in the no-rationale condition. The two thematic problems were the envelope problem mentioned earlier, involving the rule: "If an envelope is sealed, then it must have a 20 cent stamp"; and a "cholera" problem, involving the rule: "If a passenger's form says 'Entering' on one side, then the other side must include 'cholera'."

In addition to varying the inclusion of a rationale, we also varied subjects' prior experience with a rule by using subjects in Michigan and in Hong Kong. Whereas subjects in Michigan were not familiar with the postal rule, since no similar rule had been in effect in the United States, subjects in Hong Kong were familiar with it, since a similar rule was in effect until about 6 months before the experiment was run. Few of the subjects in either location would be expected to have had experience with the cholera rule. In general, those who have had experience with the rules should be able to perceive them as permissions, even though they may appear arbitrary to other subjects. The schema hypothesis therefore predicts that for the no-rationale condition only subjects in Hong Kong given the envelope problem would do well, but for the rationale condition



subjects in both Hong Kong and Michigan would do well on both thematic problems.

In contrast, the syntactic view predicts that performance would be similar across all conditions, since the forms of the conditional statements were identical in the rationale and no-rationale versions for subjects in both places. Even allowing for differences in the tendency to invite the converse assumption, the syntactic view would still predict that the frequency of selecting the *not-q* case would be constant across conditions. The domain-specificity view also predicts that the rationale should have no effect. However, it predicts that the performance of Hong Kong subjects on the envelope problem should be superior to performance in all other conditions, since Hong Kong subjects alone were familiar with the postal rule.

### Method

**Subjects.** Eighty-two students who were enrolled in an introductory psychology course at the Chinese University of Hong Kong participated in the experiment as partial fulfillment of the course requirement. Eighty-eight students at the University of Michigan participated in the experiment for the same reason. None of the participants had had any prior experience with the selection task.

**Procedure.** Subjects at each location were randomly assigned to two equal-sized groups. Each subject received one version of each of two thematic problems: a rationale version of one problem, and a no-rationale version of the other problem. Half of the subjects at each location received the rationale version of a problem, and the other half received the no-rationale version of the same problem. Subjects were run in groups of 8 to 10. All subjects were told to think carefully and solve the problems as best they could. To ensure that subjects arrived at the best answer they were capable of, they were allowed as much time as they needed, and were also allowed to make corrections. Subjects were encouraged to write brief explanations of their responses. As mentioned earlier, the two problems were the envelope problem and the cholera problem. The envelope problem preceded the cholera problem. For the Hong Kong subjects, who were bilingual, the rule in each problem was stated in both English and Chinese.

**Materials.** The no-rationale version of the envelope problem stated, "You are a postal clerk working in some foreign country. Part of your job is to go through letters to check the postage. The country's postal regulation requires that if a letter is sealed, then it must carry a 20-cent stamp. In order to check that the regulation is followed, which of the following four envelopes would you turn over? Turn over only those that you need to check to be sure."

The above paragraph was followed by drawings of four envelopes, one carrying a 20-cent stamp, a second carrying a 10-cent stamp, a third one labeled "back of sealed envelope," and a fourth one labeled "back of unsealed envelope."

The rationale version of the envelope problem was identical to the no-rationale version, except that the conditional rule (underscored) was immediately followed by the sentences: "The rationale for this regulation is to increase profit from personal mail, which is nearly always sealed. Sealed letters are defined as personal and must therefore carry more postage than unsealed letters."

The no-rationale version of the cholera problem stated "You are an immigration officer at the International Airport in Manila, capital of the Philippines. Among the documents you

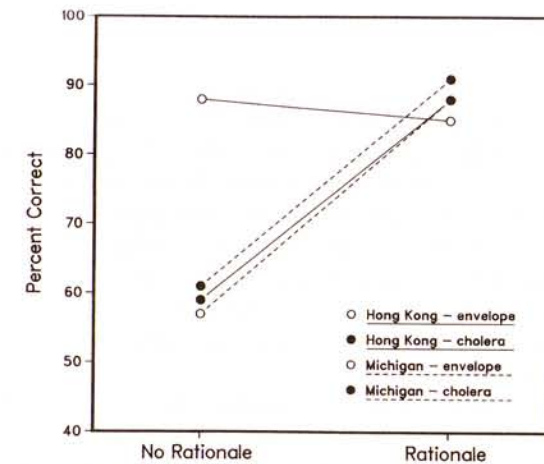


FIG. 1. Percentage of subjects who solved the selection task correctly in each condition as a function of provision of a rationale (Experiment 1).

have to check is a sheet called Form H. One side of this form indicates whether the passenger is entering the country or in transit, while the other side of the form lists names of tropical diseases. You have to make sure that if the form says 'ENTERING' on one side, then the other side includes cholera among the list of diseases. Which of the following forms would you have to turn over to check? Indicate only those that you need to check to be sure." The above paragraph was followed by drawings of four cards. One of them carried the word "TRANSIT," another carried the word "ENTERING," a third listed "cholera, typhoid, hepatitis," and a fourth listed "typhoid, hepatitis."

The rationale version of the cholera problem was identical to the no-rationale version except that instead of saying that the form listed names of tropical diseases, it said that the form listed inoculations the passenger had had in the past 6 months. In addition, the conditional rule (underscored) was followed by the sentence, "This is to ensure that entering passengers are protected against the disease."

### Results

Figure 1 presents the percentage of subjects who solved the selection problem in each condition. The pattern of results was precisely as predicted by the schema hypothesis. The rationale versions produced uniformly high success rates for subjects at both locations for both thematic problems, whereas the no-rationale versions produced a high success rate only for the envelope problem with Hong Kong subjects. The difference in frequency of correct solutions as a function of provision of a rationale was tested using the  $\chi^2$  statistic for each problem and subject group. Except for the envelope problem with the Hong Kong subjects, for whom the rationale was redundant as predicted, all conditions produced a significantly higher success rate for the rationale versions ( $p < .01$  for each of the 3 location-problem conditions). The frequency of successfully se-

lecting the *not-q* case reflects the same pattern of performance as the frequency of solving the entire problem correctly.

Performance levels for the no-rationale groups were higher in the present experiment than in other studies using subjects lacking experience with similar rules (Griggs & Cox, 1982). It is difficult to interpret such differences in absolute performance levels across subject populations. It may be that our subjects were sometimes able to provide their own implicit rationales for the stated rules even when none were provided by the experimenter. Our procedure of allowing for corrections might also have contributed to the higher performance level.

The results of Experiment 1 provide clear support for the schema hypothesis. Since experience on the given domains did not differ between the rationale and the no-rationale groups, the effect of the rationales cannot be due to the amount of specific experience. And since the syntactic form of the *if-then* rules remained constant across all conditions, the effect of the rationales cannot be accounted for by the syntactic view either.

## EXPERIMENT 2

It might be argued that since the rationales in Experiment 1 were not content free, their introduction might have changed the nature of the relevant experience brought to bear on the problems. For example, although specific experience with the postal rule per se was not affected by introduction of the rationale, the idea of increasing profit—probably familiar to most subjects—may have prompted subjects to check envelopes carrying relatively small amounts of postage to ensure that they did not unduly reduce profit. Similarly, the idea of protection against a disease may prompt subjects to check passengers unprotected against it. In both cases, the rationales may encourage checking the *not-q* case, the omission of which is a frequent error in selection problems. The relevant experience evoked by the rationales would extend beyond the specific conditional statements, but would nonetheless be content specific.

To provide clearcut evidence for abstract schemas that are not bound to any domain-specific content, we tested performance on a selection problem that described a permission situation abstractly, with no reference to any concrete content. Subjects were asked to check regulations that have the general form, "If one is to take action 'A,' then one must first satisfy precondition 'P.'" To demonstrate that concreteness of the *if-then* rule, in the absence of a facilitating schema such as a permission, does not lead to logically correct responses, subjects were also tested on an arbitrary "card" version of the selection problem involving a rule specifying concrete entities.

## Method

**Subjects.** Forty-four University of Michigan undergraduates enrolled in psychology courses volunteered for the experiment. None of the students had had any previous experience with the selection paradigm.

**Materials.** Each subject was given two selection problems. One was an abstract description of a permission, stating, "Suppose you are an authority checking whether or not people are obeying certain regulations. The regulations all have the general form, 'If one is to take action 'A,' then one must first satisfy precondition 'P.'" In other words, in order to be permitted to do 'A,' one must first have fulfilled prerequisite 'P.'" The cards below contain information on four people: one side of the card indicates whether or not a person has taken action 'A,' the other indicates whether or not the same individual has fulfilled precondition 'P.'" In order to check that a certain regulation is being followed, which of the cards below would you turn over? Turn over only those that you need to check to be sure."

The above instructions were followed by drawings of four cards stating the four possible cases: "has taken action A," "has not taken action A," "has fulfilled precondition P," and "has not fulfilled precondition P."

The other problem involved an arbitrary card rule stating, "Below are four cards. Every card has a letter on one side and a number on the other. Your task is to decide which of the cards you need to turn over in order to find out whether or not a certain rule is being followed. The rule is: 'If a card has an 'A' on one side, then it must have a '4' on the other side. Turn over only those cards that you need to check to be sure.'" Although this rule has often been labeled "abstract" in the literature, we would like to call attention to the distinction between the arbitrariness of the relation and the abstractness of the entities involved in the rule (Wason & Shapiro, 1971). The above rule specifies an arbitrary relation between specific, concrete entities.

Drawings of four cards followed, showing four possible cases: "A," "B," "4," and "7." To more closely match the syntactic form of the cases in the permission problem, cases that negated terms in the *if-then* rule were so indicated explicitly. The card showing "7" carried the caption "i.e., not '4,'" and the card showing "B" carried the caption "i.e., not 'A.'" In addition, the modal *must* was included in the arbitrary version of the rule to match the syntactic form of the permission rule.

**Procedure.** Subjects were given the same general instructions for solving the problems as in Experiment 1, except that they were not allowed to change answers on a previous problem. Subjects were run in small groups. The ordering of the two problems was counterbalanced across subjects. The four cases to be selected in each problem were either ordered *p*, *not-p*, *q*, *not-q*, or the reverse. Each subject received a different ordering of the cases in each problem. The ordering of the cases was counterbalanced across problems.

## Results and Discussion

In order to assess performance on the permission and card problems independently of any transfer from one to the other, an analysis was performed on data from just the first problem solved by each subject. Although the permission problem was more abstract than the card problem, 61% of the subjects solved the permission problem correctly, whereas only 19% solved the card problem correctly,  $\chi^2(1) = 7.76$ ,  $p < .01$ . Since the permission problem made no reference to any domain-specific content, and the syntactic form of the *if-then* rules was matched



across the permission and card problems, superior performance on the permission problem provides strong evidence for the existence of an abstract permission schema.

The effect of the ordering of the two problems did not approach significance; however, the card problem was more often solved correctly when it followed the permission problem (39%) than when it preceded it (19%), suggesting possible positive transfer. In contrast, the permission problem was less often solved correctly when it followed the card problem (48%) than when it preceded it (61%), suggesting possible negative transfer. Collapsing over the two orders of the problems, 55% of the subjects solved the permission problem correctly, whereas only 30% of the same subjects solved the card problem correctly. This difference was significant when tested with a binomial test of symmetry ( $p = .01$ ). The order of the four alternative choices had no significant effect on the frequency of solving a problem correctly. The frequency of successfully selecting the *not-q* case reflects the same pattern of performance as the frequency of solving the entire problem correctly.

### EXPERIMENT 3

The knowledge contained in the permission schema should affect performance in other tasks besides the selection paradigm. For example, since rules in the schema govern and aid the rephrasing of sentences from *if-then* into *only-if* form and vice versa, such rephrasings of permission statements should follow certain consistent patterns, some of which correspond well with formal logic. In contrast, since transformations of arbitrary conditional statements are not guided by any rule that corresponds well with formal logic, performance on such rephrasings should be no different from chance.

According to standard logic a conditional of the form *if p then q* is equivalent to *p only if q*, in the sense that the two statements have identical truth tables. As Evans (1977) has noted, the *only-if* form stresses the necessity of the consequent—i.e., the fact that *q* must hold in order for *p* to be the case. The *only-if* form is thus closely related to the contrapositive of the *if-then* form (i.e., *if not-q then not-p*), which also emphasizes the necessity of *q*.

Because people do not in general use an inference rule equivalent to the contrapositive, we would expect them to have great difficulty in rephrasing between *if-then* and *only-if* forms for arbitrary statements (Braine, 1978). There will be no rules to help them decide whether a statement in the form *if p then q* should be rephrased into *p only if q* or its converse, *q only if p* (and vice versa).

In contrast, such rephrasings of permission statements should follow certain consistent patterns. Consider the following two possible rephras-

ings into *only-if* form of an *if-then* permission statement, "If the action is to be taken, then the precondition must be satisfied":

(5) The action is to be taken only if the precondition is satisfied.

(6) The precondition must be satisfied only if the action is to be taken. Although only (5) is a valid rephrasing ((6) would be false if there were some other reason for the precondition being necessary), both are plausible inferences. Nonetheless, (5) is a more natural and direct inference than (6). A possible reason is that a statement in the form *p only if q* carries the connotation that *q* is necessary for *p* as well as prior to it in time (Evans, 1977; Evans & Newstead, 1977), both aspects of which are central to what it means to constitute a precondition or prerequisite. Hence, the form is highly compatible with the content in Statement (5), whereas Statement (6) carries the implication that taking the action is the prerequisite for the necessity of satisfying the precondition, which is a very circuitous way of saying, "If the action is not to be taken, then the precondition need not be satisfied." There seems to be no natural way of stating a permission in an *only-if* form in which the precondition precedes the action. It follows that subjects are more likely to produce Statement (5) than Statement (6) (or corresponding variants) when asked to phrase a permission statement in an *only-if* form. Since (5) is the strictly valid inference, it follows that subjects will appear to follow the dictates of formal logic in rephrasing a permission statement from *if-then* into *only-if* form.

Such a difference in naturalness will not guide the rephrasing of permission statements in the reverse direction, from *only-if* form as in (5) into *if-then* form. Either the action or the precondition can be the antecedent of a permission statement in an *if-then* form without any awkwardness. Rules 1 and 3 of the permission schema described in the introduction are examples of the two orderings,

(1) If the action is to be taken, then the precondition must be satisfied.

(3) If the precondition is satisfied, then the action may be taken.

According to formal logic only (1) is a valid rephrasing of (5) (with the caveat that a deontic logic is required to account for the introduction of *must* in (1); see below); as noted in the introduction, (3) could be false if the stated precondition were necessary but not sufficient for the action. Nonetheless, both (1) and (3) are pragmatically plausible and natural inferences in most permission contexts. We therefore do not expect any difference in subjects' propensity to produce the two forms of *if-then* sentences in our rephrasing task. It follows that for permission statements, subjects' rephrasings will appear to follow the dictates of formal logic more closely when the direction is from *if-then* into *only-if* form rather than vice versa. This asymmetry is only apparent, however, in that the entire predicted response pattern follows from the nature of the information contained in the permission schema.



The schema hypothesis also generates predictions about the introduction of modals into rephrasings. The concept of permission is based on the deontic concepts of "possibility" and "necessity." The modals that express these concepts allow inference patterns beyond the scope of standard propositional logic. For example, applying a rule of standard propositional logic to the permission statement, "A customer is to drink an alcoholic beverage only if she is at least eighteen," we obtain the supposedly equivalent statement, "If a customer is to drink an alcoholic beverage, then she is at least eighteen." However, this rephrasing is quite unnatural because it tends to be interpreted as a claim that drinking an alcoholic beverage *causes* the person to be 18. To maintain the sense of permission, it is much more natural to introduce the modal *must* into the consequent: "If a customer is to drink an alcoholic beverage, then she *must* be at least eighteen." In contrast, introduction of the modal is not dictated for arbitrary statements, which are not interpreted deontically. For example, the statement, "A card has an 'A' on one side only if it has a '4' on the other" can be rephrased as, "If a card has an 'A' on one side, then it has a '4' on the other." In this case introduction of *must* ("then it *must* have a '4' on the other") is unnecessary, since the original statement has no deontic implications. Accordingly, the schema hypothesis predicts that *must* will be introduced in rephrasing from *only-if* to *if-then* form for permission statements but not for arbitrary statements.

Similarly, *can* or its synonyms will be introduced in rephrasing from *if-then* to *only-if* form more often for permission than for arbitrary statements. For example, the alcohol rule discussed in the last paragraph is more naturally stated as, "A customer *can* drink alcohol only if she is at least eighteen," rather than, "A customer drinks alcohol only if she is at least eighteen." The modal *can*, or its synonyms such as *may*, *is to*, or *is allowed to*, serves to retain the sense of a social regulation. In contrast, arbitrary statements do not require any modal (e.g., "A card has an 'A' on one side only if it has a '4' on the other").

### Method

**Subjects.** Fifty-two undergraduates at the University of Michigan, none of whom had prior experience with the selection task, served as subjects.

**Procedure.** All subjects received four problems, two based on permission statements and two on arbitrary statements. One statement of each type was presented in *if-then* form and one in *only-if* form. For each statement subjects first performed the standard selection task and then attempted to rephrase the statement into an alternative form (i.e., *if-then* into *only-if* or vice versa).

**Materials.** In addition to the usual selection-task instructions, the first page of the booklet given to subjects explained that *if-then* statements can be rephrased into *only-if* form and vice versa. An arbitrary statement was used as an example: "If the tablecloth is brown, then the wall is white" corresponds to "The tablecloth is brown only if the wall is white."

The two permission statements were the "cholera" rule used in Experiment 1 (the ratio-

TABLE 1  
Percentage Correct on Selection Task (Experiment 3)

Given form	Rule type		Mean
	Permission	Arbitrary	
If-then	67	17	42
Only-if	56	4	30
Mean	62	11	

nale version), and the "alcohol" rule used above as an example. The arbitrary statements were the card problem and a "bird" problem, which in *if-then* form involved the statement, "If a bird has a purple spot underneath each wing, then it must build nests on the ground." As this example illustrates, all statements included *must* in their *if-then* forms in order to equate the syntactic structure of the permission and arbitrary statements.<sup>1</sup>

Each problem was presented on a separate page of the booklet. The selection task was presented at the top of each page. The basic statement was then repeated below, and subjects were asked to write the equivalent rephrasing in either *if-then* or *only-if* form. Which statements were presented in which form, and the order of the problems, were counterbalanced across subjects.

### Results and Discussion

**Selection task.** Table 1 presents the percentage of subjects who gave logically correct responses in the selection task as a function of the type of rule (permission and arbitrary) and the form of the rule (*if-then* or *only-if*). The data were analyzed using analysis of variance. We will report the results collapsed across the two problems of each type, since the overall pattern held for the individual problems.

As Table 1 indicates, subjects were far more accurate in choosing the two correct alternatives, *p* and *not-q*, for permission statements (62%) than for arbitrary statements (11%),  $F(1,51) = 131, p < .001$ . This result is of course predicted by the hypothesis that people are able to apply a specialized schema to reason about permission statements. In addition, performance was more accurate when the rules were stated in *if-then* rather than *only-if* form,  $F(1,51) = 5.22, p < .05$ . These two factors, the type and form of the rule, did not significantly interact.

**Rephrasing.** According to the schema hypothesis, modals should be systematically introduced into rephrased permission statements to preserve their deontic sense, whereas modals will not be introduced into arbitrary statements. Moreover, whereas permission statements of the

<sup>1</sup> In a further experiment we compared selection-task performance for an arbitrary rule (the card problem) with or without *must* in the consequent. Performance did not differ across the alternative versions.



TABLE 2

Percentage "Correct" Rephrasings, Including and Excluding Modals (Experiment 3)

Given form	Permission			Arbitrary		
	Modal	No modal	Total	Modal	No modal	Total
If-then	42 <sup>a</sup>	29	71	4 <sup>a</sup>	33	37
Only-if	31 <sup>b</sup>	11	42	6 <sup>b</sup>	42	48

<sup>a</sup> Can *p* only if *q*.<sup>b</sup> If *p* then must *q*.

form *if p then must q* should be readily rephrased into the form *p only if q* (or *can p only if q*), permission statements of the form *p only if q* would likely be rephrased into two modal forms: *if p then must q* or *If q then can p*. Only the first of the two modal forms is a strictly valid inference from the original statement.

Table 2 reports the percentage of subjects who rephrased rules of each type and form into forms in which *p* was ordered before *q*, with or without the inclusion of modals. This ordering of *p* and *q* corresponds to that dictated by formal logic, and hence will be referred to as "correct," although we emphasize that within our schema framework certain forms that reverse the order of *p* and *q* also constitute pragmatically appropriate inferences. Two transformations from a statement in the form *if p then q* were scored as correct: *p only if q* (no modal) and *can p only if q* (with modal). Similarly, two transformations from a statement in the form *p only if q* were scored as correct: *If p then q* (no modal) and *if p then must q* (with modal). A response was thus scored as correct if the propositions *p* and *q* were placed as the antecedent and the consequent, regardless of the insertion or omission of the appropriate modal. Since there are only two possible permutations of *p* and *q*, subjects would be expected to achieve 50% accuracy if they ordered the propositions randomly.

As Table 2 indicates, the rephrasing results were entirely in accord with the schema hypothesis. Arbitrary statements in either the *if-then* or the *only-if* form were not rephrased correctly with a frequency significantly different from the chance level of 50%. The interaction between the form of the given statement (*if-then* versus *only-if*) and its content (permission versus arbitrary) was highly significant,  $F(1,51) = 19.2, p < .001$ . Permission statements in *if-then* form were rephrased correctly significantly more often than arbitrary *if-then* statements,  $F(1,51) = 21.6, p < .001$ , whereas permission statements in *only-if* form were not rephrased correctly more often than arbitrary statements.<sup>2</sup> As predicted, *only-if* per-

<sup>2</sup> In an earlier experiment, essentially the same pattern of results for rephrasing from *if-then* into *only-if* forms was obtained with subjects at the Chinese University of Hong Kong.

mission statements were often rephrased into the alternative form *if q then can p*. This alternative rephrasing was produced in 38% of the cases for *only-if* permission statements versus only 2% of the *only-if* arbitrary statements.

The data in Table 2 also reveal that among the correct rephrasings, modals tended to be introduced for permission but not for arbitrary statements. For *if-then* permission statements there was a nonsignificant tendency to introduce *can* or a synonym (i.e., *can p only if q*) more often than not, whereas for *if-then* arbitrary statements the correct rephrasings were much more likely to omit any modal,  $\chi^2(1) = 11.8, p < .001$ . Similarly, for *only-if* permission statements correct rephrasings included a modal (i.e., *if p then must q*) more often than not,  $\chi^2(1) = 4.55, p < .05$ , whereas for *only-if* arbitrary statements correct rephrasings more often omitted any modal,  $\chi^2(1) = 14.4, p < .001$ . Thus for both correct and incorrect rephrasings, modals were consistently inserted into transformations of permission statements but not of arbitrary statements.

## GENERAL DISCUSSION

The present results support the view that people typically reason using schematic knowledge structures that can be distinguished both from representations of specific experiences and from context-free syntactic inference rules. In Experiment 1, a rationale designed to evoke a permission schema facilitated performance on selection problems for which subjects lacked specific experience. Indeed, provision of a rationale raised performance to the same level of accuracy as did prior experience with the rule. Neither the specific-experience view nor the syntactic view can account for the observed performance pattern.

Experiment 2 demonstrated that a selection problem based on an abstract statement of a permission rule, totally devoid of concrete content, produced substantially more accurate performance than did an arbitrary rule. This result is damaging to both the syntactic and the specific-experience view. Finally, Experiment 3 provided evidence that evocation of a permission schema affects not only performance on the selection task, but also how subjects rephrased sentences from *if-then* into *only-if* forms and vice versa. In particular, statements in the form *if p then q* were rephrased into the form *p only if q* much more frequently for permission than for arbitrary statements, and rephrasings of permission statements produced a pattern of introduction of modals (*must*, *can*) totally unlike that observed for arbitrary conditional statements that lack a deontic context. Again, neither of the alternative views can account for the observed pattern of results.



### *Comparison with Other Approaches*

Our results thus speak strongly for the existence of pragmatic schemas; the findings are inexplicable according to either the specific-experience view or the syntactic view. Nonetheless, our findings need not be interpreted as evidence against the very possibility of the two extreme modes of reasoning. It is conceivable that alternative knowledge structures relevant to deductive reasoning coexist within a population and even within an individual. Cheng, Holyoak, Nisbett, and Oliver (1985) propose a possible set of relations between logical rules, specific experience, and pragmatic schemas. Although the three levels of knowledge structures may coexist, the apparent priority of the pragmatic level in reasoning has important implications for attempts to alter performance on reasoning tasks by direct instruction. Cheng et al. (1985) compared the impact on selection-task performance of purely formal logic training with that of training based on a pragmatic schema for obligation. They found that purely formal training was quite ineffectual, whereas instruction in the nature of obligations improved performance on a range of conditional rules that could be interpreted as expressing obligations.

Other theorists have suggested that schemas (Rumelhart, 1980; Wason, 1983) or scenarios (Pollard, 1982) play a role in deductive reasoning; however, previous discussions have said little about the types and nature of the information that might be included in such schemas or scenarios. One suggestion related to the present proposal is that performance on the selection task is facilitated if subjects are oriented toward checking for violations, rather than testing a hypothesis (See Griggs, 1983; Yachanin & Tweney, 1982). 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. However, 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, as Griggs (in press) and Yachanin (1985) have shown. In addition, the pattern of selections will only correspond to that required by formal logic if the schema yields the same solution as does the formal conditional. Although the permission schema does so when the given *if-then* statement is in the form of Rule 1, other regulation schemas have a different structure. For example, many obligations are pragmatically biconditional. Thus the rule, "If a child has reached age six, then he or she must enter school" may be given an "if and only if" interpretation, in which case the pattern of choices on a selection task will not correspond to that specified by the formal conditional, even if the subject checks for violations.

It is also clear from the results of Experiment 3 that the impact of the permission schema on performance is broader than simply encouraging violation checking. The rephrasing results indicate that evocation of the schema has consequences for a linguistic task involving declarative knowledge. Even if such declarative knowledge is derived from more basic procedural knowledge, performance on the linguistic task certainly goes beyond what could be described as orientation toward violation checking.

We do not claim, however, that all variations in performance on reasoning problems can be accounted for solely in terms of variations in the reasoning schemas evoked by different problems. For example, Wason and Green (1984) demonstrated that more accurate performance is observed when the selection task is simplified by only offering the subject alternatives based on the consequent (i.e., *q* and *not-q*), omitting those based on the antecedent. Wason and Green also found that subjects were more accurate when the rule related properties of a unitary object (e.g., "If the figure on the card is a triangle then it has been colored red"), rather than properties of disjoint objects (e.g., "All the triangles have a red patch above them"). The positive effects of such task manipulations are most likely due to decreases in the overall cognitive load imposed by the task.

### *Causal Schemas and Linguistic Anomalies*

Although the present paper dealt most directly with the permission schema, we expect that a number of other schemas are used to reason about conditional rules. We have already mentioned schemas for obligations. An obligation is very similar to a permission except that the temporal direction is reversed. In a permission, performing an action requires satisfaction of a precondition, whereas in an obligation, a certain situation requires execution of a subsequent action.

Outside of the realm of social regulations, the concept of "causation" appears to correspond to a family of reasoning schemas (Kelley, 1972, 1973). There are very likely several subtypes of causal schemas, varying on such basic dimensions as whether the causal relation is deterministic or probabilistic and whether single or multiple causes are believed to produce the effect. In addition, as we noted earlier, schemas relating causes and their effects are closely related to schemas for "evidence" (e.g., an observed effect is evidence for the operation of its known cause).

Schematic knowledge about causation and evidence can account for anomalies sometimes created by the contrapositive transformation (which changes statements in the form *if p then q* into the form *if not-q then not-p*). Note the transformations of the following two sentences:

- (7) If the bomb explodes, then everyone will die.
- (8) If one takes proper care of a plant, then it grows.



They result in the following pragmatically anomalous contrapositives:

(7a) If not everyone will die, then the bomb does not explode.

(8a) If a plant does not grow, then one does not take proper care of it.

In contrast, the transformations of the following two sentences,

(9) If there is smoke, then there is fire.

(10) If one has been inoculated against cholera, then one is immune to it.

result in meaningful contrapositives:

(9a) If there is no fire, then there is no smoke.

(10a) If one is not immune to cholera, then one has not been inoculated against it.

No syntactic interpretation of the connective *if-then* in terms of either standard or natural logic can account for the difference in acceptability between (7a) and (8a) on the one hand, and (9a) and (10a) on the other.<sup>3</sup> The temporal direction of *if-then* statements hypothesized by Evans and Newstead (1977)—although a factor in determining acceptability, as we shall see—also cannot fully account for the difference. Sentences (10) and (10a), for example, are both acceptable, despite the antecedent and the consequent being ordered temporally in opposite directions.

But let us consider the transformations in terms of pragmatic knowledge about causation, which could be represented by rules attached to a causal schema. The contrapositive transformation reverses the antecedent and the consequent of a conditional. The inference, "If (cause), then (effect)," in a causal schema has the contrapositive, "If (absence of effect), then (absence of cause)," where the absence of the effect serves as evidence for concluding the absence of the cause. The above two conditionals have a common temporal restriction involving the relative temporal order of cause and effect. When the cause and the effect are temporally ordered by world knowledge, as in Sentences (7), (8), and (10), the event interpreted as the cause (or its absence) must temporally precede the effect (or its absence). Notice that this temporal restriction hinges on the semantic content of the events, regardless of which event is logically the antecedent or the consequent. Whereas the antecedent should be prior to the consequent in the conditional, "If (cause), then (effect)," the consequent should be prior to the antecedent in the conditional, "If (evidence: absence of effect), then (conclusion: absence of cause)."

<sup>3</sup> The anomalousness of (7a) and (8a) can be avoided by changes of tense. For example, (7a) can be changed into "If not everyone dies, then the bomb did not explode." Such adjustments, however, still cannot circumvent the issue of *differences* in acceptability, which can simply be rephrased as: Why do some contrapositive transformations require tense adjustment whereas others do not?

If the temporal order of a causal relation expressed in a conditional sentence violates the above restriction, the sentence will sound anomalous. This may occur in the contrapositive transformation of conditionals in which the antecedent and consequent are not temporally ordered by tense. In such cases, the *if-then* frame imposes a forward temporal direction on them (Evans & Beck, 1981; Evans & Newstead, 1977). Thus, the meaningful temporal order in Sentence (8), "If one takes proper care of a plant, then it grows," becomes anomalously reversed upon transformation into Sentence (8a), "If the plant does not grow, then one does not take proper care of it." Sentence (8a) suggests that the plant's lack of growth (the supposed effect) precedes one's failure to take proper care of it (the supposed cause). A similar anomalous reversal occurs in Sentence (7a). Notice that the anomalousness of Sentence (7a) disappears when the priority of the absence of the cause (the consequent) is specified by tense: "If not everyone will die, then the bomb is not exploding."

The remaining examples do not violate the above restriction. In the case of Sentence (9), "If there is smoke, then there is fire," both tense and world knowledge indicate that the evidence and conclusion are continuous and contemporaneous states. Since the events are contemporaneous, the contrapositive transformation causes no change in the temporal order, therefore yielding a meaningful Sentence in (9a). Sentence (10a), "If one is not immune to cholera, then one has not been inoculated against it," also does not violate the temporal restriction mentioned above, despite the events being temporally ordered by world knowledge. In this case explicit tense markers indicate that the conclusion temporally precedes the evidence, rendering the sentence meaningful.

The above examples illustrate how pragmatic knowledge of causation can account for the differing effects of the contrapositive transformation. It is not the case that *p* must occur prior to *q* for statements in the form *if p then q* in order to be acceptable. Rather, when the conditional expresses a temporally ordered causal relation, *p* must occur prior to *q* if *p* expresses the cause (or its absence), and the reverse if *p* expresses the effect (or its absence). This restriction does not apply when the events are contemporaneous. And as noted earlier, different temporal restrictions apply if an *if-then* statement is interpreted in terms of a noncausal schema such as permission or obligation (also see Cheng et al., 1985).

### Conclusion

In the present paper we have applied the concept of pragmatic reasoning schemas to explain three different types of phenomena: the complex patterns of performance observed in Wason's selection task, patterns of rephrasing between statements in *if-then* and *only-if* forms (including



introduction of modals), and linguistic anomalies involving the contrapositive transformation of certain causal statements. Our theoretical approach has other potential directions for development. In other work (Cheng et al., 1985) we have interpreted the effects of alternative methods of training on deductive reasoning in terms of the pragmatic-schema hypothesis.

Another direction that bears mention because of its perennial interest is the relationship between reasoning and language. Our approach to reasoning implies that the schematic structures that guide everyday reasoning are primarily the products of induction from recurring experience with classes of goal-related situations. Reasoning rules are fundamentally based on our pragmatic interpretations of situations, rather than on the syntactic interpretation of sentences. Our view thus diverges from the Whorfian hypothesis that thought is shaped by the language one speaks, particularly, it has been argued (Bloom, 1981), for such abstract concepts as the conditional. The results of Experiment 1 (as well as of the experiment mentioned in Footnote 2) in fact provide suggestive evidence in favor of our position. The Hong Kong subjects received conditional rules in Chinese, a language which (unlike English) has distinct colloquial connectives corresponding to the concepts *if* and *if and only if* (*ruguo jui* and *ruguo cai*, respectively). A Whorfian might suppose that these expressions would allow Chinese speakers to distinguish more readily between these two confusable senses of *if-then*, and therefore perform more accurately on selection problems. However, no such advantage was detected in our experiments. Although these null results are far from conclusive, there is certainly no convincing evidence that cross-linguistic syntactic differences in expression of conditionals have any impact on reasoning performance (Au, 1983; Cheng, 1985). Our framework implies that if reasoning performance is found to vary across populations, the explanation will lie not in linguistic differences, but rather in cultural differences regarding pragmatically important goals and situations.

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