

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 task 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 irrevocable 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, & Rumain, 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 explained 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

