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Discussion

On the natural selection of reasoning theories*

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Competing theories of human reasoning

Scientific theories, like living organisms, interact in a complex ecology. Theories that provide alternative explanations of the same domain of phenomena are natural competitors, much like organisms attempting to occupy the same biological niche. Like their biological counterparts, theories are subject to a process of natural selection. A variety of interacting criteria, such as generality, parsimony and agreement with observations, lead to the eventual acceptance or rejection of theories by a scientific community. In this paper we will examine the merits of two closely related but competing theories of human reasoning: the pragmatic schema theory we have previously proposed (Cheng & Holyoak, 1983, 1984, 1985; Cheng, Holyoak, Nisbett, & Oliver, 1986; Nisbett, Fong, Lehman, & Cheng, 1987), and the social exchange theory developed by Cosmides (1985, 1989). Specially, we will critically evaluate the arguments and evidence that Cosmides (1989) advances in support of the greater merit of the latter theory, and discuss findings, both from previous studies (including Cosmides' own experiments) and from an experiment reported here, that lead to an opposite conclusion.

Within the broad context of psychological theories of human reasoning, the approaches that we and Cosmides have advocated are very similar. Both theories attempt to take a middle ground between the view that people typically reason using domain-independent formal rules (e.g., Braine, 1978; Braine, Reiser, & Rumain, 1984; Inhelder & Piaget, 1955/1958; Rips, 1983) and the view that people are only able to reason using their memory of domain-specific experiences (e.g., Griggs & Cox, 1982; Manktelow & Evans,

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1979; Reich & Ruth, 1982). The central data addressed by both theories involve the complex pattern of content effects observed in Wason's (1966) selection task. In this task subjects are given a conditional rule of the form *If p then q*, and are asked to select which of four given cards must be turned over to decide whether or not the rule holds. Each card has information regarding the antecedent (*p* or *not-p*) on one side and information regarding the consequent (*q* or *not-q*) on the other side. The subject is shown only one side of each card. The facing sides of the four given cards correspond to the *p*, *not-p*, *q*, and *not-q* cases, and the correct response (in terms of the formal logic of the material conditional) is to examine the *p* and the *not-q* cases. When the content of the rule is arbitrary (e.g., "If the card has a vowel on one side, then it has an even number on the other"), subjects seldom select the formally correct combination, and have particular difficulty in realizing that the *not-q* case could potentially violate the rule. In contrast, some non-arbitrary rules (e.g., "If you are to drink alcohol, then you must be over eighteen") yield a much higher frequency of formally correct responses (Johnson-Laird, Legrenzi, & Legrenzi, 1972; Wason & Shapiro, 1971; for reviews see Evans, 1982, and Wason, 1983). Such content effects cannot be explained by theories based solely on formal rules.

Our theory and that of Cosmides both attempt to characterize the nature of the knowledge that leads to content specificity of reasoning, and argue that such knowledge, although not purely formal, is more general than specific remembered experiences. Our proposal (Cheng & Holyoak, 1983, 1984, 1985) was 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)" (Cheng & Holyoak, 1985, p. 395). We argued that some regulations, such as permissions (in which the consequent specifies a precondition that must be met if the action specified in the antecedent is to be taken) and obligations (in which the consequent specifies an action that must be taken when the condition specified in the antecedent occurs) are represented by rules that yield the logically correct pattern of responses in the selection task. For example, we proposed that the permission schema contains the following four rules:

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.

When a rule in the form of Rule 1 is given in a selection problem that evokes a permission schema, then Rule 4 above would lead to checking the *not-q* case. In the rule, "If you are to drink alcohol, then you must be over eighteen", for example, subjects know that they should check someone who is under age because Rule 4 suggests that one needs to be sure that that person does not drink alcohol. The four rules above define a conditional permission. Cheng et al. (1986) similarly defined a conditional obligation, which like a conditional permission can map onto the material conditional. Nisbett and Cheng (1988) discussed rules based on a combination of permission and obligation that do not map onto the material conditional. When an "if-then" statement evokes a schema that does not map onto the material conditional, or when no schema is evoked at all, then performance will be less likely to conform to the specification of formal logic.

Similarly, Cosmides proposes that facilitation results when "social contract algorithms" are evoked. "A social contract relates *perceived benefits* to *perceived costs*, expressing an exchange in which an individual is required to pay a cost (or meet a requirement) to an individual (or group) in order to be eligible to receive a rationed benefit from that individual (or group). Cheating is the failure to pay a cost to which one has obligated oneself by accepting a benefit, and without which the other person would not have agreed to provide the benefit (Cosmides, 1985). The algorithms that regulate human social exchange – the 'social contract algorithms' – should include a 'look for cheaters' procedure. In a social exchange situation for which a subject has incomplete information, a 'look for cheaters' procedure would draw attention to any person who has *not* paid the required cost (has he illicitly absconded with the benefit?) and to any person who has accepted the benefit (has he paid the required cost?). Such a procedure, operating on the cost-benefit representation of a social contract, maps directly onto the Wason selection task" (1989, p. 197). Thus from the point of view of social exchange theory, a person who is under age has not "paid the cost" of attaining the required age, and hence should be checked to be sure the "benefit" of drinking alcohol is not being illicitly exercised.

Note that although the title of Cosmides' (1989) paper is "The logic of social exchange", and she uses the term "social exchange" interchangeably

with "social contract", a parenthetical qualification in her definition above broadens the concept of a cost in the exchange to include "meeting a requirement". This parenthetical qualification is inherently at odds with the concept of an exchange: a requirement (e.g., attaining a minimum drinking age) is not generally an exchangeable entity that can be given in payment to some "individual (or group)". This semantic anomaly underlies the syntactic deviance of the critical phrase in her definition above, "an exchange in which an individual is required to pay a cost (or *meet a requirement*) *to an individual* ..." [italics added].[1] Cosmides faces a dilemma. On the one hand, she clearly needs to broaden her definition of an exchange to include situations in which no cost is paid in order to account for the many non-exchange contexts (e.g., the drinking age rule) that have yielded facilitation. On the other hand, by stretching her definition in this way she is left with either an incoherent concept (if she retains her definition as is), or a concept that includes non-social-exchange permissions (if she replaces the concept of a cost in her theory by the more general concept of a requirement), thus abandoning her claim that social exchange is crucial. Apparently unaware of the existence of the above dilemma, she proceeds to adopt the broader definition (i.e., replacing the concept of "paying a cost" with the more general concept of "meeting a requirement") when she felt the need to explain some otherwise embarrassing result, and the narrower definition (i.e., omitting the parenthetical qualification of "meeting a requirement") when she felt the need to make the claim that social exchange is crucial.

We can thus distinguish two versions of social exchange theory, which differ in the definition of what counts as a "social exchange" rule. Omitting Cosmides' parenthetical modification of a cost to a requirement, we obtain what we will term "actual social exchange" theory, in which a rationed benefit requires the payment of a cost to the benefactor. This is the prototypical exchange situation that Cosmides' stresses throughout her paper. Replacing the concept of a cost by the more general concept of a requirement, we obtain what we will term "pseudo-exchange" theory (because no social exchange need occur at all), in which a rationed benefit is conditional on the fulfilment of a requirement.

As Cosmides correctly observes, "All social contracts involve permission" (1989, p. 236). Her social contracts are therefore a subset of permissions (which are a subset of regulation schemas, which are a subset of pragmatic

[1] In Cosmides' (1989) footnote 8, she reiterates her broadened definition: "... in a social exchange, it is not strictly necessary that each side suffer a cost in the course of providing a benefit to the other side ...; what is essential, is that each side be provided with a benefit. The providing of a benefit to the other party is *required*, and usually (although not necessarily) entails a cost ..." (italics in original).

reasoning schemas). The "rationed benefit" in a pseudo-exchange is a subset of the "action to be taken" in our permission schema, and the "requirement" in a pseudo-exchange corresponds to the "precondition" in our permission schema. Pseudo-exchanges are therefore a subset of permissions. Similarly, the "rationed benefit" and "cost" in an actual social exchange are, respectively, subsets of the "action to be taken" and the "precondition" in our permission schema. Actual exchanges are therefore a subset of pseudo-exchanges, which are in turn a subset of permissions. Outside of the larger subset of pseudo-exchanges, there are permissions in which the action to be taken is not a rationed benefit.

The set-inclusion relations above provide the basis for a difference between the predictions of the two versions of social exchange theory and pragmatic reasoning schema theory, a difference on which Cosmides focused. To her explanation of facilitation in Wason's selection task, Cosmides adds the assumption that social contract rules have a privileged status: they are the only type of rules that will produce facilitation (defined as higher frequencies of formally correct responses) in Wason's selection task. (As we will see, her justification for this assumption concerns the adaptive value of social contracts in the evolutionary history of humans.) "A non-SC permission rule is a rule that lacks the cost–benefit structure of a social contract, but that does fit the action–precondition representation of a permission. If social contract theory is correct, then the standard social contract will elicit a high percentage of the predicted social contract response, *P & not-Q*, but the non-SC permission rule will not" (1989, p. 243). Cosmides claims that this generalization is supported by an examination of previous studies investigating content effects on performance in the selection task, as well as by the results of her Experiments 5–9. We will question this conclusion (for both versions of social exchange theory) in the following section.

Although Cosmides (1989), like us, believes that reasoning schemas arose as a result of their pragmatic usefulness, she stresses that her theory differs from ours with respect to the hypothesized origins of reasoning schemas. Whereas we described pragmatic schemas as "abstract knowledge structures induced from ordinary life experiences" (Cheng & Holyoak, 1985, p. 395), Cosmides proposes that knowledge of social exchange is based on "Darwinian algorithms" which provide "specialized learning mechanisms that organize experience into adaptively meaningful schemas ..." (1989, p. 195). In Cosmides' view, the evidence she offers in support of her prediction that only social-contract rules will yield facilitation in the selection task indicates that such knowledge is not the product of general inductive mechanisms. Rather, she believes there exist innate specialized mechanisms for reasoning about, or learning to reason about, social-exchange situations.

We will now consider three related issues raised by Cosmides (1989). These are: (1) her claim that only social exchanges yield facilitation; (2) her criticisms of the experiments reported by Cheng and Holyoak (1983, 1984, 1985); and (3) her arguments concerning the origins of reasoning schemas.

Pragmatic reasoning outside of social exchanges

Evidence from previous studies

Cosmides claims that "No thematic rule that is not a social contract (e.g., rules about food, transportation, or school) has ever produced a content effect that is both robust and replicable" (1989, p. 200), and that "standard social contract rules are the only thematic rules to elicit strong and replicable content effects on the Wason selection task" (1989, p. 200), citing a long list of previous studies. In fact, however, it is by no means the case that all facilitatory regulations previously examined in studies of the selection task involve social exchange, of either the actual or pseudo variety.

Facilitatory rules that are not actual social exchanges

Actual social exchange theory predicts that facilitation by content in Wason's selection task will be limited to rules that deal with actual social exchanges, in which a cost is incurred to receive a benefit. However, consider the drinking age rule, which according to Cosmides (1989, p. 225) is a "highly familiar standard social contract." It is only a social contract according to pseudo-exchange theory. It is not clear how being above a certain age constitutes a "cost" to the potential drinker. Being a certain age is neither a type of goods nor a service. It seems that for the requirement to be considered a cost, it has to be undesirable in some sense. But reaching the age of eighteen is generally not considered undesirable. Even if it is to be construed as some sort of "cost", what is the "individual (or group)" to whom it is given in payment? No "exchange" between two parties is taking place when someone satisfies an age requirement.

Another rule that lacks the structure of an actual social exchange, but which yields reliable facilitation, was tested by Cheng and Holoyak (1983; 1985, Experiment 1). About 90 percent of college subjects solving the "rationale" version of our "cholera problem" checked the formally correct answer. Set in the context of an immigration office at the Manila International Airport, the rule was "If the form says 'ENTERING' on one side, then the other side includes cholera among the list of diseases" (p. 401). In the rationale version, this rule was accompanied by the information that the form

listed "inoculations that the passenger had had in the past six months," and that a cholera inoculation was required "to ensure that entering passengers are protected against the disease." No social exchange is taking place in this situation: having a recent inoculation so that one is protected against a disease is not a "cost" paid to another "individual (or group)". Rather, the rationale indicates that the rule is a conditional precautionary rule of the sort discussed by Manktelow and Over (in press). A conditional precaution is either a type of obligation or a type of permission, depending on whether the rule applies as the result of the occurrence of a condition that is not under voluntary control (an obligation), or as the result of a voluntary choice to undertake an action that has a precondition (a permission) (also see Girotto, Blaye, & Farioli, in press).

Facilitatory rules that are neither actual nor pseudo-exchanges

Even if we consider pseudo-exchanges, Cosmides remains incorrect in her claim that all facilitatory regulations previously examined in studies of the selection task involve social exchange. Manktelow and Over (in press) raise the example of the "Sears department store rule" (D'Andrade, 1982), which involves the regulation, "If any purchase exceeds $30, the receipt must have the signature of the department manager on the back." This rule reliably produces facilitation. Cosmides asserts without explanation (1989, p. 200) that it involves a social contract. However, as Manktelow and Over point out, it is hard to see how for a purchase to exceed a certain sum is a rationed benefit to be obtained by the department manager by his or her signing (it is simply a condition that occurs), nor is it apparent how the manager pays the customer the "cost" of signing. This rule does not seem to involve an exchange between two parties at all, and does not even seem to satisfy the definition of a pseudo-exchange, because it is not clear that the rule involves a rationed benefit.

The Sears rule has the form of a conditional obligation. As Girotto et al. (in press) have noted, Cosmides (1989) appears to have missed a major distinction between permission and obligation, taking it to be no more than a matter of alternative temporal orders. (Indeed, Cosmides conflates the two, and then misleadingly refers to our approach as a narrow "permission schema theory", when in fact we discussed pragmatic schemas for regulations such as permissions and obligations, as well as for causal and diagnostic relations.) Girotto et al. (in press) observe that in a permission rule the antecedent typically specifies a desired action (e.g. "If a child wants to play, then he/she must stay outside"), whereas in a conditional obligation the consequent specifies an action to be taken in response to an antecedent condition which may occur independently of the will of the subject (e.g., "If a child is sick, then he/she

must stay inside"). Thus obligation situations typically do *not* involve social exchanges under either definition. Indeed, to interpret the above example as an instance of Cosmides' definition of actual or pseudo social exchange would require claiming that being sick is a "benefit".

Girotto et al. (in press) had 7-year-old children perform a simplified version of the selection task with obligation, permission and arbitrary rules. The rules were unfamiliar to the children, and were based on a game situation involving toy bees. The permission rule, 'If a bee buzzes, then it must stay outside", was presented with the rationale that the rule was necessary to avoid disturbing the queen bee. This rule thus constituted an actual social exchange with a clear cost–benefit structure: buzzing, which Girotto et al.'s bees enjoy, is the benefit, and staying outside, which their bees do not enjoy, is the cost. The obligation rule, "If a bee is sick, then it must stay outside", was accompanied by the rationale that it was imposed by the queen bee to avoid spreading the disease to baby bees. This rule did not involve either actual or pseudo social exchange. Girotto et al. found that both these rules produced statistically equivalent facilitation relative to an arbitrary rule ("If a bee buzzes, then it is outside") presented simply as a rule of the game. (See also Girotto, Light, & Colbourn, in press.)

Manktelow and Over (in press) provide an example of facilitation in the absence of any social exchange or even any social situation. They presented college students with what they called a "conditional prudential obligation", "If you clean up spilt blood, then you must wear rubber gloves." The point of the rule was to avoid serious diseases that may be transmitted by contact with blood. The scenario was constructed to avoid any suggestion that the task was one of "looking for cheaters", or that cleaning up blood was in any sense a "benefit" for which one must pay the "cost" of wearing rubber gloves. Because cleaning up spilt blood is not a "rationed benefit", this obligation rule involves neither an actual nor a pseudo social exchange. Yet Manktelow and Evans found a high degree of facilitation of selection-task performance when this precautionary rule was tested. In this scenario, neither cleaning up blood nor wearing rubber gloves provides any direct benefit, but *conforming* with the rule provides the indirect benefit of avoiding a disaster.

Lack of facilitation by so-called "permission" rules

Cosmides claims that "a number of permission rules that lack a cost–benefit structure ... have not elicited content effects" (1989, p. 239). She classified these rules as expressing a permission on the basis of the rule fitting the form of Rule 1 of the permission schema. For example, Cox and Griggs (1982) tested the following "apparel-color" rule, "If a person is wearing blue, then that person must be over 20 years old", and found that only 25 percent of

the subjects produced the *p* and *not-q* response pattern. Although the rule is in the form of Rule 1 of the permission schema, such a rule evokes a permission schema only in so far as the context clarifies it as a permission, as Experiment 1 of Cheng and Holyoak (1985) showed. None of the rules that Cosmides classified as a permission yet did not produce facilitation was accompanied by a context that disambiguated it as a permission. Without such a context, the "apparel-color" rule, for example, can be given a non-permission interpretation, such as that people older than 20 like wearing blue much more than people under 20. The findings discussed by Cosmides therefore do not constitute evidence against the hypothesis that permission problems without a cost–benefit structure do produce facilitation.

In summary, contrary to Cosmides' claim that no thematic rule that is not a social contract has ever produced reliable content effects in Wason's selection task, literature on the task shows that numerous permission and obligation rules that do not involve any kind of social exchange or even any social context have reliably produced facilitation.

Evidence from experiments of Cosmides (1989)

Surprisingly, even the evidence presented by Cosmides (1989) herself, offered as support of her claim that social contract rules are the only thematic rules to elicit content effects in the Wason selection task, in fact refutes her own theory in its "actual social exchange" version. This ironic twist results from her unannounced slippage from actual social exchange theory into pseudo-exchange theory as she stepped from her hypothesis to the construction of her test materials.

Cosmides' evidence for facilitation due to social exchange

Given that all social contracts are social permissions, the results of Cosmides' Experiments 1–4, in which she found superior selection-task performance for "social contract" rules as opposed to "descriptive" rules that did not fit the permission schema, necessarily lend at least as much support to pragmatic schema theory as to social contract theory. Although Cosmides is clearly aware of this limitation, that does not prevent her from slipping into claims such as, "A high percentage of 'falsifying' responses to an unfamiliar standard social contract is predicted by only social contract theory" (1989, p. 209). In fact, Cosmides' evidence not only fails to uniquely support actual social contract theory, it contradicts it.

To support her actual social exchange theory, Cosmides examined selection performance on variants of two problems that she claims to involve unfamiliar social-exchange rules (Problems 1 and 4 in her Appendix, used in

Experiments 1, 3, 6 and 9). The facilitation reported for these problems may be regarded as the most direct positive support she offers for her theory. Quite contrary to her claim, however, an examination of the "standard social contract" versions of her problems reveals that in neither of these cases do the rules involve actual social exchange; they instead involve non-social-exchange permissions.

The "cassava root" problem states that when a man marries, he gets a tattoo on his face, and that only married men have tattoos on their faces. Because cassava root is an aphrodisiac, and only married people are supposed to have sexual relations, the elders decree: "If a man eats cassava root, then he must have a tattoo on his face." In the context of this story it is not at all clear that having a tattooed face, or being married, is to be construed as a "cost" paid to another party to obtain cassava root. There is no suggestion that men in the story are so cynical about marriage that they perceive it as a price paid to obtain cassava root. Indeed, it is not obvious that the rule involves an exchange between two parties at all. Rather, the rule is a non-social-exchange permission, in which a prerequisite that is not a "cost" paid to someone must be satisfied in order for one to take a desired action.

Similarly, neither is the rule in the other "standard social contract" problem an actual social exchange. In the "ostrich eggshell" story, duiker meat is a desirable meat that is scarce. To earn the privilege of eating it, a boy must have found an ostrich eggshell, which is a difficult hunting task the accomplishment of which signifies a boy's transition into manhood. Whereas it is clear that having the meat is a benefit, it is not clear why mastering hunting skills or reaching manhood is to be considered an undesirable "cost". Moreover, to whom is the "cost" of mastering hunting skills or reaching manhood given, in payment for the meat? As in the "cassava root" rule, the "ostrich eggshell" rule is a non-social-exchange permission in which there is a non-cost prerequisite. Thus, the results of Cosmides' Experiments 1 and 3 support pragmatic schema theory (and also Cosmides' pseudo-exchange theory) but contradict actual social-exchange theory.

Cosmides' evidence against facilitation due to non-social exchange permissions

In view of the evidence (including Cosmides' own findings) that has accumulated, revealing robust facilitation with social regulations other than social contracts, it is surprising that the experiments of Cosmides (1989) purport to demonstrate the absence of such effects. Indeed, to our knowledge she is the only investigator who has claimed to have failed to find facilitation in the selection task with a permission or obligation rule accompanied by a rationale for the rule. Inspection of the three "non-social contract permis-

sion" problems that she used in these experiments (Problems 10, 12 and 13 in her Appendix, and variations of them), however, reveals that the results she reports are uninterpretable. Cosmides compared pairs of unfamiliar social contract and non-social contract "permission rules" which in each case involved lengthy scenarios that differed in a host of uncontrolled ways. For example, the "social contract" version of the "cassava root" problem (Problem 1) says that "the elders ... distrust the motives and intentions of bachelors" (1989, p. 263), the group whose adherence to the rule is under question. In contrast, the "non-social contract permission" version of the problem (Problem 12) says that the corresponding group consists of "such law-abiding people" (1989, p. 272). Furthermore, whereas the "social contract" version of both the "cassava root" and "ostrich eggshell" problems concern checking for violations of an established rule that is to be upheld, the "non-social contract permission" versions concern testing the truth of a hypothesized rule, a task difference known to influence performance (Yachanin & Tweney, 1982). Nothing in the definition of a permission schema calls for the introduction of such extraneous differences, which we will not enumerate. Such glaring methodological flaws are sufficient to render the results she obtained with these problems uninterpretable.

But the situation for her argument is even worse. The "non-social contract" versions of the "cassava root" and "ostrich eggshell" problems (Problems 12 and 13), unlike the "social contract" versions, are written so unclearly that the critical rule involved has at least five alternative interpretations. For all three "non-social contract permissions" that she tested, all or most of the interpretations of the critical rule strongly imply that at least two of the four core rules of the permission schema, if not all of them, are mismatched. Given such mismatches, the probability of the schema being evoked should accordingly decrease, and the probability of the schema being rejected even if it is evoked should increase. The details of the ways in which her three so-called "non-social contract permissions" violate the permission schema are tedious and of no theoretical interest; a summary is provided in the Appendix.

Cosmides' (1989) experiments thus provide no evidence favoring her pseudo-exchange theory over pragmatic schema theory, and they add to the considerable evidence indicating that actual social contract theory is untenable.

Evidence from a new experiment

Although the evidence accumulated by other investigators provides clear evidence that non-social contract regulations yield facilitation in the selection

task, we felt it would be useful to perform an experiment using abstract materials. For comparison, we also included unfamiliar but concrete materials.

Materials

Four scenarios and rules, presented in Table 1, were cast in the frame of a selection task. Three of the versions were based on variants of a situation in which members of a primitive tribe follow a custom according to which if one is going out at night, one must tie a piece of volcanic rock around one's ankle. Two of these versions involved scenarios that made it clear that the rule was a conditional precaution, as the natives believed the piece of rock afforded protection from vicious spirits. Like the comparable rule studied by Manktelow and Over (in press), our precaution rules may be considered

Table 1. *Versions of selection task problems*

Costly precaution

A primitive tribe in the Kalama Islands believes that vicious spirits roam the night, but that they do not enter people's houses. These people also believe that buying a small piece of volcanic rock which the village priest blessed that day and fastening it around one's ankle will protect one from the spirits. The priest is able to charge a large sum of money for the blessed rocks because the priest's blessing is believed to have power over the spirits. Tribespeople therefore have the following rule: *If one is going out at night, then one must tie a "blessed" piece of volcanic rock around one's ankle.*

Free precaution

A primitive tribe in the Kalama Islands believes that vicious spirits roam the night, but that they do not enter people's houses. These people also believe that fastening a small piece of volcanic rock (which is abundant and free on the islands) around one's ankle will make one invisible to the spirits and thus safe from them. Tribespeople therefore have the following rule: *If one is going out at night, then one must tie a small piece of volcanic rock around one's ankle.*

Non-precaution

Early explorers who made contact with a primitive tribe in the Kalama Islands reported that the people have a strange custom that involves wearing a small piece of volcanic rock around one's ankle. The explorers reported that the tribespeople had the following rule: *If one is going out at night, then one must tie a small piece of volcanic rock around one's ankle.*

Abstract precaution

Suppose you are responsible for ensuring whether people who are about to engage in certain hazardous activities have taken the precautionary measures necessary for protecting them from harmful effects inherent in those activities. The precautions take the general form: *If one is to engage in hazardous activity H, then one must have protection P*, where H is any hazardous activity, and P is the appropriate protection for the particular activity.

either permissions or obligations, depending on whether there is or is not voluntary control over "going out at night", yielding an interpretation of the event as respectively a desired action to be taken, or as a condition that occurs independently of one's will.

The two versions of the primitive-tribe precaution differed in whether the scenario implied that the protection involved any cost. In the "costly precaution" version, the necessary pieces of rock had to be purchased at great expense from a priest whose blessing endowed the rock with its protective power; whereas in the "free precaution" version the rocks cost nothing. Thus in neither of these scenarios did the rule involve a direct social exchange; however, the costly-precaution version may be interpreted as involving an indirect exchange (the rule connotes that for the benefit of being protected against vicious spirits, one has to pay the high cost of the blessed rocks). Accordingly, actual social exchange theory must predict either that neither of the two versions, or only the costly-precaution version, should produce consistent selection of the logically correct *p* and *not-q* alternatives. In contrast, pragmatic schema theory predicts that both versions will yield robust facilitation, and that the stated cost of the precaution will be irrelevant to subjects' performance on the selection task.

In the non-precaution version the scenario provided no rationale for interpreting the rule as a precaution or any other type of conditional regulation; the rule was presented as an arbitrary hypothesis to be tested. Accordingly, pragmatic schema theory predicts that subjects' selections on this version will differ from the logically correct choices. Work on hypothesis testing suggests that due to a "positive-test" strategy, there will be an increased tendency to select the *q* case, the outcome predicted by the hypothesis (see Klayman & Ha, 1987).

Finally, the rule in the remaining version was an "abstract precaution". The scenario provided was very general, and the rule was highly abstract: "If one is to engage in hazardous activity H, then one must have protection P." This abstract-precaution version was modeled after the abstract permission rule that Cheng and Holyoak (1984; 1985, Experiment 2) found to be facilitatory. Note that since engaging in a hazardous activity is not typically considered a "rationed benefit", the abstract precaution is neither an actual nor a pseudo social exchange. The current study, unlike the earlier experiment of Cheng and Holyoak (1984, 1985), allowed a direct comparison of the benefit conveyed by concrete but unfamiliar regulations versus an abstract form of the same type of regulation. Given the greater difficulty people typically have in reasoning with abstract material, we expected that the abstract-precaution version would yield somewhat less facilitation than the costly-precaution and free-precaution versions, although more than the non-precaution version.

Each version was accompanied by four cards representing cases that could be checked to evaluate the rule. In the costly-precaution and free-precaution versions a mother was said to be checking that her children would not be harmed; in the non-precaution version a visiting anthropologist was said to be checking whether the children were following the rule. The cards respectively represented a child who will go out at night, won't go out, has a piece of rock around the ankle, and does not have a piece of rock around the ankle. In the abstract-precaution version the cards respectively represented a person who is going to engage in activity H, is not going to engage in H, has protection P, and does not have P.

Procedure and subjects

One of the four versions was presented to each subject on a 1-page handout. In each case the selection task involved indicating which of four cards representing people needed to be checked. In all versions subjects were asked to check only those cards that needed to be turned over. One hundred and forty-four UCLA undergraduates, enrolled in a course on human information processing, served as subjects. They were tested at the beginning of the course, before any coverage of reasoning. Approximately equal numbers of subjects received each of the four versions.

Results and discussion

Table 2 presents the percentage of subjects in each condition who correctly selected the *p* and *not-q* alternatives, as well as the percentage who made each of the four individual responses. As predicted by pragmatic schema theory, all three of the precaution conditions produced a higher percentage of correct selections than did the non-precaution condition, $\chi^2(1) = 25.7$, $p < .001$ for both the costly-precaution and free-precaution conditions, $\chi^2(1) = 8.19$, $p < .005$ for the abstract-precaution condition. The percentage correct was identical (86%) for the two concrete-precaution conditions, a figure

Table 2. *Performance on selection task as a function of content*

		Type of response (%)			
Problem version	% Correct	*p*	*not-p*	*q*	*not-q*
Costly precaution ($N = 37$)	86	97	5	8	92
Free precaution ($N = 37$)	86	92	5	3	92
Abstract precaution ($N = 34$)	62	97	9	15	68
Non-precaution ($N = 36$)	28	89	25	47	78

significantly higher than the 62 percent correct obtained for the abstract condition, $\chi^2(1) = 5.72$, $p < .025$.

Inspection of the results for the four individual responses revealed that the abstract-precaution condition differed from the two concrete-precaution conditions only with respect to the *not-q* response: the abstract precaution produced more failures to select *not-q* than did the two concrete conditions, $\chi^2(1) = 6.58$, $p < .025$. The non-precaution condition differed from the three precaution conditions with respect to the *q* and *not-p* responses. It yielded more erroneous *q* choices than did any other condition, $\chi^2(1) = 8.58$, $p < .005$ for comparison with the abstract precaution, which has the highest frequency of this response among the other three conditions. It also yielded more erroneous *not-p* choices than did either the costly or free precautions, $\chi^2(1) = 5.47$, $p < .025$ for each comparison. Note that the percentage of *not-q* choices for the non-precaution condition was quite high (78%), and did not differ significantly from the percentages obtained for the three precaution conditions. The present non-precaution problem thus yielded substantially more *not-q* choices than does the classic Wason's card problem, for which a frequency of less than 20 percent is typical (e.g., the average of four experiments by Johnson-Laird & Wason, 1970). It seems possible that although the non-precaution rule itself was arbitrary, the context of scientific hypothesis-testing in which it was embedded elicited a relevant schema, albeit not one that maps onto the formal conditional. This possibility merits further research. Finally, in accord with pragmatic schema theory but not actual social exchange theory, the costly-precaution condition did not differ from the free-precaution condition on any response type.

These results thus add to the substantial body of evidence indicating that, contrary to the prediction of social exchange theory, facilitation in the selection task can be readily obtained with unfamiliar regulations that do not involve social exchange, any type of "rationed benefit", or even any social situation at all. Furthermore, a reduced but substantial degree of facilitation can be obtained with an abstract statement of a conditional precaution, which is neither an actual nor a pseudo exchange, thus extending the similar findings for an abstract permission statement reported by Cheng and Holyoak (1984, 1985).

Cosmides' criticisms of experiments of Cheng and Holyoak

Both pragmatic schema theory and social exchange theory predict that domain-specific knowledge about particular rules is not necessary to obtain facilitation in reasoning; what is crucial is that the context of the rule should

provide cues that evoke an appropriate schema. Cheng and Holyoak (1985; also 1983, 1984) reported two experiments that provide evidence against the specific-knowledge view. Cosmides (1989) raises a number of criticisms of these experiments in the course of motivating her own attempts to address this issue. As her criticisms are accompanied by an inaccurate description of our experiments, a brief review seems warranted.

In one of our experiments (Cheng & Holyoak, 1983; 1985, Experiment 1), we had subjects solve two selection problems. One problem was accompanied by a rationale that was likely to evoke a permission schema, whereas the other was not. Subjects were significantly more likely to select the *p* and *not-q* cases when a rationale was provided (unless they were already familiar with the rule, in which case performance was high even without the rationale). The results were thus in accord with the prediction of pragmatic schema theory: specific prior knowledge of a rule is not required to obtain facilitation.

Cosmides (1989) misdescribes several aspects of this experiment. First, she claims that in the rationale condition "contextual information gave the rules a clear cost-benefit structure, thereby making them social contracts" (1989, p. 203). This claim holds only under her pseudo-exchange definition of social contract, in which "cost" is no more than a "requirement". As we mentioned earlier, the "cholera problem", one of the two problems in this experiment, contained a precautionary rule that is a non-social exchange permission.

Second, Cosmides claims that in the no-rationale condition the "rule had been stripped of any context whatsoever" (1989, p. 203). This characterization is puzzling in view of the fact that the no-rationale version for the above "cholera" rule began, "You are an immigration officer at the International Airport in Manila ... Among the documents you 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' ..." (Cheng & Holyoak, 1985, p. 401). The rationale version provided exactly the same context as did the no-rationale version, with the exception that in the former the phrase "lists inoculations the passenger had had in the last 6 months" replaces "lists names of tropical diseases", and the sentence "This is to ensure that entering passengers are protected against the disease" was added after the rule. The manipulation of the schema-evoking cues was thus more restricted than Cosmides implies.

Cosmides then argues that the contextual information provided by the rationale might have cued additional relevant or related experiences from long-term memory. As we have seen, however, the amount of additional context provided by the rationale was considerably less than Cosmides implies in describing the no-rationale version as "contextless" (1989, p. 204), al-

though as we ourselves pointed out, "... 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" (Cheng & Holyoak, 1985, p. 402).[2] Cosmides further notes that performance on the no-rationale versions, although significantly below the roughly 85 percent correct achieved for the rationale versions, was nonetheless quite high in absolute terms (roughly 60% correct). She suggests that the high peformance on the no-rationale versions may have been due to subjects having some relevant knowledge; in addition, subjects were allowed to return to the earlier problem and correct their answer if they desired. These are, once again, not original observations: "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" (of the no-rationale versions relative to similar rules used in earlier studies) (Cheng & Holyoak, 1985, p. 402). All of which, contrary to Cosmides' claim, strengthens rather than weakens the interpretation of our results. The effect on evoking a schema of providing its goal is robust: despite the inclusion of factors that aided performance in the no-rationale versions, the small changes in wording that created the rationale versions increased performance by a further 25 percent.

In another experiment reported by Cheng and Holyoak (1984; 1985, Experiment 2), we compared performance with an abstract statement of a permission situation to performance with Wason's (1966) arbitrary letter-digit rule. Subjects in the abstract permission condition were told that certain 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'." Wason's arbitrary

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[2]The only clear formulation of the memory-cueing view yields the hypothesis that amount of direct experience with a rule predicts facilitation. This is the view refuted by the results of our experiment, as we concluded: "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" (Cheng & Holyoak, 1985, p. 402). Looser versions of the memory-cueing view, which simply argue that remindings can influence reasoning, seem to us impossible to entirely rule out for any selection-task experiment conducted on adult subjects. In Cosmides' (1989) own experiments, for example, analogical reasoning could plausibly have helped to produce the facilitation obtained for her "social contract" rules. Thus for one of her "unfamiliar social contract" rules, the context indicated that a precondition must be satisfied before a favorite food can be eaten – a familiar type of circumstance to any child who has had to clean their room to earn a cookie. More generally, if rules that are of the same (or at least analogous) type have never been encountered, a tested rule is unlikely to be one for which people have developed schemas, innate or induced. The critical weakness of looser formulations of the memory-cueing view, however, is that they are not predictive; rather, they provide only post hoc explanations of when facilitation is or is not obtained.

letter-digit rule is the baseline for measuring people's purely formal reasoning against which content effects are typically compared in the literature. For the first problem solved, subjects were correct 61 percent of the time with the abstract permission rule, versus only 19 percent for the letter-digit rule, providing further support for our prediction that specific experience with a concrete rule is not necessary to obtain facilitation.

In trying to explain away the facilitation we obtained for this abstract permission rule, Cosmides is led to weaken her definition of a social contract even further than in her pseudo-exchange version. Despite her earlier recognition that social contracts are a proper subset of permissions, she now claims that the content-free statement of the permission rule is itself a social contract! "After all, saying that one must fulfill or satisfy a precondition in order to be permitted to do something, is just another way of saying that one must pay a cost *or meet a requirement*" (1989, p. 239, italics added). She further objects to our use of the term "permit" in our statement of an abstract permission ("In order to be permitted to do 'A', one must have fulfilled prerequisite 'P' "), on the grounds that the term "permit" suggests a social contract: "saying that someone is permitted to take action 'A' linguistically marks action 'A' as a rationed benefit: It implies that the person *wants* to take action 'A' ..." (1989, p. 239; italics in original). She suggests that to avoid a social contract interpretation, the term should be left out of our materials.

Why Cosmides should object to the use of the word "permit" in our "permission" rules, given the obvious morphological linkage, is unclear. If it were indeed the case that the term "permit" carries the meaning that the relevant action is a rationed benefit, her objection to our use of the term "permit" in stating an abstract permission would merely indicate that in her opinion we should not have proposed what she is proposing. But in fact, as we and others have argued, there are permitted actions (e.g., in precautionary permissions) that do not involve any "rationed benefit". To adapt the example of Manktelow and Over (in press), suppose that to protect the safety of its staff a hospital establishes the rule, "In order to be permitted to clean up spilt blood, a staff member must wear rubber gloves." According to Cosmides' notion of the "linguistic marking" of the term "permit", the use of the term in this rule implies that cleaning up spilt blood is a "rationed benefit" for hospital staff, and that the staff *want* to clean up blood. Speakers of English in the age of AIDS may judge for themselves the plausibility of this claim about the semantics of "permit".

The need to explain away the facilitation we obtained for the abstract permission rule presses Cosmides to further argue that "although [this experiment] was intended to eliminate the memory-cueing problem, it actually exacerbated it. By putting the permission rule in its content-free form, sub-

jects are able to draw on a vast well of experiences with its terms" (1989, p. 205). If this criticism were correct, it would imply that an abstract rule should yield greater facilitation than even a familiar (and certainly any unfamiliar) concrete rule. This prediction is highly implausible in view of the fact that considerable evidence from memory research indicates that abstract terms are relatively poor retrieval cues (Paivio, 1971). Moreover, it is directly contradicted by the results reported both by Cheng and Holyoak (1985) and in the present paper. Note that the performance level on the abstract permission rule in the second experiment of Cheng and Holyoak (1985) was actually lower, not higher, than performance on the concrete rules accompanied by a rationale in the first experiment. A more direct comparison is provided in the study we have described here, in which within a single experiment performance proved significantly lower with the abstract precaution than with either of the two concrete versions.

Finally, Cosmides (1989) argues that the Wason "letter-digit" card problem – long the standard baseline for comparison in the selection-task literature – was not an appropriate comparison in our Experiment 2. She claims we should have instead compared performance on the abstract permission rule to performance on the following: "Suppose you are a scientist checking to see whether certain rules are true. The rules all have the general form, 'If one takes action A, then situation B will occur. In other words, situation B always occurs after one takes action A' " (Cosmides, 1989, p. 206). This suggestion is methodologically unsound. Clearly, the purest measure of the impact of evocation of a permission schema on reasoning should be based on comparison with a rule that can evoke *no* schema (except that for the formal conditional, if such a schema exists). Massive evidence from previous studies by a dozen or more investigators indicates that the letter-digit rule satisfies this criterion. The rule Cosmides advocates, however, might well evoke some non-permission schema, such as a causal or hypothesis-testing schema, which would produce its own distinctive pattern of responding on the selection task. Indeed, the relatively high frequency of *not-q* choices elicited by the non-precaution rule tested in the experiment reported in the presented paper – a rule couched in terms of scientific hypothesis-testing – lends considerable credence to this possibility.

In summary, Cosmides' (1989) criticisms of our experiments are devoid of merit.

The origins of reasoning schemas

The issue that Cosmides (1989) raises – whether facilitation in Wason's selection task is obtained only for social exchange rules, or for the broader class of social regulations – is one that might seem to be of relatively modest import for the overall enterprise of cognitive science. Cosmides, however, has a grander vision: "Whether the human cognitive architecture contains an array of special purpose, domain specific, procedure-rich modules, or consists of a few, major, domain-general information-processing mechanisms, is very much at issue in modern cognitive science. ... If this and other empirical studies establish that even human reasoning is not unitary and domain general, but instead governed by an array of special purpose mechanisms, this will provide substantial support for a modular approach to cognitive psychology. These studies have been designed to contribute to the resolution of this issue, by widening the debate from psycholinguistics into the field of human reasoning, and they provide empirical support for an evolutionary and modular approach outside of psycholinguistics" (1989, p. 260).

It is not immediately apparent exactly what view Cosmides is advancing. One of the subtitles of her paper is the question, "Has natural selection shaped how humans reason?" Given that human information processing, like all properties of biological organisms, presumably has arisen as the result of evolution, it is hard to imagine how anyone (who is not a creationist) could fail to answer in the affirmative. But it appears that Cosmides wishes to champion a more specific view. She believes that reasoning algorithms "are innate, or else the product of experience structured by innate algorithms that are specialized for reasoning about social exchange" (1989, pp. 260–261). In contrast, she argues that pragmatic schema theory "accepts domain-specific procedures, but explains them as the product of an overarching domain-general process" (1989, p. 254).

Any discussion of the origins of reasoning schemas is bound to be speculative. We would certainly agree with Cosmides that no one, including ourselves, has developed a serious theory of the origins of reasoning schemas. We simply add that "no one" includes Cosmides as well. The above quotation provides about as explicit a position as she offers: reasoning about social contracts is either "innate" (presumably meaning a matter of maturation, more or less independent of experience in social relations), "or else the product of experience structured by innate algorithms" – something akin to a Chomskian LAD ("language acquisition device"), which we will dub SCAD ("social contract acquisition device"). She offers three basic lines of argument in favor of postulating that reasoning schemas are innate or derived from a SCAD. Her arguments are based on: (1) her supposed evidence that only

social contract rules yield facilitation in reasoning tasks; (2) reasons why the ability to reason about social contracts would have been useful to prehistoric humans; and (3) claims that general learning mechanisms are unable to plausibly account for the acquisition of reasoning schemas. We will consider each of these lines of argument.

Are reasoning schemas limited to social contracts?

Cosmides' most substantive line of argument favoring innateness/SCAD is that since people consistently investigate potential violations only with social contract rules, and not with other classes of rules concerning familiar types of situations, the mechanism responsible for acquiring knowledge of social contracts must be highly specialized. This argument, of course, suffers from the fact that its premise is demonstrably false: abundant evidence shows that performance on the selection task is facilitated for rules (involving obligations and permissions) that do not involve exchange at all, as we have discussed.

Moreover, there are *a priori* reasons to reject this line of argument for innateness/SCAD. In claiming that people do not reliably detect violations of rules from other familiar types of situations, such as causal and descriptive regularities, Cosmides implicitly assumes that detecting violations as defined by the checking of the *p* and *not-q* cases in Wason's selection task is the *sine qua non* of successful reasoning with conditionals. For example, as evidence that people are "not good at detecting violations of causal rules" (1989, p. 257), she notes that people often do not select the potentially disconfirming *not-q* case in a selection task when the rule is interpreted causally (Cheng et al., 1986). There are reasons to suppose, however, that rational disconfirmation in reasoning about causation should differ from that in reasoning about deontic regulations. For example, the claim that smoking causes lung cancer is not falsified by a single observation of a smoker who does not contract cancer, nor by an observation of a cancer victim who did not smoke. Rather, people appear to assess causal claims by assessing whether the probability of the effect is greater when the potential cause occurs than when it does not (Cheng & Novick, 1989, in press), a judgment that involves all four possible combinations of the presence versus absence of cause and effect. Aside from the issue of the probabilistic versus deterministic nature of the cause, Klayman and Ha (1987) have argued that the "positive test" strategy – the strategy of testing cases that are expected or known to have the property of interest rather than those expected or known to lack that property – can be a very good hypothesis-testing heuristic under realistic conditions. Such a strategy would lead to checking the cases *p* and *q* in Wason's selection task. In general, why should one expect reasoning performance as defined by

checking the formally correct cases in Wason's selection task to measure whether or not people have acquired adaptive inferential rules *regardless* of the pragmatic context in question?

What does utility to prehistoric humans imply about the origins of schemas?

According to Cosmides (1989), "The ecological and life-historical conditions necessary for the evolution of social exchange were manifest during hominid evolution" (1989, p. 195). In particular, she claims that Pleistocene hunter-gatherers engaged in many forms of social exchange, and hence would have needed inferential procedures to detect cheating. It should be readily apparent that this plausible hypothesis by itself has no implications at all for the origins of reasoning schemas. Knowledge of how to detect cheating might have been innate, derived by a SCAD, or learned by general inductive mechanisms – the utility of such knowledge simply means that it ought to be acquired somehow.

When one adopts a broader view of the pragmatic functions of reasoning, it seems peculiar that an evolutionary perspective would lead one to fixate on social exchange situations as the central locus of selective pressure. Certainly it would have been useful for the Pleistocene hunter-gatherers to know how to detect violations of actual social contracts, such as "If you skin the deer, then I'll give you a roast to eat." But surely natural selection, during prehistoric and even modern times, would also favor those who could grasp a precautionary rule such as "If you hunt tigers, then be sure to carry a sharp spear", and who would therefore sensibly refrain from harassing such creatures with only a brittle stick in hand. Survival value would also accrue from knowing how to evaluate causal claims, such as "If the waters are still and deep, then fish will gather there"; moreover, the adaptive response would not be to reject the advice after once failing to find fish in a still, deep pool. Thus, not only is Cosmides empirically incorrect in claiming that social exchange situations have some uniquely privileged status in human reasoning, but it is unclear why one would believe this erroneous prediction follows from considerations of importance for survival.

Could inductive mechanisms produce adaptive reasoning schemas?

According to Cosmides' third line of argument in favor of innateness/SCAD, it is implausible that general inductive learning could account for reasoning about social contracts, because people supposedly reason well only about social contract situations, and not about other types of situations (e.g., non-social contract permissions and causal regularities) for which one would have

expected general inductive mechanisms also to generate schemas. This line of argument is undermined by the failures of the first two: since social contract rules are *not* unique in fostering violation checking, and the formally correct answer in Wason's selection task is *not* the sole criterion for adaptive reasoning in all situations involving conditional rules, it follows that more than SCAD underlies human reasoning. The evidence for schematic reasoning outside the realm of social exchange does not, of course, compel the interpretation that schemas are acquired by a general learning mechanism. Perhaps in addition to SCAD there is a PAD ("precaution acquisition device"), a CAD ("causation acquisition device"), a MAD ("morality acquisition device"), and so on. The larger burden of proof, however, falls on proponents of the less parsimonious view. Cosmides has provided no empirical evidence that favors postulating innateness of specific inductive mechanisms rather than broader inductive mechanisms.

Cosmides makes two other arguments against the plausibility of general inductive mechanisms. First, she claims that since compliance with rules is more frequent than their violation, induction should have created schemas "that look for compliance, not cheating" (1989, p. 258). At most, however, this argument suggests that people should have learned how to assess compliance *in addition* to learning how to assess cheating, and Cosmides offers no evidence that people do not know how to assess compliance with regulations. (Typical versions of Wason's selection task using regulations only ask subjects to check for violations.) Her final argument is the query, "Without built-in, domain-specific knowledge defining what counts as cheating, how could one develop a 'look for cheaters' procedure?" (1989, p. 259). One could as well ask, "Without built-in specific knowledge defining what counts as a car that won't start, how could one develop a procedure for detecting a broken-down car?" Possible answers to both questions include noticing failures to achieve certain types of goals, and simply being instructed by someone else.

We certainly do not claim that general inductive mechanisms can demonstrably account for the acquisition of reasoning schemas; as we noted earlier, no one has proposed a rigorous theory of such schema acquisition. However, current conceptions of general inductive mechanisms have minimal resemblance to the naive associationism that Cosmides sets up as her foil. Her idea of the most plausible mechanism for general induction, adapted from the British Empiricists, is exemplified by a scenario in which "The sight of one white swan may mean nothing, but if one sees a hundred white swans and no black ones, one might begin to associate whiteness with swans, and one might induce the rule 'all swans are white'. The more experiences one has, the stronger the association becomes, and the more likely one is to

induce a rule" (1989, p. 256). For comparison, the general framework for induction proposed by Holland, Holyoak, Nisbett, and Thagard (1986) stresses the importance of constraints of various degrees of generality in determining whether and how readily knowledge about a regularity in the environment will be induced. Two of the most general constraints they proposed involve the role of failed expectations concerning goal attainment in triggering inductions, and the role of knowledge about variability of classes of objects and events in determining the propensity to generalize. Within this framework it is clear that pragmatically useful inductions will often be triggered not by a hundred repeated observations, but by as few as one (Nisbett, Krantz, Jepson, & Kunda, 1983). Constraints such as the above may play an important role in the induction of reasoning schemas.

Appendix

Violations of the permission schema by Cosmides' (1989) "Non-Social Contract Permission" Scenarios

"Cassava root" problem

There are five possible interpretations of the critical rule in the "non-social contract permission" version of the "cassava root" problem, only one of which does not contradict the permission schema. This version of the "cassava root" problem states that the Kaluame people are divided into two clans: all of the members of one clan have facial tattoos; none of the members of the other clan have facial tattoos. The Kaluame people have two staple foods – cassava root and molo nuts. To prevent the extinction of these two staples, "the elders decided to divide the Kaluame people in half, so that, roughly, one clan would live where the cassava root grows, and eat only cassava root, and one clan would live where the molo nuts grow, and eat only molo nuts. That way, neither food source would be overwhelmed by too many people" (1989, p. 271). To complicate matters, "one clan had more people than the other, so 10% of the larger clan were asked to live and eat with the smaller clan." (This complication is absent in the "social contract" version.) The story then went on to say, "The elders expressed the law governing eating arrangements thus: 'If a man eats cassava root, then he must have a tattoo on his face.' " Given the context in which the rule appears, five possible interpretations of the rule are:

(1) The small clan lives where cassava roots grow, and its members have facial tattoos. But 10 percent of the larger clan, who do not have facial

tattoos, can also eat cassava root. The critical rule then is regarded as merely a rough description of the eating arrangement, rather than a regulation. This interpretation of the rule – quite consistent with the word "roughly" earlier in the passage – clearly is not a permission by our definition, because all four core rules of our permission schema are violated in this context.

(2) The small clan lives where cassava roots grow, and its members have facial tattoos. The larger clan has no facial tattoos, and 10% of its members bring food from their own clan to eat with the smaller clan, for they are not allowed to eat cassava root. Each clan is allowed to eat only its own staple. In this case, the rule is interpreted as a strict, biconditional regulation, "A man eats cassava root if and only if he has a tattoo on his face." Under this interpretation, the rationale of dividing the clans to prevent extinction of the staples is rational if it is assumed that there are 10% more molo nuts than cassava roots, but there is more living space where cassava roots grow. This interpretation of the rule leaves Rules 2 and 3 of the permission schema mismatched. Whereas Rule 2 when applied to this problem states that "if a man is not to eat cassava root, then he need not have a tattoo on his face", the problem context implies that "if a man is not to eat cassava root, then he must not have a tattoo on his face." Similarly, whereas Rule 3 when applied to this problem states that "if a man has a tattoo on his face, then he may eat cassava root", the problem context, given that there are only two staple foods, implies that "if a man has a tattoo on his face, then he must eat cassava root."

(3) The larger clan lives where cassava roots grow, and its members have facial tattoos. Assuming that the smaller clan, whose members have no facial tattoos, do not intrude into the larger clan's territory or steal from them (there is no suggestion of that in the story; in fact, the reader is told that the Kaluame are a law-abiding people), then the rule in this case may be regarded as merely a description of the eating arrangement, rather than a regulation. Being a description, none of the rules of the permission schema applies. If it is assumed that as in (1), the 10 percent of the larger clan eat the smaller clan's food, then the description is a conditional. If it is assumed that as in (2), the 10 percent of the larger clan bring their own food over to eat with the smaller clan, then the description is a biconditional.

(4) The larger clan lives where cassava roots grow, and its members have facial tattoos. But, assume that members of the smaller clan may have stolen cassava root from the larger clan's territory, even though the story suggests otherwise. This is the only interpretation of the rule that fits a permission.

(5) The larger clan lives where cassava roots grow, and its members have facial tattoos. But, assume that members of the smaller clan may have taken cassava root from the larger clan's territory, not because they have stolen it

(in which case they are not permitted to eat it according to the rule), but because the rule no longer applies (in which case no permission is being violated). This is one of the interpretations suggested by the text: "If any of them are breaking it, it must be because the plants flourished and the elders repealed the law." In this context, the truth of a hypothesized rule is being tested, rather than an established permission rule being checked. Thus, the permission schema does not apply.

In sum, of the five or six possible interpretations above, the only one that does not contradict the permission schema is the one that fits the scenario as stated least of all. Given that only one of the many interpretations results in a permission, and the other interpretations do not evoke schemas that map onto the material conditional, it is not surprising that relatively few of Cosmides' subjects chose the "*p* and *not-q*" response pattern.

"Ostrich eggshell" problem

The "ostrich eggshell" problem has a highly similar structure to the cassava root problem, and hence suffers from an analogous set of problems.

"Grover High School" problem

In addition to the above two problems that have an "unfamiliar" context, Cosmides also tested "social contract" against "non-social contract permission" problems with the "familiar" context of the assignment of students from various towns to high schools (Problem 10). According to the "non-social contract" version,

> It is important that certain rules for assigning students from various towns to the appropriate school district be followed, because the population statistics they provide allow the Board of Education to decide how many teachers need to be assigned to each school. If these rules are not followed, some schools could end up with too many teachers, and other schools with too few.
>
> Students are to be assigned either to Grover High School or to Hanover High School.
>
> Some students live in the town of Grover City, some live in Hanover, and some live in Belmont. There are rules that determine which school a student is to be assigned to: the most important of these rules is:
>
> "If a student is to be assigned to Grover High School, then that student must live in Grover City" (1989, p. 270).

For the following four reasons, this problem is likely to lead to a biconditional interpretation. First, in real life, students in the U.S. are assigned to local public schools. A realistic rule in terms of this problem would state the

converse of the given rule, "If a student lives in Grover City, then that student is to be assigned to Grover High School." Second, the "rationale", instead of clarifying the rule as a permission, encourages the assumption of the converse. For the "population statistics" to guide "how many teachers need to be assigned to each school", assignment of students should be conditional on the location of residence (as in the converse), rather than location of residence conditional on assignment of students (as in the given rule). Third, the story states that there are three towns, with only two schools, one each in two of the towns. Given that Grover City has its own high school (this is an assumption in the "non-social contract permission" version based on the matching names of the towns and the schools; it is not explicitly stated there as in the "social contract" version), it seems reasonable to assume that all students living in Grover City would be assigned to Grover High School. Such an assumption, as in the "unfamiliar" problems discussed above, implies that Rules 2 and 3 of the permission schema would be mismatched. The evocation of the permission schema would therefore be unlikely.

Furthermore, the "social contract" and "non-social contract permission" versions of the school problem differ on the nature of the possible violations of the rule. Whereas violations in the "non-social contract permission" version are due to a secretary's absent-minded mistakes, without any intention of violating any regulation, violations in the "social contract" version are due to volunteer workers, who, as ambitious mothers who want their children to attend a better high school, "might have been tempted to cheat on the rule" (1989, p. 270).

In her Experiments 8 and 9, Cosmides presented "switched" rules that supposedly were in the form of Rule 3 of the permission schema, but performance did not improve. However, in the "switched" version of the "non-social contract permission" rules, the word "may" was consistently left out of all the rules. For example, the "switched" rule for the Grover City School problem states, "If a student lives in Grover City, then that student is to be assigned to Grover High School." Such rules constitute the sole information that Cosmides assumes would evoke the permission schema. Contrary to Cosmides' assertion, the omission clearly produces a mismatch to Rule 3, which in the context would state, "If a student lives in Grover City, then that student may be assigned to Grover High School." Because the critical rule in these "switched" materials blatantly contradicts one of the core rules in the permission schema, and the materials contain no other information that is relevant to a permission, it is most unlikely that the permission schema would be evoked.

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