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Evidence for the Innateness of Deontic Reasoning

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Abstract: When reasoning about deontic rules (what one may, should, or should not do in a given set of circumstances), reasoners adopt a violation-detection strategy, a strategy they do not adopt when reasoning about indicative rules (descriptions of purported state of affairs). I argue that this indicative–deontic distinction constitutes a primitive in the cognitive architecture. To support this claim, I show that this distinction emerges early in development, is observed regardless of the cultural background of the reasoner, and can be selectively disrupted at the neurological level. I also argue that this distinction emerged as a result of selective pressure favouring the evolution of reasoning strategies that determine survival within dominance hierarchies.

If seven decades of empirical investigations of human reasoning have shown us nothing else, they have shown us that our reasoning strategies vary as a function of problem content (Byrne, 1989; Cheng and Holyoak, 1985, 1989; Cheng, Holyoak, Nisbett and Oliver, 1986; Cosmides, 1989; Cummins, 1995, in press; Cummins, Lubart, Alksnis and Rist, 1991; Evans, 1989; Griggs and Cox, 1982, 1983; Henle, 1962; Manktelow and Over, 1991; Revlin and Leirer, 1978; Roberge, 1982; Thompson, 1994, 1995; Thompson and Mann, 1995; van Duyne, 1974; Wason, 1968; Wason and Johnson-Laird, 1972; Wason and Shapiro, 1972; Wilkins, 1928). While robust, pervasive, and readily evoked, the significance of content effects is far from clear. Initial explanations attributed them to the idiosyncratic influence of an individual's knowledge on a content-free, syntactically-driven reasoning process (Braine, 1978; Braine and O'Brien, 1991; Henle, 1962; Rumain, Connell and Braine, 1983). In recent years, however, a groundswell of opinion has arisen that it is in the evocation of content effects that the true nature of the human reasoning architecture is to be found. Human reasoning varies as a function of content because the human reasoning architecture consists of a collection of domain-specific

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acquired schemas (Cheng and Holyoak, 1985, 1989; Cheng et al., 1986), evolved modules (Cosmides, 1989; Cosmides and Tooby, 1989, 1992, 1994), or model-building strategies (Johnson-Laird and Byrne, 1991; Manktelow and Over, 1991) rather than a collection of syntactically-driven rules. For this reason, different contents evoke different domain-relevant reasoning strategies.

1. *The Indicative-Deontic Distinction in Adult Reasoning*

One of the most robust content effects in the literature is what I will call the *indicative–deontic distinction*. Indicative reasoning is reasoning about the epistemic status of rules. It can be analyzed in terms of hypothesis-testing, that is, testing the truth content of a rule that describes a purported state of affairs. Deontic reasoning, on the other hand, is reasoning about what one may, ought, or must not do in a given set of circumstances (Hilpinen, 1971, 1981; Manktelow and Over, 1991). Virtually all of our social institutions presuppose a capacity to understand and reason about what is permitted, obligated, prohibited, cautioned, or advised. Failure to reason effectively about deontic rules can have disastrous consequences, including scolding, expulsion, legal action, and even incarceration. We also presume the capacity to reason deontically in most of our child-rearing and social interactions, appealing to this presumed capacity whenever we utter a permission, promise, warning, or threat.

Human reasoners treat these two types of rules very differently, adopting a violation-detecting strategy when reasoning about deontic rules and a confirmation-seeking strategy when reasoning about indicative rules. The clearest examples of the indicative–deontic distinction are based on the Wason card selection task, a task unique not only in its simplicity but in its ability to generate robust content effects (Wason, 1968). This task consists of asking reasoners which of four cards must be turned over in order to test a particular conditional rule ($p \rightarrow q$). The four cards correspond, respectively, to the antecedent of the conditional (p), its consequent (q), and the denial of each (not-p, not-q). For example, consider the following problem: A friend relates to you the observation that in Arizona 'If you go to Phoenix, you travel by train.' In front of you are four cards that have a person's destination on one side and his or her means of transportation on the other. Your task is to indicate all and only those cards that must be turned over in order to test whether or not your friend was telling the truth. Your choices are 'Phoenix', 'Tucson', 'Train' and 'Car'. If you are like the vast majority of people, you selected 'Phoenix' and 'Train', that is, p and q.

Now consider the following case. You are to pretend that you work for the Arizona transportation bureau, and it is your job to enforce a new law aimed at reducing air pollution due to car emissions. The law is 'If you go to Phoenix, you must travel by train.' You're shown the same four cards, and are asked to indicate all and only those cards that must be turned over in order to determine whether or not the rule is being followed. If you're

% p and not-q choices	(a) "Abstract" Content Conditionals
6%	If there is a 3 on one side of any card, then there is a D on its other side. (Wason, 1968, Exp. 1)
8%	If there is a square on one side, then there is a red scribble on the other side. (Wason, 1968, Exp. 2)
29%	Every card which has a vowel on one side has an even number on the other side. (Wason and Shapiro, 1971, Exp. 1)
12%	Every card which has a D on one side has a 3 on the other side. (Wason and Shapiro, 1971, Exp. 2)
4%	If there is a vowel on one side of the card, then there is an even number on the other side of the card. (Wason and Johnson-Laird 1972)
8%	If a letter has A on one side, then it has a 3 on the other side. (Johnson-Laird, Legrenzi and Legrenzi, 1972)
8%	Every card which has a D on one side has a 5 on the other side. (van Duyne, 1974)
12%	If a card has a D on one side then it has a 5 on the other side. (van Duyne, 1974)
0–4%	If a card has an 'A' on one side, then it has a 5 on the other side. (Griggs and Cox, 1982, Exp. 1–3)
4%	If a card has an A on one side, then it has a 3 on the other side. (Cox and Griggs, 1982, Exp. 1)
5%	If a card has an 'A' on one side, then it has a 5 on the other side. (Griggs and Cox, 1983, Exp. 1)
0%	If a card has a vowel on its letter side, then it has an even number on its number side. (Platt and Griggs, 1983)
19%	If there is an 'A' on one side of the card, then there is a "4" on the other side of the card. (Cheng and Holyoak, 1985, Exp. 2)

Figure 1 Some examples of conditional rules used in studies of adult human reasoning, and average reported performance. The conditionals in (a) are abstract in that they do not describe situations with which most people are familiar. Average performance is uniformly low. The conditionals in (b) are neutral in content; they embed familiar situations, but they do not convey social regulations. Average performance does not differ appreciably from that observed on abstract conditionals. The conditionals in (c) vary in terms of familiarity and abstractness, yet they all describe permission situations. Average performance on these social regulations is uniformly high.

like most people, it seems apparent now that 'Phoenix' and 'Car', that is, p and not-q must be turned over.

The travel problem is an example of an indicative rule, and the most frequently observed response pattern (p and q) constitutes seeking rule-confirming evidence. The law problem is an example of a deontic rule, and the most frequently observed response pattern (p and not-q) constitutes seeking rule violations. This is what I mean by the indicative–deontic distinction in human reasoning. Its robustness is readily apparent in Figure 1(a)–(c).

Figure 1(a) shows the low level of violation checking observed when

% p and not-q choices	(b) *Neutral Thematic Content Conditionals*
62%	Everytime I go to Manchester, I travel by car. (Wason and Shapiro, 1971, Exp. 2)
8%	Everytime Ottawa is on one side, car is on the other side (Bracewell and Hidi, 1974)
22%	Everytime I go to Manchester, I travel by car. (Gilhooly and Falconer, 1974)
9%	Everytime I go to Miami, I travel by car. (Griggs and Cox, 1982)
25%	If a person is wearing blue, then the person must be over 19. (Cox and Griggs, 1982, Exp. 1)
54%	If a person is under 19, then the person must be drinking Coke. (Cox and Griggs, 1982, Exp. 2)
20%	If a person is over 19, then the person must be drinking beer. (Cox and Griggs, 1982, Exp. 3)
4%	If I eat haddock, then I drink gin. (8 food and drink combinations tested) (Reich and Ruth, 1982, Exp. 1)
12%	When I go to work, I hurry/When I travel to France, I go by plane/When the fruit are yellow, they are ripe/When it is early, Molly serves tea. (Reich and Ruth, 1982, Exp. 2)
17%	If a bird on the island has a purple spot under its wing, then it makes its nest on the ground. (Cheng and Holyoak, 1985, Exp. 3)
60%	If an envelope is sealed, then it must have a 20 cent stamp. (Cheng and Holyoak, 1985, Exp. 1) (When presented without accompanying permission rationale.)
60%	If a passenger form says 'Entering' on one side, then the other side must include 'cholera' (Cheng and Holyoak, 1985, Exp. 1) (When presented without accompanying permission rationale.)

Figure 1 (b).

unfamiliar, neutral contents are embedded in the task, from 0% to about 25%. Figure 1(b) shows an equally low incidence level when familiar neutral contents are embedded. But a dramatically different picture appears in Figure 1(c); here violation detection selections range from 50% to 96%, substantially higher than on the equally familiar but neutral content problems in Figure 1(b). What the problems in Figure 1(c) have in common is this: they all embed permission and obligation contents, and hence, by definition, require deontic reasoning. The indicative–deontic distinction is also readily evoked among reasoners of varying educational backgrounds (Cheng, Holyoak, Nisbett and Oliver, 1986), and on other reasoning tasks, such as conditional arguments (Fillenbaum, 1978; Thompson, 1994), paraphrasing (Fillenbaum, 1975, 1976; Thompson and Mann, 1995) and equivalence judgments (Fillenbaum, 1976).

Numerous proposals have been put forth to explain the indicative–deontic distinction. The first is pragmatic reasoning schema theory (Cheng and Holyoak, 1985, 1989; Cheng, Holyoak, Nisbett and Oliver, 1986). According to this theory, adults excel at deontic reasoning because deontic concepts

% p and not-q choices	(c) *Deontic Content Rules*
88%	If a letter is sealed, then it has a 50 lire stamp on it. (Johnson-Laird, Legrenzi and Legrenzi, 1972)
75–96%	If a person is drinking beer, then the person must be over 19. (Cox and Griggs, 1982, Exps 1–3)
72%	If a person is drinking beer, then the person must be over 19. (Griggs and Cox, 1982, Exp. 3)
70%	If a person is drinking beer, then the person must be over 19. (Griggs and Cox, 1983, Exp. 1)
50%	If a student studies philosophy, then he is at Cambridge. Embedded in scenario involving eligibility for grant support (van Duyne, 1974)
58%	Every student who studies physics is at Oxford. Embedded in scenario involving eligibility for grant support (van Duyne, 1974)
85%	If a purchase exceeds $30, then the receipt must have the signature of the departmentstore manager on the back. (Griggs and Cox, 1983, Exp. 1)
90%	If an envelope is sealed, then it must have a 20 cent stamp. (Cheng and Holyoak, 1985, Exp. 1) (When presented with accompanying permission rationale.)
90%	If a passenger's form says 'Entering' on one side, then the other side must include 'cholera' (Cheng and Holyoak, 1985, Exp. 1) (When presented with accompanying permission rationale.)
61%	If one is to take action A, then one must first satisfy precondition P (Cheng and Holyoak, 1985, Exp. 2)
75%	If a man eats cassava root, then he must have tattoo on his face. (Cosmides, 1989, Exp.
89%	If someone stays overnight in the cabin, then that person must bring along a bundle of wood from the valley. (Gigerenzer and Hug, 1992, Exp. 2)
63%	If you tidy your room, then I will let you go out to play. (Manktelow and Over, 1991, Exp. 2)
42%	If the purchases exceed 10,000 francs, then the salesman must stick on the back of the receipt a voucher gift for a gold bracelet. (Plitzer and Nguyen-Xuan, 1992, Exp. 1)

Figure 1 (c).

constitute classes of frequently-encountered situations for which collections of domain-specific, goal-orientated rules are induced. One such schema, the permission schema, details the relationship between actions and preconditions, such as 'If the precondition is satisfied, then the action may be taken.' A second theoretical explanation is social exchange theory, which analyzes deontic reasoning in terms of cost/benefit analysis and cheater detection (Cosmides, 1989; Cosmides and Tooby, 1994). These strategies are proposed to be innate, having been selected for during the evolution of our species in order to reason effectively about social exchange (cooperative action for mutual benefit). A third theory explains the deontic effect in terms of the construction and manipulation of models based on subjective utility (Manktelow and Over, 1991, 1995). Finally, a fourth theory models performance on the selection task in terms of optimal data selection using decision theory

(Oaksford and Chater, 1994). In the indicative case, reasoners choose to inspect instances that are expected to yield the most information about which of two competing hypotheses are true (i.e. 'if p is true, then q must be true as well' or 'p and q are independent'). According to this model, the expected information gain for the q card is greater than the expected information gain for the not-q card. In the deontic case, on the other hand, reasoners choose instances with an eye toward maximizing expected utility. In this case, a violation-detection strategy maximizes the expected utility function. The indicative–deontic distinction therefore indicates that human reasoning is optimally adapted to the environment, or domain, to which it is applied.

Despite the very considerable differences among these theoretical explanations, they all have two things in common. The first is that human reasoning strategies are domain specific; people do not – and ought not to – use the same strategies when reasoning about indicative and deontic contents. The second commonality is *the central role afforded violation detection in deontic reasoning*. There is general agreement among descriptive and normative theorists that a crucial part of reasoning deontically is appreciating the necessity of detecting violations of deontic rules. For example, in the case of permissions, one must ensure that no one has taken a specified action unless specified preconditions have been satisfied (e.g. 'If you want to take a book out of the library <permitted action>, you must have a valid library card <condition>'.) In the case of obligations, one must ensure that no one has avoided doing what is obligated under the specified circumstances (e.g. 'If you lost a library book <condition>, you must pay $25 in fines <obligatory action>.') In the case of prohibitions, one must ensure that no one has done something forbidden (e.g. 'No one may slide down the slide backwards.')

In contrast, what constitutes optimal performance on indicative reasoning tasks (where reasoners are asked to test the truth of a rule) is the subject of some controversy. Traditionally, violation detection played a central role in normative theories of indicative reasoning because observing a violation of an indicative rule (hypothesis) disproves the rule (e.g. finding a white raven disproves the rule 'all ravens are black') and hence provides incontrovertible proof of the rule's truth content (Popper, 1959). Seeking confirming evidence, the typical strategy employed by adults on indicative reasoning tasks, was considered at best a bias in the reasoning process and at worst an error because a confirming instance does not provide incontrovertible evidence about the rule's truth content (Evans, 1989; Wason, 1968). Many contemporary philosophers of science reject this exclusive emphasis on falsification strategies (e.g. Churchland, 1986; Federov, 1972; MacKay, 1992; Putnam, 1974; Quine, 1953), as does the decision-making analysis of card selection performance described above (Oaksford and Chater, 1994).

However one measures the normative value of these strategies, the fact remains that when reasoning about deontic rules, adults spontaneously adopt a violation-detection strategy, and when reasoning about indicative rules, they spontaneously adopt confirmation-seeking strategies. There is agreement among theorists that this distinction is a direct reflection of innate or acquired domain-specificity in the human reasoning process. I will take this claim one step further and argue for the existence of a domain-specific module devoted exclusively to deontic contents.

At the heart of my position lies an evolutionary argument: evolutionary theory is based on the assumption that there is a causal relationship between the adaptive problems a species repeatedly encounters during its evolution and the design of its phenotypic structures. The structure in question here is a functional one—the human reasoning architecture. My position is that the most pressing adaptive problems primates (and probably all other social creatures) faced during their evolution were ones of within-species social coordination and social interaction, producing enormous pressure to develop strategies to solve these problems. The colonial insects solved them by evolving members of different social 'castes', such as queen bees and worker bees. Mammals seem to have solved them by evolving cognitive architectures that enable them to be good social reasoners. In contrast, there was no corresponding pressure to be a good scientific reasoner. In fact, it was not until the evolution of language and the symbolic representation schemes it afforded (e.g. mathematics) that scientific reasoning emerged. From this perspective, social reasoning was primary, and scientific reasoning is a late-emerging capacity.

More specifically, I will argue that a domain-specific deontic reasoning module evolved for the very important purpose of solving problems that frequently arise within a dominance hierarchy—the social structure that characterizes most mammalian and avian species. Remaining within the social group reduces the risk of death due to predation, increases the chances of reproductive success (due to greater access to potential mates and mating opportunities), as well as increasing the viability of survival of the young. Using data from primatological studies, I will argue that remaining and surviving within a dominance hierarchy depends crucially on the capacity to detect and respond appropriately to permissions, obligations, prohibitions, promises, threats and warnings. Failure to do so carries a high risk of inciting agonistic encounters or ostracism. The core component of this domain-specific module is violation-detection: to reason effectively about deontic concepts, it is necessary to recognize what constitutes a violation, respond to it appropriately (which often depends on the respective status of the parties involved), and appreciate the necessity of adopting a violation-detection strategy whenever a deontic situation is encountered.

I will argue that this analysis explains a variety of data, including (a) why people access different strategies when reasoning about deontic and indicative situations, (b) why violation detection is the preferred strategy in deontic tasks, (c) why that preference emerges early in development, and (d) why it is observed regardless of very substantial cultural and educational differences among reasoners. I will also present evidence from neuropsychology suggesting that social reasoning and decision-making is dissociable at the neuropsychological level from other types of intelligent reasoning, thereby producing the 'smoking gun' of phenotypic structures that evolved in response to these hypothesized evolutionary pressures. Finally, I will consider in greater detail alternative explanations for the indicative–deontic distinction including rule-based theories (Braine and O'Brien, 1991; Osherson, 1974, 1975; Rips, 1994), pragmatic schema theory (Cheng and Holyoak, 1985, 1989), social exchange theory (Cosmides, 1989; Cosmides and Tooby, 1994), utility theory (Manktelow and Over, 1991, 1995), and optimal data selection theory (Oaksford and Chater, 1994).

2. *Deontic Reasoning in Non-Human Primates*

Homo sapiens is a primate species whose ancestors diverged within the primate line a scant five million years ago. At a molecular (DNA) level, humans and chimpanzees are only 1% different. Because evolution builds upon existing structures, it seems reasonable to assume that certain characteristics of human reasoning may have roots that reach deep into our evolutionary past, prior to the splitting of hominids within the primate line.

The most striking of these characteristics is that, like human reasoning, the reasoning of non-human primates is subject to content effects. For example, squirrel monkeys and chimpanzees can perform transitive inference on object-oriented tasks only after considerable drilling with paired stimuli (Gillan, 1981; McGonigle and Chalmers, 1977). Yet they readily make transitive inferences while making complex kin and dominance rank discriminations among individuals in their social groups (Dasser, 1985, pp. 16–19; Cheney and Seyfarth, 1990, pp. 91–96). Within their social groups, they also evidence an appreciation of causality and reciprocity that is not apparent in their dealing with physical objects (Cheney, 1978; Datta, 1983a–c; Seyfarth, 1981). So pervasive is this 'social content effect' that the nature of primate intelligence is generally believed to have been shaped by the exigencies of life within the social group (Cheney and Seyfarth, 1985, 1988, 1990; Humphrey, 1976; Jolly, 1966; Whiten and Byrne, 1988a). As Cheney and Seyfarth (1985, p. 39) put it, 'among primates, evolution has acted with particular force in the social domain'.

So what exactly are the exigencies of life within non-human primate social groups? Their social interactions are characterized by (a) dominance relations and (b) coalition and alliance formation. In fact, non-human primates have been described as consummate tacticians, with much of this tactical reasoning aimed at jockeying for position within the dominance hierarchy (e.g. Whiten and Byrne, 1988a, 1988b; Harcourt and de Waal, 1992).

In functional terms, a dominance hierarchy is simply the statistical observation that 'particular individuals in social groups have regular priority of access to resources . . . in competitive situations' (Clutton-Brock and Harvey, 1976, p. 215). In its most developed form, it is transitive, meaning that if A has priority over B, and B has priority over C, then A has priority over C, and so on. The role of dominance is most pronounced in situations characterized by high levels of competition for resources, such as high population density or the onset of breeding season (Clutton-Brock and Harvey, 1976). Contrary to folk wisdom, dominance ranking is not correlated with size. Instead, one's rank in the hierarchy depends crucially on the ability to form and maintain strong alliances, the *sine qua non* of social skills (Harcourt, 1988; Harcourt and DeWaal, 1992; Packer, 1977; Seyfarth and Cheney, 1984; Smuts, 1985). There is therefore a direct relation between social reasoning skill and the ability to dominate resources and hence increase chances of survival.

The social reasoning that is required to secure and maintain a high-ranking place within the dominance hierarchy is shot through with deontic concepts. Consider first the concepts of permission and prohibition. Those who currently dominate resources determine who may engage in which activities when, and they punish transgressors. For example, dominant males monopolize reproduction opportunities by aggressing against females and subordinate males who are caught socializing or consorting. De Waal (1982) describes a dominant male whose peculiar means of punishing errant females involved jumping up and down on them. Because of the high risks involved in such forbidden liaisons, females and subordinate males often engage in deception, such as concealing their trysts and suppressing their copulation cries; subordinate males also hide their erections behind their hands when their courtships are interrupted by dominant males (Kummer, 1988; de Waal, 1988). Deceptions of this kind have also been observed for hiding other forbidden behaviours, such as stealing food, failing to share food, or grooming forbidden individuals (for numerous examples, see Byrne and Whiten, 1988; Whiten and Byrne, 1988b). For example, one baboon spent twenty minutes inching behind a rock so that a dominant male could not see her grooming a subordinate male.

In order to avoid agonistic encounters, it is therefore crucial to reason effectively about what is *permitted* and what is *forbidden*. This requires, at the very least, the capacity to classify instances into these two categories (e.g. 'won't elicit aggression' and 'will elicit aggression', respectively), and to respond appropriately (e.g. 'indulge in the activity, if I so desire' and 'refrain from engaging in the activity, regardless of my desires', respectively).

Discriminating between these classes does not necessarily require engaging in some activity first and then suffering the consequences; the individual can instead attend to the *warning* or *threat* signals communicated by another group member. These signals are typically uttered when another individual is attempting to do something forbidden, and they are typically heeded. Male vervet monkeys, for example, utter threat grunts at rivals who attempt to copulate with estrus females (Cheney and Seyfarth, 1990, p. 227). Male silverback gorillas sometimes utter warning or threat cough-grunts to juveniles who play too boisterously near them or who come too close to the human observer (Cheney and Seyfarth, 1990, p. 227). These threat signals, therefore, serve to communicate a prohibition, and avoiding an agonistic encounter requires the capacity to recognize the prohibition and refrain from engaging in the forbidden activity.

Life within existing dominance hierarchies, therefore, requires detecting and responding appropriately to permissions, prohibitions, and warnings. Lower-ranking individuals attempt to engage in forbidden activities in order to secure a larger share of resources, and higher-ranking individuals defend their privileged access to resources by detecting and punishing acts of cheating. This is the essence of permission and prohibition structures: those in positions of authority (or dominance) determine who may engage in which activities when, and threaten or punish transgressors.

It is in the interest of subordinates, on the other hand, to broaden their access to available resources. In other words, it is in their interest to move up in rank. For example, among male primates, rank within the dominance hierarchy is acquired and maintained through dyadic aggression, and alliances determine the fate of outranked individuals, including alpha males whose rank is usurped (Chapais, 1988, 1992; Datta, 1983a–b; Goodall, 1986; Harcourt and Stewart, 1987; Harcourt and de Waal, 1992; Riss and Goodall, 1977; Uehara, Hiraiwa-Hasegawa, Hosaka and Hamai, 1994). Alpha males who form or already possess strong alliances with other males maintain a relatively high, stable position within the group, while those who have no alliances or weak alliances are ostracized, maintaining a solitary existence outside the group (Goodall, 1986; Riss and Goodall, 1977; Uehara, Hiraiwa-Hasegawa, Hosaka and Hamai, 1994; de Waal, 1982).

Alliances are therefore crucial to survival within primate troupes, and, importantly, alliances are formed and maintained on the basis of reciprocal *obligations*. Cheney and Seyfarth have reported that vervet monkeys are more likely to respond to calls from non-kin during agonistic encounters if the caller has groomed them recently; they also form the strongest alliances with individuals who groom them most often (Cheney and Seyfarth, 1990, pp. 67–69; Seyfarth, 1976; Seyfarth and Cheney, 1984). Reciprocal obligations, therefore, have the structure of a *promise* as in 'If you groom me, I'll support you in a fight.' A promise constitutes a commitment on the part of the promiser that becomes an obligation once the promisee has satisfied the conditions of the commitment (e.g. 'You've groomed me, so now I must support you in your fight'), and a permission from the viewpoint of the promisee to engage in some activity (e.g. 'I may engage in this fight because you will support me in return for my grooming.') (Politzer and Nguyen-Xuan, 1992)

This appreciation of obligation structures is also imbued with a 'machiavellian' sophistication: individuals prefer to groom and to assist individuals of higher rank than themselves. This preference presumably is due to the fact that support from higher-ranking individuals during agonistic encounters has greater effect than support from lower-ranking individuals. For example baboons, macaques, and vervet monkeys form matrilineal hierarchies in which any female is dominant to all the females that are subordinate to her mother, and she is subordinate to all the females that are dominant to her mother (Chapais, 1992; Cheney and Seyfarth, 1990; Prud'Homme and Chapais, 1993). During agonistic encounters, support is typically given to the higher-ranking females who in turn intervene in conflicts when they themselves are dominant to the target of the aggression. By aiding higher-ranking females, lower-ranking females form strong alliances based on reciprocal obligations that enable them to move up in rank.

If changing rank crucially depends on reciprocity, then effective reasoning about obligations requires that violations of reciprocity yield negative consequences for the cheater. There is some evidence that alliances among some species of non-human primates are indeed of a transactional nature, with both parties monitoring the contribution of the other and discontinuing the collaboration if too large an imbalance is detected. De Waal (1992) reported observing a subordinate male terminate his long-term alliance with an alpha male in response to the alpha male's increasingly frequent refusals to support him in contests with another male over access to oestrus females. Similarly, male *Papio anubis* baboons who refuse to assist other males in abducting females are less likely to receive aid than males who do (Alcock, 1984, p. 486). Woodruff and Premack (1979) reported that chimpanzees misinform or fail to inform individuals about the location of food if the individual failed to share food with them in the past.

Primate field studies, therefore, suggest that the capacity to detect and respond appropriately to a variety of deontic structures and their violations plays a crucial role in determining an individual's fate within primate social groups. Failure to adhere to these implicit prescriptive rules leads to banishment from the social group, a situation that can have disastrous consequences for survival. Failure to detect violations can result in encroachments on one's domination of resources. Clearly, if our reasoning architecture evolved in response to the need to reason effectively about adaptively crucial problems, and survival depends crucially on staying within the social group, then few problems carry greater survival consequences among social species than those involving deontic contents. This strongly suggests that deontic reasoning strategies—or their precursors—are part of our primate genetic heritage, and that violation detection is the most crucial of these strategies.

3. *The Indicative–Deontic Distinction Emerges Early in Human Development*

Evidence that the indicative–deontic distinction constitutes a fundamental division in the human reasoning architecture comes from a variety of sources. The first and most incontrovertible evidence comes from my own laboratory (Cummins, in press). I have found evidence of this distinction in the reasoning performance of children as young as three years of age. The procedure involves a story about a group of toy mice, some of whom are inside a house and some of whom are in the backyard. Although the mice are visually identical, some of them can squeak and some of them can't. The only way to tell the mice apart is to squeeze them. The drama in the story comes from the fact that a neighbourhood cat chases the mice whenever he hears anyone squeaking. For this reason, it is not safe for the squeaky mice to be outside. In the indicative condition, Minnie Mouse tells the children that 'It's not safe outside for the squeaky mouse, so all squeaky mice *are* in the house'. They are then asked which mice must be tested to see whether Minnie is wrong, those that are in the house or those that are outside. In the deontic condition, Queen Minnie Mouse tells them that 'It's not safe outside for the squeaky mice, so all squeaky mice *must stay* in the house'. The child is then asked which mice must be tested to ensure that no one disobeys the Queen, those that are in the house or those that are outside. Notice that in both cases, the squeaky mice are in danger when outside. The only difference is whether the child is testing a hypothesis (i.e. Is Minnie Mouse wrong?) or ensuring that a deontic rule has not been broken (i.e. Did anyone disobey the Queen?).

Across two experiments, 82% of four-year-olds and 64% of three-year-olds in the deontic case chose to inspect the potentially violating case, that is, those in the 'backyard'. In contrast, only 32% of four-year-olds and 35% of three-year-olds made that selection in the indicative case. The magnitude of this difference is comparable to that observed in the adult reasoning literature (see Figure 1). These results show quite clearly that even very young children adopt of violation-detection strategy when reasoning about deontic rules, and a confirmation-seeking strategy when reasoning about indicative rules. Moreover, using a procedure similar to this with six- to nine-years-olds, Girotto and his colleagues have demonstrated that the indicative–deontic distinction cannot be reduced to greater familiarity with individual rules (Girotto, Gilly, Blaye and Light, 1989; Girotto, Light and Colbourn, 1988; Light, Blaye, Gilly and Girotto, 1989; Light, Girotto and Legrenzi, 1990). This distinction seems to emerge quite early in development, and persists throughout adulthood. It is, it seems, a very fundamental cognitive distinction, and suggests the evocation of domain-specific reasoning strategies.

Recent work by Harris and Nuñez (in press) suggests that children not only distinguish between indicative and deontic rules, but that they genuinely understand deontic rules better than they do indicative rules. Their task consisted of stories containing a rule in conditional form (that is, 'if p, then q'), and four pictures that corresponded to each possible combination of p and not-p with q and not-q (Experiment 4). In the deontic task, the rule was a permission, such as 'If you play outside, you must wear a coat.' The pictures depicted e.g. a child playing outside wearing a coat (p and q), a child playing indoors wearing a coat (not-p and q), a child playing indoors without a coat (not-p and not-q), and a child playing outdoors without a coat (p and not-q). The child's task was to point to the picture showing the story character 'being naughty and not doing what he or she is supposed to do'. In the indicative task, the rule was an hypothesis, such as 'If Sally plays outside, she always wears a coat.' The pictures were the same, and the child's task was to point to the picture that showed the story character 'doing something different and not doing what she said'. Notice that this task does not fall prey to the normative reasoning controversy cited above because it simply measures one's capacity to recognize rule violations, regardless of what one believes about the necessity of seeking out such violations to test the rules.

Harris and Nuñez found that three- and four-year-old children were better at identifying the instances that violated the permission rule than the indicative rule. Moreover, they tended to justify their choices on the permission task by referring to the fact that the protagonist had not met the condition specified as necessary for taking the action. In contrast, they typically gave irrelevant justifications ('It's just that one') or were unable to justify their choices on the indicative task. This suggests that they grasped the full meaning of the permission rules better than they did the indicative rules.

Perhaps the reason young humans show such precociousness for deontic structures is because, like non-human primates, their social interactions appear to be governed by dominance hierarchies which determine who is permitted to play with whom where and with which toys. Transitive dominance hierarchies are evident in the interactions of children as young as three, and can be reliably reported verbally by four-year-olds, meaning that children as young as three can perform the transitive inferences that are necessary to work out transitive dominance relations (Smith, 1988). Yet, this skill does not transfer readily to non-social stimuli. Like non-human primates, they can perform object-based transitive reasoning only if they are extensively drilled on the object pairs upon which the inference is to be performed (Bryant and Trabasso, 1971). Truly content-free transitive reasoning does not reliably appear until six years of age (Smith, 1998, pp. 103–4).

Evidence of certain aspects of deontic reasoning is also apparent in the social interactions of very young children. Within the first year of life, infants participate in turn-taking games with adults, suggesting an appreciation of the *reciprocal* nature of certain social interactions (Vandell and Wilson, 1987). Reference to social rules appear in children's justifications of their own behaviour as early as 24 months of age (Dunn, 1988). And by the age of three, children are selective in their distribution of altruistic acts, preferring to aid those who have aided them in the past (Smith, 1988).

To summarize, the indicative–deontic distinction emerges early in human development and colours the reasoning process throughout adulthood. Regardless of their age, reasoners tend to adopt a violation-detection strategy when reasoning about deontic rules, and a confirmation-seeking strategy when reasoning about the epistemic status of indicative rules. This strongly suggests a fundamental, primitive distinction in our cognitive architecture. Furthermore, the structure of deontic situations is more easily grasped by young children than is the structure of indicative rules. The ease and speed with which young children learn about, detect, understand, and reason about deontic situations is most consistent with the existence of an innate domain-specific reasoning module that is evoked when a situation with deontic content is encountered.

4. *The Indicative-Deontic Distinction in Cross-Cultural Studies of Reasoning*

If the indicative–deontic distinction reflects a fundamental division in our reasoning architecture, then it should be observed universally, that is, regardless of culture. Because folk societies are relatively isolated from modern industrialization and its education systems, they presumably provide a more accurate picture of the types of reasoning strategies that characterized our hunter-gatherer forebears. To my knowledge, no one has looked for content effects in preliterate cultures. Nonetheless, there is indirect evidence of the indicative–deontic distinction in the reasoning of members of such societies.

Indicative reasoning typically has been investigated in folk societies by using classical syllogisms. An example cited by Scribner (1975, p. 155) on syllogistic reasoning among the Kpelle of West Africa illustrates in high relief the usual result observed in these studies:

> E: All Kpelle men are rice farmers. Mr Smith (this is a Western name) is not a rice farmer. Is he a Kpelle man?
> S: I don't know the man in person. I have not laid eyes on the man himself.
> E: Just think about the statement.
> S: If I know him in person, I can answer that question, but since I do not know him in person I cannot answer that question.
> E: Try and answer from your Kpelle sense.
> S: If you know a person, if a question comes up about him, you are able to answer. But if you do not know a person, if a question comes up about him, it's hard for you to answer it.'

As this excerpt shows, the reasoner does not seem to grasp the fact that the dilemma can be resolved via reasoning. Instead, he is concerned with retrieving and verifying facts, a strategy that does not fare well in this type of task. In fact, the reasoner's responses seem to suggest that he believes he is trying to explain something very simple to an experimenter who is a complete dunce.

A very different picture emerges, however, when members of preliterate cultures are asked to reason about moral dilemmas, problems with clear deontic contents. Comparison of studies from eight different traditional folk societies showed that 100% of the samples reported reasoning that was dominated by concern with maintaining social equilibrium and social harmony through the adherence to social regulations (Snarey, 1985). Like the societies of non-human primates, social accord in such societies is maintained through what Pope Edwards described as 'cooperation and reciprocal obligations within a hierarchical structure of authority relationships' (Pope Edwards, 1982, p. 276). In other words, a dominance hierarchy.

One oft-cited study by Harkness, Pope Edwards and Super (1981) on rural

Kenyans (Kipsigis community) makes this clear. The reasoning of six traditional leaders on several moral dilemma reasoning tasks showed three consistent results. First, in contrast to content-free reasoning, deontic reasoning is remarkably sophisticated. For example, contrast the following protocol with the one reported above. The dilemma was whether a boy should obey his father and give him money he had earned when the father had promised the boy he could keep it for himself (Harkness, Pope Edwards and Super, 1981, pp. 595–6):

> A child has to give you what you ask for just in the same way as when he asks for anything you give it to him. Why then should he be selfish with what he has? A parent loves his child and maybe [the son] refused without knowing the need of helping his father ... By showing respect to one another, friendship between us is assured and as a result this will increase the prosperity of our family.

Unlike the syllogism protocol, the reasoner does not complain that he does not know the people in question, and he does not attempt to solve the dilemma through fact retrieval. Instead, this protocol reflects a wealth of deontic concepts, particularly reciprocal obligation. Reciprocity was in fact a recurring theme in many of the observed protocols, although, interestingly, not in terms of a strict accounting of benefits given or received. These men believed that when an item was given in good faith, the receiver was honour-bound to return the favour in the future. (In fact, so strong and pervasive is this belief and so freely are goods given away that western missionaries often mistakenly concluded that members of the pre-literate cultures had no concept of private property.) This type of reciprocity is evidence of sensitivity to obligation structures—one is obligated to return the help given one in time of need.

Second, the dominance hierarchy that pervades social interactions and social reasoning in non-human primate societies and children's social groups had its counterpart here in that all six men settled dilemmas in favour of the person with higher rank or status.

Third, a recurring issue in these protocols is the treatment of those who break social rules. The traditional Kipsigis response was banishment, that is, *exclusion from future social interactions and social contracts.* Clearly, the capacity to detect violations of deontic rules looms large in folk societies, where the fate of each individual depends crucially on the cooperative acceptance of social norms.

To summarize, cross-cultural studies of human reasoning show a clear distinction between indicative reasoning and deontic reasoning. In contrast to the sparse (or absent) reasoning strategies evoked by indicative reasoning tasks, deontic reasoning tasks evoke strategies that are sophisticated and conceptually rich. Moreover, the strategy of choice in deontic situations was violation-detection. Clearly, the evocation of violation-detection reasoning strategies in response to deontic rules does not depend on a reasoner's culture nor on the level of education achieved. Just as clearly, two recurring themes in these reasoning protocols are authority (dominance) and reciprocal obligations. This is particularly crucial to my position because the structure of these societies (particularly hunter-gatherer societies) and the survival pressures their members face provide a glimpse into our own evolutionary past. The need to reason effectively about authority/dominance structures and reciprocal obligations looms exceedingly large in these communities. Failure to adhere to permission and obligation structures leads to banishment from the social group, a situation that can have disastrous consequences for survival. Clearly, if our reasoning architecture evolved in response to the need to reason effectively about adaptively crucial problems, and survival depends crucially on staying within the social group, then few problems carry greater survival consequences in hunter-gatherer societies than those involving deontic contents.

5. The Neurological Dissociability of Indicative and Deontic Reasoning

Prefrontal lobe syndrome is a pattern of impaired reasoning performance that results from bilateral damage to the ventromedial prefrontal cortical lobes (Damasio, 1994). This syndrome is characterized by an impaired capacity to reason effectively about socio/emotional stimuli while leaving other types of intelligent reasoning virtually untouched. Damasio (1994) reported the case of a successful, middle-aged businessman who suffered bilateral damage to the prefrontal cortex as a result of a benign tumour. After surgery to remove the tumour, the patient regained all of his previous intellectual capacities, yet went on to make disastrous personal and financial decisions which resulted in two divorces and a bankruptcy. Closer inspection of his reasoning capacities in the laboratory revealed a selective impairment socio-emotional reasoning.

Ablation studies in monkeys provide even more striking evidence of specific social reasoning impairments (Damasio, 1994, pp. 74–5). Monkeys with bilateral prefrontal ablations (both ventromedial and dorsolateral) do not maintain normal social relations within their troops despite the fact that nothing in their physical appearance has changed. They show diminished self-grooming and reciprocal grooming behaviour, greatly reduced affective interactions with others, diminished facial expressions and vocalizations, and sexual indifference. They can no longer relate properly to others in their troop and others cannot relate to them. As a result, and this is crucial to my position, they can no longer operate effectively within their social dominance hierarchies, or as Damasio puts it (p. 75):

> It is fair to assume that monkeys with prefrontal damage can no longer follow the complex social conventions characteristic of the

> organization of a monkey troop (hierarchical relations of its different members, dominance of certain females and males over other members, and so on.)

Damage to other sections of the cortex—even those resulting in paralysis—do not impair these social skills.

Prefrontal syndrome is the 'smoking gun' in my collection of evidence since it constitutes definitive evidence that social reasoning can be selectively dissociated from other types of reasoning at the neurological level, and that damage to these areas impacts most severely on the capacity to respond effectively to the social rules that underlie the dominance hierarchy.

Before leaving this section, I would like to contrast prefrontal syndrome with another neurological syndrome in order to make an important point. Autism is a neurodevelopmental syndrome whose most vivid impact at the cognitive level is an impaired ability to reason about the mental states of others (see Baron-Cohen, Tager-Flusberg and Cohen, 1993). As one autistic adult put it 'Other people seem to have a special sense by which they can read other people's thoughts' (Frith, Morton and Leslie, 1991, p. 436)—a description that bears an uncanny resemblance to Krebs and Dawkins' (1984) notion of 'mind-reading', that is, the capacity to forecast the behaviour of others. In autism, this 'mind blindness' (Baron-Cohen, 1995) makes it extremely difficult (if not impossible in some cases) to engage in normal reciprocal social interactions. Moreover, autistic individuals typically fail reasoning tasks that require them to reason effectively about others' beliefs (Frith et al., 1991). This suggests that 'theory of mind' reasoning is neurologically distinct from other types of reasoning.

'Theory of mind' reasoning, however, should not be confused with deontic reasoning. Theoretically, the capacity to engage in deontic reasoning does not presuppose a capacity to represent or reason about others' mental states. Put simply, it is conceivable that one can appreciate which actions are permitted or forbidden in which circumstances without also appreciating the motivation or mental states of the individual making the rules. For example, even three-year-olds reason about deontic rules in the same way adults do (Cummins, in press; Harris and Nuñez, in press), but a developmental change in performance occurs between three and four years of age in terms of the effectiveness with which children can reason about others' beliefs (Baron-Cohen, Leslie and Frith, 1985; Wimmer and Perner, 1983). This suggests that the capacity to engage in deontic reasoning may emerge earlier (and perhaps be a more fundamental distinction in mammalian reasoning architectures) than the capacity to reason effectively about the belief states of others.

6. Alternative Explanations of the Indicative–Deontic Distinction

The indicative–deontic distinction in human reasoning performance is a real distinction that emerges early in human development, persists into adulthood, is observed among members of pre-literate societies, and has its counterpart in the reasoning of non-human primates. When reasoning about deontic rules, reasoners tend to adopt a violation-detection strategy, a strategy that they do not adopt when reasoning about the epistemic status of indicative rules. I have argued that the pervasiveness and robustness of this effect is due to the evocation of innate deontic reasoning modules that evolved to enable social species to construct and exploit the deontic structures inherent in the dominance hierarchy—the social structure that determines overall survival and reproductive success. Furthermore, I have shown that damage to particular areas of the brain selectively impairs the capacity to engage in social reasoning, particularly reasoning about the dominance hierarchy.

In contrast to this view, four distinct points of view have been advanced to explain content effects in general and the indicative–deontic distinction in particular. The first, championed by Braine and O'Brien, Rips, and Osherson, is that human reasoning is based on the activation of syntax-sensitive rules, and content effects such as these reflect the operation of factors outside the rule base itself (Braine, 1978; Braine and O'Brien, 1991; Braine, Reiser and Rumain, 1984; Rumain, Connell and Braine, 1983; Osherson, 1974, 1975; Rips, 1983, 1994). The major difficulty with this view is the robust and pervasive effect of content on human reasoning performance. In order to account for observed performance patterns, major proponents of these views have taken to incorporating content-sensitive parameters (Braine and O'Brien, 1991) or modal operators (Rips, 1983, 1994) into their reasoning systems. But this essentially concedes the point that the human reasoning architecture must consist of something more than syntax-sensitive rules if the robustness and pervasiveness of content effects are to be explained.

The second view, proposed by Cheng, Holyoak and their colleagues, is that humans reason by activating domain-specific bodies of rules, called schemas, which are acquired during the lifetime of the individual through general inductive mechanisms (Cheng and Holyoak, 1985, 1989; Cheng, Holyoak, Nisbett and Oliver, 1986). Content effects like these are therefore a natural reflection of the types of schemas so induced. According to the schema theory, people adopt different strategies when reasoning about the 'travel' problem example and the 'transportation law' problem described above because the latter is a permission, a type of social problem for which most people have induced a particular schema. What we understand about permission situations is codified in a schema consisting of four rules, illustrated in Figure 2(a). A schema has also been proposed for obligations, and is illustrated in Figure 2(b).

One objection to Cheng and Holyoak's pragmatic schema view as it is currently stated is that its strictly empiricist stance does not sort well with the early emergence of deontic reasoning during childhood relative to other types of reasoning and the evidence of neurological substrates devoted to this type of social reasoning. Observing reasoning effects among three-year-olds that are as large as those cited above is generally taken as evidence in

(a)

Permission Schema proposed by Cheng and Holyoak (1985, p. 397)

Rule 1: If the action is to be taken, then the precondition must be satisfied.
Rule 2: If the action is NOT to be taken, then the precondition need NOT be satisfied.
Rule 3: If the precondition is satisfied, then the action may be taken.
Rule 4: If the precondition is NOT satisfied, then the action must NOT be taken.

(b)

Obligation Schema proposed by Cheng, Holyoak, Nisbett, and Oliver (1986, pp. 325–326)

Rule 1: If initial situation I occurs, then C must be done.
Rule 2: If situation I does NOT occur, C need NOT be done.
Rule 3: If C is done, then it does NOT matter whether I occurred; the obligation cannot be violated in this case.
Rule 4: If C has NOT been done, then I must NOT have occurred.

Note: In each schema, Rules 1 and 4 describe situations in which a violation of the regulation is possible.

Figure 2 Permission (a) and obligation (b) reasoning schemes proposed by Cheng and her colleagues

the developmental literature of innate predispositions to interpret certain stimuli in particular ways. For example, the ease with which children in this age-group exploit ontological categories in order to discipline their inductive generalizations is taken as evidence of innate or early emerging knowledge concerning these categories (e.g. Carey, 1985; Gelman and Markman, 1985, 1986). PRS would sort better with the data if it were couched in terms of an innate or early emerging predisposition (or 'preparedness'; Seligman, 1970) to attend to the structure of deontic situations.

The same objection can be raised concerning the third view, proposed by Manktelow and Over (1990, 1991, 1995), which attributes the preference for violation-detecting strategies on problems with deontic contents to the construction of mental models based on social roles and subjective utility. They argue that deontic reasoning is psychologically distinct from indicative reasoning. In the former, one is concerned about what one may or must do, and hence one's reasoning is focused on evaluating the subjective utility of the possible outcomes of one's actions. In the latter case, one is concerned primarily with a factual state of affairs, and hence one's reasoning is focused on evaluating the truth of sentences describing these states. Their objection to Cheng's schema view is that it provides no way of assessing utilities of possible actions, and no way of capturing the fact that subjective utilities differ depending on which perspective one adopts during reasoning. For example, consider the rule 'If you tidy your room, then you may go outside to play.' A child would place greater utility on going outside to play rather than being kept in, and hence his or her reasoning would focus on these possible outcomes when determining whether to take the action of tidying the room. The parent uttering the statement, on the other hand, places greater utility on having tidy rooms than untidy rooms, and hence would focus on these outcomes when determining whether or not to allow the child to go outside to play. The authors report a series of experiments in which deontic reasoning performance on the Wason card selection task varied as a function of perspective taken and the subjective utility assigned to possible outcomes (Manktelow and Over, 1991).

Unlike the general induction view offered by Cheng and Holyoak, Manktelow and Over's analysis of denotic reasoning clearly indicates that deontic reasoning is distinct from other types of reasoning. It is neutral, however, with respect to the innateness argument. Presumably, one places greater utility on actions that enhance one's survival than on those that jeopardize it whether these actions are learned (e.g. 'don't drink the water') or innate (e.g., 'fight or flee'). If I am right that deontic reasoning strategies are innate, then their analysis constitutes a possible description of the components of these innate strategies. As such, their view is not a competitor for the view offered here as much as a proposal concerning the components (subjective utility) and strategies (maximizing subjective utility) a deontic reasoning module might contain.

The same could be said of the rational analysis offered by Oaksford and Chater (1994). These authors offer an elegant analysis of performance on the indicative and deontic versions of the card selection task based on information theory (Shannon and Weaver, 1949; Wiener, 1948), Bayesian decision-making, and subjective utility. Indicative rule-testing is modelled as hypothesis-testing under conditions of uncertainty where the reasoner chooses experiments based on the amount of information that the experiment is expected to provide. Rational decision-making is defined as choosing to conduct experiments (card-turnings on the selection task) that are expected to lead to the greatest reduction in uncertainty (greatest information gain) concerning which of two hypotheses is true (i.e., 'if p is true, then q must be true as well' or 'p and q are independent'.) When it can be assumed that the incidences of p and q are low in the sample space, then the ordering of information gain for each of the four standard cards in the selection task is p > q > not-q > not-p, explaining why reasoners prefer to turn over the q card rather than the not-q card. As the probabilities associated with the incidences of p and q increase, so does the information value associated with selecting the not-q card. In contrast, selection performance on deontic versions of the selection task is explained using the same probabilistic model coupled with the assignment of different subjective utilities to each card depending on the viewpoint that is adopted during reasoning. Rational decision-making is defined in this case as selecting cards that maximize expected utility. This has the effect of producing a violation-detection strategy because the model predicts that violating instances have the greatest expected utility. Domain-dependent changes in selection performance therefore result from domain-specific knowledge that influences the parameters in the model. This analysis constitutes a proposal of how domain-specific strategies are instantiated in our reasoning architecture, or, to put it more simply, what might be 'inside' the deontic-reasoning module.

The fifth view, proposed by Cosmides and Tooby, attributes the deontic effect to the activation of innate reasoning algorithms, algorithms that were shaped by evolutionary forces in order to facilitate reasoning about *social exchange* (Cosmides, 1989; Cosmides and Tooby, 1989, 1992, 1994). They define social exchange as a species of reciprocal altruism, that is, the cooperation of two or more individuals for mutual benefit. Using this definition, social exchange is a subset of deontic situations, concerning those situations that involve reciprocal obligations. Cosmides and Tooby argue that the need for engaging in exchange of goods and services loomed large among our Pleistocene hunter-gatherer ancestors. Crucial to this theory is the notion of cheater detection. Modelling research based on game theory has repeatedly shown that reciprocal altruism can emerge as an evolutionarily stable strategy only if the participants are capable of recognizing individuals so that those who cheat may be excluded from future transactions (Axelrod, 1984; Axelrod and Hamilton, 1981; Maynard Smith, 1982; Trivers, 1971). They define cheating as taking a benefit without paying a cost. According to social exchange theory, people typically fail hypothesis testing problems (such as the 'travel' problem above) and solve denotic problems (such as the 'transportation law' problem) because the latter trigger a cheater detection strategy while the former do not.

There are two difficulties with this view. The first is an empirical one, namely that robust deontic content effects can be observed regardless of the cost associated with a particular action. For example, Cheng and Holyoak (1989) report an experiment in which reasoners were presented the rule 'If you go out at night, then you must tie a piece of volcanic rock around your ankle'. A preference for violation-detection was observed with this conditional relative to an indicative conditional regardless of whether the volcanic rock was abundant and free or expensive and difficult to obtain.

The second difficulty is that, as I pointed out in this paper, deontic problems are ones that are faced by any primate species, and indeed, any social species. This strongly suggests that the deontic content effect reaches far more deeply into our evolutionary past than the Pleistocene era, and underlies efficient reasoning about deontic contents other than the reciprocal obligation structure that characterizes the exchange of goods and services. From my perspective, this means that a primitive reasoning module governing simple yet pervasive deontic situations emerged first during mammalian evolution, and constituted the foundation upon which our species' advanced capacity for complex social exchange evolved.

To summarize, theories that describe human reasoning in terms of the activation of syntactically-driven rules do not adequately explain the pervasiveness and robustness of content effects. The strictly empiricist version of pragmatic schema theory proposed by Cheng and Holyoak and the decision-making models proposed by Manktelow and Over and by Oaksford and

Chater do not adequately explain why the structure of deontic situations is so readily understandable to even young children whereas the structure of other, equally familiar situations are not, nor why social reasoning appears to be dissociable at the neurological level. Social exchange theory runs aground on deontic effects that are not readily amenable to cost-benefit analyses. In contrast, the view offered here provides an explanation for each of these observations. The need to construct, maintain, and exploit dominance hierarchies constituted strong pressure favouring the evolution of a cognitive architecture capable of effective deontic reasoning. Because this architecture is part of our genetic heritage, effective deontic reasoning emerges early in development, is readily observed in adult humans regardless of culture, is readily observed among non-human primates, and is part of the social reasoning that is dissociable at the neurological level.

7. *Implications for a Theory of Human Reasoning*

The final question to be addressed is what implication the indicative–deontic distinction has for theories of human reasoning. Content effects in general have been interpreted to mean that the human reasoning architecture is imbued with domain-specific characteristics. The movement toward domain-specificity in the adult reasoning literature is consistent with a burgeoning developmental literature showing innate or early-emerging domain-specific knowledge. During the first year of life, infants evidence an appreciation of the distinction between living and non-living things, an appreciation that is marked by distinct sets of domain-specific knowledge. They appreciate that objects are solid, rigid, permanent entities that cannot move of their own volition, can causally influence each other only through direct contact, and whose movements are continuous in space and time (Baillargeon, 1987; Leslie, 1984; Leslie and Keeble, 1987; Spelke, 1994). In contrast, infants in this same age group access a different set of knowledge concerning social stimuli, knowledge that centers on the intentional and reciprocal nature of social interactions. They become upset when a person stands before them perfectly still, but show no distress when a similarly sized stationary object is placed before them (Tronick, Als, Adamson, Wise and Brazelton, 1978). They engage in reciprocal, turn-taking play with others (Vandell and Wilson, 1987), and respond appropriately to the meaning conveyed by a variety of emotional facial expressions (Campos and Stenberg, 1981). As early as the third year of life, children distinguish between physical and social causation, attributing physical events to energy transmissions between causes and effects, while attributing social events to the enactment of the intentions of the parties involved (Shulz, 1982). They also discipline their inductive generalizations to respect broad ontological category membership, such as the distinction between natural kinds and artifacts, and animate and inanimate objects (Gelman and Markman, 1986, 1987; Carey, 1985; Keil, 1994). The rapidity and ease with which children make distinctions between social and physical stimuli suggests a natural division in the innate nature of the mind, or, to put it in more contemporary terms, the innate structure of the human cognitive architecture.

But does this mean that *all* human reasoning can be attributed to the workings of separate, domain-specific modules? I don't think so. Intelligence researchers have compiled an impressive body of evidence for 'g', or a general intelligence factor that differs among species and among members of any given species. Humans are more intelligent across the board than chimpanzees, and individual humans and chimpanzees differ among themselves in terms of overall intelligence. In short, one could imagine special-purpose modules evolving within a context of greater overall reasoning capacity that resulted from brain expansion and specialization for language. This seems particularly plausible when one considers the enormous reasoning advantages that arose from the evolution of natural language in Homo sapiens, the *sine qua non* of an abstract, symbolic reasoning and communication system. It would be astonishing indeed if the capacity to exploit syntactic features of arguments were not part of the human reasoning architecture.

As an example, consider that children as young as two and a half years of age utter conditional statements to describe hypothetical events in a variety of domains (Bloom, Lahey, Hood, Lifter and Feiss, 1980; Bowerman, 1986; Reilly, 1986). Young children (and adults) also readily draw the Modus Ponens inference, even with relatively content-free conditionals, such as 'If there is an A, then there is a B' (Braine, 1978; Braine, Reiser and Rumain, 1984; Osherson, 1974, 1975; Rumain, Connell and Braine, 1983). This suggests that at least part of our conditional reasoning strategies are driven by purely syntactic considerations. But when the constituent propositions of a conditional utterance express a deontic structure, a specific violation-detection reasoning module is triggered—even among humans as young as three years old. This suggests that the syntactic reasoning process can be overridden (or supplemented) by the evocation of a domain-specific deontic reasoning module wherein one focuses on violation detection, and perhaps subjective utility.

Alternatively, Cosmides and Tooby (1994) recently suggested that human reasoning performance might be governed by a Universal Grammar of social interactions. Detecting cheaters in this grammar is analogous to detecting utterances that are not well formed, an analogy also suggested by Much and Schweder in 1978. The idea is that utterances such as 'I want to help him because whenever I'm in trouble he refuses to help me' are not well formed because they do not describe inferences that members of a social community would judge to be sensible.

It is not clear why Cosmides and Tooby decided to appeal to a formalism that was developed to capture the rules of well-formedness (namely a grammar) when a type of formalism already exists that was developed to capture the rules of reasonable inference (namely a logic). There are perhaps two motivations for this choice. The first is that, since the Chomskian revolution in linguistics, it has become customary to think of language and all its accoutrements as biological in origin, and perhaps this makes it easier to conceive of a grammar-type formalism having evolved as opposed to a logic-like formalism. But there is no a priori reason to believe that evolved reasoning modules cannot consist of rules of inference rather than rules of grammar.

The second motivation stems from an objection explicitly raised by Cosmides and Tooby in relation to content-free, rule-based reasoners. Automated reasoners of this type typically fall prey to the frame problem, that is, they have difficulty determining which information to attend to and which inference paths are fruitful ones to follow. The standard solution is to constrain the reasoning space to a particular domain (e.g. Freuder and Mackworth, 1994). Medical reasoners constrain their inferences only to medical diagnosis, computer system configuration reasoners reason only about system configuration, and geology reasoners reason only about geology. By constraining the types of inputs a reasoner receives and the types of inferences the system can make, the frame problem is greatly reduced.

Which brings us back again to the notion of domain specificity in human reasoning. Given that even rule-based theories have been modified to reflect the fact that certain contents produce robust qualitative shifts in reasoning performance, it is difficult to avoid concluding that there is indeed something domain-specific about significant segments of our reasoning architecture. The robustness of the deontic effect in adult reasoning regardless of culture, its early emergence in human development, and the evolutionary pressure to select for this type of reasoning given the central role played by deontic reasoning problems in primate dominance hierarchies provide a compelling case that at least one of these domain-specific segments is devoted to deontic reasoning.

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