

INSTITUTE FOR EDUCATIONAL RESEARCH
AND POLICY ANALYSIS
618 NORTH PARK
INDIANA UNIVERSITY
BLOOMINGTON, IN 47409-3895 U.S.A.

The Behavioral Ecology of Trust and Cooperation

Bobbi S. Low

**Evolution and Human Behavior Program, and
School of Natural Resources and Environment**

University of Michigan

Ann Arbor, MI 48109-1115

Introduction

Scholars in apparently disparate fields — e.g., economics, biology, political science — are currently converging in interest on the problem of cooperation. Competition among individuals over resources is virtually universal; cooperation among individuals (often in precisely the same context of resource competition) is rarer. The form of the resource is important: whether an individual or group can exclude competing individuals ("private goods," Ostrom and Ostrom 1977; examples in biology are territorially, or the immediate consumption of small patches of resources); or whether the resource constitutes a commons.

Bleak forecasts of over-exploitation due to individually-rational, group-destructive behaviors are common (e.g., Hardin 1968). Yet there are two encouraging trends. First, there is some evidence that evolved selfishness can, perhaps, be harnessed in cooperatively useful ways (Low and Heinen 1993, Heinen and Low 1992). Second, cooperation does exist, and can be a powerful force. Recent work (e.g., Ostrom 1990, Keohane 1984, Taylor and Singleton 1993, Putnam 1993, Martin 1993; see overview by Keohane, Ostrom, and McGinnis 1993) begins to delineate the conditions under which we expect more, rather than less, cooperative behavior in resource acquisition, and the conditions under which we predict longer-term (less discounting, less extractive) strategies of resource use. The problems are still complex, and exist at a variety of levels, from small communities to international. My purpose here is to step back from complex situations, and examine cooperation in non-human species and in pre-industrial human societies, seeking commonalities which perhaps can then be used in teasing apart more complex examples.

A Behavioral Ecological Approach

Despite all our cultural complexity, we humans must solve the same ecological problems as all other organisms in order to survive and reproduce. And make no mistake about it: however complex the interaction between our genes and the external environment, when family lineages die out, they are replaced by other, competing, lineages. Thus, behavioral ecologists often calculate an unfamiliar sort of self-interest: genetic self interest. Further, despite a certain amount of polemic (e.g., Lewontin et al. 1984), the evidence is accumulating that it is appropriate to apply to humans, at least for the purposes of generating hypotheses, the central paradigm in biology: that humans, like other living organisms, have evolved to maximize their genetic contribution to future generations through producing offspring and assisting non-descendant relatives; that the particular strategies accomplishing such maximization will differ in specifiable ways in different environments; and, just as for other mammals, these strategies will typically differ between the sexes. Humans can,

through their extensive elaboration of devices like nepotism and reciprocity, respond in complex and subtle ways; this does not mean that selection is absent.

This paradigm implies that genetic conflicts of interest exist: that individuals strive to increase their own inclusive fitness (Hamilton 1964, Grafen 1991: 9-13), in a finite world, at the expense of non-related individuals. It does not imply that only "genetically determined" mechanisms are available to do so. Genes and environment clearly interact, and no attempt can succeed which either ignores genetic components, or seeks to explain behavior simply as a series of genetically-programmed events. We know^r that members of families are more alike than strangers, and the wealth of twins-raised-apart studies make it clear that many very subtle traits have strong genetic components. But we also know that intrafamilial correlations of traits such as cognitive ability differ among populations, and there are strong sex-by-generation and ethnic group-by-generation interactions (e.g., DeFries et al. 1982). That is, intrafamilial similarities arise both through genetic and environmental (family environment) influences, and are further modified by external (cultural environmental) factors.

Looking at human behavior across times and places means, of course, that it is important to examine the conditions driving behaviors to be similar, and also those which will drive the behaviors to differ. One major difference between humans and other organisms, of course, is the existence of our particular kind of consciousness, allowing complex social responses to varying conditions, frequently through extremely well-developed cultural transmission and technology (cf. Humphrey 1983, Alexander 1990, 1987, Cavalli-Sforza and Feldman 1981, Lumsden and Wilson 1981, Boyd and Richerson 1986, Durham 1991). Humans are also exceptionally long-lived, and several generations may overlap. We live sometimes in population densities extraordinary for a vertebrate. We create and accumulate heritable resources, and we extend the period of our parental effort to a degree not known in any other species; in fact, parental investment does not end, even at death (e.g., inheritance rules and wills; see Smith et al. 1987).

Humans can cooperate through extensively developed reciprocity, including indirect reciprocity; often there are complex sets of group-imposed rules restricting the competition of individuals (Alexander 1987, Boyd and Richerson 1986). Families, and in particular coalitions of related men, may specify and restrict mate choice to a degree unknown in any other organism (Flinn and Low 1986).

Behavioral ecological theory predicts that cooperation will occur under specific conditions: first, among relatives who live together; second, in long-lived social species, capable of recognizing individuals and likely to have repeated interactions. Biologists, as well as social scientists, have profited from the "tit-for-tat" analytic approach (Axelrod and

Hamilton 1981). In non-human species, there is accumulating evidence that only rewarded cooperation is likely to continue (Nowak and Sigmund 1993). Here, too, there is convergence between disciplines: Ostrom's (1990: 91) design principles of long-enduring common-property resource groups (clearly defined boundaries, participation by those affected, graduated sanctions, and the general properties of being usually small-scale and not highly variable in wealth of participants) converge strongly with what behavioral ecologists predict about cooperation, both in non-humans and in pre-industrial societies. But, from the biological perspective, genetic rewards count as well as proximate rewards of energy or status. Thus, we expect more importance to factors that increase reproductive competitive ability (e.g. cooperation in raids for cattle, etc; see Low 1993a).

The Contexts of Cooperation

The general patterns of cooperation in other species and in pre-industrial societies thus include genetic relatedness and long-term reciprocal interactions (facilitated by living in small, non-stratified groups). Male-male cooperative ventures tend to center about "mating effort" — status striving, warfare for women or resources to attract or buy women, etc (Low 1990a). Female-female coalitions tend to be smaller-scale, less volatile, but with lower reward possibilities — more local, parental efforts such as cooperative food gathering. The sexes cooperate in parental care, although the typical pattern is for the division of labor to leave men able to spend more effort on mating, and the acquisition of subsequent wives (e.g. Betzig 1986, Hartung 1982). Thus the differing reproductive return curves (Low 1993b) are important: females pay a *per capita* cost in parental care, while much male effort is directed towards the acquisition of, e.g., status and wealth — which has a high fixed cost, but can be continually "re-used" in mating effort. Men are thus more likely to undertake risky, high-stakes ventures, while women's cooperation is likely to be lower-key.

Over and above these general patterns, some ecological influences seem likely. If, for example, cooperative strategies can function to reduce risk of failure (e.g. food-sharing), then we expect such strategies in environments in which risk of low food is great. Though we still do not expect indiscriminate cooperation, external extremes and uncertainties seem likely to promote some kinds of cooperation. Here, then, I will explore ecological and social correlates of traits that may predispose people to cooperate.

Materials and Methods

The sample comprised the 186 societies of the Standard Cross-Cultural Sample (Murdock and White 1969), which is stratified for geographic distribution and language

group, and for which available ethnographies are by qualified ethnographers resident with the society for a substantial period of time. One difficulty is immediately apparent: what measure shall we use, in comparing ethnographic data, to infer cooperativeness? No published (refereed) codes exist for cooperativeness. Here, I have chosen some previously coded societal traits that should be related to the ability to work cooperatively: the degree to which children are taught to trust, and to be generous and honest with others. The existence of trade implies some complementary heterogeneity of interests that could promote cooperation, and I have used trade as an indicator.

Data were coded from the *Ethnographic Atlas* (Murdock 1967), *Atlas of World Cultures* (Murdock 1981), and Murdock and Wilson (1972) for density, group size, mobility, marital residence, number of subsistence modes and importance of each subsistence type, type of animal husbandry, and type and intensity of agriculture. Murdock and Morrow (1970) produced codes for level of trade, degree to which food is stored, and "food condition" (variation in food availability). The codes for storage and trade were linked to "food condition," but "food condition" had in addition a subjective judgment about food abundance from unspecified environmental sources. Thus, codes reflected conditions such as "no significant storage, food remarkably constant" or "few simple techniques, food relatively constant year to year but varying seasonally." I separated these codes to allow analysis of trade separate from food availability and storage.

Codes for the perceived or reported frequency of warfare, famine, and natural disasters were taken from Ember and Ember (1992). Data for inculcation of children to be trusting, honest, and generous, were taken from Barry et al. (1976). Codes from Whyte (1978) were used for the contribution of women to the subsistence base. Codes for risk of exposure to serious pathogens (diseases and parasites) were taken from Low (1988, 1990b).

Plant productivity and plant community type were coded from *The Times Atlas of the World*, Seventh Edition (1985). Data from *World Weather Records* were coded for temperature (heat extremes, cold extremes) and rainfall extremeness, temperature and rainfall range of variation, and the coefficient of variation of rain, and the predictability, constancy, and contingency of effective rainfall were measured using Low's (1979) modification of Colwell's procedure. Data were coded for the earliest dates and longest period of available information, involving an assumption that the period for which data are available is representative of past conditions for many societies. Variation in the length of time for which data are available does not affect the validity of the computations (Low 1978).

For reasons of space, new codes are not reproduced here, but are freely available to interested scholars on request.

Non-parametric statistical tests were used. When variables were at least ordinal, and the relationship was linear, Spearman's Rho (Conover 1980) was calculated. For non-linear relationships, Kruskal-Wallis and Fisher Exact tests were used (Conover 1980). To check the distribution and strength of the association, two-way tables were used, and Chi-square and Phi were calculated. Multivariate analyses were done using logistic regression (Finney 1971).

Results

Ecological Factors and the Inculcation of Trust

As population density increased, the degree to which children were trained to trust others decreased somewhat ($n=134$, $\rho = -0.166$, $p=0.055$). This is hardly surprising; as the proportion of strangers, neither friends nor relatives, increases, the less fruitful trust is likely to be as a first approach. Population density, in turn, is strongly correlated with plant productivity, and non-extreme climatic conditions. Trust showed no relationship to the degree of nomadism ($n=128$, $d.f.=1$, $X^2 = -0.027$, $p=0.87$). Nomadic societies, however, strongly taught children to be generous more than expected ($n=99$, $d.f.=1$, $X^2=4.19$, $p=0.04$), a phenomenon perhaps related to the uncertainty of resource acquisition in nomadic life (Low 1989).

As the degree of risk of infection from serious, life-threatening pathogens increased, children were less strongly taught to trust others ($n=137$, $\rho = -0.185$, $p=0.03$). Here, the issue is not simply "stranger," but the risk from any individual. Pathogen stress shows a number of strong relationships with social factors (Low 1988, 1990b); it appears to change the costs and benefits of a variety of social relationships. Importantly, as the risk of infection by serious pathogens increases, fewer men are suitable, healthy husbands, and the degree of polygyny increases (and, thus, the proportion of unmarried men, and the degree of male-male competition).

The inculcation of trust varied non-linearly with community size ($n=135$, $d.f.=3$, $kw=8.87$, $p=0.03$). In small communities (<50 people, $n=19$), in which people lived largely with extended kin groups, the intensity with which children were taught to trust was moderately high; it reached a maximum in communities of 51-200 people ($n=50$) and 201-5000 ($n=61$). In societies with very large communities ($n=5$), children were not taught to trust others.

The intensity of trust inculcation showed no pattern with the importance of gathering, hunting, agriculture, or fishing in the food base. Interestingly, as animal husbandry increased in contribution to subsistence, children were taught to trust marginally

less ($n=134$, $\rho=-0.158$, $p=0.07$); it is probably important that animal husbandry and frequency of internal warfare (which also is associated with low trust) are positively related ($n=151$, $\rho=0.231$, $p=0.005$) — that is, wars are frequent over resources such as cattle, used for brideprice. Like polygyny, these indicate heightened male-male competition.

Social Factors and the Inculcation of Trust

A number of important ecological and social factors covary, and there may well be a chain of causality. As pathogen stress increased, the degree of polygyny increased. Children in monogamous and polyandrous societies were more frequently taught to trust others than children in polygynous societies ($n=135$, $d.f.=2$, $X^2=8.22$, $p=0.016$). Thus, the most pathogen-stressed areas have both the highest degree of polygyny, and the lowest inculcation of trust.

Patterns of marital residence were strongly related to the intensity of trust inculcation ($n=137$, $d.f.=4$, $X^2=16.05$, $p=0.003$). In patrilocal societies, in which related groups of men co-reside, children are less strongly taught to trust others, while in matrilineal, avunculocal, and neolocal societies they are strongly inculcated to trust more than expected.

When internal warfare occurred more frequently than every ten years, children were taught to trust others much less than in societies in which such warfare was rare ($n=109$, $X^2=13.9$, $d.f.=2$, $p=0.008$). No significant pattern emerged with the frequency of external warfare. These patterns carry over into other social behaviors. When trust inculcation is low (as in polygynous societies, or societies with frequent internal warfare), boys are trained to be more aggressive ($n=117$, $\rho=-0.444$, $p<0.0001$) and competitive ($n=107$, $\rho=-0.303$, $p=0.0015$). Societies in which trust inculcation is low are also societies likely to have theories of witchcraft as important explanations ($n=96$, $X^2=6.39$, $d.f.=1$, $p=0.014$).

The ways in which community leaders are chosen or emerge are also related to children's inculcation in trust ($n=137$, $d.f.=8$, $X^2=16.87$, $p=0.03$). Societies in which there is hierarchical or complex community leadership tend to teach children to trust less strongly than expected, as opposed to societies with a headman or council.

The existence of trade suggests a complementary heterogeneity of needs, and perhaps the need for repeated interactions. Trade is more common when temperature and rainfall conditions vary greatly ($n=82$, $\rho=0.222$, $p=0.05$). It decreases as the importance increases of gathering ($n=180$, $\rho=-0.264$, $p=0.0004$), and hunting ($n=180$, $\rho=-0.328$, $p=0.00001$); it is marginally related to the importance of fishing ($n=180$, $\rho=-0.133$, $p=0.07$) and agriculture ($n=180$, $\rho=0.120$, $p=0.11$); and it increases strongly with the importance of animal husbandry ($n=180$, $\rho=0.424$, $p=0.00001$). Despite these patterns,

the inculcation of trust is not at all related to the importance of trade ($n=135$, $\rho=-0.014$, $p=0.86$), nor to any of the subsistence types.

Discussion: Is there an ecology of trust?

Perhaps the strongest relationships between trust and other factors are those that reflect the most basic, broad predictions: that community size and degree of relatedness, degree of polygyny (reflecting competition among men), for example, will show relationships. And this makes sense. Physical factors, if extreme, are most likely to favor morphological or physiological, rather than social, responses (Low 1989, 1990a). Extremes in range of variation and unpredictability of variation in time or space will increase the complexity and cost of response.

Humans can respond far more complexly than other species; this is most evident in response to social factors (Low 1989). There are many subtle patterns, fitting under the general heading of direct and indirect reciprocity — cooperation. In fact, though not reflected by any of the codes here, information sharing and turn-taking with respect to food gathering may lower the variance (lower risk of failure), and for poorer hunters, increase the average return (Kaplan and Hill 1985). It may well be that many societies treat unpredictable variables not as uncertainties about which little is known, but as risks (i.e., assigning heuristically some probability of failure).

As we continue to explore human responses to environmental constraints, this represents a rich area for research. Sometimes a chain of response is evident. For example, climatic extremes, probably through their impact on plant productivity, influence human density and mobility; these in turn correlate with pathogen, starvation and protein deficiency risks. Similarly, physical and biological factors can intensify sexual selection, and sexual selection can generate individual and social strategies. Social unpredictabilities appear much more likely than simple physical pressures to generate complex social responses, including the formation of cooperative coalitions. While direct and indirect reciprocity are important, any system of reciprocity may be vulnerable to manipulation and deception.

Finally, a caveat. What people say may not be what they do, or what all individuals do. The codes for inculcation of trust, for example, arise from ethnographers' judgements, sometimes from interviews and self-reports by the people interviewed rather than from quantitative assessments. We need better measures of cooperation in preindustrial societies.

The Ecology of Cooperation in Non-Humans

Data from other species are consistent with the current findings. Cooperative care of infants is often performed by older siblings — "helpers at the nest." This behavior is typical in species in which the required resources for successful establishment are rare or difficult to acquire: acorn woodpeckers, several ground squirrels, scrub jays, and, in periods of resource shortage, wolves and Cape hunting dogs. Thus, kinship predisposes to cooperation.

When non-relatives care for others' dependent offspring, often other issues are at stake. In elephants (Dunbar 1983), for example, subordinate females sometimes associate with the calves of dominant females, offering some protection in return for access to water holes, which dominant females control. In some primates, too, non-parents may offer inexpensive care; the literature, however, remained confused for some time, muddling nepotistic care with harassment by reproductive competitors (see Wasser 1983).

Groups, with a superficial appearance of conjoint interests, can form in contexts not requiring cooperation; the principal such condition is the presence of rare and localized resources (e.g., a waterhole in the desert). In this case, there may be no advantage to coming together, so short-term, non-cooperative aggregations of animals are what we see. Truly cooperative coalitions occur in the following contexts, under quite specific conditions: feeding, predator avoidance, sexual selection (mate competition), and parental care and competition. Many species forage in groups, but most of these groups are not cooperative, but a matter of mutual exploitation. A group of sandpipers probing along the beach is seeking buried molluscs, whose location is not obvious, and which, when found, can't be eaten or protected from exploitation by others. So when one individual makes a "hit," others rush over and probe nearby. When the patch is exhausted, they move on. Truly cooperative foraging occurs when, for example, prey species weigh more than 1/3 the weight of their vertebrate predator, and it is difficult for a single individual to make a kill (e.g. many species hunted by wolves, Cape hunting dogs, lions), or when the prey moves in large groups (some fish predators cooperatively make the attack strikes: the first strike confuses the prey, second strikes are likely to be successful).

Two levels of group formation appear in predator avoidance as well. The first, like the mutual exploitation in feeding, is not cooperative. Prey species living in areas with little safe cover are no more conspicuous in groups than alone, but their chance of being caught, once seen, is $1/n$. Hamilton (1961) called this "selfish herd" behavior. Cooperative predator defense occurs in several primate species: several males, each unable to defend against a predator alone, will cooperate in defense. In familial-living species (some marmots, some ground squirrels), individuals cooperate in acting as "sentries."

Sex-Specific Cooperation. There are strong sex differences in cooperation in other species, and in most pre-industrial societies. In many species, cooperation among individuals is an effective strategy both to gain resources directly and to gain dominance that results in resource acquisition. Cooperation is known among males, among females, and between males and females. However, because reproductive return curves differ for different kinds of effort (Low 1990a, 1993b), there are crucial differences between males and females. It is probably true that coalitions evolved as, and may remain, reproductive strategies. Further, at least in polygynous societies, the potential reproductive gains, as well as the variance, are likely to be greater for men than for women (Low 1990a, 1993b). In most mammalian species, same-sex coalitions exist relatively briefly (Low, 1990a). In primates, however, long-term cooperation to compete is common. Individuals form coalitions of varying stability for reproductive reasons. If certain kinds of coalitions become, in their elaboration, indistinguishable from politics, then it is important to discern whether there are differences between the sexes in the coalitions formed or their outcomes.

Cooperation between males, both relatives and non-relatives, can be important in sexual selection. Cheetah (Frame 1985) and lion (Packer 1986) males cooperate to get territories, and thus access to females. Chimpanzees (deWaal 1982, 1986) cooperate in alliances related to dominance, status, and access to females in such a complex way that deWaal called the process "chimpanzee politics." Dolphin males form coalitions — and sometimes temporary "super-coalitions" to keep other males from groups of females (Connor 1986). In this context, female coalitions are quite different: e.g., yellow baboon (Wasser 1983) and bonnet macaque (Silk and Boyd 1983) matrilineal groups cooperate in harassing lower-status female reproductive competitors.

Struggles among males for status, territory, or harem control are often not always simple individual strife, but may involve coalitions. Thus, males may cooperate to gain territories (resource control) or dominance (direct access to matings). The context is therefore that of mating effort (Low 1990a, 1993b). Males may or may not be related, and coalitions may be temporary and fluid if they involve non-relatives. Many species of primates are regarded as "one-male" groups; however, even in those species, male coalitions in the mating context are known, although rare. In redtail and patas monkeys, several males may cooperatively invade a single male's group and mate with the females (Cords 1986). In gorillas (Fossey 1983) and gelada baboons (Dunbar 1983), a subordinate male may share breeding rights with the dominant for long periods. In most monkeys with multi-male groups, tolerant or cooperative relationships among males are nonetheless rare (Nishida and Hirawa-Hasegawa 1986); most males are simply competitors. This is particularly true for species in which males, upon adolescence, transfer groups. In this situation, males are

seldom related. In male-bonded groups, in which males remain in the natal group, cooperation is more common; in red colubus monkeys, for example, only natal males are accepted into adult coalitions (Struhsaker and Leland 1986). Exceptional among the female-bonded, male-transfer species are savannah baboons and chimpanzees, in which males do form coalitions. In chimpanzees, male coalitions change over time, and show little correlation with social bonds, as measured by association (de Waal 1984, 1986). Though complexities are evident (Smuts 1985, 1986a), in primates for which studies have been done, high male dominance rank is associated with high male reproductive success (see review by Silk 1986:322), and thus male formation of coalitions in the context of achieving high rank is not surprising.

For females in most mammalian species, no relationship is evident between status and reproductive success (cf. Gouzoules et al. 1982), and female-female coalitions tend to center around parental effort. In lions, closely-related females share parental care and hunting duties (Bertram 1978). In some primates, groups of related females may cooperate to get resources useful to their offspring, and prevent others' access (Smuts 1985, 1986b), or to harass subordinate females in reproductive condition (Wasser 1983). In the species with female harassment of competitors, less dominant females have difficulty raising offspring successfully (Wasser 1983). However, because the variance in reproductive success is less than that of males, the impact of dominance on reproductive success for females is less marked than for males. In chimpanzees, female coalitions are quite stable, and overlap with the pattern of social bonds (de Waal 1984). In gorillas, female kin are friendlier and more tolerant than non-kin; and all coalitions involve kin against non-kin (Stewart and Harcourt 1986). In a number of species, there is evidence that females form coalitions to intervene in aggressive encounters on behalf of maternal kin far more often than on behalf of other individuals, and to incur greater risk for maternal kin (Silk 1986). The aggressive encounters may involve other females, or males (Smuts 1985, 1986b).

Nonetheless, reciprocal altruism does occur among non-related females, although it appears that reciprocity is less intense among non-relatives. Non-kin coalitions, incurring little risk for coalition members, are often directed against lower-ranking females (Wasser 1983, Chapais 1983). Coalitions among non-related females are rarer overall than coalitions involving non-related males, and the context of female cooperation, again, tends to be parental effort.

Thus, in non-human species, there are important sex differences in the formation and function of same-sex coalitions. Male coalitions seem largely to serve status (mating effort) competition; male rank and male coalitions are fluid, and non-related males may form coalitions. Female coalitions involve parental effort such as nursing (lions), foraging, and

the support of particular individuals.— kin and friends (primates). Female coalitions, though they may involve both kin and non-kin, appear to be more kin-biased than male coalitions. In most non-human primate species, males fight more intensely and injure each other more than do females (Smuts 1986b).

In all sexual species, there is at least a temporary male-female cooperation to produce offspring. In environments requiring the parental effort of both parents in feeding offspring, for example, males and females form lasting pair bonds, and cooperate in getting and distributing resources. Some male behavior will be directed toward guarding, or other behavior that increases the certainty of paternity. In species in which a single parent is markedly less successful than two parents in raising offspring, the male-female coalition may persist, sometimes for the lifetimes of the individuals. When it does so, monogamous breeding systems result. When either parent can raise offspring alone, desertion is likely (Trivers 1972, Beissinger 1987), and the two sexes are likely to garner resources independently, or cooperate while appearing to monitor the appropriateness of desertion (Beissinger 1987).

Human Coalitions in Traditional Societies.

In humans, while the situation is obviously more complex, there does seem to be some pattern. Two very different conditions seem likely to lead to strong male-female bonds. In harsh environments in which a man and a woman can form effective resource coalitions, they are likely to do so, and the coalitions will follow confluence of reproductive interests (i.e., husband-wife; Flinn and Low 1986). Such male-female coalitions center around garnering resources for offspring, and are likely to be strongest in situations in which male and female interests are identical — monogamy. Brother-sister coalitions may exist in conditions in which certainty of paternity is low (cf. Alexander 1977, 1979). Male-female coalitions will be relatively weaker in polygynous situations, in which the male's reproductive interests are identical to those of all his wives and children, and overlap with the interests of any particular wife inversely with the number of wives.

Male-male coalitions are associated with status competition (Chagnon 1982, 1988), and with resources that can be more effectively obtained and protected by groups of males (war, heritable land of lasting value, some large game; Low 1993a). One of the most important contexts of male-male competition is that of warfare (Low 1993a). As expected, related men are most likely to help one another; for example, among the Yanomamö, warriors in an attacking group are significantly more closely related to each other than to their victims.

While male-male coalitions are likely to be among brothers (Flinn and Low 1986), and associated with patrilocal residence, more-or-less fluid coalitions of this sort arise among men of various relatedness, and among non-relatives in many societies. Such male-male coalitions may function outside the household, and may exert considerable power and control significant resources. In our evolutionary past, men may have had more to gain from high-stakes politics than women. Male-male coalitions will exist in spite of conflict of reproductive interests of the men involved, and only if each member can gain sufficient resources or influence to better his position compared to operating alone. This may be why such coalitions are so fluid.

Coalitions among women, like male-female coalitions (and unlike male-male coalitions), tend to operate in the familial sphere, and are unlikely to be powerful outside the household; yet the reproductive interests of co-wives, even if sisters, can never approach the maximum degree of confluence that monogamous husband-wife coalitions exhibit. Female-female coalitions may arise among female relatives or co-wives, and appear to function for the exchange of information (e.g., location of good foraging spots), child care, and subsistence-related work (cf. Irons 1983). Resources garnered are used for offspring, family, and important reciprocators, and significant resource control is unlikely. These coalitions are almost never significant beyond the household boundaries; even female solidarity groups tend to be among relatives.

For a woman, the areas of potential conflict of interest over the distribution of resources seem likely to be: distribution to her relatives, distribution to her female reciprocators (related or unrelated), distribution to her husband's relatives, distribution to her husband's reciprocators, and distribution to his other wives in a polygynous situation. The use of resources for the man, the woman, and their offspring together are unlikely to be a source of conflict.

Differences in the potential reproductive returns, in the usual degree of relatedness of cooperators, and in the sphere of activity (familial, few resources vs. extra-familial or community, major resource/status acquisition) seem likely to be reflected by differences in the behavior of the individuals involved. Consider the options open, if they are dissatisfied, to the following individuals: a monogamously married woman, a polygynously married woman, a man in a coalition of other related and non-related men. For the man, options depend on his resources and his connections in other coalitions, and include: fighting for power openly within the coalition, trying to manipulate the rules so that the coalition operates to his own advantage, or leaving — changing coalitions. Even though women's natal families have some importance as support, for neither of the women is changing coalitions liable to be a successful option. Within families open conflict is seldom

successful (e.g., Beals 1961) for a variety of reasons, and avoidance of conflict is common (Blood 1960). A monogamously married woman loses the only ally whose reproductive interests are virtually identical to hers, and if she remarries must begin reconstructing the same confluence of interests (cf. Daly and Wilson 1984, 1985, 1987 on child abuse patterns). A polygynously married woman also has few options, and must operate in a coalition with a lesser confluence of reproductive interests with her husband. Such a woman may control few resources, cannot easily find a new coalition, and is unlikely to gain by open confrontation within the family. A major cause of divorce is conflict among co-wives, whose reproductive interests differ though these conflicts are less if co-wives are sisters. Further, a discarded wife cannot easily gain status and resources by a second, more desirable, marriage.

Collier and Rosaldo (1981) noted this difference in sphere of male versus female activities, and puzzled over the lack of ritual and cultural conceptualization of female roles; they suggested that "marriage organizes obligations, and . . . such obligations shape political life." Their discussion of the centrality of marriage to men's lives highlights the importance of male-male coalitions, in the community sphere, as mating effort. Male-male and female-female coalition differences, related to reproductive gain, are broader than the various asymmetries created by different marriage arrangements.

When do women compete directly for resources — when do women's coalitions function more like men's coalitions? There seem to be two such conditions, both more prevalent in Africa than elsewhere (Low 1992). In complex matrilineal or dual inheritance societies, a powerful woman, while not increasing her own number of children, may increase her grandchildren by passing her wealth and power to her son (e.g., historical Ashanti, Rattray 1923). Even when such systems are changed by contact with industrialized societies, traditions of women's independence and power, even though they no longer yield reproductive gains, may persist and thrive.

In sum, the sexual dimorphism in human coalitions parallels that in other species to a surprising degree, particularly in light of existing cultural diversity. Mating and parental effort have very different return curves for effort expended. Because we are mammals, much of women's reproductive (parental) investment must start all over for each child, although earlier-born children, when old enough, can help in food-gathering and child care. In contrast, much of a man's reproductive (mating) effort is expended as a fixed cost — getting power and status, which function just as effectively in obtaining a second or third mate as a first. Male-male coalitions center around the mating aspects of reproductive effort, frequently involve variously related men, and operate in the community sphere. Female-female coalitions involve sisters or unrelated co-wives, center around the parental

aspects of reproductive effort, involve fewer resources, tend to be less fluid, and operate in the familial sphere.

Detecting Cheaters

All of the patterns described here are, to some degree, vulnerable to "cheating." Even parental care is potentially exploitable by non-relatives. In many species (e.g. wood ducks), females may sneak into the nests of others and lay eggs, forcing the parasitized female to provide parental care for offspring not her own. In some cases, the exploiters need not even be the same species: for example, the Kirtland's Warbler is currently endangered, and faces a serious problem in a fairly new parasitic exploitation by Cowbirds, who lay eggs for the Kirtland's Warbler to raise. If "cheating" occurs even at such crude levels, think how important the detection of cheating must be in more subtle situations.

If we have evolved to help our family (who carry identical genes) and friends (who will also help us), it follows that we might be discriminating in our help. Indeed, as we accumulate evidence, it looks less and less as if our brains are structured as computers working on logical premises. Indeed, social interactions are so important that they may color the way we think at the deepest levels.

Consider two problems that are formally identical. Here are four cards. The rule is that any card with an "A" on the front must have a "3" on the back (if P then Q). Which cards must you turn over to see if the rule is followed, or violated?

A	B	5	3
---	---	---	---

In the second problem, you are a bouncer in a bar. The rule is that anyone who is drinking a beer must be at least 21 years old (if P then Q). Four people are sitting at a table: one you know to be 25, one is drinking a beer, one is 16, and one is drinking a coke. Whom do you ask for proof of age?

These problems are formally identical; the efficient, logical solution is: check P (A, or drinking beer) and not-Q (5, and under 21). There is no requirement that if not-P then not-Q (e.g. a 25-year old can drink a coke). Yet people solve the problems quite differently: about 25% of people solve the abstract problem, while almost 80% solve the problem in the context of detecting cheaters on the social rules (Cosmides 19XX).

Could it be simple familiarity, since more people know about drinking rules than about card rules? Apparently not; one can vary the familiarity of both abstract and social problems, and it makes no difference to solution rates — what always matters is whether there is a possibility for cheating the social rules. Consider another example: if Harry has paid, he must take the ticket (this if-P-then-Q is equivalent to detecting altruists: making sure that someone takes his or her benefits). Formally, this problem is identical to the

others: If Harry has paid (P), then he must accept the ticket he has paid for (Q). When people are asked which of the four cards they would turn over

Paid	Not Paid	Has ticket	No Ticket
------	----------	------------	-----------

they generate quite illogical "solutions." The logical solution is, again, to check "paid" (P) and "no ticket" (not-Q). Instead, a large proportion of people check to see whether "not paid" is paired with "ticket" when the initial problem makes it clear that Harry has already paid!

Further experiments make it clear how important one's viewpoint is. Consider the problem: If an employee has worked ten years or more (P), then the employee is entitled to a pension (Q); if the employee has worked less than 10 years (not-P) then s/he is not entitled to a pension (not-Q). Note that in this problem, we are concerned both that P is paired with Q, and that not-P is paired with not-Q (binary), in contrast to our first problems.

>10 years	<10 years	Get pension	No pension
-----------	-----------	-------------	------------

How people solve this problem depends greatly on whether they are given the role of employer or employee. From an employer's viewpoint, a cheater is "<10 years, gets pension" — and this is what people told they are employers look for. On the other hand, people told they are employees look for ">10 years, no pension." Formally, both conditions fail to meet the logical rules — yet how people solve them depends entirely on their perspective as employer or employee. "Employers" never check to see if someone is not getting a pension, despite having worked ten years or more; and "employees" never check to see if someone having worked less than ten years is nonetheless getting a pension.

As the experiments accumulate, one thing is abundantly clear: though we clearly can learn logic, we nonetheless appear to solve problems at least initially in the context of our social history. And in that social history, we appear to have been concerned with protecting our own rights under the social rules, rather than protecting the rights of others. And even the crude patterns detected here, also suggest that self-interest, rather than group interest, has always been the crucial issue.

Literature Cited

- Alexander, R. D. 1977. Natural selection and the analysis of human sociality. pp XX in C. E. Goulden (ed.). *Changing scenes in the natural sciences: 1776-1976*. Bicentennial Symposium Monograph, Phil. Acad. Nat. Sci. Special Publ. 12.
- Alexander, R. D. 1979. *Darwinism and human affairs*. Seattle: University of Washington Press.

- Alexander, R. D. 1987. *The biology of moral systems*. New York: Aldine De Gruyter.
- Alexander, R. D. 1990.
- Barry, H. III, L. Josephson, E. Lauer, and C. Marshall. 1976. Traits inculcated in childhood. 5. Cross-cultural codes. *Ethnology* 15: 83-114.
- Beals, A. R. 1961. Cleavage and internal conflict: An example from India. *Conflict Resolution* V(1):27-34.
- Beissinger, S. R. 1987. Mte desertion and reproductive effort in the Snail Kite. *Animal Behaviour* 35: 1504-1519.
- Bertram, B. C. R. 1978. *Pride of Lions*. New York: Scribner.
- Betzig, L. L. 1986. *Despotism and differential reproduction: A Darwinian view of history*. New York: Aldine.
- Blood, R. O. 1960. Resolving family conflicts. *Conflict Resolution* IV(2):209-219.
- Boyd, R., and P. J. Richerson. 1986. *Culture and the Evolutionary Process*. University of Chicago Press Chicago.
- Cavalli-Sforza, L. L., and M. W. Feldman. 1981. *Cultural transmission and evolution*. Princeton: Princeton University Press.
- Chagnon, N. 1982. Sociodemographic attributes of nepotism in tribal populations: Man the rule-breaker. in Kings' College Sociobiology Group (eds). *Current problems in sociobiology*. Cambridge: Cambridge University Press.
- Chagnon, N. 1988. Life histories, blood revenge, and warfare in a tribal population. *Science* 239: 985-992.
- Chapais, 1983.
- Chapais, B. 1983. Dominance, relatedness, and the structure of female relationships in rhesus monkeys. pp. XX in R. A. Hinde (ed.). *Primate social relationships: an integrated approach*. Oxford: Blackwell.
- Collier, J. F., and M. Rosaldo. 1981. Politics and gender in simple societies. pp. XX in S. B. Ortner, and H. Whitehead (eds.). *Sexual meanings: the cultural construction of gender and sexuality*. Cambridge Univ. Press, Cambridge.
- Connor, R. 1986. Pseudo-reciprocity: Inverting in mutualism. *Animal Behaviour* 34: 1562-1566.
- Conover, W. J. 1980. *Practical non-parametric statistics*. 2nd ed. New York: Wiley.
- Cords, Marina. 1986. Forest guenons and patas monkeys: Male-male competition in one-male groups, p. 98-11 in B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, and T. T. Struhsaker (eds.). *Primate Societies*. Chicago: Univ. Chicago Press.
- Cosmides, L. 198XX.

- Daly, M., and M. Wilson. 1984. A sociobiological analysis of human infanticide, pp. 487-502 in G. Hausfater and S. B. Hrdy (eds.) *Infanticide: Comparative and Evolutionary Perspectives* pp. 487-502. New York: Aldine.
- Daly, M., and M. Wilson. 1985. Child abuse and other risks of not living with both parents. *Ethology and Sociobiology* 6: 197-210.
- Daly, M., and M. Wilson. 1987. Children as homicide victims. pp 201-214 in R. J. Gelles and Jane B. Lancaster (eds.). *Child Abuse and Neglect: Biosocial Dimensions* pp. 201-214. New York: Aldine.
- DeFries, J. C., R. P. Corley, R. C. Johnson, S. G. Vandenberg, and J. R. Wilson. 1982. Sex-by-generation and ethnic group-by-generation interactions in the Hawaii Family Study of Cognition. *Behavior Genetics* 12: 223-230.
- Dublin, H. 1983. Cooperation and reproductive competition among female African elephants, p 291-315 in S. K. Wasser, ed. *Social Behavior of Female Vertebrates*. New York: Academic Press.
- Durham, W. H. 1991. *Coevolution: Genes, Culture, and Human Diversity*. Stanford: Stanford University Press.
- Ember, C. R., and Melvin Ember. 1992. Resource unpredictability, mistrust, and war: A cross-cultural study. *Journal of Conflict Resolution* 36(2):242-262.
- Finney, D. J. 1971. *Probit analysis*, third ed. Cambridge Univ. Press, London.
- Flinn, M. V., and Bobbi S. Low. 1986. Resource distribution, social competition, and mating patterns in human societies. In D. Rubenstein and R. Wrangham, editors. *Ecological aspects of social evolution*. Princeton: Princeton University Press.
- Fossey, D. 1983. *Gorillas in the Mist*. Boston: Houghton Mifflin.
- Frame, G. W. 1985. Cheetahs of the Serengeti. pp. 42-43 in D. MacDonald (ed.). *The Encyclopedia of mammals*. New York: Facts on File Publications.
- Gouzoules, H., S. Gouzoules, and L. Fedigan. 1982. Behavioral dominance and reproductive success in female Japanese monkeys (*Macaca fuscata*). *Anim. Behaviour* 30: 1138-1150.
- Grafen, A. 1991. Modelling in behavioural ecology, pp. 1-31 in J. R. Krebs and N. B. Davies (eds.). *Behavioural ecology* 3rd ed. London: Blackwell Scientific.
- Hamilton, W. D. 1961. Geometry for the selfish herd. *J. Theoret. Biology* 31: 295-311.
- Hamilton, W. D. 1964. The genetical evolution of social behaviour III. *J. Theoretical Biology* 7: 1-52.
- Hardin, G. 1968. The tragedy of the commons. *Science* 162: 1243-1248.
- Hartung, J. 1982. Polygyny and the inheritance of wealth. *Current Anthropol.* 23: 1-12.

- Heinen, J. T., and Bobbi S. Low. 1992. The behavioral ecology of of environmental conservation. *Environmental Conservation* 19(2): 105-116.
- Humphrey, N. K. 1983. *Consciousness regained: Chapters in the development of mind*. Oxford: Oxford University Press.
- Irons, William. 1983. Human female reproductive strategies, p. 169-213 in Samuel K. Wasser, ed. *Social Behavior of Female Vertebrates*. Academic Press, New York.
- Kaplan, H., and K. Hill. 1985. Hunting ability and reproductive success among male Ache foragers: Preliminary results. *Current Anthropology* 26:131-133.
- Keohane, R. 1984. *After hegemony*. Princeton: Princeton University Press.
- Keohane, R., E. Ostrom, and M. McGinnis. 1993. Linking local and global commons: Monitoring, sanctioning, and theories of self-organization in common pool resources and international regimes, p 1-15 in R. Keohane, M. McGinnis, and E. Ostrom (eds) *Proceedings of a Conference on Linking Local and Global Commons*. Indiana University Workshop in Political Analysis and Theory, Bloomington IN.
- Lewontin, R. C, S. Rose, and L. J. Kamin. 1984. *Not in Our Genes: Biology, Ideology, and Human Nature*. New York: Pantheon Books.
- Low, Bobbi S. 1978. Environmental uncertainty and the parental strategies of marsupials and placentals. *Amer. Naturalist* 112: 197-213.
- Low, Bobbi S. 1988. Pathogens and polygyny in humans. p. 115-127 in L. Betzig, M. Borgerhoff Mulder, and P. Turke (eds.) *Human reproductive behavior: A Darwinian Approach*. Cambridge Univ. Press, Cambridge.
- Low, Bobbi S. 1989a. An evolutionary perspective on the training of children. *J. Comparative Psychology* 103: 311-319.
- Low, Bobbi S. 1989b. Human responses to environmental extremeness and uncertainty: A cross-cultural perspective, p. 229-255 in Cashdan, E. (ed.). *Risk and uncertainty in tribal and peasant societies*. Westview Press, Boulder.
- Low, Bobbi S. 1989c. Occupational status and reproductive behavior in 19th century Sweden: Locknevi Parish. *Social Biology* 36: 82-101.
- Low, Bobbi S. 1990a. Sex, power, and resources: Male and female strategies of resources acquisition. *International Journal of Contemporary Sociology* 27: 45-71.
- Low, Bobbi S. 1990b. Pathogen stress and human marriage systems. *American Zoologist*. 30: 325-339.
- Low, Bobbi S. 1990c. Occupational status, land ownership, and reproductive behavior in 19th century Sweden: Tuna Parish. *American Anthropologist*. 92: 115-126.
- Low, Bobbi S. 1992. Sex, coalitions, and and politics in preindustrial societies. *Politics and the Life Sciences* 11(1): 63-80.

- Low, Bobbi S. 1993a. An evolutionary perspective on war. pp. 13-56 in H. Jacobson and W. Zimmerman (eds.). *Behavior, Culture, and Conflict in World Politics*. Ann Arbor: U. Michigan Press.
- Low, Bobbi S. 1993b. Ecological demography: A synthetic focus in evolutionary anthropology. *Evolutionary Anthropology* 1(5): 177-187.
- Low, Bobbi S., and Alice L. Clarke. 1991. Family patterns in 19th century: Impact of occupational status and landownership. *Journal of Family History* 16(2): 117-138.
- Low, Bobbi S., Alice L. Clarke, and Kenneth Lockridge. 1992. Toward an ecological demography. *Population Development Review* 18(1): 1-31.
- Low, Bobbi S., and J. T. Heinen. 1993. Population, resources, and environment: Implications of human behavioral ecology for conservation. *Population and Environment* 15(1): 7-41.
- Lumsden, C. J., and E. C. Wilson. 1981. *Genes, mind, and culture*. Harvard University Press.
- Martin, L. L. 1993. Common dilemmas: Research programs in common-pool resources and international cooperation, p 147-166 in R. Keohane, M. McGinnis, and E. Ostrom (eds) *Proceedings of a Conference on Linking Local and Global Commons*. Indiana University Workshop in Political Analysis and Theory, Bloomington IN.
- Murdock, George Peter. 1967. *Ethnographic Atlas*. Univ Pittsburgh Press, Pittsburgh.
- Murdock, George Peter. 1981. *Atlas of World Cultures*. Univ Pittsburgh Press, Pittsburgh.
- Murdock, G. P. , and Diana O. Morrow. 1970. Subsistence economy and supportive practices: Cross-cultural codes I. *Ethnology* 9: 302-330.
- Murdock, George Peter, and D. White. 1969. Standard cross-cultural sample. *Ethnology* 8:329-369.
- Murdock, George Peter, and Suzanne Wilson. 1972. Settlement patterns and community organization: Cross-cultural codes 3. *Ethnology* 11:254-295.
- Nishida, T. and M. Hiraiwa-Hasegawa. 1986. Chimpanzees and bonobos: Cooperative relationships among males. p. 165-178 in B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, and T. T. Struhsaker (eds.). *Primate Societies*. Chicago: Univ. Chicago Press.
- Nowak, and Sigmund. 1993.
- Ostrom, E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. New York: Cambridge University Press.
- Ostrom, E., and V. Ostrom. 1977. Public goods and public choices. In *Alternatives for Delivering Public Services*, ed. E. S. Savas, 7-49. Boulder, CO: Westview Press.

- Packer, Craig. 1986. The ecology of sociality in felids. p. 429-451 in D. I. Rubenstein and R. W. Wrangham (eds). *Ecological aspects of social evolution*. Princeton: Princeton University Press.
- Putnam, R. D. 1993. Democracy, development, and the civic community: Evidence from an Italian experiment. p 95-146 in R. Keohane, M. McGinnis, and E. Ostrom (eds) *Proceedings of a Conference on Linking Local and Global Commons*. Indiana University Workshop in Political Analysis and Theory, Bloomington IN.
- Silk, Joan B. 1986. Social behavior in evolutionary perspective. p 318-329 in B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, and T. T. Strusaker (eds.). *Primate Societies*. Chicago: University of Chicago Press.
- Silk, J. B., and R. Boyd. 1983. Cooperation, competition, and mate choice in matrilineal macaque groups. in S. Wasser (ed) *Social behavior of female vertebrates*. New York: Academic Press.
- Smith, M. S., B. J. Kish, and C. B. Crawford. 1986. Inheritance of wealth as human kin investment. *Ethology and Sociobiology* 8(3): 171-182.
- Smuts, Barbara Boardman. 1985. *Sex and Friendship in Baboons*. Aldine, New York.
- Smuts, Barbara Boardman. 1986a. Sexual competition and mate choice. p 385-399 in B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, and T. T. Strusaker (eds.). *Primate Societies*. Chicago: University of Chicago Press.
- Smuts, Barbara Boardman. 1986b. Gender, aggression, and influence. p. 400-412 in B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, and T. T. Strusaker (eds.). *Primate Societies*. Chicago: University of Chicago Press.
- Stewart, K. J., and A. H. Harcourt. 1986. Gorillas: variation in female relationships. p. 155-164 in B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, and T. T. Strusaker, eds. *Primate Societies*. Chicago: University of Chicago Press.
- Struhsaker, T. T., and L. Leland. 1986. Colobines: Infanticide by adult males. pp. 830-88 in B. B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham, and T. T. Struhsaker. (eds.) *Primate Societies*. Chicago: University of Chicago Press.
- Taylor, M, and S. Singleton. 1993. The communal resource: Transaction costs and the solution of collective action problems, p 66-94 in R. Keohane, M. McGinnis, and E. Ostrom (eds) *Proceedings of a Conference on Linking Local and Global Commons*. Indiana University Workshop in Political Analysis and Theory, Bloomington IN.
- Trivers, Robert. 1972. Parental investment and sexual selection, in B. Campbell, ed. *Sexual Selection and the Descent of Man*. Chicago: Aldine.
- Waal, F. de. 1982. *Chimpanzee Politics*. Harper & Row, New York.

- Waal, F. de. 1984. Sex differences in the formation of coalitions among chimpanzees. *Ethology and Sociobiology* 5: 239-255.
- Waal, F. de. 1986. The integration of dominance and social bonding in primates. *Quart. Rev. Biology* 61: 459-479.
- Wasser, S. K. 1983. Reproductive competition and cooperation among female yellow baboons, p 350-390 in S. K. Wasser, ed. *Social Behavior of Female Vertebrates*. New York: Academic Press.
- Whyte, Martin K. 1979. *The status of women in pre-industrial society*. Princeton University Press, Princeton.