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Cooperation and Conflict between Kith, Kin, and Strangers

Game Theory by Domains

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Perhaps the majority of meaningful social interactions involve opportunities for cooperation juxtaposed with dangers of conflict. Brutus and Caesar, Jung and Freud, Lennon and McCartney all had famously productive friendships preceding their infamously nasty splits. Even the closest of relationships—those involving family members—are occasionally staging grounds for marital spats, sibling rivalries, and parent-offspring conflicts (Trivers, 1974). There are numerous historical instances of rulers, such as Edward IV of England and Selim I, Sultan of the Ottoman Empire, who ordered the executions of their own brothers. And even informal interactions between casual friends, such as an invitation to dinner or a party, involve various trade-offs, and may require deciding between a mini-betrayal and a minor self-sacrifice. Do you stick with your commitment to go to a distant coworker's birthday dinner or skip it when a better friend invites you out? More generally, how do people come to decisions about prioritizing their own immediate interests or those of their acquaintances, friends, or families?

Although evolutionary models are also premised on the harsh economic realities of a gene-centered view of behavioral decision making, advances in evolutionary research have contributed to our redefinition of what motivates "economic man." Most evolutionary models of social relationships presume that self-interest intrinsically incorporates the interests of other people via factors such as inclusive fitness and reciprocity (Buunk & Schaufeli, 1999; Kurland & Gaulin, 2005; Maynard-Smith, 1982). Evolutionary theorists have also recently been considering other recurring factors that modulate self-interest in social contexts, such as punishments and reputation costs for those who cheat on social contracts. It would be a great mistake to regard *Homo economicus* as dead (Aktipis & Kurzban, 2004). Instead, he has been dressed in more epistemologically presentable attire. Many modern evolution-informed economic models presume that people behave—with very important exceptions (e.g., Burnham & Phelan, 2000; Hagen & Hammerstein, 2006)—in ways that serve their proximate ability to survive and succeed and, ultimately, reproduce (but see Symons, 1992).

Evolutionary psychologists have elucidated the fitness consequences of a number of the decision-rules humans use to navigate social contexts, personal relationships, and the distribution of their scarce resources. While some of these rules are applied in navigating through group contexts, others are directed toward specific targets: evaluating the attractiveness of a potential mate, deciding whether one's current partner requires higher levels of mate-guarding, or dealing with a business associate who has just cheated you. To the extent that such individual decision-rules can be quantified, a game theoretic framework may provide a useful method of examining the effects of these decision-rules on strategic behavior within such human dyadic interactions. One appealing feature of game theory analyses is the ability to quantify trade-offs, self-presentations, negotiations, and plays and counter-plays of everyday life in the real world. By incorporating evolved decision rules and biases into a game theoretic framework, it may be possible to simultaneously make game theory more realistic and make evolutionary models more quantitatively precise.

Our ancestors interacted most frequently and most intimately with kin and other individuals who we would today call in-laws. Beyond that, our ancestors had the remainder of their meaningful social interactions with people they expected to see again and on whom they might very well have depended for reciprocal benefits. Both of these generalizations continue to be true of most people in the world today, and even North Americans and Europeans still have most of their meaningful interactions with either close kin or members of long-term reciprocal alliances. To accomplish important tasks that humans everywhere need to accomplish, people need other people. And reciprocal relationships still help pool risks even in some modern environments where the odds of starving to death or being attacked by predators are lower than they were in the ancestral past.

MODULARITY AND SOLUTIONS TO RECURRING SOCIAL PROBLEMS

Evolutionary theorists generally presume that the brain solves problems by executing problem-specific psychological mechanisms that were shaped by the processes of natural selection (e.g., Cosmides & Tooby, 1992; Gigerenzer & Selten, 2001). This view challenges traditional models that attempt to explain the range of human thought and behavior with the application of one or two broad and unqualified domain-general principles (such as "repeat behavior that led previously to rewards" or "maximize reproductive fitness"). The modularity assumption posits that selection processes lead to the development of efficient, specialized solutions to recurrent problems faced by organisms living in specialized niches (for a recent review, see Barrett & Kurzban, 2006). It has been argued that these specialized solutions to complex problems can be simultaneously relatively quick and fairly accurate (Gigerenzer, Todd, & the ABC Research Group, 1999).

Supporting the validity of the modularity assumption, broad-ranging evidence indicates that learning and cognition operate according to different rules and employ different neural architectures and mental subroutines to process and respond to information about words, faces, tastes, potential physical threats, and so on (Kenrick, Sadalla, & Keefe, 1998; Sherry & Schacter, 1987). Because our human ancestors were social animals who lived in small groups, decision-rules for behaviors promoting mutually beneficial social relationships would have been an important subset of the design features passed on to generations of modern humans. Selection should have favored traits that assisted in regulating cooperative behavior—striking a balance between the desire to maximize one's own benefits in the present and the need to incur costs to stay in the good graces of the other group members, and thereby capitalizing on future potential benefits.

We, and other researchers, have suggested elsewhere that humans universally confront persistent problems in a set of broad social domains (e.g., Bugental, 2000; Buss, 2003; Gigerenzer, 1997; Kenrick, Li, & Butner, 2003; Sundie, Cialdini, Griskevicius, & Kenrick, 2006). The particular framework we adopt here considers six key domains of social life: forming coalitions, gaining and maintaining status, protecting oneself and valued others from threats, finding mates, maintaining romantic bonds, and caring for offspring. Our ancestors would have had to solve a set of problems within each of these domains in order to survive and reproduce. Modern humans face similar social challenges. Pursuit of such goals requires cleverly negotiating a relevant set of social relationships that naturally oscillate between cooperation and conflict, as the other parties in those relationships simultaneously pursue their own objectives.

The kinds of recurring conflict and cooperation individuals experience in their social relationships vary systematically depending on the social domain within which one is exchanging scarce resources. For example, parents caring for their children do not expect reciprocation of benefits in the same way as do friends exchanging gifts, and the rules of exchange between men and women during courtship likely differ from those between higher and lower status individuals in a social network (Foa & Foa, 1980; Clark & Mills, 1979; Fiske, 1992; Kenrick & Trost, 1989). Coalitional behaviors are more likely among kin, or individuals who have a history of sharing resources with one another—two decision rules based on well-established principles of kin selection and reciprocal altruism (Burnstein, Crandall, & Kitayama, 1994; Van Vugt & Van Lange, 2006). Evolutionary psychologists presume that such psychological mechanisms or decision-rules, though heritable, are also quite sensitive to environmental input (Kenrick, Neuberg, Zierk, & Krones, 1994; öhman & Mineka, 2001). Many decision-rules can be conceptualized as "if-then" statements, where environmental input plays a fundamental role in determining which decision-path is chosen.

Evolutionary researchers have made significant progress in understanding human behavior through their search for various adaptive decision rules. Some of these mechanisms have been outlined in primarily qualitative terms (Kenrick, Li, et al., 2003; Kenrick, Maner, & Li, 2005; Sundie et al., 2006). We suggest next that it is possible to begin converting the qualitatively different decision-rules into more precise quantitative estimates (see also Van Lange, 1999). Those quantitative estimates can then be integrated into the study of strategic behavior using a game theoretic framework. We will consider how qualitative decision-rules may be converted into quantitative weights, which will increase in precision as research continues to illuminate the specifics of the underlying decision biases.

RECASTING THE CLASSIC PRISONER'S DILEMMA

The prisoner's dilemma is one of game theory's simplest and most widely known frameworks for analyzing strategic behavior (Rapaport & Chammah, 1965; Van Vugt & Van Lange, 2006). As depicted in Figure 18.1 , the dilemma arises from a payoff structure in which, in the one-shot version, each player's best choice is to defect on his or her partner, resulting in lower benefits than each would have had if instead they had both cooperated. As depicted in the leftmost grid in Figure 18.1,

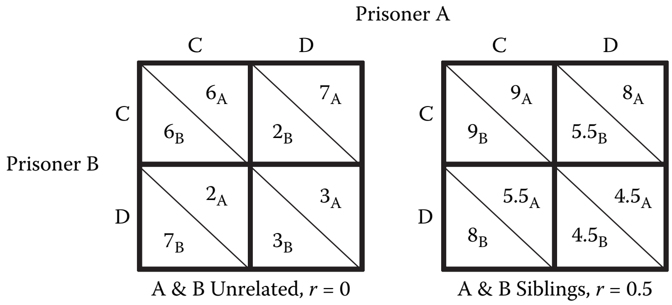

Figure 18.1 Using a standard set of payoffs in the prisoner's dilemma game played defection is the dominant strategy. The same payoffs in game played by siblings, incorporating their Hamilton's r of .5, lead to mutual cooperation. In the figure on the right, the payoffs become prisoner A's own plus half of his brother's.

the payoffs include the temptation to defect (T), a reward for cooperating if both do (R), a punishment for mutual defection (P), and a sucker's pay-off for cooperating when the partner defects (S). The prisoner's dilemma requires that $T > R > P > S$[1] . This game is one in which the Nash equilibrium (a situation in which no player can gain by changing strategy) is not Pareto optimal (no player can be made better off without decreasing another player's welfare). When each player yields to the temptation to defect, their joint social welfare is lower than it would be if both cooperated. The basic logic of such models has been expanded to encompass repeated rounds of play between multiple players to help understand broader dilemmas that may contribute to key social problems, including overpopulation, environmental destruction, and international conflict (e.g., Axelrod, 1984).

In this chapter, we exclusively focus on strategic behavior at the individual level, as it plays out between pairs of individuals in very different types of social relationships. In this way we can explore how evolved decision-rules change payoffs of various strategies depending on the nature of the relationship between the two individuals and the specific social context in which an interaction occurs. Applying principles grounded in evolutionary biology, we will reconsider how the outcomes of simple strategic games can change when evolved decision constraints are quantified and incorporated into the payoffs individuals face. We will consider, for example, how one's own payoffs change when inclusive fitness between the players is incorporated into the game theoretic framework.

We will reexamine this basic payoff structure as it applies in six central domains of social interaction. We will suggest that payoff structures leading to the prisoner's dilemma in interactions between strangers get transformed by decision-biases that change the psychological game when individuals interact with kin, unrelated coalition members, members of out-groups, potential mates, existing mates, and people above and below them in status hierarchies (for related ideas, see Kelley & Thibaut, 1978; Van Lange, 1999). Those transformations are qualitatively and quantitatively different within each of these relationship types and are further influenced by evolutionarily relevant variables such as the decision-maker's sex and phase-of-life history.

HOW DOMAIN-SPECIFIC BIASES MIGHT ALTER COOPERATIVE TRADE-OFFS

In the previous section, we argued that human beings are equipped with qualitatively different decision-rules for thinking about their relationships within the different domains. Many of the decisions people make in their interactions with friends, relatives, acquaintances, and strangers are intrinsically linked to cooperation and conflict. Does a man give a quarter to the demanding beggar or

[1] An additional constraint, $T + S < 2R$, may also be imposed.

tell him to get a job? Does a woman bang on the ceiling to get her musician neighbor to lower the volume on his bass guitar, or does she put in earplugs? Does a young man pick up the tab at the restaurant for the fifth time in a row, or ask his dating partner whether she is familiar with the concept of turn-taking? Does a wife clean the kitchen uncomplainingly, or initiate a possible marital spat about the distribution of domestic labor? Does a mother yield to her daughter's loud lobbying for a sugary treat at the market, or say "no" and risk the possibility that the situation will escalate into an embarrassingly full-blown public tantrum? To the extent that our ancestors confronted analogous interactions, one might expect that we have inherited inclinations to make these decisions in ways that kept costly conflicts to a minimum and to choose conflict over cooperation only when the estimated probabilistic benefits outweighed estimated costs. Obviously, the benefits and costs to self and other are very different in different relationships because our interests align differently with strangers, unrelated neighbors, dating partners, spouses, and blood relatives. In what follows, we consider the specific kinds of resources exchanged and some important constraints on the relative value of those resources within each social domain.

ALLIANCE FORMATION

> the "Struggle for Existence," which has taught [insects] the lesson of self-sacrifice to the community, [also teaches that the] devotion of mother to child, and friend to friend ... recognizes that mutual help and sympathy are among the most powerful weapons [of survival]. (Buckley, 1889) Q1

For most of human evolutionary history, our ancestors lived in small, highly interdependent groups (Sedikides & Skowronski, 1997). By cooperating with others, they accomplished things they could not have hoped to accomplish individually. Simply pooling unreliable resources (such as hunted meat) with other group members, some researchers argue, could have provided insurance against starvation (Hill & Hurtado, 1996), translating ultimately into reproductive success.

There are, however, costs as well as benefits to cooperating with others: it takes time and resources to help others, and others may be motivated to take a little more than they give in return. Alliance members also directly and indirectly compete with one another for food, status, mates, and other resources (Alcock, 1993; Hill & Hurtado, 1996). How much to cooperate, and with whom, is influenced by two very powerful evolutionary principles: inclusive fitness and reciprocity. The trade-offs involved in cooperation are more favorable with other people who share our genes and with people who have established long-term mutually beneficial patterns of sharing with us.

Cooperating With Kin

From an inclusive fitness perspective (Hamilton, 1964), it should be expected that there are psychological mechanisms in place that, everything else equal, cause people to be more inclined to deliver benefits to kin than nonkin. Conversely, if your relatives exact costs on you, there are also indirect costs to them. Research with species ranging from ground squirrels to humans suggests lower thresholds for engaging in various types of cooperative behavior among neighbors who are closely related (e.g., Burnstein et al., 1994; Essock-Vitale & McGuire, 1985; Sherman, 1981).

A consideration of inclusive fitness provides the clearest and simplest example of how what would otherwise be a prisoner's dilemma can be transformed by evolutionarily important factors. Two brothers share roughly half of their genes[2] , hence (from the gene's perspective) 100 units of benefit to one brother are worth 50 units of benefit to the other. If one takes this into account in considering the classic trade-off between cooperation and conflict depicted in Figure 18.1, cooperation becomes the dominant strategy.

[2] Brothers shared approximately 50% of the genes that are free to vary within the human population.

This is true for brothers across a wide range of payoffs, but not all. For some payoffs (and degrees of relatedness), defection will still be the dominant strategy. The example of royal family members killing their competitors for the throne vividly illustrates that not all is cooperative within families. It is possible to precisely specify "zones" where cooperation would be a dominant strategy for brothers, but not strangers (Kenrick, Sanabria, Sundie, & Killeen, 2006).

Just as "zones of cooperation" can be calculated for brothers, they can be calculated for other relatives by incorporating appropriately different weights for grandchildren (.25 instead of .50), cousins (.125), and so on (Burnstein et al., 1994). Additional ecological precision could be added to such models by taking into account other life-history and ecological factors. For example, being willing to take a loss in an interaction with a sibling should theoretically be more likely if that sibling is in his or her late teens or early twenties (at the beginning of the reproductive years) compared to a sibling who is relatively younger or past reproductive age. The number of siblings would theoretically be relevant as well: A 2-year-old in a two-child family is, from a reproductive exchange perspective, worth more than the same child in a ten-child family because of the opportunity costs associated with investing in one individual when the possibility of investing in others is present. Similarly, a sibling who is in good health and who is highly attractive might also elicit less competitive rivalry than one who does not manifest cues to high reproductive potential (cf. Kurland & Gaulin, 2005).

Dyadic Alliances With Nonkin

Whereas cooperation is less contingent on past history of reciprocation among close kin, collaboration between less related individuals is linked to a history of reciprocal sharing (e.g., Essock-Vitale & McGuire, 1985; Fiske, 1992; Trivers, 1971). According to the principle of reciprocal altruism, our ancestors would have benefited from cooperating with others to the extent those others were likely to reciprocate (e.g., Axelrod & Hamilton, 1981; Trivers, 1971). If one expects to see another group member repeatedly, and one has reason to believe that this individual is trustworthy, then cooperation on any given interaction is less chancy than it would be with a stranger.

As in the case of kinship, membership in a dyadic reciprocal alliance ought to be associated with cognitive mechanisms designed, where possible, to keep the two interactants in the cooperate/cooperate cell. Yielding to the temptation to defect by betraying another individual can undermine a long-term productive reciprocal relationship (Frank, 1988). Indeed, there is evidence that people are quite sensitive to violations of social contracts (Cosmides & Tooby, 1989, 1992). Further, there is evidence that people will occasionally be willing to take additional losses to punish defectors (Gintis, Bowles, Boyd, & Fehr, 2003). While taking losses to punish defectors might not seem advisable in a one-shot prisoner's dilemma with a stranger, it is easier to justify over the longer term (Hagen & Hammerstein, 2006). Those who are willing to punish cheaters are establishing a reputation that can serve to reduce the probability that others will try to exploit them in the future (Frank, 1988; Kurzban, DeScioli, & O'Brien, in press).

A person's thresholds for cooperation and conflict are also likely to be influenced by group size, one's number of alternative alliance partners, and their relative frequency of interaction. For example, members of a large group may feel they have a larger pool to draw close alliance partners from. They could therefore afford to be more selective in choosing alliance partners, and more strict in enforcing the rules of exchange. However, the tolerance for free-riding may be higher when fewer good alternatives are accessible. For example, if a person has just moved to a new neighborhood, or joined a new group, he or she may be less demanding in his or her interactions with alliance partners. These are all factors that one could, in principle, quantify (i.e., counting the number of alternative partners available, the number of those regarded as members of one's inner circle, and the psychological proximity of any given alliance partner).

STATUS

Social status is a key factor in human social groups (D. E. Brown, 1989; Cummins, 1998; Eibl-Eibesfeldt, 1989; Henrich & Gil-White, 2001). Around the world, "dominant" versus "submissive" is one of the two primary dimensions on which people evaluate others (Wiggins & Broughton, 1985). Even in face-to-face interactions between complete strangers, relative status differences emerge quickly and spontaneously (Fisek & Ofshe, 1970). As Henrich and Gil-White (2001) have argued, "status" as used by social scientists is usefully separable into dominance, coercive power over others, prestige, and respect for an individual, often because of his or her skills or accomplishments.

For both sexes, there are adaptive advantages to holding high prestige and status within one's group, as both potentially increase access to resources and play important roles in the formation and maintenance of alliances. These advantages, in turn, can be leveraged to enhance one's reproductive success. Of course, striving for prestige and dominance brings concurrent costs. Establishing dominance through antagonistic encounters may be physically risky or even life threatening. Striving for prestige also requires investment of scarce resources such as the time and energy to master skills, gain knowledge, and so forth. Maintaining one's current level of status, once it is acquired, involves ongoing costs such as investing energy in competition with new challengers and eliciting resentment in underlings who do not enjoy the same benefits of status.

There is a sex-based asymmetry in the returns to status because women have a stronger preference for status when choosing mates than men do (Li & Kenrick, 2006). Dominant men, for example, can offer relatively greater protection and access to resources—both useful when caring for offspring. Consequently, males are, compared to females, more motivated to seek high levels of prestige and dominance (Hill & Hurtado, 1996; see also Sidanius & Kurzban, 2003). Men are also more likely than women to monitor their relative status within the group (Gutierres, Kenrick, & Partch, 1999). In interactions with peers, coming out on the losing side of any exchange may translate into a loss of one's perceived dominance within the group, and such losses should be of more concern and consequence for males. This might lead to systematic differences in how potential losses are weighted in decision making, with men weighting this factor more strongly than women. This pattern of results would be consistent with research indicating that males respond more aggressively when a "loss of face" is at stake (e.g., Wilson & Daly, 1985).

Like dominance, prestige can influence many different types of social interactions because high-prestige individuals can exchange their knowledge, skills, and so forth for different types of resources, both physical and social (Henrich & Gil-White, 2001; Fiske, 1992; Haslam, 1997). As Henrich and Gil-White (2001) explore in some detail, low-status individuals might be likely to defer to high-prestige individuals in many of the social "games" that are played by virtue of the benefits, either direct or as a result of externalities, generated by high-prestige people (Tooby & Cosmides, 1996; Levine & Kurzban, 2006). People of low prestige might be willing to endure costs that are difficult, but perhaps not impossible, to quantify to obtain the benefits of association with high-prestige individuals.

SELF-PROTECTION AND GROUPS

As with other primate species (Wrangham, 1987), ancestral humans frequently confronted threats from members of other groups (Baer & McEachron, 1982). Additionally, intragroup competition over status and material resources led to recurrent threats from in-group members among humans and other primate species (Daly & Wilson, 1988). Such threats often lead people to respond aggressively (e.g., Berkowitz, 1993; Dodge, Price, Bachorowski, & Newman, 1990). In addition to increasing aggressive behavior, threats also enhance affiliative motivation (Geary & Flinn, 2002;

Griskevicius, Goldstein, Mortensen, Cialdini, & Kenrick, 2006; Taylor et al., 2000; Wisman & Koole, 2003). There is safety in numbers, and a threat-induced affiliation motivation can lead to the formation of larger groups (Diamond, 1997; Kenrick et al., 2003).[3] Because males were more likely to be involved in direct conflicts with other groups, men might be expected to more easily and spontaneously band together under external threat (Tiger, 1969; Sidanius & Pratto, 1999; Van Vugt & De Cremer, in press).

Very generally, because coordinated, cooperative, intergroup conflict is historically (Keegan, 1993) and probably phylogenetically (Boehm, 1992) a largely male phenomenon, one might expect
Q2 male "coalitional psychology" (Kurzban, Cosmides, & Tooby, 2001) and its concomitant in-group bias to be more easily activated and of greater strength than the analogous psychology in women. Consistent with this logic, Van Vugt and De Cremer (in press) found that competition with an outside group led men (more than women) to contribute in a public goods task. Conversely, we would expect that men would also be more likely to disfavor out-group members in cooperative decisions.

Depending on the availability of resources, the outcomes of out-group members may be either orthogonal to one's own (when resources are abundant) or opposed (when there is competition over scarce resources). Social psychologists have long observed that intergroup hostilities increase as resources get scarce (Hovland & Sears, 1940; Hepworth & West, 1988). Because members of powerful groups might be more likely to severely punish defections during economically harsh times, the effects of limited resources might act differently on members of numerically or politically dominant or nondominant groups. One might expect that members of dominant groups, but not members of weaker minorities, are more likely to defect on the out-group in such times. When groups are more equated in power and/or numbers, iterated interactions ought to be more likely to follow a tit-for-tat rule, especially when resources are scarce.

MATE SELECTION

Because *Homo sapiens* is a sexually reproducing species, a key task is to find a mate. Human beings have only a small number of offspring in whom they invest considerable resources; hence there is a strong evolutionary incentive to make those decisions carefully. According to the logic of parental investment theory (Trivers, 1972), human females are presumed to be generally more selective than males because females' reproductive capacities are inherently more limited. Abundant research
Q3 supports this reasoning (e.g., Buss, 1989; Kenrick, Sadalla, Groth, & Trost, 1990, 1993 ; Li & Kenrick, 2006; Schmitt, 2005).

Although human males are in principle capable of having a large number of offspring at low cost, most human mating occurs within the context of long-term committed relationships in which the male contributes substantial resources to his offspring. As a consequence, males are also selective, particularly if the relationship is expected to involve long-term commitment (Kenrick et al., 1990; Li & Kenrick, 2006). The two sexes, on average, contribute somewhat different resources to their offspring: females contribute relatively more physiological resources through gestation and nursing, while males contribute by providing food, protection, and so on. There are life-history differences in the ability to provide these resources, with young postpubescent females being relatively highest in reproductive resources, but males peaking in their ability to provide indirect resources much later in life. As a consequence, women tend to emphasize resource potential in choosing men as partners, and therefore choose relatively older partners, whereas males tend to place relatively more emphasis on cues to fertility and health, and to tend to prefer females in the years of peak fertility (Kenrick & Keefe, 1992; Kenrick, Gabrielidis, Keefe, & Cornelius, 1996).

[3] We ignore here the vast literature and complications surrounding cooperation in groups (e.g., Boyd & Richerson, 2006) as it is far beyond the scope of this chapter. We simply note here that humans form groups that engage in conflict, and that this social reality can alter payoff structures in decision making in important ways.

During early phases of mate selection, females have potentially more to lose from choosing a partner who will not remain committed. Consistently, females have relatively higher thresholds for trusting a man's commitment than the reverse (Haselton & Buss, 2000). These considerations would lead us to expect that men and women will make different trade-offs during courtship. Men seeking long-term relationships should be willing, if not eager, to display their inclination toward sharing resources with their mate, in the interest of securing a high-quality mate for that type of reproductive relationship (see Miller, 2000, for an extended discussion). Women, on the other hand, ought to be more reticent to chance resource loss, and more willing to test the limits or a male's inclination to suffer losses on her behalf, since this willingness to share may serve as a signal of relationship commitment (Haselton & Buss, 2000).

Because mating can be usefully construed as a market (e.g., Waynforth & Dunbar, 1995), men's decisions to expend resources might be mediated by a potential partner's relative mate quality and, conversely, women's mate quality might regulate expectations regarding men's willingness to expend resources. In short, high-quality women can expect to fetch a high price on the mating market (e.g., Todd, 1997). Decision making in this domain would also be expected to vary with life-history changes in reproductive value. In the early reproductive years, the average female's reproductive value will outweigh the average male's. This equalizes later, and then reverses as the average female's reproductive value more rapidly declines (Kenrick & Keefe, 1992). Hence, young men might be willing to provision the largest percentage of their resource base to a potential long-term romantic partner. As men age, and their absolute level of resources increases, that same level of provisioning to a romantic partner would become relatively less costly.

This type of strategizing might also be affected by other factors. A man's willingness to expend resources on a female might follow an inverted U-shaped distribution, such that he is unwilling to expend resources on females he regards as below him in mate value, and perhaps also reticent to take resource risks on women who are clearly out of his range. In short, men can be expected to have adaptations that reflect a payoff structure in which maximizing one's return is not simply investing in the best possible mate, but investing where the marginal return is highest. Models of mate selection and signaling should reflect the importance of the marginal, rather than absolute, return on investments.

MATE RETENTION

Human infants are initially completely helpless, and young children are also dependent on their parents for protection, food, information, and other resources. Hence, their chance of survival is improved when resources are provisioned by both parents (Geary, 1998; Hrdy, 1999). Cross-culturally, a recurring feature of human social organization is cooperative relationships in which both parents contribute to the offspring's welfare (D. E. Brown, 1989). Thus, beyond merely attracting a mate, a key adaptive problem for both sexes is to maintain mating bonds with desirable partners (Buss & Schmitt, 1993; Flinn, 1988; Gangestad & Simpson, 2000).

Individuals involved in long-term mating relationships enter into what Clark and Mills (1979) term communal, as opposed to exchange, relations: they are more likely to share with one another without continuous explicit assessment of relative costs and benefits (Fiske, 1992; Tooby & Cosmides, 1996). For example, although a pair of college roommates might keep track of who owns which containers of milk and cereal, such detailed accounting is not (usually) found in (smoothly functioning) marriages. Long-term relationships, in this sense, cause a confluence of interests such that the welfare of one individual is, by virtue of this confluence, of benefit to the other individual (S. L. Brown & R. M. Brown, 2006; Fiske, 1992; see Tooby & Cosmides, 1996, for an extended discussion).

This confluence of interests should have profound effects on an individual trying to balance his or her own costs and benefits against those of another individual. This analysis can transform

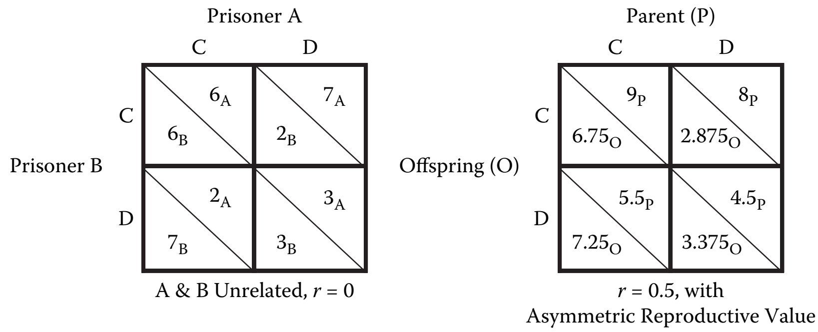

Figure 18.2 A parent and child (r = .5) playing the prisoner's dilemma where the parent has 25% remaining reproductive value and the child has 100% remaining reproductive value. The child's payoffs are his own plus .125 times the parent's payoffs, and the parent's payoffs are his own, plus .5 times the child's. The dominant strategy for the parent is to cooperate, while the dominant strategy for the child is to defect.

payoffs in a way similar to that described in Figure 18.2 . However, mating relationships are not permanent in the same way that blood relationships are, and the degree of confluence of interests varies across mated couples in a number of ways. For example, the existence of shared children is perhaps the single strongest case of a confluence of interests. If you and I share a child, we both have an interest in that child's success. Hence, I have an interest in your continued well-being and ability to invest. Of course, these calculations can be complicated by other variables. For example, if you have other children by other partners, or other mating opportunities, then this diminishes the overlap in our interests, and should attenuate my willingness to sacrifice for you.

In short, whereas coincident interests are a potentially powerful force in altering computations of costs versus benefits to self and others, opportunity costs should also figure prominently in evolved psychology. To the extent that one's investment in other relationships might yield a larger marginal return, one should expect that investment should be diverted toward these higher return social opportunities. Individuals may decide to terminate a given mateship depending on factors such as existence of offspring, the availability of resources to each parent within and outside the relationship, presence and quality of same-sex interlopers on the social horizon, and the sex ratio in the local mating pool (Kenrick & Trost, 1987; Guttentag & Secord, 1983). This, in turn, should be something to which our evolved psychology should be acutely attuned, and designed to prevent. Indeed, people experience notoriously high levels of anger and jealousy when their partners terminate a courtship (Buss, 2000; Kenrick & Sheets, 1994). These emotions probably serve several functions, not the least of which is to regain a mate who is either desirable or particularly valuable because he or she is the parent of one's offspring (there is only one person with a similar fitness interest in one's offspring as oneself—the other parent). Well-designed affective and behavioral regulation systems should take these factors into account and motivate action to remain in relationships with those who share one's (genetic) interests.

PARENTAL CARE

As just noted, human social life is not governed by one overarching principle, such as "maximize one's number of offspring" (Symons, 1992). However, reproductive fitness is clearly enhanced when one expends resources to further the welfare of one's own offspring and the offspring of one's close genetic relatives. Because both men and women face inherent constraints on reproduction, the trade-offs involved in allocating scarce resources across all available genetic outlets differ depending on factors such as life-history stage and the age range of individuals involved; investment in one genetic outlet cannot be invested in another outlet, including potential future offspring (Trivers, 1972). For example, a child produced by a young parent is, in essence, in competition with that parent's yet-to-be-born offspring for resources. If a child is born to a parent approaching the end of his or her reproductive lifespan, on the other hand, all else equal, there are fewer opportunity costs for the investment in that offspring, making present investment more likely.

Parents and children are as related as full siblings ($r = .5$). However, parents tend to invest more in their children than their siblings for several reasons. For example, the marginal benefit to young individuals is likely to be greater than the marginal benefit of investment to adults, and children have greater remaining reproductive value relative to full siblings, particularly if those siblings are older and have other access to resources. As Kurland and Gaulin (2005) note:

> Due to senescence, older individuals are less efficient at converting resources into offspring. Moreover, benefits passed to younger individuals tend to exert their effects over a longer part of the life span. Thus, aid is expected to flow from older to younger individuals because the two differ in reproductive value (the age-specific expectation of future offspring; Fisher, 1958). (p. 458)

More formally, child and parent might weight benefits delivered to the other at .5 (their genetic relatedness), but discount them according to the other's remaining reproductive value. This can transform different kinds of strategic interactions because of the differential discounting of benefits (see Figure 18.2).

In addition to remaining reproductive value, the opportunity cost of investing in any given offspring is tempered by paternity certainty. Fathers and their kin are potentially subject to the opportunity costs of mistakenly investing in a child who is not their genetic relative. Based on a review of literature on paternal certainty, Kurland and Gaulin (2006) estimate that the average rate of paternity certainty in the general population is 90%. Of course, if a man's partner displays cues that lead him to further doubt paternity, the expected discount in investment in that child may be even greater. Q4

In addition, the fact that men can produce offspring much later in their life history leads to another asymmetry. Once past their reproductive span, women have no opportunity costs associated with future direct offspring. Men, on the other hand, who have the possibility of future offspring during most of their life span, essentially always have opportunity costs associated with investing in current offspring, including potential investment in finding an additional mate and investing in additional descendants. Very broadly, this leads to the prediction that women's psychology will be designed to invest in offspring more than in men.

Parents' willingness to invest resources in a given child should be mediated by the existence of other children and, further, parents and children are expected not to agree about the allocation of benefits across children (Trivers, 1974). Even though a child and her (full) sibling are, like the child and her parent, related to one another by $r = .5$, there is a conflict of interest regarding a parent's investment in a given child. As Trivers (1974) observed, the parent will be, all else equal, generally motivated to invest similarly in multiple children, each of whom is related 50%. However, the child is related to herself 100%, so she should be motivated to demand more than an equal share of the parents' resources, because any resources diverted to siblings are subject to an r-discounted self-benefit.

Along the same lines, because people toward the end of their lives have limited possibilities for reproduction, their opportunity cost with respect to future potential offspring approaches zero. Investment in descendants—children and grandchildren—can still enhance reproductive fitness by increasing the likelihood that those descendants' genes will be passed on to future generations. The mechanisms designed to deliver these benefits should take into account the array of alternatives (children, grandchildren) and their point in their life history, all in the interest of maximizing marginal benefits (multiplied by r, as always).

These systems should also be sensitive to parental uncertainty, an issue discussed at length by DeKay (1998; see also Laham, Gonsalkorale, & von Hippel, 2005). For a mother's mother, there are no uncertain genetic links to her grandchildren in this line, and several studies have indicated that mother's mothers are in fact the grandparents who invest most in such offspring. The father's father, on the other hand, has two uncertain links, and paternal grandfathers are generally the least investing grandparents. However, Laham et al. (2005) found that the reduction in investment by paternally linked grandparents is modified by the existence of other grandchildren. If a paternal grandmother has grandchildren by both her daughter and her son, her investment in the son's offspring is reduced. If, however, she only has sons, then she invests relatively more in those grandchildren, presumably because there is no competition for her investment that would yield a higher marginal payoff.

DISCUSSION

Perhaps the main take-home message of our arguments is that many variables should be expected to act as inputs to decision-making systems designed to take advantage of opportunities for cooperation and navigate the potential costs of conflicts—and each of these inputs should have an effect on downstream decision making. Careful attention to the principles of kin selection theory, opportunity costs, and ideas drawn from an understanding of how to achieve success in markets should direct investigations in domains such as friendship, protecting oneself from enemies, seeking status, searching for mates, trying to keep an existing mate, and interacting with one's offspring. The design of the decision-making apparatus in each domain can be predicted to include features that incorporate relevant variables such as individuals' sex and life-history phase, mate value, the density and sex of other players, and the distribution of resources.

The prisoner's dilemma, used here as an example, is almost certainly not the modal payoff structure in human social interactions. For each domain, it is important to develop formal structures that model the interaction in question. In mating, the prisoner's dilemma is not nearly as relevant as market mechanisms, and ideas drawn from the relevant areas of economics can be fruitfully applied in this area (Kurzban & Weeden, 2005; Todd, 1997). Behavioral game theorists have developed any number of other games, each of which might be more or less well suited to understanding a particular set of real-life circumstances (e.g., Barash, 2003; Camerer, 2003).

S. L. Brown and R. M. Brown (2006) have suggested the interesting concept of "fitness interdependence" to describe the extent to which two individuals are affected by one another's outcomes, and would therefore be expected to act altruistically toward one another (see also Fiske, 1992; Tooby & Cosmides, 1996). Although there are likely to be distinct psychological systems designed to interact with friends as opposed to relatives, it makes some sense to consider how the different mediating variables are ultimately transformed into a decision-weight that encompasses one's valuation of the other's outcomes. Identifying the particular inputs that affect decision making with kin, friends, potential mates, and so forth should be a focus of future work. Specifically, formalizing the variables—such as life-history variables—that are likely to influence these decisions is an important direction for theoretical development.

In this chapterr, we have focused on dyadic interactions. We have considered a number of factors related to players external to a given dyad, such as the existence of additional siblings. When considering individual decisions, those other genetic relatives can be construed as opportunity costs for the investment of scarce resources. These costs may be factored into the net cost/benefit computations associated with the calculation of a single decisional outcome. Of course, dyadic partners make their decisions in complex social networks. How you treat neighbor A may affect how your neighbor B treats you, and how you in turn treat neighbor C, and so on (e.g., Levine & Kurzban, 2006). Game theorists have begun to consider how individual decisions unfold in complex social networks (e.g., Nowak & May, 1992; Nowak & Sigmund, 2004). These group-level dynamics are also likely to unfold in different ways as a function of the decision-rules used in different social domains (Kenrick, Li, et al., 2003; Kenrick & Sundie, in press). And, different decision-rules favor the emergence of different social geometries across the different social domains.

It bears reiterating the straightforward point that models are not meant to replace empirical data collection, but to assist in theory building. Models and empirical data collection can, and should, be mutually informative; with models helping to spell out the implications of theoretical assumptions, and empirical data helping to make the models more ecologically valid. Some of our reasoning in this chapter is based on existing empirical findings, but much of our speculation remains to be empirically tested.

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COMMENTS

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