

Risk-taking, Intrasexual Competition, and Homicide

Martin Daly and
Margo Wilson
McMaster University

In this chapter, we take an evolutionary psychological approach to risky decision making, social competition, sex differences, and homicide. By "evolutionary psychology," we mean the pursuit of psychological science with active consideration of current theory and knowledge in evolutionary biology, which is the field concerned with elucidating the process that gave form to brains, mind, and behavior (Daly & Wilson, 1999).

Modern evolutionists are predominantly concerned with elucidating the functional organization of living creatures ("adaptationism"), with particular reference to the creative role of Darwinian selection ("selectionism"). Although effective psychological scientists (like other life scientists; see Mayr, 1983) have always been adaptationists, they have not always been sophisticated selectionists. Psychologists have wandered down innumerable garden paths as a result of assuming that the adaptive complexity of brains and minds is organized to maximize some relatively proximal goal like happiness or homeostasis or self-actualization, rather than what evolutionary biology tells us that such complexity must really be organized to achieve, namely Darwinian fitness: the proliferative success of the focal individual's genes, relative to their alleles, in circumstances like those confronted by its evolving ancestors.

Here, we are primarily concerned with showing how an adaptationist perspective on human psychology and action can contribute to an understanding of confrontational risk-taking and lethal interpersonal violence. It is already widely appreciated that much social conflict and undesirable behavior is in some sense a consequence of the natural selective advantages enjoyed by the most selfish, and hence prolific, phenotypes, but an evolutionary perspective can take us much further than these truisms. Consideration of how selection has shaped such specifics as time preferences, social comparison processes, and sex differences can facilitate a more detailed understanding of variable willingness to take potentially lethal risks in social conflicts. If we are to mitigate the ills caused by such antisocial behavior, it will be important to elucidate exactly how human decision making implicitly computes costs and benefits, how we discount the future, and how these processes respond to imperfect predictors of outcomes, both in ontogeny and in facultative responsiveness to variable aspects of one's immediate situation. Our homicide research, as discussed below, indicates that willingness to use dangerous competitive tactics depends in predictable ways on one's material and social circumstances and life prospects. As far as we are aware, however, not much is yet known about perceptions and evaluations of the costs, benefits, and uncertainties associated with risky decision making as a function of one's material and social circumstances.

We are encouraged by recent efforts (for example, Burnstein, Crandall & Kitayama, 1994; Cosmides, 1989; Cosmides & Tooby, 1996; Gigerenzer & Hoffrage, 1995; Gigerenzer, Hoffrage, & Kleinbölting, 1991; Rode, Cosmides, Hell, & Tooby, 1999; Wang, 1996a, b) to posit and test evolutionary psychological explanations for the seemingly irrational aspects of the ways in which people process information and order their priorities. Continued success in this endeavor will depend on generating sound hypotheses about the nature of the adaptive problems that emotional reactions and other psychological processes were designed to solve, and about how these psychological phenomena are contingently responsive to life circumstances.

Risky Decision Making

Theory and research in behavioral ecology, economics, and psychology have converged on a conception of "risk" as payoff variance (for

example, Bernoulli, 1738; Friedman & Savage, 1948; Real & Caraco, 1986; Rubín & Paul, 1979; Winterhalder, Lu & Tucker, 1999). The riskier of two choices with equal expected values is that with the higher payoff variance. Preference for that option is called risk proneness or risk seeking, while preference for the low-variance option is called risk aversion. The "adaptive" or optimal response to risk is then dependent upon the form of the function relating immediate payoffs to some relatively distal but somehow more fundamental outcome, usually in another currency. In economic analyses, immediate payoffs are typically monetary, and the fact that people do not behave as if money's value is a linear function of its quantity is captured by the postulation of a higher-order, hidden currency called "utility." To an evolutionist, the subjective value represented by the economist's "utility" is still a relatively proximal currency whose functional forms have evolved as means to the end of maximizing a more distal quantity, namely fitness.

If risk-seeking inclinations predominated, social life would consist largely if not entirely of proposing and accepting even-money bets. Fortunately, risk-aversion predominates, and since Bernoulli (1738), it has been explained primarily in terms of the diminishing marginal utility of money: even-money bets are unattractive because the positive utility of a gain is almost always smaller, in absolute value, than the negative utility of a loss of the same face value. But Bernoulli's answer was too pat: Rabin (2000) has argued persuasively that diminishing marginal utility does not even come close to explaining the magnitude of risk aversion in everyday economic decision making, and it seems clear that additional psychological phenomena must be invoked. One appealing hypothesis is that people are averse to loss as well as to risk. In a classic study, Kahneman & Tversky (1979) showed that people respond very differently when identical outcomes are "framed" as gains or losses: whereas a large majority prefer a sure \$1,500 gain (the risk-averse choice) over letting a coin toss determine whether they would get \$1,000 or \$2,000, for example, they switch to risk seeking when exactly the same end states are instead portrayed as an initial award of \$2,000 followed by a choice between relinquishing \$500 or tossing a coin to see whether one must relinquish \$1,000 or nothing. It seems that losing ground from a state already attained has a negative utility in its own right, but why an evolved psyche should work like this has yet to be elucidated. Wilson

et al. (1998) proposed one possible answer, namely "that relinquishing, prior gains has evolved to be aversive in the specific context of social bargaining because, in ancestral environments, to relinquish prior gains was to advertise weakness, inviting future demands for further concessions" (p. 504).

In any event, people (and other animals) are not always risk averse, and efforts to elucidate the contingent controls of risk seeking constitute an active area of evolutionary psychological theorizing and research. One area in which men sometimes choose higher-risk options is when present circumstances are perceived as dead ends. For example, history reveals that successful explorers, warriors and adventurers have often been men who had few alternative prospects for attaining material and social success. Later-born sons of aristocratic families were the explorers and conquerors of Portuguese colonial expansion, for example, while inheritance of the estate and noble status went to first-born stay-at-homes (Boone, 1988). Similarly later-born sons and other men with poor prospects have been the ones who risked emigration among more humble folk (for example, Clarke, 1993), a choice that sometimes paid off handsomely, as in European colonial expansion, but must surely have more often led to material and genetic oblivion (for example, Courtwright, 1996). In these cases, the seemingly risky choice is really not so risky, insofar as the predictable consequence of choosing the low-risk option has scarcely more utility than the more dramatic disasters associated with failure under the high-risk option.

Experimental studies of nonhuman, animal foraging decisions have established the ecological validity of such a risk preference model. Rather than simply maximizing the expected (mean) return in some desired commodity, such as food, animals should be—and demonstrably are—sensitive to variance as well (Real & Caraco, 1986). For example, seed-eating birds are generally risk averse, preferring a low-variance foraging situation over one with a similar expected yield but greater variability, but they become risk seeking, that is switch to a preference for the high-variance option, when their body weight or blood sugar is so low as to promise overnight starvation and death unless food can be found at a higher-than-average rate (Caraco, Martindale, & Whittam, 1980). Although the high-variance option increases the bird's chances of getting exceptionally little, a merely average yield is really no better—dead is dead—and the starving

birds accept an increased risk of finding even less in exchange for at least some chance of finding enough. Such experiments, in which alternative responses yield identical mean return rates but different variances, reveal that several seed-eating birds (Barkan, 1990; Caraco & Lima, 1985), as well as rats (Hastjarjo, Silberberg, & Hursh, 1990; Kagel, Green, & Caraco, 1986), switch from risk aversion to risk proneness if their caloric intake is sufficiently reduced.

One can imagine numerous human parallels besides the explorers, adventurers, and warriors mentioned above. Taking dangerous risks to unlawfully acquire the resources of others might be perceived as a more attractive option when safer lawful means of acquiring material wealth yield a pittance, even if the expected mean return from a life of robbery is no higher and the expected life span is shorter (Daly & Wilson, 1997).

There is abundant experimental evidence that human decision making is sensitive to variance as well as to expected returns in less dramatic domains than life-threatening ventures. Psychologists and economists, using various hypothetical lottery or decision-making dilemmas, have documented that people's choices among bets of similar expected value are affected by the distribution of rewards and probabilities (Lopes, 1987, 1993), as well as being influenced by whether numerically equivalent outcomes are portrayed as gains or losses (Kahneman & Tversky, 1979). The psychological underpinnings of these choices among alternative uncertain outcomes have been conceptualized, as in the bird research, as a matter of "risk attitudes" ranging from risk aversion to risk seeking.

In practice, the concept of risk attitudes remains more behavioristic than cognitive. It is usually operationalized simply as risk avoidance or risk seeking, alternatives that could be mediated by any of various psychological processes, including adjustments of the subjective utilities of the outcomes or their subjective probabilities or both. Relatively few risk researchers have concerned themselves with such distinctions. Most are satisfied with performance measures and "as if" descriptions of the implied "decision rules," partly because subjective utilities and probabilities need not even correspond to quantities that are actually computed in the heads of creatures who are exhibiting subtle adaptive modulations of their risky decisions. For psychologists, however, the cognitive characterization of risk attitudes (that is, a correct account of how the organism combines and

uses information) is a worthy goal, and the logic of sexual selection theory suggests that psychological quantities akin to both subjective utility and subjective probability may vary between the sexes and in relation to life history variables and cues of relative success in intrasexual competition. Psychological research on variations in risk acceptance has hitherto focused primarily on sources of variability between people, including sex differences (for example, Zuckerman, 1994; Trimpop, 1994), with less attention to circumstantial determinants. It is of course well known that males are often more risk accepting than females, and there is also some recognition of life-span developmental changes in risk attitudes. But with few exceptions (for example, Wilson & Daly, 1985; Cashdan & Smith, 1990; Gardner, 1993; Rode et al., 1999), research on human risk attitudes has not yet been greatly influenced by evolutionists' ideas about what facultative psychological adaptations designed by selection might be expected to look like.

Economists and decision theorists usually insist that "risk" must be distinguished from both uncertainty and peril, but these distinctions seem artificial from an evolutionary perspective. The distinction between risk and uncertainty reflects the fact that "risky" decisions among options with precisely known probabilities are analytically tractable in a way that decisions in the face of "uncertainty" (unknown outcome probabilities and/or magnitudes) are not. With the exception of certain phenomena like national lotteries, however, circumstances in which outcome probabilities are known with precision are rare and are surely not the circumstances to which people's or other animals' evolved decision-making machinery (by which term we encompass both "reason" and psychophysiological responses that are more typically deemed "emotional") is adapted. Where an evolutionist is likely to apply a probabilistic analysis—analogue to that of an economist seeking the "rational" choice—is not in modeling the decision processes of an individual organism dealing with risk (or uncertainty) in its environment but in modeling the effects of Darwinian selection in the past. Regardless of whether outcome probabilities are known with precision, decision makers have evolved to respond to cues as statistical predictors of outcomes and ultimately of fitness consequences.

Similarly, decision theorists insist that risk and peril must be distinguished, not because they refer to domains in which distinct

decision-making adaptations operate but for analytic convenience. When "risk" is restricted to outcome variance in a single, common currency, it is much clearer how to proceed with an analysis of optimal decision making than if gains are tallied in one currency—such as calories or mating opportunities—and losses in another, seemingly incommensurate currency—such as injury or death. But to an evolutionist, the common payoff currency is again fitness, and animals do indeed behave in ways that effectively weight costs, such as the risk of death, against benefits such as mating opportunities (for example, Daly, Behrends, Wilson, and Jacobs, 1992). The example of risk-sensitive foraging by seed-eating birds, discussed above, provides a good example of how the risk of death and positive returns in another currency can be integrated into a single quantitative analysis of optimal decision making.

Sex Differences in Risk Acceptance?

There is a selectionist rationale for anticipating sex differences in utility functions and in willingness to accept or seek risk. Its premise is that ancestral males were subject to more intense sexual selection (the component of selection due to differential access to mates) than were ancestral females, with resultant effects on various sexually differentiated attributes, including adaptations for intrasexual competition and risk evaluation.

Successful reproduction, in *Homo* as in most mammals, has always required a substantial minimum investment on the part of the female, but not necessarily on the part of the male. Female fitness has been limited mainly by access to material resources and by the time and energy demands of each offspring, but the fitness of males, the sex with lesser parental investment, is much more affected by the number of mates (Bateman, 1948; Trivers, 1972). It follows that the expected fitness payoffs of increments in "mating effort" (by which term we encompass both courtship and intrasexual competition over potential mates) diminish much more rapidly for females than for males, and it is presumably for this reason that such effort constitutes a larger proportion of the total reproductive-effort budget of male mammals, including men, than is the case for their female counterparts.

Following Bateman (1948), Williams (1966) and Trivers (1972), sex differences in the variance in reproductive success are widely

considered indicative of sex differences in intrasexual competition. Relatively high variance generally entails both a bigger prize for winning and a greater likelihood of failure, both of which may exacerbate competitive effort and risk acceptance. Bigger prizes warrant bigger bets, and a high probability of total reproductive failure means an absence of selection against even life-threatening escalations of competitive effort on the part of those who correctly perceive their present and probable future standing to be relatively low. Although it is worth cautioning that fitness variance represents only the potential for selection and that variations in fitness could in principle be nonselective (Sutherland, 1985), intrasexual fitness variance appears to be a good proxy of sexual selection's intensity, since it is a good predictor of the elaboration of otherwise costly sexually selected adaptations. In comparative studies, sex differences in such attributes as weaponry for intraspecific combat are apparently highly correlated with the degree of effective polygamy of the breeding system, that is with sex differences in fitness variance (Clutton-Brock, Albon, & Harvey, 1980).

All evidence indicates that our species is, and long has been, effectively polygynous, albeit to a lesser degree than many other mammals. Successful men can sire more children than any one woman could bear, consigning other men to childlessness, and this conversion of success into reproductive advantage is cross-culturally ubiquitous (Betzig, 1985). Of course, great disparities in status and power are likely to be evolutionary novelties, no older than agriculture, but even among relatively egalitarian foraging peoples, who make their living much as did most of our human ancestors, male fitness variance consistently exceeds female fitness variance (Hewlett, 1988; Hill & Hurtado, 1995; Howell, 1979). Moreover, in addition to the evidence of sex differences in the variance of marital and reproductive success in contemporary and recent societies, human morphology and physiology manifest a suite of sex differences consistent with the proposition that our history of sexual selection has been mildly polygynous: size dimorphism with males the larger sex, sexual bimaturism with males later maturing, and sex differential senescence with males senescing faster (Harcourt, Harvey, Larson, & Short, 1981; Möller, 1988).

There is substantial evidence that men are more accepting of risk than women are. Men die in accidents at much higher rates than do

women, (for example, Holinger, 1987; Wilson & Daly, 1997), and as we shall see, the sex difference is even larger for death in aggressive altercations. Men also expose themselves to greater hazards in their recreational activities (for example, Lyng, 1990, 1993), in substance abuse (for example, Irwin et al., 1997; Millstein, 1993), and in less assiduous health monitoring and preventive health care (women visit physicians much more often than their male counterparts, after one has accounted for birth-related visits and for sex differences in rates of accident and illness (for example, Woodwell, 1997). Wilson et al. (1998) hypothesized that men would be less sensitive than women to environmental health hazards, and tested this idea by asking students to choose between alternative job prospects in which the more attractive financial option was also the one that required living in a more polluted city, with specified statistical health hazards. The sexes did not differ significantly in their responses to variation in the magnitude of the financial incentive, although males appeared to be somewhat more affected thereby, but they differed dramatically in their responses to variations in pollution and attendant health hazards. These negative attributes were important deterrents to women, but were completely disregarded by men (Figure 1).

Sexual selection theory and comparative considerations suggest not only that men will be more risk prone than women, but also that they are likely to be more concerned about their status relative to same-sex rivals. Under effective polygyny, male fitness is not just relatively variable, but also more strongly dependent upon relative social standing than female fitness, and there is considerable evidence that social status affects a man's "mate value" substantially more than it affects a woman's (Buss, 1989). These considerations suggest that social comparison motives and computation are apt to be sexually differentiated in interesting ways, but in the absence of a functional theory of how men's and women's social agendas may differ, social psychologists interested in social comparison processes have paid scant attention to possible sex differences. Studies of children, however, clearly show that boys are much more interested in hierarchical ranking than girls; they are also more consensual in their evaluations thereof, apparently because they pay more attention to rank and therefore assess it better (for example, Strayer & Strayer, 1976).

Risk taking can yield prestige as well as material gains, especially where accepting or advocating risk is likely to be interpreted as

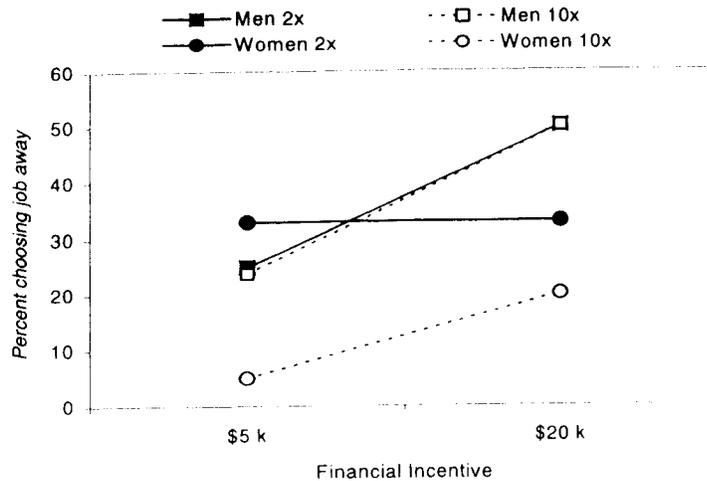


Figure 1. Percent of men and women choosing the job option that would entail moving to another city, with either a \$5,000 or \$25,000 incentive above the hometown job, and either a 2-fold or 10-fold increase in risk of respiratory problems. (Data from Wilson et al., 1998.)

indicative of confidence and, by implication, competence. This is one possible explanation for the "risky shift" phenomenon, whereby groups often arrive at riskier decisions than individuals, as well as providing a potential explanation for the fact that most such research has been conducted on males, who exhibit the phenomenon more reliably than females (for example, Kogan & Wallach, 1964). On the basis of sexual selection theory, we might expect an audience of peers to affect men more than women if displays of successful risk taking enhanced the reputations of ancestral men. Successful risk taking is indeed admired, and there is also some evidence that men are in fact responsive to the presence of an audience. For example, young male drivers take greater risks, even fatal risks, in the presence of peers than when alone (Chen, Baker, Braver, & Li, 2000; Ebbesen & Haney, 1973; Jackson & Gray, 1976; Konecni, Ebbesen & Konecni, 1976), an effect that is less conspicuous or absent in women.

We have investigated sex differences in risk acceptance and in audience effects thereon, with the use of a simple betting paradigm developed by Berg & Rietz (1997). Subjects in a first experiment were 257 undergraduates—142 men and 115 women. They were asked to pick a number between 1 and 100, ending in 5 (for example, 5, 15, 25 ... 95), and told that they would win if they drew a higher number than the one they had chosen, from a bin of 100 poker chips numbered 1 to 100. The winner's payoff increased as higher numbers were chosen, but the probability of winning declined (Table 1). Subjects

were given all the information in the first three columns of Table 1, but the expected values shown in column 4, which are maximal when subjects choose either 45 or 55, were inexplicit. Payoffs were real and immediate.

Figure 2 shows the distribution of the two sexes' choices in this experiment. Men were more likely than women to choose the low-probability, high-payoff options (85 or 95), whereas most of those who chose high-probability, low-payoff options were women. The mean choice for men was 59.3 ± 21.3 (SD), and for women 46.1 ± 20.7 . Moreover, even if one confines attention to those who "correctly" chose an expected-value-maximizing option (45 or 55), there is still a significant sex difference, with women preferring the safer 45 and men the riskier 55.

In a second experiment, we tested whether men and women were differentially affected by an audience. The 325 undergraduate subjects, 149 men and 176 women, were scheduled to participate in groups of four (not all subjects always appeared), which were randomly assigned to "public" or "private" choice conditions. All subjects received the same instructions, but in the private condition they were sequestered separately before being asked to write down their choice of number (as per Table 1), while in the public condition, subjects were asked to announce their choices in front of the others. For unknown reasons, choices were somewhat more risk averse and the average sex difference was somewhat smaller in this second experiment (conducted at a different time of year, with a different student cohort) than in the first, but the audience effects were exactly as we anticipated. Women were not demonstrably affected by witnesses, whereas men made riskier bets before witnesses (regardless of sex) than when alone (Figure 3).

Young Men as the Most Risk Accepting Demographic Group

The proposition that the "taste for risk" has been shaped by sexual selection suggests not only that it is apt to be sexually differentiated,

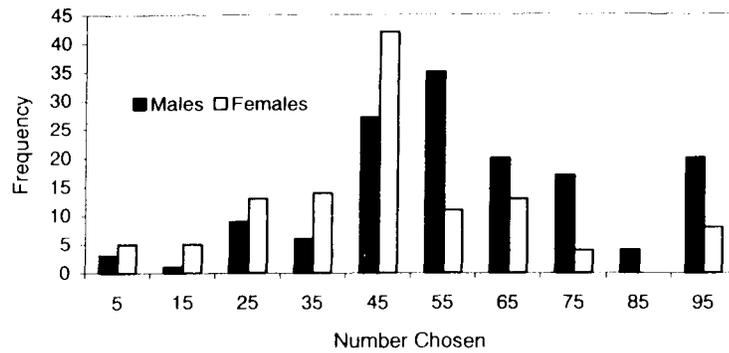


Figure 2. Frequency distribution of the numbers chosen by undergraduate men and women playing the monetary gamble portrayed in Table 1.

Table 1. *A Simple Monetary Gamble (after Berg & Rietz [1997])*

Number Chosen	Winner's Payoff (\$)	p(win)	Expected value (\$)
5	0.25	.95	0.2375
15	0.75	.85	0.6375
25	1.25	.75	0.9375
35	1.75	.65	1.1375
45	2.25	.55	1.2375
55	2.75	.45	1.2375
65	3.25	.35	1.1375
75	3.75	.25	0.9375
85	4.25	.15	0.6375
95	4.75	.05	0.2375

Note: Synopsis of instructions: Pick a number between 1 and 100, ending in 5 (5,15,25,...95). This Urn contains 100 poker chips numbered 1 through 100. Draw a chip. If it has a number higher than The number you chose, you win. How much depends on your chosen number.

but also that it might vary in relation to reliable aspects of ancestral life histories. The life stage at which men have been selected to compete most intensely for status and its perquisites appears to have been young adulthood (Daly & Wilson, 1990). Partly, this is a matter of changing social situations. Once men are husbands, they have something to lose in risky competition, and once they are fathers, they have still more to lose (if paternal investment has been important to children's welfare, as it surely has; for example, McLanahan, 1999). The intense, complex sociality of the human animal also has the crucial and unusual property that early competitive success has lasting reputational and political consequences. In most animals, a

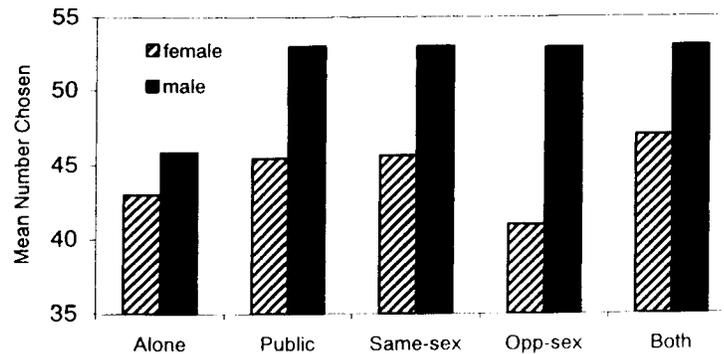


Figure 3. Mean numbers chosen by men and women playing the monetary gamble in Table 1, choosing privately versus publicly. Men made riskier bets in public than when alone ($p < .01$) regardless of sex of the witnesses; women were not demonstrably affected by witnesses.

male's access to mates and other resources depends heavily on his current competitive prowess. Risk proneness may therefore continue to increase with age as one's residual reproductive value and hence the costs, in foregone futures, of failing in a risky venture decline. But this cannot have been the case in ancestral *Homo sapiens*, for it is apparently an aspect of human nature that risk acceptance peaks dramatically in youth.

Several lines of evidence about life-span development support the conclusion that young men constitute a demographic class specialized by a history of selection for maximal competitive effort and risk taking. Some of this evidence is morphological and physiological (Daly & Wilson, 1990), but young men also appear to be psychologically specialized to embrace danger and confrontational competition. In various activities, for example, young men have been found to be especially motivated by competition and especially undeterred by danger (Bell & Bell, 1993; Gove, 1985; Jonah, 1986; Lyng, 1990;).

Demographers refer to death by accident, suicide, or homicide as death by "external" causes, and all such causes of death are more obviously affected by an individual's risk attitudes than is the likelihood of death by "internal" causes (that is, disease). It is therefore telling that all of these external causes of death rise steeply in young adults, and moreover, that this is especially true for men, so that external causes of death are maximally sexually differentiated at this

life stage (Daly & Wilson, 1988,1990; Holinger, 1987; Wilson & Daly, 1985). Of course, men die of internal causes at higher age-specific rates than women, too, but the fact that men senesce faster and die younger than women even when they are protected from external sources of mortality is itself a reflection of our species' history of sexual selection, indicating that these sex differences in mortality have prevailed long enough and persistently enough that male physiology has evolved to discount the future more steeply than female physiology.

From a psychological point of view, it is interesting to inquire how age- and sex-specific variations in effective risk proneness are instantiated in perceptual and/or decision processes. One possibility is that time horizons or discount rates change such that future rewards become relatively unattractive and present ones loom large. Other psychological processes that promote risk taking can also be envisaged. One could become more risk prone as a result of intensified desire for the fruits of success or intensified fear of the stigma of nonparticipation, or finding the adrenaline rush of danger pleasurable in itself, of underestimating objective dangers, or overestimating one's competence, or of ceasing to care whether one lives or dies. And of course, more than one of these mediating processes may be at work simultaneously. As drivers, for example, young men both underestimate objective risks and overestimate their own skills, in comparison to older drivers (Brown & Groeger, 1988; Finn & Bragg, 1986; Matthews & Moran, 1986; Trimpop, 1994). There is also some evidence that the pleasure derived from skilled encounters with danger diminishes with age (Gove, 1985; Lyng 1990, 1993). In general, "sensation-seeking" inclinations, as measured by preferences for thrilling, dangerous activities, are higher in men than in women and decrease with age (Zuckerman, 1994).

Youths are especially unlikely to seek medical assistance or other health enhancing preventive measures (Adams, Schoenborn, Moss, Warren, & Kann, 1995; Millstein, 1989), and young men are the demographic group that is most willing to take risks with drugs and intoxicants and chances of contracting sexually transmitted diseases (Irwin, 1993; Irwin, Igra, Eyre, & Millstein, 1997; Millstein, 1993). Because young men are relatively risk prone in diverse domains, it is tempting to invoke some common denominator of risk attitude. However, it is not very well established that risk acceptance in one domain predicts the same individual's risk taking in other domains (but see

Irwin et al. 1997). Zuckerman (1994) has argued that what he calls "sensation-seeking" is a stable personality characteristic: a domain-general mindset that is highly correlated with individual differences in neuron membrane physiology. He has developed a "sensation-seeking scale," on which men score significantly higher than women, and both sexes (but especially men) score highest in young adulthood. We asked subjects who participated in the hypothetical job-choice dilemma (Figure 1) to complete the Zuckerman scale, and we, too, found a significant sex difference, but "sensation-seeking" scores were unrelated to subjects' choice responses to the dilemma. We are presently conducting research aimed at assessing the degree to which risk acceptance is consistent within individuals across domains and across alternative operational definitions of "risk."

Sex Differences in Killing Same-Sex Unrelated Persons

Homicidal violence provides an interesting window on competitive risk taking. Of course, not all homicides are necessarily competitive, but a very large proportion clearly are, especially where homicide rates are high (Daly & Wilson, 1988, 1990). In particular, those cases in which victim and killer are unrelated, same-sex adults are transparently competitive: most are status contests, and those that are not occur mainly in the context of material expropriation or sexual rivalry (Wilson & Daly, 1985). These competitive contests between unrelated same-sex persons constitute the most variable component of homicide rates and hence the great majority of cases where homicide rates are high but a lesser proportion where rates are low (Daly & Wilson, 1988). And they are overwhelmingly a male affair, everywhere (Table 2).

More specifically, same-sex, nonrelative homicides are perpetrated predominantly by young men (Daly & Wilson, 1990); the age-sex pattern in Figure 4 is typical, although rates vary widely. Police investigative reports reveal that these cases are predominantly status disputes in contexts where "face" is at stake, and richer descriptions suggest that the presence of witnesses is often germane to the development of these contests (Polk, 1994). In our study of Detroit cases, a substantial proportion of same-sex, nonrelative homicides occurred in the presence of witnesses known to both antagonists, especially if the parties were relatively young (Table 3).

Table 2. *Number of Same-Sex Nonrelative Homicides for Which Information on Sex and Relationship of Killer and Victim Were Available*

Location/Years	Homicides	
	Male	Female
Chicago 1965-1989	9761	229
Detroit, 1972	316	11
Miami 1980	358	0
Canada 1974-1990	3881	94
England & Wales 1977-1990	3087	108
Scotland 1953-1974	143	5
Iceland 1946-1970	10	0
Tzeltal (Mexico) 1938-1965	15	0
Bison-Horn Maria (India) 1920-41	36	1 ^a
Munda (India)	34	0
Oraon (India)	26	0
Bhil (India) 1971-1975	50	1 ^a
Tiv (Nigeria) 1931-1949	74	1
BaSoga (Uganda), 1936-1955	38	0
Gisu (Uganda) 1948-1954	44	2
Banyoro (Uganda) 1936-1955	9	1 ^a
Alur (Uganda) 1945-1954	33	1 ^a
BaLuyia (Kenya) 1949-1954	65	3 ^a
JoLuo (Kenya) ca. 1979	22	2 ^a
!Kung San (Botswana) 1920-1955	12	0

Note: Data from Daly and Wilson, 1988, and unpublished data.

^a Victim and killer were unrelated co-wives of a polygynous man in the lone female-female cases in the Maria, Bhil, Banyoro, and Alur samples, as well as in one of the three Baluyai cases and one of two JoLuo cases. We include co-wife cases, despite otherwise excluding marital as well as genetic relatives, because unrelated co-wives represent a female analogue of male-male rivalries.

The robust "age-crime curve" illustrated in Figure 4 extends to nonlethal violence and property crimes, too (albeit sometimes less dramatically and with some differences in its precise peaks and slopes), and it has been the subject of considerable discussion by criminologists. Hirschi and Gottfredson (1983; see also Gottfredson & Hirschi, 1990) created something of a furor in sociological criminology by arguing that this age pattern is "invariant across social and cultural conditions" and "cannot be accounted for by any variable or combination of variables currently available to criminology" (p. 554), concluding that it must therefore be "biological."

Hirschi & Gottfredson's notion of a "biological" explanation is regrettably common in the social sciences: the antithesis of a "social" or "environmental" explanation, to be invoked when something is bafflingly "invariant." The irony is that theory and research in

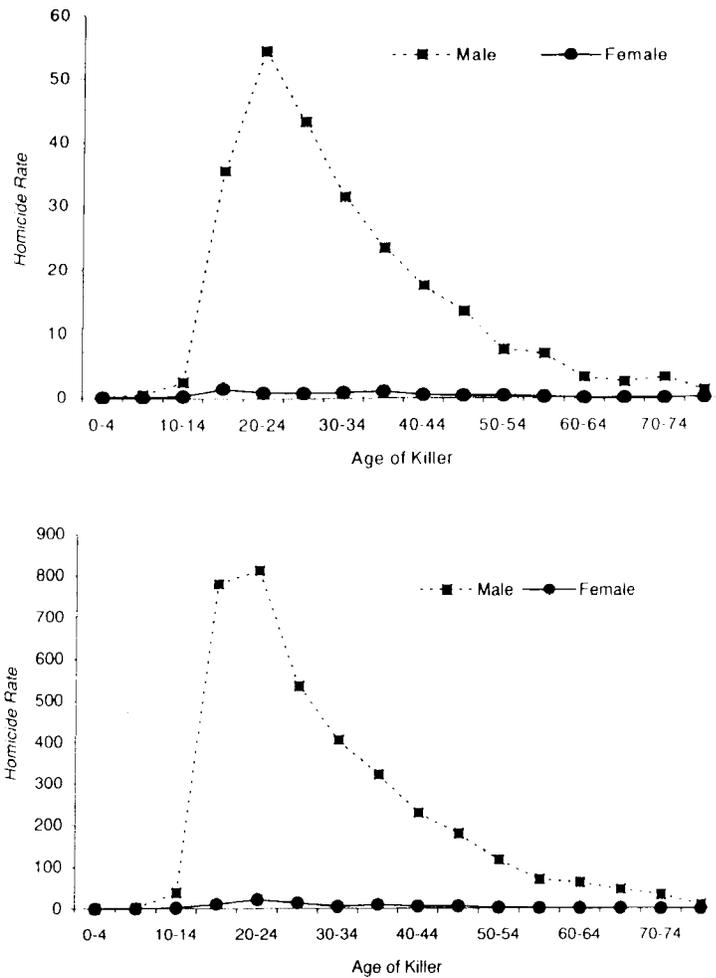


Figure 4. Age-specific homicide rates (homicides per million persons per annum) for men and women who killed an unrelated person of the same sex in Canada, 1974–1992 (upper panel), and in Chicago, 1965–1989 (lower panel). Data include all homicides known to police for whom a killer was identified. (Data from Wilson & Daly 1994).

behavioral ecology, sociobiology, and evolutionary psychology are primarily focused on contingent responses to social and material circumstances. No behavioral biologist would expect a complex animal like *Homo sapiens* to be insensitive to its social circumstances when "deciding" whether to accept a risk or escalate a contest. Thus, if it were indeed the case that the age-crime pattern is manifested without

Table 3. *Numbers of Homicides in Detroit, 1972, in Which Victim and Killer Were Unrelated Men*

Killer's age (years)	No. Homicides	Acquaintance Present (%) ^a
16-19	27	52
20-24	51	37
25-44	89	23
45-54	21	14
≥ 55	13	23

Note: Wilson and Daly (unpublished data)

^a Refers to percent of cases in which there was at least one acquaintance of both the victim and the killer present at the homicide incident.

circumstantial modulation, that fact would be as astonishing to an evolutionist as to any mainstream sociologist. But as it happens, we can withhold our astonishment: Hirschi and Gottfredson's claims are overstatements, contradicted by the homicide data. Wilson and Daly (1985) found that both employment status and marital status were major modulators of the age-specific likelihood of becoming involved in a male-male, nonrelative homicide (see also Daly & Wilson 1990). The kernel of truth in Hirschi and Gottfredson's assertions is that a peak in youth occurred whether one was married or not and whether one was employed or not. But how much of an age effect would remain if the age-associated direct effects of employment, marital status, parental status (hitherto uninvestigated), and perhaps other circumstantial correlates of age could be simultaneously controlled? Nobody yet knows, and we think both alternatives are conceivable, that is, that circumstantial correlates of age might account for virtually all the age-related variability, or that evidence of an evolved life history, with competitive prowess and inclination maximal in young adulthood, might still be substantial.

Daly and Wilson (1990) also suggested that men who are *formerly* married revert to the relatively risk prone and hence dangerous mindset of same-age single men, but they did not present evidence in support of this claim. Figure 5 provides such evidence: divorced and widowed men are more like single men than like those currently married in the rates at which they kill other unrelated men. If anything, they are even worse. These data speak against the hypothesis that the "pacifying effect" of being married is not a genuine effect at all, but a correlational consequence of the selection of different kinds of

men into the unmarried and married groups; such a hypothesis might accommodate the elevation of violence among the divorced (another select subgroup) but it cannot as readily accommodate the behavior of those who have been widowed. Thus, we favor the conclusion that marriage really is pacifying, or in other words, that currently married men are relatively risk averse in competition, presumably because they already possess that which the competition is largely about and have something to lose. Mazur and Booth's (1998) longitudinal data, showing that testosterone levels fall when men marry and rise again when the marriage ends, are readily interpreted in the same light.

Risk Acceptance and Discounting of the Future

The rate at which one "discounts the future" is the rate at which the subjective value of future consumption diminishes relative to the alternative of present consumption (or, if you like, the interest rate required to motivate foregoing consumption). If A discounts the future more steeply than B, then A will value a given present reward relative to expected future rewards more highly than B and will be less tolerant of "delay of gratification." Psychologists, economists, and criminologists have found that young adults, the poor, and criminal offenders all tend to discount the future relatively steeply. Such tendencies have been called "impulsivity" and "short time horizons," or, more pejoratively, impatience, myopia, lack of self-control, and incapacity to delay gratification. Behind the use of such terms lie two dubious presumptions, namely that steep discounting is pathological and that the appropriate weighting of present rewards against future investments is independent of life stage and socioeconomic circumstance.

Wilson and Herrnstein (1985), for example, reviewed persuasive evidence that men who engage in predatory violence and other risky criminal activity have different "time horizons" than law-abiding men, weighing the near future relatively heavily against the long term. What they failed to note is that adjustment of one's personal time horizons can be an adaptive response to predictive information about the stability of one's social order and ownership rights and one's expected longevity (Daly & Wilson, 1990; Gardner, 1993; Hawkes, 1993; Rogers, 1991, 1994).

Much of the literature on these matters treats the capacity to delay

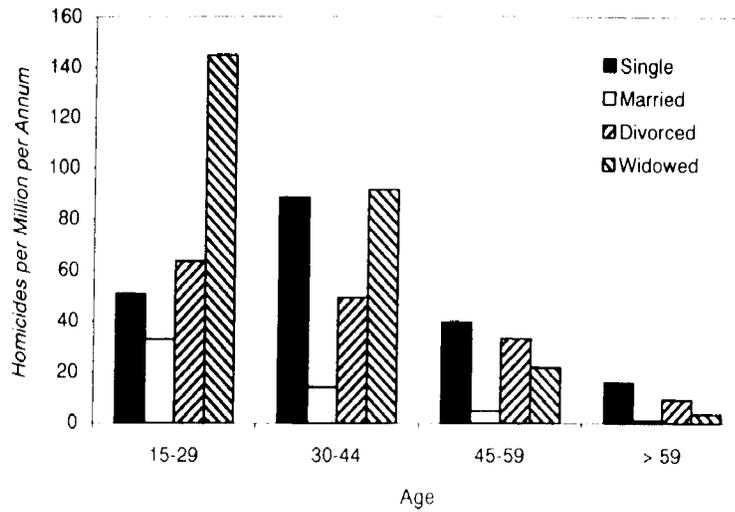


Figure 5. Rates at which men killed unrelated men in Canada, 1974–1992, in relation to the killer's age and marital status.

gratification as a proxy for intelligence. This is an anthropomorphic stance, predicated on assuming that ability to plan ahead and adjust present behavior to long-term future expectancies is a hallmark of complex cognitive capacity in which the human animal is unmatched. From an evolutionary perspective, however, discounting and delay of gratification represent essentially the same issue as that addressed by Fisher (1930) and all subsequent life-history theorists: namely, how is the future optimally weighted in deciding present allocations of effort (Candolin, 1999; Clinton & LeBoeuf, 1993; Grand, 1999; Roitberg et al., 1992; von Holst, Hutzelmeyer, Kaetzke, Khaschei, & Schönheiter, 1999)? In ancestral environments, the right answer depended on the expected present and future reproductive payoffs of alternatives, expectations that varied in relation to cues to which organisms—brainless creatures (and plants) as well as sophisticated cognizers—evolved facultative responses. From this perspective, what selects for readiness to "delay gratification" is a high likelihood that present somatic effort can be converted to future reproduction, and rather than reflecting stupidity, short time horizons characterize those with short life expectancies, those whose likely sources of mortality are independent of their actions, and those for whom the expected fitness returns of present striving are positively accelerated rather than exhibiting diminishing marginal returns.

How human beings and other animals discount the future has been described in considerable detail by experimental psychologists, but a fuller understanding of these processes requires the infusion of evolutionary adaptationist insights. The most noteworthy conundrum concerns the shape of discount functions, which are often, perhaps typically, hyperbolic (Kirby & Herrnstein, 1995). The puzzling thing about hyperbolic discount functions is that they engender predictable reversals of preference between alternative futures with different time depths and hence predictable regret of what will become bad decisions in retrospect. In consequence, people and other animals may even invest effort in erecting impediments to their own anticipated future choices of action (Kirby & Herrnstein, 1995). *Why* are the psychological underpinnings of time preference such as to produce these seemingly maladaptive internal struggles? This question can only be addressed by interpreting the relevant decision processes as adaptations to the structure of problems in nature. Kacelnik (1997) has provided a satisfying answer to the hyperbolic discounting problem by showing that such discounting is an expected consequence of mental evaluations whose function is to maximize rate of return while foraging or otherwise "investing" time in a task with sporadic returns. The real world never confronts animals with choices between rewards after different "delays," followed by obligate time-outs that make choosing the longer delay optimal. Rather, animals face options with different prey encounter rates or expected rates of return, and the opportunity to resume foraging after an interval is under one's own control. Thus, the decision maker effectively treats the delay as time invested in the task and only gets it "wrong" because of the artificiality of the lab situation.

Rogers (1994, 1997) has brought evolutionary reasoning to bear on the issue of optimal age-specific rates of future discounting, given the age-specific mortality and fertility schedules of human populations. His analysis suggests that people of both sexes should have evolved to have the shortest time horizons and to be maximally risk accepting in young adulthood. More specifically, his theoretical curve of age-specific optimal discount rates looks very much like the actual human life-span trajectory of reckless risk proneness that may be inferred from data on accidental death rates and homicide perpetration. This striking result seems paradoxical, given the argument that indicators of a short or uncertain expected future life

span should be cues favoring risk acceptance. The factors responsible for Rogers's counterintuitive result are certain peculiarities of human life history and sociality, namely gradually diminishing fertility long before death and a shifting allocation of familiarly controlled resources between personal reproductive efforts and descendants' reproductive efforts.

As argued above, criminal violence, and especially homicide in urban America, can be considered an outcome of steep future discounting and escalation of risk in social competition. On the notion that people are sensitive to social information predictive of their probable futures, Wilson and Daly (1997) hypothesized that homicide rates would vary as a function of local life expectancy and tested this idea in Chicago, a city divided into 77 longstanding "community areas" (neighborhoods) with relatively stable boundaries and social and economic characteristics. In 1990, male life expectancy at birth in these neighborhoods ranged from 54.3 to 77.4 years, even with the effect of homicide as a cause of death removed, and this life expectancy proved to be the best available predictor of neighborhood-specific homicide rates (which ranged from 1.3 to 156 homicides per 100,000 persons per annum). The bivariate correlation between these variables was $-.88$ (Figure 6).

Is it possible that people actually respond to something like a perception of local life expectancy? It is certainly conceivable that the human psyche produces what is in effect a semistatistical apprehension of the distribution of local life spans, based on the fates of salient others. If a young man's grandfathers were both dead before he was born, for example, and some of his age-mates are already dead too, discounting the future could be a normal, adaptive reaction. Moreover, if this mortality appears to be due to "bad luck" that is more or less independent of the decedent's behavior, it would make all the more sense to elevate risk acceptance in the pursuit of immediate advantage. If such inference processes exist, they are unlikely to be transparent to introspection, but they could be revealed in expressed attitudes and expectations. The direct testimony of the U.S. urban poor contains many articulate statements about the perceived risk of early death, the unpredictability of future resources, and the futility of long-term planning (for example, Hagedorn, 1988, Jankowski, 1992). One interesting question for psychological research is how relevant mental models and subjective parameters develop and are adjusted

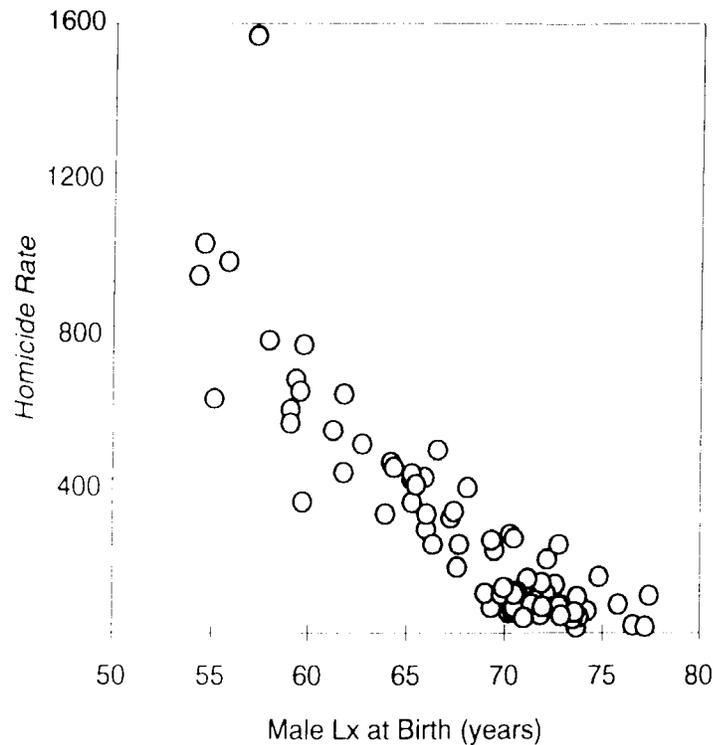


Figure 6. Neighborhood-specific homicide rates (per million per annum) in relation to male life expectancy at birth (with effects of homicide mortality removed) for 77 Chicago neighborhoods, 1988-1993 (data from Wilson & Daly, 1997).

over the life span. Another is whether media representations, including even fictitious ones, can affect such development in the same way as information about known relatives and neighbors.

Local life expectancy appears to be predictive of future discounting in nonviolent domains, too, and we suggest that cues of life expectancy may actually affect inclinations to invest in the future through education, preventive health measures, and savings, as well as decisions about the timing of major transitions and life events. In our Chicago data, the neighborhood-specific rate of absenteeism from school for nonmedical reasons ("truancy") is another variable that is negatively correlated with life expectancy. Somewhat surprisingly, this correlation is even stronger for primary school truancy ($r = -0.50$, $N = 77$, $p < .001$) than for high school ($r = -0.32$, $N = 77$, $p < .001$). One possible interpretation is that parents' inclination to "invest"

in education (to enforce school attendance) varies (as, presumably, does that of the children themselves) in relation to indicators of the likelihood that such investments in the future will eventually pay off. Similarly, studies of teenage mothers (Burton, 1990; Geronimus 1992, 1996) support the idea that the timing of major life events may be adjusted in relation to one's life expectancy. Although early reproduction among the poor is commonly viewed as an instance of social pathology and failure to exercise choice, these authors find that teenage mothers are active decision makers who expressly wish to become mothers and grandmothers while still young and efficacious because of anticipated problems of early "weathering" and poor health, and a general anticipation of a life course more compressed in time than that of more affluent people. Wilson and Daly (1997) also found support for the hypothesis that reproduction will occur earlier in the life span as one moves from high to low life-expectancy neighborhoods. The median age of new mothers was 22.6 years in the 10 Chicago neighborhoods with the shortest life expectancies, 25.4 in the 10 nearest the median, and 27.3 in the 10 neighborhoods with the longest life expectancies.

Inequity and Lethal Competitive Violence

Homicide rates are highly variable between times and places (for example, Archer & Gartner, 1984). The arguments and analyses that we have presented above suggest that much of this variability reflects variation in the severity of male-male competition. When rewards are inequitably distributed and those at the bottom of the resource distribution feel they have little to lose by engaging in reckless or dangerous behavior, escalated tactics of social competition, including violent tactics, become attractive. When the perceived perquisites of competitive success are smaller, and even those at the bottom have something to lose, such tactics lose their appeal. One might therefore expect that income inequality will account for a significant portion of the variability in homicide rates, and indeed it does.

Cross-national analyses have consistently found the Gini Index (Sen, 1973) of income inequality (which equals 0.0 when all units, usually households, have identical incomes and approaches 1.0 when all income accrues to the single wealthiest unit) to be a strong predictor of homicide rates. In fact, Gini consistently outperforms almost all other

predictors, including various indices of average income or welfare, suggesting that it is relative rather than absolute deprivation that has the greater effect on levels of violent competition. Krohn (1976), for example, found the Gini to be the best predictor of national homicide rates ($r = .6$) among several economic and social indices. The unemployment rate predicted homicide significantly less well ($r = .23$), and controlling for both unemployment and energy consumption per capita (an indicator of overall economic development) did not reduce the Gini-homicide correlation. Messner (1982) found the rate of population growth and the Gini Index to be significant predictors of homicide rates, while such candidate predictors as gross domestic product (GDP) per capita, percent urban dwellers, and school participation had no discernible effects. Krahn, Hartnagel, and Gartrell (1986) used data from a wider range of countries than had previous studies, and from several years, and found that Gini, population growth, GDP per capita, and the percent of 15- to 19-year-olds in school were the best predictors of homicide rates. Ethnic diversity, divorce rate, young adults as percent of population, defense expenditures, percent urban, and percent literate were weaker predictors that were significant in some analyses. Gartner (1990), however, found the divorce rate to be the single best predictor in 18 developed nations, with Gini second, and lesser impacts of several other variables. Interaction effects have also been noted: Krahn et al. (1986) claim that income inequality has a stronger effect on homicide rates in more democratic societies, while Avison and Loring (1986) found its impact to be greater where ethnic diversity was greater. Only Gartner's (1990) study disaggregated the overall homicide rate, and she found that Gini predicts the rates at which adults, but not children, are killed, and is a stronger predictor of men's than of women's victimization. In general, the results of these cross-national studies are highly compatible with the proposition that homicide rates "assay" the local intensity of competitive conflict, especially among men.

If inequity and the perception thereof indeed provoke escalated tactics of social competition and hence homicide, one might also expect to see more local effects. Research on income inequality and homicide rates within, rather than between, nations is relatively scarce, but the results are striking. Kennedy, Kawachi and Prothrow-Stith (1996) found that the Gini Index was significantly correlated with many components of mortality across the 50 United States in

1990, but with none more highly than homicide. Blau and Blau (1982) found that income inequality accounted for more of the variance in homicide rates among 125 U.S. cities than other measures including percent below the poverty line. Wilson and Daly (1997) analyzed data at a still finer level, namely the 77 Chicago neighborhoods, and found a bivariate correlation of $r = .75$ between an income inequality measure and the homicide rate.

Despite this abundant evidence, the proposition that inequity per se is relevant remains controversial. In an early study of income inequality's effects on property crime, Jacobs (1981, p. 14) asserted that regardless of whether one is comparing nations, states, or cities, the correlation between inequality and average income is "always negative," and this tendency for low average income and high income inequality to go hand in hand challenges the conclusion that inequity per se is critical. However, the literature provides several partial answers to this challenge. As noted above, cross-national analyses generally indicate that income inequality is a better predictor of homicide than measures of average welfare or economic development, and the more local studies support the same conclusion. In the United States, Gini is a strong predictor of state homicide rates while median household income is not, despite the two economic measures' substantial negative correlation ($r = -.57$) with one another (Figure 7). In Chicago, Wilson and Daly (1997) reported that income inequality provided significant additional prediction of neighborhood homicide rates beyond that afforded by the best predictor—male life expectancy—whereas median household income did not. Nevertheless, the substantial collinearity among economic measures continues to bedevil interpretation of such data, and it would be useful to find a case in which Jacobs's generalization is contravened by a positive association between average income and income inequality. Daly, Wilson, and Vasdev (2000) noted that the Canadian provinces provide such a case and found in various analyses that the association between inequality and homicide rates was at least as strong as in the U.S., whereas average income was apparently irrelevant (Figure 8).

The dramatic association between inequitable access to resources and homicide in modern nation states may not extend to traditional nonstate societies more like the foraging societies within which we evolved. Homicide rates in hunter-gatherers dwarf those of modern nation states (Daly & Wilson, 1988), even though material inequity

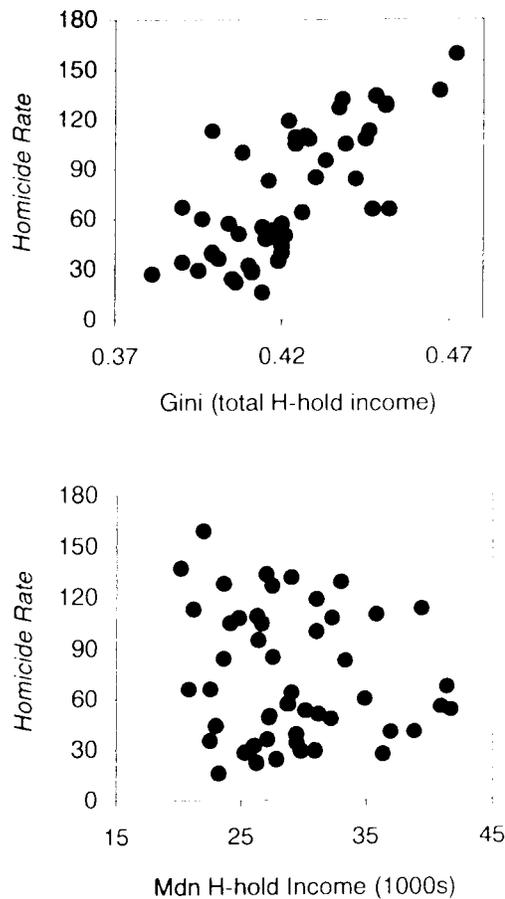


Figure 7. Income inequality predicts state homicide rates: United States 1990. Upper panel: Gini coefficient computed on basis of total household income. Lower panel: Median household income in U.S. dollars. (Data from Daly, Wilson, & Vasdev, 2000).

is seldom extreme. One reason for high homicide rates in these relatively egalitarian societies is the absence of modern medicine, which makes a broader range of wounds life-threatening, but a possibly more important reason is the absence of police power and an effective system of disinterested third-party justice. Without effective police and judiciary, a credible threat of personal or kin violence is a crucial social asset regardless of one's wealth or status, and the familiar tendency for violence to be primarily a recourse of the disadvantaged

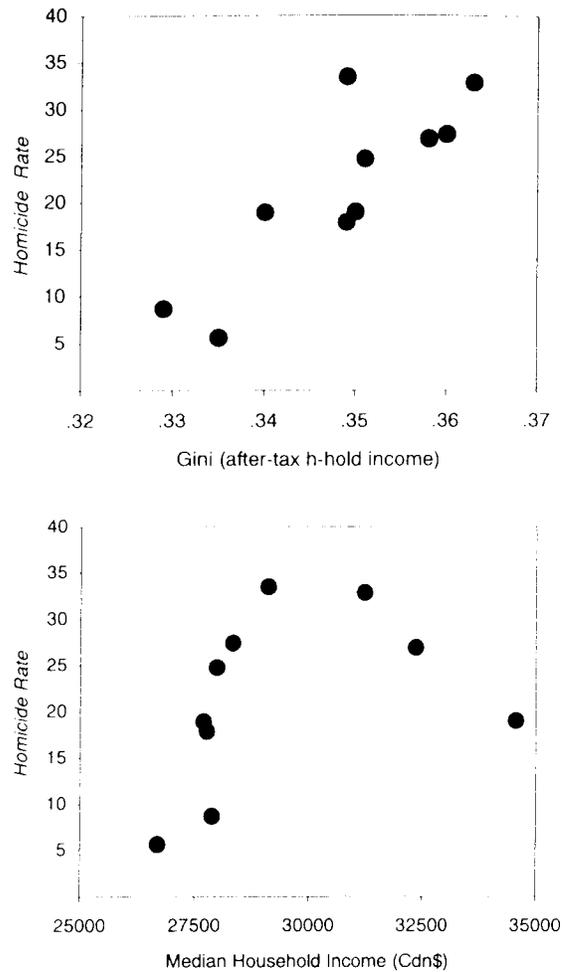


Figure 8. Income inequality predicts provincial homicide rates: Canada 1981-1996. Upper panel: Gini coefficient computed on basis of after-tax household income. Lower panel: Median household income in Canadian dollars. (Data from Daly, Wilson, & Vasdev, 2000).

disappears (for example, Chagnon, 1988). Nevertheless, we would still expect that *ceteris paribus*, dangerous tactics of social competition will be more attractive to those who have less to lose.

Our Chicago analyses, plus consideration of the social environments in which humans evolved, make us suspect that the social

comparison processes mediating the effects of inequity probably operate at a more local level than that which has been the focus of most criminological and economic research on income inequality's effects. The lives and deaths of personally known individuals are especially salient to one's mental model of one's life prospects. Nevertheless, it is also interesting to ask whether a more global perception that one lives in a "winner-take-all society" (Frank & Cook, 1995) inspires competitive escalation, and whether media portrayals (including even fictional ones) affect mental models of the rewards available to the winners.

Social scientists have long been interested in the socially undesirable effects of inequality. Where our evolutionary psychological approach differs from prior accounts is in the suggestion that inequality has its effects not only by virtue of nonadaptive or maladaptive stress effects but also by inspiring a "rational" escalation of costly tactics of social competition. This consideration complicates causal analysis, because it implies that the distribution of age-specific mortality is more than an outcome variable, having feedback effects on its own causal factors and hence on itself. Although we excluded homicide mortality from our analyses of the "effects" of life expectancy, for example, in order to eliminate spurious autocorrelational effects, it is likely that local levels of homicidal violence affect expectations of future life, discount rates, and hence further violence.

The causal links among these phenomena are dauntingly complex. If people react to a bad local milieu by discounting the future and lowering their thresholds for risk and violence, for example, the behavioral results will exacerbate the very problems that provoked them, as well as contributing to fear, distrust, and perhaps even economic inequality itself. Living where the resources that one accumulates are apt to be stolen also exacerbates these tendencies. Wilkinson (1996) argues that the behavioral and health effects of unequal resource distributions reflect breakdowns in social and community relations, a proposition that we do not dispute. But exactly how the correlated phenomena of poverty, inequality, injustice, and exogenous threats to life and well-being affect the perceptions, motives, and actions of individuals remains to be elucidated.

Conclusion

By taking an adaptationist perspective on risk taking and the motives underlying lethal interpersonal violence, we feel that otherwise seemingly irrational, immoral, and dysfunctional behavior can be better understood as reflecting the operation of sophisticated motivational and information-processing mechanisms. Risk has been conceived by psychologists, economists, and behavioral ecologists as payoff variance, and risk proneness is "rational" (and is in fact observed) when the decision maker's need or aspiration level is greater than the expected value (Caraco et al., 1980; Kacelnik, 1997; Lopez, 1987, 1993; Rode et al., 1999). Evolutionary psychologists have argued that apparent distortions in probabilistic inference are often the result of artificial information formats that an evolved human psyche is unprepared to handle (for example, Gigerenzer, this volume; Cosmides & Tooby, 1996). This is certainly true, but we also need to consider whether apparent distortions such as underestimation of hazards reflect adaptively modulated responses to aspects of the decision maker's current situation and future prospects, including the intensity of competition. The psyche did not evolve to produce numerical estimates of outcome likelihood but to generate actions that delivered the highest fitness in ancestral environments.

At present, adaptationist analysis of response to risk is best developed with regard to foraging (Kacelnik & Bateson, 1996), but we believe that it will prove to be even more useful for understanding social and sexual competition, in which subtle, facultative response to outcome distributions, local demography, and one's relative position and trajectory is rewarded. In a mildly polygynous species like *Homo sapiens*, intrasexual competition is statistically more intense among males than females, in young adulthood, among the unmarried, in communities with greater inequities in social and material wealth, and where future years of life are few or uncertain. These considerations have helped us to explain, and in some cases to discover, patterned variation in homicide rates, but our predictions are for the most part only directional rather than precise, and there is great scope for further theorizing. We also anticipate that this adaptationist approach to risk and discounting will illuminate many other spheres of social activity in addition to homicide.

References

- Adams, P. F., Schoenborn, C. A., Moss, A. J., Warren, C. W., & Kann L. (1995). Health-risk behaviors among our nation's youth: United States 1992. *Vital Health Statistics Series 10, No. 192*. Bethesda Maryland: National Center for Health Statistics.
- Archer, D., & Gartner, R. (1984). *Violence and crime in cross-national perspective*. New Haven CT: Yale University Press.
- Avison, W. R., & Loring, P. L. (1986). Population diversity and cross-national homicide: The effects of inequality and heterogeneity. *Criminology, 24*, 733-749.
- Barkan, C. P. L. (1990). A field test of risk-sensitive foraging in black-capped chickadees (*Parus atricapillus*). *Ecology, 71*, 391-400.
- Bateman, A. J. (1948). Intra-sexual selection in *Drosophila*. *Heredity, 2*, 349-368.
- Bell N. J., & Bell, R. W. (1993). *Adolescent risk taking*. Newbury Park CA: Sage.
- Berg J. & Rietz T. (1997). Do unto others: A theory and experimental test of interpersonal factors in decision making under uncertainty. Unpublished manuscript.
- Bernoulli, D. (1738). Exposition of a new theory on the measurement of risk. *Econometrica, 22*, 23-36.
- Betzig L. (1985). *Despotism and differential reproduction: A Darwinian view of history*. New York: Aldine de Gruyter.
- Blau, J., & Blau, P. (1982). The cost of inequality. *American Sociological Review, 47*, 114-129.
- Boone, J. L. (1988). Parental investment, social subordination, and population processes among the 15th and 16th century Portuguese nobility. In L. Betzig, M. Borgerhoff Mulder, & P. Turke (Eds.), *Human reproductive behaviour*. Cambridge: Cambridge University Press.
- Brown, I. D., & Groeger, J. A. (1988). Risk perception and decision taking during the transition between novice and experienced driver status. *Ergonomics, 31*, 585-597.
- Burnstein, E., Crandall, C., & Kitayama, S. (1994). Some neo-Darwinian decision rules for altruism: Weighting cues for inclusive fitness as a function of the biological importance of the decision. *Journal of Personality & Social Psychology, 67*, 773-789.
- Burton, L. M. (1990). Teenage childbearing as an alternative life-course strategy in multigenerational black families. *Human Nature, 1*, 123-143.
- Buss, D. M. (1989). Sex differences in human mate selection: Evolutionary hypotheses tested in 37 cultures. *Behavioral & Brain Sciences, 12*, 1-49.
- Candolin, U. (1999). The relationship between signal quality and physical condition: Is sexual signalling honest in the three-spined stickleback? *Animal Behaviour, 58*, 1261-1267.
- Caraco, T., & Lima, S. (1985). Foraging juncos: Interaction of reward mean and variability. *Animal Behaviour, 33*, 216-224.
- Caraco, T., Martindale, S., & Whittam, T. S. (1980). An empirical demonstration of risk-sensitive foraging preferences. *Animal Behaviour, 28*, 820-830.

Daly, M. & Wilson, M. (2001). Risk-taking, Intrasexual Competition, and Homicide. *Nebraska Symposium on Motivation, 47*: 1-36.

- Cashdan, E., & Smith, E. A. (Eds.). (1990). *Risk and uncertainty in tribal and peasant economies*. Boulder CO: Westview Press.
- Chagnon, N. A. (1988). Life histories, blood revenge, and warfare in a tribal population. *Science, 239*, 985-992.
- Chen, L. H., Baker, S. P., Braver, E. R., & Li, G. (2000). Carrying passengers as a risk factor for crashes fatal to 16- and 17-year-old drivers. *Journal of the American Medical Association, 283*, 1578-1582.
- Clarke, A. L. (1993). Behavioural ecology of human dispersal in 19th century Sweden. Unpublished doctoral dissertation, University of Michigan.
- Clinton, W. L., & LeBoeuf, B. J. (1993). Sexual selection's effects on male life history and the pattern of male mortality. *Ecology, 74*, 1884-1892.
- Clutton-Brock, T. H., Albon, S. D., & Harvey, P. H. (1980). Antlers, body size, and breeding group size in the Cervidae. *Nature, 285*, 565-567.
- Cosmides, L., (1989). The logic of social exchange: Has natural selection shaped how humans reason? Studies with the Wason selection task. *Cognition, 31*, 187-276.
- Cosmides, L. & Tooby, J. (1996). Are humans good intuitive statisticians after all? Rethinking some conclusions from the literature on judgement under uncertainty. *Cognition, 58*, 1-73.
- Courtwright, D. T. (1996). *Violent land: Single men and social disorder from the frontier to the inner city*. Cambridge MA: Harvard University Press.
- Daly, M., Behrends, P. R., Wilson, M. I., & Jacobs, L. F. (1992). Behavioural modulation of predation risk: Moonlight avoidance and crepuscular compensation in a nocturnal desert rodent, *Dipodomys merriami*. *Animal Behaviour, 44*, 1-9.
- Daly, M., & Wilson, M. (1988). *Homicide*. Hawthorne NY: Aldine de Gruyter.
- Daly, M., & Wilson, M. (1990). Killing the competition. *Human Nature, 1*, 83-109
- Daly, M., & Wilson, M. (1997). Crime and conflict: Homicide in evolutionary psychological perspective. *Crime and Justice, 22*, 251-300.
- Daly, M., & Wilson, M. (1999). Human evolutionary psychology and animal behaviour. *Animal Behaviour, 57*, 509-519.
- Daly, M., Wilson, M., & Vasdev, S. (in press). Income inequality and homicide rates in Canada and the United States. *Canadian Journal of Criminology, 43*.
- Ebbesen, E. B., & Haney M. (1973). Flirting with death: Variables affecting risk-taking at intersections. *Journal of Applied Psychology, 3*, 303-324.
- Finn, P., & Bragg, B. W. E. (1986). Perception of the risk of an accident by young and older drivers. *Accident Analysis & Prevention, 18*, 289-298.
- Fisher, R. A. (1930). *The genetical theory of natural selection*. Oxford: Clarendon Press.
- Frank, R. H., & Cook, P. J. (1995). *The winner-take-all society*. New York: Simon and Schuster.
- Friedman, M., & Savage, L. J. (1948). The utility analysis of choices involving risk. *Journal of Political Economy, 56*, 279-304.
- Gardner, W. (1993). A life-span rational-choice theory of risk taking. In N. J.

- Bell & R. W. Bell (Eds.). *Adolescent risk taking* (pp. 66-83). Newbury Park CA: Sage.
- Gartner, R. (1990). The victims of homicide: A temporal and cross-national review. *American Sociological Review, 55*, 92-106.
- Geronimus, A. T. (1992). The weathering hypothesis and the health of African-American women and infants: Evidence and speculation. *Ethnicity & Disease, 2*, 207-221.
- Geronimus, A. T. (1996). What teen mothers know. *Human Nature, 7*, 323-352.
- Gigerenzer, G., & Hoffrage, U. (1995). How to improve Bayesian reasoning without instruction: Frequency formats. *Psychological Review, 102*, 684-704.
- Gigerenzer, G., Hoffrage, U., & Kleinbölting, H. (1991). Probabilistic mental models: A Brunswikian theory of confidence. *Psychological Review, 98*, 506-528.
- Gottfredson, M. R., & Hirschi, T. (1990). *A general theory of crime*. Stanford CA: Stanford University Press.
- Gove, W. R. (1985). The effect of age and gender on deviant behavior: A biopsychosocial perspective. In A. S. Rossi (Ed.), *Gender and the life course* (pp. 115-144). New York: Aldine.
- Grand, T. C. (1999). Risk-taking behaviour and the time of life history events: Consequences of body size and season. *Oikos, 85*, 467-480.
- Hagedorn, J. D. (1988). *People and folks*. Chicago: Lake View Press.
- Harcourt, A. H., Harvey, P. H., Larson, S. G., & Short, R. V (1981). Testis weight, body weight, and breeding system in primates. *Nature, 293*, 55-57.
- Hastjarjo, T., Silberberg, A., & Hursh, S. R. (1990). Risky choice as a function of amount and variance in food supply. *Journal of the Experimental Analysis of Behavior, 53*, 155-161.
- Hawkes, K. (1993). Why hunter-gatherers work: An ancient version of the problem of public goods. *Current Anthropology, 34*, 341-361.
- Hewlett, B. S. (1988). Sexual selection and paternal investment among Aka pygmies. In L. Betzig, M. Borgerhoff Mulder, & P. Turke (Eds.), *Human reproductive behaviour*. Cambridge: Cambridge University Press.
- Hill, K., & Hurtado, A. M. (1995). *Ache life history*. Hawthorne NY: Aldine de Gruyter.
- Hirschi, T., & Gottfredson, M. R. (1983). Age and the explanation of crime. *American Journal of Sociology, 89*, 552-584.
- Holinger, P. C. (1987). *Violent deaths in the United States*. New York: Guilford Press.
- Howell, N. (1979). *The demography of the Dobe !Kung*. New York: Academic Press.
- Irwin, C. E. (1993). Adolescence and risk taking. In N. J. Bell & R. W. Bell (Eds.), *Adolescent risk taking*. Newbury Park CA: Sage.
- Irwin, C. E., Igra, V., Eyre, S., & Millstein, S. (1997). Risk-taking behavior in adolescents: The paradigm. *Annals of the New York Academy of Sciences, 817*, 1-35.

Daly, M. & Wilson, M. (2001). Risk-taking, Intrasexual Competition, and Homicide. *Nebraska Symposium on Motivation*, 47: 1-36.

- Jackson, T. T., & Gray, M. (1976). Field study of risk-taking behavior of automobile drivers. *Perceptual and Motor Skills*, 43, 471-474
- Jacobs, D. (1981). Inequality and economic crime. *Sociology and Social Research* 66, 12-28.
- Jankowski, M. S. (1992). *Islands in the street*. Berkeley: University of California Press.
- Jonah, B. A. (1986). Accident risk and risk-taking behaviour among young drivers. *Accident Analysis & Prevention*, 18, 255-271.
- Kacelnik, A. (1997). Normative and descriptive models of decision making: Time discounting and risk sensitivity. In G. Bock & G. Cardew (Eds.). *Characterizing human psychological adaptations*(pp. 51-70). Ciba Foundation Symposium 208. London: Wiley.
- Kacelnik, A., & Bateson, M. (1996). Risky theories: The effects of variance on foraging decisions. *American Zoologist*, 36, 402-434.
- Kagel, J. H., Green, L., & Caraco, T. (1986). When foragers discount the future: Constraint or adaptation? *Animal Behaviour*, 34, 271-283.
- Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision-making under risk. *Econometrica*, 47, 263-291.
- Kennedy, B. P., Kawachi, I., & Prothrow-Stith, D. (1996). Income distribution and mortality: Cross sectional ecological study of the Robin Hood index in the United States. *British Medical Journal*, 312, 1004-1007, 1194.
- Kirby, K. N., & Herrnstein, R. J. (1995). Preference reversals due to myopic discounting of delayed reward. *Psychological Science*, 6, 83-89.
- Kogan, N., & Wallach, M. A. (1964). *Risk taking: A study in cognitive and personality*. New York: Holt.
- Konecni, V. J., Ebbesen, E. B., & Konecni, D. K. (1976). Decision processes and risk-taking in traffic: Driver response to the onset of yellow light. *Journal of Applied Psychology*, 61, 359-367.
- Krahn, H., Hartnagel, T. F., & Gartrell, J. W. (1986). Income inequality and homicide rates: Cross-national data and criminological theories. *Criminology*, 24, 269-295.
- Krohn, M. D. (1976). Inequality, unemployment and crime: A cross-national analysis. *Sociological Quarterly*, 17, 303-313.
- Lopes, L. L. (1987). Between hope and fear: The psychology of risk. *Advances in Social Psychology*, 20, 255-295.
- Lopes, L. L. (1993). Reasons and resources: The human side of risk taking. In N. J. Bell & R. W. Bell (Eds.), *Adolescent risk taking* (pp. 29-54). Newbury Park CA: Sage.
- Lyng, S. (1990). Edgework: A social psychological analysis of voluntary risk taking. *American Journal of Sociology*, 95, 851-856.
- Lyng, S. (1993). Dysfunctional risk taking: Criminal behavior as edgework. In N. J. Bell & R. W. Bell (Eds.), *Adolescent risk taking* (pp. 107-130). Newbury Park CA: Sage.
- Matthews, M. L., & Moran, A. R. (1986). Age differences in male drivers'

- perception of accident risk: The role of perceived driving ability. *Accident Analysis & Prevention*, 18, 299-313.
- Mayr, E. (1983). How to carry out the adaptationist program? *American Naturalist*, 121, 324-334.
- Mazur, A., & Booth, A. (1998). Testosterone and dominance in men. *Behavioral & Brain Sciences*, 21, 353-397.
- McLanahan, S. (1999). Father absence and the welfare of children. In E. M. Hetherington (Ed.), *Coping with divorce, single parenting, and remarriage: A risk and resiliency perspective* (pp. 117-145). Mahwah NJ: Lawrence Erlbaum.
- Messner, S. F. (1982). Societal development, social equality, and homicide: A cross-national test of a Durkheimian model. *Social Forces*, 61, 225-240.
- Millstein, S. G. (1989). Adolescent health: Challenges for behavioral scientists. *American Psychologist*, 44, 837-842.
- Millstein, S. G. (1993). Perceptual, attributional, and affective processes in perceptions of vulnerability through the life span. In N. J. Bell & R. W. Bell (Eds.), *Adolescent risk taking* (pp. 55-65). Newbury Park CA: Sage.
- Möller, A. P. (1988). Ejaculate quality, testes size, and sperm competition in primates. *Journal of Human Evolution*, 17, 479-488.
- Polk, K. (1994). *When men kill*. Cambridge: Cambridge University Press.
- Rabin, M. (2000). Diminishing marginal utility of wealth cannot explain risk aversion. In D. Kahneman & A. Tversky (Eds.), *Choices, values and frames* (202-208). New York: Cambridge University Press.
- Real, L., & Caraco, T. (1986). Risk and foraging in stochastic environments. *Annual Review of Ecology & Systematics*, 17, 371-390.
- Rode, C., Cosmides, L., Hell, W., & Tooby, J. (1999). When and why do people avoid unknown probabilities in decisions under uncertainty? Testing some predictions from optimal foraging theory. *Cognition*, 72, 269-304.
- Rogers, A. R. (1991). Conserving resources for children. *Human Nature*, 2, 73-82.
- Rogers, A. R. (1994). Evolution of time preference by natural selection. *American Economic Review*, 84, 460-481.
- Rogers, A. R. (1997). The evolutionary theory of time preference. In G. Bock & G. Cardew (Eds.), *Characterizing human psychological adaptations* (pp. 231-252). Ciba Foundation Symposium 208, London: Wiley.
- Roitberg, B. D., Mangel, M., Lalonde, R. G., Roitberg, C. A., van Alphen, J. J. M., & Vet, L. (1992). Seasonal dynamic shifts in patch exploitation by parasitic wasps. *Behavioral Ecology*, 3, 156-165.
- Rubin, P. H. & Paul, C. W. (1979). An evolutionary model of taste for risk. *Economic Inquiry*, 17, 585-596.
- Sen, A. (1973). *On Economic Inequality*. Oxford: Oxford University Press.
- Strayer, F. F., & Strayer, J. (1976). An ethological analysis of social agonism and dominance relations among preschool children. *Child Development*, 47, 980-989.

Daly, M. & Wilson, M. (2001). Risk-taking, Intrasexual Competition, and Homicide. *Nebraska Symposium on Motivation*, 47: 1-36.

- Sutherland, W. J. (1985). Measures of sexual selection. *Oxford Surveys in Evolutionary Biology*, 1, 90-101.
- Trimpop, R. M. (1994). *The psychology of risk taking behavior*. Amsterdam: North-Holland.
- Trivers, R. L. (1972). Parental investment and sexual selection. In B. Campbell (Ed.), *Sexual selection and the descent of man, 1871-1971* (pp. 134-179) Chicago: Aldine.
- von Holst, D., Hutzelmeyer, H., Kaetzke, P., Khaschei, M., & Schönheiter, R. (1999). Social rank, stress, fitness, and life expectancy in wild rabbits. *Naturwissenschaften*, 86, 388-393.
- Wang, X. T. (1996a). Domain-specific rationality in human choices: Violations of utility axioms and social contexts. *Cognition*, 60, 31-63.
- Wang, X. T. (1996b). Framing effects: Dynamics and task domains. *Organizational Behavior and Human Decision Processes*, 68, 145-157.
- Wilkinson, R. G. (1996). *Unhealthy societies: The afflictions of inequality*. London: Routledge.
- Williams, G. C. (1966). *Adaptation and natural selection*. Princeton NJ: Princeton University Press.
- Wilson, J. Q., & Herrnstein, R. J. (1985). *Crime and human nature*. New York: Simon & Schuster.
- Wilson, M., & Daly, M. (1985). Competitiveness, risk-taking and violence: The young male syndrome. *Ethology & Sociobiology*, 6, 59-73.
- Wilson, M., & Daly, M. (1993). Lethal confrontational violence among young men. In N. J. Bell & R. W. Bell (Eds.), *Adolescent risk taking* (pp. 84-106). Newbury Park CA: Sage.
- Wilson, M., & Daly, M. (1997). Life expectancy, economic inequality, homicide and reproductive timing in Chicago neighbourhoods. *British Medical Journal*, 314, 1271-1274.
- Wilson, M., Daly, M., & Gordon, S. (1998). The evolved psychological apparatus of human decision making is one source of environmental problems. In T. Caro (Ed.), *Behavioral ecology and conservation biology* (pp. 501-523) New York: Oxford University Press.
- Winterhalder, B., Lu, F., & Tucker, B. (1999). Risk-sensitive adaptive tactics: Models and evidence from subsistence studies in biology and anthropology. *Journal of Archaeological Research*, 7, 301-348.
- Woodwell, D. A. (1997). National ambulatory medical care survey: 1995 summary. National Center for Health Statistics (Centers for Disease Control & Prevention, Atlanta) *Advance Data*, 286, 1-28.
- Zuckerman, M. (1994). *Behavioral expressions and biosocial bases of sensation seeking*. Cambridge: Cambridge University Press.