

Original Article

Sex Differences in Everyday Risk-Taking Behavior in Humans

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Abstract: Sexual selection theory predicts that males will tend to behave in ways that are more risky than females. We explored this in humans by studying two everyday situations (catching a bus and crossing a busy road). We show that humans are competent optimizers on such tasks, adjusting their arrival times at a bus stop so as to minimize waiting time. Nonetheless, single males pursue a more risky strategy than single females by cutting waiting times much finer. Males are also more likely than females to cross busy roads when it is risky to do so. More importantly, males are more likely to initiate a crossing in high risk conditions when there are females present in the immediate vicinity, but females do not show a comparable effect in relation to the number of males present. These results support the suggestion that risk-taking is a form of “showing off” used as mate advertisement.

Keywords: risk, sex differences, optimization, behavioral decisions, road-crossing

Introduction

Evolutionary theory predicts that, in polygamously mating species, young males will be more willing to take risks in an effort to breed successfully than young females. This is most conspicuous in lekking species, where males may exhibit bright plumage or conspicuous displays that make them more susceptible to predation than is the case for females. In species like humans where risk-taking may itself become a form of display, this sex difference may be exaggerated and risk-taking may characterize many aspects of behavior. Many studies have noted that young human males are more prone than females to take risks in relation to conflict (Campbell, 1999; Daly and Wilson, 1988; Wilson and Daly, 1993,) and sexual behavior (Clift, Wilkins, and Davidson, 1993; Poppen 1995), as

well as in such situations as car driving (Chen, Baker, Braver, and Li, 2000; Flisher, Ziervogel, Charlton, Leger, and Roberston, 1993; Harre, Field, and Kirkwood, 1996), accident risk (Fetchenhauer and Rohde, 2002), drug-taking (Tyler and Lichtenstein, 1997), gambling and financial decisions (Bruce and Johnson, 1994, Powell and Ansic, 1997) and outdoor activities (Howland, Hingson, Mangione, and Bell, 1996, Wilson, Daly, Gordon, and Pratt, 1996). Indeed, psychological studies have found that females find risky situations more stressful than males do (Kerr and Vlaminkx, 1997). In this context, risk-taking by males may be a form of mating display (Hawkes, 1990, 1991).

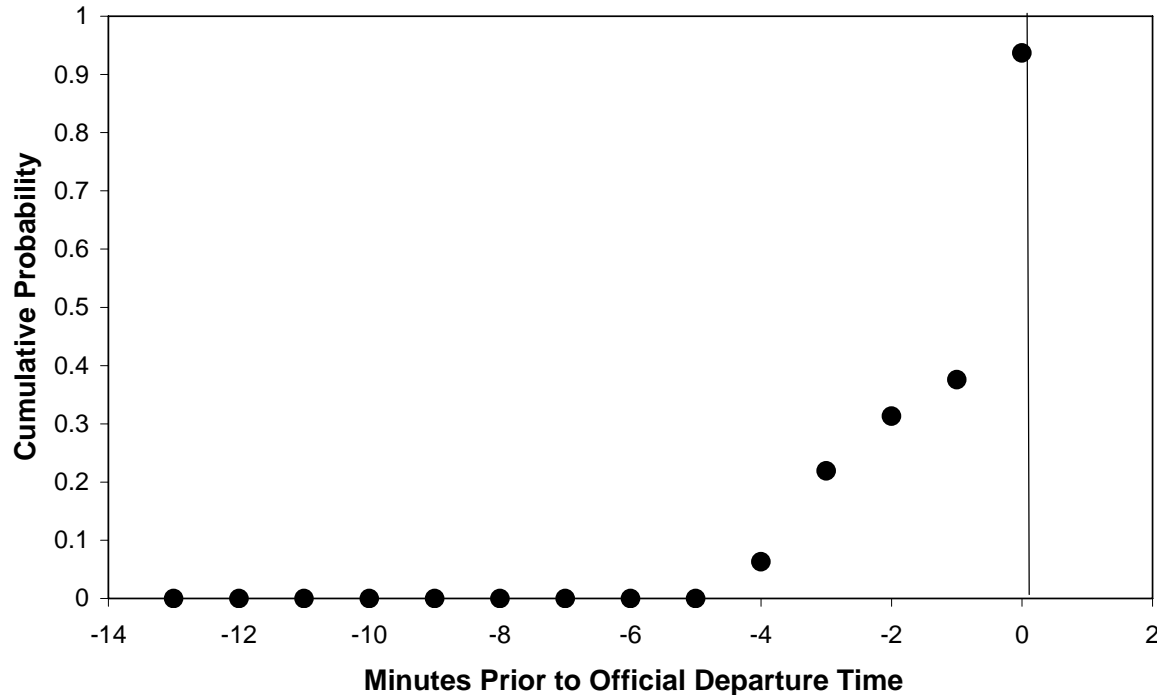
Most of these studies of humans focus on situations that, in one degree or another, are life-threatening (or which may have serious consequences for subsequent health and wealth). In this paper, we report results showing that sex differences in risk-taking occur even in simple everyday situations that do not necessarily incur significant risks. We consider two examples: catching a bus and crossing a road.

We use these data to explore two separate issues. The first offers us the opportunity to examine the trade-offs between the costs and benefits of alternative courses of action: individuals can either arrive early (but thereby incur a cost because they have to wait in the cold: playing safe) or they can arrive closer to departure time (but at the risk that the bus may already have left by the time they arrive at the bus stop: risky strategy). The riskiness of the latter option is created by the fact that buses often leave before their official departure times (especially if the bus has already filled to capacity). The second study allows us to explore more directly the possibility that risk-taking may be a form of male mating display (*sensu* Hawkes, 1991).

Methods

The observations for the first study were carried out at a single bus stop which students habitually use to get to the University of Liverpool campus (about 2.5km distant). Most of the housing in the immediate area of the bus stop is student accommodation. A bus to the university campus specifically provided for students starts its journey at this bus stop. The bus usually arrives up to 12 minutes before its official departure time and waits at the stop. All the observations were carried out on the bus that was officially timed to depart at 0940 a.m.: departure times were, however, randomly distributed around the official departure time. Figure 1 gives the cumulative frequency distribution for all bus departure times, relative to the official departure time of 0940 hrs. For convenience, all times have been converted to the number of minutes before the official bus departure time. The data are given as the proportion of all buses ($n = 32$) that departed up to and including the minute shown.

Figure 1. Cumulative probability distribution of actual bus departure times ($n = 32$ days). The vertical line marks the official bus departure time. The X-axis is scaled as the number of minutes prior to the official departure time of the bus.



The arrival times of individual males and females and the subsequent bus departure times were noted on 32 mornings over a four-month period during the winter months. However, only those days on which the bus left at the appointed time (or later) were included in the analyses of risk-taking behavior in order to be sure that all arrivals up to and including the minute at which the bus should have gone could be counted. This yielded a sample of 20 mornings. On two of these, the bus left later than the appointed time, but only arrivals up to and including the official departure time were counted for analysis. The arrival times of 475 females and 524 males were recorded in the samples for the 20 days used in the analysis.

The second study was carried out at a busy road crossing in the middle of the University campus over the midday period. The crossing point was provided with a light-controlled pedestrian crossing. Individual subjects were selected as they approached the crossing and the following variables recorded: sex and approximate age (by decade) of subject, risk state of road on approach, whether the subject crossed or waited, risk state of the road when the subject crossed, whether the subject was a leader or a follower when he/she crossed, number and sexes of all individuals on the subject's side of the crossing

point at the moment he/she crossed. Over a three month period, a total of 500 males and 500 females were sampled in this way. The risk state of the road was defined in terms of the risk of being hit by a vehicle when crossing at that moment (see Table 1).

Table 1. Risk state of the road crossing.

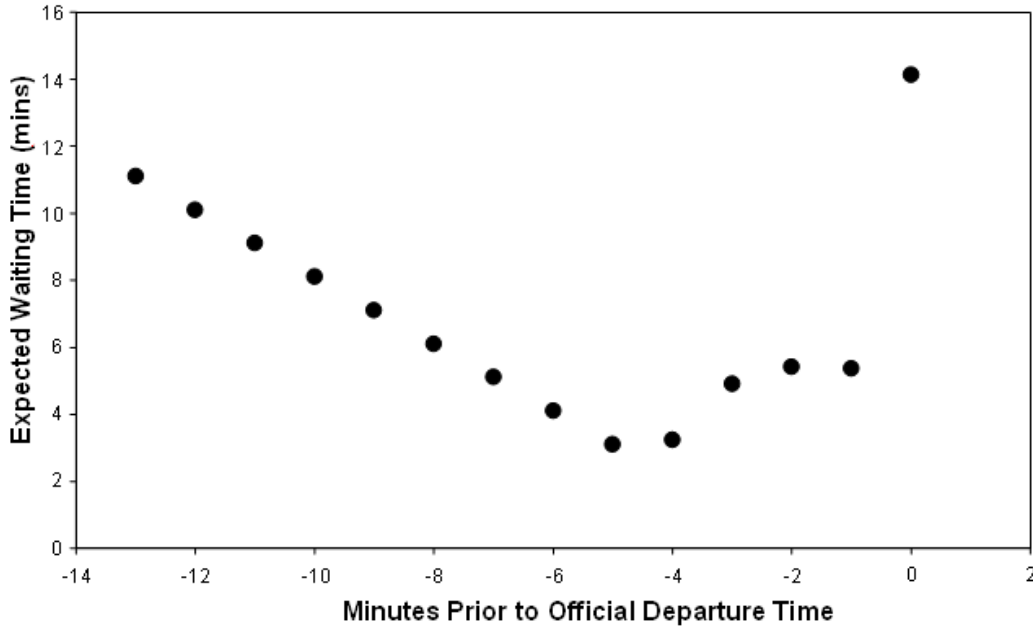
Risk State	Definition
No risk	Traffic stationary at traffic signal; safe to cross
Low risk	Traffic can approach, but no vehicles within 50m
Risky	Vehicle approaching (within 50m) but not at crossing
High risk	Vehicles passing through the crossing

Results

Optimizing bus waiting time

The bus departure times given in Figure 1 can be used to calculate the mean delay to the next bus at each minute, noting that individuals who miss the bus at time 0 minutes have to wait on average a further 14.12 minutes for the next student bus. (This is calculated as the weighted delay to the departure of the next bus, given that the official departure time is 15 minutes after the first, but with a probability density function for departure times similar to that shown in Figure 1.) The results are shown in Figure 2. The minimum delay occurs at minute 5, and this represents the optimal arrival time that trades off time spent waiting in the cold by arriving early against the risk of missing the bus.

Figure 2. Predicted waiting time for individuals arriving at indicated times prior to the official departure time of the bus, estimated from the actual departure times given in Figure 1.

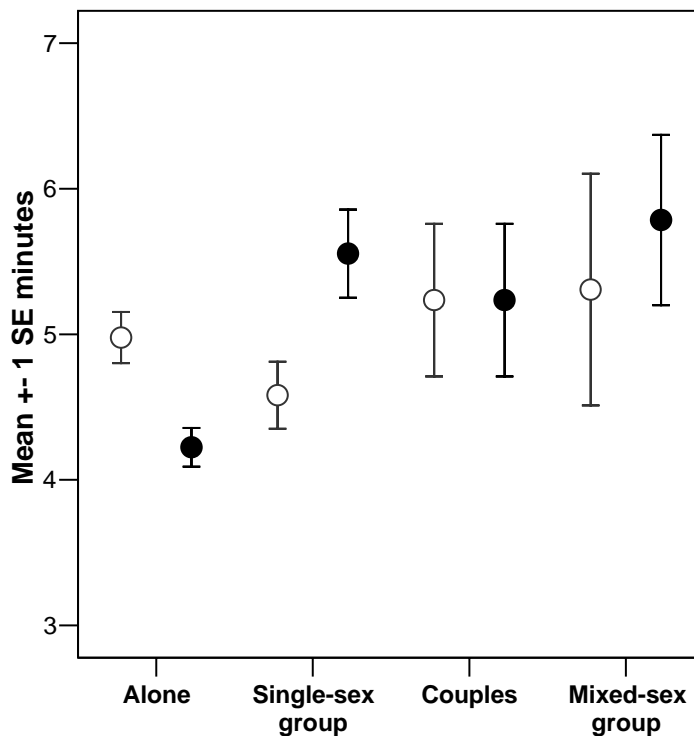


Females were more likely to arrive in groups than were males (42.0% vs. 28.6%, respectively: $\chi^2 = 19.71$, $df = 1$, $p < 0.001$). Therefore, to avoid confounds due to social factors and pseudoreplication when individuals arrive in groups, we separate out individuals who arrive alone from those who arrive in groups. Figure 3 gives the mean minutes prior to departure at which males and females in different group types arrived. Males arriving alone did so significantly later than females arriving alone (mean arrival times: $4.22 \pm 0.133SE$ vs. $4.98 \pm 0.176SE$ minutes prior to departure, respectively; Kolmogorov-Smirnov test: $Z = 1.609$, $n = 375,275$, $p = 0.011$). Note that the mean arrival time for females (4.98 minutes prior to departure) is almost exactly the optimal arrival time identified in Figure 2 (five minutes). Since there is considerable variance in the data, we divided arrival times into three blocks differing in riskiness: minutes 12-6 (cautious period), minutes 5-4 (optimal period) and minutes 3-0 (risky period). Females arriving alone (i.e. those whose arrival times are not influenced by others) were significantly more likely to arrive during the cautious period, whereas males arriving alone were more likely to arrive during the risky period ($\chi^2 = 10.75$, $df = 2$, $p = 0.001$). These results stand even when days are considered as the unit of analysis (for subjects arriving alone, medians of 43.7% of males vs. 28.2% of females arrived during the risky period: Wilcoxon matched pairs test, $n = 20$ days, $p = 0.033$ 2-tailed).

When individuals arrived on their own, males did so significantly later than females (i.e. they cut the waiting time to a minimum). However, when they arrived in single sex

groups, males were more likely to arrive earlier than females (though not significantly so: means of $5.55 \pm 0.303SE$ vs. $4.58 \pm 0.230SE$; Kolmogorov-Smirnov test, $n = 86$ and 138 , $p = 0.157$). A likely explanation for this is that these males were actually late for the previous bus: this suggestion is reinforced by the fact that female arrival times do not vary significantly across group type (Kruskal Wallis $\chi^2 = 1.92$, $n = 424$, $df = 3$, $p = 0.589$), whereas those for males do (Kruskal Wallis $\chi^2 = 17.38$, $n = 446$, $df = 3$, $p = 0.001$). Moreover, when males accompanied females in couples, their arrival times were the same as those for single females (Kolmogorov-Smirnov $Z = 0.614$, $n = 43,275$, $p = 0.846$), but significantly different from (and later than) those for single males ($Z = 2.382$, $n = 43,375$, $p = 0.044$), suggesting that male behaviour was being driven by that of the females.

Figure 3. Mean \pm SE of number of minutes prior to the departure of the next bus that males (solid symbols) and females (open symbols) arrived at the bus stop in groups of different composition.

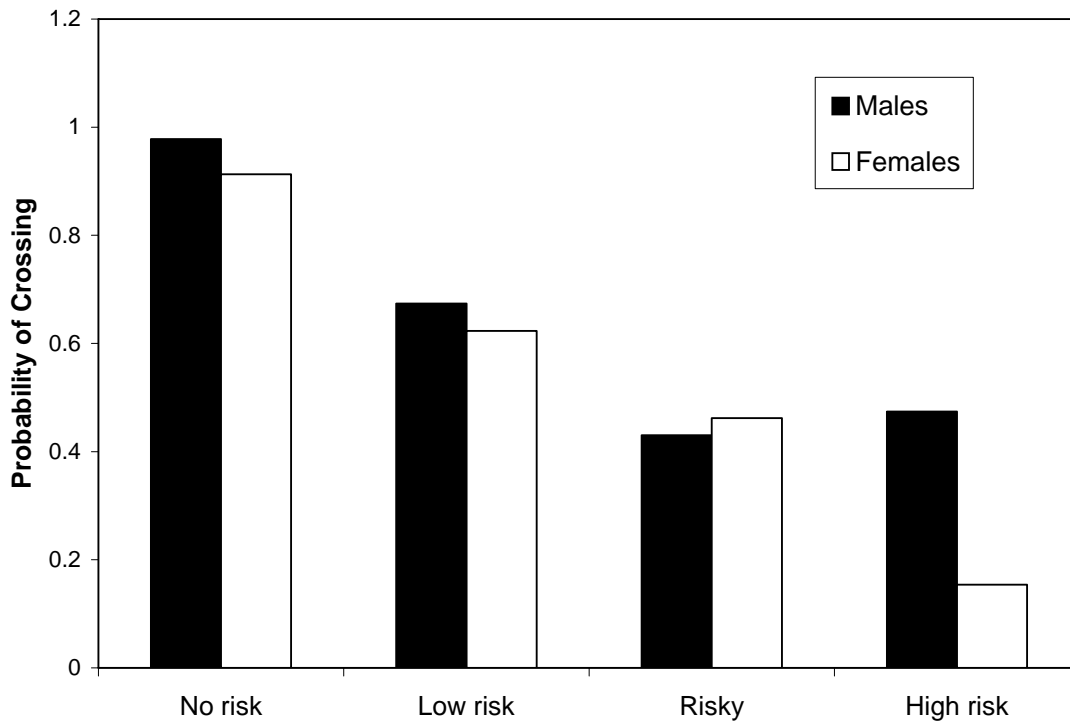


Road-crossing

Figure 4 shows the frequencies with which males and females crossed the road at different risk states. Males are significantly more likely to cross the road at higher risk states than females ($\chi^2 = 32.56$, $df = 3$, $p < 0.001$). This is reinforced by a comparison of

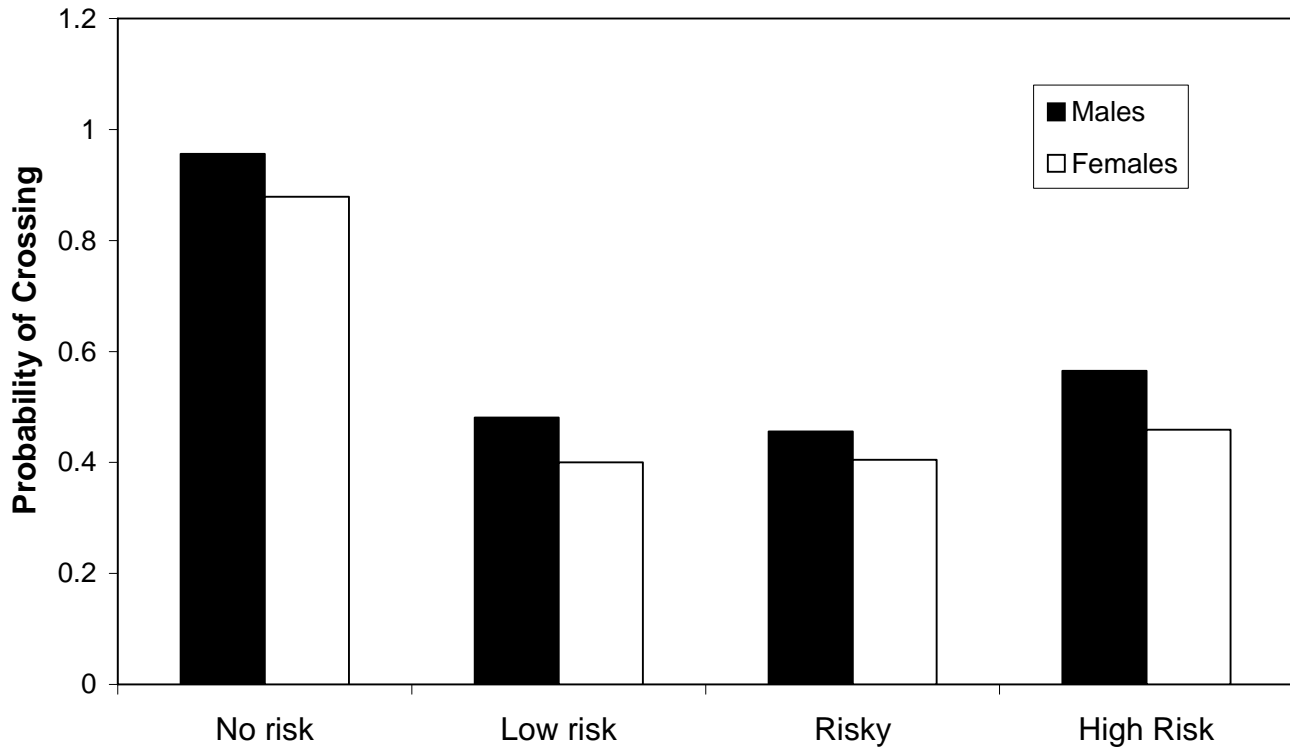
sex differences in the riskiness at road crossing for individuals who approached the road when it was on the highest risk state (vehicles on the crossing): males arriving at this risk state crossed at significantly more risky states than females did ($\chi^2 = 52.27$, $df = 3$, $p < 0.001$).

Figure 4. Frequencies with which males and females crossed the road at different risk states.



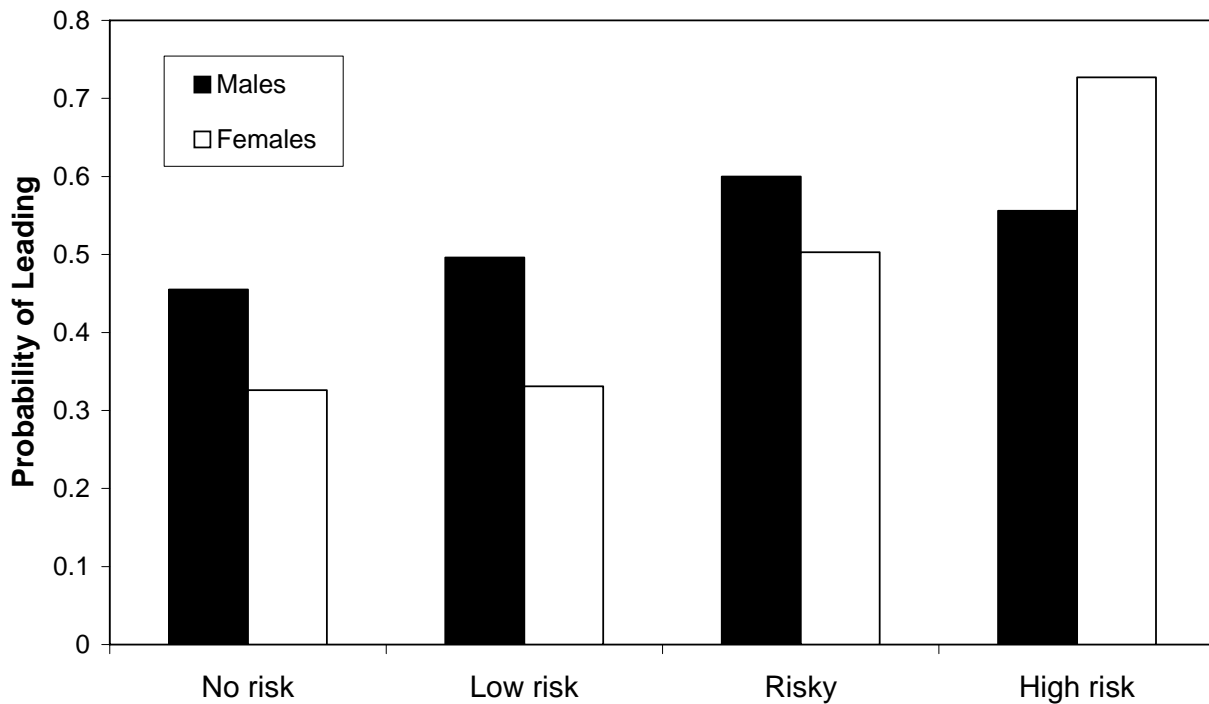
In a significant number of instances, the subject arrived at the crossing when a vehicle was approaching or on the crossing (high risk states). In these cases, subjects either crossed or waited until the risk state of the crossing was reduced. Figure 5 plots the probability of crossing for the two sexes in relation to the risk state of the road at the moment of arrival. Overall, males are less likely to wait than females ($\chi^2 = 19.02$, $df = 1$, $p < 0.001$), and this difference was true at each risk state except the lowest (no risk: $\chi^2 = 2.49$, $df = 1$, $p > 0.05$).

Figure 5. Relative frequency with which males and females would wait rather than cross in relation to the risk state of the road on their arrival at the crossing.



Overall, males were more likely to act as leaders (initiators of a crossing) than were females (Figure 6: $\chi^2 = 12.15$, $df = 1$, $p < 0.001$). This was true at all risk levels except very risky, where, paradoxically, females were more likely to lead than follow compared to males. However, males were three times more likely to cross in the highest risk category than females were (90 vs. 33 occasions) and, in absolute terms, were twice as likely to be leaders (50 vs. 24 occasions).

Figure 6. Probability that males and females act as leaders (initiate a crossing) in relation to the risk state of the road on crossing.



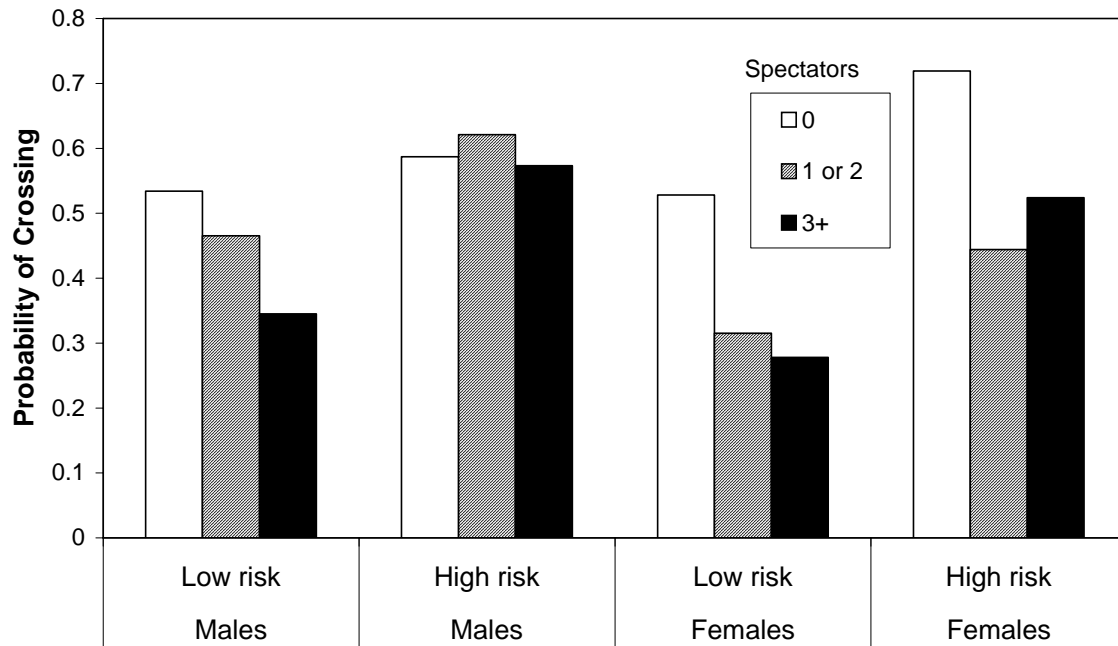
To examine spectator effects on risk-taking, we analyzed the risk at crossing in relation to the number of males and females on the subject's side of the road at the moment of crossing for those occasions when the subject was a leader (i.e. initiated a crossing). Table 2 gives the resulting analyses of variance, with risk state at crossing as the dependent

variable. The number of females present (but not the number of males) has a significant effect on the male's crossing pattern, but females show only a weak (non-significant) effect due to the number of males present. Figure 7 plots these data in the form of the probability of initiating a crossing (i.e., acting as "leader") as a function of the number of members of the opposite sex present for high and low risk states at crossing. While the probability of crossing typically declines as audience size increases for both sexes, it remains high for males in the high risk condition, suggesting a greater willingness to take risks when there are females present to display to.

Table 2. ANOVA for risk state at crossing for each sex in relation to numbers of males and females present at the time.

Variable	<i>F</i>	<i>df</i>	<i>p</i>
<hr/>			
(a) <i>Males</i>			
Number of males	1.24	13,406	0.251
Number of females	1.78	14,406	0.039
Males x females	1.11	66,406	0.271
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(b) <i>Females</i>			
Number of males	1.69	13,413	0.060
Number of females	0.54	12,413	0.891
Males x females	1.32	60,413	0.065
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Figure 7. Probability with which males and females initiated a road crossing (i.e. were leaders) in relation to risk state and the number of members of the opposite sex who were waiting on their side of the road. Low risk states are “no risk” and “slight risk;” high risk states are “risky” and “very risky”.



Discussion

We have shown that males are more likely to take risks than females, even in everyday situations that are relatively unlikely to incur life-threatening costs. This suggests that risk-taking is a pervasive feature of human male psychology. In addition, we have shown that males' risk-proneness even at this level is related to the presence of females in the immediate vicinity. We infer from this that male risk-taking is a form of mating display (*sensu* Hawkes, 1990), comparable to other forms of mate advertising peculiar to modern humans (e.g. display of mobile phones: Lycett and Dunbar, 2000). In this case, risk-taking is assumed to reflect something about gene quality rather than the resources a male has to offer.

Even though both sexes seemed to be quite efficient at optimizing their arrival times

at a bus stop so as to trade off the risk of missing the bus against waiting time, males and females appear to differ in their willingness to pursue risky strategies in this context. Males are more likely to cut their arrival times fine (and sometimes miss the bus as a result, thereby incurring longer waiting times than they need have done in cold winter temperatures, as well as being late for a class). An alternative explanation for these results might be that human females are more resistant to cold and are therefore more willing to spend longer in cool temperatures by arriving early. However, sex differences in subcutaneous fat volume might be expected to have exactly the opposite effect: the issue is not how long you spend waiting for a particular bus but the risk of having to wait for the *next* bus because you arrived after your target bus had left. With their lower subcutaneous fat volumes, males ought to be more risk-averse than females because they would bear more significant costs from heat-loss if they missed the bus. In contrast, heat-loss cannot possibly be an explanation for the sex differences in road-crossing behavior, yet similar sex-biases in risk-taking emerge from this study. This suggests that the sex differences observed in the bus study are genuine differences in risk-sensitivity.

It is worth pointing out here that, in evaluating the optimal arrival time in the bus study, we considered only the expected waiting time. Part of the costs of waiting lie in the rate of heat loss when exposed to low ambient temperatures. While we treated this as more or less constant (and modest), a change in local climatic conditions can be expected to have a significant impact on the optimal arrival time. As ambient temperatures fall, so the cost of waiting increases and the optimal arrival time can be expected to drift towards the official bus departure time (minute 0) and the payoff function (as shown in Figure 2) will become more strongly peaked. Conversely, as temperatures rise, so the constraints on waiting time will weaken and the payoff function should become flatter. We should thus expect to see differences both between locations and, within locations, between seasons and days in both the shape of the payoff function and the consequent behavior of individuals.

The difference in risk-taking behavior might be the result of either of two rather different effects. One is that males are more prone to risk-taking as a form of display and merely implement it under all conditions; the other is that males are more reluctant to waste time on inessential activities (such as waiting at a bus stop). For females, such an activity may have additional functional benefits in terms of social interaction (e.g. servicing social relationships). Because males may be less social than females, waiting around at bus stops may be less advantageous for them. Some support for this second interpretation is given by the suggestion that males were less social than females in our sample: they were more likely than females to arrive at the bus stop alone rather than in groups. In either case, we interpret these proximate functional considerations as being derivative of differences between the sexes in long term reproductive strategies.

However, perhaps the strongest evidence in support of a generic advertising hypothesis is the fact that risk-taking by males during road-crossings is directly affected by the presence of female (but not male) spectators, whereas the female's behavior is only marginally (and non-significantly) influenced by the presence of males. Indeed, females are more likely to act as followers than leaders in these situations. These observations make it much less likely that it is social factors that are driving the sex differences in risk-taking behavior.

Groups clearly impose constraints on the behavior of individuals, since the stability of a group through space and time depends on its members compromising on their preferred options. Males in mixed sex groups seem to give way to females' demands as far as arrival time is concerned, and are thus more likely to optimize arrival time than lone males (itself a suggestion that mate-searching tactics may be more important than purely social considerations). In contrast, the apparently optimal behavior of males in single-sex groups (at least compared to single males) is probably an artifact: the arrival times for males in single-sex groups are clearly bimodal, with peaks at three minutes and eight minutes before departure. No less than a third of males in groups arrived nearer to the departure time of the previous bus (i.e. more than seven minutes before the bus's official departure time). One explanation might be that males in single sex groups in fact behave like single males, except that grouping has the effect of slowing them down in order to accommodate the slowest member, such that they are more likely to miss the bus. These individuals thus appear in our data as early arrivals when they are in fact late-comers. This is reflected in the fact that the minute eight peak is much higher in single sex group males than it is for single males (where the minute three and minute one peaks are higher). In contrast, males in mixed-sex groups behave very differently: reproductive and mate choice considerations seem to dictate that males fall into line with female behavioral patterns in these groups.

Whatever the proximate reasons for the behavior patterns shown by males might be (e.g. the desire to spend longer in bed, a dislike of waiting around), the fact is that their behavior is shifted into a more risky part of the state space relative to that for females. Although they did not consider sex differences as such, Hoffrage, Weber, Hertwig, and Chase, (2003) have shown, at least for children, that risk-taking does seem to generalize across contexts: children who were more prone to taking risks when crossing roads were also more prone to taking risks in gambling games. Sexual selection theory would suggest that this is a consequence of males' behavior being driven more strongly by the demands of mating tactics than that of females.

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