Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Journal of Theoretical Biology 239 (2006) 450–459
Journal of Theoretical Biology
www.elsevier.com/locate/yjtbi

Violent men have more sons: Further evidence for the generalized Trivers–Willard hypothesis (gTWH)

Satoshi Kanazawa*

Interdisciplinary Institute of Management, London School of Economics and Political Science, Houghton Street, London WC2A 2AE, UK

Received 31 May 2005; received in revised form 25 July 2005; accepted 10 August 2005
Available online 21 October 2005

Abstract

The generalized Trivers–Willard hypothesis (gTWH) [Kanazawa, S., 2005a. Big and tall parents have more sons; further generalizations of the Trivers–Willard hypothesis. J. Theor. Biol. 235, 583–590] proposes that parents who possess any heritable trait which increases the male reproductive success at a greater rate than female reproductive success in a given environment have a higher-than-expected offspring sex ratio, and parents who possess any heritable trait which increases the female reproductive success at a greater rate than male reproductive success in a given environment have a lower-than-expected offspring sex ratio. One heritable trait which increases the reproductive success of sons significantly more than that of daughters in the ancestral environment is the tendency toward violence and aggression. I therefore predict that violent parents have a higher-than-expected offspring sex ratio (more sons). The analysis of both American samples and a British sample demonstrates that battered women, who are mated to violent men, have significantly more sons than daughters.

Keywords: Evolutionary psychology; Offspring sex ratio; Trivers–Willard hypothesis; Generalized Trivers–Willard hypothesis (gTWH)

1. Introduction

In their classic paper, Trivers and Willard (1973) suggest that parents might under some circumstances be able to vary the sex ratio of their offspring in order to maximize their reproductive success. The Trivers–Willard hypothesis (TWH), which has become one of the most influential propositions in evolutionary biology, proposes that, for all species for which male fitness variance exceeds female fitness variance, male offspring of parents in better material and nutritional condition are expected to have greater reproductive success than their female siblings, because their greater size allows them to outcompete their intrasexual rivals and monopolize available reproductive opportunities. The converse is true of offspring of parents in poorer material and nutritional condition, because the smaller males, who are not intrasexually competitive, are excluded from mating opportunities. Parental condition affects the reproductive prospects of female offspring to a much lesser extent. Almost all females get to reproduce some offspring, even though no female can produce a large number due to their greater obligatory parental investment into each offspring (Trivers, 1972). Trivers and Willard (1973) thus hypothesize that parents in better condition should produce more male offspring than female offspring. Their facultative parental investment into male and female offspring should be similarly biased. These predictions have been supported by data from a large number of experiments with a wide array of species (Venezuelan opossum: Austad and Sunquist, 1986; Red deer: Clutton-Brock et al., 1986; Spider monkey: Symington, 1987). Recent meta-analyses of the TWH and facultative sex ratio manipulation include Ewen et al. (2004) for birds, Sheldon and West (2004) for ungulates specifically, and Cameron (2004) for mammals in general.

*Tel.: +44 2079557297.
E-mail address: s.kanazawa@lse.ac.uk.

0022-5193/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jtbi.2005.08.010

Evolutionary psychologists have since applied the original formulation of the TWH to modern humans and derived further hypotheses. Sons' expected reproductive success depends largely on the parents' wealth, so that sons from wealthy families are expected to attain much greater reproductive success than sons from poor families. This is because sons from wealthy families typically inherit the wealth from their fathers, and can in turn invest the resources into their offspring. Women prefer to mate with men with greater resources, and thus wealthy men throughout human evolutionary history have been able to attract a large number of high-quality mates (Betzig, 1986).

In contrast, daughters' expected reproductive success is largely orthogonal to parents' wealth, because it mostly depends on their youth and physical attractiveness. Men in general prefer younger and physically more attractive women, not wealthy women, for their mates (Buss, 1989; Kanazawa, 2003). The TWH in both of its specifications (offspring sex ratio and biased parental investment) has been supported with data from a wide variety of human societies, including the contemporary United States (Betzig and Weber, 1995; Gaulin and Robbins, 1991; Kanazawa, 2001; Mueller, 1993). Cronk (1991) provides a comprehensive review of the empirical evidence in support of the hypothesis, and Trivers (2002, pp. 120–122) adds a brief update on the status of the TWH.

While the TWH is one of the most celebrated principles in evolutionary biology and the preponderance of empirical evidence supports it, it has nonetheless received some criticisms. Myers (1978) and Leimer (1996) provide analytical critiques of the TWH's predictions. A comprehensive review (Brown, 2001) and a meta-analysis (Brown and Silk, 2002) find no consistent evidence for the TWH in the nonhuman primate literature. For the human populations, Koziel and Ulijaszek (2001) provide only qualified support, and Freese and Powell (1999), Keller et al. (2001), Ellis and Bonin (2002) find no support for the TWH for contemporary North America.

2. Generalized Trivers–Willard hypothesis (gTWH)

While the TWH in its original formulation has specifically to do with material and economic conditions of parents and their ability to vary the sex ratio of their offspring in response to such conditions, the basic insight behind it may be more general. The fundamental assumption underlying the TWH is that, if males are expected to attain greater reproductive success than females, *for whatever reason*, then parents may have more sons than daughters. If, in contrast, females are expected to attain greater reproductive success than males, *for whatever reason*, then parents may have more daughters than sons. While female fitness variance is much smaller than male fitness variance among mammalian species, there is still variance among females, and some women do better than others, in terms of the quality, if not quantity, of their offspring.

Kanazawa (2005a) thus proposes the gTWH:

> gTWH: Parents who possess any heritable trait which increases male reproductive success at a greater rate (or decreases male reproductive success at a smaller rate) than female reproductive success in a given environment will have a higher-than-expected offspring sex ratio (more males). Parents who possess any heritable trait which increases female reproductive success at a greater rate (or decreases female reproductive success at a smaller rate) than male reproductive success in a given environment will have a lower-than-expected offspring sex ratio (more females).

Since parental wealth and status are two heritable (at least culturally, if not genetically) traits of parents which increase the sons' reproductive success to a much greater degree than they increase the daughters', the original formulation of the TWH (Trivers and Willard, 1973) is indeed a special case of the gTWH as stated above. Burley's (1986) experiment has previously demonstrated a similar effect of parental attractiveness on the offspring sex ratio among zebra finches.

There has been some emerging evidence for the gTWH with respect to a variety of heritable traits which increase the reproductive success of offspring of one sex or the other.

2.1. Brain types

Kanazawa and Vandermassen (2005) synthesize the TWH with Baron-Cohen's extreme male brain theory of autism. Baron-Cohen (1999, 2002, 2003; Baron-Cohen and Hammer, 1997; Baron-Cohen, Lutchmaya and Knickmeyer, 2004) postulates systemizing (figuring things out) and empathizing (relating to people) as two orthogonal continua along which a person's brain can vary. He calls the brain of someone who is higher on the systemizing dimension than on the emphasizing dimension "the male (Type S) brain," and that of someone who is higher on the empathizing dimension than on the systemizing dimension "the female (Type E) brain." Baron-Cohen further suggests that the Type S brain was adaptive for ancestral men while the Type E brain was adaptive for ancestral women, and that brain types are substantially heritable. Kanazawa and Vandermassen then derive logical implications of the convergence of Baron-Cohen's theory and the TWH, and predict that, if Type S brain increases male reproductive success in the ancestral environment and Type E brain increases female reproductive success in the ancestral environment, then individuals with strong Type S brains (such as engineers and mathematicians) should have more sons than daughters, and individuals with strong Type E brains (such as nurses and school teachers) should have more daughters than sons. Their analysis of the 1994 US General Social Surveys confirms their predictions.

2.2. Body size

In the ancestral environment, where male intrasexual competition for mates was both fierce (due to the absence of socially imposed monogamy) and largely if not entirely physical in character, big and tall men had particular advantages over smaller and shorter men. In contrast, large body size was not particularly adaptive for ancestral women. Probably for this reason, taller men to this day have greater reproductive success than shorter men (Nettle, 2002a; Pawlowski et al., 2000), but shorter women have greater reproductive success than taller women (Nettle, 2002b). And body size (height and weight) is substantially heritable (Chambers et al., 2001; Silventoinen et al., 2001). Kanazawa (2005a) therefore predicts that taller and heavier parents have a higher-than-expected number of sons, and shorter and lighter parents have a lower-than-expected number of sons (or a higher-than-expected number of daughters). His analysis of both lifetime number of children and recent pregnancies from the National Child Development Study and the British Cohort Study largely supports his predictions.

2.3. Physical attractiveness

Physical attractiveness is one heritable characteristic which increases daughters' reproductive success much more than sons'. Men universally seek women who are physically attractive for both long- and short-term mating (Buss, 1989) because physical attractiveness is a phenotypic marker of genetic and developmental health (Thornhill and Møller, 1997). In contrast, women seek physically attractive men only for short-term mating (extra-pair copulations) but not for long-term mating, for which resources and status are more important (Buss, 1989; Gangestad and Simpson, 2000). The logic of the gTWH would therefore predict that physically attractive parents should have higher-than-expected number of daughters, and, conversely, lower-than-expected number of sons. Kanazawa's (2005b) analysis of the National Child Development Study and the British Cohort Study demonstrates that physically more attractive women have more girls and produce more female fetuses.

2.4. Language impairment

Tallal et al. (1989) show that mothers (but not fathers) with a developmental language impairment have an exceedingly high sex ratio (.7143: 25 boys vs. 10 girls). Women normally have greater language and communication skills than men, and thus language impairment is relatively more problematic and maladaptive for girls than for boys. It is an example of a heritable trait that would decrease female reproductive success to a much greater extent than it decreases male reproductive success, and thus the gTWH would predict that language-impaired parents should have more sons than daughters.

There is therefore converging and accumulating evidence that parental ability to vary offspring sex ratio, first recognized by Trivers and Willard in 1973, may be more general than originally thought. The condition that triggers a biased sex ratio may not be limited to the parents' material and economic condition, but may extend to all factors that affect the sex-specific reproductive success in a given environment, so long as such factors are heritable.

Another heritable trait which increases sons' reproductive success much more than daughters' is the tendency toward violence and aggression. In the ancestral environment, much of male intrasexual competition for mates was physical in nature. Even today violent and aggressive men in contemporary hunter-gatherer societies tend to have more wives and greater reproductive success (Chagnon, 1997; Redmond, 1994). The most prolific father in recorded history, with at least 1042 children, was the emperor of Morocco in the late 16th and early 17th century named Moulay Ismail *the Bloodthirsty*. He was reputed to have killed 30,000 people by his own hands.

Men's testosterone levels, which on the one hand predict their aggression and violence (Booth and Osgood, 1993; Dabbs and Morris, 1990), also predict their dominance rank (Mueller and Mazer, 1996). And men's tendency toward aggression and violence, measured by baseline testosterone levels, is highly heritable (Harris et al., 1998; Rushton et al., 1986). I therefore predict that *violent men have higher-than-expected offspring sex ratio* (*more boys*). I test this prediction by examining the offspring sex ratio of battered women, taking wife batterers as but one example of violent men.

3. Empirical analysis

3.1. Bivariate analysis of American samples

The normal human secondary sex ratio is 105 boys to 100 girls, with the proportion of boys of .5122 (Grant,

Table 1
The proportion of sons among the general population and battered women—American data

A. General population (United States)

Data source		Parity									
		1	2	3	4	5	6	7	8	9	Total
1994 US GSS	Male	554	417	212	122	50	27	18	9	6	1415
	Female	486	408	226	101	57	21	12	5	2	1318
	Total	1040	825	438	223	107	48	30	14	8	2733

Proportion male = .5177, $t = .5729$, *ns*.

B. Battered women

(i) *Primary data*

Data source		Parity										
		1	2	3	4	5	6	7	8	9	10	Total
San Diego	Male	263	201	108	39	20	5	—	—	—	—	636
	Female	253	175	90	41	13	4	—	—	—	—	576
	Total	516	376	198	80	33	9	—	—	—	—	1212
Chicago	Male	166	112	64	37	16	9	3	1	0	0	408
	Female	155	109	55	28	12	8	4	1	1	0	373
	Total	323	221	119	65	28	17	7	2	1	0	781

(ii) *Secondary data*

Source	Study	Male	Female	Total
Journal of family violence	Ware et al., 2001	221	180	401
	Levendosky and Graham-Bermann, 2001	61	59	120
Holden et al., 1998a	Sternberg et al., 1998	29	17	46
	Moore and Pepler, 1998	52	61	113
	Hughes and Luke, 1998	32	26	58
	Rossman, 1998	86	83	169
	Laumakis et al., 1998	16	19	35
	Holden et al., 1998b (study 1)	20	17	37
	Holden et al., 1998b (study 2)	17	13	30
	Holden et al., 1998b (study 3)	30	20	50
Geffner et al., 2000	Pepler et al., 2000	27	19	46
	Rossman and Ho, 2000	82	76	158
	Sudermann et al., 2000	14	17	31
Rossman et al., 2000	Jaffe et al., 1986	36	22	58
	Jouriles et al., 1987	22	23	45
	Kerig, 1998	58	48	106
	Gordis et al., 1997	18	14	32
	Total	821	714	1535

Proportion male = .5286, $t = 1.9527$, $p < .03$ (one-tailed).

1998). The representative data from the US General Social Survey (GSS) bear this out. In 1994, the GSS asked its respondents to list all of their children and their sex by parity. Table 1 (Panel A) presents the data only for biological children (excluding adopted and step children). The proportion of boys among the 2733 biological children listed by the representative sample of noninstitutionalized adult Americans is .5177, which is statistically no different from the theoretical proportion of .5122 ($t = .5729$, *ns*).

There are only two data sets on battered women available at ICPSR (Inter-university Consortium for Political and Social Research at the University of Michigan) which measure the sex of their children: Chicago Women's Health Risk Study, 1995–1998 (ICPSR 3002), and Nature and Scope of Violence Against Women in San Diego (California), 1996–1998 (ICPSR 3019). Both surveys ask a sample of battered women residing in shelters to list all of their children and their sex by parity. Table 1 (Panel B-i) presents the distribution of sex of these children of battered women by parity.

Beyond these two primary data sets, however, it proves very difficult to assess the distribution of sex among children of battered women. Neither of the two large national surveys of violence against women—Canadian Violence Against Women Survey and the National Violence Against Women Survey in the US—measures the sex of the respondents' children. Since January 2000, however, the *Journal of Family Violence* has published two relevant studies with original empirical data. I include these secondary data in my analysis. (See Table 1, Panel B-ii.)

Because studies of *battered women* do not seem to yield the essential information for testing my hypothesis, I now turn to the studies of *children of battered women*. Typically, these studies first sample battered women, and include one child from each woman (either randomly selected or the eldest child) to include in their sample of children exposed to domestic violence. A sample of children thus drawn should be an unbiased sample of all children born by battered women.

Two recent edited volumes, *Children Exposed to Marital Violence* (Holden et al., 1998a,b) and *Children Exposed to Domestic Violence* (Geffner et al., 2000), include original empirical studies of children of battered women. I include eight studies presented in all five chapters in the "Research" section of the first volume, and all three studies from the second volume which measure the sex of the children. In addition, Rossman et al. (2000, Chapter 3) provide a comprehensive review of the literature on the age and sex differences in the effect of exposure to domestic violence. Their Table 3.1 (pp. 41–43) lists 16 published articles on how boys and girls differentially react to such experiences. I use the four studies on this list which have both an unbiased sample and all necessary information.

As Table 1 (Panel B) shows, the proportion of boys among the 3528 children of battered women, combined from the primary and secondary data sources, is .5286, which is statistically significantly ($t = 1.9527$, $p < .03$, one-tailed) higher than the normal sex ratio of .5122.[1] These data support my prediction that violent men are more likely to have sons than daughters.

Bivariate comparisons of battered women with the general population of mothers, however, are susceptible to spuriousness and open to the possibility of alternative explanations. I will therefore test my prediction more rigorously in a multivariate analysis of a British sample.

[1]The t-statistics for a significance test of proportions is $t = (p - \pi)/\sqrt{(\pi(1-\pi))/n}$, where p = sample proportion (.5286), π = population proportion under the null hypothesis (.5122), and n = sample size (3528).

3.2. Multivariate analysis of a British sample

3.2.1. Data

I use the 1999–2000 combined followup sample of the National Child Development Study (NCDS) and the 1970 British Cohort Study (BCS70). The NCDS originates in the "Perinatal Mortality Survey," which examines social and obstetric factors associated with still birth and infant mortality. All babies born in Great Britain (England, Wales, and Scotland) during the week of March 03–09, 1958, were contacted for inclusion into the study. The initial sample in 1958 consists of more than 17,000 babies. All surviving children, who remained in the United Kingdom, have subsequently been followed in order to examine their health, education, social and economic circumstances, in 1965 (age 7), 1969 (age 11), 1974 (age 16), 1981 (age 23), and 1991 (age 33).

The BCS70, originally developed as the British Birth Survey in line with the NCDS, includes all babies born in Great Britain during the week of April 05–11, 1970. The initial sample contains over 17,000 babies. All surviving members of the cohort, who still reside in the United Kingdom, have since been followed in 1975 (age 5), 1980 (age 10), 1986 (age 16), and 1996 (age 26).

The 1999–2000 followup is the first integrated survey of the NCDS and BCS70. It contains 22,680 respondents (11,419 respondents from the NCDS, who are 41–42 years old, and 11,261 respondents from the BCS70, who are 29–30 years old). For my analysis of battered women, I limit my sample to women only ($n = 11,585$).

3.2.2. Dependent variable

The NCDS/BCS70 asks its respondents to list all members of their household, their precise relationships to the respondents (if respondents' children, then if they are biological, adopted, step, or foster children), and their sex (among other characteristics). From these questions, I can count the number of biological sons and daughters of the respondents who still reside with them in 1999/2000. The respondents may list up to nine household members, any number of which may be their biological children.

The NCDS/BCS70 then asks its respondents about all their other biological children who do not live with them, and their sex (among other characteristics). From these questions, I can enumerate all of respondents' noncoresident biological children. The respondents may list up to eight noncoresident biological children. The sum of these figures. (0–17) measures the total number of all biological children of both sexes that the respondents have had, who are still alive in 1999/2000.

I use the count measures (the number of sons and daughters), rather than the ratio measure (such as Number of sons/Number of daughters) because ratio measures have a couple of undesirable features at the individual level. First, when the denominator is zero (for instance, if the individual has no daughters), the ratio is mathematically undefined. However, one can get around this problem by adding an epsilon to the denominator (so that the dependent measure becomes Number of sons/Number of daughters + .0001, for example). More importantly, however, ratio measures cannot distinguish between two sonless individuals with different numbers of daughters. If someone has no sons and one daughter $\left(\frac{0}{1}\right)$, and someone else has no sons and five daughters $\left(\frac{0}{5}\right)$, both of them would have zero as a dependent measure, even though the latter individual is much more prone to producing daughters than the former individual. Because of these problems, I use the number of sons or daughters as the dependent variable, while controlling for the number of children of the opposite sex (see below).

3.2.3. Independent variable

My primary independent variable of interest is the women's experience with domestic violence. The NCDS/BCS70 asks its respondents to list all the spouses or partners with whom they have lived in their lives, including the current one, up to nine spouses. For each of these (ex-)spouses, the NCDS/BCS70 asks a series of questions, such as when the relationship began, when it ended, and how often they argued before the relationships ended. One of the questions the NCDS/BCS70 asks is whether the argument with a given spouse ever resulted in physical violence (1 = yes, 0 = no). By counting the number of "yes" responses, I can measure the number of spouses who engaged in domestic violence on at least one occasion.[2]

On the whole, the incidence of domestic violence experienced by women in the NCDS/BCS70 is relatively low: 92.6% ($n = 10,723$) of women report no experience with domestic violence, 7.0% ($n = 813$) report one violent spouse, .4% ($n = 47$) report two, and .0173% ($n = 2$) report three. The very low variance in the crucial independent variable ($\sigma^2 = .0818$) makes its significant effect on the dependent variable (see below) all the more remarkable.

3.2.4. Control variables

3.2.4.1. Social class. Because the TWH in its original formulation, applied to human populations, explains the offspring sex ratio in terms of the material wealth of the parents, it is important to control for parental social status, in order to estimate the *partial* effect of physical abuse on the offspring sex ratio, *net* of the effect of social class. I therefore control for respondents' years of education (measured as the age at which the respondent first left full-time continuous education), their net (take-home) income (in GBP), and their self-reported social class (1 = unskilled, 2 = partly skilled, 3 = skilled manual, 4 = skilled nonmanual, 5 = managerial or technical, 6 = professional).

3.2.4.2. Risk factor. There are a couple of risk factors which affect the number of children a woman might have. First, while one does not necessarily have to be married to have children in a liberal western society like the United Kingdom, marriage is nonetheless a significant risk factor for childbirth; married people are far more likely to have children than unmarried people. I therefore control the respondents' current marital status (1 = currently married, 0 = otherwise).

Second, because women can have more sons or daughters, not necessarily because they are more likely to have children of one sex or the other, as I argue above, but because they have more children (both sons and daughters), I control for the number of biological children of the opposite sex, to estimate whether the experience of physical abuse has an effect on the number of biological children of one sex *net of* the number of biological children of the opposite sex.[3] Naturally, the bivariate correlation between the number of boys and the number of girls is significantly (albeit very weakly) positive ($r = .0343$, $p < .001$, $n = 11,585$). (But see below for their partial correlation).

3.2.5. Results

Table 2 presents the results of the OLS regression of the number of boys or girls on the experience of domestic violence, along with a set of control variables discussed above.[4] The left column shows that, net of social class, current marital status, and the number of girls, the experience of domestic violence significantly

[2]Measuring the number of abusive husbands with a set of dummy variables, rather than continuously, with no abusive husbands as the reference category, does not alter the substantive findings and shows that it is having one abusive husband which significantly increases the number of boys, and having additional abusive husbands does not have any further effect.

[3]Because the total number of children is very highly (and mathematically necessarily) correlated with both the number of boys ($r = .7269$) and the number of girls ($r = .7113$), entering it as a control variable, rather than the number of children of the opposite sex as I do below, swamps the effects of all other control variables. However, the results are still consistent with gTWH. The number of abusive husbands has a significantly ($p < .05$) positive effect on the number of boys, and a significantly ($p < .05$) negative effect on the number of girls. No other variables in the equations, except for the total number of children, have a significant effect. The results presented in Table 2 are therefore a conservative estimate of the empirical support for gTWH.

[4]The dependent variables in my analysis, the number of boys and the number of girls, are not normally distributed and their distributions instead have positive skews. It is therefore strictly speaking inappropriate to use OLS, which assumes both the normal distribution of the dependent variable and homoskedasticity. Using ordinal regression, which assumes neither, however, does not alter the substantive findings at all.

Table 2
The effect of physical abuse on the number of sons and daughters British data

	Number of boys	Number of girls
Physical abuse	1324***	.0321
	(.0334)	(.0312)
Social class		
Years of education	−.0123***	−.0083***
	(.0023)	(.0022)
Respondent's income	−.0000***	−.0000***
	(.0000)	(.0000)
Self-reported social class	−.1057***	−.1013***
	(.0069)	(.0067)
Risk factors		
Currently married (1 = yes)	.4716***	.4522***
	(.0171)	(.0168)
Number of girls/boys	−.0738***	−.0708***
	(.0100)	(.0096)
Constant	1.0787	.9823
	(.0447)	(.0439)
R^2	.1014	.0947
n	10,350	10,350

Note: Main entries are unstandardized regression coefficients. Numbers in parentheses are standard errors.
***$p<.001$.

($p<.001$) increases the number of boys that women have. This result supports my prediction.

In contrast, the right column shows that, net of the same control variables, the experience of domestic violence does *not* increase the number of girls that women have. This is also consistent with my prediction. The results in Table 2 suggest that being married to an abusive husband results in an eighth of a boy but no increase in girls. It therefore appears that the experience of domestic violence increases the number of sons that women have, while having no effect at all on the number of daughters that they have.

Table 2 also shows that, despite their positive bivariate correlation, the number of children of one sex has a significantly (p's $<.0001$) *negative partial* effect on the number of children of the opposite sex. The more boys women have, the fewer girls they have; the more girls they have, the fewer boys they have. Significantly negative partial correlations between the number of boys and the number of girls suggest that parents specialize in producing children of one sex or the other. This is consistent with patterns found elsewhere with both American and British data (Kanazawa, 2005a; Kanazawa and Vandermassen, 2005).

Fig. 1 shows that women who have ever had an abusive husband have a significantly larger number of boys than women who have never had an abusive husband (.7912 vs. .7007, $t=-2.6977$ $p<.01$). In contrast, these two groups of women do not differ in

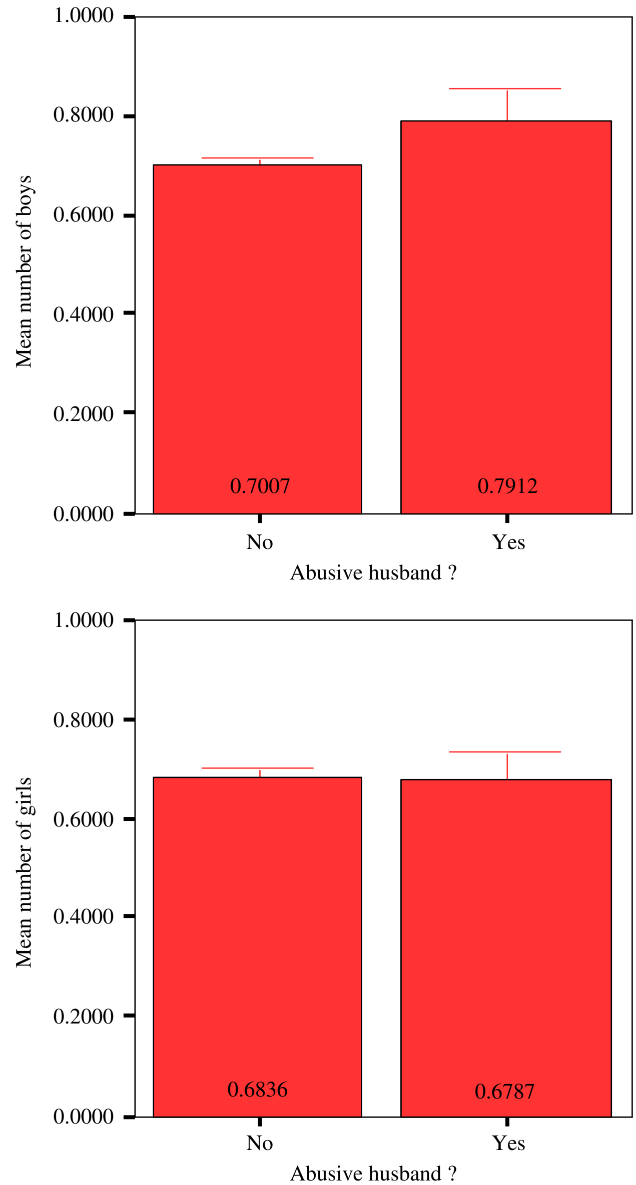

Fig. 1. Mean number of boys and girls by the experience of spousal abuse. *Note*: Error bars denote the 95% confidence intervals the mean.

the mean number of girls they have had (.6787 vs. .6836, $t=.1648$, *ns*).

4. Discussion

The empirical results, both from the bivariate analysis of American samples and the multivariate analysis of a British sample, demonstrate that violent men who batter their wives are more likely to have sons than other men. The logic of the generalized Trivers–Willard hypothesis (gTWH) provides one potential explanation for the significantly higher offspring sex ratio among violent men. The gTWH posits that parents with any heritable traits which increases the reproductive success of male offspring much more than that of female offspring have a higher-than-expected number of sons. Tendency toward violence and aggression is one highly heritable trait which disproportionately increases the reproductive success of sons much more than that of daughters, especially in the context of the ancestral environment.

One of the empirical limitations of the study is that the data come only from women both in the United States and the United Kingdom. I therefore cannot rule out the possibility that it is the battered women who increase the likelihood of having more sons rather than their violent husbands. Unlike Grant's (1998) maternal dominance hypothesis, the gTWH is completely mute on which parent determines or influences the sex of the offspring.

Together with the earlier studies, which suggest that parents' brain types bias the offspring sex ratios (Kanazawa and Vandermassen, 2005), that taller and bigger parents have more sons (Kanazawa, 2005a), physically more attractive women have more daughters (Kanazawa, 2005b), and mothers with a language impairment have more sons (Tallal et al., 1989), the current study provides further support for the gTWH. However, more research is necessary to investigate the empirical status of the gTWH before firmly establishing it as a biological principle. On the other hand, given how completely different the current environment of contemporary Western societies is from the ancestral environment, to which our entire body is adapted (for example, violent men today tend to get into trouble with the law and end up in jail, thereby *reducing* their reproductive opportunities rather than enhancing them), it is nonetheless remarkable that *any* effect is detectable in the contemporary data.

At least two of the factors so far found to be associated with biased sex ratios (brain types and aggression) are known to be correlated with levels of testosterone (Baron-Cohen et al., 2004; Soler et al., 2000). At the same time, Manning et al. (2002) show that individuals with low 2D:4D ratios (the ratio of the length of the index finger to the length of the ring finger) have more sons and daughters. Manning (2002) hypothesizes that the 2D:4D ratio may be an accurate (inverse) indicator of the prenatal exposure to testosterone. While the evidence for Manning's hypothesis has so far been only indirect, the current prospective longitudinal study of children whose exposure to prenatal testosterone has been precisely measured by the amniotic fluid in their mother's womb (Baron-Cohen et al., 2004) should in time be able to establish this causal connection. If Manning turns out to be right, then it is very likely that levels of testosterone provide a key *proximate* mechanism for biased offspring sex ratio, while the gTWH explains its *ultimate* causes.

References

Austad, S.N., Sunquist, M.E., 1986. Sex ratio manipulation in the common opossum. Nature 324, 58–60.
Baron-Cohen, S., 1999. The extreme male brain theory of autism. In: Tager-Flusberg, H. (Ed.), Neurodevelopmental Disorders. MIT Press, Cambridge, pp. 401–429.
Baron-Cohen, S., 2002. The extreme male brain theory of autism. Trends Cognitive Sci. 6, 248–254.
Baron-Cohen, S., 2003. The Essential Difference. Penguin, London.
Baron-Cohen, S., Hammer, J., 1997. Is autism an extreme form of the male brain? Adv. Infancy Res. 11, 193–217.
Baron-Cohen, S., Lutchmaya, S., Knickmeyer, R., 2004. Prenatal Testosterone in Mind: Amniotic Fluid Studies. MIT Press, Cambridge.
Betzig, L.L., 1986. Despotism and Differential Reproduction: A Darwinian View of History. Aldine, New York.
Betzig, L., Weber, S., 1995. Presidents preferred sons. Polit. Life Sci. 14, 61–64.
Booth, A., Osgood, D.W., 1993. The influence of testosterone on deviance in adulthood: assessing and explaining the relationship. Criminology 31, 93–117.
Brown, G.R., 2001. Sex-biased investment in nonhuman primates: can Trivers & Willard's theory be tested? Anim. Behav. 61, 683–694.
Brown, G.R., Silk, J.B., 2002. Reconsidering the null hypothesis: is maternal rank associated with sex ratios in primate groups? Proc. Natl Acad. Sci. 99, 11252–11255.
Burley, N., 1986. Sex-ratio manipulation in color-banded populations of zebra finches. Evolution 40, 1191–1206.
Buss, D.M., 1989. Sex differences in human mate preferences: evolutionary hypotheses tested in 37 cultures. Behav. Brain Sci. 12, 1–49.
Cameron, E.Z., 2004. Facultative adjustment of mammalian sex ratios in support of the Trivers–Willard hypothesis: evidence for a mechanism. Proc. R. Soc. London Ser. B 271, 1723–1728.
Chagnon, N.A., 1997. Yanomamö, fifth ed. Harcourt Brace, Fort Worth.
Chambers, M.L., Hewitt, J.K., Schmitz, S., Corley, R.P., Fulker, D.W., 2001. Height, weight, and body mass index. In: Hewitt, J.K., Emde, R.N. (Eds.), Infancy to Early Childhood: Genetic and Environmental Influences on Developmental Change. Oxford University Press, London, pp. 292–306.
Clutton-Brock, T.H., Albon, S.D., Guinness, F.E., 1986. Great expectations: maternal dominance, sex ratios and offspring reproductive success in red deer. Anim. Behav. 34, 460–471.
Cronk, L., 1991. Preferential parental investment in daughters over sons. Hum. Nat. 2, 387–417.
Dabbs Jr., J.M., Morris, R., 1990. Testosterone, social class, and antisocial behavior in a sample of 4,462 men. Psychol. Sci. 1, 209–211.
Ellis, L., Bonin, S., 2002. Social status and the secondary sex ratio: new evidence on a lingering controversy. Soc. Biol. 49, 35–43.
Ewen, J.G., Cassey, P., Møller, A.P., 2004. Facultative primary sex ratio variation: a lack of evidence in birds? Proc. R. Soc. London Ser. B 271, 1277–1282.
Freese, J., Powell, B., 1999. Sociobiology, status, and parental investment in sons and daughters: testing the Trivers–Willard hypothesis. Am. J. Sociol. 106, 1704–1743.
Gangestad, S.W., Simpson, J.A., 2000. The evolution of human mating: trade-offs and strategic pluralism. Behav. Brain Sci. 23, 573–644.
Gaulin, S.J.C., Robbins, C.J., 1991. Trivers–Willard effect in contemporary North American society. Am. J. Phys. Anthropol. 85, 61–69.
Geffner, R.A., Jaffe, P.G., Sudermann, M. (Eds.), 2000. Children Exposed to Domestic Violence: Current Issues in Research,

Intervention, Prevention, and Policy Development. Haworth, New York.
Gordis, E.B., Margolin, G., John, R.S., 1997. Marital aggression, observed parental hostility, and child behavior during triadic family interaction. J. Fam. Psychol. 11, 76–89.
Grant, V.J., 1998. Maternal Personality, Evolution, and the Sex Ratio: Do Mothers Control the Sex of the Infant? Routledge, London.
Harris, J.A., Vernon, P.A., Boomsma, D.I., 1998. The heritability of testosterone: a study of Dutch adolescent twins and their parents. Behav. Genet. 28, 165–171.
Holden, G.W., Geffner, R., Jouriles, E.N., 1998a. Children Exposed to Marital Violence: Theory, Research, and Applied Issues. American Psychological Association, Washington, DC.
Holden, G.W., Stein, J.D., Ritchie, K.L., Harris, S.D., Jouriles, E.N., 1998b. Parenting behaviors and beliefs of battered women. In: Holden, G.W., Geffner, R., Jouriles, E.N. (Eds.), Children Exposed to Marital Violence: Theory, Research, and Applied Issues. American Psychological Association, Washington, DC, pp. 289–334.
Hughes, H.M., Luke, D.A., 1998. Heterogeneity in adjustment among children of battered women. In: Holden, G.W., Geffner, R., Jouriles, E.N. (Eds.), Children Exposed to Marital Violence: Theory, Research, and Applied Issues. American Psychological Association, Washington, DC, pp. 185–221.
Jaffe, P., Wolfe, D., Wilson, S.K., Zak, L., 1986. Family violence and child adjustment: a comparative analysis of girls' and boys' behavioral symptoms. Am. J. Psychiatry 143, 74–77.
Jouriles, E.N., Barling, J., O'Leary, K.D., 1987. Predicting child behavior problems in maritally violent families. J. Abnormal Child Psychol. 15, 165–173.
Kanazawa, S., 2001. Why we love our children. Am. J. Sociol. 106, 1761–1776.
Kanazawa, S., 2003. Can evolutionary psychology explain reproductive behavior in the contemporary United States? Sociol. Q. 44, 291–301.
Kanazawa, S., 2005a. Big and tall parents have more sons: further generalizations of the Trivers–Willard hypothesis. J. Theor. Biol. 235, 583–590.
Kanazawa, S., 2005b. Beautiful women have more daughters: a further implication of the generalized Trivers–Willard hypothesis (gTWH). Interdisciplinary Institute of Management. London School of Economics and Political Science.
Kanazawa, S., Vandermassen, G., 2005. Engineers have more sons, nurses have more daughters: an evolutionary psychological extension of Baron-Cohen's extreme male brain theory of autism. J. Theor. Biol. 233, 589–599.
Keller, M.C., Nesse, R.M., Hofferth, S., 2001. The Trivers–Willard hypothesis of parental investment: no effect in the contemporary United States. Evol. Hum. Behav. 22, 343–360.
Kerig, P.K., 1998. Gender and appraisals as mediators of adjustment in children exposed to interparental violence. J. Fam. Violence 13, 345–363.
Koziel, S., Ulijaszek, S., 2001. Waiting for Trivers and Willard: do the rich really favor sons? Am. J. Phys. Anthropol. 115, 71–79.
Laumakis, M.A., Margolin, G., John, R.S., 1998. The emotional, cognitive, and coping responses of preadolescent children to different dimensions of marital conflict. In: Holden, G.W., Geffner, R., Jouriles, E.N. (Eds.), Children Exposed to Marital Violence: Theory, Research, and Applied Issues. American Psychological Association, Washington, DC, pp. 257–288.
Leimer, O., 1996. Life history analysis of the Trivers–Willard ex-ratio problem. Behav. Ecol. 7, 316–325.
Levendosky, A., Graham-Bermann, S.A., 2001. Parenting in battered women: the effects of domestic violence on women and their children. J. Fam. Violence 16, 171–192.
Manning, J.T., 2002. Digit Ratio: A Pointer to Fertility, Behavior and Health. Rutgers University Press, New Brunswick.
Manning, J.T., Martin, S., Trivers, R.L., Soler, M., 2002. 2nd to 4th digit ratio and offspring sex ratio. J. Theor. Biol. 217, 93–95.
Moore, T.E., Pepler, D.J., 1998. Correlates of adjustment in children at risk. In: Holden, G.W., Geffner, R., Jouriles, E.N. (Eds.), Children Exposed to Marital Violence: Theory, Research, and Applied Issues. American Psychological Association, Washington, DC, pp. 157–184.
Mueller, U., 1993. Social status and sex. Nature 363, 490.
Mueller, U., Mazur, A., 1996. Facial dominance of West Point cadets as a predictor of later military rank. Soc. Forces 74, 823–850.
Myers, J.H., 1978. Sex ratio adjustment under food stress: maximization of quality or number of offspring? Am. Nat. 112, 381–388.
Nettle, D., 2002a. Height and reproductive success in a cohort of British men. Hum. Nat. 13, 473–491.
Nettle, D., 2002b. Women's height, reproductive success and the evolution of sexual dimorphism in modern humans. Proc. R. Soc.London Ser. B 269, 1919–1923.
Pawlowski, B., Dunbar, R.I.M., Lipowicz, A., 2000. Tall men have more reproductive success. Nature 403, 156.
Pepler, D.J., Catallo, R., Moore, T.E., 2000. Consider the children: research informing interventions for children exposed to domestic violence. In: Geffner, R.A., Jaffe, P.G., Sudermann, M. (Eds.), Children Exposed to Domestic Violence: Current Issues in Research, Intervention, Prevention, and Policy Development. Haworth, New York, pp. 37–57.
Redmond, E., 1994. Tribal and Chiefly Warfare in South America. University of Michigan Museum, Ann Arbor.
Rossman, B.B.R., 1998. Descartes's error and posttraumatic stress disorder: cognition and emotion in children who are exposed to parental violence. In: Holden, G.W., Geffner, R., Jouriles, E.N. (Eds.), Children Exposed to Marital Violence: Theory, Research, and Applied Issues. American Psychological Association, Washington, DC, pp. 223–256.
Rossman, B.B.R., Ho, J., 2000. Posttraumatic response and children exposed to parental violence. In: Geffner, R.A., Jaffe, P.G., Sudermann, M. (Eds.), Children Exposed to Domestic Violence: Current Issues in Research, Intervention, Prevention, and Policy Development. Haworth, New York, pp. 85–106.
Rossman, B.B.R., Hughes, H.M., Rosenberg, M.S., 2000. Children and Interparental Violence: The Impact of Exposure. Brunner/Mazel, London.
Rushton, J.P., Fulker, D.W., Neale, M.C., Nias, D.K.B., Eysenck, H.J., 1986. Altruism and aggression: the heritability of individual differences. J. Personality Soc. Psychol. 50, 1192–1198.
Sheldon, B.C., West, S.A., 2004. Maternal dominance, maternal condition, and offspring sex ratio in ungulate mammals. Am. Nat. 163, 40–54.
Silventoinen, K., Kaprio, J., Lahelma, E., Viken, R.J., Rose, R.J., 2001. Sex differences in genetic and environmental factors contributing to body-height. Twin Res. 4, 25–29.
Soler, H., Vinayak, P., Quadgno, D., 2000. Biosocial aspects of domestic violence. Psychoneuroendocrinology 25, 721–739.
Sternberg, K.J., Lamb, M.E., Dawud-Noursi, S., 1998. Using multiple informants to understand domestic violence and its effects. In: Holden, G.W., Geffner, R., Jouriles, E.N. (Eds.), Children Exposed to Marital Violence: Theory, Research, and Applied Issues. American Psychological Association, Washington, DC, pp. 121–156.
Sudermann, M., Marshall, L., Loosely, S., 2000. Evaluation of the London (Ontario) community group treatment programme for children who have witnessed woman abuse. In: Geffner, R.A.,

Jaffe, P.G., Sudermann, M. (Eds.), Children Exposed to Domestic Violence: Current Issues in Research, Intervention, Prevention, and Policy Development. Haworth, New York, pp. 127–146.
Symington, M.M., 1987. Sex ratio and maternal rank in wild spider monkeys: when daughters disperse. Behav. Ecol. Sociobiol. 20, 421–425.
Tallal, P., Ross, R., Curtiss, S., 1989. Unexpected sex-ratios in families of language/learning-impaired children. Neuropsychologia 27, 987–998.
Thornhill, R., Møller, A.P., 1997. Developmental stability, disease and medicine. Biol. Rev. 72, 497–548.
Trivers, R.L., 1972. Parental investment and sexual selection. In: Campbell, B. (Ed.), Sexual Selection and the Descent of Man 1871–1971. Aldine, Chicago, pp. 136–179.
Trivers, R., 2002. Natural Selection and Social Theory: Selected Papers of Robert Trivers. Oxford University Press, Oxford.
Trivers, R.L., Willard, D.E., 1973. Natural selection of parental ability to vary the sex ratio of offspring. Science 179, 90–92.
Ware, H.S., Jouriles, E.N., Spiller, L.C., McDonald, R., Swank, P.R., Norwood, W.D., 2001. Conduct problems among children at battered women's shelters: prevalence and stability of maternal reports. J. Fam. Violence 16, 291–307.