Gender differences in financial risk aversion and career choices are affected by testosterone

Paola Sapienza[a], Luigi Zingales[b], and Dario Maestripieri[c,1]

[a]Kellogg School of Management, Northwestern University, Evanston, IL 60208; [b]University of Chicago Booth School of Business, Chicago, IL 60637; and [c]Department of Comparative Human Development, University of Chicago, Chicago, IL 60637

Communicated by James J. Heckman, The University of Chicago, Chicago, IL, July 1, 2009 (received for review December 15, 2008)

Women are generally more risk averse than men. We investigated whether between- and within-gender variation in financial risk aversion was accounted for by variation in salivary concentrations of testosterone and in markers of prenatal testosterone exposure in a sample of >500 MBA students. Higher levels of circulating testosterone were associated with lower risk aversion among women, but not among men. At comparably low concentrations of salivary testosterone, however, the gender difference in risk aversion disappeared, suggesting that testosterone has nonlinear effects on risk aversion regardless of gender. A similar relationship between risk aversion and testosterone was also found using markers of prenatal testosterone exposure. Finally, both testosterone levels and risk aversion predicted career choices after graduation: Individuals high in testosterone and low in risk aversion were more likely to choose risky careers in finance. These results suggest that testosterone has both organizational and activational effects on risk-sensitive financial decisions and long-term career choices.

economic risk | hormones | sex differences | neuroeconomics

Women are, on average, more risk averse than men in financial decision-making (1). Gender differences in financial risk aversion, in turn, can be associated with differences in career choices: For example, in our academic institutions, ≈36% of female MBA students choose a risky career in finance (e.g., investment banking or trading), whereas 57% of male students do so. Although social and cultural expectations for risk behavior and career choices in men and women differ, biological differences between the sexes could play an important role in these differences in behavior.

One important biological difference between men and women involves the hormone testosterone. Higher levels of testosterone in males can result in gender differences in behavior and cognition through the organizational or the activational effects of this hormone. The former refers to permanent modification of brain structure and function during prenatal and early postnatal life due to exposure to testosterone, whereas the latter refers to the transient effects of circulating testosterone on the brain during postnatal life, and especially after puberty (2). In humans, testosterone has been shown to enhance the motivation for competition and dominance (3), reduce fear (4, 5), and alter the balance between sensitivity to punishment and reward (6). Testosterone has also been associated with extremely risky behavior such as gambling and alcohol use (7–9). However, the evidence that testosterone can affect financial risk-taking or other aspects of economic decision-making is currently mixed (10–14).

In this study, we investigated whether interindividual variation in testosterone can account for both between- and within-gender variation in financial risk aversion and career choices. We investigated the possible activational effects of testosterone by analyzing the relationship between salivary concentrations of this hormone and an experimental measure of financial risk aversion. The possible organizational effects of testosterone on risk aversion were investigated by analyzing variation in prenatal testosterone exposure. This was done in two ways: first, we used the ratio between the length of the 2nd (index) finger and the 4th (ring) finger (2D:4D ratio) as a marker of prenatal testosterone exposure. Fingers have receptors for sex steroid hormones and their length is affected by hormone exposure in utero: in particular, the 2D:4D ratio has been shown to be negatively correlated with prenatal testosterone exposure and to be lower in men than in women (15, 16). Second, prenatal testosterone has been shown to affect a child's sociability and ability to empathize (17), which, in turn, can be reliably measured by the "Reading the Mind in the Eyes" test developed by Baron-Cohen (18). This test involves guessing the feeling expressed in 34 pairs of eyes. Lower prenatal testosterone exposure is associated with higher performance on this test, and women typically score higher than men (18). Hence, as another proxy for prenatal exposure to testosterone, we used the Baron-Cohen test.

Subject population was a large ($n = 550$) cohort of MBA students at the University of Chicago. Although these students may not be representative of human populations in general, we believe that they represent an optimal subject population for this study for several reasons. First, MBA students are familiar with financial risk by virtue of their training, thereby minimizing the chance of uninformed responses to our experimental tests. Second, many of them enter the world of finance, where they have opportunities to make important financial decisions. Thus, working with this subject population allows us to measure risk attitudes among professional financial decision makers. Third, our subject population was relatively homogeneous in age, cultural and educational background, and socioeconomic status, thereby minimizing the effects of many potential confounds on the variables of interest. Finally, we were able to assess our subjects' career choices after they graduated from their MBA program.

Results

Risk Aversion and Salivary Testosterone. As expected, men exhibited significantly lower risk aversion than women ($P < 0.01$; Fig. 1). As also expected, men had significantly higher levels of salivary testosterone than women ($P < 0.01$; Fig. 2).

We found a significant negative correlation between salivary testosterone concentrations and risk aversion across men and women ($r = -0.1793$; $P = 0.01$; Table 1). When the analysis was controlled for gender, however, the effect of testosterone on risk aversion was no longer statistically significant ($P = 0.11$). When data were analyzed separately for men and women, the negative relationship between risk aversion and testosterone was weak and not statistically significant among men, but stronger (almost 7 times greater) and statistically significant ($P = 0.02$) among women (see Table 1).

The correlation between testosterone and risk aversion may not reflect a causal relation between these variables but rather

Author contributions: P.S. and L.Z. designed research; P.S. and L.Z. performed research; P.S., L.Z., and D.M. analyzed data; and P.S., L.Z., and D.M. wrote the paper.

The authors declare no conflict of interest.

[1]To whom correspondence should be addressed. E-mail: dario@uchicago.edu.

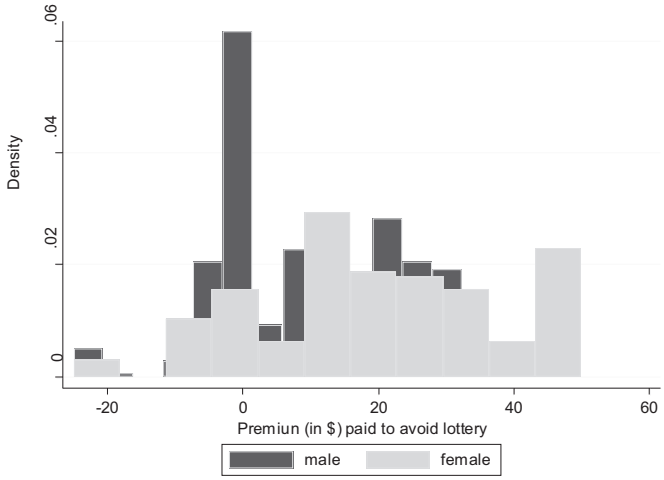

Fig. 1. Distribution of the $ premium a subject was willing to pay to avoid a 50/50 lottery that paid either $0 or $200. The distribution for male subjects (dark gray) indicates that men are less risk averse than women (light gray).

be due to a third variable independently correlated with testosterone and risk aversion. In our study, married individuals (both men and women) had lower testosterone levels than unmarried individuals. Married people are also known to be more risk averse than unmarried people. However, when our analysis was controlled for marital status, the estimated coefficient of risk aversion on testosterone remained substantially the same. The time of day that testosterone was measured, age, and ethnicity had nonsignificant effects on salivary testosterone levels: When the analysis was controlled for these variables, the association between testosterone and risk aversion remained virtually unchanged.

While it is still possible that other omitted variables influence both testosterone concentrations and risk aversion, these results suggest that the relationship between testosterone and risk aversion is robust in our data. The finding that this relationship is stronger at lower levels of testosterone and for women is consistent with two alternative hypotheses: (*i*) that there are nonlinear effects of testosterone on risk aversion and/or (*ii*) that testosterone may affect behavior and cognition differently in men and women. Because the latter hypothesis cannot be tested without data on the mechanisms through which testosterone acts

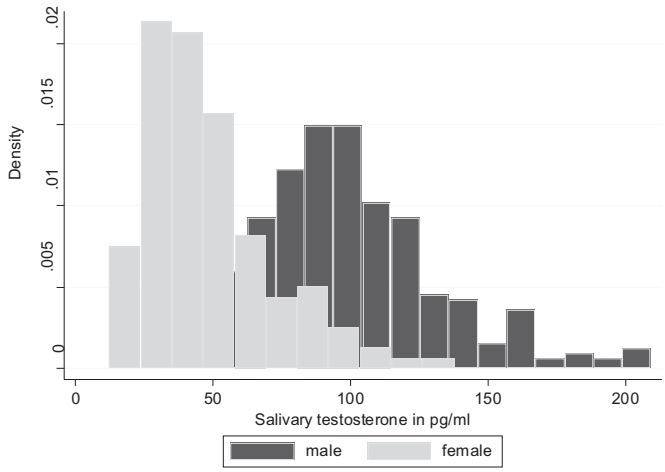

Fig. 2. Distribution of the concentrations of salivary testosterone in men and women. Men (dark gray) have significantly higher concentrations of salivary testosterone than women (light gray).

on the brain of men and women, we concentrated on the nonlinearity hypothesis. Previous studies have shown that testosterone has nonlinear effects on spatial cognition such that individuals with intermediate levels of this hormone (women with high testosterone and men with low testosterone) perform better on spatial cognition tasks than individuals at the extremes of the distribution (women with low testosterone and men with high testosterone) (19, 20). When applied to our data, the nonlinearity hypothesis predicts that (*i*) testosterone will show a linear relationship with risk aversion at lower concentrations of this hormone, regardless of gender, and (*ii*) there will be no gender differences in risk aversion among men and women with similarly low levels of testosterone. Although among women there were some outliers with testosterone concentrations almost as high as those of the men with the highest testosterone, 90% of women had testosterone concentrations $<$83.30 pg/mL. The men with testosterone concentrations $<$83.30 pg/mL were 31% of the total. Thus, to obtain a sample of men and women with comparable levels of testosterone, we focused our attention on subjects with testosterone levels $<$83.30 pg/mL.

As predicted by the nonlinearity hypothesis, among the women and men with comparable concentrations of testosterone, there was a significant negative correlation between testosterone and risk aversion (Table 1). The effect of testosterone on risk aversion was still statistically significant after controlling for gender in the analysis (see column VI in Table 1), whereas the gender dummy was not statistically significant. Thus, for comparable levels of testosterone, there was no difference in risk aversion between men and women.

Risk Aversion and Prenatal Testosterone Exposure. The hypothesis that testosterone has not only activational, but also organizational effects on risk aversion was investigated by examining the relationship between risk aversion and two different markers of prenatal testosterone exposure, the 2D:4D ratio and the performance on the Baron-Cohen test.

Consistent with our expectations, women's 2D:4D ratio was significantly higher than men's. There was no significant correlation between digit ratios and salivary concentrations of testosterone. In Table 2 we report the results of a linear regression analysis examining the relation between risk aversion and digit ratio. Risk aversion was positively correlated with the digit ratio, suggesting that high risk aversion was associated with low prenatal testosterone exposure. The effect, however, was small and nonsignificant. When data were analyzed separately for men and women, we found that the effect was mostly driven by women ($P = 0.10$).

As expected, women showed a significantly higher percentage of correct responses in the Baron-Cohen test than men did. There was no significant correlation between individual scores on the Baron-Cohen tests and digit ratio ($r = -0.0629$, $P = 0.1796$) (21). Table 3 reports the linear regression of our measure of risk aversion on the Baron-Cohen proxy for prenatal testosterone exposure. The estimated coefficient was positive and statistically significant ($P = 0.01$) in a two-tailed t test. This result suggests that higher levels of prenatal testosterone are negatively correlated with risk aversion. As with digit ratios, however, this effect was small. The regression coefficient did not change when we inserted a gender dummy in the analysis (column II in Table 4). When data were analyzed separately for men and women, the Baron-Cohen proxy for prenatal testosterone had a significant positive effect on risk aversion in women, but not in men. This result was not due to the greater left tail of the distribution of men's scores. When we reduced the sample by dropping the observations below the 10% of men's scores (equal to 22 right answers), the results were essentially unchanged.

Table 1. Regression of risk aversion on testosterone

	Whole sample				Low testosterone levels			
	Both genders		Men	Women	Both genders		Men	Women
	I	II	III	IV	V	VI	VII	VIII
Testosterone (pg/mL)	−0.082***	−0.042	−0.020	−0.137**	−0.211***	−0.144*	−0.079	−0.171*
	(0.022)	(0.026)	(0.029)	(0.057)	(0.058)	(0.079)	(0.126)	(0.099)
Gender: Female = 1		5.230**				3.807		
		(2.202)				(3.119)		
Observations	460	460	320	140	225	225	99	126
R-squared	0.032	0.044	0.002	0.030	0.051	0.058	0.003	0.022

This table shows Ordinary Least Squares regressions of the premium a subject was willing to pay to avoid a 50/50 lottery $0/$200 on the level of salivary testosterone. There is a negative correlation between risk aversion and salivary testosterone, but the effect is driven by women. When the sample is restricted to subjects with <83.3 pg/mL of testosterone, there is a negative and strongly significant correlation between risk aversion and salivary testosterone across men and women. In column VI, the indicator variable for gender is not statistically significant suggesting that, for comparable low levels of testosterone, once we account for testosterone, there is no difference in risk aversion between men and women. Heteroschedasticity robust standard errors are reported in brackets. * Means significantly different from zero at the 10% level (two-tail *t* test), ** at the 5% level, and *** at the 1% level.

Risk Aversion, Testosterone, and Career Choices. In Table 4 we report the results of a probit model examining the relation between the choice of a risky career in finance and salivary testosterone. There was a positive correlation between salivary testosterone and the choice of a finance career, but this correlation became nonsignificant after the analysis was controlled for gender. When only individuals with testosterone concentrations <83.30 pg/mL were used in the analyses, however, salivary testosterone levels were positively correlated with career choices, but significance was reduced at 10%. Most importantly, after we controlled for salivary testosterone, the likelihood of entering the finance field did not differ between men and women.

This effect was not limited to salivary testosterone. As column IV shows, the digit ratio, which is negatively correlated with prenatal testosterone, was negatively correlated with the probability of starting a career in finance. In contrast, the other proxy for prenatal testosterone, the Baron-Cohen test, was not correlated with career choices (column V). Finally, in column VI, we show that salivary and prenatal levels of testosterone have independent effects on career choices. After controlling for both activational and organizational effects of testosterone, the 25% point difference in entering the finance field between men and women disappears.

Discussion

When taken together, the results of this study suggest that testosterone has both organizational and activational effects on financial risk aversion in men and women and that these effects influence important career choices. Higher prenatal exposure to testosterone and higher circulating levels of this hormone were associated with lower risk aversion. The organizational effects of testosterone on risk aversion appeared to be weaker than the activational effects, perhaps because prenatal hormone exposure was assessed with indirect measures. In both cases, the relation between testosterone and risk aversion was stronger in women than in men. However, when individuals with relatively low concentrations of testosterone (90% of women and 31% of men) were compared, the gender difference in risk aversion disappeared and within-gender variation in this measure was accounted for by variation in testosterone. This suggests that the relationship between testosterone and risk aversion is stronger at lower than at higher concentrations. Although in our subject population the relation between testosterone and risk aversion continued to be lower for men than for women even in the subsample of men with low testosterone concentrations, a stronger correlation between testosterone and risk aversion in men has been reported by another recent study (10). Differences between studies in the strength of the relation between men's testosterone and risk aversion may be due to differences in the characteristics of the subject populations (MBA students vs. college undergraduates). Although the use of MBA students as a subject population may limit the generalizability of our findings, if we want to study the effect of testosterone on actual risk taking in financial markets this is an ideal subject population, because these students are destined to become major players in financial markets.

Variation in testosterone-dependent risk aversion accounted for both between and within-gender variation in the probability of choosing a risky career in finance. Individuals who were high

Table 2. Regression of risk aversion on digit ratio

	Whole sample			Only men		Only women	
	I	II	III	IV	V	VI	VII
Average digit ratio	41.766	9.544	−2.370	−37.161	−43.285	79.034	86.532
	(32.215)	(32.523)	(36.832)	(40.959)	(42.457)	(50.192)	(68.884)
Gender: Female = 1		7.544***	9.575***				
		(2.615)	(3.477)				
Testosterone (pg/mL)			0.037		0.051		−0.019
			(0.044)		(0.050)		(0.094)
Observations	181	181	175	116	112	65	63
R-squared	0.007	0.052	0.054	0.006	0.017	0.024	0.021

This table shows Ordinary Least Squares regressions of the premium a subject was willing to pay to avoid a 50/50 lottery $0/$200 on the 2D:4D digit ratio. Risk aversion is positively correlated with the digit ratio. Heteroschedasticity robust standard errors are reported in brackets.
* Means significantly different from zero at the 10% level (two-tail *t* test), ** at the 5% level, and *** at the 1% level.

Table 3. Regression of risk aversion on Baron-Cohen "Reading the mind in the eyes" test scores

	Whole sample			Only men		Only women	
	I	II	III	IV	V	VI	VII
Baron-Cohen eye test	0.595***	0.508**	0.507**	0.219	0.223	1.319***	1.244***
	(0.222)	(0.217)	(0.218)	(0.254)	(0.255)	(0.422)	(0.418)
Gender: Female = 1		6.997***	4.859**				
		(1.780)	(2.193)				
Testosterone (pg/mL)			−0.041		−0.020		−0.122**
			(0.026)		(0.029)		(0.058)
Observations	457	457	457	317	317	140	140
R-squared	0.015	0.049	0.054	0.002	0.004	0.056	0.080

This table shows Ordinary Least Squares regressions of the premium a subject was willing to pay to avoid a 50/50 lottery $0/$200 on his/her score in Baron-Cohen "reading the mind in the eyes" test. Test scores are negatively correlated with risk aversion. Heteroschedasticity robust standard errors are reported in brackets. * Means significantly different from zero at the 10% level (two-tail *t* test), ** at the 5% level, and *** at the 1% level.

in testosterone and low in risk aversion were more likely to choose risky finance careers after graduation. After controlling for both activational and organizational effects of testosterone, the strong gender difference in the likelihood of entering the finance field virtually disappeared. Therefore, both prenatal and circulating testosterone levels can affect risk-sensitive financial decisions and long-term career choices in business. Because risky careers in finance may also require greater willingness to compete, the correlation with testosterone may also reflect this possibility. A relation between testosterone and career paths has also been reported by other studies (22, 23).

Future studies should examine the possibility that there may be biological differences in the molecular mechanisms through which testosterone affects brain and behavior in men and women. Future studies should also address the interplay of biological and sociocultural factors in the emergence and maintenance of between- and within-gender differences in financial decision-making and other types of risk behavior.

Materials and Methods

Subjects. As part of a mandatory course, all MBA students in the 2008 cohort ($n = 550$; 381 males, 169 females) at the University of Chicago Graduate School of Business were asked to participate in a laboratory experiment to investigate the relationship between risk attitude and hormonal variables. Of the total students, 473 of them provided informed consent to the use of risk attitude and hormonal data. Data for 13 participants could not be used for hormonal analyses because of technical problems with sample collection or hormonal assays. Therefore, these individuals were excluded from this study. Of the remaining 460 participants, 320 were males and 140 females.

General Procedure. All students were tested on two days (October 3 and October 5, 2006). Tests were conducted in the afternoon, between 1:30 PM and 5:00 PM. Students were randomly assigned to one of two separate testing sessions each day: The early session began at 1:30 PM ($n = 333$; Day 1 = 167; Day 2 = 166), whereas the late session began at 3:30 PM ($n = 224$; day 1 = 111; day 2 = 114). All sessions used an identical protocol. Students were assigned to one of four rooms in which the experiment took place. The room assignment was completed alphabetically using their last names. The session and room assignment were communicated to the students five days before the experiment via E-mail, along with instructions for the test.

Upon arrival to their assigned room, students received a set of materials that included: a $20 bill as their participation fee, a copy of the instructions they had received via E-mail, a few blank sheets of paper, consent forms, a couple of vials, and a unique randomly assigned number that was used to identify each subject. The students were asked not to communicate with one another and reminded that their interaction with others would remain anonymous. At this point, the students played a computer game to assess their risk aversion tendencies (see below). The computer game was programmed and run using z-Tree (24). Student's received feedback on specific games and on the behavior of other students a few days later through an E-mail. For those students who earned more than their $20 participation fee, the payment of the additional money was completed via a check and delivered to the students' mailfolder.

Measurement of Risk Aversion. We measured risk aversion using the Holt and Laury's algorithm (25). Students played a computer game in which they were presented with an array of choices between a risky lottery and varying

Table 4. Risk aversion and career choices

	I	II	III	IV	V	VI
	Whole sample		Low testosterone	Whole sample		
Testosterone (pg/mL)	0.002***	0.001	0.006*			0.003*
	(0.001)	(0.001)	(0.003)			(0.002)
Average digit ratio				−4.262***		−4.730***
				(1.342)		(1.420)
Baron-Cohen eye test					−0.003	
					(0.007)	
Gender: Female = 1		−0.182**	−0.085	−0.276***	−0.223***	−0.128
		(0.072)	(0.107)	(0.085)	(0.055)	(0.123)
Observations	379	379	165	152	392	146
Pseudo R-squared	0.023	0.035	0.049	0.115	0.03	0.139

This table shows maximum likelihood estimates of a probit model where the dependent variable is equal to one if the subject has chosen finance as his/her first job after graduation, and zero otherwise. This variable is regressed on the level of salivary testosterone. The coefficients reported are the marginal effects on the probability that the first employment is a finance job from an infinitesimal change in the testosterone level, and a discrete change in the gender variable (when included). The marginal effect is calculated at the mean values of all regressors. There is a positive correlation between a finance career and salivary testosterone, especially in the sample of subjects with <83.3 pg/mL of testosterone. Heteroschedasticity robust standard errors are reported in brackets. * Means significantly different from zero at the 10% level (two-tail *t* test), ** at the 5% level, and *** at the 1% level.

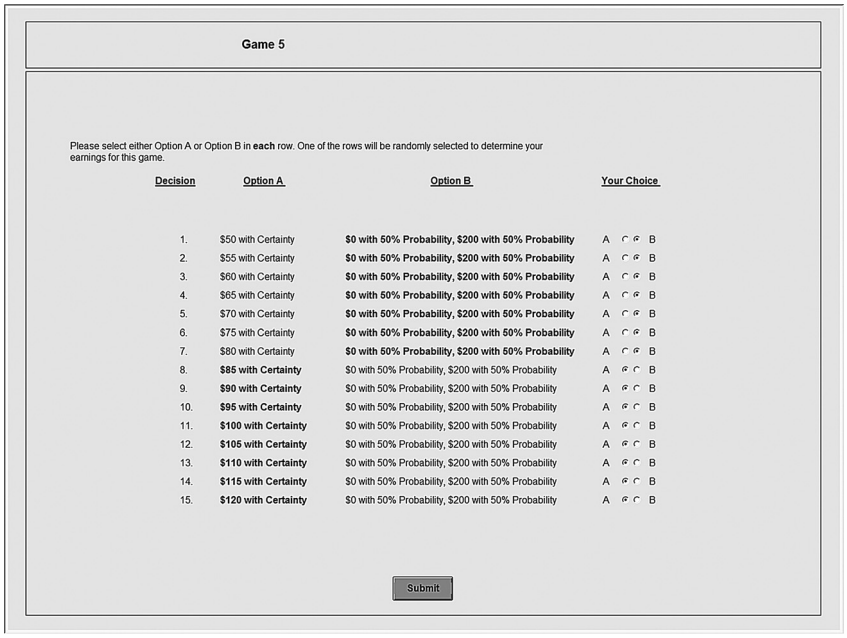

Fig. 3. Illustration of the choice faced by students in the experiment that assesses their risk aversion. The game was programmed in z-Tree and the figure reports the actual screenshot. To make the choice more salient the option chosen is embolden, as shown in the picture.

certainty equivalents. They were asked to choose 15 times between a guaranteed dollar amount (ranging from $50 in the first choice to $120 in the fifteenth choice) and a lottery that pays either $200 or zero with equal probability (see Fig. 3). At the end of the game, one of the 15 choices was randomly chosen and subjects were paid according to their decision (and the lottery drawn) in that choice. An extremely risk-averse individual was expected to always choose the guaranteed dollar amount, whereas a very risk-tolerant individual was expected to always choose the lottery. In between, as the guaranteed amount increases, a subject should cross over from the lottery to the guaranteed amount as a function of his/her risk aversion. The more risk tolerant the subject is, the higher the guaranteed amount at which the switch will occur. Therefore, the amount at which an individual switches is a measure of his/her level of risk tolerance. Alternatively, the difference between the expected value of the game ($100) and the amount at which the student switches can be interpreted as the insurance premium the student is willing to pay to avoid the lottery. This is a measure of his/her risk aversion. This measure of risk aversion can be easily mapped onto the Arrow Pratt measure of risk aversion commonly used in the economic literature (26). All of our results are the same when using this alternative measure.

Saliva Collection. Two saliva samples were collected from each student, one at the beginning of the test session (1:30 PM or 2:50 PM) and the other two hours later, after the students completed their tests (3:30 PM or 4:50 PM). ≈2–3 mL of saliva was collected by passive drool into plastic vials. In some cases, saliva production was stimulated by brief chewing of sugarless gum. Previous studies have suggested that afternoon hormone levels are more stable and therefore better suited for psychoneuroendocrine studies (27).

All samples were immediately placed into dry ice and transported to Dr. Robert Chatterton's Endocrinology Laboratory at Northwestern University, where they were frozen at −80 °C until assayed. Before assay, samples were thawed and centrifuged to reduce viscosity. Salivary concentrations of testosterone and cortisol were measured by RIA, using antisera prepared within the laboratory (28). Cross-reactivity of the cortisol serum with cortisone was nonexistent, whereas cross-reactivities of the testosterone serum with other androgens were minimal. The lower sensitivity of the assays was 0.07 ng/mL for cortisol and 7.5 pg/mL for testosterone. Intra-assay coefficients of variation (CVs) were all ≤10% and interassay CVs were ≤15%. All samples were assayed in duplicate, and the average of duplicates was used in all analyses.

The testosterone concentrations measured before and after the test were highly positively correlated across all of the subjects. Therefore, for the purposes of this study, we used the average concentration of salivary testosterone in the pretest and the posttest sample as our independent variable.

Digit Ratio Measurement. For a subset of study participants (117 males and 66 females), we scanned their right and left hand, measured the length of their second and fourth finger, and calculated their ratio (2D:4D ratio). Finger length was measured using a digital caliper. Measurements were made in triplicate and we averaged the three readings of the fingers' length before calculating the ratio (21). For a subset of subjects ($n = 80$) scans were made in duplicate using different scan machines. All data analyses were done using the average ratio of the left and right hand measures. The results were similar if we used the left hand or the right hand measurements separately.

Correlation Among Testosterone Indicators. Salivary testosterone was negatively correlated with the average digit ratio (−0.10) and the Baron-Cohen eye test (−0.06), but in neither case this correlation was statistically significant. The correlation between the average digit ratio and the Baron-Cohen eye test was also nonsignificant (0.003) (see ref. 21).

Career Data. Data on career decisions at graduation (we recorded the field in which the students accepted job offers at graduation, almost 2 years after the students had participated in the study) were available for 379 students. We distinguished between finance and nonfinance careers, because finance careers (e.g., investment banking) are considerably riskier but associated with higher economic payoffs than careers in other fields. Ten years after graduation, MBA students who pursue finance careers earn, on average, 2.8 times as much as students who pursue careers in other fields. Higher expected earnings come at the cost of higher risk: 10 years after graduation the standard deviation in salaries of people who chose finance is twice as large as the standard deviation of salaries in other fields.

ACKNOWLEDGMENTS. We thank Ernesto Reuben for his excellent research assistantship during the project and Nicole Baran, Moshe Hoffman, and Paul Rogerson for their help in hand scanning. This work is part of a larger project funded by the Templeton Foundation and the Zell Center for Risk Research. We also thank the Center for Research in Security Prices and the Initiative on Global Markets at the University of Chicago Booth School of Business for financial support (L.Z.).

1. Byrnes JP, Miller DC, Schafer WD (1999) Gender differences in risk taking: A meta-analysis. *Psych Bull* 125:367–383.
2. Baron-Cohen S (2003) *The Essential Difference*: *The Truth About the Male and Female Brain* (Basic Books, New York).
3. Archer J (2006) Testosterone and human aggression: An evaluation of the challenge hypothesis. *Neurosci Biobehav Rev* 30:319–345.
4. Hermans E, Putman P, Baas J, Koppeschaar H, van Honk J (2006) A single administration of testosterone reduces fear-potentiated startle in humans. *Biol Psychiatry* 59:872–874.

5. van Honk J, et al. (2004) Testosterone shifts the balance between sensitivity for punishment and reward in healthy young women. *Psychoneuroendocrinology* 29:937–943.
6. Takahashi T, Sakaguchi K, Oki M, Homma S, Hasegawa T (2006) Testosterone levels and discounting delayed monetary gains and losses in male humans. *Neuroendocrinology Lett* 27:439–444.
7. Dabbs JM, Morris R (1990) Testosterone, social class, and antisocial behavior in a sample of 4,462 men. *Psychol Sci* 1:209–211.
8. Mazur A (1995) Biosocial models of deviant behavior among male army veterans. *Biol Psychology* 41:271–293.
9. Blanco C, Ibanez A, Blanco-Jerez CR, Baca-Garcia E, Saiz-Ruiz J (2001) Plasma testosterone and pathological gambling. *Psychiatry Res* 105:117–121.
10. Apicella CL, et al. (2008) Testosterone and financial risk preferences. *Evol Hum Behav* 29:384–390.
11. Burnham TC (2007) High-testosterone men reject low ultimatum game offers. *Proc R Soc Lond B* 274:2327–2330.
12. Coates JM, Herbert J (2008) Endogenous steroids and financial risk taking on a London trading floor. *Proc Natl Acad Sci USA* 105:6167–6172.
13. Coates JM, Gurnell M, Rustichini A (2009) Second-to-fourth digit ratio predicts success among high-frequency financial traders. *Proc Natl Acad Sci USA* 106:623–628.
14. Zethraeus N, et al. (2009) A randomized trial of the effect of estrogen and testosterone on economic behavior. *Proc Natl Acad Sci USA* 106:6535–6538.
15. Manning JT, Scutt D, Wilson J, Lewis-Jones DI (1998) The ratio of 2nd to 4th digit length: A predictor of sperm numbers and concentrations of testosterone, luteinizing hormone and oestrogen. *Hum Reprod* 13:3000–3004.
16. McIntyre MH (2006) The use of digit ratios as markers for perinatal androgen action. *Reprod Biol Endocrinol*, 10.1186/1477–7827-4–10.
17. Knickmeyer R, Baron-Cohen S, Raggatt P, Taylor K, Hackett G (2006) Fetal testosterone and empathy. *Horm Behav* 49:282–292.
18. Baron-Cohen S, Wheelwright S, Hill J, Raste Y, Plumb I (2001) The ''Reading the Mind in the Eyes'' Test revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *J Child Psychol Psychiatr* 42:241–251.
19. Moffat SD, Hampson E (1996) A curvilinear relationship between testosterone and spatial cognition in humans: Possible influence of hand preference. *Psychoneuroendocrinology* 21:323–337.
20. Kimura D (1999) *Sex and Cognition* (MIT Press, Cambridge, MA).
21. Voracek M, Dressler SG (2006) Lack of correlation between digit ratio (2D:4D) and Baron-Cohen's ''Reading the Mind in the Eyes'' test, empathy, systemizing, and autism-spectrum quotients in a general population sample. *Person Individ Differ* 41:1481–1491.
22. Dabbs JM (1992) Testosterone and occupational achievement. *Social Forces* 70:813–824.
23. White RE, Thornhill S, Hampson E (2006) Entrepreneurs and evolutionary biology: The relationship between testosterone and new venture creation. *Organiz Behav Hum Decis Process* 100:21–34.
24. Fischbacher U (2007) *z-Tree*: *Zurich Toolbox for Ready-Made Economic Experiments* (Univ of Zurich, Zurich).
25. Holt CA, Laury SK (2002) Risk aversion and incentive effects. *Amer Econ Rev* 92:1644–1655.
26. Camerer CF (1992). Recent tests of generalizations of expected utility theory. *Utility Theories*: *Measurement and Applications*, eds Edwards W, Norwell, MA (Kluwer, Dordrecht, The Netherlands), pp 207–251.
27. Gray PB, Campbell BC, Marlowe FW, Lipson SF, Ellison PT (2004) Social variables predict between-subject but not day-to-day variation in the testosterone of US men. *Psychoneuroendocrinology* 29:1153–1162.
28. Chatterton RT, Vogelsong KM, Lu YC, Hudgens GA (1997) Hormonal responses to psychological stress in men preparing for skydiving. *J Clin Endocrin Metab* 82:2503–2509.