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Androgens and Competitiveness in Men

Coren L. Apicella
Harvard University and Harvard Medical School

Anna Dreber
Institute for Financial Research (SIFR)
and Harvard Kennedy School

Peter B. Gray
University of Nevada-Las Vegas

Moshe Hoffman
University of Chicago

Anthony C. Little
University of Stirling

Benjamin C. Campbell
University of Wisconsin-Milwaukee

In this study, we investigate the association between a number of hormonal variables (circulating testosterone, facial masculinity, 2D:4D digit ratio, and cortisol) and competitiveness in a sample of 93 men aged 18–23. Competitiveness is measured by self-selection into a competitive setting versus a piece-rate scheme. We find no robust correlations between any of the hormonal variables and competiveness, though there are some suggestive patterns in the data which merit further exploration.

Keywords: competitiveness, hormones, neuroeconomics, gender differences

A number of recent papers examine the relationship between biological and genetic markers and experimentally elicited economic preferences (Apicella et al., 2008; Dreber et al., 2009a; Knafo et al., 2007; Kuhnen & Chiao, 2009; Sapienza, Zingales, & Maestripieri, 2009). We contribute to this growing field by investigating the association between testosterone and cortisol, two important steroid hormones, and competitiveness in an experimental task. The relationship between hormones and competition is well documented in the behavioral endocrinology literature, with a majority of the observed effects occurring in men. For instance, testosterone and cortisol rise in anticipation to competition and testosterone increases in winners relative to losers after competitions (see Archer, 2006, for review). This "winner-loser" response has been found for physical competitions, for example, wrestling (Elias, 1981) and tennis (Booth, Shelley, Mazur, Tharp, & Kittok, 1989), nonphysical competitive encounters, for example, chess (Mazur, Booth, & Dabbs, 1992), and chance-based competitions, for example, coin-tosses (McCaul, Gladue, & Joppa, 1992). While pre- and postevent changes in cortisol

Coren L. Apicella, Department of Anthropology, Harvard University, and Department for Health Care Policy, Harvard Medical School; Anna Dreber, Institute for Financial Research (SIFR) and Women and Public Policy Program, Harvard Kennedy School; Peter B. Gray, Department of Anthropology, University of Nevada-Las Vegas; Moshe Hoffman, Department of Economics, University of Chicago; Anthony C. Little, Department of Psychology, University of Stirling; Benjamin C. Campbell, Department of Anthropology, University of Wisconsin-Milwaukee.

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Correspondence concerning this article should be addressed to Anna Dreber, Institute for Financial Research (SIFR) and Women and Public Policy Program, Harvard Kennedy School, Drottninggatan 89, 11360 Stockholm, Sweden. E-mail: anna.dreber@sifr.org

and testosterone have been examined, this study is the first to examine whether baseline levels of these steroid hormones are related to individual differences in men's willingness to engage in competitions. We measure competitiveness, defined here as a preference for competition, by having participants self-select into either a tournament or a piece-rate payment scheme.

Testosterone, a steroid hormone produced primarily by the testes in men, is responsible for the development and maintenance of masculine features. Circulating testosterone has been positively related to a number of social behaviors in men including dominance, status-seeking (Kemper, 1990; Mazur, 1985; Mazur & Booth, 1998) and economic risk taking (Apicella et al., 2008). While it is widely understood that testosterone promotes the pursuit of dominance, the behavioral channels by which it exerts this influence are less clear (Mazur & Booth, 1998). While aggression and violence are sometimes used to increase status and dominance, they represent extreme and possibly maladaptive behaviors. One more socially acceptable way for men to increase their dominance would be to engage in competitions against other men. In this study, we ask whether baseline levels of circulating testosterone are associated with men's preferences for competition.

Early in ontogeny, while still in the womb, and again during puberty, testosterone permanently organizes the brain and programs how individuals respond to the current circulating levels of testosterone. It is therefore necessary to also consider testosterone exposure during these critical periods of development especially since androgen exposure in utero and during puberty often bear little relation to current circulating levels of testosterone in adulthood (Wallen & Hassett, 2009). To do this, we use the ratio between the second finger and fourth finger (2D:4D) (Manning et al., 1998) and degree of facial masculinity as proxies for testosterone exposure in utero and during puberty, respectively. Lower digit ratios have been associated with greater androgen exposure in utero[1] and most recently researchers have found that lower digit ratios are associated with increased profits and risk taking in high-frequency traders (Coates, Gurnell, & Rustichini, 2009; Coates & Page, 2009). Facial masculinity is used as a marker for pubertal testosterone exposure because many masculine facial features, such as jaw width, develop during puberty under the influence of testosterone (Johnston et al., 2001). Prior research has found that men with more masculine faces take greater economic risks (Apicella et al., 2008). In this study, we examine whether trait-like testosterone measures, including baseline testosterone levels, digit ratios, and facial masculinity are associated with variation in the willingness to compete across men.

Cortisol, a hormone produced by the adrenal glands, is thought to be important in competitions. While cortisol is also commonly associated with psychological and physiological stress (Hennessy & Levine, 1979), feelings of anxiety and fear (Korte, 2001; Erickson et al., 2003) and avoidant behavior (Roelofs, Elizinga, & Rotteveel, 2005), there is evidence that suggests that mild increases in cortisol are important in competitions because cortisol mobilizes resources to help individuals prepare for challenges (Roney, Lukaszewski, & Simmons, 2007; Roney, Simmons, & Lukaszewski, 2010). Given this, it is not surprising that cortisol and anxiety increase concurrently in anticipation of contests (Salvador, Suay, González-Bono, & Serrano, 2002). This study aims to extend these recent findings and examine whether baseline levels of cortisol are negatively associated with the preference to avoid competitions.

Most studies find that women are less competitive than men (Datta Gupta, Poulsen, & Villeval, 2005; Gneezy, Niederle, & Rustichini, 2003; Niederle & Vesterlund, 2007) and one theorized source of this difference is testosterone (Croson & Gneezy, 2009). While hormones provide one possible proximate mechanism for explaining sex differences, ultimate explanations rely on understanding the different adaptive pressures faced by ancestral men and women. Sex differences are considered concomitants of the processes of intersexual selection and intrasexual selection. Relative to females, male reproductive success is affected more by their ability to obtain mates. Males may compete directly for mates or they may compete for resources, territory or status, all of

[1] The best evidence for this comes from the observations that a sex difference in digit ratios is present after birth and that individuals who suffer from congenital adrenal hyperplasia, characterized by increased exposure to androgens in utero, also have lower digit ratios (Brown, Hines, Fane, & Breedlove, 2002).

which serve to increase their mating opportunities (Darwin, 1871; Trivers, 1972). Thus, males are concerned with gaining dominance as the spoils of increased status often result in mates (Wrangham, 1999). Consequently, the preference to compete should be more pronounced in men compared to women. However, increasing evidence suggests that individual differences in hormone levels across men may be associated with different life-history strategies whereby some men invest more in parenting effort and others in mating effort (Archer, 2006; Gray, Kahlenberg, Barrett, Lipson, & Ellison, 2002; Gray, Kruger, Huisman, Wissing, & Vorster, 2006). As a result, testosterone levels may be correlated with different behaviors in men, such as competitiveness, associated with the adoption of either a mating or parenting strategy (Archer, 2006). While we only examine the relationship between androgens and competitiveness in men, the present study may shed some light on the foundations of this sex difference by increasing our understanding of the role of biology on competitiveness more generally.

Experimental Design

Subjects were recruited by fliers distributed on the Harvard University campus, and through email solicitation to undergraduate residential houses in the spring of 2007. A total of 98 male subjects between the age of 18 and 23 years participated in the study, out of which 97 completed the competition task. Out of these 97 men, 88 individuals reported themselves as heterosexual and 7 as homosexual. One individual self-reported as bisexual and 1 individual reported an unknown sexual orientation. We classify these 9 individuals as nonheterosexual. One outlier with testosterone levels more than 3 *SD*s above the mean was excluded from all analyses as were three outliers with cortisol levels more than 3 *SD*s from the mean, leaving 93 subjects. Finally, 1 participant was not photographed. The study was approved by Harvard's institutional review board. Written consent was obtained from all subjects before participating in the study.

Following informed consent, each subject was asked to provide an unstimulated saliva sample for hormonal measurement by spitting through a straw into a vial. Subjects then filled out a brief questionnaire that included the competitiveness measure. Our competitiveness measure is adapted from Gneezy and Potters (1997) and involves asking subjects to self-select into either a piece rate scheme or a tournament, in a maze solving task. Each subject was first given a practice maze and told that he would solve similar mazes as the practice one for 5 min. Before solving the mazes, participants were asked to choose between two payment options: Option 1, the piece rate scheme, gives the subject 25 cents for every maze solved. In option 2, subjects would get 75 cents for every maze solved if the subject solved at least as many mazes at the person who last completed the study. If the subject solved less mazes than the person who last completed the study, he would get $0. Option 2 is thus a tournament. This type of binary measure of competitiveness is common in economics and the measure has previously produced gender differences (Gneezy, Leonard, & List, 2009; Niederle & Vesterlund, 2007).

After completion of the questionnaire and mazes, subjects' hands were scanned, and a full-frontal facial photograph was obtained. Hands were scanned using a high resolution scanner. Digits were later measured from the center of the flexion crease proximal to the palm to the tip of the finger. 2D:4D was not calculated for 17 individuals because of unclear creases in fingers or substandard image quality of the scans. Finally, one participant left before being photographed. Using the photos, four sexual dimorphism measures were taken from marked face points as used in previous studies (Little et al., 2008; Penton-Voak et al., 2001). The measures taken here are identical to Little et al. (2008) that includes more details of the measurements and a diagram displaying point placement. The identification of these features has been found to be reliable in previous studies (Grammer & Thornhill, 1994; Scheib, Gangestad, & Thornhill, 1999). Facial masculinity was assessed by combining these four measures on the face including cheekbone prominence, jaw height/lower face height, lower face height/face height, and face width/lower face height. All measures were first converted to a z-score before combing into a masculinity score. High scores indicate increased facial masculinity. These measurements have been found to be sexually dimorphic in previous studies (Little et al., 2008; Penton-Voak et al., 2001) although it

is still unclear how much of dimorphism is because of variation in pubertal testosterone levels. However, testosterone during human male development facilitates the growth of bone by increasing outside bone diameter and bone mass (Vanderschueren & Bouillon, 1995). It has also been found that the mandibular ramus length, upper anterior face height, and total cranial base length all are significantly shorter in boys with delayed puberty as compared to controls, and that boys given low doses of testosterone demonstrate a significantly rate of growth in these features compared to untreated subjects (Verdonck, Gaethofs, Carels, & de Zegher, 1999).

Saliva samples were frozen on the same day they were supplied and stored at −20 °C. At the end of the collection period, all samples were packed in dry ice and shipped via FedEx, overnight delivery, to the Human Behavioral Endocrinology Laboratory at the University of Nevada, Las Vegas, where they were assayed. Samples were still frozen upon arrival. Testosterone assays relied on commercially available kits (Salimetrics EIA, product number: 1–2402). Sample and standard reactions were run in duplicate and the sample concentrations used in the analyses are the averages of the duplicates. Interassay coefficients of variation were 13.2% for low pools and 7.1% for high pools. The intrassay coefficient of variation was 6.8%. Cortisol assays relied on commercially available kits (Salimetrics EIA, product number: 1–3002). The intrassay CV was 7.5% and the interassay CV 3.8%.

Both testosterone and cortisol display a diurnal rhythm with higher concentrations in the morning. Saliva samples were collected between 1 p.m. and 3 p.m., with no significant differences in testosterone concentrations found between subjects as a function of the hour in which the samples were collected. For cortisol, however, there is a significant difference. In the analysis we therefore residualize the cortisol measure on time of collection and use this variable in the analyses that follow. Because the outcome variable is binary, we use logit regressions throughout, with robust standard errors. All analysis is performed with the Data Analysis and Statistical Software STATA 9.

Results

Summary statistics are provided in Table 1 and a correlation matrix is provided in Table 2.

Table 1
Summary Statistics for Variables Used in Analyses

Variable	*M*	*SD*	*N*
Competitiveness (0 or 1)	0.710	0.456	93
Testosterone (pg/ml)	99.28	33.54	93
Facial masculinity	−0.061	2.126	92
Left 2D:4D	0.952	0.031	83
Right 2D:4D	0.953	0.030	86
Cortisol (μg/dL)	0.155	0.028	93

Out of the 93 men participating in the task the majority chose to compete (66 chose competition, 27 chose piece-rate scheme). Table 3 shows the regression analysis. The nonheterosexual men in the sample are significantly less competitive than the heterosexual men (p = .010). Regressing competitiveness on the hormonal variables separately while controlling for sexual orientation, we find no significant hormonal predictors of competitiveness (circulating testosterone: p = .564, facial masculinity: p = .133, left 2D:4D: p = .435, right 2D:4D: p = .798, cortisol: p = .437). When controlling for all the different hormonal variables as well as sexual orientation at the same time, the results remained nonsignificant (circulating testosterone: p = .704, facial masculinity: p = .161, left 2D:4D: p = .399, right 2D:4D: p = .449, cortisol: p = .870). Men who chose to compete did not perform better than those that did not (solved 5.1 vs. 4.4 mazes, Wilcoxon's rank-sum/Mann–Whitney test: p = .115).

Concluding Remarks

The main finding of this study is that there is no significant association between circulating testosterone, cortisol and men's preference to compete in a sample of almost 100 men. Given our sample size and the complex nature of hormones and behavior, the null results in this paper should be treated with some caution.

Decades of research have linked hormones with behaviors, and correlational studies, such as the one described here, are a useful first approach in uncovering hormonal influences on individual differences. However, within the growing field of behavioral endocrinology, it has become increasingly apparent that few simple cause and effect relationships exist. This is also likely to be true for economic behaviors.

Table 2
Correlation Matrix for Variables Used in Analyses

	Competitiveness	Nonhetero	Testosterone	Facial masc.	Left 2D:4D	Right 2D:4D	Cortisol
Competitiveness	1.0000						
Nonhetero	−0.2771 (0.0060)	1.0000					
Testosterone	0.0260 (0.8018)	0.1562 (0.1265)	1.0000				
Facial masc.	0.1406 (0.1719)	0.0256 (0.8034)	0.0716 (0.4880)	1.0000			
Left 2D:4D	0.0727 (0.5031)	0.1245 (0.2477)	0.1607 (0.1370)	0.0228 (0.8339)	1.0000		
Right 2D:4D	−0.0165 (0.8773)	0.0569 (0.5920)	0.0711 (0.5057)	−0.0354 (0.7406)	0.7034 (0.0000)	1.0000	
Cortisol	−0.0443 (0.6714)	−0.0941 (0.3644)	0.0104 (0.9209)	−0.1138 (0.2747)	−0.0893 (0.4166)	−0.1325 (0.2183)	1.0000

Note. *p* values in parentheses.

Table 3
Regression Table Competitiveness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Nonhetero	−2.213 (0.86)***	−2.265 (0.83)***	−2.339 (0.95)**	−2.856 (1.14)**	−1.988 (0.88)**	−2.298 (0.92)**	−2.534 (1.36)*
Testosterone		0.003 (0.006)					0.002 (0.006)
Facial masc.			0.175 (0.12)				0.181 (0.13)
Left 2D:4D				6.075 (7.77)			8.803 (10.4)
Right 2D:4D					−2.307 (9.03)		−10.327 (13.6)
Cortisol						−6.624 (8.51)	1.710 (10.5)
Constant	1.114 (0.25)***	0.792 (0.60)	1.146 (0.26)***	−4.585 (7.39)	3.281 (8.62)	2.153 (1.35)	2.170 (10.1)
Observations	93	93	92	83	86	93	75

Note. Column 1–6 represent individual regression results for each predictor variable controlling for sexuality. Column 7 represents the full regression analysis entering all predictor variables. Robust standard errors in parentheses.
* significant at 10%. ** significant at 5%. *** significant at 1%.

Instead, relationships between hormones and behavior are often bidirectional and can be easily be influenced by individual perceptions and social contexts. Therefore, while we did not find a relationship between baseline measures of cortisol and testosterone and competition this does not rule the existence of such relationships if competition were operationalized differently. It is also important to note that baseline levels of hormones may not be related to economic preferences across men but rather changes in hormones within men could affect their preferences and may be responsible for the preference shifts often observed in economics. Interestingly, men who lose competitive interactions and experience a decrease in testosterone relative to those who lose but experience an increase in testosterone are less likely to demand a rematch (Mehta & Josephs, 2006). One further issue lies in the binary nature of our competitiveness measure. Such forced choice decisions necessarily limit power in the analysis. However, this is one of the two most common measures of competitiveness used in economic research and has yielded significant associations in the past using smaller samples than the one described here (Gneezy, Leonard, & List, 2009).

There are several other papers that examine the role of androgens and related measures on economic behavior, with mixed results. For instance, masculine digit ratios for the right hand have been linked to higher profits and risk taking in traders (Coates, Gurnell, & Rustichini, 2009; Coates & Page, 2009). However, the relationship between 2D:4D and risk is far from conclusive. While one study finds a negative relationship between 2D:4D and risk taking in a Swedish sample this was not replicated it in a more ethnically diverse United States sample (Dreber & Hoffman, 2007). Two additional studies have also failed to find an association between 2D:4D and risk (Apicella et al., 2008; Pearson & Schipper, 2009). Like digit ratios, the effect of testosterone on economic behavior is also unclear. Using the same sample described here, a positive relationship between risk taking and testosterone was found (Apicella et al., 2008). However, another study on both male and female MBA students reports an association between testosterone and risk taking in high testosterone women but not in men (Sapienza, Zingales, & Maestripieri, 2009). Three randomized studies find mixed results. One study where postmenopausal women were either given testosterone, estrogen, or placebo exogenously, found no effect of any of these hormones on economic preferences including risk, though competitiveness was not included in the study (Zethraeus et al., 2009). In regards to testosterone, it is unclear whether exogenous administration of the hormone would affect women since their brains are not organized early in development to respond to the activating effects of testosterone later in life as happens for men. The results of Zethraeus et al. (2009), however, suggest that exogenous testosterone and estrogen have little effect on economic behavior in women. Two other studies find mixed results on the importance of exogenous testosterone administration on behavior in the Ultimatum game. One study finds that women given testosterone give higher offers as proposers but finds no effect on responder behavior (Eisenegger, Naef, Snozzi, Heinrichs, & Fehr, 2009), whereas another study finds that the difference in what a man proposes as proposer and his minimum acceptable offer as responder decreases with testosterone exposure (Zak et al., 2009).

Future research should explore the role of androgens on competitiveness in women. Compared to men, women are underrepresented in top positions in most sectors and this pattern holds across societies. A number of explanations have been suggested to explain the gender gap, including men's greater propensity to compete. Much debate about sex, sex differences, and hormones and the relationships among them has ensued during the last half century. While the role of hormones in producing physiological and morphological differences between the sexes is well established, the role of hormones in producing cognitive and behavioral differences is less clear (Hines, 1982). One study reported that women are less likely to self-select into a tournament during times in their cycle when progesterone and estrogen levels are high (Buser, 2009). One possibility is that sex differences in competitiveness are because of the inhibitory actions of estrogen and progesterone in women; however, another study finds the opposite effect of the menstrual cycle (Wozniak, Harbaugh, & Mayr, 2009). Finally, recent studies suggest that cultural factors

may play an important role in determining the gender gap (Niederle & Yestrumskas, 2008; Dreber, von Essen, & Ranehill, 2009; Gneezy, Leonard, & List, 2009). For instance, a recent study found no gender differences in competitiveness in prepubescent Swedish children between the ages of 8–10 (Dreber, von Essen, & Ranehill, 2009) which suggests the gender gap in competitiveness emerges after childhood if it emerges at all (Gneezy, Leonard, & List, 2009). In interpreting this evidence, it is important to recall that cultural and biological explanations need not be mutually exclusive, because hormone levels may respond to environmental stimuli.

Identifying the various biological and cultural factors, as well as their interaction, is particularly important if policy implications are to be drawn from endocrinological studies of economic phenotypes. While the null results of this study help to further our understanding of the role of biology on economic behavior, the mixed results to date necessitate the need for future work using larger and more diverse samples before definitive conclusions about the role of hormones on economic behavior can be reached. We suggest that future work examine the role of exogenous testosterone administration on men's economic behavior. Additionally, we advocate for the publication of null results, as publication bias often results in the lack of countervailing evidence.

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