

Video Article

Combining Behavioral Endocrinology and Experimental Economics: Testosterone and Social Decision Making

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Abstract

Behavioral endocrinological research in humans as well as in animals suggests that testosterone plays a key role in social interactions. Studies in rodents have shown a direct link between testosterone and aggressive behavior¹ and folk wisdom adapts these findings to humans, suggesting that testosterone induces antisocial, egoistic or even aggressive behavior². However, many researchers doubt a direct testosterone-aggression link in humans, arguing instead that testosterone is primarily involved in status-related behavior^{3,4}. As a high status can also be achieved by aggressive and antisocial means it can be difficult to distinguish between anti-social and status seeking behavior.

We therefore set up an experimental environment, in which status can only be achieved by prosocial means. In a double-blind and placebo-controlled experiment, we administered a single sublingual dose of 0.5 mg of testosterone (with a hydroxypropyl- β -cyclodextrin carrier) to 121 women and investigated their social interaction behavior in an economic bargaining paradigm. Real monetary incentives are at stake in this paradigm; every player A receives a certain amount of money and has to make an offer to another player B on how to share the money. If B accepts, she gets what was offered and player A keeps the rest. If B refuses the offer, nobody gets anything. A status seeking player A is expected to avoid being rejected by behaving in a prosocial way, i.e. by making higher offers.

The results show that if expectations about the hormone are controlled for, testosterone administration leads to a significant increase in fair bargaining offers compared to placebo. The role of expectations is reflected in the fact that subjects who report that they believe to have received testosterone make lower offers than those who say they believe that they were treated with a placebo. These findings suggest that the experimental economics approach is sensitive for detecting neurobiological effects as subtle as those achieved by administration of hormones. Moreover, the findings point towards the importance of both psychosocial as well as neuroendocrine factors in determining the influence of testosterone on human social behavior.

Protocol

1. Subject Recruitment

1. Subjects are recruited via an on-line database⁵ containing a list of about 3000 student volunteers. From this list we only contact women who have not previously participated in similar studies and ask them whether they are interested in participating in this study. We invite exclusively women as the time course of neurophysiological effects after acute testosterone administration is well established among women^{6,7}. For men, this time course is not yet very well understood.
2. The interested subjects are then screened in a telephone interview to exclude medication intake, somatic diseases, hormonal contraception or any neurological or psychiatric disorders.
3. Because endogenous levels of sex hormones tend to be low and stable within the first part of the female menstrual cycle we conduct a second telephone interview to gain information about stability and duration of the cycle. Subjects are then invited to come to the experiment within 10 days from the beginning of their menstrual cycle. They are further instructed to abstain from alcohol or caffeine intake and smoking for 24 hours before the experiment.
4. Subjects are invited in groups of an average size of 12 to the experimental laboratory of the Institute for Empirical Research in Economics, in Zurich, Switzerland.

2. Experimental Procedure

1. All sessions start at 1.00 pm to control for the circadian variation in steroid hormone levels.
2. We conduct a pregnancy test before the beginning of the experiment to preclude pregnancy.
3. In preparation of the experiment, the testosterone and visually indistinguishable placebo pills are randomly distributed to twelve workstations marked one to twelve within the laboratory room by a person who is not involved in the experiment otherwise.
4. At the entrance to the laboratory, each of the twelve subject draws a card with a concealed number on it. The numbers range from one to twelve.
5. Subjects are then taken to the laboratory room which is endowed with a total of 36 computer workplaces. Subjects are instructed to seek out and sit down by the workplace marked with the same number as indicated on the card they drew at the entrance.
6. All subjects read and sign the informed consent form.
7. We measure baseline salivary testosterone and cortisol concentrations using the IBL SaliCaps Kit (IBL-Hamburg, Hamburg, Germany) for saliva specimen collection. Subjects are requested to transfer 1 mL of saliva into the test tubes, which are then immediately frozen at -80°C.

- Subjects are requested to take the sublingual pill into their mouth, to chew it and keep the disintegrated substance in their mouth for one minute. To achieve maximal contact of the HP- β -CD testosterone inclusion complex with the oral mucosa, subjects are instructed to make circling movements with their tongue. After one minute, the remainder of the substance is swallowed using 100 mL water.
- Immediately following the substance administration, subjects are required to complete different questionnaires. We measure mood and arousal by means of the Multidimensional Mood Questionnaire (MDBF)⁸ and anxiety and anger traits and states, by means of the State-Trait Anxiety Inventory⁹ and the State-Trait Anger Expression Inventory¹⁰. These questionnaires have the purpose of controlling for any possible effects of subjects' incidental mood, anger and anxiety states as well as for personality characteristics. Furthermore, subjects complete the validated German versions of the 90-item Symptom Checklist (revised version)¹¹ to measure their psychological health. Those who have very high scores (two standard deviations above the mean, indicating poor psychological health) are excluded from the data analysis. Due to the established time lag of four hours for the appearance of behavioral effects after sublingual application of 0.5 mg testosterone in young, healthy women^{6,7}, a long waiting period is an integral part of our study. During this period, our subjects are required to stay in the laboratory room and keep themselves quietly occupied. This is to ensure that no social interaction outside the laboratory takes place which could give rise to confounded measures.

3. Ultimatum Game

- Subjects then receive the instructions for their role in the game and the payoff rules on paper and are asked to read them. We check their comprehension of the payoff structure by having them complete several control questions at the end of the instructions.
- We then summarize the experimental procedure orally. The reason for this is to ensure that subjects know that everyone else has the same information about the structure of the game and how the payoffs are determined, which is also referred to as "common knowledge". The summary is as follows:
- "The Ultimatum Game is played with two types of players, a proposer and a responder, who have to agree on the division of 10 monetary units (MUs). The proposer can decide on the distribution of the 10 MUs. In this experiment, the proposers can propose offers of 5, 3, 2, or 0 MUs to the responder. The responder then has to either accept or reject this proposal. If the responder accepts the proposer's offer, the proposed allocation will be implemented and paid. However, the responder can also reject the proposal; in this case neither party earns anything."
- We ensure a clear separation between an offer that is regarded as fair (5 MUs) and offers that are perceived as unfair (3, 2 or 0 MUs) by restricting the offers to 5, 3, 2 or 0 MUs. Subjects are randomly and anonymously assigned to the role of either the proposer or the responder and then remain in this role for the whole experiment. Every proposer makes three propositions on the distribution of MUs while paired with three different randomly selected interaction partners. No pair of subjects interacts more than once. They never learn the identity of the persons with whom they are matched in the experiment. The proposer does not receive feedback about the responders' choices until the end of the experiment. All decisions in the ultimatum game are implemented in zTree software and presented on computer screens¹².
- Because testosterone is one of the most widely discussed hormones in the popular press it is possible that subjects have a preformed belief (true or false) about its effects¹³. Furthermore, because ethical concerns require researchers to inform subjects that they will either receive a placebo or testosterone the prior knowledge about testosterone may pollute a possible impact of testosterone on behavior. Therefore we assess the perceived group assignment by asking the subjects whether they think they have received testosterone or the placebo pill.
- The perceived group assignment is recorded in the final questionnaire together with a few socioeconomic characteristics. During the last questionnaire we prepare subjects' payment.

4. Subject Payment

- Subjects receive a base fee of one hundred Swiss francs for participation in the experiment. The use of real monetary incentives greatly reduces a potential social desirability bias and biased self-perceptions. Therefore, each subject receives one Swiss franc (approximately 1 US\$) for each MU earned in the ultimatum game. Each subject receives his or her earnings consisting of the base fee plus the earned MUs in private at the end of the experiment.

Discussion

An indication that your results are valid is if the average offers observed is similar to what other studies found. Typically, average offers are between 30 - 40% of the total amount and approximately half of the subjects offer the equal share¹⁴. On the other hand, a likely indicator that subjects did not understand the rules of the game is if offers of more than 50% are observed. It is worth noting, however, that there is considerable heterogeneity in the distribution and average offers observed in studies around the world¹⁵.

As in all behavioral economics experiments¹⁶, sincerity and credibility are important facets. If by the end of the procedure, subjects believe they have been or might have been tricked, deceived or misled, this is a strong indication that something went wrong in the procedure and the plausibility of any results is cast into doubt. An important aspect of achieving credibility and avoiding doubts is the correct implementation of incentives. Similarly, anonymity and subjects' belief in anonymity are further vital criteria of any successful experiment. Since the number of subjects is relatively small in behavioral economics experiments (around 30 - 60 per treatment) it is important to check the randomization into the treatment groups. Ideally, the distributions of important personality variables are similar in the different treatment groups (in our case the testosterone and placebo group). If the distributions are not similar one has to take this into account in the statistical analysis of the data.

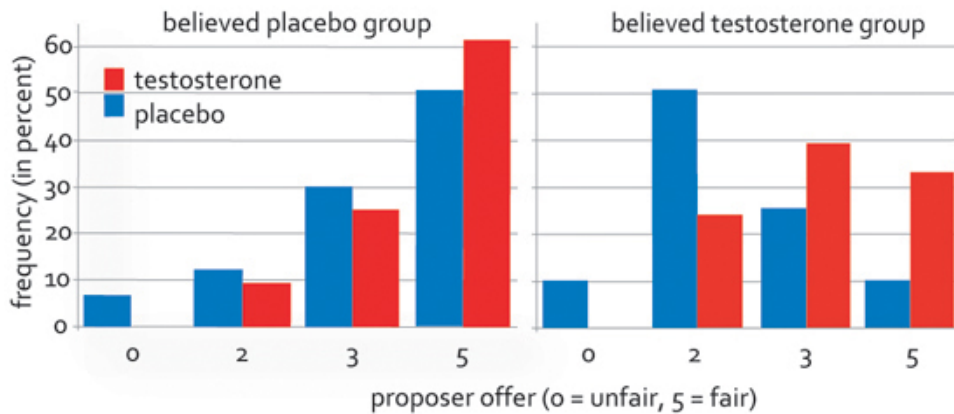


Figure 1. The distribution of proposers' offers across treatments and beliefs. **Left panel:** distribution of offers in the placebo and the testosterone group in those subjects who believed that they received placebo. **Right panel:** distribution of offers in the placebo and the testosterone group in those subjects who believed that they received testosterone.

Our results show that the experimental procedure is successful in that subjects who are expected to behave in a standard manner (i.e. those who received placebo) make decisions that are in line with standard ultimatum game behavior. Furthermore, the approach described herein has proven to be sensitive to pharmacological challenges as subtle as those achieved by testosterone administration (figure 1). Finally, we show that expectations about the impact of a substance on behavior seems to have a powerful influence in social decision making situations: those who believed to have received testosterone make substantially lower offers than those who believed to have received placebo (compare the distributions in left and right panel of figure 1) ¹⁷.

This protocol, correctly applied, provides the means to test the effects of acute single dose testosterone on human social decision making behavior.

Disclosures

No conflicts of interest declared.

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References

- Edwards, D. A. Early Androgen Stimulation and Aggressive Behavior in Male and Female Mice. *Physiology & Behav* 4, 333-338 (1969).
- Archer, J. Testosterone and human aggression: an evaluation of the challenge hypothesis. *Neurosci Biobehav R* 30, 319-345 (2006).
- Mazur, A. & Booth, A. Testosterone and dominance in men. *Behav Brain Sci* 21, 353-363; discussion 363-397 (1998).
- Josephs, R. A., Newman, M. L., Brown, R. P. & Beer, J. M. Status, testosterone, and human intellectual performance: stereotype threat as status concern. *Psychol Sci* 14, 158-163 (2003).
- Greiner, B. in *Forschung und wissenschaftliches Rechnen: GWDG Bericht 63* eds Kurt Kremer & Volker Macho) 79-93 (Ges. für Wiss. Datenverarbeitung, 2004).
- van Honk, J. *et al.* A single administration of testosterone induces cardiac accelerative responses to angry faces in healthy young women. *Behav Neurosci* 115, 238-242 (2001).
- van Honk, J., Peper, J. S. & Schutter, D. J. Testosterone reduces unconscious fear but not consciously experienced anxiety: implications for the disorders of fear and anxiety. *Biol Psychiatry* 58, 218-225 (2005).
- Steyer, R., Schwenkmezger, P., Notz, P. & Eid, M. Der Mehrdimensionale Befindlichkeitsfragebogen (MDBF) [Multidimensional Mood Questionnaire]. (Hogrefe, 1997).
- Laux, L., Glanzmann, P., Schaffner, P. & Spielberger, C. D. Das State-Trait-Angstinventar (Manual for the State-Trait Anxiety Inventory). (Beltz, 1981).
- Schwenkmezger, P., Hodapp, V. & Spielberger, C. D. Das State-Trait-Aergerausdruck-Inventar STAXI [The State-Trait Anger Expression Inventory (STAXI)]. (Verlag Hans Huber, 1992).
- Derogatis, L. R. SCL-90-R, administration, scoring & procedures manual-I for the R(evised) version., (Johns Hopkins University School of Medicine: Eigendruck., 1977).
- Fischbacher, U. z-Tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics* 10, 171-178 (2007).
- Bjorkqvist, K., Nygren, T., Bjorklund, A. C. & Bjorkqvist, S. E. Testosterone Intake and Aggressiveness - Real Effect or Anticipation. *Aggressive Behav* 20, 17-26 (1994).
- Camerer, C. F. Behavioral game theory: experiments in strategic interaction. (Princeton University Press, 2003).
- Henrich, J. *et al.* "Economic man" in cross-cultural perspective: Behavioral experiments in 15 small-scale societies. *Behavioral and Brain Sciences* 28, 795-855 (2005).
- Bardsley, N., Cubitt, R. P., Loomes, G. & Moffatt, P. Experimental economics : rethinking the rules. (Princeton University Press, 2009).
- Eisenegger, C., Naef, M., Snozzi, R., Heinrichs, M., & Fehr, E. Prejudice and truth about the effect of testosterone on human bargaining behaviour. *Nature* 463, 356-359, (2010).