HAMPSHIRE COLLEGE

Influences of Testosterone, Aggression and Anger on Ultimatum Game Behavior

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Introduction

The Ultimatum Game

The Ultimatum Game is an economic game where one person is given a sum to divide between themself and a second person. The second player then chooses whether to accept or reject the division. If the second player accepts, they get the portion offered, but if they reject, neither player gets anything. If players act solely to maximize their own gain, the second player should always accept the sum offered, no matter how low. Yet countless replications of the Ultimatum Game have shown that a significant number of people will reject offers of less than half the total[1], even when the dollar amount offered is a sizable sum[2].

What motivates this rejection? Some argue that low offers violate the second player's sense of "fairness". Rejection behavior does vary in cultures with different norms of fairness[3], but not always in a way that the fairness hypothesis predicts[4]. Others suggest that rejection behavior has a strong emotional component, and can be better predicted by personality variables such as anger, aggression, dominance and impulsiveness. A study by Pillutla and Murninghan found a strong correlation between feelings of anger and the decision to reject low offers (.51) but a weak, non-significant effect of feelings of unfairness (.10)[5].

Testosterone and Aggression

Anger and aggression can be observed indirectly through physiological measures, in addition to questionnaires and experimental manipulations. The androgen hormone testosterone has been linked to aggression, especially provoked aggression, by a number of studies[6,7]. If one considers an "unfairly low" Ultimatum Game offer to be a form of aggression, one can view rejection of low offers as a form of provoked aggression. There have been few studies measuring testosterone as it relates to Ultimatum Game behavior, although one such study did find that digit ratio, an indicator of prenatal testosterone levels, was correlated with rejections[8].

Possible Connections

This study attempts to explore the relationship between testosterone, aggression, and Ultimatum Game behavior in further detail. We looked at dynamic testosterone levels in saliva, along with digit ratio and several self-report measures of aggression, as they related to rejections of low offers and offers to others. We developed the following hypotheses:

- **Aggression, as measured by the Buss-Perry Aggression Questionnaire (BPA), would be positively correlated with rejections of low offers and offers to others.**
- **Testosterone, as measured by digit ratio and by saliva testosterone levels, would be positively correlated with rejection of low offers and offers to others.**
- **Aggression and testosterone would be positively correlated with each other.**

Methods

_____Subjects were 37 college undergraduates, male and female, between the ages of 18-25. They were told that they were taking part in an "Ultimatum Game Network". They were shown offers that they were told had been made by others, and asked to accept or reject them. Before each offer was made, they were shown a picture of the person who had made the offer. They were also told that some offers were computer generated. For those trials, a picture of a computer was shown. After each trial, a screen showing the amount of money earned in that trial was shown (see Figure 1).

This study was done in conjunction with an EEG investigation of Ultimatum Game behavior. Subjects gave a baseline saliva sample and were then prepared for ERP recording (a process which generally took 10-20 minutes). After the Ultimatum Game Network was explained to them, they were presented 660 total offers. Halfway through, a second testosterone sample was taken. After they had completed the second half, subjects were asked to make ten offers to others in the network. They were then administered the aggression questionnaires, digit ratio was measured and, finally, they were debriefed.

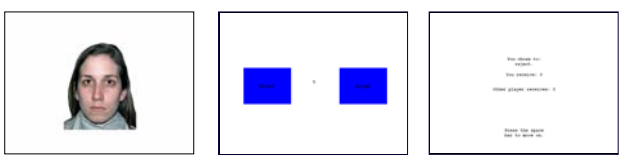


Figure 1. Stimuli presented to subjects. Subjects were presented with the face of another member of the Ultimatum Game Network, and asked to accept or reject their offer. In half of all trails, a computer was shown instead.

Methods (cont.)

Testosterone: Saliva Samples

Subjects were instructed not to eat or drink anything besides water for an hour before the experiment. They were run between 6 p.m. and 10 p.m. at night in order to minimize diurnal variation in circulating testosterone concentrations.

Testosterone concentrations were measured by assaying the saliva samples in anti-testosterone antibody-coated wells. The assay was done twice, several hours apart, in order to assess the validity of the measures. Testosterone levels in the two assays were highly correlated ($r = 0.776$, $p < 0.001$) but significant differences remained (two-sided t test: $t = 1.99$, $p < 0.001$), possibly due to degradation of the samples after thawing.

Two different saliva testosterone variables were calculated: baseline testosterone level, taken from the first sample collected, and change in testosterone, calculated by subtracting the testosterone concentration in the first sample from the concentration in the second.

Testosterone: Digit Ratio

Subjects' hands were scanned onto a computer, and three different raters took measurements of the length of the index and ring finger. Digit ratio was calculated by dividing the length of the second, or index, finger by the length of the fourth, or ring, finger. After assessing for inter-rater reliability, the average of these measurements were used.

Results

Behavioral Results

Rejections and reaction times were analyzed for the four different types of offers.

Offers	One	Two	Three	Five
Rejection Rate	66%	59%	42%	2%

Subjects generally followed one of two strategies. One group (n = 9) accepted virtually all offers, with rejection percentages never reaching higher than 5%. The majority of subjects (n = 22) tended to reject all offers of 1 dollar, and accept all offers of 5 dollars, with rates of acceptance for offers of 2$ and 3$ varying. Only three subjects failed to utilize one of these strategies.

Aggression and Behavior

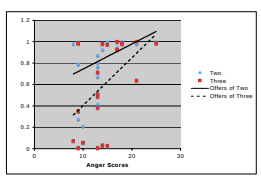


Figure 2. Anger and Rejection Behavior. Subjects who rated higher on the anger subscale of the BPA were more likely to reject offers of two and three.

- BPA has four subscales: physical aggression, verbal aggression, anger and and hostility. High scores indicate greater aggression.
- Mean BPA Score: 69.4 (n = 37, SD = 19.9).
- Subscale scores significant correlated with total score and with each other ($p < .001$).
- No correlations between BPA and rejection for all subjects together, but with subects who accepted all offers excluded, high scores on the anger subscale of the BPA were positively associated with rejections of offers of two ($r = 0.437$, $p = 0.042$) and three ($r = 0.489$, $p = 0.021$, see Figure 2).

Testosterone

We calculated the change in testosterone as concentration of the first sample subtracted from the second sample, giving us an average increase of (0.049 pg/dL), a change which was not significant (two-tailed t test: $t = 2.03$, $p = 0.154$).

There was a strong influence of gender:

- Males had significantly higher saliva testosterone levels than females (two tailed t-test: $t = 2.03$, $p < 0.001$).
- Males had marginally lower digit ratio (mean male ratio: 0.955; mean female ratio: 0.975; $t = 2.04$, $p = 0.083$).

No relationship between digit ratio and testosterone levels were found.

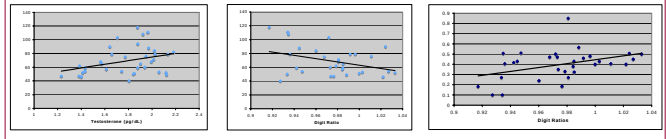
Results (cont.)

Testosterone and Aggression

- Significant positive correlation between overall score on the BPA and baseline testosterone ($r = 0.339$, $p = 0.043$, see Figure 3).
- Additional correlations between baseline testosterone and the physical aggression ($r = 0.502$, $p = 0.002$) and verbal aggression ($r = 0.373$, $p = 0.025$) subscales.
- Digit ratio was negatively correlated with total BPA score ($r = -0.360$, $p = 0.046$, see Figure 4) and the physical aggression subscale ($r = -0.397$, $p = 0.027$) at significant levels.

Testosterone and Behavior

- No correlations between saliva testosterone and any of the experimental measures.
- The only significant correlation was a positive one between digit ratio and average offer ($r = 0.409$, $p = 0.022$, see Figure 5).



Figures 3 and 4. The BPA and Testosterone. Subjects with high BPA scores had higher baseline testosterone levels (Figure 3) and lower, or masculinized, digit ratios (Figure 4). **Figures 5. Testosterone and Average Offers.** Subjects with higher, or feminized, digit ratios made higher offers to others.

Discussion

- The decision to pursue a no rejection strategy does not appear related to either testosterone levels or self-reported aggressive traits. However, if a subject chooses to reject increasingly low offers, their rates of rejection may be linked to how prone they are to anger. Because these questionnaires were administered *after* the subjects made their rejections, it is possible that the low offers increased subjects' self-perceived anger at that moment, rather than being due to trait angry tendencies. Either way, **this result suggests that anger and not just a general sense of fairness helps motivate rejections in the Ultimatum Game, although it may not influence the decision to reject.**
- Testosterone levels were correlated with scores on the BPA, suggesting that both the saliva sampling and digit ratio were at least somewhat valid measures. However, there was no relation found between testosterone levels and rejection behavior. This could be due to the experimental design, which may have minimized a sense of being challenged either through disbelief, distance, or repetition of trials. It may also mean that testosterone does not play a role in rejection behavior. There was a correlation between digit ratio and average offer which, since it was made after the rejection trials, become less a pure first player offer and more of a response to others, making the results difficult to interpret. However, taken at face value, **this result suggests that organizational testosterone levels, not dynamic levels, have more influence on this type of behavior**.
- This study suggests a number of avenues for exploration. Replicating the study while simplifying the design might allows us to tell if our negative or confusing results are due to design choices or to real, underlying phenomenon (or lack thereof). If it can be shown that trait anger, testosterone, and Ultimatum Game behavior truly are linked, it would be interesting to explore how anger, dominance, and testosterone influence and are influenced by other decisions to punish in every day life.

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