



# **Testosterone Administration Moderates Effect of Social Environment on Trust in Women Depending on Second-to-Fourth Digit Ratio**

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**Universiteit Utrecht**

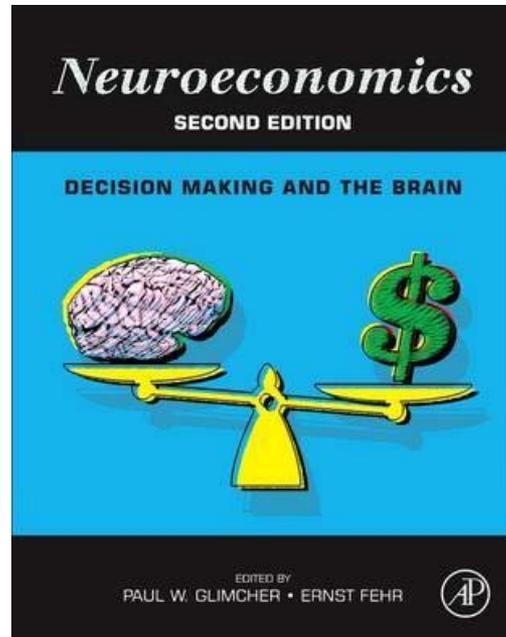


## Co-authors

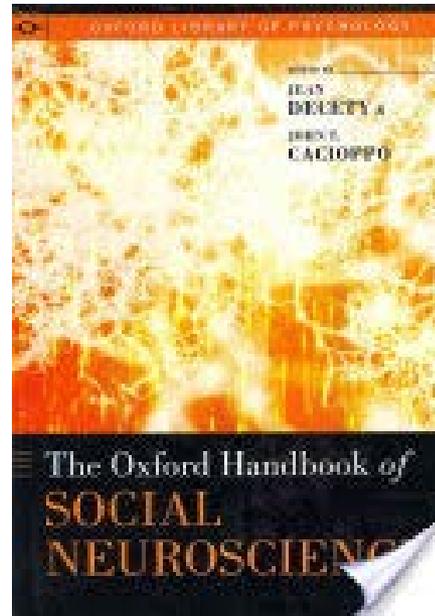
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# Neuroscience in the social sciences

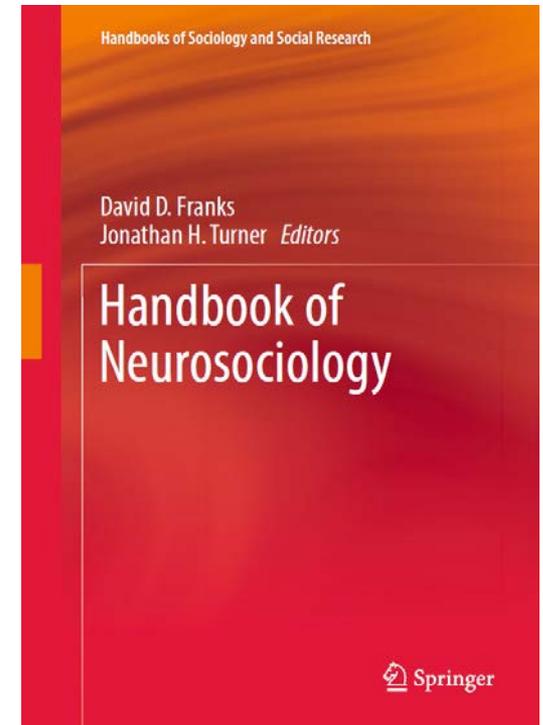
2009/2014



2015



2013



# Core features of our approach

- **Underlying intuition: the fruitfulness of neuroscience theoretical ideas and empirical methods for the social sciences should be assessed by considering specific applications and their merits rather than by only considering “first principles”**
- **Our application**
  - **Trust problems**
  - **Focus on testosterone effects**
  - **Method: drug administration**
- **New contribution: focus on the interaction effects of “biology” (testosterone) and “social environment”**

## LETTERS

### Oxytocin increases trust in humans

Michael Kosfeld<sup>1\*</sup>, Markus Heinrichs<sup>2\*</sup>, Paul J. Zak<sup>3</sup>, Urs Fischbacher<sup>1</sup> & Ernst Fehr<sup>1,4</sup>

Trust pervades human societies<sup>1,2</sup>. Trust is indispensable in friendship, love, families and organizations, and plays a key role in economic exchange and politics<sup>3</sup>. In the absence of trust among trading partners, market transactions break down. In the absence of trust in a country's institutions and leaders, political legitimacy breaks down. Much recent evidence indicates that trust contributes to economic, political and social success<sup>4,5</sup>. Little is known, however, about the biological basis of trust among humans. Here we show that intranasal administration of oxytocin, a neuropeptide that plays a key role in social attachment and affiliation in non-human mammals<sup>6–8</sup>, causes a substantial increase in trust among humans, thereby greatly increasing the benefits from social interactions. We also show that the effect of oxytocin on trust is not due to a general increase in the readiness to bear risks. On the contrary, oxytocin specifically affects an individual's willingness

to bear risks in a monetary payoff. However, the trustee violating the investor's trust. As sharing the trustee, a selfish trustee will never hurt the investor because the investor and the trustee interact in a trust experiment.

The investor is therefore caught in a dilemma: if the trustee shares, the investor increases his payoff to the risk that the trustee will abuse this trust. If the investor is worse off than if he had not trusted to the trustee, the trustee has an unfair payoff to the investor. Substantial evidence exists to show that such risks<sup>23–24</sup>. Moreover, the aversion of risk seems to have an important role across different social groups in the context of our game<sup>25</sup>. We show that oxytocin overcomes their aversion against these risks

whether

## LETTERS

### Prejudice and truth about the effect of testosterone on human bargaining behaviour

C. Eisenegger<sup>1</sup>, M. Naef<sup>1,2</sup>, R. Snozzi<sup>1</sup>, M. Heinrichs<sup>3</sup> & E. Fehr<sup>1</sup>

Both biosociological and psychological models, as well as animal research, suggest that testosterone has a key role in social interactions<sup>1–7</sup>. Evidence from animal studies in rodents shows that testosterone causes aggressive behaviour towards conspecifics<sup>7</sup>. Folk wisdom generalizes and adapts these findings to humans, suggesting that testosterone induces antisocial, egoistic, or even aggressive human behaviours. However, many researchers have questioned this folk hypothesis<sup>1–6</sup>, arguing that testosterone is primarily involved in status-related behaviours in challenging social interactions, but causal evidence that discriminates between these views is sparse. Here we show that the sublingual administration of a single dose of testosterone in women causes a substantial increase in fair bargaining behaviour, thereby reducing bargaining conflicts and increasing the efficiency of social interactions. However, subjects who believed that they received testosterone—regardless of whether they actually received it or not—behaved much more unfairly than those who believed that they were treated with placebo. Thus, the folk hypothesis seems to generate a strong negative association between subjects' beliefs and the fairness of

negotiations. Testosterone induces status seeking, in particular in those social situations that constitute a potential challenge to a person's status. Thus, in settings such as prisons, where rigid social hierarchies impose subordinate positions on individuals, those who are predisposed to seek social status may question the hierarchy in antisocial and rebellious ways. The evidence mentioned above<sup>10,11</sup> is thus also consistent with the social status hypothesis.

Although the social status hypothesis constitutes a plausible alternative to the folk hypothesis, it unfortunately remains largely based on correlative evidence<sup>1–5</sup>. However, a clean separation of the two hypotheses is possible because testosterone-induced status seeking may take a prosocial dimension if the prosocial behaviour enables individuals to master a challenge in order to secure their social position and thus to attain access to resources. Among the interactive games developed to examine prosocial behaviour<sup>12,13</sup>, the ultimatum bargaining game<sup>14–20</sup> can be used for this purpose. In this game real money is at stake and two parties, A and B, have to agree on the division of 10 money units (MUs). Party A, the proposer, can propose how the 10 MUs will be allocated between A and B. Party B, the

### BRIEF COMMUNICATIONS ARISING

#### New evidence on testosterone and cooperation

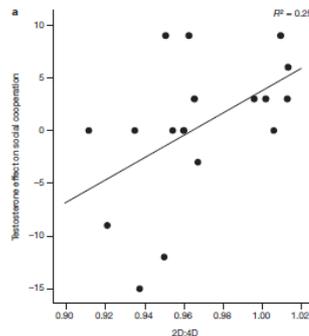
ARISING FROM C. Eisenegger, M. Naef, R. Snozzi, M. Heinrichs & E. Fehr *Nature* 463, 356–359 (2010)

In February 2010, Eisenegger *et al.* reported increased fair bargaining behaviour after administration of testosterone in an ultimatum game<sup>2</sup>. However, unfair offers in the ultimatum game are typically rejected; thus, not only the motives for social cooperation but also the threat of financial punishment may have accounted for these effects. Here, using the public goods game (PGG), we unambiguously show increased social cooperation after testosterone administration, but only among subjects with low levels of prenatal testosterone (measured by the right

hand's second-to-fourth-digit ratio (2D:4D)). This finding establishes positive effects of testosterone on social cooperation, with prenatal hormonal priming providing for important individual variability.

Eisenegger *et al.* show increased fairness in bargaining behaviour after testosterone administration in young females, and the authors suggest that this prosocial behaviour is strategically driven by concerns for social status<sup>1</sup>. Indeed, in the ultimatum game such strategic concerns have a role, and the hormone testosterone repeatedly has been associated with status concerns in humans and other animals<sup>2,3</sup>. However, unfair ultimatum game offers are typically rejected with all money being lost. Hence, the threat of financial punishment may have played a part in fair bargaining behaviour after testosterone administration<sup>4</sup>. We therefore tested the effects of testosterone on social-cooperative behaviours with the PGG, a game without such threat of financial punishment, wherein non-cooperation can actually lead to greater profits<sup>5</sup>. In an experiment (approved by our ethics committee) we administered testosterone and placebo on separate days to 24 female students in a double-blind within-subject design<sup>6</sup>, and tested them in a three-player PGG lasting eight rounds. Each round the players received an endowment of 3 monetary units (MU), which they could either keep for themselves or contribute to the public good<sup>7</sup> (see Methods).

Using a repeated-measures generalized estimating equations (GEE) analysis over all eight trials (PGG placebo versus testosterone) we found no main effect of testosterone (Wald  $\chi^2 = 0.048$ ,  $P = 0.826$ ). However, we also measured a proxy of prenatal testosterone, the 2D:4D ratio<sup>8,9</sup>, which has recently been shown to be a powerful predictor for effects of testosterone administration on social function<sup>10</sup> (Methods). With 2D:4D ratio as covariate in the analyses the effect of testosterone on social cooperation was significant (Wald  $\chi^2 = 9.630$ ,  $P = 0.002$ ) as, importantly, was the 2D:4D  $\times$  testosterone interaction (Wald  $\chi^2 = 10.140$ ,  $P = 0.001$ ) (Fig. 1a). Next, we applied a median split on the 2D:4D measurements to compare individuals with relatively low versus high prenatal testosterone exposure. GEE analyses revealed that in both groups testosterone increased the subjects' low



## Remainder of the presentation

- **Trust and testosterone: some background and hypothesis**
- **Experimental design**
- **Results**
- **Discussion: (why) is all this relevant for sociology?**

# **Trust and testosterone: Some background and hypothesis**

# Testosterone effects on human behavior I

- **General argument in the literature: testosterone effects in humans differ in different environments**
- **However, experiments with a design that includes variation of the social environment are almost completely missing (exception: Mehta et al. 2015)**
- **Our experiment *does* include variation of the social environment**

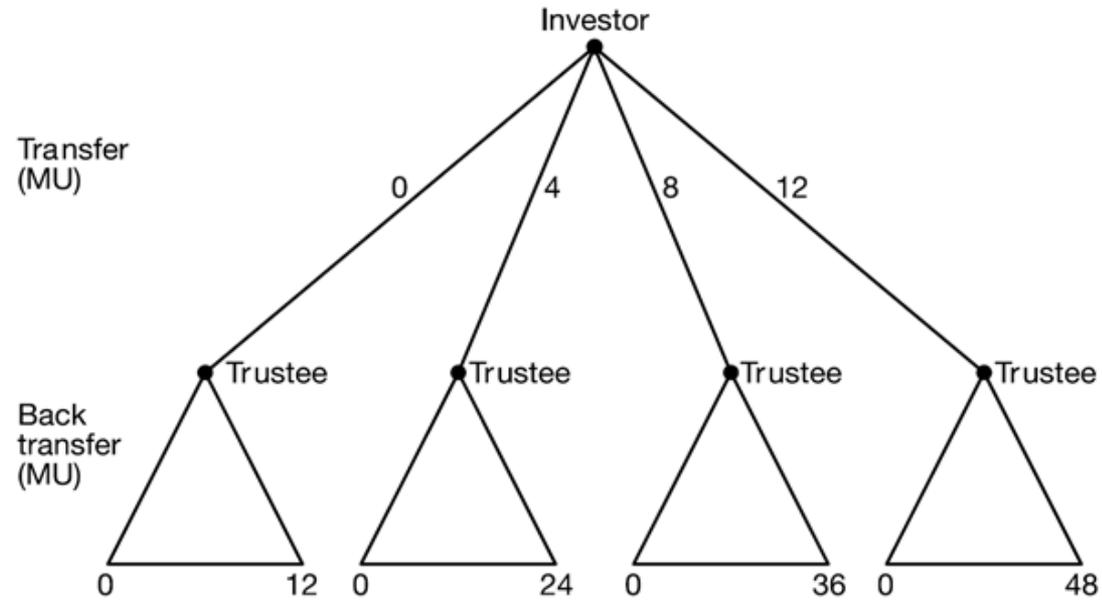
# Testosterone effects on human behavior II

- Typical argument in the literature: in humans, testosterone does not trigger aggressive and antisocial behavior per se
- Rather, testosterone induces behaviors that are motivated by seeking dominance and status
- Thus, (1) when aggression is a means of generating or securing dominance and status, testosterone will induce aggression; (2) when dominance and status derive from other and non-aggressive behaviors, the relation between testosterone and aggression will disappear
- Example (Eisenegger et al. 2010): fair bargaining behavior is instrumental with respect to acquiring dominance and status, hence testosterone is positively related to fair offers in the Ultimatum Game
- *Note: we do not explore these effects*

# Testosterone effects on human behavior III

- **Alternative argument on *cognitive effects*:** testosterone negatively affects cognitive empathy (cognitive perspective taking, mentalizing, Theory of Mind), i.e., the ability to anticipate on others' behavior
- **Additional argument:** such effects are due to the interaction of current activational effects of testosterone administration with organizational effects of fetal testosterone on brain development
  - Fixed marker for fetal testosterone is the right hand's second (index) to fourth (ring) finger length ratio (2D:4D ratio)
  - Quite some empirical evidence for the interaction effect
- **We explore *these* effects**

# Trust Game (version Kosfeld et al. 2005)



# **Trust Game**

**(version Kosfeld et al. 2005)**

- **Two actors: investor and trustee**
- **Investor and trustee receive endowment of 12 points each**
- **Investments: investor can invest 0, 4, 8 or 12 (trustfulness)**
- **Investment is tripled and given to the trustee**
- **Sharing: trustee can return any amount from 0 to what he received including his endowment to the trustor (trustworthiness)**

# Standard game theory: Assumptions and implications for Trust Game

## *Assumptions:*

- **A1: game-theoretic rationality (equilibrium behavior); roughly: utility maximization, given (one's expectations of) others' behavior**
- **A2: selfishness ("utility = own money")**

## *Implications:*

- **For one-shot Trust Game: no trustfulness, no trustworthiness**
- **For finitely repeated Trust Game with incomplete information of investor about the trustee: trustfulness and trustworthiness in many (early) rounds as a result of conditional cooperation of the investor and reputation building of the trustee**
  - **Endgame effect: trust breaks down towards the end of the repeated game**

## Trust Game: Empirical evidence

- ***One-shot Trust Game:*** quite some trustfulness and trustworthiness
- ***Repeated Trust Game:*** less trustfulness and less trustworthiness than implied by the standard assumptions
- **General impression:** “standard economic models based on full rationality and narrow self-interest tend to overestimate the difficulties of promoting trust in one-shot situations, and underestimate the difficulties in ongoing interactions” (Bolton & Ockenfels 2009: 31)
- **Hence, there is something to explain...**

# Our basic arguments

1. Cognitive perspective taking (anticipating on other's behavior) is more demanding in the repeated game than in the one-shot game: other than in the one-shot game, own behavior in a current round of the repeated game can have repercussions for other's behavior in multiple future rounds
2. Cognitive perspective taking is more demanding for investor than for trustee
  - One-shot game and final round of repeated game: no cognitive perspective taking needed for trustee; investor must anticipate on trustee behavior
  - Earlier rounds of repeated game: trustee must anticipate exclusively on future investor behavior; investor must *also* anticipate on whether and how the trustee might anticipate on future investor behavior (*one more step of strategic reasoning*)
    - Compare similar arguments on why effects of network embeddedness are typically weaker than effects of dyadic embeddedness and why they are stronger for the trustee than for investors. Also, compare similar arguments on iterated reasoning in, e.g., beauty contest games

# Hypothesis

- Testosterone negatively affects cognitive perspective taking → *core hypothesis*: testosterone reduces the differences in investor behavior (trustfulness) between the one-shot and the repeated game
  - Effect will depend on the interaction of testosterone administration and 2D:4D

# Hypothesis on testosterone effects: Remarks

- The hypothesis is on associations between testosterone levels, cognitive abilities, and observable behavior rather than on underlying psychobiological mechanisms that generate such associations
  - On such underlying mechanisms and on the interaction organizational effects of fetal testosterone and activational effects of testosterone administration:
    - Eisenegger et al. 2011 (*Trends in Cognitive Science*)
    - Bos et al. 2012 (*Frontiers in Neuroendocrinology*)
    - Crockett & Fehr 2014 (in Glimcher & Fehr (eds.) 2014)

# **“Biology x social environment”**

- **Note the core feature (and new contribution) of our study: we focus on the interaction effects of “biology” (testosterone) and “social environment” (one-shot vs. repeated interaction) on behavior**

# Biology x social environment effects on trustfulness

**Social conditions:**  
one-shot vs. repeated

**Macro outcomes:**  
Pareto-(sub)optimality

**Macro**

**Micro**

Cognitive perspective taking

Preferences,  
information,

testosterone  
(biology)

**Individual effects:**  
trustfulness

# Experimental design

# Lab experiment

- **Subjects play Trust Games in the lab (ELSE lab UU; z-Tree software)**
- **Anonymous interactions with actual other subjects in the lab**
- **Complete game structure provided in the instructions; no deception**
- **Points earned represent actual money for the subjects**



# Subjects

- Protocol approved by UMCU ethics committee
- Subjects (standard procedures)
  - 82 women; between 18 and 30 years old (14 per session, one session of 12)
  - Subjects use one-phase pill and are not in the stop-week (to control for hormonal change due to menstrual cycle)
  - No medication
  - No history of psychological illness

# Administration of testosterone / placebo

- 0.5 mg testosterone in a solution with water, cyclodextrine and ethanol administered sublingually
  - Placebo is the same, without testosterone
- ➔ Standard procedures
- Testosterone level in blood is 10-fold after 15 minutes
  - After 1.5 hours, the blood levels are normal
  - Physiological effects (mainly elevated vaginal pulse amplitude) are known to peak after 4 hours
  - 73% of subjects guess to have received placebo; guesses unrelated to substance received

## Morning session

- Hand scan (to measure 2D:4D digit-ratio as proxy for fetal testosterone exposure; standard procedure)
- Collecting saliva for measurement testosterone level
- Short questionnaire
  - Profile of mood states (POMS)
  - Behavioral inhibition scale (BIS)
  - Behavioral activation scale (BAS)
  - Anger and anxiety
- Administration of substance (around 10:30)
  - Between subjects design

## Afternoon session

- Collecting saliva for measurement testosterone level
- POMS
- Dictator game (around 14:30)
- Six one-shot Trust Games with six different anonymous partners (*stranger matching*)
- Gambles
- One repeated Trust Game (six rounds) with an anonymous partner (*partner matching*)
- Charity question
- Moral dilemmas
- Questionnaire

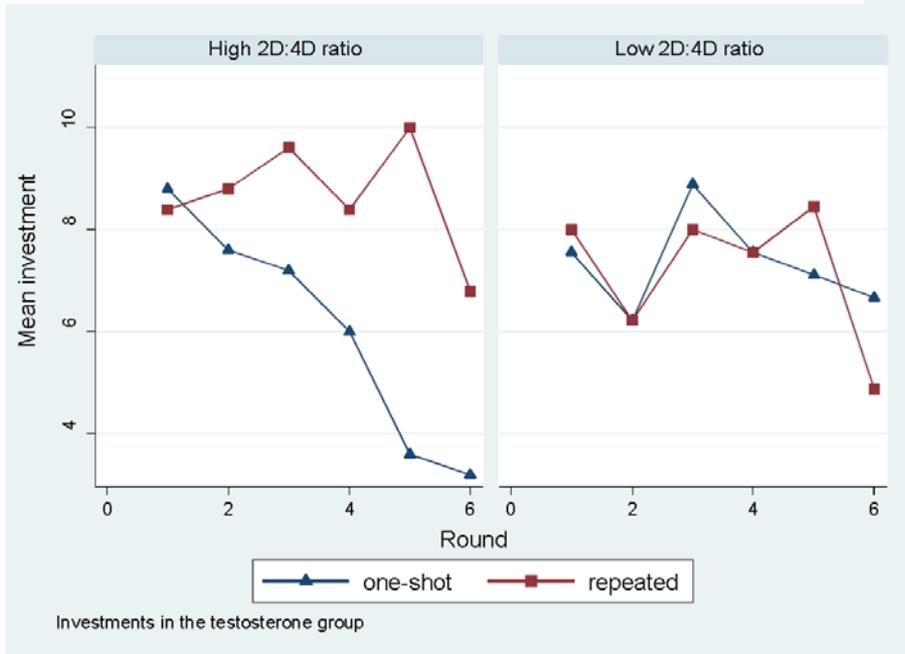
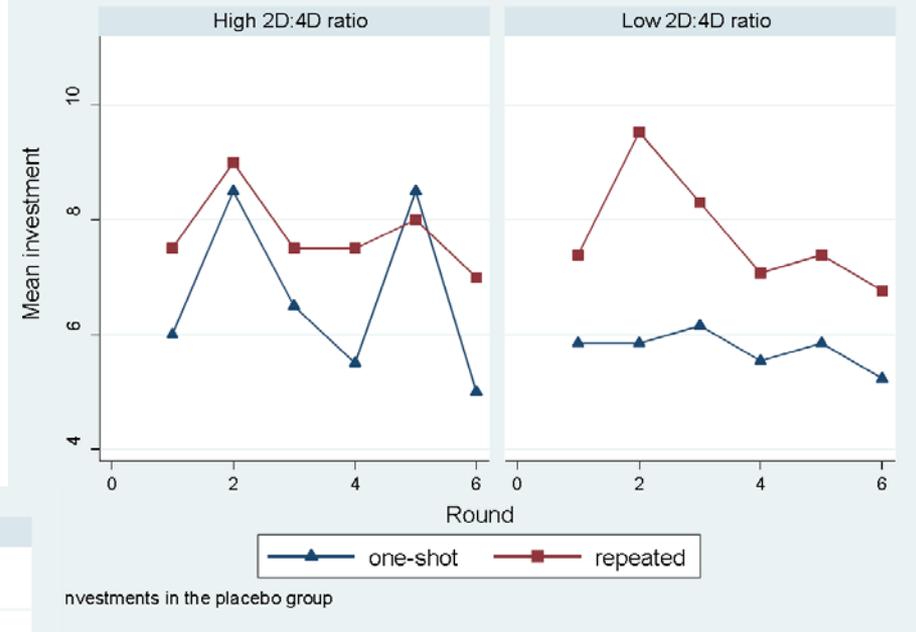
## Further design details

- Each subject plays always in the *same role*, either as investor or as trustee → 480 observations from 40 investors; 492 observations from 41 trustees
- Partner has the same substance with probability 0.5 and the other substance with probability 0.5
- Balanced observations of subjects starting with the one-shot games or starting with the repeated game
- Questionnaire at the end: subject characteristics; statements on trust; subjective beliefs on experimental condition (testosterone versus placebo) and beliefs on testosterone effects,...

# Results

# Trustfulness: investments over periods

## Placebo



## Testosterone

# Trustfulness: Explanatory analysis

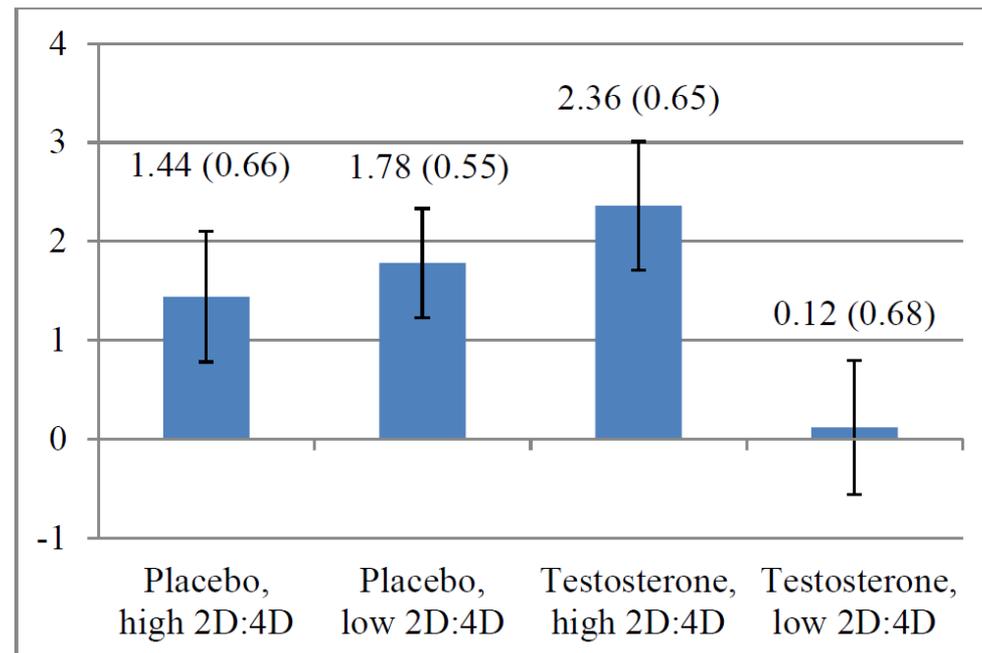
- **Hierarchical linear model**
  - **Observations clustered within subjects**
  - **Random effects at subject level**
  - **Variables: testosterone vs. placebo group; one-shot vs. repeated games; 2D:4D ratio; period (continuous + dummy last period); treatment (first vs. second); relevant interactions**
- **We compare average marginal effects of testosterone for four subgroups: (testosterone vs placebo) x (high vs. low 2D:4D)**

# **Trustfulness: Impression from descriptives**

- **Positive effect on trustfulness of repeated game compared to one-shot game for three groups**
- **Endgame effect**
- **No large difference in trust between testosterone and placebo condition for subjects with low fetal testosterone; neither for the one-shot games nor for the repeated games**
- **Difference between one-shot and repeated game disappears in testosterone condition for subjects with high fetal testosterone**
  - ➔ **Evidence for testosterone effects on cognitive perspective taking, depending on administration x 2D:4D**

# Trustfulness: Results

- Reconfirmation of results for games without drug manipulation: positive effect of repeated compared to one-shot games, endgame effect
- No main effect of testosterone administration; no main effect of 2D:4D
- Average marginal effect of “repeated” depends on testosterone administration and fetal testosterone



# Robustness analyses

- Findings are robust for a broad range of alternative analyses including:
  - Multi-level interval regression
  - Cross-classified multi-level models to account for clustering of observations in partners
  - Continuous measurement of fetal testosterone (digit ratio)
  - Controlling for moods and psychological traits, risk preferences, subjects' belief on whether they received testosterone or placebo, substance received by partner
- Testosterone effect is not moderated by any of these variables

# Discussion and conclusion

## **New design feature**

- **Variation of the social environment included in the experimental design: one-shot vs. repeated game**
- **Focus on the interaction effects of “biology” (testosterone levels) and social conditions (one-shot vs. repeated interactions) on human behavior (voluntary cooperation)**

## **Main empirical conclusion**

- **Support for hypothesis on negative effect of testosterone on cognitive perspective taking**
  - **Effect depends on interaction of testosterone administration and fetal testosterone exposure (2D:4D digit ratio)**
- **This result (and specifically the interaction of testosterone administration and fetal testosterone exposure) is in line with quite some other evidence on testosterone effects**

## **(Why) is all this relevant for sociology?**

- **Trust Game – social dilemmas – problem of social order**
- **One-shot versus repeated Trust Game: effects of embeddedness on trust – *social* conditions for voluntary cooperation**

# **(Why) is all this relevant for sociology?**

## **Continued...**

- **Hypothesis on how testosterone levels ("biology") *interact* with social conditions ("sociology") in their effects on trust: stronger case for including neuroscience arguments and methods in sociological research than exclusively hypotheses on main effects of testosterone levels ("biology") on voluntary cooperation *in addition to* main effects of social conditions ("sociology")**
- **Analysis can be extended to interaction of testosterone with network embeddedness**

**Thanks for your attention!**

- **Paper**

**Buskens, V., W. Raub, N. van Miltenburg, E.R. Montoya, J. van Honk (2016) Testosterone Administration Moderates Effects of Social Environment on Trust in Women Depending on Second-to-Fourth Digit Ratio, *Scientific Reports*, forthcoming**

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