



Research

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Neurobiology

Low second-to-fourth digit ratio predicts indiscriminate social suspicion, not improved trustworthiness detection

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Testosterone administration appears to make individuals less trusting, and this effect has been interpreted as an adaptive adjustment of social suspicion, that improved the accuracy of trusting decisions. Here, we consider another possibility, namely that testosterone increases the subjective cost of being duped, decreasing the propensity to trust without improving the accuracy of trusting decisions. In line with this hypothesis, we show that second-to-fourth digit ratio (2D:4D, a proxy for effects of testosterone in the foetus) correlates with the propensity to trust, but not with the accuracy of trusting decisions. Trust game players ($n = 144$) trusted less when they had lower 2D:4D (high prenatal testosterone), but their ability to detect the strategy of other players was constant (and better than chance) across all levels of digit ratio. Our results suggest that early prenatal organizing effects of testosterone in the foetus might impair rather than boost economic outcomes, by promoting indiscriminate social suspicion.

1. Introduction

Within the human repertoire of social behaviours, the propensity to trust and the capacity to trust wisely are the pillars of prosperous societies. Recent research on the neurobiology of trust has focused on the impact of the hormone testosterone on the propensity to trust, and speculated on its effect on the capacity to trust wisely [1–4].

Experimental evidence suggested that testosterone affects our propensity to trust—but it is contentious whether this effect is sharp (adaptively adjusting social suspicion, and so improving the accuracy of trust decisions) or blunt (decreasing the global propensity to trust, without improving accuracy).

Recent data have been interpreted as supporting the sharp view. In one study, highly trusting subjects rated photographed faces as less trustworthy after receiving a dose of testosterone, whereas subjects who did not trust easily did not show the effect. It was speculated that testosterone adaptively increased social vigilance, the better to prepare overly high-trusting individuals for social competition [1]. In another study, the administration of testosterone led to increased amygdala responses during trustworthiness evaluations, which was interpreted as reflecting a more vigilant response to signals of untrustworthiness [2].

Not all data are consistent with the sharp view, though. In fact, testosterone administration is known to impair the ability to read motives and intentions from the eye region of the face [3], and to disrupt the ability to successfully collaborate [4]. More importantly, the sharp view is not needed to account for existing data: testosterone could bluntly decrease the propensity to trust, as a result of an increased aversion to being duped. Indeed, the behavioural impact of testosterone mostly relates to the maintenance of status [5,6], and

64 being duped is a status threat [7]. As a result, being duped
 65 in an economic interaction results in two distinct losses: a
 66 financial loss and a status loss [8]. If testosterone-stimulated
 67 players assign a large weight to status losses, they should
 68 trust everyone less because of betrayal aversion [9,10] and
 69 independently of financial prospects. That is, they might
 70 sacrifice financial prospects in order to minimize the risk of
 71 a status loss.

72 To find out whether testosterone results in a sharp or
 73 blunt decrease of interpersonal trust, we conducted a Trust
 74 Game in which we could record both the propensity to
 75 trust and the quality of trusting decisions. In this game, a
 76 player (the Investor) is endowed with an initial sum of
 77 money and decides whether she will transfer this endowment
 78 to another player (the Trustee). If the endowment is trans-
 79 ferred, it is multiplied by three and the Trustee then
 80 decides how much to send back to the Investor. A perfectly
 81 accurate performance in the Trust Game would allow Invest-
 82 tors to transfer to those, and only those, Trustees whose
 83 decision is to reciprocate.

84 Rather than provoking a transient increase in testosterone,
 85 we recorded the 2D:4D ratios of all Investors (index finger
 86 length divided by ring finger length). 2D:4D is a proxy for
 87 prenatal testosterone exposure, which brings about a perma-
 88 nent organizing effect on the brain [11,12]. Low 2D:4D ratios
 89 map onto higher amounts of testosterone, as well as higher
 90 sensitivity to circulating testosterone [3,13]. As a consequence,
 91 what we are considering in this experiment is not direct testos-
 92 terone stimulation, but rather an organizing effect of
 93 testosterone early in development. According to the sharp
 94 view, we should observe that low 2D:4D ratios predict quali-
 95 tatively better trusting decisions in the Trust Game. According
 96 to the blunt view, we should observe that low 2D:4D ratios
 97 predict quantitatively fewer trusting decisions.

100 2. Material and methods

102 Female undergraduates ($n = 144$) from the University of Leuven,
 103 Belgium, played Investors in 14 games, each time with a different
 104 Trustee. Sitting in front of a computer, they were endowed with
 105 4 euro for each game, which started with a fixation cross
 106 (1000 ms). Next, the picture of the Trustee was presented for
 107 5500 ms. This black-and-white picture was cropped (left and
 108 right facial boundaries, chin and top of the eyebrows) to mini-
 109 mize display of clothing or hairstyle. Participants indicated
 110 whether they wanted to transfer money to the Trustee. They
 111 did not receive feedback about their decisions after each individ-
 112 ual game. They were, however, informed that one game would
 113 be randomly selected after the experiment, and that they
 114 would receive whatever money they made in that game.

115 Trustees strategies and pictures came from a previous study
 116 in which 79 young adults were asked to indicate how much
 117 they would send back in case the Investor transferred the endow-
 118 ment. They were given three options: return zero (the *abuser*
 119 strategy), return the exact amount that was transferred (the *neutral*
 120 strategy) or return half of the new global amount (the *cooperator*
 121 strategy). All Trustees were informed that they would be ran-
 122 domly paired with Investors and receive the money they made
 123 based on their strategy.

124 The pictures shown to Investors were extracted from movies
 125 of Trustees, recorded after they had been familiarized the game.
 126 We selected 14 pictures (seven men, seven women) including six
 cooperators, two neutral players and six abusers. We showed in a
 previous article that these pictures carried information about the

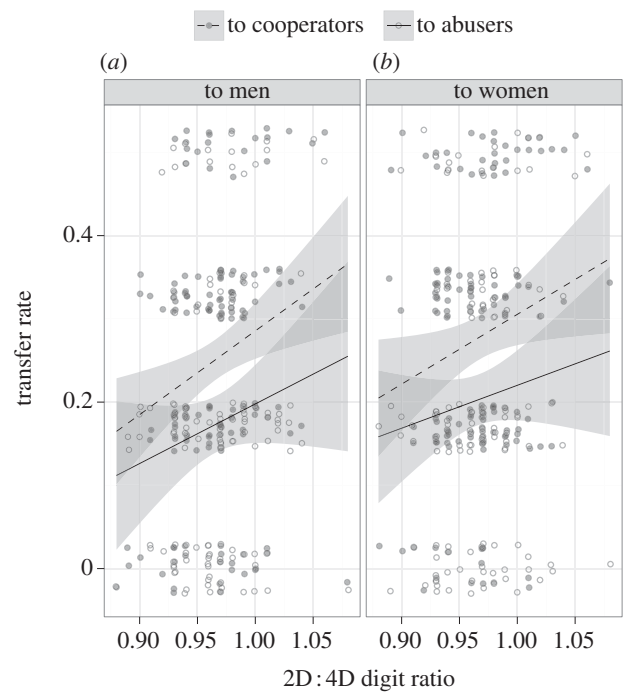


Figure 1. Transfer rates as a function of Investor's digit ratio: the two regression lines correspond to transfers to cooperators and abusers, the panels (a) and (b) display results for male and female Trustees, respectively.

Trustees' strategies, which could be unconsciously picked up by Investors [14].

Finally, all Investors had their right hand scanned. Scans were magnified 200 per cent, and finger length was measured using Adobe Photoshop measurement tool, from fingertip to the middle point of the proximal crease. Fifty scans were randomly selected for recoding by the same rater as well as by a second rater. Intra- and inter-raters measures were highly correlated ($r > 0.94$). Raw data have been deposited in Dryad ([15]; <http://dx.doi.org/10.5061/dryad.4tn86>).

101 3. Results

The distribution of 2D:4D ratios was in the expected range [16], from 0.88 to 1.08, $m = 0.966$, $s.d. = 0.035$. Transfer rates spanned the full range from 0 to 100 per cent, $m = 45$, $s.d. = 23$.

We ran a repeated-measure ANOVA on transfer rates, where the gender and the strategy (abuser versus cooperator) of Trustees were entered as repeated factors, and the 2D:4D ratio of the Investor was entered as a continuous covariate. Figure 1 provides a visual display of the results, which unambiguously supported the blunt view.

We found a main effect of Trustee's strategy on transfer rates, $F_{1,142} = 41.3$, $p < 0.001$, reflecting the fact that Investors transferred more to Trustees whose strategy was to reciprocate (52.3%) than to Trustees whose strategy was to abuse (38.6%). This result confirms that Investors could detect valid cues about the Trustees' strategies, based on their pictures.

We also found a main effect of Trustee's gender, $F_{1,142} = 7.4$, $p = 0.01$, reflecting the fact that our female participants trusted other women more than men. More importantly, and in line with the blunt view on testosterone and trust, we found a main effect of 2D:4D ratio, $F_{1,142} = 5.7$, $p = 0.02$, which was not moderated by Trustee's strategy, $F_{1,142} < 1$, $p = 0.58$. The Pearson correlation coefficient between transfer

rate and 2D : 4D ratio was 0.20. Investors in the lower quartile of 2D : 4D transferred to 39 per cent of Trustees, whereas Investors in the highest quartile of 2D : 4D transferred to 49 per cent of Trustees. As shown by these findings, and as clearly displayed in figure 1, *Investors with lower 2D : 4D ratios trusted less, but not better*. Their mistrust was higher all across the board, for abusers and cooperators alike.

4. Discussion

We found that lower 2D : 4D ratios predicted increased social suspicion, in line with previous research that showed a similar effect after testosterone stimulation. Critically, though, our protocol also measured the quality of trusting decisions. We were able to show that the increased social suspicion that came with lower 2D : 4D ratio, bluntly applied to all partners, rather than sharply targeting abusers.

This result cannot be directly compared with that obtained with acute testosterone administration. Our research is correlational, and we did not measure the circulating testosterone levels of Investors. With this caveat, our findings nonetheless cast doubt on the view that testosterone stimulation would adaptively adjust social suspicion, making individuals more sensitive to signals of untrustworthiness.

References

- Bos PA, Terburg D, van Honk J. 2010 Testosterone decreases trust in socially naive humans. *Proc. Natl Acad. Sci. USA* **107**, 9991–9995. (doi:10.1073/pnas.0911700107)
- Bos PA, Hermans EJ, Ramsey NF, van Honk J. 2012 The neural mechanisms by which testosterone acts on interpersonal trust. *NeuroImage* **61**, 730–737. (doi:10.1016/j.neuroimage.2012.04.002)
- van Honk J, Schutter DJ, Bos PA, Kruijt AW, Lentjes EG, Baron-Cohen S. 2011 Testosterone administration impairs cognitive empathy in women depending on second-to-fourth digit ratio. *Proc. Natl Acad. Sci. USA* **108**, 3448–3452. (doi:10.1073/pnas.1011891108)
- Wright N, Bahrami B, Johnson E, Di Malta G, Rees G, Frith C, Dolan R. 2012 Testosterone disrupts human collaboration by increasing egocentric choices. *Proc. R. Soc. B* **279**, 2275–2280. (doi:10.1098/rspb.2011.2523)
- Eisenegger C, Haushofer J, Fehr E. 2011 The role of testosterone in social interaction. *Trends Cogn. Sci.* **15**, 263–271. (doi:10.1016/j.tics.2011.04.008)
- Joseph RA, Sellers JG, Newman ML, Mehta PH. 2006 The mismatch effect: when testosterone and status are at odds. *J. Pers. Soc. Psychol.* **90**, 999–1013. (doi:10.1037/0022-3514.90.6.999)
- Eisenegger C, Naef M, Snozzi R, Heinrichs M, Fehr E. 2010 Prejudice and truth about the effect of testosterone on human bargaining behaviour. *Nature* **463**, 356–359. (doi:10.1038/nature08711)
- Fehr E. 2009 On the economics and biology of trust. *J. Eur. Econ. Assoc.* **7**, 235–266. (doi:10.1162/JEEA.2009.7.2-3.235)
- Bohnet I, Greig F, Herrmann B, Zeckhauser R. 2008 Betrayal aversion: evidence from Brazil, China, Oman, Switzerland, Turkey, and the United States. *Am. Econ. Rev.* **98**, 294–310. (doi:10.1257/aer.98.1.294)
- Hong K, Bohnet I. 2007 Status and distrust: the relevance of inequality and betrayal aversion. *J. Econ. Psychol.* **28**, 197–213. (doi:10.1016/j.joep.2006.06.003)
- Manning JT. 2012 Resolving the role of prenatal sex steroids in the development of digit ratios. *Proc. Natl Acad. Sci. USA* **108**, 16 143–16 144. (doi:10.1073/pnas.1113312108)
- Zheng Z, Cohn MJ. 2012 Developmental basis of sexually dimorphic digit ratios. *Proc. Natl Acad. Sci. USA* **108**, 16 289–16 294. (doi:10.1073/pnas.1108312108)
- van Honk J, Montoya ER, Bos PA, van Vugt M, Terburg D. 2012 New evidence on testosterone and cooperation. *Nature* **485**, E4–E5. (doi:10.1038/nature11136)
- Bonnefon JF, Hopfensitz A, De Neys W. 2012 The modular nature of trustworthiness detection. *J. Exp. Psychol. Gen.* (doi:10.1037/a0028930)
- De Neys W, Hopfensitz A, Bonnefon JF. 2013 Data from: low second-to-fourth digit ratio predicts indiscriminate social suspicion, not improved trustworthiness detection. *Dryad Digit. Repository* (doi:10.5061/dryad.4tn86)
- Manning JT. 2002 *Digit ratio*. Piscataway Township, NJ: Rutgers University Press.
- Johnson N, Mislin A. 2011 Trust games: a meta-analysis. *J. Econ. Psychol.* **32**, 865–889. (doi:10.1016/j.joep.2011.05.007)

Our results are better explained by assuming that testosterone stimulation (or a lower 2D : 4D ratio) is associated with an increased subjective cost of interpersonal betrayal, and more specifically, with an increased concern about the status loss incurred when being the dupe of another individual. This increased concern about status loss would in turn result in an increased distrust of other agents, but not in an improved ability to detect their trustworthiness.

From a strictly economic point of view, this increased distrust can be an asset or a liability, depending on the prevalence of abusers in a given population. In a population where abusers are sufficiently rare, any decrease in interpersonal trust will result in impaired financial outcomes. Such was the case in our sample of Trustees, among which the return rate was 45 per cent. More generally, the meta-analytic average for return rates in trust games is above 35 per cent [17], which is sufficient for blind distrust to be a liability.

In sum, a testosterone-driven fixation on betrayal aversion is likely to come at a financial cost in common environments. As a consequence, and in view of our findings, future investigations on hormones and trust will have to take a dimmer view on the effects of testosterone, which is likely to disrupt cooperation without improving trustworthiness detection.

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