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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 suggests 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

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

To find out whether testosterone results in a sharp or blunt decrease of interpersonal trust, we conducted a trust game in which we could record both the propensity to trust and the quality of trusting decisions. In this game, a player (the investor) is endowed with an initial sum of money and decides whether she will transfer this endowment to another player (the trustee). If the endowment is transferred, it is multiplied by three and the trustee then decides how much to send back to the investor. A perfectly accurate performance in the trust game would allow investors to transfer to those, and only those, trustees whose decision is to reciprocate.

Rather than provoking a transient increase in testosterone, we recorded the 2D : 4D ratios of all investors (index finger length divided by ring finger length). 2D : 4D is a proxy for prenatal testosterone exposure, which brings about a permanent organizing effect on the brain [11,12]. Low 2D : 4D ratios map onto higher amounts of testosterone, as well as higher sensitivity to circulating testosterone [3,13]. As a consequence, what we are considering in this experiment is not direct testosterone stimulation, but rather an organizing effect of testosterone early in development. According to the sharp view, we should observe that low 2D : 4D ratios predict qualitatively better trusting decisions in the trust game. According to the blunt view, we should observe that low 2D : 4D ratios predict quantitatively fewer trusting decisions.

2. Material and methods

Female undergraduates ($n = 144$) from the University of Leuven, Belgium, played investors in 14 games, each time with a different trustee. Sitting in front of a computer, they were endowed with 4 Euro for each game, which started with a fixation cross (1000 ms). Next, the picture of the trustee was presented for 5500 ms. This black-and-white picture was cropped (left and right facial boundaries, chin and top of the eyebrows) to minimize display of clothing or hairstyle. Participants indicated whether they wanted to transfer money to the trustee. They did not receive feedback about their decisions after each individual game. They were, however, informed that one game would be randomly selected after the experiment, and that they would receive whatever money they made in that game.

Trustees strategies and pictures came from a previous study in which 79 young adults were asked to indicate how much they would send back if the investor transferred the endowment. They were given three options: return zero (the *abuser* strategy), return the exact amount that was transferred (the *neutral* strategy) or return half of the new global amount (the *cooperator* strategy). All trustees were informed that they would be randomly paired with investors and receive the money they made based on their strategy.

The pictures shown to investors were extracted from movies of trustees, recorded after they had been familiarized with the game. 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 trustees' strategies, which could be unconsciously picked up by investors [14].

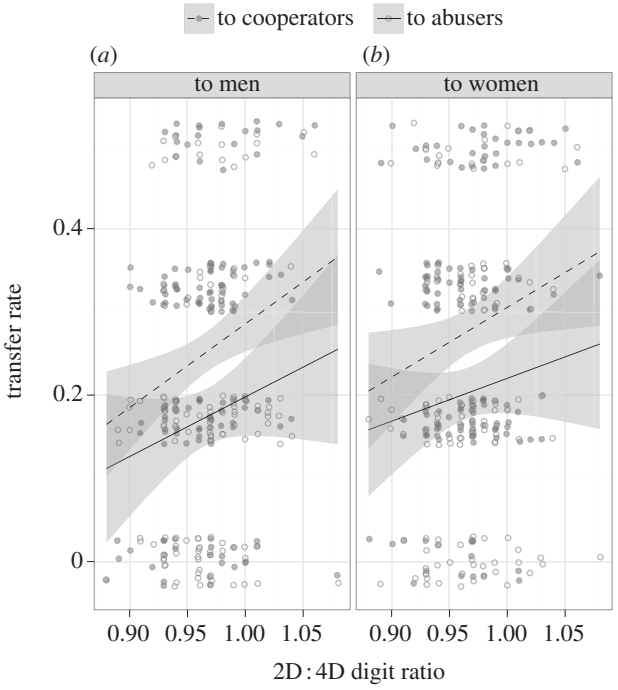

Figure 1. Transfer rates as a function of investor's digit ratio: the two regression lines correspond to transfers to cooperators and abusers, panels (*a*) and (*b*) display results for male and female trustees respectively.

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).

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 a 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 a 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. 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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