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A Note on Trust and Testosterone[1]

1 The Trust Game

Consider the Trust Game. The game (see Figure 1) involves two actors, the trustor (actor 1) and the trustee (actor 2). The game starts with a move of the trustor. She can choose between placing or not placing trust. If trust is not placed, the interaction ends and the trustor receives payoff P_1, while the trustee receives payoff P_2. If trust is placed, the trustee chooses between honoring and abusing trust. If he honors trust, the payoffs for trustor and trustee are $R_i > P_i$, $i = 1, 2$. If trust is abused, the payoff for the trustor is

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[1] I was a teaching and research assistant („Studentische Hilfskraft") in Carl Friedrich Gethmann's group at the University of Essen in the 1970s. „Dalle" helped me a lot in finding my way in science as a cognitive and social system. His „Oberseminar", including dinner afterwards, was fascinating (and very entertaining). We often disagreed in this seminar, Dalle and others knowing how to advocate their own positions. With hindsight and meanwhile own experience in leading research groups and supervising students, I much respect, too, the ways in which he coped with „jugendlicher Übermut" of various members of his group, myself included after I had learned from Dalle and others that it makes sense to come up with arguments in a seminar, rather than keeping arguments for yourself, even for a somewhat shy student. I later on decided to continue in sociology rather than philosophy. After I had left his group in the 1980s, we had only very occasional correspondence and met only once when he invited me for a talk in Essen in the 1990s. Also due to these circumstances, my contribution is – as far as I can see – not related to his own work in a systematic way (I avoid the conventional move for Festschrift-authors to focus on common interests in interdisciplinary work or to use the brief discussion of a methodology of science-issue in section 3 below to claim a loose relation; in fact, the focus on testosterone effects could be considered the better link to some features of Dalle's Oberseminar in the 1970s). Still, I find it an honor to be able to contribute a brief note to this Festschrift. My note is very much a result of ongoing joint work with Vincent Buskens and Jack van Honk at Utrecht University and I am grateful to both of them for allowing me to use ideas that result from our collaboration (including the use of some material from V. Buskens, W. Raub: „Rational Choice Research on Social Dilemmas") and for helpful comments. Financial support by the Netherlands Organization for Scientific Research (NWO) under grants S 96–168 and PGS 50–370 for the PIONIER-program „The Management of Matches" and under grant 400–05–089 for the project „Commitments and Reciprocity" is gratefully acknowledged.

$S_1 < P_1$, while the trustee receives $T_2 > R_2$. Think of payoffs in terms of money (or another valuable) for the respective actor. The game is played as a non-cooperative game, i. e., actors cannot make binding agreements or binding unilateral commitments. Actors are fully informed about all features of the game (roughly, each actor knows that the game in Figure 1 is played, knows that the other actor knows this, and so forth).

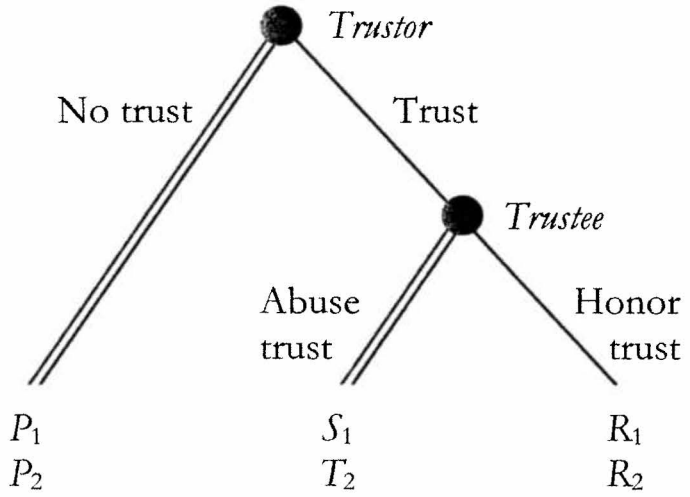

Figure 1: The Trust Game ($S_1 < P_1 < R_1$, $P_2 < R_2 < T_2$)

Assume (1) that actors are „selfish" in the sense of „utility = own money" and (2) that actors are „rational" in the standard game-theoretic sense of (subgame perfect Nash) equilibrium behavior, i. e., roughly, each actor behaves as if he or she maximizes his or her expected utility, given the other actor's strategy.[2] Under these assumptions, the trustee would abuse trust, while the trustor does not place trust (in a sense, anticipating on the trustee's abuse of trust if trust would be placed). If trust is not placed, however, both trustor and trustee are worse off than when trust is placed and honored.

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[2] See P. Dasgupta: „Trust as a Commodity"; D. M. Kreps: „Corporate Culture and Economic Theory"; C. Snijders: *Trust and Commitments*, chaps. 1–4; V. Buskens: *Social Networks and Trust*, chaps. 1–3 on the Trust Game. Here and subsequently throughout the paper we neglect quite some further assumptions and „technicalities". Readers may consult the literature mentioned as well as, e. g., E. Rasmusen: *Games and Information* for a textbook on non-cooperative games.

As Rapoport aptly put it[3], individual rationality in the sense of incentive-guided and goal-directed behavior as conceptualized in the Nash equilibrium leads to collective irrationality in the sense of Pareto-suboptimality in the Trust Game. Such a „conflict" between individual and collective rationality is the core feature of a social dilemma and trust relations are a paradigmatic example of a social dilemma involving two actors. The Trust Game is a one-sided version of the famous Prisoner's Dilemma in the sense that only one actor, the trustee, has an incentive for „opportunistic" behavior. While „social dilemma" is a label commonly used in social psychology and also sociology, such a situation is often referred to as a „problem of collective action" or the „tragedy of the commons" in political science and as a „public goods problem" in economics. For various and well-known reasons, the analysis of such situations is a core topic of social theory and social philosophy.[4]

2 Explaining trust[5]

Other than the theoretical analysis implies, everyday experience indicates and systematic empirical research confirms that trustors are sometimes trustful and place trust, while trustees are sometimes trustworthy and honor trust. Similar phenomena are known from research on other social dilemmas: actors sometimes manage to „solve" such dilemmas. Here, we mention only two explanations why actors are sometimes trustful and trustworthy.

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[3] A. Rapoport: „Prisoner's Dilemma".

[4] For economics, see J. O. Ledyard: „Public Goods". See V. Buskens and W. Raub: „Rational Choice Research on Social Dilemmas" for a recent survey from a sociological perspective and, e. g., B. Lahno: *Versprechen* for social philosophy.

[5] See V. Buskens and W. Raub: „Rational Choice Research on Social Dilemmas" for further information on the material covered in this section.

2.1 Repeated interactions

One explanation focuses on repeated interaction.[6] Assume that trustor and trustee play the game in Figure 1 again and again. More precisely, assume that after each Trust Game another Trust Game is played with probability w ($0 < w < 1$), while the repeated interaction ends after each round with probability $1 - w$. In such an indefinitely repeated Trust Game, the trustor can use a conditional strategy that rewards a trustee who honors trust by placing trust again in future games. Conversely, the trustor can punish abuse of trust through not placing trust in at least some future games. If the trustor uses a conditional strategy, the trustee can gain T_2 rather than R_2 in the short run by abusing trust. However, abusing trust will then be associated with obtaining only P_2 in (some) future encounters with no trust placed by the trustor, while honoring trust will result in larger payoffs than P_2 in those future encounters if the trustor goes on placing trust. Thus, anticipating that the trustor may use a conditional strategy, the trustee has to balance short-term ($T_2 - R_2$) and long-term ($R_2 - P_2$) incentives. It can be shown that the indefinitely repeated Trust Game, under some additional standard assumptions, has an equilibrium such that trust is placed and honored in each round if and only if the continuation probability w is large enough compared to some threshold involving the trustee's payoffs T_2, R_2, and P_2.

As a variant on this approach, assume that the Trust Game is repeated finitely often. Clearly, in the final round, equilibrium behavior requires that trust would be abused and no trust will be placed. However, this means that behavior in the last but one round cannot have effects on behavior in the final round. Hence, no trust will be placed in the last but one round and so forth, back to the first round. Things now change dramatically by introducing incomplete information. Assume that there is a positive ex-ante probability π that the trustee actually has no incentive to abuse trust, i. e., his payoff from abusing trust is $T_2^* < R_2$ (an alternative assumption leading to essentially the same results would be to assume that the trustee has no opportunity to abuse trust with probability π). The trustor knows the probability π but cannot di-

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[6] See, e. g., M. Taylor: *The Possibility of Cooperation* and R. Axelrod: *The Evolution of Cooperation* for influential applications. See C. F. Camerer and K. Weigelt: „Experimental Tests of a Sequential Equilibrium Reputation Model"; P. Dasgupta: „Trust as a Commodity" for work on repeated Trust Games with incomplete information.

rectly observe whether the trustee's payoff from abusing trust is T_2 or T_2^*. Now, if the trustor places trust in some round of the repeated game that is not the final round, trust may be honored for one of two very different reasons. First, the trustee's payoff could be $T_2^* < R_2$ so that there is no incentive at all for the trustee to abuse trust. Second, the trustee's payoff could be $T_2 > R_2$ but the trustee follows an incentive for reputation building. The trustee knows that if he abuses trust, the trustor can infer for sure that the trustee's payoff from abusing trust is $T_2 > R_2$ and will thus never place trust again in future rounds. On the other hand, if the trustee honors trust, the trustor remains uncertain about the trustee's incentives and may place trust again in the future. Conversely, the trustor can anticipate on such behavior of the trustee and may therefore be inclined to indeed place trust. In this game, the trustor can control the trustee in that placing trust in future rounds depends on honoring trust in the current round and the trustor can learn about the incentives of the trustee from the trustee's behavior in previous rounds. The result is a subtle interplay of a trustor who tries to learn about and to control the trustee, taking the trustee's incentives for reputation building into account, and a trustee who balances the long-term effects of his reputation and the short-term incentives for abusing trust, taking into account that the trustor anticipates on this balancing. It can then be shown that the game has an equilibrium that does involve placing and honoring trust in some and possibly many rounds of the repeated game. More precisely, in that equilibrium, the game starts with trust being placed and honored in a number of rounds. Afterwards, a second phase follows in which the trustor and the trustee with $T_2 > R_2$ randomize their behavior until the trustor does not place trust or the trustee abuses trust. After trust has not been placed or has been abused for the first time, the third and last phase starts in which no trust is placed until the end of the game. A remarkable feature of the model is that quite some honored trust can be induced by equilibrium behavior even if the probability π that the trustee has no incentive to abuse trust is small.

Note that both under indefinitely often as well as finitely repeated interactions, trust – in the sense of both trustfulness and trustworthiness – can be a result of individually rational behavior of selfish actors („trust as a result of enlightened self-interest").

2.2 One-shot interactions

Even if the Trust Game is played only once, experiments show, quite some trust is placed and honored. Similar evidence is available for other social dilemmas. To account for such findings, one option is to relax the rationality assumption and employ a bounded rationality perspective. For example, one could assume that subjects are used to repeated interactions that are common in life outside the laboratory. The assumption then is that subjects erroneously apply rules in isolated encounters that are appropriate when interactions are repeated. More generally, Binmore argues that behavior in experimental games can be expected to be consistent with the assumption of selfish game-theoretic rationality only if the game is easy to understand, adequate incentives are provided, and sufficient time is available for trial-and-error learning.[7]

Second, there are approaches that maintain the rationality assumption but modify the selfishness assumption. These approaches thus abandon the assumption that subjects care exclusively about their own material resources in the sense of „utility = own money". Rather, it is assumed that subjects, or at least some subjects, have other-regarding preferences. To get a flavor of how assumptions on other-regarding preferences can be used to account for placing and honoring trust in a Trust Game as an isolated encounter, consider a simple version of a social preferences model, namely, Snijders' guilt model.[8] Assume that actor i's utility is given by $U_i(x_i, x_j) = x_i - \beta_i \max(x_i - x_j, 0)$ with monetary payoffs x_i and x_j for the actors i and j and $\beta_i \geq 0$ a parameter representing i's guilt due to an inequitable allocation of monetary payoffs. Hence, in a Trust Game with payoffs in terms of money and $P_1 = P_2$ and $R_1 = R_2$, the trustee's utility from abused trust would be $T_2 - \beta_2(T_2 - S_1)$, while utilities correspond to own monetary payoffs in all other cases. Furthermore, assume actor heterogeneity with respect to the guilt parameter β_i in the sense that there are actors with a large guilt parameter, while β_i is small or even equals

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[7] See overviews on one-shot games in C. F. Camerer: *Behavioral Game Theory*; C. F. Camerer, E. Fehr: „Measuring Social Norms and Preferences Using Experimental Games"; J. O. Ledyard: „Public Goods". On a bounded rationality perspective, see K. Binmore: *Game Theory and the Social Contract*, chap. 0.4.2 and similar arguments in D. M. Kreps: *Game Theory and Economic Modelling*.

[8] See, e. g., E. Fehr and K. M. Schmidt: „The Economics of Fairness, Reciprocity and Altruism" for an instructive overview of models including other-regarding preferences and C. Snijders: *Trust and Commitments*.

zero for other actors, namely, those with selfish preferences. Finally, assume incomplete information of the trustor on the trustee's guilt parameter, with π being the probability that β_2 is „large enough" so that the trustee's utility from abusing trust is smaller than his utility from honoring trust, i. e., $T_2 - \beta_2(T_2 - S_1) < R_2$. „Large enough" thus means $\beta_2 > (T_2 - R_2)/(T_2 - S_1)$. Equilibrium behavior now requires that a trustee with $\beta_2 > (T_2 - R_2)/(T_2 - S_1)$ honors trust, while a trustor places trust if $\pi > (P_1 - S_1)/(R_1 - S_1)$.

Again, we have arguments why trust will be sometimes placed and honored. These arguments either involve dropping the assumption of game-theoretic rationality or they involve dropping the selfishness assumption.

3 Neuroscience and research on social dilemmas

Applications of theoretical ideas and methods as well as technical tools of neuroscience to human action and interaction are flourishing since the late 1990s. The number of empirical studies is rapidly growing. Various reviews and edited volumes as well as special issues of journals are meanwhile available and the first handbook has appeared recently.[9]

Neuroscience applications to human interactions include empirical studies on social dilemmas.[10] Research in this area can be potentially useful for various reasons of which we mention only one that derives from a methodology of science argument. The empirical evidence that trust is sometimes placed and honored and similar empirical evidence on other social dilemmas is not always easily reconcilable with the standard assumptions of individually rational and selfish behavior. Thus, alternatives to these assumptions are desirable. From a methodology of science perspective, though, a typical problem associated with such alternative assumptions is that they are, compared to the standard assumptions, less parsimonious and more complex and are thus endangered by less testability. Hence, it is essential to ensure that alternative

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[9] Review: C. F. Camerer, G. Loewenstein, D. Prelec: „Neuroeconomics". Edited volumes: C. Frith and D. Wolpert (eds.): *The Neuroscience of Social Interaction*; J. T. Cacioppo and G. G. Berntson (eds.): *Social Neuroscience*. Special issues: *Games and Economic Behavior*, edited by A. Rustichini (2005) and *Economics and Philosophy*, edited by G. Bonanno et al. (2008). Handbook: P. Glimcher et al. (eds.): *Neuroeconomics*.

[10] E. g., K. McCabe et al.: „A Functional Imaging Study of Cooperation"; J. K. Rilling et al.: „A Neural Basis for Social Cooperation"; A. G. Sanfey et al.: „The Neural Basis of Economic Decision-Making".

assumptions not only account for well-known empirical evidence that is hard to reconcile with the standard assumptions but that alternative assumptions also offer new predictions. The application of theoretical ideas, methods, and tools from neuroscience might be helpful in this respect and the added value of such applications will depend among other things on contributing to the generation and empirical test of new predictions.[11]

Quite some studies in this field employ brain imaging methods such as PET and fMRI, but also electric brain stimulation, studies of psychopathology and brain damage in humans, psychophysical measurement, and diffusion tensor imaging.[12] However, another approach has emerged recently that uses neuropharmacological manipulation and studies the effects of substances such as the neuropeptide oxytocin. The pioneering experiment by Kosfeld, Heinrichs, Zak, Fischbacher, and Fehr in this field showed that exogenously administering oxytocine induces more trustfulness in a game that closely resembles the Trust Game. Baumgartner, Heinrichs, Vonlanthen, Fischbacher, and Fehr explore the neural mechanisms underlying such effects by combining oxytocin administration with the use of fMRI.[13]

4 Trust and testosterone: outline for an experiment

Building upon the Kosfeld et al. experimental paradigm, we (Buskens, Van Honk, Raub) are currently studying the effects of administering another hormone, namely, testosterone on trustfulness as well as trustworthiness. More specifically, we wish to discriminate between alternative hypotheses on such behavioral effects. The first hypothesis (H1) is that increased testosterone levels are associated with behavior that represents increased selfishness, possibly also in the sense that actors behave as if they derive additional utility rather than guilt and, thus, disutility from an inequitable allocation of mone-

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[11] K. R. Popper: „Truth, Rationality, and the Growth of Scientific Knowledge"; I. Lakatos: „Falsification and the Methodology of Scientific Research Programmes". See also E. Fehr and C. F. Camerer: „Social Neuroeconomics" for a discussion of this issue.

[12] See the overview in C. F. Camerer, G. Loewenstein and D. Prelec: „Neuroeconomics", section 2.

[13] M. Kosfeld et al.: „Oxytocin Increases Trust in Humans". See P. J. Zak, A. A. Stanton and S. Ahmadi: „Oxytocin Increases Generosity in Humans" for a similar study on the effects of oxytocin on human generosity. T. Baumgartner et al.: „Oxytocin Shapes the Neural Circuitry of Trust and Trust Adaptation in Humans".

tary payoffs that is in their advantage. The alternative hypothesis (H2) is that increased testosterone levels are associated with behavior of actors as if they are more inclined to individual rationality. Note that these are indeed alternative hypotheses: while H1 is on how testosterone relates to selfish behavior, H2 is on how testosterone relates to individually rational behavior – and selfishness is not the same as individual rationality. Note, moreover, that these are hypotheses on how testosterone levels are associated with observable behavior rather than on the underlying psychobiological mechanisms that generate such associations.[14]

Employing the insights sketched above on how to explain trustfulness and trustworthiness, it becomes transparent how these alternative hypotheses can be tested experimentally against each other. Consider an experiment in which subject play one-shot as well as repeated Trust Games with suitably chosen parameters for the monetary payoffs as well as for the number of iterations of the game or for the continuation probability w. H1 would then imply that increased testosterone levels should be related to less trustfulness as well as less trustworthiness in *both* the one-shot and in the repeated Trust Game. In the one-shot game, the effect of testosterone would be that actors behave as if the guilt parameter β becomes smaller. This would imply a negative effect on trustworthiness. Assuming that trustors anticipate this, a negative effect on trustfulness likewise follows. Such a negative effect on trustfulness furthermore follows when extending the guilt model in a meanwhile standard way by adding a component in the trustor's utility function that represents envy due to unequitable payoffs in favor of the trustee.[15] In the repeated game, the effect of testosterone would be behavior as if the short-term incentive to abuse trust is larger. As a consequence, less trustfulness as well as less trustworthiness is expected for the same values of the other parameters such as the continuation probability w in the case of the indefinitely often repeated Trust Game or the number of games in the finitely repeated version.

Conversely, H2 would imply *different* effects of increased testosterone levels in the one-shot and in the repeated Trust Game. For the *one-shot Trust Game*, H2 would imply that increased testosterone levels should *not* be related *posi-*

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[14] See, e. g., J. Van Honk and D. J. L. G. Schutter: „Testosterone Reduces Conscious Detection of Signals Serving Social Correction" on psychobiological mechanisms possibly underlying testosterone effects on human behavior.

[15] E. g., E. Fehr, K. M. Schmidt: „A Theory of Fairness, Competition, and Cooperation".

tively and might even be related *negatively* to trustfulness and trustworthiness, depending on whether trustfulness and trustworthiness in the one-shot Trust Game are driven by other-regarding preferences or by bounded rationality. Assuming that trustfulness and trustworthiness in the one-shot game are driven by other-regarding preferences, one would expect no effect of testosterone levels in the one-shot game under H2 since under H2 there would be no relation between testosterone levels and preferences. Assuming that trustfulness and trustworthiness in the one-shot game are driven by bounded rationality, one would even expect a negative relation between testosterone levels and trustfulness as well as trustworthiness under H2.

For the *repeated Trust Game*, though, H2 would imply that increased testosterone is related *positively* to trustfulness as well as trustworthiness. The reason is that, for appropriate values of the parameters, trustfulness and trustworthiness are a result of individually rational behavior. Thus, under H2, one would expect less deviation from this individually rational pattern. Note, too, that the one-shot Trust Game is strategically „simpler" than the repeated versions of the game and that it is less intuitively „transparent" for subjects what individually rational equilibrium behavior implies for the repeated Trust Games compared to the one-shot version. Given H2, this should strengthen the testosterone effect in the repeated game.

We are in the process of conducting experiments on testosterone effects on trustfulness as well as trustworthiness along these lines, employing a variant of the Trust Game, namely, the version that was used by Kosfeld et al. Obviously, our sketch abstracts from many details of the experimental design such as manipulation checks and measurements of a number of control variables. Specifically, the design includes measurements of various beliefs of subjects on whether or not they belong to the experimental group with increased testosterone levels or to the placebo control group as well as beliefs of subjects on testosterone effects on their own and their partner's behavior.[16] We will report on these design features in future publications, obviously together with results of the experiment.

[16] To simplify, we have abstracted more or less completely from such beliefs. They require a considerably more detailed discussion.

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