Biological Psychology 93 (2013) 52–57

Contents lists available at SciVerse ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

Variability in ratings of trustworthiness across the menstrual cycle

Anna Ball[a,*], Claudia C. Wolf[a], Sebastian Ocklenburg[a], Burkhard L. Herrmann[b], Marlies Pinnow[a], Martin Brüne[c], Oliver T. Wolf[d], Onur Güntürkün[a]

[a] Institute of Cognitive Neuroscience, Department Biopsychology, Faculty of Psychology, Ruhr-University Bochum, Germany
[b] Department of Endocrinology, Faculty of Medicine, University of Essen, Germany
[c] Department of Psychiatry, Psychotherapy, Psychosomatics and Preventive Medicine, LWL University Hospital of the Ruhr-University Bochum, Germany
[d] Department of Cognitive Psychology, Faculty of Psychology, Ruhr-University Bochum, Germany

ARTICLE INFO

Article history:
Received 26 April 2012
Accepted 10 January 2013
Available online 23 January 2013

Keywords:
Interpersonal trust
Menstrual cycle
Evolutionary perspective
Game theory

ABSTRACT

This study investigated how trusting behavior varies in naturally cycling women, as a function of sex and attractiveness of players in a trust game, at three distinct phases of the menstrual cycle. Women acted more cautiously in an investment game at the preovulatory phase, compared to the menstrual and the mid-luteal phase. Reduced willingness to trust in strangers was particularly expressed toward male players at this time. The increase of estradiol levels from menses to the preovulatory phase was negatively correlated with trust in attractive male other players, whereas the increase of progesterone levels from menses to the mid-luteal phase was positively associated with trust in unattractive female other players. No particular contribution of a single hormone level could be identified for the generally reduced willingness to trust in strangers in the preovulatory phase. Thus, the results emphasize the impact of the menstrual cycle on interpersonal trust, although the exact mode of hormonal action needs to be further investigated.

1. Introduction

The ability to correctly judge other people's trustworthiness is of high ecological importance to individuals living in social groups. Therefore, it is thought to have been shaped by evolutionary pressures, and to have become embedded in the human congenital repertoire (Haselton and Ketelaar, 2005; De Dreu et al., 2011). Trusting behavior develops during ontogenesis through individual learning, and is triggered by external, social and situational contexts. A growing body of evidence demonstrates that interpersonal trust is also influenced by internal, biological factors, such as fluctuations in hormone levels (Frye, 2009). Especially, sex hormone receptors are widespread in the central nervous system (Stumpf and Sar, 1976), and these steroids have powerful neuromodulatory properties (Sherwin, 2003) and modulating effects on perceptive, motivational, and cognitive processes, including interpersonal trust (Frye, 2009). The hormonal modulation of interpersonal trust has been investigated extensively in social neuroscience, often by applying game theoretical approaches to empirically measure trust-related cognitive processes (e.g., Chang et al., 2010; Hillebrandt et al., 2011; Unoka et al., 2009) and to examine hormonal effects on trusting behavior (Kosfeld et al., 2005; Baumgartner et al., 2008; Mikolajczak et al., 2010; Zak et al., 2005) One general conclusion from these studies is that the hormonal modulation of trust-related social cognitive processes seems to act on the regulation of agonistic and antagonistic, or activating and inhibiting processes. For instance, an inhibiting, or trust decreasing effect has been documented for the gonadal hormone testosterone: Bos et al. (2010) found significantly decreased judgments of trustworthiness in women after the application of 0.5 mg testosterone, compared to a placebo. This androgen also fluctuates in naturally cycling women and peaks in the late follicular phase (Sinha-Hikim et al., 1998). Therefore, Johnson and Breedlove (2010) postulated an evolutionary advantage for a testosterone modulated preovulatory decline in ratings of trustworthiness for women at risk of being overly trustful when evaluating strangers. However, this assumption has not been tested in naturally cycling women across the menstrual cycle. In general, very little is known about how the considerable hormone fluctuations, as they naturally occur in the course of the ovulatory cycle, affect interpersonal trust.

It is known from administration studies that hormone effects on human behavior depend on social and individual context conditions (Bartz et al., 2011; Bos et al., 2012a). For instance, the trust increasing effect of the neuropeptide oxytocin described in Kosfeld et al. (2005) was absent when research participants

* Corresponding author at: Department of Biopsychology, Faculty of Psychology, Ruhr-University Bochum, D-44780 Bochum, Germany. Tel.: +49 234 32 26804; fax: +49 234 32 14377.
E-mail address: anna.ball@ruhr-uni-bochum.de (A. Ball).

0301-0511/$ – see front matter
http://dx.doi.org/10.1016/j.biopsycho.2013.01.005

were interacting with a computational random generator, instead of with other people. Also, the trust decreasing effect of testosterone described in Bos et al. (2010) was not global, but was driven by the subgroup of participants with high baseline trust, that is to say, individuals with an increased likelihood of being betrayed. It can be assumed that steroid sex hormones have evolved neuromodulatory properties because they allow for flexible adaptations to social contexts. Such adaptations can, for example, be manifest in processing social (and, thus, mainly facial) cues (Jones et al., 2008). This assumption is backed-up by accumulating evidence from the social neurosciences: The gonadal hormone progesterone can bind to specific receptors in the brain, which accumulate in the amygdala. The amygdala is known to play a role in person perception and, thus, the ability to judge the trustworthiness of others (Adolphs, 2003). High levels of progesterone have also been found to be related to an increased sensitivity to facial cues carrying sources of threat or contagion (Conway et al., 2007), and accordingly, with a biased behavioral tendency toward avoidance as opposed to approach (Derntl et al., 2008). Such effects have been discussed as reflecting an adaptation to increased costs of social and physical threat or danger in pregnant women, in whom progesterone concentrations steadily increase.

Taken together, there is a gap in the literature concerning effects of endogenous sex hormones on interpersonal trust. The menstrual cycle builds an excellent model to study effects of naturally occurring hormone fluctuations on cognitive functioning. However, it also demands exact experimental planning and control of possible confounding factors. The present work is set out to close this gap, by investigating effects of alterations in the cycle-regulating hormone concentrations progesterone, estradiol, testosterone, luteinizing hormone (LH) and follicle stimulating hormone (FSH) on interpersonal trust. To this end, 33 naturally cycling women were tested at three distinct phases of the menstrual cycle in counterbalanced order. Testing of naturally cycling women was paralleled with testing of two same-aged control groups with stable hormone concentrations: A group of 33 women using a hormonal contraceptive (and therefore with suppressed endogenous hormone levels), and a group of 30 young men. We decided to use a combined game theoretical and social cue rating approach in order to assess the behavioral readiness to trust as a function of the type of interaction partner. As previous work has shown, hormone effects on trust do not seem to be global, but to be sensitive to, and to be calibrated by environmental factors (Delton et al., 2010; Bos et al., 2012b). We hypothesized that the readiness to trust in other individuals might be increased in the period of highest likelihood of conception preceding ovulation at mid-cycle, and that this readiness to trust might be decreased in the pregnancy-resembling mid-luteal period of the menstrual cycle, in which progesterone and estradiol concentrations peak in concert. We further assumed that these cycle-dependent alterations in trusting behavior might not be global, but might be expressed differently toward male and female, as well as toward rather attractive and rather unattractive individuals during the distinct periods. From an evolutionary perspective, it can be assumed that facilitated trust toward attractive males during the fertile preovulatory phase, as well as facilitated trust toward other females in the pregnancy-resembling luteal phase, would be adaptive (Gangestad and Thronhill, 2008; McKibbin and Shackelford, 2011). If fluctuations in gonadal sex hormones have activating effects on interpersonal trust, we expected this measure to be generally lower and less variable in women with suppressed endogenous hormone levels. If hormone fluctuations cause systematic changes in trusting variables in women, we expected no systematic changes of these variables in men across three testing sessions.

2. Methods

2.1. Participants and design

Participants were recruited via advertisements on campus of Ruhr-University Bochum, Germany, and were invited to attend three testing sessions. A monetary exchange experiment was conducted with three groups, using an intra-subject design. The first group consisted of 33 naturally cycling women who reported that they had not experienced any kind of hormonal intervention for at least 6 months prior to testing and had regular cycles ranging from 26 to 30 days. The second group consisted of 33 women who reported using a vaginal ring (Nuva®Ring) as a hormonal contraceptive for at least 6 months prior to testing. Because significant hormonal fluctuations were not expected in this group, these participants served as the control group for the naturally cycling women. Additionally, 30 young men were tested to control for general sex differences in ratings of trustworthiness.

For every naturally cycling woman, three test sessions that depended on when the menstrual cycle began were arranged according to reference values for progesterone and estradiol provided by Stricker et al. (2006). One test session took place during the menstrual phase (days 2–5), when the concentration of sex hormones is lowest. Another session was arranged between days 11 and 15 of the cycle, during the preovulatory LH-peak and the highest concentrations of estradiol and testosterone, and corrected for individual cycle length. Yet another session was scheduled for the mid-luteal phase (days 19–23) in order to have the women tested at their highest progesterone concentrations and the second surge of estradiol. The cycle phase in which women entered the testing series was counterbalanced, but the three sessions took place within the same or two consecutive cycles. Test sessions were organized in a similar way for the women using hormonal contraceptives, taking the day of applying a new vaginal ring as day 1. They were then scheduled for a test session between ring cycle days 2 and 5, followed by a session between ring cycle day 11–15 and one shortly before or directly after removing the ring between ring cycle days 19 and 23. For the male participants, test sessions were arranged with 8–10 days intervals. Individual test sessions were allocated randomly to the menstrual cycle phase sessions of the naturally cycling women, to control for test order effects. The time of day was held constant (either 9 a.m. or 1 p.m.) across all test sessions for each participant, to control for circadian variability in hormone release.

Anonymity was guaranteed at all times. The study protocol was approved by the ethics committee of the Ruhr-University Bochum, and all participants gave written, informed consent before participation. They were reimbursed for participation with a fixed charge and could earn some extra money, depending on their performance in the trust game.

2.2. Trust game

A modified version of the trust game described in Kosfeld et al. (2005) was used. In contrast to previous studies, natural hormone states were used in the current experiment, instead of administering hormones. Covering the individually distinct cycle phases requires testing participants separately, not with up to 12 persons in a room, as it is typically the case. In the version of the trust game used here, participants always assumed the position of the investor, and a black-and-white photo of a fictive trustee was presented on a computer screen, against a black background. The participants were told that the trustees were students from a South German university who had played the same game and whose responses had been recorded. Since they would receive the original answer of every trustee, the participants had to judge the trustworthiness of the other player by sending 0, 4, 8, or 12 money units (MU) of their initial endowment. Thus, if their judgment was faulty and they entrusted too much to a deceiving player, their overall payoff would decrease.

Pictures of the fictive trustees' faces (provided by an internal database of the Institute for Cognitive Neuroscience at Ruhr-University Bochum, Germany) had previously been judged for attractiveness on a seven-point Likert-scale by 30 female volunteers. Using the MathWorks™ software Matlab® (version 7.8.0) and the Biopsychology Toolbox (Rose et al., 2008), three parallel versions of the trust game were then constructed with five attractive and five unattractive male trustees, and five attractive and five unattractive female trustees, respectively. The games were programmed to present the 20 pictures in random order. The trustees' back transfers were held at a constant level of 40–60% of their payoff, so that all trustees were equally cooperative. If a participant invested, for instance, 8 MU in a given trustee, this amount was tripled and added to the other player's 12 MU initial endowment ($(8 \times 3) + 12 = 36$). In this example, the computer randomly chose an amount between 14.4 and 21.6 MU and sent it back to the investor.

The actual experiment was preceded by six training trials, to reinforce the participant's impression of participating in a quasi-social interaction. This was achieved by presenting six faces from the middle of the attractiveness scale (three males and three females). A random event generator chose two of these six players to betray the participant's trust by not sending any MU back. The experimenter commented this and reinforced the participants to look for signs of trustworthiness before taking a decision. In the experimental game, the participants were alone in the experimental room, in order to control for bystander effects (Earley, 2010). They played 20 trials with one second inter-trial intervals. The total payoff was presented on the screen only after the last trial, and the participants immediately received their