ISTS#1825672, VOL 0, ISS 0

Acute psychosocial stress increases third-party helping but not punishing behavior

Zhen Zhen, Huagen Wang, Ruida Zhu, Shen Zhang, Tao Jin, Shaozheng Qin, and Chao Liu

QUERY SHEET

This page lists questions we have about your paper. The numbers displayed at left are hyperlinked to the location of the query in your paper.

The title and author names are listed on this sheet as they will be published, both on your paper and on the Table of Contents. Please review and ensure the information is correct and advise us if any changes need to be made. In addition, please review your paper as a whole for typographical and essential corrections.

Your PDF proof has been enabled so that you can comment on the proof directly using Adobe Acrobat. For further information on marking corrections using Acrobat, please visit http://journalauthors.tandf.co.uk/production/acrobat.asp; https://authorservices.taylorandfrancis.com/how-to-correct-proofs-with-adobe/

The CrossRef database (www.crossref.org/) has been used to validate the references.

AUTHOR QUERIES

Q1 The funding information provided has been checked against the Open Funder Registry and we failed to find a match. Please check and resupply the funding details if necessary.

Q2 Please provide a short biography of the authors.

STRESS
https://doi.org/10.1080/10253890.2020.1825672

Taylor & Francis
Taylor & Francis Group

ORIGINAL RESEARCH REPORT

Acute psychosocial stress increases third-party helping but not punishing behavior

Zhen Zhen[a], Huagen Wang[b,c,d], Ruida Zhu[b,c,d], Shen Zhang[b,c,d], Tao Jin[b,c,d], Shaozheng Qin[b,c,d] and Chao Liu[b,c,d]

[a]Psychological Health Education and Counseling Center, Ocean University of China, Qingdao, China; [b]State Key Laboratory of Cognitive Neuroscience and Learning and IDG/McGovern Institute for Brain Research, Beijing Normal University, Beijing, China; [c]Center for Collaboration and Innovation in Brain and Learning Sciences, Beijing Normal University, Beijing, China; [d]Beijing Key Laboratory of Brain Imaging and Connectomics, Beijing Normal University, Beijing, China

ABSTRACT

Despite extensive research on the effects of stress on the brain and behaviors, there is a debate whether stress promotes prosocial behaviors, especially acute stress due to intricate costly punishment in the ultimatum game. Therefore, the present study introduced an irrelevant third party to examine how acute stress and the triggered cortisol influence third parties' punishing and helping behaviors as more convincing altruistic behaviors. The 65 participants were exposed to a psychosocial stressor ($n = 33$) or a control condition ($n = 32$). Afterwards, two third-party intervention tasks (a token allocation task and criminal scenario judgment task) were completed, during which the participants, as an "irrelevant" third party, could choose whether to sacrifice their own interests to help the victim or punish the transgressor. Participants' affective states, heart rate, and salivary cortisol were repeatedly measured throughout the experiment. Results showed that acute stress can lead to more third-party helping behaviors but not more punishing behaviors. Specifically, participants under stress tended to transfer more monetary units to the victim in the token allocation task than the control-group participants, and they tended to help the victim in the scenario task. In contrast, there was no significant difference in punishing behavior between the stressed and control participants. These findings reveal that acute psychosocial stress triggers the "tend and befriend" response, which might reflect the prosocial intuition under acute stress.

HIGHLIGHTS

- Acute psychosocial stress promotes altruistic behaviors toward an irrelevant third party.
- The raised prosocial tendencies are specific to third-party helping but not to punishing behaviors in both real and fictitious scenario tasks.

ARTICLE HISTORY
Received 22 February 2020
Accepted 12 September 2020

KEYWORDS
Psychosocial stress; third-party intervention; tend and befriend; prosocial; third-party punishment; third-party helping

1. Introduction

Stress, especially psychosocial stress, is prevalent in daily life. Exposure to acute stress not only has a profound impact on brain and cognition (McEwen et al., 2015) but also affects human prosocial behaviors (Buchanan & Preston, 2014). The effects of stress on social behavior can be both negative (undermining) and altruistic (adaptive).

As the classical "fight or flight" response to acute stress (Cannon, 1933), several studies have found that acute stress shapes offensive or defensive social interactions. Reduced trust behaviors (Feldmanhall et al., 2015; Steinbeis et al., 2015), lower donations to charity (Vinkers et al., 2013), and increased egoistic decision-making (Starcke et al., 2011) were elicited by the neuroendocrinological stress response in certain situations.

In contrast to the "fight or flight" response, the promotion of prosocial behaviors supported by the "tend and befriend" response (Taylor et al., 2000) to acute stress has also been verified by recent evidence. Participants show more trust, sharing, and generosity (Sollberger et al., 2016; Takahashi et al., 2007; von Dawans et al., 2012, 2019), and make more altruistic moral decisions (Singer et al., 2017) after experiencing stress, suggesting that stressed individuals become friendlier and more prosocial to gain social support to relieve anxiety caused by stress.

Among these inconsistencies, the elusory results of the stress effects on costly punishment behavior in the ultimatum game (UG) drew our attention. It was found that costly punishment has not to be impacted immediately after acute stress (Vinkers et al., 2013; von Dawans et al., 2012), or be reduced as the less rejection of even unfair offers (Steinbeis et al., 2015; only for women: Youssef et al., 2018). In the UG, when faced with a decision on allocating a sum of money proposed by a partner, participants as the responder, can either accept the offer (e.g. 90:10) so that both receive the money as suggested, or reject unfair offers so that both

CONTACT Shaozheng Qin szqin@bnu.edu.cn; Chao Liu liuchao@bnu.edu.cn State Key Laboratory of Cognitive Neuroscience and Learning and IDG/McGovern Institute for Brain Research, Beijing Normal University, Beijing 100875, China

receive nothing (i.e. 0:0) (Güth et al., 1982). Rejection of the unfair offer (i.e. perishing together unless the allotment is fair) is defined as costly/altruistic punishment (Fehr & Gächter, 2002; Henrich et al., 2006) or as strong reciprocity (Fehr et al., 2002; Gintis, 2000) for its essential role in enforcing social norms (i.e. fairness) and boosting cooperation. This altruistic punishment is believed to be driven by negative emotions (e.g. aversion, outrage) induced by unfairness (i.e. inequality aversion) (Fehr & Schmidt, 1999; Sanfey et al., 2003). However, as a self-defense behavior, this second-party punishment might be interacted with the affected direct self-interest (Civai et al., 2012) and urges for revenge (Strobel et al., 2011), which would not be a pure prosocial behavior.

Therefore, we introduced an uninvolved third-party condition wherein direct self-interest and revenge are unlikely to play a role. People are particularly sensitive to injustice and the third-party observers, even uninvolved in the violation, will incur costs to punish norm violators. We call this kind of punishment "third-party punishment" (Fehr & Fischbacher, 2004). It is an evolutionarily stable strategy universally, enabling intense social cooperation in humans despite genetic heterogeneity. In virtually all legal systems and most societies, moral norms are enforced mostly through third-party punishment. Study showed that the third party preferred for equal outcomes, while the second party preferred for these unequal but self-advantageous outcomes (Civai et al., 2012). Third-party punishment systems (integrating the harm to victims and assessment of the wrongdoers' motives) seem more executive than the affective second-party punishment systems (Krueger & Hoffman, 2016). It is driven by the perception of equality and fairness without the interaction of direct self-interest, which could be a more convincing prosocial behavior. Moreover, when faced with an unjust situation (e.g. unfair events or crimes), a third party generally has three response options: punishing the transgressor, helping the victim, or doing nothing out of self-protection. Third-party helping behaviors happen even more frequently in daily life as a robust prosocial behavior to promote survival and well-being (Leliveld et al., 2012). Both third-party punishment and helping behaviors are altruistic, reflecting the sacrifice of self-interest to resist injustice (Lotz, Baumert, et al., 2011). The present study adopts the third-party intervention paradigm (Hu et al., 2015; Leliveld et al., 2012) to examine the effects of psychosocial stress on two persuasive prosocial behaviors. Moreover, due to the different psychological (Davis, 1983; Pfattheicher & Keller, 2014) and neural (Hu et al., 2015; Stallen et al., 2018) mechanisms of punishing and helping, we can explore the preference to punish or help under acute psychosocial stress.

The present study implemented a revised version of the Trier Social Stress Test (TSST) to induce psychological, autonomic, and endocrinal responses. Stress-related effects on behavioral tendencies (i.e. punishing transgressors, helping victims, and maintaining self-interest) in third-party intervention tasks were then explored. Since the most common norm transgression in daily life is crime, in addition to the economic game task to explore distribution injustice, we added a criminal scenario judgment task to simulate similar trilemma scenes. In addition, we recruited both male and female participants to avoid the limitation of studies involving only men. This design allowed us to examine third-party individuals' prosocial behaviors (i.e. whether they were willing to sacrifice their self-interest to resist injustice) under stress as well as their inclination to punish or to help.

2. Methods

2.1. Participants

We recruited 65 young healthy college students in this study. Participants were randomly assigned to either the stress condition ($n = 33$; $M_{age} = 22.03$ years, $SD_{age} = 2.10$, 16 females) or the control condition ($n = 32$; $M_{age} = 22.09$ years, $SD_{age} = 2.08$, 16 females). One participant was excluded for issuing extreme responses (beyond 3 SD) in the third-party intervention task. To control the potential influence of non-experimental factors on the HPA-axis reactivity of stress, the following rigorous screening criteria were set: (1) no alcohol or nicotine abuse; (2) no chronic diseases or mental disorders; (3) no medication use within 2 weeks; (4) no current periodontitis; (5) no major exams within 2 weeks; (6) no circadian disruption (i.e. adequate sleep and no chronic overnight work); (7) no women in the 7 days before and after the onset of menses to avoid the confounders of variance in stress responsiveness in the late luteal phase and the menstrual period (Asso & Braier, 1982; Kask et al., 2008; Ossewaarde et al., 2010); (8) no contraceptives use; and (9) no high-intensity exercise before the experiment. They were also asked to refrain from food and drink (besides water), but not to be in hunger, for two hours before the experiment to prevent a brisk cortisol response to a standard lunch (Rosmond et al., 1998, 2000). All subjects were right-handed with normal or corrected-to-normal vision. This study was approved by the Institutional Review Board of the State Key Laboratory of Cognitive Neuroscience and Learning at Beijing Normal University. All subjects read and signed the informed consent form before the experiment.

2.2. Experimental procedure

In consideration of the diurnal variability of cortisol activity, experiments were carried out between 1:30 pm and 6:00 pm. Upon their arrival at the lab, participants were taken to the testing room, where they were given an explanation of the synopsis of the experiment and completed questionnaires for 20 minutes. After that, their baseline heart rate was recorded, saliva samples (S_1) were collected, and the Positive and Negative Affect Scale (PANAS, PA_1, and NA_1) was administered. Participants then took part under either the stress or the control condition. Immediately after the TSST, saliva samples were collected (S_2) and the PANAS (PA_2 and NA_2) was administered. The subjects then completed a third-party intervention task (including both the token allocation task and the scenario task). The third and fourth saliva samples (S_3, S_4) were collected and the PANAS (PA_3 and NA_3, PA_4 and NA_4) was administered 15 min and 25 min after the TSST. Heart rate was recorded throughout the TSST and the entire task. Lastly, they were debriefed about the purpose of the

experiment and paid. The general experimental procedure is outlined in Figure 1.

2.3. Trier social stress test

2.3.1. Stress induction

Acute stress was induced by a revised version of the TSST (Kirschbaum et al., 1993). The modified TSST was shown to be as effective as (Buchanan et al., 2009) or even more effective (Boesch et al., 2014; Buchanan et al., 2012) than the original TSST in eliciting cortisol responses. This psychosocial stress induction paradigm consisted of a 5-minute preparation stage, a 5-minute public speaking stage, and a 5-minute mental arithmetic stage. Subjects were instructed to prepare an unscripted oral speech to defend themselves against an accusation of shoplifting in front of the managers of the store. They were asked to make their statements specific and precise, because the evaluation of their performance was going to be based on how convincing, organized, articulate, and enthusiastic they were during their presentation. After 5 minutes of preparation, they were escorted to another room, where they delivered the speech in front of an evaluation panel of two trained experimenters (one male and one female). If the participants ran out of things to say, they were prompted to keep going until 5 minutes were up. After the 5-minute speech, subjects were asked to perform a mental arithmetic task in which they serially subtracted the number 13 from 1022 as quickly and accurately as possible and started over at 1022 if they made a mistake. The experimenters, who dressed in white coats and maintained a neutral expression without providing any feedback except for necessary instructions, were present and observed the participants throughout the period, with the whole process being video recorded.

2.3.2. Control condition

The control condition was consistent with the stress condition in terms of duration and cognitive load, with the exception that the social and self-relevant threat components were removed. This condition included a 5-minute preparation stage, a 5-minute speech stage, and a 5-minute written arithmetic stage. The control group was instructed to prepare a summary overview of a general travel article and then read their summary aloud for 5 minutes. They were then required to perform a simple arithmetic task for 5 minutes. The participants stayed in a room alone for the entire task.

2.4. Third-party intervention task

2.4.1. The token allocation task

Upon arrival, participants were asked to draw lots among three player roles (i.e. A, B, C), but all the lots are set as player C in advance. In such a way, the participants believed that they were assigned to be player C (the third party) randomly. To make sure that participants believed in the cover story, they were told that participants who were selected by lot as player A and B would be escorted to the downstairs laboratory to complete the experiment where another trained experimenter (the confederate) is there. They were placed in separate cubicles and informed that they would remain anonymous during and after the experiment. All participants (player C) received an endowment of 50 monetary units (MUs; 10 MUs = RMB 1) per round. They were told to observe a set of allocations of 100 MUs between several pairs of players, the proposer (player A) and recipient (player B), who were playing the dictator game (DG) simultaneously in the downstairs laboratory. Player A received an endowment of 100 MUs per round and could decide how to distribute these MUs between him/herself and the recipient with 10 MUs as a unit. Player B had to receive the MUs passively. The participants were told that the number of trials was determined by the number of pairs of players A and B, but this was pre-programmed to be three trials in random order (A:B = 90:10, 70:30, and 50:50). The participants were asked to choose from three options: transferring MUs to deduct from player A's MUs, transferring MUs to add to player B's MUs, or keeping MUs for themselves. If the subjects chose to deduct or to add, then they continued to decide how many MUs they wanted to transfer from their own 50 MUs, with 1 MU as a unit. The cost ratio was 1:3, as in previous studies (Hu et al., 2015; Leliveld et al., 2012). That is, every 1 MU player C transferred could deduct 3 MUs from player A or add 3 MUs to player B. After the instruction, the experimenter would call the confederate downstairs, in front of participants, to prepare for the start. After about 1 minute, the experiment started formally. Participants were debriefed before leaving to make sure they believe in the cover story.

At the end of three trials, subjects completed a subjective fairness perception scale on which they rated the fairness of all possible offers player A could make (A:B = 100:0; 90:10; 80:20; 70:30; 60:40; 50:50; 40:60; 30:70; 20:80; 10:90; 0:100) from 1 (*very unfair*) to 4 (*very fair*). To avoid a spillover effect on the subsequent scenario task, all participants completed a short, irrelevant cognitive task consisting of three intuitive calculation questions and two simple pictorial questions.

2.4.2. The scenario task

To increase ecological validity, we tested the third-party intervention behavior using a scenario task. Based on Prooijen (2010), we compiled two crime scenarios, one of a robbery and the other of a traffic accident (see Appendix), in which participants were about to make an urgent call to avoid huge economic losses for themselves when they witnessed a robbery or a traffic accident. They were instructed to put themselves in the two situations and prioritize calling 110 for the police (i.e. punishing the offenders), calling 120 for the first aid center (i.e. helping the victims), or making their personal call (i.e. maintaining self-interest). After each scenario, they were asked to assess its severity on a 7-point scale, from 1 (*not serious at all*) to 7 (*extremely serious*).

2.5. Data acquisition and analysis

2.5.1. Physiological measures

Saliva samples were collected with Salivette sampling devices (Sarstedt, Rommelsdorf, Germany) and stored at −20 °C until

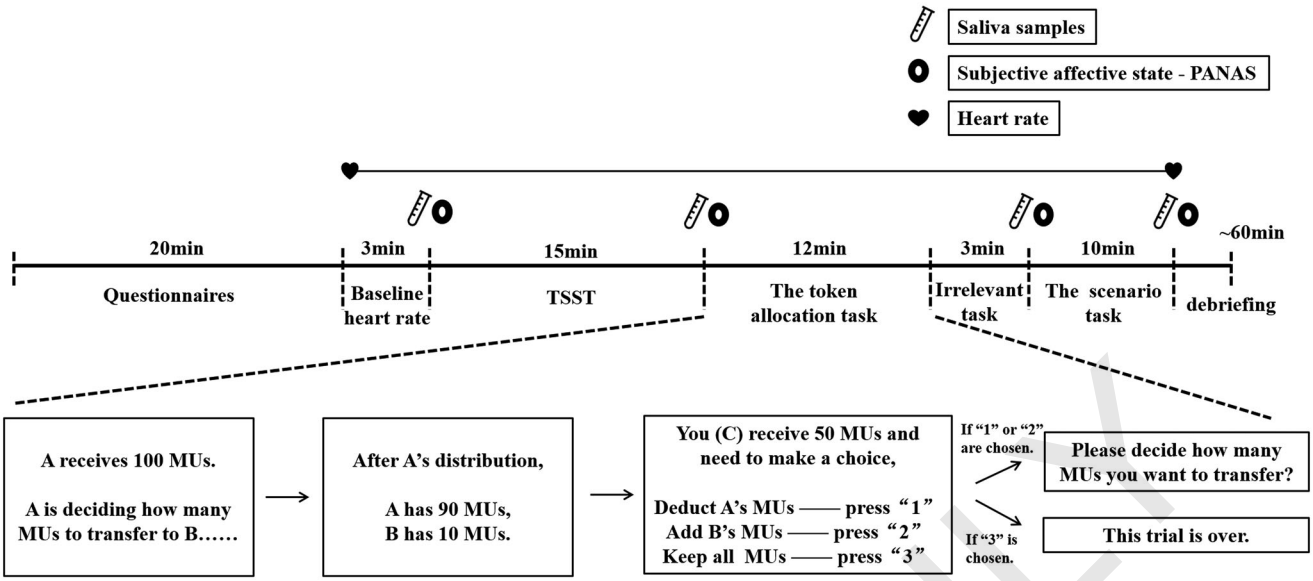

Figure 1. Experimental procedure and the flow chart of the token allocation task. Timeline depicting the procedure for collecting saliva samples, measuring subjective affective state (PANAS), recording heart rate, administering the TSST, and implementing the third-party intervention tasks.

analysis. The samples were thawed and centrifuged at 3500 rpm for 5 minutes. The concentration of salivary cortisol was analyzed by electrochemiluminescence immunoassay (Cobas e 601, Roche Diagnostics, Numbrecht, Germany). The intra- and inter-assay variations for cortisol were below 10%.

Heart rate was continuously measured by portable equipment (POLAR RCX3) with a Polar WearLink and a heartrate monitor. Heart rate was monitored for 3 minutes as baseline and was recorded throughout the subsequent tasks. The task interval was selected to yield the average value of heart rate in each stage.

2.5.2. Psychological and personality measures

The PANAS (Watson et al., 1988) was used to measure the current subjective affective states of participants. The scale has a total of 20 items describing different feelings and emotions, with 10 items for positive affective states (e.g. "interested," "excited") and 10 items for negative affective states (e.g. "nervous," "scared"). The participants were asked to score each item on a 5-point scale based on their current affective state, from 1 (*very slightly or not at all*) to 5 (*extremely*). The average scores for positive affective states and negative affective states were calculated.

To ensure that subjects in the stress group and control group were homogeneous in stress-related status and personality traits, all participants completed the following inventories: the Perceived Stress Scale (Cohen et al., 1983), the State-Trait Anxiety Inventory (Spielberger et al., 1971), Type A Behavior Pattern Scale (Boyuan, 1985), the Barratt Impulsiveness Scale (Patton et al., 1995), and the Interpersonal Reactivity Index (Davis, 1983).

2.5.3. Data management and analysis

To examine whether acute stress was successfully induced, two-way mixed analysis of variance (ANOVAs) were conducted on salivary cortisol, heart rate, and subjective affective state, with group (stress, control) as the between-subjects variable and acquisition time period as the within-subjects variable.

For the two third-party intervention tasks, the number of subjects choosing each of the three options (deducting from player A's MUs, adding to player B's MUs, or keeping MUs for oneself) in the token allocation task and the number of subjects making each of the three first phone calls (the police, the first aid center, or the personal call) in the scenario task were compared using two chi-square tests. In addition, for the token allocation task, for the subjects deciding to punish or to help, two-way ANOVA with group (stress, control) and choice (deducting, adding MUs) was used to analyze the average number of MUs transferred from player A or to player B in the two unfair conditions (A:B = 90:10 and 70:30, respectively).

To investigate stress-induced cortisol responses, the area under the curve with respect to the increase (AUCi) in salivary cortisol concentration were calculated as individual salivary cortisol responses. $AUCi = 1/2 \cdot (S_1 + S_2) \cdot T_{S2-S1} + 1/2 \cdot (S_2 + S_3) \cdot T_{S3-S2} + 1/2 \cdot (S_3 + S_4) \cdot T_{S4-S3} - S_1 \cdot (T_{S2-S1} + T_{S3-S2} + T_{S4-S3})$, in which T denotes the time interval between two successive salivary samplings expressed in hours (Pruessner et al., 2003).

The Greenhouse-Geisser correction was used when the requirement of sphericity in the repeated-measures ANOVA was not met. The η^2 measure of effect size was included where appropriate. The analysis of main effects and all pairwise comparisons were performed with Bonferroni corrections of statistical significance.

3. Results

3.1. Psychological, physiological, and endocrinal stress responses

We first examined the psychological, physiological, and endocrinal stress responses to verify the effectiveness of psychosocial stress induction. For the negative affect data, we conducted mixed two-way ANOVA with group as a between-

subject factor and time as a within-subject factor. This analysis revealed significant main effects of group (F (1, 62) = 4.32, p = .042, partial η^2 = 0.065) and acquisition time (F (3,186) = 11.56, p < .001, partial η^2 = 0.157) and a significant interaction of acquisition time and group (F (3,186) = 12.79, p < .001, partial η^2 = 0.171). Simple effects analysis showed that the interaction was driven by the significantly higher negative affective state after the TSST (NA_2) in the stress group than in the control group (p < .001) (Figure 2(A)). For positive affective state, the mixed two-way ANOVA showed significant main effects of time (F (3,186) = 11.82, p < .001, partial η^2 = 0.16), reflected in a lower positive affective state at the final measurement (PA_4) than in the previous three measurements (p < .001), but no significant main effect of group or significant interaction of acquisition time and group.

With regard to the heart rate data, unclear equipment-wearing problems led to missing data in two participants. The mixed two-way ANOVA for the remaining 62 subjects revealed a significant main effect of acquisition time (F (4,240) = 87.72, p < .001, partial η^2 = 0.594) and a significant interaction of acquisition time and group (F (4,240) = 30.27, p < .001, partial η^2 = 0.335). Simple effects analysis found no significant difference between the two groups in terms of baseline heart rate (p > .05). During the TSST, the heart rate was significantly higher in the stress group than in the control group (public speaking stage: p = .006; mental arithmetic stage: p = .012) (Figure 2(B)).

For the salivary cortisol data, mixed two-way ANOVA showed a significant main effect of acquisition time (F (3,186) = 11.23, p < .001, partial η^2 = 0.153) and a significant interaction of acquisition time and group (F (3,186) = 7.38, p < .001, partial η^2 = 0.106). Simple effects analysis revealed that the baseline salivary cortisol level (S_1) in the stress group was not significantly different from that of the control group (p > .05), and the salivary cortisol level measured after TSST treatment (S_3) was significantly higher in the stress group than in the control group (p = .013) (Figure 2(C)). Of the 32 participants in the stress group, 22 (68.75%) showed an effective cortisol increase of at least 1.5 nmol/l (Miller et al., 2013). This percentage of cortisol responders corresponds to the results of previous studies (Kirschbaum et al., 1993). These results indicate that the psychosocial stressor successfully induced psychological, physiological, and endocrinal stress responses.

In addition, to investigate the gender differences in stress responses, we calculated the changes in cortisol concentration, heart rates and negative emotions from baseline to peak (peak delta) (Kelly et al., 2008), and the analyses of covariance (ANCOVAs) were conducted (with the between-subjects gender factor and using age as a covariate). Results did not show any significant gender differences in responses to TSST (peak delta of cortisol: F (1, 63) = 0.171, p = .681; peak delta of heart rates: F (1, 61) = 0.360, p = .551; peak delta of negative emotions: F (1, 63) = 0.039, p = .843).

3.2. Results in the third-party token allocation task under acute stress

According to the χ^2 test, there was no significant difference between the two groups in terms of the number of subjects who chose to deduct from player A's MUs, to add to player B's Mus, or to keep all MUs for the three offer conditions (for the 90:10 condition: χ^2 (2,64) = 0.14, p = .931; 70:30: χ^2 (2,64) < .001, p = 1.0; 50:50: χ^2 (2,64) = 2.07, p = .355).

For the number of MUs transferred to player A or B in the two unfair allocation conditions, the two-way ANOVA in the 90:10 condition revealed a significant main effect of group, F (1,47) = 10.26, p = .002, partial η^2 = 0.179, but no significant main effect of choice and no significant interaction of group and choice. Further pairwise comparisons showed that the stress group was more willing to add more MUs to player B than was the control group (p = .01) in the 90:10 condition (Figure 3). No significant effects in the 70:30 condition were found.

For the subjective fairness perception, a mixed two-way ANOVA with group as a between-subjects variable and offer (A:B = 100:0; 90:10; 80:20; 70:30; 60:40; 50:50; 40:60; 30:70; 20:80; 10:90; 0:100) as a within-subjects variable revealed a significant main effect of offer, F (10,620) = 187.52, p < .001, partial η^2 = 0.752, and a significant interaction of group and offer, F (10,620) = 2.70, p = .021, partial η^2 = 0.042. Further simple effects analysis showed that the stress group perceived more fairness than the control group when the A:B offers were 30:70 and 20:80 (in 30:70 condition, p = .011; in 20:80 condition, p = .012) (Figure 4). The results showed that stressed participants were more inclined to advantageous offers (i.e. A: B = 30:70; 20:80) to victims (player B).

For the AUCi of salivary cortisol, we divided all participants across the stress and control group into low and high cortisol responders groups on a median split of their AUCi scores. The subsequent $\chi 2$ test indicated no significant difference between these two groups on the number of subjects with one of the three choices. For the amount of transferred MUs, the two-way ANOVAs with cortisol responders group (high, low) and choice (deducting, adding MUs) in the two unfair conditions respectively also showed no significant differences. The results did not indicate significant relationships between cortisol responses and third-party intervention behaviors.

3.3. Results in the third-party scenario task under acute stress

Regarding the number of subjects who chose to call the police, call the first aid center, or place a personal call in the two scenarios, the χ^2 test showed a significant difference between the two groups in the traffic accident scenario, χ^2 (2, 64) = 12.71, p = .002, mainly reflecting that more stressed participants prioritized helping victims than did control group participants. In the robbery scenario, the results were not significant, χ^2 (2, 64) = 3.46, p = .178 (Figure 5).

For the severity scores of the two scenarios, an independent-samples t-test indicated that the stress group scored the situation as more serious than the control group did in both scenarios (traffic accident scenario, t (62) = 3.39, p = .001; robbery scenario, t (62) = 2.08, p = .042). The results for the criminal scenario task indicated that stressed participants have a tendency to help victims and rated the scenarios as more serious.

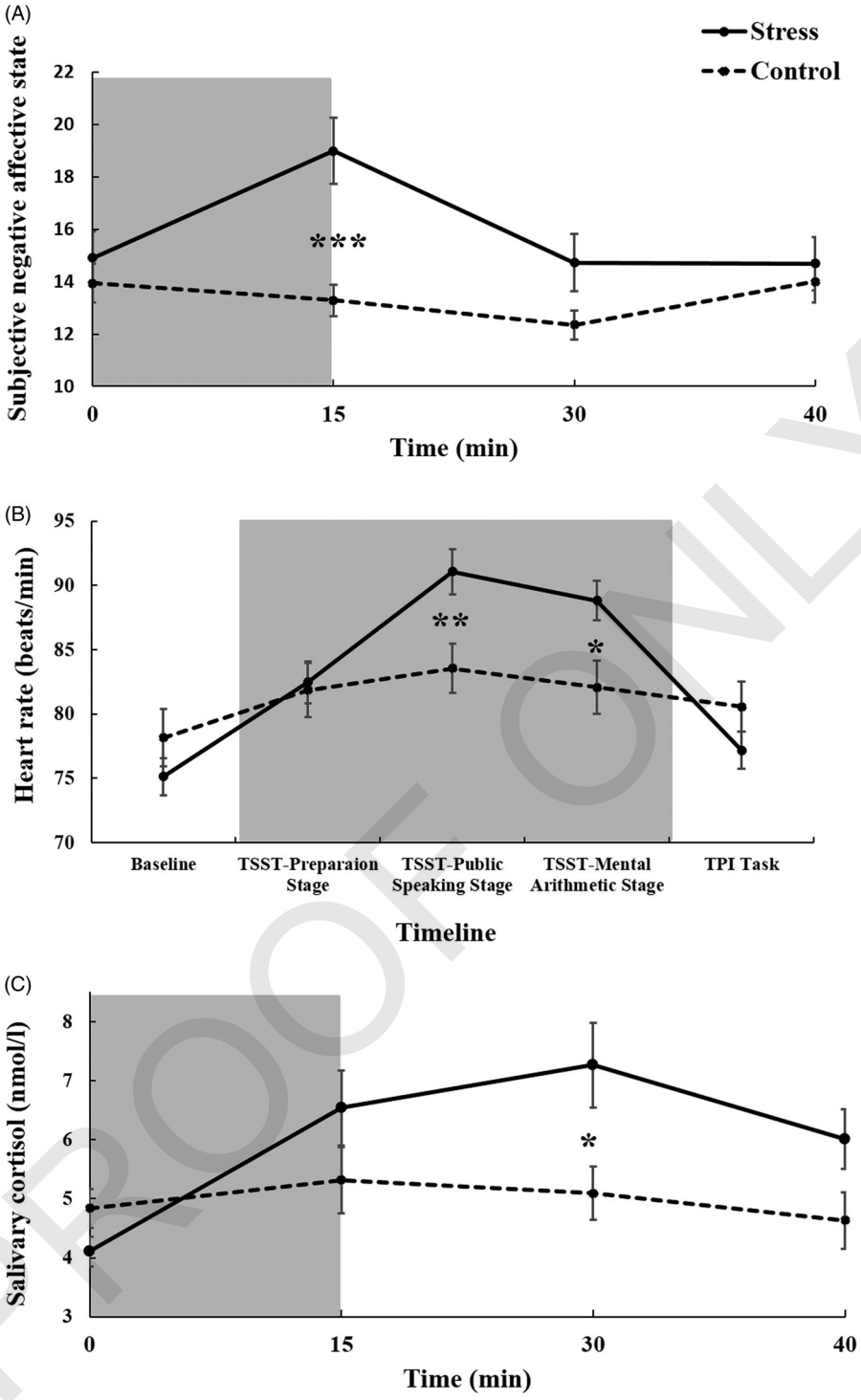

Figure 2. (A) Subjective negative affective state across the experiment for the two groups. (B) Heart rate across the experiment for the two groups. (C) Salivary cortisol concentrations across the experiment for the two groups. Gray color indicates the TSST period. ***$p < .001$, **$p < .01$, *$p < .05$.

In both tasks, results revealed no significant difference between the two groups on all the stress-related status and personality scales (all *ts* $<$ .06, all *ps* $>$ .05). For the two third-party intervention tasks, the analysis did not show any significant main effects or interactions with gender.

4. Discussion

In sum, the present evidence supports the "tend and befriend" response of acute stress. Using the modified TSST paradigm, we successfully induced psychosocial stress, as indicated by elevated psychological, autonomic, and endocrinal responses. Results revealed that psychosocial stress led to an increase in prosocial behaviors toward an irrelevant third party. Specifically, compared with control-group participants, participants under stress tended to transfer more money units to the victim in the extreme unfair token allocation condition, and they showed a trend of helping the victim in the scenario task. Critically, this stress-induced prosociality enhancement seemed specific to third-party helping but not

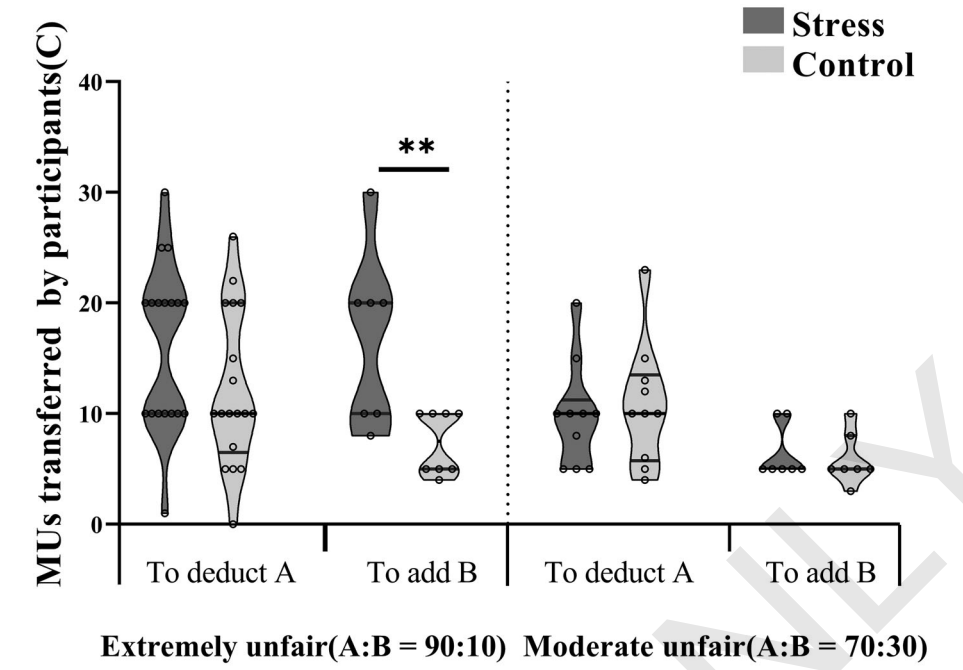

Figure 3. MUs transferred by participants (player C) to players A and B for the two groups in the two unfair conditions. $^{**}p < .01$, $^{*}p < .05$.

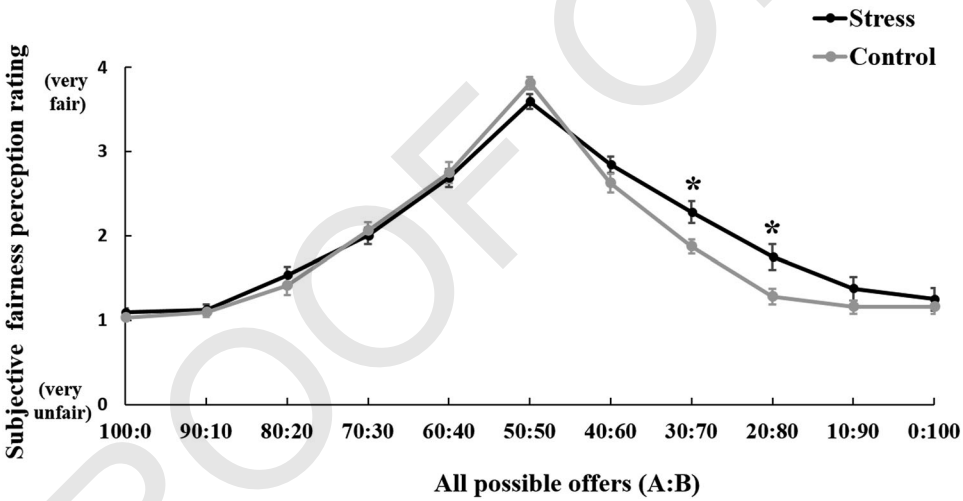

Figure 4. The subjective fairness perception rating of all possible offers for the two groups. $^{**}p < .01$, $^{*}p < .05$.

punishing behaviors, since no significant differences were found for the third-party punishing behaviors between the stress and control groups in the two tasks. Third-party helping behavior entails sacrificing one's benefits to help the victims. It is the most representative prosocial and altruistic behavior (Rilling & Sanfey, 2011), directly and robustly reflecting the "tend and befriend" responses of stress.

Why does acute stress lead to a third-party helping tendency? Tracing the "tend and befriend" response, humans show a tendency to affiliate in threatening times. This strategy can protect people and their offspring through social interactions benefiting a good reputation, whereby they may receive joint protection and relieve distress (Taylor, 2006). Studies have indeed indicated that prosocial behavior can mitigate the negative effects of stress (DeVries et al., 2003; Raposa et al., 2016). Moreover, third-party helping is an effective conflict management strategy to prevent the detrimental effects of conflict stress (Giebels & Janssen, 2005). Increased third-party helping behavior might be an effective strategy for individuals in stressful circumstances to ensure social reciprocity and relieve anxiety.

Furthermore, one review advanced a stress-induced deliberation-to-intuition (SIDI) model, which is well supported in the decision-making field, positing that in stressful situations, fast, habitual, and gut responses may dominate over slow, goal-directed, and deliberate responses (Yu, 2016). These two responses are rooted in the famous "dual-process" theory, which posits two decision-making routes called Systems 1/2. System 1 runs fast and with little effort with the "hot" emotional neural circuitry of the salience network, while System 2 operates slowly and with greater effort with the neural circuitry of the executive control network (Menon et al., 2007; Sanfey & Chang, 2008). In general situations, these two neurocognitive systems are balanced to make an optimal choice.

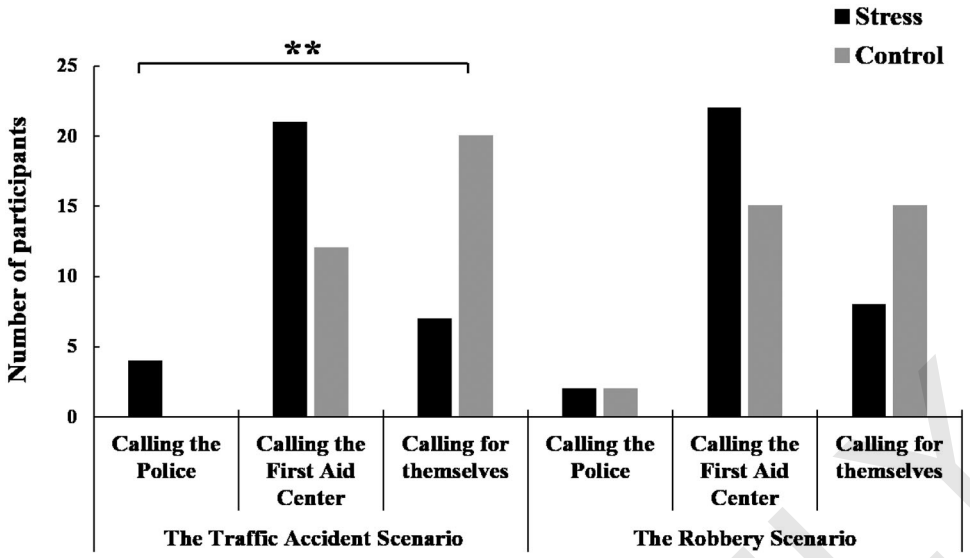

Figure 5. The number of participants who chose to call the police, call the first aid center, and make a personal call in the two scenarios. $^{**}p < .01$, $^{*}p < .05$.

During times of unpredictable and uncontrollable stress, the intuition neural system is upregulated and the deliberation neural system is downregulated (Hermans et al., 2014), leading to a shift from flexible, goal-directed behavior to more rigid stimulus-response, habitual behavior, as the SIDI model indicates. Moreover, across a range of experimental designs, studies have consistently confirmed that subjects are more cooperative, but not selfish when reacting intuitively (Rand et al., 2012; Rand & Epstein, 2014). Researchers have proposed the social heuristic hypothesis (SHH), suggesting that intuition favors cooperation and altruism (Rand et al., 2013, 2014). According to the SHH, individuals have internalized intuitive reactions that are typically advantageous to boost our everyday life, and these intuitions will be generalized even to times under uncertainty. Combining the SIDI model and the SHH, it seems that the intuitive social decision-making under stress should be prosocial and altruistic, as represented by third-party helping.

Regarding there being increases only in third-party helping but not punishing behaviors under acute stress, there are several viewpoints. Although they both can maintain social norms, punishing and helping behaviors are still essentially different. Helping behavior is a clear altruistic behavior, while punishment, even third-party punishment as a "strong reciprocity" behavior, is an expression of attack (Feshbach, 1964). The emotion accompanying punishment leads it to be typically considered an angry and impulsive response (Pfattheicher & Keller, 2014), while helping behavior is mainly driven by sympathy and empathy (Davis, 1983; Tomova et al., 2016; Wolf et al., 2015). We explicate this result as follows, combining it with other analyses in our studies.

First of all, punishing and helping behaviors might have disparate outcomes. Researchers have found that helpful third parties gained more rewards than third-party punishers (Raihani & Bshary, 2015). From the perspective of social reciprocity, the act of helping an individual in need might create opportunities for direct reciprocity from the person being helped or from uninvolved bystanders (Adams & Mullen, 2013; Raihani & Bshary, 2015; Sylwester & Roberts, 2013), as recent studies have shown that generosity is a signal of trustworthiness, while punishment of selfishness is not (Przepiorka & Liebe, 2016), and the punisher runs the risk of retaliation by the transgressor. The threat of reprisals might lead individuals to avoid punishment when other non-confrontational options are available (Dreber et al., 2008; Herrmann et al., 2008; Rockenbach & Milinski, 2006). Therefore, punishment might be inefficient for self-interest in the long term. Second, concern for transgressors or victims matters. When subjects have only two options, punishing offenders or helping victims, there is no significant difference between the two choices (Hu et al., 2015; Leliveld et al., 2012; Lotz, Okimoto, et al., 2011). However, when the degree of concern for transgressors or victims changes, the preference for punishing or helping changes correspondingly (David et al., 2017; Lotz, Okimoto, et al., 2011). Our results for the subjective fairness perception scale indicate that the stressed individuals rated advantageous offers to victims (i.e. A:B offers of 30:70 and 20:80) as fairer and more acceptable than the control group, confirming that acute psychosocial stress probably increased subjects' concern for the victims in the third-party intervention task, triggering greater third-party helping behaviors (Gromet & Darley, 2009; Lotz, Okimoto, et al., 2011).

The present study did not find significant results regarding acute stress-induced cortisol responses (AUCi) and third-party intervention behaviors. Several studies have found inconsistent relationships between cortisol responses and social decision-making, such as positive relationships with affiliation (Berger et al., 2016), altruism (Singer et al., 2017), egotism (Starcke et al., 2011), and negative relationships with trust (Takahashi et al., 2005) decisions. The effects seem to be ambivalent in these studies, and the exact mechanism of how cortisol responses modulate social decision-making needs further exploration. Our study found that neither gender nor personality influences the effects of acute stress on third-party intervention behaviors, although several previous studies found individual differences under acute stress (gender differences: Nickels et al., 2017; Turton & Campbell, 2007; personality differences: Takahashi et al., 2005). These

inconsistencies reflect the intricate process whereby acute stress affects social decision-making and suggest that we need further explorations of the complex underlying mechanism.

There are several limitations to the present study. First, the sequence of two third-party intervention tasks was fixed, as the token allocation task always preceded the criminal scenario task. The sequence matters, for it involves an important factor, time. Under the biphasic-reciprocal model (Hermans et al., 2014), the neuroendocrine level, cellular level, and the brain system level all change over time. As time passes, the changing stress response and consequent effects on social behaviors differ (Vinkers et al., 2013). Although the two third-party intervention tasks were all completed within 40 min after the stressor onset, time-dependent effects could also influence the results. Second, the sample size in present study is relatively small ($N = 65$) (e.g. the main effect of group on the amount of transferred MUs, partial $\eta^2 = 0.179$) for a behavioral study with a between-subjects design. Third, for the female participants, we had a relatively laxer standards, since studies have shown that women have the most similar cortisol responses with men during their luteal phase (Kajantie & Phillips, 2006; Kirschbaum et al., 1999). Besides the fluctuant late luteal phase, it indicates that the early luteal phase might be the quite suitable phase for female participants in stress studies. Lastly, we adopted the modified TSST as a psychosocial stressor because of the more effective stress response it elicited, but we neglected the fact that the scenario of defending oneself against a charge of shoplifting might have priming effects that confounded the subsequent third-party intervention task. We are unsure if the priming effect was the main cause of our results. Since in the field of social moral decision making, the scenario of being accused of shoplifting resembles the process of imposing a moral threat on individuals and releasing them at the end of TSST. Previous studies have found that such a phenomenon, such as cleansing after recalling unethical behaviors, can reduce people's helping percentage to the third party (Xu et al., 2014; Zhong & Liljenquist, 2006) and increase harsh moral judgment to others (Zhong et al., 2010). These results are just the opposite of our results with an increased third-party helping behavior. From this perspective, our results might not be explained by the priming effect. However, we must recognize that the scenarios of being accused of shoplifting could be an impact on third-party intervention behaviors that reminds us to strictly control the interference of irrelevant variables. Further studies can investigate whether the conventional TSST with the mock job scenario has the same effect on third-party prosocial behavior. In addition, through eliminating possible social factors, the impact of nonsocial stressors (e.g. the Cold Pressor Task) on third-party prosocial behavior might be the other directions.

In conclusion, by extending previous findings on second-party situations, our study demonstrates that acute stress enhances prosocial and altruistic behaviors, specifically helping behavior, but not antisocial and egoistic behaviors in third-party situations.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the Major Project of National Social Science Foundation [19ZDA363], the National Key R&D Program of China [2017YFC0803402], the National Natural Science Foundation of China (NSFC) [31871094, 71572018, 31522028, 81571056, 2014NT15], the Beijing Municipal Science & Technology Commission [Z151100003915122], the National Program for Support of Top-notch Young Professionals, and the Thousand (Young) Talents Program of China.

Q1

References

Q2

Adams, G. S., & Mullen, E. (2013). Increased voting for candidates who compensate victims rather than punish offenders. *Social Justice Research*, *26*(2), 168–192. https://doi.org/10.1007/s11211-013-0179-x

Asso, D., & Braier, J. R. (1982). Changes with the menstrual cycle in psychophysiological and self-report measures of activation. *Biological Psychology*, *15*(1–2), 95–107. https://doi.org/10.1016/0301-0511(82)90034-5

Berger, J., Berger, J., Heinrichs, M., Dawans, B., Von, J. S., Way, B., & Chen, F. (2016). Cortisol modulates men's affiliative responses to acute social stress. *Psychoneuroendocrinology*, *63*, 1–9. https://doi.org/10.1016/j.psyneuen.2015.09.004

Boesch, M., Sefidan, S., Ehlert, U., Annen, H., Wyss, T., Steptoe, A. & La Marca, R., (2014). Mood and autonomic responses to repeated exposure to the Trier Social Stress Test for Groups (TSST-G). *Psychoneuroendocrinology*, *43*, 41–51. https://doi.org/10.1016/j.psyneuen.2014.02.003

Boyuan, Z. (1985). Psychophysiological reaction in cardiovascular disease: A study on the behavior pattern of coronary heart disease patients. *Acta Psychologica Sinica*, *17*(3), 90–97.

Buchanan, T. W., Bagley, S. L., Stansfield, R. B., & Preston, S. D. (2012). The empathic, physiological resonance of stress. *Social Neuroscience*, *7*(2), 191–201. https://doi.org/10.1080/17470919.2011.588723

Buchanan, T. W., & Preston, S. D. (2014). Stress leads to prosocial action in immediate need situations. *Frontiers in Behavioral Neuroscience*, *8*, 5. https://doi.org/10.3389/fnbeh.2014.00005

Buchanan, T. W., Tranel, D., & Kirschbaum, C. (2009). Hippocampal damage abolishes the cortisol response to psychosocial stress in humans. *Hormones and Behavior*, *56*(1), 44–50. https://doi.org/10.1016/j.yhbeh.2009.02.011

Cannon, W. B. (1933). The wisdom of the body. *American Journal of Sociology*, *38*(4), 603.

Civai, C., Crescentini, C., Rustichini, A., & Rumiati, R. I. (2012). Equality versus self-interest in the brain: Differential roles of anterior insula and medial prefrontal cortex. *NeuroImage*, *62*(1), 102–112. https://doi.org/10.1016/j.neuroimage.2012.04.037

Cohen, S., Kamarck, T. W., & Mermelstein, R. J. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, *24*(4), 385–396.

David, B., Hu, Y., Krüger, F., & Weber, B. (2017). Other-regarding attention focus modulates third-party altruistic choice: An fMRI study. *Scientific Reports*, *7*, 43024. https://doi.org/10.1038/srep43024

Davis, M. H. (1983). measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, *44*(1), 113–126. https://doi.org/10.1037/0022-3514.44.1.113

DeVries, A. C., Glasper, E. R., & Detillion, C. E. (2003). Social modulation of stress responses. *Physiology & Behavior*, *79*(3), 399–407. https://doi.org/10.1016/S0031-9384(03)00152-5

Dreber, A., Rand, D., Fudenberg, D., & Nowak, M. (2008). Winners don't punish. *Nature*, *2*, e06723. http://www.nature.com/nature/journal/v452/n7185/abs/nature06723.html

Fehr, E., & Schmidt, K. M. (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics*, *114*(3), 817–868. https://doi.org/10.1162/003355399556151

Fehr, E., & Fischbacher, U. (2004). Third-party punishment and social norms. *Evolution and Human Behavior*, *25*(2), 63–87. https://doi.org/10.1016/S1090-5138(04)00005-4

Fehr, E., Fischbacher, U., & Gächter, S. (2002). Strong reciprocity, human cooperation, and the enforcement of social norms. *Human Nature*, *13*(1), 1–25. https://doi.org/10.1007/s12110-002-1012-7

Fehr, E., & Gächter, S. (2002). Altruistic punishment in humans. *Nature*, *415*(6868), 137–140. https://doi.org/10.1038/415137a

Feldmanhall, O., Raio, C. M., Kubota, J. T., Seiler, M. G., & Phelps, E. A. (2015). The effects of social context and acute stress on decision making under uncertainty. *Psychological Science*, *26*(12), 1918–1919. https://doi.org/10.1177/0956797615605807

Feshbach, S. (1964). The function of aggression and the regulation of aggressive drive. *Psychological Review*, *71*(4), 257–272. https://doi.org/10.1037/h0043041

Giebels, E., & Janssen, O. (2005). Conflict stress and reduced wellbeing at work: The buffering effect of third-party help. *European Journal of Work and Organizational Psychology*, *14*(2), 137–155. https://doi.org/10.1080/13594320444000236

Gintis, H. (2000). Strong reciprocity and human sociality. *Journal of Theoretical Biology*, *206*(2), 169–179. https://doi.org/10.1006/jtbi.2000.2111

Gromet, D. M., & Darley, J. M. (2009). Punishment and beyond: Achieving justice through the satisfaction of multiple goals. *Law & Society Review*, *43*(1), 1–38. https://doi.org/10.1111/j.1540-5893.2009.00365.x

Güth, W., Schmittberger, R., & Schwarze, B. (1982). An experimental analysis of ultimatum bargaining. *Journal of Economic Behavior & Organization*, *3*(4), 367–388.

Henrich, J., McElreath, R., Barr, A., Ensminger, J., Barrett, C., Bolyanatz, A., Cardenas, J. C., Gurven, M., Gwako, E., Henrich, N., Lesorogol, C., Marlowe, F., Tracer, D., & Ziker, J. (2006). Costly punishment across human societies. *Science*, *312*(5781), 1767–1770. https://doi.org/10.1126/science.1127333

Hermans, E. J., Henckens, M. J. a G., Joëls, M., & Fernández, G. (2014). Dynamic adaptation of large-scale brain networks in response to acute stressors. *Trends in Neurosciences*, *37*(6), 304–314. https://doi.org/10.1016/j.tins.2014.03.006

Herrmann, B., Thöni, C., & Gächter, S. (2008). Antisocial punishment across societies. *Science*, *319*(5868), 1362–1368. https://doi.org/10.1111/aman.12147

Hu, Y., Strang, S., & Weber, B. (2015). Helping or punishing strangers: Neural correlates of altruistic decisions as third-party and of its relation to empathic concern. *Frontiers in Behavioral Neuroscience*, *9*, 24. https://doi.org/10.3389/fnbeh.2015.00024

Kajantie, E., & Phillips, D. I. W. (2006). The effects of sex and hormonal status on the physiological response to acute psychosocial stress. *Psychoneuroendocrinology*, *31*(2), 151–178. https://doi.org/10.1016/j.psyneuen.2005.07.002

Kask, K., Gulinello, M., Bäckström, T., Geyer, M. A., & Sundström-Poromaa, I. (2008). Patients with premenstrual dysphoric disorder have increased startle response across both cycle phases and lower levels of prepulse inhibition during the late luteal phase of the menstrual cycle. *Neuropsychopharmacology*, *33*(9), 2283–2290. https://doi.org/10.1038/sj.npp.1301599

Kelly, M. M., Tyrka, A. R., Anderson, G. M., Price, L. H., & Carpenter, L. L. (2008). Sex differences in emotional and physiological responses to the Trier Social Stress Test. *Journal of Behavior Therapy and Experimental Psychiatry*, *39*(1), 87–98. https://doi.org/10.1016/j.jbtep.2007.02.003

Kirschbaum, C., Pirke, K., & Hellhammer, D. (1993). The Trier Social Stress Test–a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, *28*(1–2), 76–81. https://doi.org/10.1159/000119004

Kirschbaum, C., Kudielka, B. M., Gaab, J., Schommer, N. C., & Hellhammer, D. H. (1999). Impact of gender, menstrual cycle phase, and oral contraceptives on the activity of the hypothalamus-pituitary-adrenal axis. *Psychosomatic Medicine*, *61*(2), 154–162. https://doi.org/10.1097/00006842-199903000-00006

Krueger, F., & Hoffman, M. (2016). The emerging neuroscience of third-party punishment. *Trends in Neurosciences*, *39*(8), 499–501. https://doi.org/10.1016/j.tins.2016.06.004

Leliveld, M. C., Dijk, E., & Beest, I. (2012). Punishing and compensating others at your own expense: The role of empathic concern on reactions to distributive injustice. *European Journal of Social Psychology*, *42*(2), 135–140. https://doi.org/10.1002/ejsp.872

Lotz, S., Baumert, A., Schlösser, T., Gresser, F., & Fetchenhauer, D. (2011). Individual differences in third-party interventions: How justice sensitivity shapes altruistic punishment. *Negotiation and Conflict Management Research*, *4*(4), 297–313. https://doi.org/10.1111/j.1750-4716.2011.00084.x

Lotz, S., Okimoto, T. G., Schlösser, T., & Fetchenhauer, D. (2011). Punitive versus compensatory reactions to injustice: Emotional antecedents to third-party interventions. *Journal of Experimental Social Psychology*, *47*(2), 477–480. https://doi.org/10.1016/j.jesp.2010.10.004

McEwen, B. S., Bowles, N. P., Gray, J. D., Hill, M. N., Hunter, R. G., Karatsoreos, I. N., & Nasca, C. (2015). Mechanisms of stress in the brain. *Nature Neuroscience*, *18*(10), 1353–1363. https://doi.org/10.1038/nn.4086

Menon, V., Schatzberg, A. F., Keller, J., Glover, G. H., Kenna, H., Reiss, A. L., & Greicius, M. D. (2007). Dissociable intrinsic connectivity networks for salience processing and executive control. *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience*, *27*(9), 2349–2356. https://doi.org/10.1523/JNEUROSCI.5587-06.2007

Miller, R., Plessow, F., Kirschbaum, C., & Stalder, T. (2013). Classification criteria for distinguishing cortisol responders from nonresponders to psychosocial stress: Evaluation of salivary cortisol pulse detection in panel designs. *Psychosomatic Medicine*, *75*(9), 832–840. https://doi.org/10.1097/PSY.0000000000000002

Nickels, N., Kubicki, K., & Maestripieri, D. (2017). Sex differences in the effects of psychosocial stress on cooperative and prosocial behavior: Evidence for 'flight or fight' in males and 'tend and befriend' in females. *Adaptive Human Behavior and Physiology*, *3*(2), 171–183. https://doi.org/10.1007/s40750-017-0062-3

Ossewaarde, L., Hermans, E. J., van Wingen, G. A., Kooijman, S. C., Johansson, I.-M., Bäckström, T., & Fernández, G. (2010). Neural mechanisms underlying changes in stress-sensitivity across the menstrual cycle. *Psychoneuroendocrinology*, *35*(1), 47–55. https://doi.org/10.1016/j.psyneuen.2009.08.011

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the barratt impulsiveness scale. *Journal of Clinical Psychology*, *51*(6), 768–774. https://doi.org/10.1002/1097-4679(199511)51:6<768::AID-JCLP2270510607>3.0.CO;2-1

Pfattheicher, S., & Keller, J. (2014). Towards a biopsychological understanding of costly punishment: The role of basal cortisol. *PLoS One*, *9*(1), e85691. https://doi.org/10.1371/journal.pone.0085691

Prooijen, J. van, (2010). Retributive versus compensatory justice: Observers' preference for punishing in response to criminal offenses. *European Journal of Social Psychology*, *85*, 72–85. https://doi.org/10.1002/ejsp

Pruessner, J. C., Kirschbaum, C., Meinlschmid, G., & Hellhammer, D. H. (2003). Two formulas for computation of the area under the curve represent measures of total hormone concentration versus time-dependent change. *Psychoneuroendocrinology*, *28*(7), 916–931. https://doi.org/10.1016/S0306-4530(02)00108-7

Przepiorka, W., & Liebe, U. (2016). Generosity is a sign of trustworthiness—the punishment of selfishness is not. *Evolution and Human Behavior*, *37*(4), 255–262. https://doi.org/10.1016/j.evolhumbehav.2015.12.003

Raihani, N. J., & Bshary, R. (2015). Third-party punishers are rewarded, but third-party helpers even more so. *Evolution; International Journal of Organic Evolution*, *69*(4), 993–1003. https://doi.org/10.1111/evo.12637

Rand, D., & Epstein, Z. (2014). Risking your life without a second thought: Intuitive decision-making and extreme altruism. *PLoS One*, *9*(10), 1–6. https://doi.org/10.1371/journal.pone.0109687

Rand, D. G., Greene, J. D., & Nowak, M. a. (2012). Spontaneous giving and calculated greed. *Nature*, *489*(7416), 427–430. https://doi.org/10.1038/nature11467

Rand, D. G., Peysakhovich, A., Kraft-Todd, G. T., Newman, G. E., Wurzbacher, O., Nowak, M. A., & Greene, J. D. (2014). Social heuristics shape intuitive cooperation. *Nature Communications*, *5*, 3677. https://doi.org/10.1038/ncomms4677

Rand, D. G., Tarnita, C. E., Ohtsuki, H., & Nowak, M. A. (2013). Evolution of fairness in the one-shot anonymous Ultimatum Game. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(7), 2581–2586. https://doi.org/10.1073/pnas.1214167110

Raposa, E. B., Laws, H. B., & Ansell, E. B. (2016). Prosocial behavior mitigates the negative effects of stress in everyday life. *Clinical Psychological Science*, *4*(4), 691–698. https://doi.org/10.1177/2167702615611073

Rilling, J. K., & Sanfey, A. G. (2011). The neuroscience of social decision-making. *Annual Review of Psychology*, *62*, 23–48. https://doi.org/10.1146/annurev.psych.121208.131647

Rockenbach, B., & Milinski, M. (2006). The efficient interaction of indirect reciprocity and costly punishment. *Nature*, *444*(7120), 718–723. https://doi.org/10.1038/nature05229

Rosmond, R., Dallman, M. F., & BjöRntorp, P. (1998). Stress-related cortisol secretion in men: Relationships with abdominal obesity and endocrine, metabolic and hemodynamic abnormalities. *Journal of Clinical Endocrinology & Metabolism*, *83*(6), 1853–1859. https://doi.org/10.1210/jc.83.6.1853

Rosmond, R., Holm, G., & Bjorntorp, P. (2000). Food-induced cortisol secretion in relation to anthropometric, metabolic and haemodynamic variables in men. *International Journal of Obesity*, *24*(4), 416–422. https://doi.org/10.1038/sj.ijo.0801173

Sanfey, A. G., & Chang, L. J. (2008). Multiple systems in decision making. *Annals of the New York Academy of Sciences*, *1128*, 53–62. https://doi.org/10.1196/annals.1399.007

Sanfey, A. G., Rilling, J. K., Aronson, J. a., Nystrom, L. E., & Cohen, J. D. (2003). The neural basis of economic decision-making in the Ultimatum Game. *Science*, *300*(5626), 1755–1758. https://doi.org/10.1126/science.1082976

Singer, N., Sommer, M., Döhnel, K., Zänkert, S., Wüst, S., & Kudielka, B. M. (2017). Acute psychosocial stress and everyday moral decision-making in young healthy men: The impact of cortisol. *Hormones and Behavior*, *93*, 72–81. https://doi.org/10.1016/j.yhbeh.2017.05.002

Sollberger, S., Bernauer, T., & Ehlert, U. (2016). Stress influences environmental donation behavior in men. *Psychoneuroendocrinology*, *63*, 311–319. https://doi.org/10.1016/j.psyneuen.2015.10.017

Spielberger, C. D., Gonzalezreigosa, F., Martinezurrutia, A., Natalicio, L. F. S., & Natalicio, D. S. (1971). The state-trait anxiety inventory. *Interamerican Journal of Psychology*, *5*(3&4), 620. https://doi.org/10.30849/rip/ijp.v5i3%20&%204.620

Stallen, M., Rossi, F., Heijne, A., Smidts, A., De Dreu, C. K. W., & Sanfey, A. G. (2018). Neurobiological mechanisms of responding to injustice. *The Journal of Neuroscience*, *38*(12), 2844–2954. https://doi.org/10.1523/JNEUROSCI.1242-17.2018

Starcke, K., Polzer, C., Wolf, O. T., & Brand, M. (2011). Does stress alter everyday moral decision-making? *Psychoneuroendocrinology*, *36*(2), 210–219. https://doi.org/10.1016/j.psyneuen.2010.07.010

Steinbeis, N., Engert, V., Linz, R., & Singer, T. (2015). The effects of stress and affiliation on social decision-making: Investigating the tend-and-befriend pattern. *Psychoneuroendocrinology*, *62*, 138–148. https://doi.org/10.1016/j.psyneuen.2015.08.003

Strobel, A., Zimmermann, J., Schmitz, A., Reuter, M., Lis, S., Windmann, S., & Kirsch, P. (2011). Beyond revenge: Neural and genetic bases of altruistic punishment. *NeuroImage*, *54*(1), 671–680. https://doi.org/10.1016/j.neuroimage.2010.07.051

Sylwester, K., & Roberts, G. (2013). Reputation-based partner choice is an effective alternative to indirect reciprocity in solving social dilemmas. *Evolution and Human Behavior*, *34*(3), 201–206. https://doi.org/10.1016/j.evolhumbehav.2012.11.009

Takahashi, T., Ikeda, K., & Hasegawa, T. (2007). Social evaluation-induced amylase elevation and economic decision-making in the dictator game in humans. *Neuro Endocrinology Letters*, *28*(5), 662–665.

Takahashi, T., Ikeda, K., Ishikawa, M., Kitamura, N., Tsukasaki, T., Nakama, D., & Kameda, T. (2005). Interpersonal trust and social stress-induced cortisol elevation. *Neuroreport*, *16*(2), 197–199. https://doi.org/10.1097/00001756-200502080-00027

Taylor, S. E. (2006). Tend and befriend: Biobehavioral bases of affiliation under stress. *Current Directions in Psychological Science*, *15*(6), 273–277. https://doi.org/10.1111/j.1467-8721.2006.00451.x

Taylor, S. E., Klein, L. C., Lewis, B. P., Gruenewald, T. L., Gurung, R. A., & Updegraff, J. A. (2000). Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight. *Psychological Review*, *107*(3), 411–429. https://doi.org/10.1037/0033-295x.107.3.411

Tomova, L., Majdandžić, J., Hummer, A., Windischberger, C., Heinrichs, M., & Lamm, C. (2016). Increased neural responses to empathy for pain might explain how acute stress increases prosociality. *Social Cognitive and Affective Neuroscience*, *12*(3), 401–408.

Turton, S., & Campbell, C. (2007). Tend and befriend versus fight or flight: Gender differences in behavioral response to stress among university students. *Journal of Applied Biobehavioral Research*, *10*(4), 209–232. https://doi.org/10.1111/j.1751-9861.2005.tb00013.x

Vinkers, C. H., Zorn, J. V., Cornelisse, S., Koot, S., Houtepen, L. C., Olivier, B., Verster, J. C., Kahn, R. S., Boks, M. P. M., Kalenscher, T., & Joëls, M. (2013). Time-dependent changes in altruistic punishment following stress. *Psychoneuroendocrinology*, *38*(9), 1467–1475. https://doi.org/10.1016/j.psyneuen.2012.12.012

von Dawans, B., Fischbacher, U., Kirschbaum, C., Fehr, E., & Heinrichs, M. (2012). The social dimension of stress reactivity: Acute stress increases prosocial behavior in humans. *Psychological Science*, *23*(6), 651–660. https://doi.org/10.1177/0956797611431576

von Dawans, B., Ditzen, B., Trueg, A., Fischbacher, U., & Heinrichs, M. (2019). Effects of acute stress on social behavior in women. *Psychoneuroendocrinology*, *99*, 137–144. https://doi.org/10.1016/j.psyneuen.2018.08.031

Watson, D., Clark, L. a., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. https://doi.org/10.1037//0022-3514.54.6.1063

Wolf, O. T., Schulte, J. M., Drimalla, H., Hamacher-Dang, T. C., Knoch, D., & Dziobek, I. (2015). Enhanced emotional empathy after psychosocial stress in young healthy men. *Stress*, *18*(6), 631–637. https://doi.org/10.3109/10253890.2015.1078787

Xu, H., Bègue, L., & Bushman, B. J. (2014). Washing the guilt away: Effects of personal versus vicarious cleansing on guilty feelings and prosocial behavior. *Frontiers in Human Neuroscience*, *8*(1), 97–95. https://doi.org/10.3389/fnhum.2014.00097

Youssef, F. F., Bachew, R., Bissessar, S., Crockett, M. J., & Faber, N. S. (2018). Sex differences in the effects of acute stress on behavior in the ultimatum game. *Psychoneuroendocrinology*, *96*, 126–131. https://doi.org/10.1016/j.psyneuen.2018.06.012

Yu, R. (2016). Stress potentiates decision biases: A stress induced deliberation-to-intuition (SIDI) model. *Neurobiology of Stress*, *3*, 83–95. https://doi.org/10.1016/j.ynstr.2015.12.006

Zhong, C. B., & Liljenquist, K. (2006). Washing away your sins: Threatened morality and physical cleansing. *Science*, *313*(5792), 1451–1452. https://doi.org/10.1126/science.1130726

Zhong, C. B., Strejcek, B., & Sivanathan, N. (2010). A clean self can render harsh moral judgment. *Journal of Experimental Social Psychology*, *46*(5), 859–862. https://doi.org/10.1016/j.jesp.2010.04.003

Appendix

A.1. The Robbery Scenario

One day on the way home, you're going to make a very urgent call, and a tremendous economic loss will be inevitable if you don't call immediately. All of a sudden, a scene emerges:

One person (P) grabbed another person's (Q) money, and P hurt Q who was wounded on the ground, P shouted and then run away.

You were the only witness and you saw P's appearance. You can:

① Call 110 (the police) and tell the police the robber P's appearance and direction;

② Call 120 (the first aid center) to help the injured Q; or

③ Make your emergency call to avoid the tremendous economic loss.

Please arrange these calling options in order of priority:_____

A.2. The Traffic Accident Scenario

One day on the way home, you're going to make a very urgent call, and a tremendous economic loss will be inevitable if you don't call immediately. All of a sudden, a scene emerges:

One driver (P) knocked down a pedestrian (Q) for driving offenses, P shouted and then drove away.

You were the only witness and saw the license plate number of P's car. You can:

① Call 110 (the police) and tell the police the driver P's license plate number;
② Call 120 (the first aid center) to help the injured Q; or
③ Make your emergency call to avoid the tremendous economic loss.

Please arrange these calling options in order of priority:_____