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Acute stress counteracts framing-induced generosity boosts in social discounting in young healthy men

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ABSTRACT

Most individuals are willing to forego resources for the benefit of others, but their willingness to do so typically declines as a function of social distance between the donor and recipient, a phenomenon termed social discounting. We recently showed that participants were more altruistic towards strangers when a costly generous choice was framed as preventing a monetary loss to the other rather than granting them a gain. Here, we asked if acute stress would diminish this frame effect on social discounting. To test this hypothesis, 102 male participants engaged in either the Maastricht Acute Stress Task, or a matched, non-stressful control procedure. They subsequently played a two-frame dictator game version of the social discounting paradigm. Whereas both frame conditions were economically equivalent, in the give frame, participants were asked how much money they would share with other persons on variable social distance levels, and in the take frame, they decided on how much money to take away from the others. While non-stressed control participants showed increased generosity toward strangers in the take compared to the give frame, similar to previous findings of our group, stress attenuated this frame effect on social discounting by reducing generosity toward strangers in the take frame. These findings confirm that stress can corrupt prosocial motives and social norm compliance, diminishing prosocial tendencies toward unfamiliar others.

1. Introduction

Most individuals are willing to forego resources for the benefit of others. However, their willingness to do so typically declines as a function of social distance between donor and recipient, i.e., how much the donor cares about the recipient, a phenomenon termed social discounting (Jones and Rachlin, 2006; Strombach et al., 2015). Social discounting is relatively robust within individuals (Archambault et al., 2019; Kalenscher, 2017; Vekaria et al., 2017), yet it is also malleable. For example, we and others have shown that generosity toward socially close others, e.g., friends and family, can be increased by psychosocial stress (Margittai et al., 2015) or psychopharmacological manipulation (Margittai et al., 2018), and generosity towards strangers can be decreased by transcranial magnetic stimulation (Soutschek et al., 2016; cf. also Gallo et al., 2018). In addition, we recently demonstrated that the way the decision problem was described influenced social discounting (Sellitto et al., 2019): we found that participants were much more altruistic towards others, especially strangers, when the resource allocation problem in the social discounting task was framed as a decision to obtain a personal financial benefit at the other's expense (*take frame*[1]) versus to financially benefit the other at an own personal expense (*give frame*), even when actual economic outcomes were equivalent across frames. For example, people alloted more money to a stranger when being asked how much of a monetary endowment they would take away from that person (*take frame*) compared to when being asked how much of their own endowment they would share (*give frame*). Such framing-induced boosts in generosity towards others is likely to reflect the observation that people are more sensitive to others' losses than gains (De Dreu and McCusker, 1997; Evans and van Beest, 2017; Ishii and Eisen, 2018; Ispano and Schwardmann, 2017; Takahashi, 2013), and they are consequently reluctant to increase their own payoff at the expense of others' welfare (Bardsley, 2008; Baumeister et al., 1994; Chang et al., 2011; Chang and Sanfey, 2013; Crockett et al., 2014). We recently argued (Sellitto et al., 2019; cf. also Decety & Cowell, 2018)

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[1] Note that the terminology used here differs from the one used in Sellitto et al. (2019): the 'give' frame was termed 'gain' frame in Sellitto et al. (2019), and the 'take' frame was termed 'loss' frame. We chose to use a different terminology from Sellitto et al. (2019) to highlight the differences in task details between the two studies, and to better reflect the nature of the frame manipulation used here.

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that this differential sensitivity to others' gains and losses, and its impact on social discounting is likely to be the result of compliance to the social norm to avoid causing harm to others, which is an important prerequisite for sustainable social relationships.

Generosity, prosocial behavior and social discounting are strongly influenced by acute stress (Margittai et al., 2015, 2018). For example, recent evidence suggests that individuals may react to stress with a "tend-and-befriend"-response (Berger et al., 2016; Margittai et al., 2015, 2018, 2015; Sollberger et al., 2016; Taylor, 2006; Taylor et al., 2000; Von Dawans et al., 2019, 2011) – an increase in costly generosity towards others to mobilize social support in stressful times. Because of their desire to protect, and thus avoid damaging, their social relationships, tend-and-befriend implies that stressed individuals would be even less inclined to cause harm to others. Consequently, stress should amplify the above-mentioned frame effect on social discounting by shifting decisions in the *take* frame away from financially hurting others towards being even more generous toward them.

However, often, the social response to stress is *not* tend-and-befriend, but fight-or-flight (Cannon, 1932; Dedovic et al., 2009; McCarty, 2016; Rodrigues et al., 2009). Fight-or-flight responses involve antagonistic social behaviors aimed at promoting own survival and well-being, potentially at the opponent's expense. This social response to stress has been described almost a century ago (Cannon, 1932), and its discovery has had great impact on the animal and human literature (Haller, 2018; Haller et al., 1998; Jansen et al., 1995; Kruk et al., 2004; McCarty, 2016; Sandi and Haller, 2015; Sgoifo et al., 1996; Sgoifo and Papi, 1995; Terbeck et al., 2016, 2012; White et al., 2019). In humans, antagonistic fight-or-flight-like responses might manifest as higher egocentricity and reduced other-regarding behavior. For example, a recent study found that stress can induce spiteful punishment, weakened trust and reduced reciprocity (Steinbeis et al., 2015). Also, another recent study showed that, under stress, the neural representations of self- and other-regarding values diverged more than in a non-stress condition (Tomova et al., 2020). Furthermore, stress was found to diminish the willingness to share resources (Starcke et al., 2011; Steinbeis et al., 2015; Vinkers et al., 2013) and the stress hormone cortisol has been associated with an increased tendency towards egoistic decision making in everyday moral dilemmas (Starcke et al., 2011). Combined, this suite of evidence tentatively suggests that stress can lead to less other-regarding thinking combined with an erosion of moral and social norms (but see Singer et al., 2017; Nickels et al., 2017). Because, as mentioned above, the frame effect on social discounting likely depends on other-regarding considerations and social norm compliance (Sellitto et al., 2019), stressed individuals reacting in a fight-or-flight-like manner should fail to show frame-dependent differences in generosity toward others. Thus, rather than amplifying it, acute stress would be expected to dampen the frame effect.

Taken together, the frame-amplification hypothesis, inspired by the tend-and-befriend theory, predicts a stress-related amplification of the frame effect on social discounting, i.e., stressed individuals should be even more generous toward others when a resource allocation problem was framed as taking away money from others (*take frame*) versus sharing money with them (*give frame*). By contrast, the frame-attenuation hypothesis, inspired by the fight-or-flight model, states that stressed individuals will show a diminished frame effect on social discounting.

In order to decide between these hypotheses, we pseudo-randomly assigned 102 male participants either to a stress procedure (Smeets et al., 2012) or a non-stress control condition and asked them to complete a social discounting task with randomly interleaved *give* and *take* frame decisions. In each trial, participants decided on the allocation of funds between themselves and another person at a variable social distance level. The *give* frame consisted of a variant of the dictator game (Bolton et al., 1998) where participants were endowed with an amount of money, and decided how much of this endowment they would share with the other person. In the *take* frame, participants were informed that the other person was endowed with an amount of money, and the participant decided how much money to take away from that person. Participants were repeatedly and explicitly instructed that the other persons would only be informed about the outcome of the share, but not about their initial endowment, or the loss of it; all that mattered for the other person was the final payoff. Both frames were economically equivalent in terms of financial outcomes.

In support of the frame-attenuation hypothesis, we found that acute stress diminished the frame effects on social discounting: while non-stressed control participants became more generous towards strangers in the take compared to the give frame, this frame-dependent change in generosity was less pronounced in stressed participants.

2. Methods

2.1. Participants

102 male participants (age M = 22.95, SD = 3.92, range = 18 - 36) were recruited within the University of Düsseldorf. One participant withdrew from participation due to pain during the stress induction. Participants were screened via telephone interview before participation. We considered participants eligible if they were male, between 18 and 40 years old, German speakers, no heavy smokers ($<$ 5 cigarettes/day), no heavy drinkers ($<$ 3 portions/day), and no regular drug users. We excluded individuals diagnosed with current psychiatric, neurological, endocrinal, cardiovascular or urological conditions, users of medication strongly affecting the central nervous system, or cardiovascular or endocrine system. Because recent findings suggest that lesbian, gay or bisexual individuals have an altered physiological CORT response to stress (Hatzenbuehler & McLaughlin, 2014) and an altered diurnal CORT profile (most likely due to minority stress, see Parra et al., 2016), only heterosexual men were included. Also, body weight interacts with CORT baselines and CORT responsiveness to stressors (Herhaus & Petrowski, 2018). Therefore, we only considered participants with a BMI below 30. Furthermore, psychology and economics majors were excluded due to potential prior knowledge about the effects of stress on cognition and economic decision making. The experiment was carried out between 14:00 and 18:00, during the circadian trough of cortisol to minimize the potential moderating role of circadian hormonal fluctuations on stress responsiveness. We asked subjects to abstain from consumption of cigarettes and caffeine for four hours before starting the experiment, food for two hours, and sex, alcohol and medication for 24 hours. We used an exclusively male sample in order to avoid differential HPA-axis activation caused by the intake of oral contraceptives and variations in menstrual cycle (Kirschbaum et al., 1999; Kudielka and Kirschbaum, 2005). All participants gave informed consent, the experiment was approved by the local ethics committee of the Heinrich-Heine-University, and it complied with the regulations of the Declaration of Helsinki.

2.2. Materials

2.2.1. Online Questionnaires

After being pseudo-randomly assigned to either the stress or the control group, but prior to being invited to the laboratory, all participants completed a number of trait questionnaires online, designed to control for potential confounding factors that might interfere with stress reactivity and/or our main outcome measures. We measured impulsivity (Barratt Impulsiveness Scale, BIS-15, Meule et al., 2011), behavioral inhibition and activation (Behavioral Inhibition / Activation Scale, BIS/BAS, Carver and White, 1994), chronotype (reduced version of the Morningness-Eveningness Questionnaire, rMEQ, Randler, 2013), chronic stress (Trier Inventory of Chronic Stress, TICS, Schulz and Schlotz, 1999), social desirability (Social Desirability Scale, SDS-17, Stöber, 2001), trait anxiety (Trait Scale of the State-Trait Anxiety Inventory, STAI, Spielberger, 1983), personality (10-item Big-5 Inventory, BFI-10, Rammstedt, 2007), psychopathy (Levenson Self-Report Psychopathy Scale, LSRP, Levenson et al., 1995), empathy (Saarbruecker Persoenlichkeitsfragebogen, SPF, Paulus, 2009), risk taking and social value orientation (number of socially-oriented decisions in the Triple Dominance Measure, SVO).

2.2.2. Stress Induction: The Maastricht Stress Test

To induce psychosocial stress, we used the Maastricht Acute Stress Test (MAST; Smeets et al., 2012, for instructions see supplemental online material), a hybrid task that combines elements of social-evaluation, physiological stress and uncontrollability. In the stress condition, participants were instructed to alternate between immersing their hand in a 0-2 °C ice water and performing a mental arithmetic task for a purportedly undefined period of time while being socially evaluated and videotaped. The experimenters wore lab coats and behaved in a rigid and non-responsive manner. The actual stress-induction always took 10 minutes, and was preceded by 5 minutes of preparation time. As in the original protocol by Smeets and colleagues (2012), overall hand immersion time summed to 6 minutes.

In the control condition, participants immersed their hand into 36 °C warm water for a total of 6 minutes, no camera recordings were made, and they were asked to count loudly and repeatedly from 1 to 25 upwards. The experimenters behaved friendly and wore no lab coats. Interval durations were equal to the stress condition.

2.2.3. Physiological and subjective stress measures

The neuroendocrine response to stress is complex, non-linear and time-dependent. In brief, organisms respond to acute stress with a rapid release of catecholamines, primarily noradrenaline through the sympathetic nervous system and a slower release of glucocorticoids (mainly cortisol in humans) as the end product of the hypothalamic–pituitary–adrenal (HPA) axis (Joels & Baram, 2009). During and shortly after stress, the physiological effects of cortisol and noradrenaline on social cognition and behavior are characterized by overlapping, combined action of non-genomic cortisol and catecholamines, followed by non-genomic cortisol action alone minutes afterwards, and finally by genomic cortisol effects that develop several hours later (Joels et al., 2011; Hermans et al., 2014).

The MAST has been shown to reliably induce physiological and psychosocial stress in participants, and stimulate the HPA axis as well as the sympathetic nervous system (Smeets et al., 2012). To quantify the intensity of stress-induction in our participants, we collected saliva samples and heart rate measures over the course of the experiment (see Fig. 1).

Saliva samples (Salivette, Sarstedt, Nürnbrecht, Germany) were analyzed for the physiological stress-markers cortisol (CORT) and salivary α-amylase (sAA), an indirect marker of sympathetic activity (Nater and Rohleder, 2009). Participants were asked to place the cotton swab into their mouth for one minute until it soaked with saliva. We collected two baseline samples before the MAST and three samples after the MAST (for timing see Fig. 1). Samples were stored at −26 °C until dispatch, and analyzed with a commercial competitive enzyme immunoassay (cortisol, IBL, Hamburg) or an enzyme liquid-phase assay (sAA). Analyses were performed by LabService Dresden GmbH.

Heart rate (HR) is regarded as a reliable and temporally well-resolved marker of sympathetic activity. We used commercial wristband photoplethysmographs (Polar A370) to make two 3-minute baseline HR recordings before MAST onset, as well as a continuous HR recording during the entire duration of the MAST.

Common stress-induction procedures, such as the MAST, come along with an increase in subjective arousal, tension, and feelings of insecurity. To capture how the MAST (vs. the control procedure) produced such feelings through the experiment, we administered the Positive and Negative Affect Scale (PANAS, Watson & Tellegen, 1989) twice before and twice after the stress-induction procedure. Participants additionally indicated feelings of stress, self-confidence, insecurity and shame on visual analogue scales (VAS, see e.g. Hellhammer and Schubert, 2012) every time the PANAS was delivered.

2.2.4. Social Discounting Task

To elicit social distance representations, we asked participants to imagine 100 people of their social environment on a hypothetical social distance scale, where 1 represents a person they feel closest to and 100 represents a random stranger whom they have never met (Jones and Rachlin, 2006; Margittai et al., 2018, 2015; Strombach et al., 2015). Participants were then asked to write down the names of people who represent social distance levels 1, 2, 3, 5, 10, 20. For social distances 50 and 100, participants were asked to imagine somewhat familiar, or completely unknown strangers, respectively. Also, participants were instructed to not select people they resent.

To assess how the framing of the decision problem moderated social discounting, we used an adapted variant of the dictator game (Archambault et al., 2019; Margittai et al., 2018, 2015) with a give and a take frame condition (Sellitto et al., 2019, see Fig. 2; Bardsley, 2008). In both conditions (see Fig. 2), participants decided how to allocate a monetary endowment between themselves and another person. In each trial in the *give* frame condition, participants received an endowment of either 13EUR, 15EUR or 17EUR, and decided how much to give to one individual they had assigned to a given social distance level. This was repeated for all three endowment levels and all eight social distance levels (1, 2, 3, 5, 10, 20, 50 or 100) in a repeated measures design. In each trial in the *take* frame condition, participants were informed that another individual on social distance level 1, 2, 3, 5, 10, 20, 50 or 100 had received an endowment of 13EUR, 15EUR or 17EUR, and they

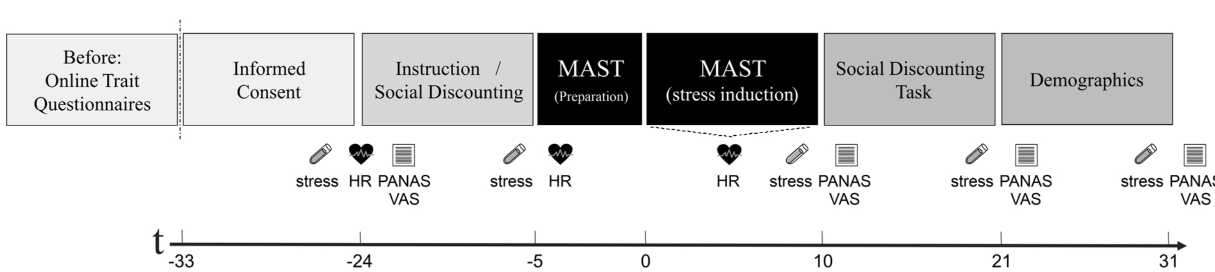

Fig. 1. *Timeline of the experimental procedure.* The x-axis depicts the time of events in minutes, relative to MAST onset. After an initial screening via phone interview, participants completed the online survey. Upon arrival in the laboratory, participants gave informed consent and were introduced to the HR-monitor and the handling of the saliva samples. We then collected the 1st saliva sample and recorded baseline heart rate for three minutes. The instructions for the social discounting task were presented, after which the participants' understanding of the task was tested using a short list of items related to the task's payoff structure. After collecting the 2nd saliva sample and recording another baseline HR signal, a standardized five-minute introduction to the MAST followed. During the MAST, HR was recorded continuously for 10 minutes. Upon completion of the MAST, a 3rd saliva sample was collected, directly segueing into the social discounting task. This was followed by completion of a demographic questionnaire, interspersed with the 4th and 5th saliva sample. All sessions took place between 14:00 and 18:00. The experiment ended with a debriefing. Subjects were paid based on one randomly chosen trial.

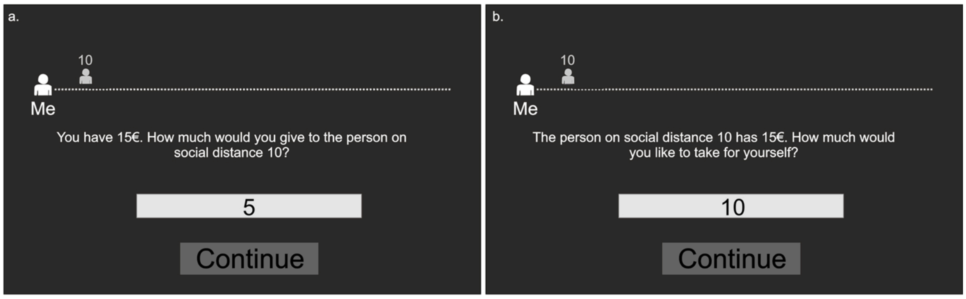

Fig. 2. *Two exemplary trials in the give and the take frame.* Panel a. shows a trial in the give frame. The participant was endowed with 15€ and chose how much to share with another person on the indicated social distance scale. In this example, the participant decided to share 5€ (33.3%) with the person assigned to social distance 10. Panel b. shows a trial in the take frame. The other person on social distance 10 had an endowment of 15€. The participant chose to take 10€ (66.6%) for herself. Give and take frames were identical with respect to final payoff distributions. Participants were explicitly instructed that the other persons would only be informed about the outcome of the share, but not about their initial endowment, or the loss of it.

decided how much money to take away from the other for themselves. To prevent semantically induced choice biases, we explained the payoff contingencies in neutral terms, and strictly avoided negatively connoted terms like "remove", "withdraw" or "take away" in the instructions and the task itself. Importantly, participants were explicitly informed that the other person was unaware of their initial endowment, and would, hence, not learn about the potential loss of it. Participants were also specifically advised that the other persons had no prior knowledge about the experiment and thus no outcome expectations; all that mattered was the final payoff allocation. All in all, each participant performed 48 trials (8 social distance levels x give/take frame x 3 endowments), presented in a pseudorandom, interleaved order. We used no deception and the task was incentive-compatible: after the experiment, one trial was randomly selected and paid out to the participant (which was added to their show-up fee) and the respective recipient (see Margittai et al. 2015). For social distance levels 50 and 100, which represented unknown to the participant, we gave the respective amount to a random stranger on the university campus.

2.3. Procedure

The procedure is outlined in Fig. 1. Upon arrival, participants signed the informed consent form. The first of two 3-minute baseline HR-recordings was made, followed by the collection of the first saliva sample and PANAS. Hereafter, participants received task instructions via laptop computer and they provided names of individuals in their social environment representing the different social distances. Using a number of comprehension items, we made sure that participants understood the task. Then, we obtained a second HR baseline recording, and took a PANAS mood questionnaire along with another saliva sample. The participant was directed into a different room to perform the MAST followed by the third saliva sample and PANAS. Participants then performed the social discounting framing task, which took no longer than 10 minutes. The fourth saliva sample was collected after task completion. Afterwards, as a manipulation check, participants were asked again about the individuals they had allocated to the different social distance levels to confirm they still remembered, and they finally completed a demographic questionnaire. Then, they were debriefed and received a fixed amount of 15EUR for participation plus the payoff of one randomly chosen trial in the social discounting framing paradigm. The money endowed by the participant to an individual in their social environment was delivered by regular mail, or given to a random person on campus for social distance levels 50 and 100, as described above.

2.4. Design and Statistics

The group or individual social discount functions are often approximated by a hyperbolic model (Jones & Rachlin, 2006; Margittai et al., 2015, 2018; Strombach et al., 2014, 2015; Strang et al., 2017; Vekaria et al., 2017). However, hyperbolic fitting procedures require variance in choices, otherwise any fitting procedure will not converge, or it will yield non-interpretable parameter estimates. This was the case in our results for a large number of choices, where in the take frame, participants often decided not to deduct money from the other person, leading to the exclusion of a large and condition-asymmetric number of participants. To circumvent this problem, we adopted a different analysis approach, resembling the one used by Archambault and colleagues (2019): we linearized the social discount function by rank-transforming social distance levels, i.e., the social distance levels 1, 2, 3, 5, 10, 20, 50 and 100 were replaced by social distance ranks 1 through 8, allowing analysis with a mixed linear model. In order to capture the effects of stress and framing on the discount rates, we regressed the factors *frame* (give vs. take frame), *stress* (stress vs. control), and the *ranked social distance level* (1-8) on trial-by-trial amounts shared with the other individual (i.e., the monetary amount given to the other in the give frame, or the amount left to the other in the loss frame). We allowed intercepts to vary for each *endowment level* (13, 15 and 17 EUR), and for each participant. We furthermore maximized the random effects structure as suggested by Barr, Levy, Scheepers and Tily (2013) and Matuschek, Kliegl, Vasishth, Baayen and Bates (2017), but only adding *frame* as a random coefficient yielded a non-degenerate, non-singular, properly convergent model. We then used backward model selection (using the *step* function from the R package lmerTest by Kuznetsova et al., 2017) to assess if any of the fixed effects, particularly the interaction terms, was redundant, but none of them was eliminated (see supplementary online materials for stepwise model comparisons). We also tested if the same results can be obtained when the ranked social distances were modelled as a categorical predictor (which we confirmed, see supplemental online materials). We predominantly used the R(3.6.1)-Packages *afex* (Singmann, in press) and *emmeans* (Lenth, 2018) for analysis, and we always tested type 3 sum of squares.

To test whether our stress induction was successful, we assessed changes in CORT, sAA, the participants' HR, as well as participants' positive and negative affect and subjective stress ratings (measured with PANAS and VAS) over the time course of the experiment. HR recordings were mean-aggregated by participant and recording, resulting in three values per participant. Before analysis, we inspected the distribution of CORT, sAA and HR and assessed normality using qq-plots (see supplemental online materials). Subsequently, we performed (natural-) log-transformations upon CORT, sAA and HR. We used mixed ANOVAs with the within-subject factor *sample* (for saliva) or *time point of measurement* (for HR or PANAS, see Fig. 1 for exact time points) and *group* (stress vs. non-stress group). Significant changes due to stress should primarily occur directly after the MAST, which we tested using simple effects analyses (see supplemental online materials). For the sake of brevity and readability, we only report relevant effects in this article (in these cases, only the interaction terms; we refer to the supplemental online material for all results).

3. Results

3.1. Trait measures

To exclude the possibility that stressed and control participants differed in trait and baseline characteristics that could confound our results, we compared their trait measures using Welch's t-Tests or Mann-Whitney-U-tests, whichever applied. Results can be found in Table 1. Applying a Bonferroni-corrected alpha-level of $\alpha = 0.005$ ($\alpha = 0.05$ divided by 10 comparisons), we find no differences between stress and control group. Note that social desirability scores (SDS) differed significantly between stress and control participants when uncorrected. We therefore repeated our main analyses with the SDS score as covariate. Our results remained robust against inclusion of SDS score, suggesting that our stress effects on framing and social discounting cannot be explained by differences in social desirability (see supplemental materials).

3.2. Physiological and subjective stress measures

3.2.1. Saliva Samples: CORT and sAA

As a manipulation check, we examined group differences on log-transformed values of salivary CORT and sAA concentrations (see Fig. 3). Out of 505 samples in total, we lost 28 CORT samples and 54 sAA-samples, mostly due to insufficient saliva.

A 5 (timepoint) x 2 (stress vs control) mixed ANOVA revealed that the MAST provoked an increase in salivary log(CORT) in the stress group compared to the control group (time point x condition interaction $F(2.03, 171.27) = 29.41$, $p < .001$, $\eta^2 = .099$ see Fig. 1). Simple effect analyses illustrate that log(CORT) was already increased directly after MAST onset in the stress group (stress vs. control group in saliva sample 3 $t(169) = -4.640$, $p < .001$ Cohen's $d = -.987$, see supplemental online material for full summary).

By contrast, we found no significant increase in log(sAA) levels between the stress and control groups: None of the stress-related factors in a 5 (timepoint) x 2 (stress vs control) mixed ANOVA, and in particular no interaction term, reached significance (time point x condition interaction $F(2.27, 173.17) = .23$, $p = .833$, $\eta^2 < .001$). Note that the lack of an effect of stress on sAA might have resulted from low statistical power due to the high number of lost sAA samples (54 samples; see above). If the analysis is run in a mixed linear model, which is – at least to some extent - capable of handling missing data, the stress group showed significantly higher sAA concentration at timepoint 5 $t(194) = -2.128$, $p = .035$, see supplemental online material for the full analysis). Thus, although caution is required, there is some indication that stress increased sAA in our task.

3.2.2. Heart Rate

A further indicator of sympathetic activation is the heart rate (HR) response (see Fig. 3). A 2 (stress vs control) x 3 (timepoint) mixed ANOVA with individual log-transformed mean HRs for the two baseline recordings and the mean of the log(HR) recording during the MAST shows a stress-related increase in heartbeats per minute for the stress group, but not the control group (recording time point x condition, $F(1.84, 189.5) = 8.61$, $p < .001$, $\eta^2 = .010$ see supplemental online materials for simple effects).

3.2.3. Subjective Stress Measures

Participants in the stress condition indicated stronger feelings of arousal, insecurity, shame and stress after the stress induction. Ratings in both the negative and the positive scale of the PANAS were increased after stress-induction (Positive: time x condition interaction; $F(2.09, 207.33) = 8.49$, $p < .001$, $\eta^2 = .035$; Negative: time x condition interaction $F(2.1, 207.7) = 9.06$, $p < .001$, $\eta^2 = .029$), with the former being most likely mediated by subjective arousal. Moreover, visual analogue scales revealed more feelings of insecurity (interaction time point x condition $F(2.88, 273.83) = 9.75$, $p < .001$, $\eta^2 = .03$), stress (interaction time point x condition $F(2.53, 240.51) = 19.56$, $p < .001$, $\eta^2 = .051$), shame (interaction time point x condition $F(2.19, 208.14) = 1.68$, $p = .187$, $\eta^2 = .008$; condition $F(1, 95) = 5.45$, $p = .022$,

Table 1
Baseline trait measures, age and BMI. To detect differences between stress and control participants, either Welch's t-Tests (t-statistics) or Mann-Whitney-U-Tests (W-statistics) were employed. Normality was examined using Shapiro-Wilk- Tests. Effect sizes are displayed on the right, either applying Cohen's d for t-tests or Cliff's Delta for Mann-Whitney-U tests.

	Stress (n = 50)		Control (n = 51)				
	M	SD	M	SD	Statistic	p-Value	Effect-Size
Impulsivity (BAR)	32.27	5.59	31.86	5.5	W = 1185.5	0.545	δ = -0.104
Behavioral activation (BAS)	40.06	4.32	41.38	4.96	t = 1.425	0.157	d = 0.235
Behavioral inhibition (BIS)	19.47	3.34	18.52	3.3	t = -1.438	0.154	d = -0.25
Social desirability (SDS)	22.41	2.62	21.08	2.51	W = 901.5	0.011	δ = 0.126
Chronic stress (TICS)	142.57	24.09	142.76	32.53	t = 0.034	0.973	d = -0.054
Psychopathy (LSRP)	53.88	10.5	50.68	8.67	t = -1.673	0.1	d = -0.383
Risk taking	2.06	1.1	1.92	1.03	W = 1188	0.534	δ = -0.092
Empathy (SPF-IRI)	40.75	5.71	41.04	5.01	t = 0.277	0.783	d = 0.034
Anxiety (STAI)	53.59	7.39	50.7	8.75	t = -1.791	0.077	d = -0.383
Chronotype (rMEQ)	12.2	4.41	12.02	3.71	W = 1297	0.884	δ = 0.048
Age	22.76	4.09	23.14	3.76	W = 1384	0.355	δ = 0.107
BMI	23.1	2.94	23.59	2.58	t = 0.961	0.339	d = 0.193

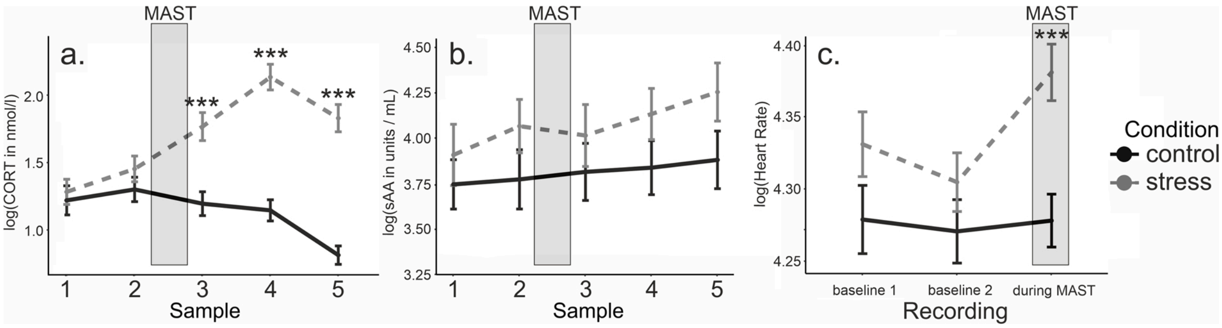

Fig. 3. *Physiological stress markers.* a. Log-transformed salivary CORT concentrations. The MAST procedure (administered as indicated by the grey bar) elicited a CORT-response in the stress, but not the control group. b. There was no significant difference in log-transformed sAA levels between stress- and control-group participants. Note that a significant difference emerged in sample 5 when analyzed using a mixed linear model (see text for details) c. Log-transformed heart rate was significantly higher in the stressed compared to control participants. No differences between the stress and control group were found at baseline-recording 1 and 2 (separate t-test: recording 1 t(97.731) = -1,600 at p = .113, Cohen's d = -.302; recording 2 t(98.723) = -1.085 at p = .280, Cohen's d = -0.216; simple effects: recording 1 t(124) = -1.744, p = .084; recording 2 t(124) = -1.261, p = .21). All error bars indicate ± 1 SEM.

$\eta^2 = .032$, yet, simple effects point to significant differences at timepoint 3) and less feelings of self-confidence (interaction time point x condition $F(2.38, 226.56) = 6.08$, $p = .001$, $\eta^2 = .013$; see appendix for simple effects) as a result of our stress induction.

In summary, despite the somewhat unclear effects of stress on sAA, all other physiological and psychological measures, including heart rate as a further marker of SAM activity, indicate success of our stress induction.

3.3. Stress diminishes the frame-effect on social discounting

Figs. 4A and 4B show the linearized social discount functions for the stress and control participants in both frames. In line with other studies on social discounting (Jones & Rachlin, 2006; Margittai et al., 2015, 2018; Strombach et al., 2015), the amount shared with others decreased monotonically across social distance in all treatment and frame conditions. In addition, participants overall shared more money in the take than the give frame, suggesting that the frame manipulation worked. More importantly, visual inspection of these figures suggests that there was no clear difference in social discounting between stress and control participants in the give frame. By contrast, in the take frame, the social discount function appeared flatter in control than stress participants, suggesting that non-stressed control participants were more generous in the take frame, in particular toward strangers, than their stressed counterparts.

To quantitatively assess how stress and framing modulated generosity in our social discounting task, we constructed a mixed linear model that regressed the main effects of stress (stress vs. control), frame (give vs. take), the ranked social distances and their interactions on the trial-by-trial amount shared with the other person, similar to the procedure done in Archambault et al. (2019). Furthermore, the model considers individual and item-specific variation by including varying intercepts for each subject and endowment level (13€, 15€, 17€) in the random effect structure. To maximize the random effect structure (Barr et al., 2013; Matuschek et al., 2017), we entered *frame* as a random coefficient varying per subject, which yielded better goodness-of-fit than an intercept-only model ($\chi^2(2) = 1811$, $p < .001$, see supplemental online materials for more information). Regression lines and standard errors are plotted in Fig. 4a and b, and treatment-coded regression estimates are displayed in Table 2. Below in this section, F-tests from an ANOVA-analysis will also be reported. The assumption of normality of residuals is met (see supplemental online materials).

Although main effects should be interpreted with caution in presence of higher order interaction terms, Table 2 shows a significant effect of social distance on amount shared as well as a significant interaction between social distance and frame, suggesting that generosity decreased

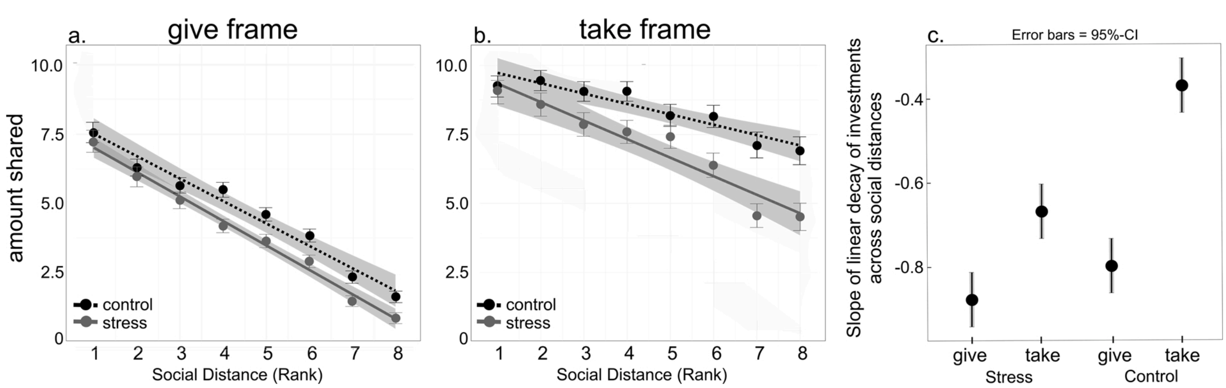

Fig. 4. Results of the Social Discounting Task. The left panel (a.) shows the mean amount shared across ranked social distances in the give frame (±standard error of the mean; SEM), as well as the fitted regression lines. Data are shown for stress and control participants separately. Panel b. shows the mean amount shared (±SEM) and regression lines of stress and control participants in the take frame. While there was no clear difference in social discounting between stressed and non-stressed control participants in the give frame (panel a), control participants showed flatter discounting than stressed participants in the take frame (panel b). This frame-dependent stress effect on generosity was most pronounced at large social distance levels, implying that stressed individuals had a diminished willingness to share with strangers in the take frame. Panel c. displays the slopes of the linearized social discount functions with 95% confidence intervals. There was a distinct difference in the slopes in the control participants, indicating flatter discounting in the take than the give frame, thus reflecting the frame effect on social discounting. This difference in the slope of the social discount function between frames was less pronounced in the stressed participants, confirming that stress diminished the frame effect on social discounting.

Table 2
Regression table for effect of stress, frame and ranked social distance on amounts shared. Effects are treatment-coded.

Regression Table / Main Model			
Predictors	Estimates	CI	p
(Intercept)	10.07	[8.57 : 11.57]	<0.001
Ranked Social Distance	−0.37	[-0.44 : -0.31]	<0.001
Stress	−0.05	[-1.79 : 1.68]	0.953
Frame	−1.77	[-2.95 : -0.58]	0.003
Ranked Social Distance * Stress	−0.3	[-0.39 : -0.21]	<0.001
Ranked Social Distance * Frame	−0.43	[-0.52 : -0.34]	<0.001
Stress * Frame	−0.35	[-2.01 : 1.32]	0.684
3-Way Interaction	0.22	[0.09 : 0.35]	0.001
σ^2	6.9		
$\tau_{00\ subject}$	18.35		
$\tau_{00\ endowment}$	0.57		
$\tau_{11\ subject/frame}$	15.48		
$\rho_{01\ subject}$	−0.82		
ICC	0.65		

All variables were treatment-Coded. References: Stress = Non-Stress, Frame = Take Frame

across social distance (i.e., social discounting) and that generosity decreased differently across social distance between frame conditions (i.e., frame effects on social discounting).

Most importantly, the results summarized in Table 2 show that the stress effect on social discounting was more pronounced in the take than the give frame; the three-way interaction between stress x frame x social distance on amount shared reached significance ($F(1, 4638.02) = 11.22$, $p < .001$), indicating that stress affected social-distance-dependent generosity differently in the take than the give frame. To break down this three-way interaction effect, we compared the regression slopes, capturing the decline in sharing across social distance, between the give and the take frames (see Fig. 4C); this was done separately for the stress and control participants. We found that the difference in regression slopes between the give and the take frames was more pronounced in non-stressed control participants compared to stressed participants (difference in give/take slopes in the control condition = 0.432, SE = 0.047, $t(4642) = 9.212$, $p < .001$; difference in give/take slopes in the stress condition = 0.211, SE = 0.046, $t(4642) = 4.547$, $p < .001$; overall difference of framing-related slope alterations between stress and control condition =. 0.221, SE = 0.066, $t(4642) = 3.348$, $p < .001$). Hence, while control participants showed flatter social discounting in the take than the give condition, indicating the frame manipulation on social discounting worked, this difference in the steepness of social discounting between frame conditions was less evident in stressed participants. In line with these findings, an analogous mixed linear regression model that included social distance as a categorical variable revealed that the stress x frame interaction only occurred at ranked social distances 7 and 8 (see supplemental online materials).

Further simple slope analyses on the three-way interaction revealed that stress affected the social discount rates primarily in the take frame, and much less so in the give frame (difference in stress/control slopes in the give frame = 0.080, SE = 0.047, $t(4642) = 1.706$, $p = .088$; estimated slope difference in the take frame = 0.300, SE = 0.047, $t(4642) = 6.444$, $p < .001$; difference of stress-related slope between take and give frame = .221 SE = .066, $t(4642) = 3.348$, $p < .001$). Taken together, this analysis supports above mentioned observation that, compared to non-stressed participants, stressed participants were selectively less generous towards strangers, but this effect was found only in the take, not in the give frame condition.

4. Discussion

People are generous, but their generosity typically decreases across social distance to the recipient of help (Jones & Rachlin, 2006; Strombach et al., 2015). We recently showed that framing a financial allocation decision as the prevention of another person's loss, rather than granting them a gain, strongly decreased the social discount rate, implying that the mere description of a decision problem can serve as a nudge to render participants much more generous towards strangers (Sellitto et al., 2019). Here, we asked if an acute social-evaluative and physical hybrid stressor amplifies or attenuates the frame effect on social discounting. We devised a task in which participants decided to share an endowment with other individuals at variable social distances (give frame), or decided to take away money from the endowment of the other individuals (take frame). We, first, replicated our previous finding (Sellitto et al., 2019) that participants exhibited flatter discounting in the take than the give frame, suggesting higher generosity toward strangers in the take frame. Importantly, our stress manipulation revealed support for the frame-attenuation hypothesis: we found that acute stress diminished the frame effect on social discounting and caused stressed participants to be equivalently generous towards others in the take and the give frames. Furthermore, in the take, but not the give frame, stressed individuals were less generous toward strangers than non-stressed controls.

Our finding of a stress-related decrease in generosity towards strangers in the take frame blends with other results demonstrating diminished willingness to share resources under stress (Starcke et al., 2011; Steinbeis et al., 2015; Vinkers et al., 2013), and, in a broader sense, they are consistent with the observation of increased egocentric, antagonistic tendencies under stress (Agnew, 2005; Sandi and Haller, 2015; Silver and Teasdale, 2005), as hypothesized by the fight-or-flight theory almost a century ago (Cannon, 1932). But what causes the stress-related diminution of the frame effect on social discounting? We recently argued that the frame effect on social discounting is the result of people's internalized hesitation to transgress the social norm of preventing harm to others, and the associated feelings of guilt and shame if they do (Sellitto et al., 2019); that is, people generally follow the "do-no-harm principle" (Baron, 1995). This means that, even though it might be socially acceptable to not share money with others in the give frame, social norms strongly prohibit taking away money from others in the take frame. Because stress is known to erode social norm compliance (Starcke et al., 2011; Steinbeis et al., 2015; Vinkers et al., 2013), social decision making of stressed individuals will likely be less influenced by social norms than that of non-stressed people, and they would consequently be less hesitant to cause financial harm to others where social norms would normally forbid doing so. This explanation can account for the fact that the frame effect on sharing behavior was most pronounced when dealing with unknown strangers: social norms guide social behavior especially towards others at larger social distance levels, but they are less relevant for generous behavior towards friends and family where people are often naturally selfless anyway, independent of social norm prescriptions (Rand et al., 2014; Strombach et al., 2015).

Notably, our finding of reduced prosociality after stress in the take frame stands in contrast with results from other experiments, including studies from us, that have shown the opposite pattern of *increased* prosociality after stress (tend-and-befriend; Berger et al., 2016; Margittai et al., 2018, 2015; Singer et al., 2017; Sollberger et al., 2016; Tomova et al., 2014; Von Dawans et al., 2019, 2012; Youssef et al., 2018). Hence, the question remains why our participants did not respond to stress with increased prosociality. It is currently unclear when and why stressed individuals show a stronger or reduced prosocial stress-response. We have recently argued that stress does not provoke *either* fight-or-flight *or* tend-and-befriend (or decreased vs. increased prosociality by proxy), but it may boost *both* tendencies at the same time (Schweda et al., 2019), as outlined in the following. Tend-and-befriend is an alleged coping strategy where stressed individuals invest into their social network in order to receive help and comfort in return (Taylor, 2006; Taylor et al., 2000). Accordingly, we have argued, and shown, that tend-and-befriend behavior is predominantly directed towards socially close others, who, unlike strangers, can potentially provide comfort and support in stressful times (Margittai et al., 2018, 2015). By contrast, fight-or-flight is a strategy primarily aimed at escaping the acute stressor. Acute stress can be expected to originate from socially distant outgroup members who are more likely to present a threat than socially close friends and family, especially at times of conflict. Consequently, aggressive, antagonistic tendencies should be largely aimed at socially distant strangers, but less so at socially close others. Even though evidence for this theory is, admittedly, still scarce (Schweda et al., 2019), our current finding of a stress-related and frame-dependent reduction in generosity towards strangers, but not socially close others, is consistent with this hypothesis.

Further questions remain. We could not replicate our previous findings that socio-evaluative stress (Margittai et al., 2015), or exogenous psychopharmacological challenges aimed at mimicking the natural endocrine response to stress (Margittai et al., 2018), selectively increased generosity towards socially close others. One possible explanation for the discrepancy in findings is the difference in the stressor used between this and our previous (Margittai et al., 2015) study; while, here, we employed the MAST (see methods), we used the group version of the Trier Social Stress Test in our previous experiment. The type of stressor matters as it has been shown to alter social behavior in several experiments. For example, according to von Dawans et al. (2018) while physical and psychosocial stressors alone impair prosocial behavior, the two combined actually restore prosociality. Though this finding is not compatible with our results, as we found less prosociality under a combined physical and psychosocial stress induction procedure, this example nonetheless illustrates the complexity of the relationship between social behavior, social norm compliance and stress. Another possibility to account for the differences in results between the current study and our previous work is the task used to elicit social preferences. The frame version of the social discounting task is more complex and procedurally different to the simple social discounting task used before (Margittai et al., 2018, 2015). Thus, task performance might not be perfectly translatable between tasks, and within-task spill-over effects are to be expected. Whatever the reason for the divergence in results, definitive conclusions about underlying mechanisms of our effects cannot be made with certainty at present. Our results pave the way for future research investigating the frame effect and its interaction with stress in shaping prosocial behaviors.

The current study involved male participants only. Following research needs to clarify whether framing and stress interactions on social discounting occur in women, too. Gender differences in social frame effects have been found before (Chowdhury et al., 2017; Ellingsen et al., 2013; Strombach et al., 2016), and we know the stress response is susceptible to variations in sex hormone concentrations (Kirschbaum et al., 1999; Kudielka and Kirschbaum, 2005). Furthermore, stress is multidimensional (Joëls and Baram, 2009), and we still lack knowledge of which mediators of the stress-response affect social behavior. Pharmacological intervention studies using, for instance, corticosteroids and adrenergic drugs, as well as conditions with time lags between stressor and task would be the optimal choice for future studies (e.g. Margittai et al., 2018, 2015; Vinkers et al., 2013). In the present study, analyses considering the involvement of specific biomarkers have only yielded non-significant results (see supplemental online materials).

In summary, our study replicates our previous findings that participants prefer more generous resource allocations to strangers when donations are framed as preventing financial harm to others. We demonstrate that stress mitigates this frame effect on social discounting, so that stressed participants are less generous towards strangers than non-stressed controls. This finding can be tentatively explained as a stress-induced diminished compliance to the social norm to "do-no-harm".

These findings contribute to our understanding of how acute stress alters decision making, social norm compliance and interpersonal harm avoidance. Thus, our study broadens our understanding of the impact our psychological state has for our everyday moral and social behavior. We believe that this result is not only relevant for cognitive scientists studying the effects of stress on cognition and behavior, it is also important for policy makers and corporate decision makers; knowing under which circumstances stress boosts or corrupts prosociality, especially towards strangers, has practical implications for charity advocacy about the way charity calls or appeals for donations could be worded.

Declaration of Competing Interest

We have no conflict of interest to declare.

Consent for publication

Not applicable.

Financial and Non-Financial Competing interest

We have no conflict of interest to declare.

Statement of responsibility

AS designed the task, ran the data collection, analyzed the data and wrote the paper, TK designed the task, wrote the paper, provided consultation at all stages of the project and funded the project, Z.M edited the paper and provided consultation at all stages of the project.

Ethics approval and consent to participate

The study was approved by the ethics committee of the Medical Faculty of the Heinrich-Heine-University in Dusseldorf. All participants gave their informed consent.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.psyneuen.2020.104860.

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