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Acute stress and altruism in younger and older adults

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ABSTRACT

Recent studies of aging and decision making suggests that altruism increases with age. It is unclear, however, whether this pattern holds when choices are made under stress, as is often the case in real-world scenarios. The current study used an intertemporal choice task in which younger and older adults received a financial endowment before making a series of consequential intertemporal decisions involving gains, losses and charitable donations. Preceding the choice task, participants were exposed to a laboratory stressor. Physiological stress reactivity was a predictor of altruistic decision making in younger adults, such that individuals with higher stress reactivity made more generous choices. Older adults showed higher altruism than younger adults overall, with altruism unrelated to stress reactivity in older adults. These findings are consistent with an age-related change in the mechanisms underlying altruistic behavior.

1. Introduction

Altruism is the motivation to help others (Andreoni, 1989). A growing literature suggests that altruism is associated with age (for a review, see Bekkers and Wiepking, 2011). In cross-sectional studies, adult age shows positive linear relationships to subjective, behavioral, and neural measures of altruism and prosocial behavior (Freund and Blanchard-Fields, 2014; Hubbard et al., 2016; Sparrow and Spaniol, 2018). Why older adults are more altruistic than younger adults is still poorly understood. Life-span theories of motivation postulate age-related changes in value orientations, such that generativity (Erikson, 1982) and ego-transcending goals (Brandtstädter et al., 2010) gain strength as we age. However, in addition to expressing intrinsic value orientations, prosocial behavior can also serve instrumental goals, such as fostering social relationships or maintaining a positive self-image (Taylor et al., 2000). The current study sought to shed light on mechanisms and boundary conditions of altruism in younger and older adults by examining the association between acute stress and altruism in both age groups.

In younger adults, acute stress sometimes promotes prosocial behavior (e.g., Margittai et al., 2015; Singer et al., 2017; Vinkers et al., 2013; Von Dawans et al., 2012) and sometimes reduces it (e.g., Starcke et al., 2011; Vinkers et al., 2013). The mixed findings may reflect the influence of opposing mechanisms, referred to as tend-and-befriend and fight-or-flight, respectively (Taylor et al., 2000). The fight-or-flight response involves confronting or removing oneself from stressful conditions (Von Dawans et al., 2012), whereas the tend-and-befriend response involves strengthening social relationships by tending to or affiliating with others (Taylor et al., 2000). Originally viewed as an evolved response to stress in females (Taylor et al., 2000), more recent findings suggest that the tend-and-befriend response also occurs in males (e.g., Margittai et al., 2015; Singer et al., 2017; Von Dawans et al., 2012). Whether a stressor produces the fight-or-flight or the tend-and-befriend response may depend on the task context, on how much time has elapsed since the onset of the stressor, and on how prosocial behavior (i.e., altruism) is measured (Singer et al., 2017). However, the bulk of the current literature is in line with an increase in prosociality in the immediate aftermath of an acute psychosocial stressor in younger adults, for both males and females. This particularly applies to studies that focus on behavioral rather than self-reported altruism; studies that involve an experimental manipulation of stress; and studies that rely on cortisol measures of stress (e.g., Margittai et al., 2015; Singer et al., 2017; Vinkers et al., 2013; Von Dawans et al., 2012).

No prior studies have examined the effect of stress on altruistic decision making in older adults. Both stress and aging are associated with alterations in brain circuits involved in valuation and decision making (for reviews, see Samanez-Larkin and Knutson, 2015; Starcke and Brand, 2012). For instance, acute stress modulates function in brain regions with receptors for stress hormones, including the prefrontal cortex (Pruessner et al., 2010). The prefrontal cortex also undergoes pronounced structural, functional, and neuromodulatory changes in aging (Erixon-Lindroth et al., 2005). An additional motivation for examining effects of stress on altruism is that many older adults face stressful circumstances that require balancing their own needs and

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those of others (e.g., caregiving, financial planning; Halfmann et al., 2013). The current study thus sought to shed light on the interaction of age and stress on altruism.

Based on the evidence that aging is associated with differences in decision making and altruistic behavior, and considering that both are sensitive to acute stress in younger adults (Hubbard et al., 2016; Samanez-Larkin and Knutson, 2015; Von Dawans et al., 2012), the current study was the first to examine these phenomena jointly in a cross-sectional design. Following exposure to a psychosocial stressor, younger and older adult participants completed a behavioral-economics task in which they made a series of financial decisions involving gains and losses that apply to the self, as well as charitable donations. In addition to the experimental outcomes, we also assessed demographic, cognitive, and affective variables of potential importance.

To date, the bulk of studies on stress and prosociality use measures of altruism that are relatively transparent to participants. The commonly used Dictator Game (Kahneman et al., 1986), for example, has been criticized for introducing elements of social desirability, which may act as threats to external validity (Jiménez-Buedo, 2015). Self-report measures of altruism may be susceptible to similar shortcomings (cf. Rushton et al., 1981). In an attempt to overcome these limitations, Sparrow and Spaniol (2018) recently developed an altruistic intertemporal choice (ITC) paradigm, in which participants must choose between smaller-sooner and larger-later outcomes (e.g., donate $5 now or donate $7.50 in 7 days?). On individual choice trials, participants thus decide not between rewards for themselves versus others, but rather between rewards differing in their magnitude and temporal delay. This task thus reduces the influence of demand characteristics, at least as compared to standard behavioral-economic games. In Sparrow and Spaniol's (2018) study, older adults made more altruistic intertemporal choices compared with younger adults, both when they were in the presence of an experimenter and when intertemporal choices were made anonymously in an online experiment.

In line with the aforementioned literature on stress and prosociality in younger adults, we expected a positive relationship between stress and altruistic intertemporal choice in younger adults (i.e., tend-and-befriend; e.g., Von Dawans et al., 2012). In older adults, however, we expected to see a reduction in the relationship between stress and altruism. This prediction was motivated by lifespan-developmental theories (Brandtstädter et al., 2010; Erikson, 1982) that postulate an age-related increase in the *intrinsic* value of altruistic actions. According to these theories, altruistic actions should be the default response in older adults, and should be immune to contextual factors such as acute stress. Given the predicted age-related asymmetry in the relationship between stress and altruism, we also expected to replicate the finding that older adults make more altruistic choices than younger adults, even following an acute psychosocial stressor.

2. Methods

2.1. Participants

All study participants provided informed consent, which was approved by the ethics committee at Ryerson University in Toronto, Ontario (REB# 2015-196-1). Younger adults were recruited through flyers in the community, advertisement websites including Kijiji and Craigslist, and social media such as Facebook. Older adults were recruited through the Ryerson Senior Participant Pool. Participants included 36 younger adults (age range: 18–30; 58% female) and 36 older adults (age range: 65–85; 63% female). The sample size was determined *a priori* using a two-tailed alpha of 0.05, a power of .80, and an effect size of $d = .73$. The latter value was the average effect size for the effect of age on altruism across Experiments 1 and 2 of a prior study that used the same populations and the same task (Sparrow and Spaniol, 2018). GPower (Faul et al., 2007) yielded a sample size of 31 participants per age group. We conservatively opted to increase this sample size to 36 per age group.

Table 1
Participant Characteristics.

	Younger Adults	Older Adults	*t*-value
Demographics	21.00 (3.44)	70.11 (4.91)	4.71***
Age	14.33 (1.71)	16.38 (1.97)	1.87
Education (years)	3.69 (1.83)	4.48 (1.66)	
Annual Income			
Cognition			
Digit-Symbol	83.81 (12.94)	60.78 (12.98)	7.54***
Vocabulary	16.97 (3.76)	24.97 (3.92)	8.84***
Numeracy	1.44 (1.08)	1.06 (1.01)	1.58
Affect			
Positive Mood	29.57 (7.46)	34.25 (7.01)	2.73**
Negative Mood	12.31 (3.09)	10.92 (1.32)	2.47*
DASS21 Depression	5.94 (4.91)	2.44 (2.20)	3.90***
DASS21 Anxiety	5.89 (3.38)	2.33 (2.85)	4.83***
DASS21 Stress	9.39 (6.03)	7.17 (5.48)	1.64
Perceived Stress	14.75 (4.61)	9.64 (4.09)	4.98***
Motivation			
BAS Drive	11.03 (2.44)	9.89 (2.25)	2.06*
BIS	20.14 (3.94)	18.96 (3.31)	1.38
Future Orientation			
CFC-Future	3.67 (.62)	3.66 (.57)	.11
CFC-Immediate	2.56 (.75)	2.29 (.73)	1.55
Altruism			
Subjective Altruism	38.78 (10.45)	50.47 (12.56)	4.29***
Dictator Charity	7.25 (2.97)	8.67 (3.13)	1.97
Dictator Other	4.36 (3.29)	7.22 (3.17)	3.76***
Self-relevance	68.08 (26.40)	69.61 (29.38)	.23
Other	65.83 (34.95)	90.54 (18.18)	3.72***
Confidence in bonus payout scheme			

Note. DASS21 = Depression, Anxiety and Stress Scale 21, BAS = Behavioral Approach System, BIS = Behavioral Inhibition System, CFC = Consideration of Future Consequences, YA = younger adults, OA = older adults. Mean values are shown, with standard deviations in parentheses.

* $p < .05$.

** $p < .01$.

*** $p < .001$ $t(70)$, two-tailed test for group differences, equal variances not assumed.

Participants reported no major health problems, including: history of neurological or neurodegenerative disorder, psychiatric disorder, cardiovascular disease, metabolic disorder, or autoimmune disorder. Participants had normal or corrected-to-normal vision and hearing, and scored within the normal to moderate range on the depression and anxiety subscales of the Depression Anxiety and Stress Scale 21 (DASS21; Lovibond and Lovibond, 1995). All older adults scored 26 or higher on the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) indicating normal cognitive status. Since smoking has been shown to increase both delay discounting (i.e., promote impulsive decision making; Mitchell, 1999) and cortisol levels (Kirschbaum et al., 1993), smokers were excluded from the study. Participants were also excluded if they were taking medications known to interfere with the hypothalamic-pituitary adrenal axes (HPA axis; e.g., antidepressants, sleeping pills, synthetic corticosteroids, beta-adrenergic agonists, hormone replacement therapy, birth control pill). Female participants were excluded if they were pregnant or intending to become pregnant, nursing, or if they reported having an irregular menstrual cycle (i.e., 24 > cycle > 32 days). Table 1 presents participant characteristics in greater detail. Participants received $15 for their participation in the two-hour experiment. They also received an individually-variable bonus payout for the intertemporal choice task.

2.2. Intertemporal choice task

The intertemporal choice task was adapted from a previous study on aging and altruism in the intertemporal choice literature (Sparrow and Spaniol, 2018). First, participants selected a charity from a list of seven

Table 2
Stress Measures.

	Younger Adults				Older Adults			
	BL	T1	T2	T3	BL	T1	T2	T3
SubjectiveStress	24.12 (27.41)	46.79 (30.10)	27.30 (21.41)	20.82 (20.60)	15.70 (17.40)	28.52 (23.63)	21.15 (18.66)	15.39 (15.53)
Systolic BP (mmHg)	104.09 (12.87)	114.38 (17.58)	107.29 (10.98)	107.06 (12.74)	125.34 (18.87)	133.63 (18.56)	129.49 (17.72)	130.69 (17.41)
Diastolic BP (mmHg)	68.12 (7.60)	79.11 (13.34)	71.83 (8.40)	72.83 (8.40)	75.11 (13.07)	81.83 (13.43)	78.11 (11.32)	77.20 (13.46)
Cortisol (μg/dL)	.28 (.14)	.32 (.17)	.38 (.24)	.32 (.20)	.18 (.08)	.21 (.13)	.27 (.16)	.26 (.15)

Note. BL = Baseline; T1 = Time 1; T2 = Time 2; T3 = Time 3; BP = Blood Pressure. Mean values are shown, with standard deviations in parentheses.

options and specified, using a visual analogue scale (VAS), how relevant the preferred charity was to them. At their own pace, participants read over the task instructions, with the understanding that they would be making a series of binary decisions between smaller-immediate and larger-later monetary outcomes. There was no right or wrong answer. Rather, participants were asked to choose the option they most preferred. The smaller-immediate option was fixed at \$5 whereas the delayed option ranged in seven magnitudes (\$4.75, \$5.25, \$5.50, \$6.00, \$6.50, \$7.00, \$7.50) and four delay periods (7, 30, 90, 180 days) yielding 28 trial combinations. The trial set was repeated three times each for intertemporal gains, losses and charitable donations, resulting in a total of 84 trials. Reward-type condition was blocked, and the block order was counterbalanced across participants in each age group. Within blocks, trials were presented in random order.

To mimic decision making outside of the laboratory, participants were endowed with a \$20 starting capital. The starting capital was presented in two envelopes, one labeled “now” and the other labeled “later”, each enclosing \$10 in cash. Participants were told that at the end of the task, one of their choices would be randomly selected by the computer and applied to their endowment. After reading the instructions, participants completed six practice trials to ensure that they understood the task, by verbally describing or physically demonstrating the decision outcome to the experimenter using the money in the envelopes (Quiz 1). After participants completed the 84 unique trials, one trial was randomly selected by the computer and applied to the starting capital. As a final check of task understanding, participants were asked to exhibit the correct payout for the randomly selected trial using their starting capital (Quiz 2). All participants included in the final sample successfully demonstrated the correct payout. Regardless of the choice outcome, participants left the session with a variable amount of money from the “now” envelope. They also received a paper IOU specifying the amount from the “later” envelope they would receive, and the date on which their check would arrive in the mail. Afterwards, participants rated how confident they were that the pay-out scheme would be implemented based on their performance with a VAS scale. For the delayed payment, an examination of bank records indicated that among those who received mailed checks, all but 6 participants cashed their checks shortly after receiving them, suggesting that most participants (92%) received the payments as intended.

2.3. Procedure

Testing sessions began after 1300 h and ended before 1700 h in order to minimize circadian fluctuations in cortisol levels (Dickerson and Kemeny, 2004). Participants received the instruction not to drink alcohol or caffeine within three hours of the study, not to eat or exercise within one hour of the study, and not to sleep within two hours of the study, as these behaviors may interfere with cortisol secretion (e.g., Lighthall et al., 2009;). After providing informed consent, participants were asked to drink a small glass of water to facilitate subsequent saliva collection. Participants then completed a battery of individual difference measures, followed by the instructions for the Trier Social Stress Test (TSST; Kirschbaum et al., 1993). The experimenter explained that the next task was a verbal task in which the participant would give a 5-min speech (i.e., “why they are a good candidate for their dream job”) in front of two evaluators trained in speech delivery. After the speech preparation period (5 min), the participant was led to a separate room on the other side of the building by the experimenter where two confederates awaited. Upon arrival, the experimenter instructed the participant to stand against the wall facing the video camera, stating that they would return once the task was done. Once the experimenter left the room and closed the door, the participant was instructed by the male confederate to give their speech (5 min). Upon completion of the speech, the female confederate provided the participant with instructions for the impromptu mental arithmetic task (5 min), in which the participant had to verbally subtract 7 from 996 sequentially. In the event that the participant’s speech was below the time limit or they provided an incorrect answer in the arithmetic task, they were instructed to continue or start from the beginning, respectively. Immediately after the arithmetic task, the confederates promptly left the testing room, and the experimenter guided the participant back to the initial testing room. Three younger and three older adults stopped the TSST prematurely (due to feelings of discomfort) who were immediately debriefed and later replaced. For those who completed the TSST, the experimenter oriented the participant to the computer and gave them the instructions for the intertemporal choice task. Upon completion of the choice task, participants received their variable payout and were debriefed.

2.4. Stress reactivity measurement

Three different measurements of stress were captured in the current

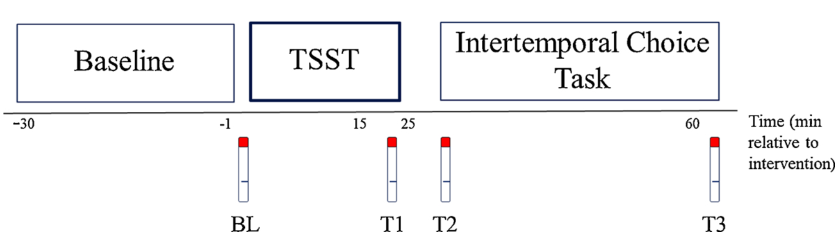

Fig. 1. Timeline of the experimental session.

study: cortisol (obtained through saliva samples), blood pressure (BP) and subjective stress measured with a VAS (see Table. 2). All stress measures were recorded at four time points (see Fig. 1) throughout the experiment: prior to the speech task instructions (baseline [BL]; −30 min), immediately after the mental arithmetic task (Time 1[T1]; + 15 min), 10 min post-stress offset (Time 2 [T2]; + 25 min), and immediately after the intertemporal choice task (Time 3 [T3]; +60). T1 was most critical for BP and subjective stress as these measurements reflected stress levels immediately after experiencing the TSST. In contrast, T2 was most critical for cortisol, given the well-documented lag between acute stress and peak cortisol concentration (i.e., 21–40 min from stressor onset; Dickerson and Kemeny, 2004).

2.4.1. Cortisol

Salivary cortisol was obtained using the passive drool technique, which required participants to exude saliva through a salivary collection aid into a collection vial (Salimetrics, Inc.). Immediately after each experimental session, saliva samples were stored in an in-house commercial freezer at −70 °C until subsequent analyses were conducted. Samples were thawed and centrifuged at 3000 rpm for 15 min to obtain a sufficient volume of clear saliva with low viscosity needed for pipetting each sample in duplicate. Salivary samples were analyzed using Salimetrics© salivary cortisol enzyme competitive immunoassay standard 96-well plate assay kit (ELISA; Salimetrics, Inc). Each plate was placed in a BioTek Eon™ high performance microplate reader (heated to room temperature, 20 °C), using Gen5 Software to reliably detect the concentration of cortisol in each sample. The volume of saliva was insufficient for one younger adult and three older adults who were later replaced. The inter- and intra-assay variances were 14.77% and 8.36% respectively, meeting the appropriate thresholds for precision and repeatability of immunoassay test results (Schultheiss and Stanton, 2009).

2.4.2. Blood pressure

Systolic and diastolic BP were measured using a BP monitor (Life Source, A&D Medical) placed on the participant's left arm. At each measurement point, participants were asked to rest their left arm on the table and keep their feet firmly planted on the floor.

2.4.3. Subjective measures

After each of the four BP recordings, subjective stress was measured using a VAS presented on an iPad (Qualtrics, Provo, UT). Participants were asked to rate the amount of stress they were currently experiencing using the touch screen on a line, with the extreme left indicating no stress, and the extreme right indicating intense stress.

2.5. Baseline psychosocial measures

A battery of questionnaires was completed to measure potential baseline correlates of intertemporal choice and altruism. Cognitive function was assessed using the Digit-Symbol task, a measure of perceptual-motor speed (Version 1 of the Digit-Symbol task; Wechsler, 1997); the Mill Hill Vocabulary Scale (Raven, 1982), an index of verbal intelligence; and the fill-in-the-blank version of the Berlin Numeracy Test (Cokely et al., 2012), a measure of numeracy. Affective states over various timescales was measured using the 20-item Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), a measure of mood; the 21-item DASS21 (Lovibond and Lovibond, 1995), a measure of depression, anxiety and stress experienced over the past week; and the 14-item Perceived Stress Scale (PSS; Cohen et al., 1983), to measure the magnitude in which circumstances in one's life are considered stressful within the past month. Motivation was measured using the 4-item BAS-Drive subscale of the Behavioral Inhibition System/Behavioral Activation System (BIS/BAS) scales (Carver and White, 1994), which measures the persistent pursuit of personal goals. Future orientation was assessed using the 14-item modified Consideration of Future Consequences Scale (CFC), which measures the extent to which participants value the future outcomes of their behavior (Joireman et al., 2012). Finally, subjective altruism was assessed using the Self-Report Altruism (SRA) scale (Rushton et al., 1981) and completion of two hypothetical trials of the Dictator Game (Kahneman et al., 1986), one trial for a stranger, the other trial for the previously chosen charity.

2.6. Data reduction

Responses on the intertemporal choice task were used to calculate the reward index for each of the three conditions (Sparrow and Spaniol, 2018; also see Benoit et al., 2011). The values of the reward index in all three conditions range from 0–1. For gains, the reward index reflects the degree to which the sum of all chosen options exceeds the minimum and is calculated as follows: [actual – minimum] / [maximum – minimum]. Constant selection of the "now" option yields a reward index of 0, whereas constant selection of the "later" option yields a reward index of 1. In contrast, for losses and donations, the reward index was calculated as (1- [actual – minimum] / [maximum – minimum]). As a result, in all three conditions, a reward index of 1 reflects choice outcomes that maximize total personal earnings (i.e., larger-later gains, smaller-immediate losses), while a reward index of 0 reflects choice outcomes that minimize total personal earnings (i.e., smaller-immediate gains and larger-later losses).

In line with Sparrow and Spaniol (2018), the altruism index was calculated by subtracting the reward index in the donation condition from the reward index in the loss condition. The justification for this difference measure was that both conditions involved a personal loss, and were therefore matched with regard to their financial effect on the decision maker. Participants who showed a *decrease* in the reward index in the donation condition, relative to the loss condition, thus received a higher altruism score.

Stress reactivity was defined by the difference between baseline and peak response, divided by baseline (i.e., BL-Peak/BL). Accordingly, cortisol reactivity was defined as the change from BL to T2, with T2 being the peak cortisol response (Dickerson and Kemeny, 2004). Subjective stress and systolic BP reactivity were defined as the change from BL to T1, with T1 representing peak response.

2.7. Data analyses

To assess the stress manipulation, independent repeated-measures analyses of variance (ANOVAs) for each of the three stress reactivity measures were conducted. To determine age differences in stress reactivity, age group was entered into the model to assess an Age x Time interaction. To evaluate the effects of age and reward type on intertemporal choice, we conducted a 2 × 3 mixed ANOVA. Significant main effects and interactions were followed-up with two-tailed *t*-tests using the Benjamini-Hochberg procedure (Benjamini and Hochberg, 1995) to keep the familywise error rate at .05 (two-tailed). Finally, to assess the relationship between acute biological stress (i.e., cortisol reactivity) and the behavioral measures from the intertemporal choice task, bivariate correlations were tested for younger and older adults. All data were assessed for parametric assumptions, including the Shapiro-Wilk test for normality. In cases of violations of normality, we also performed nonparametric analyses. We report nonparametric results only when they diverged from parametric results. The Greenhouse-Geisser correction was used to correct for violations of sphericity. Pairwise deletion was used for instances with missing data.

3. Results

3.1. Stress reactivity

Separate repeated-measures ANOVAs were conducted to assess cortisol, BP, and subjective reactivity in response to the TSST. Cortisol reactivity showed a significant main effect of time, F(1.80, 125.88) = 16.57, $p < .001$, $\eta_p^2 = .19$, with cortisol being higher at T2 ($M = .34$, $SD = .22$) than at BL ($M = .22$, $SD = .12$), $t(71) = 4.83$, $p < .01$, $d = 0.68$. This suggests that the stress manipulation was successful. The Age x Time interaction did not reach significance, $F(1.80, 125.88) = 1.25$, $p = 0.29$ $\eta_p^2 = .02$.

Systolic BP reactivity also showed a significant main effect of time, $F(2.78, 191.90) = 13.79$, $p < 0.001$, $\eta_p^2 = .17$. Systolic BP was higher at T1 ($M = 123.96$, $SD = 20.14$) than at BL ($M = 114.73$, $SD = 19.09$), $t(70) = 5.73$, $p < .001$, $d = 0.47$, consistent with an increase in stress in response to the TSST. The Age x Time interaction again did not reach significance, $F(2.78, 191.90) = 1.05$, $p = .37$, $\eta_p^2 = .02$. Reflecting this pattern, diastolic BP showed a significant main effect of time, $F(2.48, 171.27) = 22.49$, $p < .001$, $\eta_p^2 = .17$. Diastolic BP was higher at T1 ($M = 80.45$, $SD = 13.44$) than at BL ($M = 71.62$, $SD = 11.43$), $t(70) = 6.72$, $p < .001$, $d = 0.71$, consistent with an increase in stress in response to the TSST. The Age x Time interaction again did not reach significance, $F(2.48, 171.27) = 1.80$, $p = .16$, $\eta_p^2 = .03$. One younger adult missed a BP reading due to experimenter error.

Finally, subjective stress reactivity also showed a significant main effect of time, $F(2.28, 149.95) = 35.98$, $p < .001$, $\eta_p^2 = .35$, with subjective stress being higher at T1($M = 38.27$, $SD = 28.64$) than at BL ($M = 19.99$, $SD = 22.61$), $t(69) = 7.08$, $p < .01$, $d = 0.71$, in line with an increase in psychological stress following the stressor. There was a significant Age x Time interaction, $F(2.27, 149.95) = 3.40$, $p = .03$, $\eta_p^2 = .05$. We explored the interaction with separate one-way ANOVAs of time on the subjective stress measurement for each age group. The main effect of time was significant for both younger adults, $F(2.17, 71.65) = 31.35$, $p < .001$, $\eta_p^2 = .49$, and older adults, $F(2.03, 66.91) = 9.24$, $p < .001$, $\eta_p^2 = .22$. Younger adults showed a quadratic trend $F(1, 33) = 47.12$, $p < .001$, indicating that subjective stress increased from BL to T1, then continued to decrease from T2 to T3. This pattern was also observed in older adults $F(1, 33) = 11.89$, $p = .002$. We also tested for age differences at each of the four time points. Only T2 was significantly higher for younger adults ($M = 45.72$, $SD = 30.29$) relative to older adults ($M = 30.00$, $SD = 24.58$), $t(66.88) = 2.41$, $p = .02$, $d = 0.57$. Due to technical error, four participants (two from each age group) missed at least one subjective stress reading. Table 2 shows the mean changes in salivary cortisol, BP and subjective stress, separately for each age group.

Overall, the stress manipulation was successful for both younger and older adults, as indicated by objective and subjective measures of stress. As expected, cortisol was highest at T2 relative to BL, while systolic BP and subjective stress scores were highest immediately post-TSST (T1) relative to BL.

3.2. Intertemporal choice

Effects of age (younger, older) and reward type (gain, loss, and donation) on intertemporal choice and altruism were comparable to those observed previously under no-stress conditions (Sparrow and Spaniol, 2018; see Fig. 2). A mixed 2 × 3 ANOVA of Age and Reward Type on the reward index yielded a significant main effect of reward type, $F(1.57, 110.03) = 14.36$, $p < .001$, $\eta_p^2 = .17$, with the reward index being significantly higher for losses ($M = .85$, $SD = .24$) than for donations ($M = .58$, $SD = .37$), $t(71) = 5.65$, $p < .01$, $d = 0.86$. Furthermore, the reward index was significantly greater for losses ($M = .85$, $SD = .24$) than for gains ($M = .69$, $SD = .32$), $t(71) = 3.85$, $p < .02$, $d = 0.57$. No other effects reached significance. Replicating prior findings (Sparrow and Spaniol, 2018), an independent-samples t-test showed that the altruism index was higher for older adults than for younger adults, $t(67.78) = 2.33$, $p = .02$, $d = 0.55$.

3.3. Association between stress and altruism

To test our hypothesis regarding acute biological stress (i.e., cortisol reactivity) and altruism, we conducted separate Pearson bivariate correlational analyses for younger and older adults. A significant correlation between cortisol reactivity and the altruism index emerged for younger adults, $r = +.41$, $p = .01$, but not for older adults, $r = +.01$, $p = .94$ (see Fig. 3). To test whether the relationship between stress reactivity and altruistic choice differed significantly for younger and older adults, a dummy variable coding for age group was created, with younger adults as the reference group. Next, a regression model was estimated in which the altruism index was regressed on cortisol reactivity, age group, and the interaction between cortisol reactivity and age group (Cohen et al., 2003). This analysis yielded Cook's distance values exceeding the standard cut-off of 1.0 (Cook, 1977), suggesting that influential outliers were present in the analysis. One older adult was identified as having Cook's distance greater than 1.0 and was removed. After re-running the regression with the outlier removed, Cook's distance (Cook, 1977) yielded values between 0.0 and 0.11 (i.e., well beneath the standard cut-off of 1.0), suggesting that influential outliers were no longer present in this regression analysis. The Cortisol Reactivity x Age Group interaction term was a significant predictor of altruism, $F(3, 70) = 4.19$, $p = .009$. Unpacking this interaction using simple slopes (Cohen et al., 2003), the regression slope coefficient for cortisol reactivity was significant for younger adults, $p = .025$, but not for older adults, $p = .13$.

To further explore the relationship between stress and altruistic choice, we also examined correlations between the altruism index and the other stress measures (i.e., subjective stress, systolic and diastolic BP). None of these stress measures showed significant correlations with the altruism index. One possible reason is that the intertemporal choice paradigm was administered 10 min post-TSST, at which point the acute subjective and sympathetic stress response may have subsided.

3.4. Other measures

Two-tailed independent t-tests on the supplementary measures revealed several significant age differences (see Table 1). Older adults had higher vocabulary scores and lower perceptual speed than younger adults (Raven, 1982; Wechsler, 1997). Relative to their younger counterparts, older adults scored higher on positive mood and lower on negative mood (Watson et al., 1988). Younger adults reported significantly higher anxiety and depression (Lovibond and Lovibond, 1995) and perceived stress (Cohen et al., 1983). The cognitive and affective age differences are typical of those reported in cross-sectional studies of cognitive and affective aging (Samanez-Larkin and Knutson, 2015). Furthermore, older adults reported higher perceived levels of altruism and allocated a larger hypothetical amount of money in a stranger-version of the dictator game (Kahneman et al., 1986; Rushton et al., 1981). There were no age differences in self-reported income. Finally, older adults expressed significantly more confidence in the payout scheme than younger adults, $t(52.97) = 3.75$, $p < .001$, $d = 0.88$.

To explore relationships between altruism and other dimensions of interest, we examined correlations between the altruism index and the demographic, cognitive, and affective measures, separately for younger and older adults (see Table 3). For older adults, the altruism index was positively correlated with verbal intelligence, $r = +.37$, $p < .05$, but negatively correlated with an immediate focus on behavioral consequences, $r = -.47$, $p < .01$. For younger adults, the altruism index was positively correlated with stranger-version of the dictator game $r = +.52$, $p < .01$, as well as the modified charity-version of the dictator game, $r = +.55$, $p < .01$. The altruism index was not significantly correlated with any of the dictator game versions in older adults, perhaps due to their hypothetical nature. Across age groups, there were no sex differences in cortisol responsivity, $t(70) = 0.70$, $p = .49$, $d = 0.17$, or in the altruism index, $t(70) = 0.45$, $p = .87$, $d = 0.11$. In younger adults, there were no sex differences in cortisol responsivity, $t(34) = 1.09$, $p = .28$, $d = 0.36$, or in the altruism index, $t(34) = 0.53$, $p = .60$, $d = 0.18$. Likewise, for older adults, there were no sex

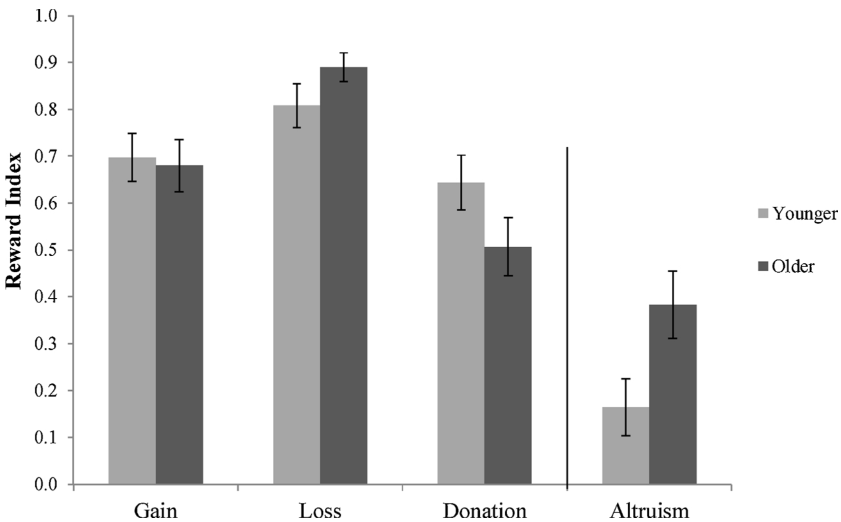

Fig. 2. Bar graph illustrating the reward index for gains, losses, and donations, as well as the altruism index, separately for younger and older adults. Higher reward index values reflect choices that optimize personal gain (i.e., larger-later gains and smaller-immediate losses and donations). Altruism is defined as the difference score between the loss and donation conditions, with a higher altruism index representing greater altruism. Error bars indicate the standard error of the mean.

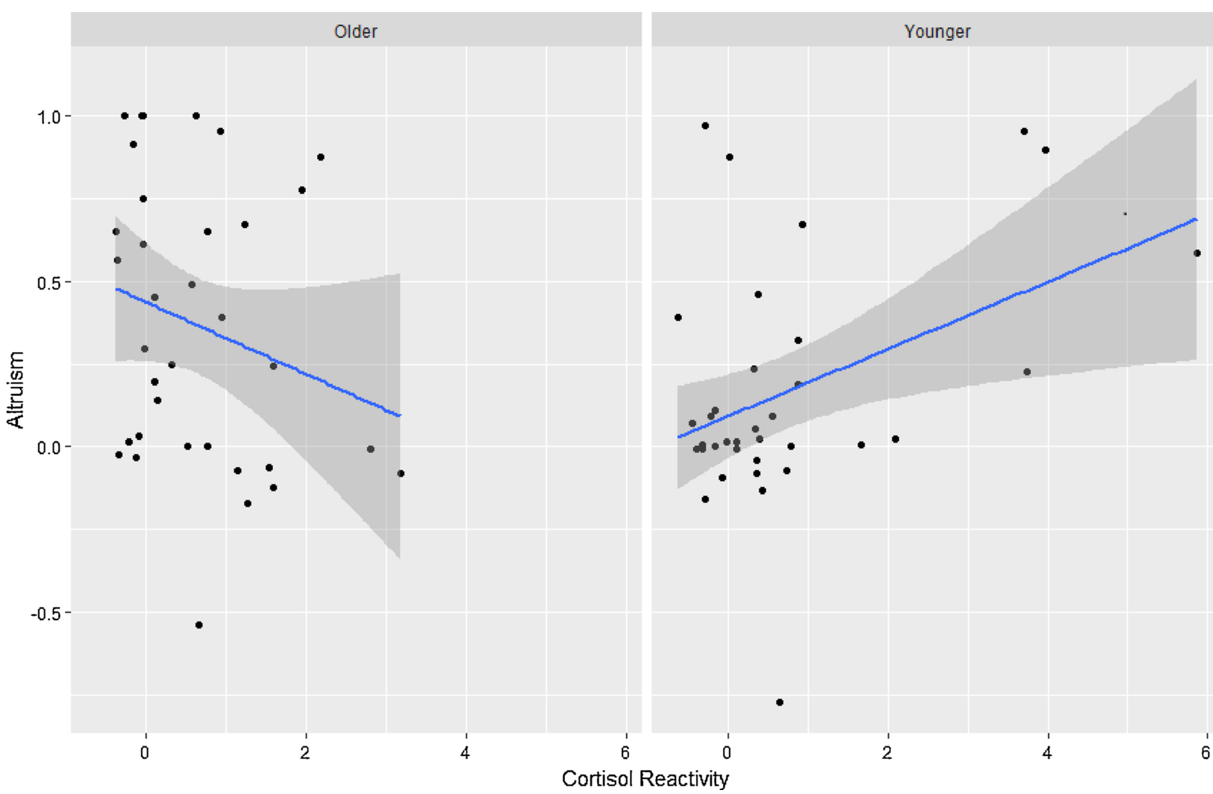

Fig. 3. Relationship between standardized cortisol reactivity and altruism in older (left) and younger (right) adults.

differences in cortisol responsivity, $t(34) = .17$, $p = .86$, $d = 0.06$, or in the altruism index $t(34) = 0.33$, $p = .74$, $d = 0.11$.

4. Discussion

The present study adds to a growing body of literature on aging and altruism, and is the first to investigate how stress affects this type of decision making. Even under stress, we replicate previous findings of an age-related increase in altruistic intertemporal choice (Sparrow and Spaniol, 2018). Novel to the current study, cortisol reactivity was positively associated with altruistic intertemporal choice in younger, but not older adults, suggesting that prosocial behavior is less context-dependent in older adults.

Earlier work on stress and altruism in younger adults has elicited mixed results. However, the current study adds to the growing body of evidence for increased altruism in response to socioevaluative threat (e.g., Margittai et al., 2015; Singer et al., 2017; Von Dawans et al., 2012). Adopting the tend-and-befriend approach may serve as a coping mechanism for younger adults to help offset the negative consequences of stressful situations. In the original formulation of the tend-and-befriend theory, stressful situations promote comfort-seeking in individuals at close social distance (Taylor et al., 2000), but the mechanisms involved may play out at larger social distances, as well. In the current study, for example, a charitable organization served as the social partner. The benefits from giving to a charity may include boosts to one's self-image (Taylor et al., 2000) or the warm glow associated with altruistic actions (Harbaugh et al., 2007). Further, although the tend-and-befriend theory was originally formulated to explain stress effects on prosociality in females (Taylor et al., 2000), several studies have observed this effect in males as well (e.g., Margittai et al., 2015;

Table 3
Pearson correlation coefficients for the individual difference measures and the altruism index.

Questionnaires and Scales	Younger Adults	Older Adults
Demographics		
Age	−.06	.12
Education	−.07	.01
Income	.19	.10
Cognition		
Perceptual Speed	.06	−.07
Vocabulary	.14	.37*
Numeracy	.07	.13
Affect		
Positive Mood	−.04	.09
Negative Mood	−.18	.16
DASS21 Depression	.18	−.04
DASS21 Anxiety	.23	−.08
DASS21 Stress	.02	−.32
Perceived Stress	−.20	−.34*
Motivation		
BAS Drive	.15	−.03
BIS	−.30	.10
Future Orientation		
CFC-Future	−.03	.21
CFC-Immediate	−.02	−.47**
Altruism		
Subjective Altruism	.18	.22
Dictator Charity	.52**	.12
Dictator Other	.55**	−.01
Self-relevance	−.23	−.11

Note. DASS21 = Depression, Anxiety and Stress Scale 21, BAS = Behavioral Approach System, BIS = Behavioral Inhibition System, CFC = Consideration of Future Consequences, YA = younger adults, OA = older adults.
** $p < .01$.
* $p < .05$.

Singer et al., 2017; Von Dawans et al., 2012). In fact, the majority of studies on stress and altruism have been limited to males. Given sex differences in cortisol responsivity and interactions between sex hormones and cortisol (Rand et al., 2016), it is interesting that the current data revealed no sex differences in cortisol responsivity or altruistic decision making. Studies with larger sex-balanced samples are needed to increase the generalizability of these findings.

Given the lack of prior empirical data on the link between stress and altruism in older adults, we had relied on lifespan theories postulating an age-related increase in the intrinsic value of altruistic action, and a disengagement from egocentric-individualistic concerns (Brandtstädter et al., 2010; Erikson, 1982). Based on these theories, we hypothesized that altruism in older adults would be less context-dependent in older adults than in younger adults. In line with this prediction, we found no relationship between cortisol responsivity and the altruism index in our older adult sample. The observed age difference in stress reactivity and altruism between our age groups may suggest that younger and older adults have different altruistic channels. Specifically, younger adults' altruistic tendencies may be more situationally contingent and instrumental than those of older adults. This interpretation is consistent with recent work on life-span changes in general benevolence (Hubbard et al., 2016). Specifically, Hubbard and colleagues found that increased general benevolence (i.e., trait-based concern for others) in older adults partly reflects a strengthening of "pure" altruistic tendencies. This was demonstrated in a paradigm that compared public and anonymous giving. The relationship between age and giving was similar when decisions were anonymous and when they were observed by an audience (a condition that may elicit one to signal their social status; Hubbard et al., 2016). Future work is needed to understand how other factors may impact altruistic decision making in older adults. For instance, our altruistic decision task incorporated the time dimension, introducing the possibility that age-related differences in time horizons (Carstensen et al., 1999) may have contributed to the current findings, although there is no strong evidence of age-related differences in intertemporal choice (see Sparrow and Spaniol, 2018).

Outside the intertemporal choice task, we attempted to capture potential age differences in temporal preferences through the Consideration of Future Consequences (CFC) measure. While there was no evidence of age differences in either the immediate or future subscales, there was a significant negative correlation, for older adults only, between the score on the immediate subscale and the altruism index. In other words, those older participants who prioritized the here-and-now demonstrated less altruism in the choice task, compared to those who prioritized the future. To the best of our knowledge, only one other study has examined associations between time perception and intertemporal choice in younger and older adults (Löckenhoff et al., 2011), who found no significant associations between two measures of future time perception (future continuity and future time perspective) and temporal discounting for gains and losses. Another factor that may influence the effects of acute stress on altruistic decision making may be the emotionality of the decision (Starcke et al., 2011). Given that the current study used relatively low-emotional altruistic decisions, perhaps stress-induced older adults would demonstrate a different pattern of prosocial decision making when faced with highly emotional decisions. This would have important implications for high-stakes decisions under stress in late life (e.g., when to end a spouse's life support).

At present, there is a lack of research examining age differences on the TSST, making age equivalence difficult to establish. For instance, older adults faced confederates who were significantly younger than themselves, and were asked to think about an age-atypical topic (i.e., their dream job). Importantly in the current study, subjective and objective stress measures confirmed the presence of a stress response in both younger and older adults. Although we should note that when we looked at age differences at each individual time point, younger adults reported a significantly higher subjective stress response after being exposed to the TSST (T1) than older adults, suggesting that younger adults perceived the TSST as more stressful. This age difference may have occurred due to the fact that objective and subjective measures of stress do not always map on to one another, even in younger adult populations (e.g., Rimmele et al., 2007).

4.1. Limitations

Common to studies that explore age differences, the cross-sectional nature of the current study is a limitation because cohort effects may have contributed to the age difference in altruistic intertemporal choice (but see Freund and Blanchard-Fields, 2014). Resource limitations prevented us from including a no-stress control group in the current study. However, in two previously-published experiments (Sparrow and Spaniol, 2018), younger and older adults completed the same task in a no-stress context. Both of these experiments showed evidence for the age-related difference in the altruism index, similar to what we found in the current study, lending confidence in the current findings. A second limitation is that older adults, compared with their younger counterparts, expressed greater confidence that the payout scheme was real. In future studies, it would be important to go to even greater lengths to ensure that younger adults do not doubt the realism of payouts before beginning the task. Third, windfall gains – as in the present study – may not be psychologically equivalent to money owned personally. In future work, it would be interesting to contrast these two types of scenarios directly. Fourth, the TSST may not be equally effective for younger and older adults. The range of cortisol reactivity values was indeed smaller in older adults (range = 3.55 μg/dL, after removal of 1 outlier) than in younger adults (range = 6.49 μg/dL). This may have contributed to the null correlation observed between the altruism index and cortisol reactivity in older adults. Finally, it would be important to replicate and extend the current findings using a continuous lifespan sample of male and female participants.

5. Conclusions

The present study is the first to examine the effects of acute stress on intertemporal choice and altruism in younger and older adults. Replicating previous work (Sparrow and Spaniol, 2018), we found an age-related increase in altruistic intertemporal choice even when participants were exposed to an acute psychosocial stressor. Cortisol reactivity was associated with prosocial behavior in younger adults, but no such relationship was found in older adults. This finding adds to the literature on aging and altruism and highlights the stability and intrinsic nature of altruism in later life.

6. Contributors

EPS was involved in the acquisition of data, data analysis and wrote the manuscript. BAA was involved in the acquisition of data and edited the manuscript. AJF and JS provided critical feedback and edited the manuscript.

Role of the funding source

Grants and funding sources had no further role in the analysis and interpretation of the data, in the writing of the report, or in the decision to submit the paper for publication.

Conflicts of interest

The authors declare no conflict of interest.

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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.2018.09.025.

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