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Original Research Report

Age, Rumination, and Emotional Recovery From a Psychosocial Stressor

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Abstract

Objectives: Exposure to psychosocial stressors often elicits increases in negative affect and blood pressure (BP). Rumination, or thinking about a stressor after it passes, is associated with delayed recovery. Given that older age is associated with greater BP reactivity to psychosocial stressors, rumination may be more detrimental to the recovery of older adults than younger adults. The current study examined this question. We hypothesized that prolonged distress resulting from rumination has greater effects on the recovery of older than younger adults.
Method: Fifty-two older (M = 69 years) and 61 younger (M = 21 years) adults were exposed to a lab stressor. Afterwards, participants were randomly assigned to a rumination condition (n = 58) or a no-instruction control condition (n = 55).
Results: Older participants in the rumination condition had delayed BP recovery relative to those in the control condition and all younger adults. Rumination did not influence affective recovery among any of the groups.
Discussion: Rumination delays BP recovery among older adults, suggesting age-specific risks associated with different types of emotion regulation strategies.

Key Words: Age—Blood pressure—Negative affect—Positive affect—Rumination—Stressor

Researchers posit that physiological arousal elicited from stressors is associated with physical health, increasing the risk for physical health conditions such as cardiovascular disease (Treiber et al., 2003). A growing number of studies have demonstrated this relationship (Piazza, Charles, Sliwinski, Mogle, & Almeida, 2013; Steptoe & Marmot, 2005). According to this research, stressor exposure increases negative affect (affective reactivity), which in turn is associated with elevated blood pressure (BP) and heart rate (physiological reactivity; Ong, Rothstein, & Uchino, 2012). Researchers suggest that repeated or prolonged physiological arousal, either from arousal during the stressor, or arousal experienced after the event (which is hereby referred to as physiological recovery), increases the risk for cardiovascular conditions (McEwen & Gianaros, 2011). Rapid recovery (returning to baseline levels of functioning) from stressors is thus considered a healthy response resulting in less wear and tear to the cardiovascular system.

Cognitive processes people use in response to stressors are associated with how quickly they recover. For example, ruminating about a recent negative event often leads to delayed recovery (Brosschot, Gerin, & Thayer, 2006). Given that older adults have greater BP reactivity to psychosocial stressors (see review by Uchino, Birmingham, & Berg, 2009) and often present with more compromised cardiovascular systems than younger adults (Gianaros & Sheu, 2009), the question remains as to whether a cognitive process that is associated with sustained emotional distress will have a stronger influence on the recovery of older than younger adults. In the current research, we hypothesized that ruminating after a stressor has a greater effect on affective and physiological recovery among older than younger adults.

Reactivity, Recovery, and Health

Stressors are common daily experiences that often elicit affective and physiological reactivity (Almeida, 2005; Glynn, Christenfeld, & Gerin, 2002). In the present study, we examine affective and physiological reactivity and recovery from a lab-based psychosocial stressor. Negative affect, including anger, fear, and sadness, is associated with cardiovascular reactivity, such as increases in BP, peripheral resistance, heart rate, and cardiac output (Sinha, Lovallo, & Parsens, 1992). Moreover, researchers suggest that heightened physiological reactivity to daily stressors accumulate over time, leading to preclinical and clinical cardiovascular health conditions (Treiber et al., 2003).

Although short-term reactivity can be adaptive (i.e., individuals must respond quickly to physical threats), long-term arousal after the event is over, referred to as delayed recovery, is associated with physical health problems (McEwen & Gianaros, 2011). Several cognitive processes may influence one's ability to recover from a stressor. Rumination, for example, includes thinking about the stressor after it desists for a prolonged period of time (Glynn, Christenfeld, & Gerin, 2007). Repetitive thought processes are likely to be labeled as ruminative when the content of those thoughts is harmful and focuses on negative emotional feelings rather than focused on active problem-solving or resolution (Smith & Alloy, 2009). For example, when younger adults are instructed to ruminate about a just-experienced stressful procedure, they experience delayed cardiovascular recovery as well as greater cardiovascular reactivity when the stressor is later recalled compared to those who did not ruminate after the procedure (Glynn et al., 2002). In the present study, we administered a rumination condition to half of the participants, hypothesizing that this rumination would result in delayed recovery.

Age and Delayed Recovery

Research is needed to better understand age differences in the associations between stressors, rumination, and affective and physiological recovery. First, although not true for all older adults, older age is commonly associated with changes in the cardiovascular system (e.g., vessel walls thicken and harden; Gianaros & Sheu, 2009), and this remodeling may have important implications for stress processes. A review of over 30 laboratory studies found that heart rate reactivity decreased with age in response to psychosocial stressors, but BP reactivity to psychosocial stressors was more pronounced (Uchino et al., 2009). BP modulation is a particularly important process to study, given that hypertension is a risk factor for many physical health problems, such as cardiovascular disease and stroke. Although a growing number of studies have examined age differences in physiological reactivity to psychosocial stressors (Uchino et al., 2009), less is known about age differences in physiological recovery from these events. If their recovery is delayed, remaining in a heightened state may be a further challenge for the physical systems of older adults.

Second, aging has a complicated relationship with emotions, because the subjective experience of positive and negative affect and the physiological components of emotion (BP) often show different age-related patterns. For example, one study found that older adults are less *affectively* reactive, but more *physiologically* reactive to psychosocial stressors than are younger adults (Uchino, Berg, Smith, Pearce, & Skinner, 2006). Moreover, the observed age differences in affective reactivity depended on whether positive or NA was considered. Older adults showed less of an increase in negative affect in response to daily stressors than did younger adults, but there was no age difference in positive affect reactivity. In addition, affective and physiological measures are only modestly correlated among younger adults (Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005), and may be even less among older adults. As a result, affective reports alone may fail to capture age differences in reactivity and recovery measures, and reports of both positive and negative affect are needed to capture the full range of affective reactivity and recovery.

Third, older adults often report using emotion regulation strategies that stand in contrast to cognitive processes such as rumination. For example, older adults often appraise stressful situations and daily life stressors less negatively than do younger adults (Carstensen, Fung, & Charles, 2003; Whitehead & Bergeman, 2014). This finding suggests that, in contrast to rumination which involves continued thinking about past negative emotions, older adults actually downplay past negative emotions. Although older adults are capable of ruminating and experiencing regret about major life events (e.g., death of a loved one; Holland, Thompson, Rozalski, & Lichtenthal, 2014; Torges, Stewart, & Nolen-Hoeksema, 2008), older adults generally report less ruminative thinking than do younger adults (Nolen-Hoeksema & Aldao, 2011; Phillips, Henry, Hosie, & Milne, 2006). This age-associated reduction in ruminative processes is likely adaptive given that rumination delays recovery from stressors.

The model of strength and vulnerability integration (SAVI) posits that age-related benefits in emotion regulation may be attenuated when people face situations where they cannot avoid distress, and consequently experience high levels of physiological reactivity (Charles, 2010; Charles & Luong, 2013). Older adults report less distress compared to younger adults when they are able to engage in strategies that allow them to avoid negative experiences. However, when they cannot avoid these experiences, the age-related benefits of emotion regulation are posited to be attenuated if not disappear completely. We believe that exposure to unavoidable psychosocial stressors and rumination after the psychosocial stressor is no longer present, as our participants are instructed to do, are examples of scenarios in which avoidance is not possible.

In one study, for example, adults ranging from middle-aged to 95-years old completed a diary study in which they reported whether they had experienced a negative exchange with a social partner (Birditt, 2013). Participants were also asked whether they had been in a situation that night where they could have felt hurt, but decided not to let themselves experience this distress. The oldest age group endorsed less negative emotions when they reported they had actively avoided feeling hurt, but had higher negative emotions than younger- or middle-aged adults when they didn't avoid the conflict. Thus, age differences may lead to not only greater reactivity to events when they cannot avoid them as shown in prior research (e.g., Uchino et al., 2006), but also slower recovery to these events. Moreover, rumination may exacerbate these age-related differences.

A large number of studies, including the abovementioned study, examine age differences in reactivity. In the present study, we were interested in examining age differences in recovery. Recovery, however, cannot be examined without taking reactivity into account. The amount by which one's BP increases during a stressor, for example, is associated with how much time it will take for BP to reach prestressor levels (Larsen & Christenfeld, 2011). Furthermore, individuals vary greatly in the degree to which they both react to and recover from stressors (McEwen & Gianaros, 2011). For these reasons, it is necessary for researchers interested in stressor recovery to include stressor reactivity in their analyses to adjust for differences in this related process (e.g., Ottaviani, Shapiro, & Fitzgerald, 2011). As such, both reactivity and recovery were assessed in the present study.

The Present Study

The present study examined age, rumination, and affective and physiological reactivity and recovery to a stressor, building on prior research in several important ways. To examine the effect of rumination on recovery, we experimentally instructed half of the older and younger participants to continue thinking about the stressor after it was over (rumination condition), with the other participants given no additional instructions (control condition). We hypothesized that people placed in a rumination condition after being exposed to a stressor would exhibit delayed affective and physiological recovery in comparison to the no-instructions condition, even after adjusting for affective and physiological reactivity. We further hypothesized that this delayed recovery would be most pronounced among older, relative to younger adults. Finally, we included both affective and physiological reactivity and recovery in our models. As previously mentioned, affective and physiological measures are not highly correlated with one another. Furthermore, researchers have found that older adults are less *affectively* reactive, but more *physiologically* reactive than are younger adults (Uchino et al., 2006). By examining both affective and physiological reactivity and recovery, we were able to examine how certain cognitive processes (e.g., rumination) influence these outcomes separately. We also explored whether the effects of rumination on recovery differed between men and women.

Method

Participants

Healthy older adults (N = 52, age range 59–88 years; M = 69 years; 27 females) were recruited to the study using flyers placed in various community venues (e.g., Starbucks Coffee, senior centers) and 61 younger adults were recruited from the undergraduate subject pool at a university (age range 18–35 years; M = 21 years; 36 females). Most of the younger participants had completed at least some college (72%). An additional 28% had Bachelor or Associate's degrees. Among the older adults, most had either some college (32.7%) or an Associate's degree or higher (65.3%), and the remaining 2% had a high school education.

To be eligible for the study, participants had to be either Caucasian (69%) or Latino (27%). Our goal was to include non-Caucasian participants, yet have sufficient members of another group to make meaningful comparisons rather than compare Caucasians with "others." We chose to sample from the Latino populations because they have been underrepresented in the aging literature. The older group was more likely to be Caucasian (n = 45) than the younger group ($x^2(2)$ = 74.46, p < .001). Participants were recruited if they were not smokers, taking medications that influence cardiovascular functioning, did not have any diagnoses of psychological or cardiovascular disorders, and were willing to travel to the lab to participate in a 2-hr experiment. The smoking and health status criteria were selected because each is associated with affective and physiological functioning (e.g., Krantz & Falconer, 1995). Interested people called the laboratory and learned about these additional criteria and participation demands (travel to the laboratory; compensation), and then decided whether to participate in the study based on their own eligibility and interest.

Measures

The main independent variables (IVs) of interest in this study were age group (older vs. younger), condition (control or rumination), and time period (baseline, task, and recovery). The main dependent variables (DVs) were positive and negative affect, and systolic BP (SBP) and diastolic BP (DBP). Participants completed a brief demographic form in addition to the measures below. The demographic form asked participants to report their gender, ethnicity, and education level, which ranged from 1 (Elementary School) to 9 (Graduate School, Master's of Doctorate degree). Greater amount of exercise and lower body mass index (BMI) are each associated with lower BP (Droyvold, Midthjell, Nilson, & Holmen, 2005; Mayo Clinic, 2012). In addition, levels of depressive symptoms are directly related to positive and negative affect. As such, we collected information on depressive symptoms as well as BMI and physical activity to examine and adjust for any group differences on these factors, if necessary. See Table 1 for baseline means by age and condition groups.

Positive and negative affect

Participants reported their current positive and negative affect using the Daily Sampler (Carstensen, Mayr, Pasupathi, & Nesselroade, 2000). On the Daily Sampler, participants recorded how much they currently experience 19 discrete emotions, 8 positive (happiness, joy, contentment, excitement, pride, accomplishment, interest, and amusement), and 11 negative (anger, sadness, fear, disgust, guilt, embarrassment, shame, anxiety, irritation, frustration, and boredom), using a Likert-type scale (1 = not at all to 7 = extremely). Items were averaged within valence to create negative ($\alpha = .90$) and positive ($\alpha = .89$) affect scales.

Blood pressure

The participant's non-dominant arm was fitted with a Critikon BP cuff using the Dinamap Procare Ambulatory Monitor (GE Medical Systems Information Technologies, Inc., Milwaukee, WI, 2006). This BP cuff automatically recorded BP every 3 min during each of the periods (baseline, task, and recovery) of the session, resulting in an average of three readings (at the beginning, middle, and end) for each period. SBP and DBP were measured to capture the highest and lowest points of pressure in the aorta and its branches, respectively (Safar, 1989). SBP is expected to increase more among those who respond with an increase in heart rate, and DBP among those who respond with an increase in peripheral resistance (Jorgenson, Johnson, Kolodziej, & Schreer, 1996). As a result, both SBP and DBP were assessed to capture the broadest range of physiological response. We aggregated the readings within each period to obtain the most reliable measures of cardiovascular functioning (Krantz & Falconer, 1995).

Physical activity

Participants reported their daily physical activity (in minutes per day and days per week) using the International Physical Activity Questionnaire long form (Hagstromer, Oja, & Sjostrom, 2006). This questionnaire asked about three types of activities—walking, moderate exercise (e.g., carrying light loads) and vigorous exercise (e.g., heavy lifting and climbing stairs)—across several domains (e.g., work, transportation, home, and leisure). Each question asked how many days over the last week, and for how many minutes each day, participants engaged in a specific activity. Time spent in each activity over the week (summed within each category) was weighted so that vigorous activities carried more weight than moderate activities, which carried more weight than walking. This measure has acceptable validity for a measure of physical activity (Hagstromer et al., 2006).

Body mass index

BMI was calculated as the ratio of participants' height to weight using the formula, BMI = (weight in pounds) × 703/(height in inches)^2 (American Cancer Society, 2013).

Depressive symptoms

Participants reported their depressive symptoms using the Center for Epidemiologic Studies Depression Scale (CES-D) scale, a 20-item questionnaire asking participants whether they experienced any of 20 symptoms over the last 7 days. Responses were recorded on a Likert-type scale where 0 = rarely or none of the time (less than one day) and 3 = all of the time (5–7 days). Item responses were summed so that higher scores reflect more depressive symptoms ($\alpha = .61$; Radloff, 1977).

Procedure

Upon arrival to the laboratory for their 2-hr appointment, participants read and signed a consent form describing that they were participating in a study designed to see how people respond to different types of tasks and how those responses

Table 1. Baseline Means and *SD*s by Age and Conditions Groups

	Older, *M* (*SD*)		Younger, *M* (*SD*)	
	Control	Rumination	Control	Rumination
Education	6.88 (1.56)	6.65 (1.72)	5.17 (0.80)	5.00 (0.84)
BMI	26.70 (5.20)	26.45 (5.13)	24.20 (3.11)	23.58 (3.98)
IPAQ	6660.19 (7698.01)	7589.25 (5415.99)	5652.79 (5192.59)	5543.53 (7274.75)
CES-D	10.85 (8.20)	8.62 (8.36)	11.52 (8.19)	12.88 (7.26)
Age	68.58 (7.05)	69.04 (7.12)	21.41 (3.24)	20.53 (3.33)
Positive affect	3.90 (0.97)	4.11 (1.44)	2.94 (1.33)	3.27 (1.19)
Negative affect	1.33 (0.36)	1.82 (1.27)	1.55 (0.54)	1.69 (0.57)
SBP	123.32 (15.14)	124.43 (14.48)	112.86 (10.86)	110.92 (11.03)
DBP	77.85 (10.25)	78.79 (9.91)	71.16 (6.46)	72.15 (8.10)

Note: BMI = body mass index; CES-D = Centers for Epidemiologic Studies Depression Scale; DBP = diastolic blood pressure; IPAQ = International Physical Activity Questionnaire; SBP = systolic blood pressure.

change as people age. All procedures conducted for this research were approved by the university's Institutional Review Board.

After placement of a BP cuff, participants completed questionnaires including baseline positive and negative affect. Participants then sat alone quietly in the testing room for a 6-min baseline period during which BP was recorded (baseline BP). After the baseline period, participants completed the arithmetic portion of the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), which required them to count backwards from 1,022 by intervals of 13 for 5 min while being constantly interrupted (e.g., "Please go as fast as you can") by two stern-looking evaluators. If participants had difficulty carrying out the task, they were instructed to count backwards by intervals of 7 s.

Immediately after the stressor, participants reported their positive and negative affect and were then randomly assigned to one of two conditions: the control condition ($n = 55$) or the rumination condition ($n = 58$). In the control condition, participants were asked to sit quietly alone in the testing room for 6 min. In the rumination condition, participants were given the following instructions used in prior research (Glynn et al., 2002):

> At this time, I would like you to recreate the mental arithmetic task in your head as best you can. Try to remember all of the details as vividly as possible. It is very important that you focus on exactly how you felt the entire time. Pretend you are going through the entire experience in your mind. Remember, this is going to take place entirely in your mind, so do not move around at all.

Two times during those 6 min, participants heard tape-recorded reminders of the instructions. Control participants were given no instructions except to sit quietly in the testing room until the experimenter returned. Afterwards, participants reported their positive and negative affect, had their height and weight assessed, were fully debriefed, and were compensated for their time ($50 for older participants or class credits for younger participants). See Figure 1 for an illustration of the study procedures.

Statistical Analyses

Baseline and reactivity analyses

T-tests were used to examine any potential baseline differences between age groups and between the control and rumination groups on sociodemographic and health characteristics. Univariate analysis of covariance (ANCOVA) examining age group differences in reactivity were used to affirm that the study was successful in eliciting a response for each outcome variable. These tests also provided a measure of reactivity, which was used as a covariate in analyses examining affective and physiological recovery. In reactivity analyses, mean task values of SBP, DBP, and positive and negative affect were entered as the DV, with age group entered as the IV. Baseline values of the DVs were entered to adjust for any age group differences in baseline affective or physiological functioning.

Hypothesis testing: Recovery analyses

To examine affective and physiological recovery (the central hypothesis in this study), we adjusted for values of each outcome at both the baseline and task periods, consistent with prior analyses of recovery (Ottaviani et al., 2011; Page-Gould, Mendes, & Major, 2010). In these univariate ANCOVAs, the between-subject variables included age group (young vs. old), condition (rumination vs. control), and their interaction. The covariates included baseline and task levels of each outcome variable, as well as gender, education, ethnicity, and BMI (where significant). In addition to examining age group differences, we also explored whether there were sex differences in the effects of rumination on recovery.

Results

Baseline

T-tests which compared age groups on sociodemographic factors and potential health-related and emotion-related covariates revealed no differences in gender composition, depressive symptoms, or self-reported exercise. Older adults had higher BMI scores ($t(89.27) = -3.20$, $p = .002$) and had obtained a higher education level ($t(72.67) = -6.77$, $p < .001$). Regarding the outcome variables of interest, older adults had higher SBP ($t\ (110) = -4.98$, $p < .001$) and DBP ($t\ (110) = -4.06$, $p < .001$), and reported higher positive affect ($t\ (111) = -3.81$, $p < .001$) at the baseline period than did younger adults. Age groups did not vary significantly on baseline negative affect. See Table 2 for these outcomes of interest.

Participants in the control and rumination conditions did not significantly differ on education, BMI, exercise, depressive

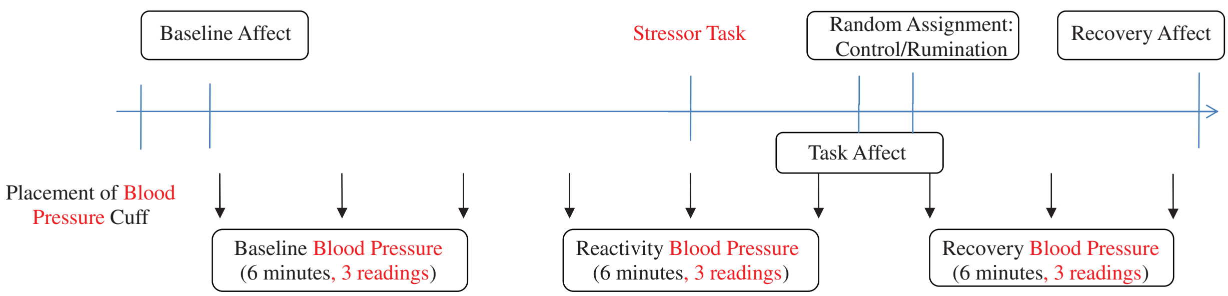

Figure 1. Study design for the three time periods.

Table 2. Mean and *SD*s by Age and Condition Groups

Variable	Group	Baseline *M* (*SE*)	Task *M* (*SE*)	Recovery *M* (*SE*)
Positive affect	Younger adults			
	Control	2.94 (1.33)	2.56 (0.18)	3.11 (0.16)
	Rumination	3.27 (1.19)	2.36 (0.17)	3.20 (0.15)
	Older adults			
	Control	3.90 (0.97)	2.46 (0.19)	3.11 (0.16)
	Rumination	4.11 (1.44)	2.49 (0.19)	2.99 (0.17)
Negative affect	Younger adults			
	Control	1.55 (0.54)	2.07 (0.19)	1.31 (0.08)
	Rumination	1.69 (0.57)	2.45 (0.18)	1.37 (0.08)
	Older adults			
	Control	1.33 (0.36)	2.87 (0.21)	1.47 (0.09)
	Rumination	1.82 (1.27)	2.13 (0.21)	1.47 (0.09)
SBP	Younger adults			
	Control	112.86 (10.86)	128.77 (1.88)	122.67 (1.29)
	Rumination	110.92 (11.03)	129.35 (1.84)	121.88 (1.26)
	Older adults			
	Control	123.32 (15.14)	130.99 (2.06)	121.87 (1.40)
	Rumination	124.43 (14.48)	135.63 (2.05)	129.28 (1.42)
DBP	Younger adults			
	Control	71.16 (6.46)	82.94 (1.07)	78.12 (0.80)
	Rumination	72.15 (8.10)	82.50 (1.02)	76.52 (0.76)
	Older adults			
	Control	77.85 (10.25)	80.59 (1.15)	78.85 (0.87)
	Rumination	78.79 (9.91)	82.47 (1.15)	81.08 (0.86)

Note: DBP = diastolic blood pressure; SBP = systolic blood pressure.

symptoms, or baseline positive affect, SBP, or DBP. Participants in the rumination condition had significantly higher baseline negative affect than controls ($t(85.13) = -2.19$, $p = .03$). Baseline negative affect was included as a covariate in all remaining models to adjust for this difference.

Reactivity

Univariate ANCOVAs revealed that both younger and older groups experienced increases in SBP and DBP during the stressor. In analyses that included all covariates, older participants were more reactive to the stressor task than younger participants on SBP ($F(1, 107) = 4.09$, $p = .05$, $\eta^2 = 0.04$). See Figure 2 for an illustration of this main effect. Positive affect decreased and negative affect increased to a similar degree for both older and younger adults. See Table 2 for means and standard deviations by age and condition groups at the baseline, task, and recovery periods. These results reinforced the need to include both baseline and reactivity measures in tests of recovery, the central question of the study.

Recovery

Our primary hypothesis that rumination would be worse for the recovery of older than younger adults was supported in separate univariate ANCOVAs for SBP and DBP that included both baseline and task values of BP in addition to the other covariates. The main effects of age on SBP ($F(1, 104) = 5.20$, $p = .03$, $\eta^2 = 0.05$) and DBP ($F(1, 104) = 9.46$, $p = .003$, $\eta^2 = 0.083$) were qualified by significant age × condition interactions. After adjusting for the covariates, older adults' SBP ($F(1, 104) = 9.87$, $p = .002$, $\eta^2 = 0.09$) and DBP ($F(1, 104) = 5.60$, $p = .02$, $\eta^2 = 0.05$) were significantly elevated during the recovery period compared to older adults in the control condition and all younger adults. See Figure 3 for these effects—there is a significant difference between younger ruminators and older controls for DBP recovery, with older controls having higher DBP than younger adults. SAVI posits that older adults are better at engaging in emotion regulation strategies, but that biological processes will show age-related decreases in functioning. It is unclear how these two competing factors will play out in the recovery of younger and older adults. Future studies examining both biological-based processes and emotion regulation strategies will further clarify how these processes work together to predict cardiovascular recovery. There was no significant effect of rumination on affective recovery for any of the participants.

The effects of the rumination condition did not significantly differ by ethnicity. The only gender difference observed was for negative affect ($F(1, 107) = 4.23$, $p = .04$, $\eta^2 = 0.04$). Among the women, rumination resulted in elevated negative affect during the recovery period relative to

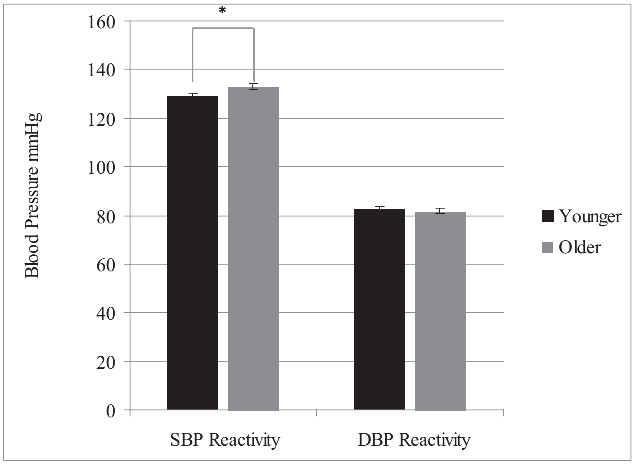

Figure 2. Age difference in systolic blood pressure and diastolic blood pressure at the task period showing reactivity. Note: this figure displays means adjusted for baseline negative affect and baseline measures of blood pressure. *$p < .05$.

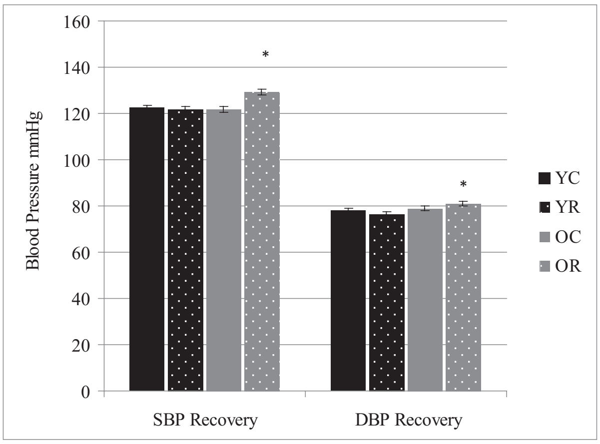

Figure 3. Age and group differences in systolic blood pressure (*$p < .01$) and diastolic blood pressure (*$p < .05$) at the recovery period. OC = older control; OR = older rumination; YC = younger control; YR = younger rumination. Note: this figure displays means adjusted for baseline negative affect and blood pressure at both the baseline and task periods.

controls, whereas the opposite was true among the men. No other gender differences in recovery were observed.

Discussion

Researchers have produced a number of studies examining age differences in *reactivity* to stressors. Less work has been devoted to age differences in *recovery* from stressors. Consistent with previous research (Uchino et al., 2006), older adults in the present study were no more *affectively* reactive, but were significantly more *physiologically* (SBP) reactive to the stressor than younger adults. We adjusted for this age difference in reactivity to test our primary hypothesis that the rumination condition would delay recovery more so for older than younger adults. After adjusting for baseline and task (reactivity) differences between older and younger adults, rumination prolonged physiological, but not affective, recovery among older adults on both SBP and DBP. The rumination condition had no influence on the affective or physiological recovery of younger adults.

Blood Pressure

Older adults had significantly elevated SBP and DBP at baseline relative to the younger adults and were significantly more physiologically reactive to the stressor – as measured by SBP – than were younger adults. Using methods established by previous researchers (Ottaviani et al., 2011; Page-Gould et al., 2010), we adjusted for these baseline and task levels of the four DVs in their respective models for the most stringent test of our hypothesis regarding affective and physiological recovery. After adjusting for baseline and task levels, both systolic and diastolic measures of BP were elevated among older participants in the rumination condition compared to all other groups during the recovery period.

Before interpreting these and other results from the current study, we want to clarify that we assume that older and younger participants followed the instructions of the protocol to the same extent. We used similar instructions from a study successfully run with younger adults in the past (Glynn et al., 2002) with people being asked to ruminate during the recovery period. We also added a 3-min reminder in the rumination condition to reinforce these instructions. However, because we had no mechanisms to observe this internal process, we have no guarantee that all people followed instructions, and particularly that younger and older adults engaged equally in this rumination process. If younger adults did follow instructions, the findings regarding the BP results support a main supposition of SAVI which posits that age-related benefits of emotion regulation will be attenuated when older adults do not disengage from distressing emotional experiences. Although we had no measure to capture their inner thoughts during the recovery period, the goal of the rumination condition was to dissuade those participants from engaging in any distraction or reappraisal emotion regulation strategies. Among older rumination participants, this task resulted in delayed physiological recovery.

Age differences in the effects of rumination may have important health implications. Older adults often report avoiding potential conflict, and when they do so, they experience less BP reactivity than younger adults (Charles, Piazza, Luong, & Almeida, 2009). Our findings suggest that, when they are placed in a situation where they are asked to dwell on the stressor, older adults' BP remains elevated to a greater extent relative to younger adults. Delayed BP recovery is damaging to the cardiovascular system (McEwen & Gianaros, 2011), perhaps even more so for older adults whose cardiovascular systems are often already compromised (Gianaros & Sheu, 2009). The avoidance behaviors commonly reported by older adults may therefore represent adaptive strategies that allow them to compensate for age-related physiological decline.

In contrast to our hypothesis, rumination had no effect on the BP of the younger participants. In another study, younger adults who engaged in rumination had a prolonged BP recovery compared to those in the control condition (Glynn et al., 2002). In that study, younger adults also had a stronger reaction to the protocol. It is possible that with lower levels of arousal in a healthy, robust individual, recovery may be less likely influenced by psychological factors. As such, the effects of rumination in the current study may not have been great enough to impede cardiovascular recovery among younger adults. Another possibility is that younger adults were ruminating during the recovery period whether they were instructed to or not. This alternative is consistent with literature showing that younger adults are more likely to ruminate than are older adults (Nolen-Hoeksema & Aldao, 2011; Phillips et al., 2006).

Affect

Both older and younger adults were affectively reactive to the TSST, as indicated by the decrease in positive and increase in negative affect immediately after the stressor. There were, however, no age differences in affective reactivity or recovery to the stressor task. In addition, the decoupling of subjective and physiological aspects of emotion observed in other studies (e.g., Davidson, 1999) was evident in the present study; rumination during the recovery period only influenced BP and not affect. One explanation for this null finding may be that the strategies employed by older adults during conflict may be efficient in regulating affective functioning, but less so for physiological modulation.

Regarding gender differences, rumination had the expected effect on negative affect recovery among women. However, male participants who were randomly assigned to the control condition had higher negative affect during the recovery period than male participants in the rumination condition. Rumination is self-reported more often among female than male participants (Nolen-Hoeksema, Morrow, & Fredrickson, 1993). In the present study, participants were instructed to think about the *details* of the stressor they had encountered and to focus on how the stressor had made them *feel*. It is possible that men may have responded to this instruction by perhaps focusing more on the *details* of the event than their *feelings* per se, whereas women focused on their affective state. In addition, it is possible that men in the rumination condition may have focused on the non-emotional aspects of the task than did men in the control condition.

Limitations and Conclusion

We speculated that older adults in the control condition would spontaneously distract themselves and thus hasten their recovery from the adverse event. Although this speculation is consistent with older adults' greater use of strategies that reduce their exposure to negative events (e.g., Charles, 2010), we did not test this assumption. We also assumed, like many studies examining age differences in behavioral and emotional processes, that both younger and older adults were following the instructions of the protocol. Although we were concerned that asking people if they had followed the instructions would place demand characteristics on the participants and yield unreliable results, future studies may need to examine whether people will admit to digressing from a protocol. In addition, despite random assignment, there was a significant difference in baseline negative affect between the older control and rumination participants. The pattern of results in the current reactivity and recovery analyses, however, did not change after adjusting for this baseline difference. Lastly, we only included healthy older adults to ensure that any age differences were not the result of medications or chronic conditions that influence hemodynamic processes. However, in future studies, researchers might want to recruit an older sample without the same health criteria used in the present study to test generalizability of the results. As such, people should be cautious when generalizing the findings to older adults who have conditions that may influence these processes.

Chronic activation of the stress systems can lead to long-term wear and tear (McEwen & Gianaros, 2011). Given age-associated declines in physical functioning (Gianaros & Sheu, 2009), older adults may be particularly at risk for health problems resulting from chronic activation of these systems. SAVI argues that older adults adaptively employ emotion regulation strategies to protect themselves from experiencing high level of arousal (Charles, 2010). This study showed that, when asked to engage in a cognitive process that made them focus on a stressor, older adults experienced delayed BP recovery relative to all other participants. These findings add to our understanding of the complex interplay between affective and physiological functioning over the life course. In addition, they suggest that research on the physiological effects of rumination among younger or middle-aged adults may provide an overly optimistic picture if people generalize these findings to older adults.

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