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Conflict and Collaboration in Middle-Aged and Older Couples: II: Cardiovascular Reactivity during Marital Interaction

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Abstract

Marital strain confers risk of cardiovascular disease (CVD), perhaps though cardiovascular reactivity (CVR) to stressful marital interactions. CVR to marital stressors may differ between middle-age and older adults, and types of marital interactions that evoke CVR may also differ across these age groups, as relationship contexts and stressors differ with age. We examined cardiovascular responses to a marital conflict discussion and collaborative problem solving in 300 middle-aged and older married couples. Marital conflict evoked greater increases in blood pressure, cardiac output and cardiac sympathetic activation than did collaboration. Older couples displayed smaller heart rate responses to conflict than did middle-aged couples, but larger blood pressure responses to collaboration–especially older men. These effects were maintained during a post-task recovery period. Women did not display greater CVR than men on any measure or in either interaction context, though they did display greater parasympathetic withdrawal. CVR to marital conflict could contribute to the association of marital strain with CVD for middle-aged and older men and women, but other age-related marital contexts (e.g., collaboration among older couples) may also contribute to this mechanism.

Keywords

marital conflict; cardiovascular reactivity; collaboration; impedance cardiography; heart rate variability; aging

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Marriage is an important influence on physical health across the lifespan. Married individuals live longer than the unmarried, and they are at reduced risk of cardiovascular disease (CVD) (Johnson, Backlund, Sorlie, & Loveless, 2000; Kaplan & Kronick, 2006), although this benefit is often stronger for men than women (Kiecolt-Glaser & Newton, 2001). Marital quality also influences health. Divorce, separation, and marital strain or conflict are associated with reduced longevity (Tucker et al, 1996), increased risk of

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hypertension and related cardiovascular complications (Baker et al., 2000), atherosclerosis (Gallo et al., 2003), coronary heart disease (De Vogli, Chandola, & Marmot, 2007; Matthews & Gump, 2002; Zhang & Hatward, 2006), and poor medical prognosis among persons with heart disease (Orth-Gomer et al, 2000; Rohrbaugh, Shoham, & Coyne, 2006). Similarly, for men low marital quality reduces otherwise beneficial effects of frequent spouse contact on progression of atherosclerosis (Janicki et al., 2005).

Physiological effects of stress are an important mechanism in models of health effects of marriage. Social support is associated with reduced physiological responses to stressful stimuli (Uchino, 2006), and this effect could contribute to health benefits of supportive relationships generally and marriage in particular (Uchino et al., 2007). Reports of marital strain are associated with larger cardiovascular and neuroendocrine responses during marital disagreements, as is hostile behavior during such interactions (Robles & Kiecolt-Glaser, 2003). These responses could contribute to health consequences of low marital quality, as heightened cardiovascular reactivity (CVR)–increases in heart rate and blood pressure in response to stressors–are hypothesized to confer increased risk of CVD.

Specifically, unlike metabolically appropriate increases in heart rate and blood pressure during physical activity (e.g., exercise), CVR during psychological stressors exceeds metabolic demands (Sapolsky, 2004; Sherwood, Allen, Obrist, & Langer, 1986). Over time, repeated and prolonged episodes of metabolically excessive CVR are hypothesized to promote sustained increases in blood pressure, development of atherosclerosis, and the precipitation of cardiovascular events (i.e., stroke; myocardial infarction) (Obrist, 1981; Schwartz et al., 2003). Consistent with this view, CVR during psychological stressors is associated with increased risk of hypertension (Matthews et al., 2004; Matthews, Salomon, Brady, & Allen, 2003), atherosclerosis (Barnett et al., 1997; Jennings et al., 2004; Matthews et al., 2006), stroke (Everson et al., 2001; Waldstein et al., 2004) and manifestations of coronary heart disease (Krantz et al., 1991). Given its potential role in associations between marital processes and CVD, the present study examined CVR during marital interactions. Specifically, we tested the effects of age, sex, and type of marital interaction on CVR. We also examined similar effects on post-interaction levels of CVR, as poor recovery following psychological stressors also contributes to CVD (e.g., Steptoe & Marmot, 2005; Stewart, Janicki & Kamark, 2006).

Aging and Adult Development

The cardiovascular diseases influenced by marital quality develop over many years, usually becoming clinically apparent during middle and later adulthood. Hence, it is important to examine mechanisms linking marital processes to disease across a wide age range. CVR to psychological stressors is generally higher in later adulthood (Jennings et al, 1997; Uchino et al., 2005; Uchino et al., 2006). Hence, marital stressors might evoke greater CVR among older adults.

The nature of marital stressors

However, marital interactions differ across adulthood in ways that might reduce CVR (Gagnon, Hersen, Kabacoff, & Van Hasselt, 1999; Rook, Mavandadi, Sorkin, & Zettel, 2007). For example, older couples sometimes display less hostility and greater affection during marital conflicts than do younger couples, and reduced physiological reactivity during these interactions (Carstensen, Gottman, & Levenson, 1995; Levenson, Carstensen, & Gottman, 1993). Therefore, physiological effects of conflict might be a less important mechanism linking marital difficulties and health among older couples.

Yet, stress may occur in other interaction contexts for older couples. Older couples engage in more conjoint efforts to manage routine tasks and challenges (i.e., collaborative problem solving) than younger couples (Baltes & Staudinger, 1996; Berg et al., 2006), and they may benefit more from such efforts (Johansson, Andersson, & Ronnberg, 2000). Couples of all ages collaborate, but it is a more important means of adapting to demands of daily life in later adulthood, in compensating for declining cognitive or physical abilities, or simply as spouses spend more time together in retirement (Dixon & Gould, 1998). Increased collaboration could be stressful for older couples, especially if it raised concerns regarding independence, competence, or control in the relationship (Ehrensaft et al., 1999; Gray-Little & Burks, 1983; Martire, Stephens, Druley, & Wojno, 2002).

Determinants of CVR

Physiological mechanisms underlying CVR may also differ with age (Cooper, Katzel, & Waldstein, 2007). Heart rate (HR) reactivity is influenced by both sympathetic and parasympathetic mechanisms, and these underlying autonomic responses may differ with age. Sympathetic influences on HR can be measured as cardiac pre-ejection period, the time elapsed between the beginning of the contraction of the heart and the moment when ejected blood forces the aortic valve to open. Shorter pre-ejection periods reflect more vigorous (i.e., rapid and forceful) ventricular contraction, an indication of increased sympathetic input to the heart. Parasympathetic influences on HR can be assessed as high frequency heart rate variability, an index of respiratory sinus arrhythmia (Cacioppo, Uchino, & Bernston, 1994). Heart rate increases during inspiration and decreases during exhalation. The proportion of HR variability that corresponds to this respiratory cycle is related to the strength of parasympathetic input to the heart, such that greater high frequency heart rate variability indicates greater parasympathetic activity.

Blood pressure reactivity is influenced by cardiac and vascular mechanisms (Sherwood et al., 1990). Cardiac influences refer to cardiac output–the amount of blood pumped from the left heart each minute. Holding other factors constant (e.g., dilation vs. constriction of the vasculature), increases in cardiac output raise blood pressure. Vascular influences on blood pressure are reflected in total peripheral resistance–the aggregate resistance to blood flow through the systemic circulation. Short-term changes in peripheral resistance generally reflect the constriction versus dilation of the vasculature. Holding cardiac output constant, increased in peripheral resistance through vascular constriction raises blood pressure, whereas dilation lowers blood pressure.

Aging is associated with increased sympathetic activity and tonic peripheral resistance, and decreased heart rate variability (Cooper et al., 2007). Psychological influences on these mechanisms might also vary with age. For example, the psychological experience of challenge evokes pre-ejection period shortening (i.e., increased sympathetic activity) and increased cardiac output, whereas threat evokes increased peripheral resistance (Blascovich & Tomaka, 1996). Similarly, active coping and effortful task engagement evoke increased cardiac output and sympathetic cardiac activity, whereas watchful observation of the environment evokes increased peripheral resistance (Brownley, Hurwitz, & Schniederman, 2000). Older couples might find marital conflict less threatening or engaging than their middle-aged counterparts (Carstensen et al., 1995), perhaps altering these underlying mechanisms. Determinants of CVR during marital interaction have not been widely studied. However, a study of young couples found that HR reactivity during negative interactions reflected increased sympathetic activity (i.e., pre-ejection period shortening) rather than parasympathetic withdrawal, and blood pressure reactivity reflected increased cardiac output, suggesting a sympathetically-mediated response (Nealey-Moore et al., 2007) as in challenge.

Sex Differences in Marital Stress and Cardiovascular Reactivity

Effects of marital interactions on CVR may differ for men and women. Women are generally more troubled by problems in close relationships than are men (Davis, Matthews, & Twamley, 1999), perhaps because relationships are more central in their self-definitions (Cross & Madson, 1997). Women often display greater CVR to marital stressors than do men, and this toll from everyday relationship stressors could contribute to their reduced health benefit from marriage (Kiecolt-Glaser & Newton, 2001). However, some studies do not find this sex difference (e.g., Broadwell & Light, 1999; Nealey-Moore et al., 2007). Further, women's greater reactivity might reflect their tendency to identify potential marital disagreements and to initiate and pursue conflict discussions (Denton, Burleson, Hobbs, Von Stein, & Rodriguez, 2001; Newton & Sanford, 2003). That is, women's greater CVR during negative marital interactions might reflect greater levels of speaking, task engagement, or active coping (Smith, Ruiz, & Uchino, 2000).

Models of gender-linked vulnerabilities to stress suggest that women may be susceptible to stressors related to relationship harmony versus discord, whereas men may be more reactive to issues of control, power, or status in the relationship (e.g., Helgeson, 2003; Smith, Gallo, Goble, Ngu, & Stark, 1998). In this view, female sex roles emphasize a broad motive complex labeled *communion,* such as concerns regarding the maintenance of relationship quality. In contrast, male sex roles emphasize a set of motives called *agency*, such as concerns about independence, achievement, status and control (Bakan, 1966; Wiggins, 1996). Hence, women may display greater reactivity when marital interactions threaten communion, as during conflict. In contrast, men may be more reactive when the interaction is related to agency, as during achievement-oriented tasks. In prior research, women tend to display greater CVR during marital interactions involving communal stressors such as disagreement, whereas men display greater reactivity when marital interactions emphasize dominance or achievement (e.g., Brown & Smith, 1992; Smith, Gallo et al., 1998).

These sex differences may also be moderated by age. As noted above, over the course of adulthood conflict could decrease in importance as a context for potentially stressful marital interaction, perhaps reducing women's physiological reactivity to such stressors. In contrast, collaborative problem solving may increase in importance. Especially for older adults, collaboration could evoke issues related to agency, such as control, competence, and independence, as collaboration takes on added importance as a means to manage daily tasks in the face of growing concerns about declining cognitive abilities and functional activity levels. If so, collaboration could be particularly stressful for older men, given sex differences in CVR during agency and communion challenges (e.g., Smith et al., 1996; 1998).

The Present Study

To examine the effects of age, sex, and interactional context on CVR and recovery in response to marital interaction, we recorded HR and blood pressure as well as determinants of these responses in middle-aged and older couples during and after two tasks - a marital conflict discussion and collaborative problem solving. We predicted that marital disagreement would evoke greater CVR and less recovery than would collaborative problem solving, given its more aversive nature. Prior studies suggested that women would respond to disagreement with greater CVR than men (Kiecolt-Glaser & Newton, 2001), although not all studies support this conclusion. If collaborative problem solving evokes concerns related to agency, men should be more responsive than women to this task (Brown & Smith, 1992; Smith et al., 1998). Prior findings of increased CVR with age (Jennings et al, 1997; Uchino et al, 2005) suggest that responses to stressful marital interactions would be larger among older than middle-aged couples. However, theory and research on age differences in interpersonal stress (Carstensen, Isaacowitz, & Charles, 1999) suggests that CVR in older individuals might be smaller than for middle-aged couples, especially during disagreement. We also predicted that collaborative problem solving would evoke greater CVR among older couples, given its greater relevance for older couples (Berg et al., 2006; Dixon & Gould, 1998). Finally, we examined affective responses, spouse appraisals, and overt behavior during these interactions (Smith et al., 2009) as mediators of age differences in CVR in response to conflict and collaboration.

Method

Participants

The Utah Health and Aging Study enrolled 146 middle-aged and 154 older couples during 2001–2005. Details of the sample, recruitment, and eligibility criteria are provided in a companion paper (Smith et al., 2009). Mean age for middle-aged wives and husbands was 43.9 (SD = 3.8, range = 32–54 years) and 45.8 years (SD = 4.0, range = 37–59), respectively, and 62.2 (SD = 4.5, range = 50–71) and 64.7 years (SD = 4.3, range = 52–76) for older wives and husbands. Mean marriage length was 18.4 years (range = 2.5 –31) for the middle-aged group and 36.4 years (range = 5 – 53) for the older group. All participants were free of pre-existing cardiovascular disease and not taking medications for cardiovascular disease (i.e., beta-blockers, calcium-blockers, anti-anginals).

Procedure

For details for the study protocol, see Smith et al. (2009). Prior to the initial laboratory session, participants completed questionnaires, including the Marital Adjustment Test

(MAT; Locke & Wallace, 1959). During that session couples participated in a disagreement discussion and a collaborative problem-solving task in a counter-balanced order. Tasks were videotaped for behavioral coding. Before both tasks, couples sat quietly, facing each other at a table but separated from view by a movable partition. For 10 minute baselines, participants completed a minimally involving task procedure (Jennings et al., 1992; Smith et al., 2000) in which an audiotape recording prompted them to turn pages in a booklet to examine pairs of landscape pictures. At one minute intervals they silently indicated which picture they preferred and turned to the next pair. After both baselines, participants completed a state affect questionnaire indicating how they felt at that moment. Blood pressure readings were taken at 90 sec. intervals during baseline; the last three readings were averaged to compute baseline values. Impedance cardiography measures were recorded continuously during baseline, and values for the time period corresponding to the final three blood pressure readings were averaged for baseline values. After baseline, the partition was removed and participants received instructions for either the disagreement or collaborative problem solving task. After the task, the partition was replaced and two blood pressure readings were recorded during a 3 minute recovery period. Participants then underwent a second baseline period identical to the first. They then completed the second task, again followed by two blood pressure readings. A schematic of this procedure is presented in Figure 1.

Disagreement Task—As described elsewhere (Smith et al., 2009), for the disagreement task a mutually identified topic was selected for discussion. Prior to the first session couples separately completed the Areas of Disagreement Questionnaire adapted from Fincham (1985), rating their level of disagreement on 13 topic areas (e.g., money, household responsibilities, etc.). Topics with the greatest combined rating of disagreement were suggested for discussion, with the instruction that, “it needs to be something that is currently an issue rather than something that has been resolved in the past.” They were also informed that the topic should be an issue that, “you can discuss for the full time period with both of you contributing to the discussion, and both of you need to feel comfortable discussing it here.” After the topic was selected, couples were told, “we are not expecting you to solve the particular issue right now; you can think of this as an opportunity to work toward making progress on the issue.”

Participants began a 6-minute unstructured conversation regarding this topic and BP was measured three times at equally spaced intervals; impedance cardiography output was measured continuously. After the 6-minute discussion, audiotaped instructions led participants through a 6-minute turn-taking section in which spouses alternated speaking for 1-minute intervals; speaking order (i.e., husband versus wife first) was counterbalanced across couples. During this segment, one BP measurement was taken during each speaking turn; impedance cardiography recording continued continuously. The turn-taking portion was followed by another unstructured conversation during which couples were instructed to discuss the topic together for 3 minutes. Two additional BP measurements were taken, along with continuous impedance cardiography recording. The structured turn-taking conversation was used to control the effects of speaking on the physiological measurements. Following the discussion task, participants completed an affect measure, indicating how they felt during the task. They then rated their partner’s behavior during the interaction. As participants completed post-task questionnaires, two additional blood pressure readings were recorded and HR and other cardiovascular measures were recorded continuously for three minutes.

Collaborative Problem Solving Task—The collaborative task is also described in the companion report (Smith et al., 2009). Couples were given a map of a fictitious town and a list of errands, and asked to plan a route and schedule to complete the errands by the shortest distance and in a designated time period. The task had the same structure as the disagreement task, and physiological measures, self-reports of state affect and ratings of spouse’s behavior were recorded on the same schedule.

Measures

Affective, cognitive, and behavioral measures—We assessed state anger and anxiety after baseline and after the interaction tasks, and participants also rated their spouses’ levels of warmth (vs. hostility) and dominance (vs. submissiveness) during the tasks. We coded task behavior, using a system that captured variations in warmth versus hostility and aspects of control or dominance and assertion (see Smith et al., 2009).

Cardiovascular responses—Dinamap 8100 monitors (Critikon; Tampa, FL) were used to assess systolic and diastolic blood pressure (SBP, DBP) and heart rate (HR). An occluding cuff was attached to the upper portion of the non-dominant arm. To assess the determinants of HR and blood pressure responses, electrocardiogram (ECG), basal thorasic impedance (Zo), and the first derivative of the impedance signal (dZ/dt) were measured continuously using Minnesota Impedance Cardiographs (Model HIC 2000, Surcom; Minneapolis, MN). This allows for the measurement of stroke volume and pre-ejection period, and the estimation of cardiac output, total peripheral resistance, and high frequency heart rate variability as an index of respiratory sinus arrhythmia (Berntson, Cacioppo, & Quigley, 1993; Sherwood et al., 1990). Four band electrodes were placed consistent with guidelines (Sherwood et al., 1990). Voltage bands were placed at the base of the neck and at the bottom of the sternum, and current electrodes were placed at least 3 cm distal to the voltage electrodes. A 4-mA AC current at 100 kHz was passed through the two current bands, and the Zo and dZ/dt signals were recorded from the voltage electrodes. The ECG, Zo, and dZ/dt signals were digitized at 500 Hz. These data were ensemble-average in 1-min epochs, and the waveforms were verified or edited before conducting analyses. Using the Kubicek equation, stroke volume (SV) was estimated and cardiac output was calculated in l/min as HR X (SV/1000) (Sherwood et al., 1990). On the basis of mean arterial pressure (MAP) and cardiac output, total peripheral resistance (TPR) was calculated in resistance units (dynes-s X cm^{-5}) as TPR = MAP/CO X 80 (Sherwood et al., 1990). Pre-ejection period was calculated as the time interval in msec between the Q-point of the ECG and the B-point of the dZ/dt signal. In this manner, HR, pre-ejection period, cardiac output, and total peripheral resistance values were determined for each 1-min interval of all experimental periods.

High frequency heart rate variability was calculated on the basis of the digitized inter-beat intervals from the ECG, initially checked and edited for artifacts using the detection algorithm of Berntson, Quigley, Jang, and Boysen (1990). A heart period time series was created from the inter-beat intervals using a weighted beat algorithm (Berntson, Cacioppo, & Quigley, 1995). Sharp transitions in the heart period time series (e.g., movement and heart rhythm artifacts) were detected and removed by smoothing (Berntson et al., 1990). A linear polynomial was fit to, and subtracted from, the heart period time series (Litvack, Oberlander, Carney, & Saul, 1995). This linear detrending acted as a high pass filter, removing very large ultralow frequency trends (including the DC component) from the input signal. The heart period time series was then band-pass filtered from 0.12 to 0.40 Hz (Neuvo, Cheng,-yu, & Mitra, 1984). The power spectrum of the heart period time series was calculated via a fast Fourier transformation and scaled to $msec^2/Hz$. Heart rate variability was calculated for each minute as a natural log of the area under the heart period power spectrum within the corner frequencies of the bandpass filter (Litvack et al., 1995).

Overview of Analyses

Mixed ANOVA was used for the main analyses. To accommodate dependency of spouses' responses, Sex was a repeated factor (Kenny, 1995). Task (collaboration vs. disagreement) and Period (i.e., initial unstructured discussion, structured interaction, second unstructured interaction within both tasks) were repeated factors.[1] Age Group was a between subjects factor. For CVR, task minus baseline change scores were calculated (Llabre et al., 1991), using the baseline immediately preceding each task and average values within periods. For recovery, a Task x Sex x Age mixed ANOVA was used on recovery–baseline change scores. To follow-up significant interactions, mean comparisons with the appropriate error term from the ANOVA were used (Bernhardson, 1975). Effect sizes are reported as eta-squared. SBP, DBP, and HR were considered primary dependent variables; the remaining measures were used to explicate effects on primary outcomes.

Variations in degrees of freedom reflect missing data, mostly from poor quality impedance cardiography signals. Because couples were the unit of analysis (Kenny, 1995), missing data for either member resulted in a missing case. Percentages of missing cases were as follows: SBP, DBP, and HR −–4.7%; pre-ejection period –35.3%; heart rate variability –21.3%; cardiac output –35.7%; total peripheral resistance –39%. Given these levels of missing data, the main measures of CVR (i.e., HR, SBP, DBP) should be interpreted with more confidence than measures of underlying determinants. Age groups did not differ in amount of missing data, and no psychosocial factors (e.g., marital satisfaction, affect, etc.) were related to missing versus non-missing status.

Results

Overview of Task Differences in Affect, Spouse Appraisals, and Behavior

Before presenting results for CVR and recovery, it is important to summarize the affective, cognitive, and behavioral distinctions between the two marital interaction contexts, reported

[1]The Period main effect (i.e., initial unstructured discussion, structured discussion, second unstructured discussion) was significant for most cardiovascular measures, indicating greater reactivity while participants were known to be talking (i.e., structured period) than when they could have been talking (i.e., unstructured discussions). However, in no cases did the Period factor interact with Task, Age, or Sex (or combinations of these factors) in such as way that one of those primary effects was found during some but not all of the levels of the Period factor. Hence, results for the period factor are not presented further.

elsewhere (Smith et al., 2009). Compared to collaboration, disagreement evoked larger increases in anger and anxiety, and spouses rated each other as more hostile (i.e., less friendly) and more controlling. For objectively coded behavior, couples displayed more control, hostile control, and assertiveness during disagreement than collaboration. During disagreement couples also displayed more warmth, primarily in the form of disclosing information and affirming the partner's comments. Behavior during collaboration primarily involved leading and following (i.e., warm control and submission). Hence, the tasks evoked distinct interactions and experiences, resembling closely the two marital contexts we intended to model as influences on CVR. Also, women displayed more anger during disagreement than did men, and they rated their spouses as more hostile. Older couples reported less anger in response to the disagreement than did middle-aged couples, and they perceived their partners as more friendly (i.e., less hostile) overall.

Baseline Cardiovascular Levels

Baseline levels of cardiovascular function and results of 2 (Age) x (2) (Sex) mixed ANOVAs of average baseline levels are presented in Table 1. Compared to men, women displayed lower baseline SBP, DBP, and cardiac output, and higher HR and heart rate variability. Consistent with prior research (Cooper et al., 2007), compared to the middle-aged group older participants displayed higher SBP, DBP, and total peripheral resistance; lower cardiac output and heart rate variability; and shorter pre-ejection periods.

An Age x Sex interaction on SBP indicated that the age group difference was somewhat larger for women than men, and the sex difference was larger for middle-aged than older participants. An Age Group x Sex interaction for baseline cardiac output indicated that middle-aged men and women did not differ but older women displayed lower resting cardiac output than did older men and middle-aged women. A significant Age Group x Sex interaction on baseline total peripheral resistance indicated that the age-related difference in women's total peripheral resistance was greater than that for men, though significant for both. Further, middle-aged men and women did not differ, but older women displayed higher resting total peripheral resistance than older men. Finally, an Age Group x Sex interaction for baseline heart rate variability indicated that the age–related difference was larger for women than for men. Overall, age–related differences in blood pressure and heart rate variability tended to be larger for women than for men. The larger age difference in women's blood pressure likely reflects their greater age-related difference in total peripheral resistance, because older women actually showed less cardiac output.

Given the repeated nature of the tasks, it is important to note that analyses of order indicated that baseline levels before the second task were equivalent or somewhat below the initial baseline, for all measures. Hence, the second baseline was successful in returning participants to initial resting levels, and equally so for older and middle-aged participants, and for men and women.

Blood Pressure Reactivity and Determinants

Results are presented for each individual cardiovascular outcome in the following text. To provide a summary of common effects across measures, main effects for Task and Age Group are presented in Tables 2 and 3, respectively.

A 2(Age) x (2) (Sex) x (2) (Task) mixed ANOVA on SBP change scores revealed a significant task main effect. As presented in Table 2, participants displayed a larger increase in SBP during disagreement than during collaboration. As presented in Table 3, an Age main effect indicated that older participants responded with a larger increase in SBP than did middle-aged participants. These main effects were qualified by a significant Sex x Task interaction, $F(1,284) = 16.73$, $p<.001$, eta-squared = .056, and a Sex x Task x Age interaction, $F(1,284) = 7.45$, $p<.01$, eta-squared = .026. Means for these effects on SBP reactivity are presented in Figure 2. Within the Sex x Task interaction, both men and women showed greater SBP reactivity during disagreement than collaboration (men: 8.9 mmHg vs. 5.9 mmHg, SE = .52, .50; women: 9.7 mmHg vs. 3.1 mmHg, SE = .53, .49), both $t(284)>3.0$, $p<.01$. During disagreement, men and women did not differ, but during collaboration men displayed larger increases in SBP than did women, $t(284) >3.0$, p<.01. Within the Sex x Task x Age interaction (see Figure 2), comparisons indicated that middle-aged and older men and women did not differ during disagreement. However, during collaboration, older men displayed greater SBP reactivity than did each of the other three groups, all $t(284) > 3.0$, $p<.01$.

The mixed ANOVA of DBP change scores revealed a significant Task main effect. As presented in Table 2, disagreement evoked greater DBP reactivity than collaboration. This effect was qualified by a Task x Age interaction, $F(1,284) = 9.27$, $p<.005$, eta-squared = .032 (see Figure 3). Follow-up comparisons indicated that for both middle-aged and older participants, disagreement evoked greater DBP reactivity than collaboration, both $t(284) > 3.0$, $p<.01$. Further, middle-aged and older groups did not differ during disagreement, but older participants displayed greater DBP reactivity during collaboration than middle-aged participants, $t(284) > 3.0$, $p<.01$.

The mixed ANOVA of cardiac output indicated disagreement evoked a significantly larger increase than collaboration, as presented in Table 2. As seen in Table 3, older participants responded with a larger increase in cardiac output across tasks than did middle-aged participants. This effect was qualified by an Age x Sex interaction, $F(1,190) = 7.89$, $p<.005$, eta-squared = .040. Follow-up comparisons indicated that the effect of Age Group was significant for men (older = .254 l/min, SE = .079; middle-aged = −.101 l/min, SE = .080), $t(190) > 3.0$, $p<.01$, but not women (older = .150 l/min, SE = .063; middle-aged = .191 l/min, SE = .064).

The mixed ANOVA of total peripheral resistance indicated a main effect for task, such that participants demonstrated little change during disagreement whereas during collaboration they displayed a significantly larger increase (see Table 2). Older participants displayed little task-related change in total peripheral resistance overall, whereas younger participants displayed a significantly larger increase (see Table 3). This latter effect was qualified by a significant Sex x Age interaction, $F(1,181) = 6.08$, $p<.02$, eta-squared = .033. Middle-aged

(28.52, SE = 21.69) and older women (31.67, SE = 22.29) did not differ in their total peripheral resistance response, whereas middle-aged men (113.95, SE = 27.05) displayed a larger increase than older men (−1.68, SE = 27.80) and than both groups of women, all $t(181) > 3.0$, $p<.01$. No other effects approached significance.

To summarize, the greater SBP and DBP reactivity evoked by disagreement than collaboration reflected increases in cardiac output and occurred despite the fact that collaboration evoked greater increases in total peripheral resistance. Also, the greater blood pressure reactivity of older participants reflects their larger increases in cardiac output, and occurred despite their smaller increases in peripheral resistance. However, it is important to note again that as expected initial resting levels of total peripheral resistance were higher in the older group.

Heart Rate Reactivity and Determinants

A 2 (Age) x (2) (Task) x (2) (Sex) mixed ANOVA of HR change indicated greater HR reactivity during collaboration than disagreement (see Table 2). Middle-aged participants displayed greater HR reactivity across tasks than older participants (see Table 3). In a Task x Age interaction, $F(1,284) = 10.47$, $p<.001$, eta-squared = .036 (see Figure 4), follow-up comparisons indicated that collaboration evoked greater HR reactivity than disagreement for both middle-aged (3.90 bpm, SE = .239; 3.25 bpm, SE = .219), $t(284) = 2.41$, $p<.05$, and older participants (3.56 bpm, SE = .240; 1.66 bpm, SE = .220), $t(284) >3.0$, $p<.01$. Further, middle-aged and older participants did not differ during collaboration, but middle-aged participants displayed greater HR reactivity during disagreement than older participants, $t(284) > 3.0$, $p<.01$.

A mixed ANOVA of pre-ejection period indicated that disagreement evoked more cardiac sympathetic activation (i.e., pre-ejection period shortening) than collaboration (see Table 2). No other effects were significant.

The three-way mixed ANOVA of changes in heart rate variability indicated that collaboration evoked a larger decrease in cardiac parasympathetic activity than did disagreement (see Table 2). Women displayed a larger decrease in heart rate variability across tasks (−.130, SE = .035) than did men (.002, SE = .038), $F(1,203) = 6.98$, $p<.001$, eta-squared = .033. No other effects were significant for heart rate variability change.

To summarize, collaboration evoked a larger increase in HR than disagreement, likely reflecting greater decrease in parasympathetic activity (i.e., heart rate variability) during collaboration. In fact, this larger and parasympathetically-mediated HR response to collaboration than disagreement occurred despite the fact that disagreement evoked greater sympathetic cardiac activation (i.e., pre-ejection period shortening) than collaboration.

Recovery Period Effects

Blood pressure and determinants—Participants displayed higher recovery period SBP following disagreement than collaboration (see Table 2), and older couples displayed greater SBP than middle-aged couples (see Table 3). In an Age x Task interaction on DBP, $F(1,286) = 4.75$, $p = .03$, eta-squared = .016, older couples displayed larger increases over baseline

DBP than did middle-aged couples after collaboration but not disagreement (see Figure 5). Further, recovery period DBP was higher following disagreement than collaboration for middle-aged but not older couples.

During recovery middle-aged couples showed lower cardiac output–below baseline levels–than did older couples (see Table 3), and there were no significant effects on total peripheral resistance during recovery. Hence, older participants' greater blood pressure during recovery reflected higher cardiac output relative to the middle-aged group.

Heart rate and determinants—Middle-aged participants displayed higher recovery period HR than older participants, and lower levels of heart rate variability (see Table 3). Age groups did not differ in pre-ejection period during recovery. Hence, the higher recovery period HR of the middle-aged group reflected greater parasympathetic withdrawal.

Exploratory Analyses of Psychosocial Mediators of Age Differences

To identify mediators of age group differences in CVR, we evaluated affective, spouse appraisal and behavioral variables that demonstrated parallel age differences (cf. Smith et al., 2009) using Sobel tests (MacKinnon et al., 2002). Although we identified several significant correlates of CVR, in no cases were these factors significant mediators of age group differences in CVR. For example, while controlling age, wives' state anger during disagreement and their ratings of husbands' affiliation during this task were associated with wives' HR reactivity, partial $r(290) = .12$ and $-.18$, both $p<.05$. Husbands' state anger was not significantly related to their HR reactivity during disagreement, partial $r(290) = .10$, $p = .084$, but wives' state anger was related to husbands' HR reactivity, partial $r(290) = .16$, $p<.01$. Further, higher scores on couples' combined marital adjustment scores were associated with reduced HR reactivity during disagreement but not collaboration, Task x MAT interaction $F(1,282) = 6.13$, $p<.015$, eta-squared = .021. However, control of these psychosocial variables did not alter the age difference in HR responses to disagreement, and in none of these cases were Sobel tests of mediation significant. Similarly, husbands' levels of warm control were significantly associated with their SBP and DBP reactivity during collaboration, partial $r(290) = .12$ and .15, both $p < .04$, but the age group difference in husbands' SBP and DBP reactivity during collaboration remained significant when their levels of warm control were controlled, and tests of mediation were again non-significant. Tests of recovery period responses revealed no significant mediators.

Discussion

CVR during stressful marital interactions may link marital strain with the development and course of CVD. Such effects likely occur over many years during middle and later adulthood. Hence, marital interaction contexts in addition to conflict are important potential influences on CVR, because conflict may decline in later adulthood and collaborative problem solving increases in importance. Further, men and women may differ in CVR during marital interaction, or in their relative responsiveness to different aspects of marital interaction. Thus, the present study tested age and sex differences in CVR during marital disagreement and collaboration.

Relative to collaboration, disagreement evoked greater SBP and DBP reactivity, driven by cardiac sympathetic activation. That is, compared to collaboration, disagreement evoked larger increases in cardiac output, larger decreases in pre-ejection period, and smaller increases in total peripheral resistance. Effects of disagreement on blood pressure persisted into a post-task recovery period. In contrast, collaboration evoked greater HR reactivity than disagreement, despite the smaller increase in cardiac sympathetic activity (i.e., less pre-ejection period shortening). The greater HR response to collaboration was apparently due to parasympathetic withdrawal, reflected in the larger decrease in heart rate variability during collaboration, and these effects also persisted into the recovery period. Hence, cardiovascular response to collaboration was characterized by a parasympathetically-mediated increase in HR and increased peripheral resistance, whereas marital disagreement evoked greater blood pressure reactivity through cardiac sympathetic activation.

The pattern of CVR evoked by disagreement suggests greater task engagement, challenge, and/or effortful coping compared to collaboration (Blascovich & Tomaka, 1996; Brownley et al., 2000). To the extent that these aspects of CVR confer increased risk of CVD, the present findings support models in which marital strain contributes to CVD through this mechanism (Kiecolt-Glaser & Newton, 2001; Rhobles & Kiecolt-Glaser, 2003). In contrast, collaboration evoked greater HR reactivity through reduced parasympathetic activation, and increased total peripheral resistance. The psychological determinants of this pattern could involve cognitive processing demands of this task (Brownley et al., 2000; Gianaros, Van Der Veen, & Jennings, 2004). The negative health consequences of the pattern of CVR evoked by disagreement are better established than the consequences of the pattern evoked by collaboration. However, increased HR reactivity, heightened total peripheral resistance, and reduced heart rate variability have been implicated in the adverse effects of stress on health (Gianaros et al., 2005; Treiber et al., 2003; Uchino et al., 2007).

Age Differences in Response to Marital Interaction

Previous theory and research suggests that older adults differ from their middle-aged counterparts in ways that could alter effects of marital processes on CVR. For example, in prior research marital conflicts were characterized by more warmth and less hostility among older couples, as well as less physiological reactivity (e.g., Carstensen et al., 1995; Levenson, Carstensen, & Gottman, 1994). In other results from the present study (see Smith et al., 2009), disagreement evoked less anger from older couples than middle-aged participants and older participants rated their spouses as warmer across both tasks. In results reported here, there was mixed evidence of reduced CVR. Older couples demonstrated less HR reactivity during conflict than middle-aged couples. However, their blood pressure responses during conflict were similar to middle-aged couples. Further, during and after collaboration older participants–especially men–displayed greater blood pressure reactivity. Hence, results for HR reactivity supported the notion that physiological costs of marital conflict are reduced among older persons, but blood pressure responses indicated that the physiological cost of a different marital interaction context (i.e., collaboration) may be greater.

Older couples engage in collaboration more frequently than middle-aged couples (Berg et al., 2006), and in the present study they reacted to it with greater CVR. To the extent that CVR contributes to CVD, collaboration during marital interactions could be an important influence on cardiovascular health among older individuals, particularly for men. These age-related differences could reflect issues surrounding agency. Older individuals often construe collaboration as necessitated by a need to compensate for their declining cognitive abilities (Berg et al., 2006), raising concerns about their level of competence, independence, and control in daily activities. Or, one spouse may feel the need to direct such efforts, a task made more difficult by the concurrent desire to manage the emotional quality of the interaction (Blanchard-Fields, 2007; Carsetnsen et al., 1999). Such agency-related challenges or threats can heighten CVR, and in the context of marital interactions this is especially true for men (Brown & Smith, 1992; Smith et al., 1998).

We attempted to find mediators of age group differences in CVR, by examining associations with affective, appraisal, and behavioral variables where we found similar age differences (Henry et al., 2007; Smith et al., 2009). For example, older participants reported higher levels of marital satisfaction and less anger during disagreement, and appraised their spouses as friendlier during the interaction tasks, factors that might have contributed to older participants' reduced HR reactivity during disagreement. Wives who reported larger increases in anger during disagreement displayed greater HR reactivity, as did their husbands. Wives who rated their husbands as more hostile during disagreement also displayed greater HR reactivity. Further, couples who reported higher marital satisfaction displayed smaller HR responses to disagreement. However, control of these factors did not attenuate the age group difference in HR reactivity during disagreement, and formal tests of mediation (MacKinnon et al., 2002) were not significant. Similarly, the greater levels of warm control displayed by older men during collaboration might reflect efforts to accomplish the instrumental task without straining relationship quality - a more salient and important goal among older couples (Blanchard-Fields, 2007; Carstensen et al., 1999). Greater engagement in this effort could evoke greater CVR. Men who displayed more warm control during collaboration had greater SBP reactivity during this task, but this behavioral variable did not mediate the age group difference in blood pressure reactivity. Hence, psychosocial variables were related to CVR in meaningful ways, but they did not mediate age differences in CVR.

The determinants of blood pressure and HR clarified the nature the CVR during marital conflict and collaboration. They also suggested additional age group differences. Across both tasks older men responded with larger increases in cardiac output and smaller increases in total peripheral resistance than did middle-aged men. This may suggest different psychological reactions, such that older men may have experienced the tasks as challenging while the middle-aged men experienced them as more threatening (Blascovich & Tomaka, 1996). Smaller changes in peripheral resistance could also reflect age-related increases in vascular rigidity (Cooper et al., 2007).

The age differences in resting cardiovascular function are consistent with prior research (Cooper et al., 2007), including higher blood pressure and peripheral resistance, lower cardiac output and heart rate variability, and shorter pre-ejection period. These differences likely reflect underlying age-related increases in vascular stiffness and sympathetic tone, increased ventricular stiffness, and reduced parasympathetic tone. The greater SBP reactivity among older participants before and following marital interaction was accompanied by higher cardiac output rather than peripheral resistance, and therefore does not seem simply to reflect the general reduction in arterial compliance (i.e., less vascular dilation to accommodate increased blood pressure) commonly associated with aging. Further, the greater blood pressure response of older participants during and after martial interactions was more pronounced for collaboration than disagreement. This suggests that psychological effects of collaboration rather than more general age-related differences in cardiovascular function may have contributed to older participants' greater blood pressure response to collaboration. The smaller HR responses of older participants were similarly task-specific, occurring during disagreement but not collaboration. Hence, this difference might reflect a psychological aspect of the task rather than a more general age-related difference in cardiac function. However, it is important to note again that we identified no such psychological mediators of these effects among the affective, appraisal, and overt behavioral responses we measured.

Sex Differences in Responses during Disagreement and Collaboration

Results reported elsewhere (Smith et al., 2009) provide evidence consistent with the hypothesis that women find relationship stressors more upsetting than do men; during disagreement they reported a larger increase in anger and rated their spouses as less friendly. However, despite these sex differences in subjective experiences, there was no evidence that women responded to disagreement with greater CVR. Both men and women displayed larger increases in SBP, DBP, cardiac output, and cardiac sympathetic activity (i.e., pre-ejection period shortening) in response to disagreement than to another form of marital interaction–collaboration, and the magnitude of these responses did not differ for men and women, even though the present study was quite well-powered to detect such sex differences. The only task-specific sex difference in CVR was a Sex x Task interaction for SBP reactivity, in which men and women did not differ in their response to disagreement but men displayed a larger response than women during collaboration.

To the extent that CVR during marital conflict contributes to effects of marital strain on CVD, these results suggest that this mechanism is important for both men and women. Consistent with prior studies in which men displayed greater CVR than women during marital interaction tasks that involve challenges other than conflict or disagreement (Brown & Smith, 1992; Smith et al., 1998), the present results also suggest that some types of common marital interactions –such as collaborative problem solving – may be more taxing for men than for women. Interestingly, women did display a larger decrease in parasympathetic activity (i.e., heart rate variability) across the two tasks, and stress-related decreases in heart rate variability confer increased risk of CVD in older women (Gianaros et al., 2005). Hence, parasympathetic mechanisms could contribute to greater vulnerability to marital stress or less benefit from marriage overall for women.

Limitations

The cross-sectional design precludes the attribution of age group differences to aging, per se, rather than cohort differences. For example, the cohort of older men studied here may be less familiar or comfortable with collaboration than the middle-aged group, resulting in greater blood pressure reactivity during collaboration. Similarly, middle-aged and older couples differ strongly in length of marriage (point-biserial $r(300) = .73$, $p<.001$). When non-manipulated variables are highly correlated, separation through analysis of covariance or similar techniques can produce highly misleading results and is not recommended (Miller & Chapman, 2001). Hence, we cannot attribute the observed age group effects on CVR specifically to age, rather than length of marriage.[2]

The two interaction tasks produced expected affective, cognitive, and behavioral differences, but it is possible that they differ from naturally occurring marital conflict or collaborative problem solving. Ambulatory assessment of cardiovascular responses to naturally occurring marital interactions would be useful in this regard. The levels of CVR to the marital interaction tasks were not as large as those often seen with other laboratory stressors, raising questions as to the relevance for disease risk of changes of this magnitude. However, it may also be possible that cardiovascular responses to potentially stressful laboratory marital interactions underestimate the magnitude of these responses in natural environments.

Although several studies support the hypothesis that CVR is associated with future risk of CVD, the status of this mechanism is best considered tentative and in need of additional research (Treiber et al., 2003). Also, our sample was predominantly White, and middle or upper middle socioeconomic status, and consisted of heterosexual couples. Future research should examine other demographic groups. Speech rate or loudness might have contributed to CVR effects observed here.[3] Also, the specific cognitive demands of the collaborative problem solving task may have contributed to the pattern of cardiovascular effects. Future research should include tasks with the different demands in order to identify the physiological consequences of collaboration. Also, although we identified meaningful affective, appraisal, and overt behavioral correlates of CVR, these factors did not mediate the age group differences. Future research should include efforts to not only identify but also explain age differences in CVR in marital interactions.

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[2]When length of marriage (LOM) as a continuous variable replaces age group in the analysis, there are significant main effects of LOM on SBP ($p<.05$) and HR ($p<.03$) reactivity, but they are weaker than the effects obtained with the age group factor. The Task x Sex x LOM interaction on SBP reactivity is significant and similar in magnitude to that obtained with the Age Group factor, as is the Task x LOM interaction on HR reactivity. However, the Task x LOM interaction on DBP is not significant. Effects of LOM during recovery were not significant. Hence, replacing age with LOM reproduces some but not all effects of age group.

[3]The total number of speech acts during the 6-minutes of both tasks was used as a general measure of the amount of speech. Middle-aged participants (mean = 65.7, SE = 1.18) produced more speech acts than did older couples (mean = 59.6, SE = 1.16), $F(1,280) = 13.6$, $p<.001$, eta-squared = .046; women (65.4, 1.07) produced more than men (60.0, 0.98), $F(1, 280) = 20.53$, $p<.001$, eta-squared = .068; and participants produced more coded speech acts during collaboration (65.9, 1.03) than during disagreement (59.4, 0.89), $F(1,280) = 45.06$, $p<.001$, eta-squared = .139. Hence, speech production as measured by number of coded speech acts did not did not correspond to the pattern of Age, Sex, or Task differences in blood pressure reactivity, CO, or PEP response. Although the pattern of Age, Sex and Task differences on HR, RSA, and TPR responses were similar to the results for the number of coded speech acts, this measure of speech activity did not correlate with any of the CVR measures during the initial 6-minute interaction period. Hence, at least by this measure of speech activity, the observed results for CVR are not due to this factor. However, it is possible that other aspects of speech could contribute to the observed effects. It is also important to note that as described previously (see footnote 1) in no cases were effects involving Task, Age and Sex on CVR found within some periods within the task but not others. Hence, similar effects during unstructured interaction periods and periods when speaking was controlled further reduce the likelihood that speech artifacts explain the observed effects.

Finally, our findings suggested that women experienced marital disagreement as more aversive than men (Smith et al, 2009), but they did not display greater responses on traditional aspects of CVR. This null result could reflect aspects of our methodology. Sex differences in physiological response to marital conflict may be more likely when couples are instructed to resolve the issue, rather than simply to discuss it. Further, sex differences may be more likely when individuals are freer to identify conflict topics on their own, initiate interactions regarding such difficulties, and pursue them in an unrestrained manner (Denton et al, 2001; Newton & Sanford, 2003). These aspects of task procedures would maximize sex differences in the tendency to identify, initiate, and pursue such issues (Christensen & Heavey, 1990). That is, the greater physiological reactivity of women often observed during marital conflict might reflect greater levels of speech or engagement in the discussion, rather than a greater tendency to respond physiologically to marital strain (c.f., Nealey-Moore et al., 2007). In the more structured interaction procedures used here, couples discussed a disagreement that they both felt was an on-going problem. This could have attenuated sex differences in task engagement that otherwise contribute to sex differences in CVR during marital disagreement.[4]

Equating husbands' and wives' levels of task involvement when testing sex differences in physiological response to marital stress could be seen as, "placing procrustean experimental restrictions on otherwise naturally occurring systems" and thereby creating, "the danger that such experimentally controlled conditions will not generalize well outside the laboratory" (Coan & Gottman, 2007, p.78).[5] Yet, relaxation of experimental controls creates interpretive ambiguities, as described above. Hence, in designing and interpreting psychophysiological studies of marital interaction, researchers face a complex trade-off between control or precision on the one hand and realism, generalizability or ecological validity on the other (Nealey-Moore et al., 2007).

Summary, Conclusions and Future Directions

Compared to another common type of marital interaction (i.e., collaboration), marital disagreement evoked a pattern of heightened CVR characterized by larger increases in blood pressure, cardiac output, and cardiac sympathetic activation. These findings support models suggesting that CVR contributes to associations between marital strain and heightened CVD risk (Rhobles & Kiecolt-Glaser, 2003; Smith & Glazer, 2006), and this mechanism is relevant for both men and women. Although we found no evidence that women are more reactive to marital stressors than are men on traditional measures of CVR (i.e. SBP, DBP, HR), across both tasks women displayed greater reductions in heart rate variability. This stress response has been found to be associated with greater CVD risk among older women (Gianaros et al., 2005). Hence, in future efforts to understand sex differences in marriage and health, parasympathetic responses to marital interactions seem worthy of additional research.

[4]It is important to note that when analyses of CVR were conducted on only the unstructured portions of the disagreement task, we still found no evidence that women were more reactive than men.

[5]The thoughtful discussion of this issue by Coan and Gottman (2007) concerned effects of conflict task procedures on behavioral processes and their associations with marital outcomes, rather than psychophysiological responses. However, their comments are relevant to this methodological challenge in psychophysiological studies of marriage (c.f., Nealey-Moore et al., 2007).

Marital conflict evoked greater blood pressure reactivity and increased cardiac sympathetic activation than did collaboration - generally for both middle-aged and older couples. Therefore, this relationship stressor could influence disease risk though this mechanism for both middle-aged and older individuals. Yet, older couples were less reactive to marital conflict than middle-aged couples, at least in terms of HR responses. Further, episodes of marital conflict may be less frequent for older couples (Gagnon et al, 1997). Hence, the psychophysiology of marital conflict could play a reduced role in associations between marital strain and CVD among older couples. However, a second marital context quite common among older couples – collaborative problem-solving - evoked greater CVR and recovery period blood pressure among older couples than for middle-aged couples, particularly for men. Hence, marital interactions other than conflict may play a role in cardiovascular risk for older adults. The age, sex, and task differences in CVR demonstrated here underscore the importance of the aging and life-span development perspective in explicating associations of social relationships with physical health, as the specific aspects of close relationships that influence physical health may wax and wane in importance across the decades of adulthood.

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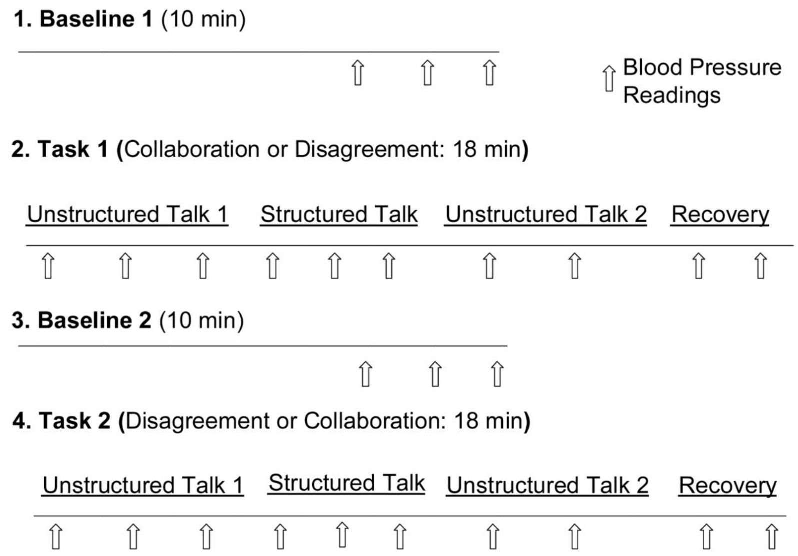

Figure 1.

Schematic of procedure for counter-balanced collaboration and disagreement tasks. Unstructured talk 1 = 6 min; structured talk = 6 min; unstructured talk 2 = 3 min; recovery = 3 min.

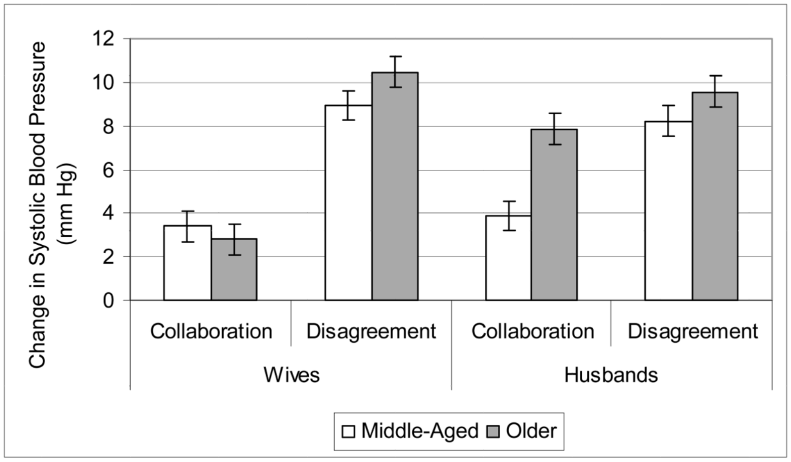

Figure 2.

Systolic blood pressure reactivity (task mean – baseline) during interaction tasks.

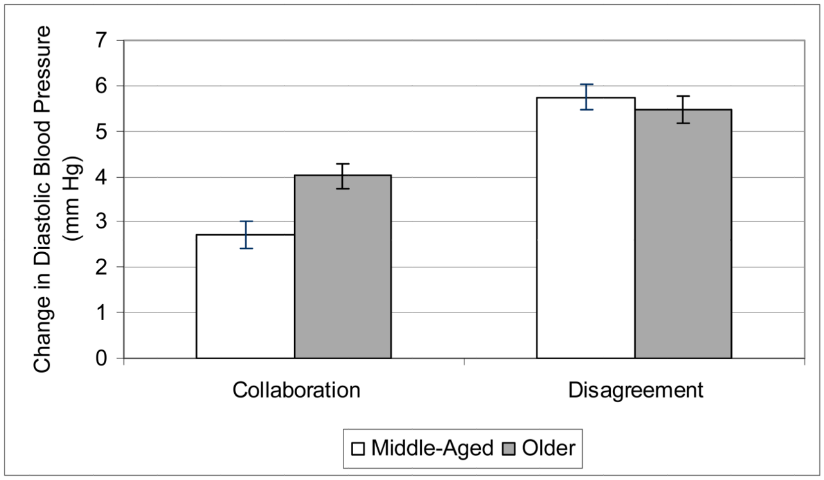

Figure 3.
Diastolic blood pressure reactivity (task mean baseline) during interaction tasks.

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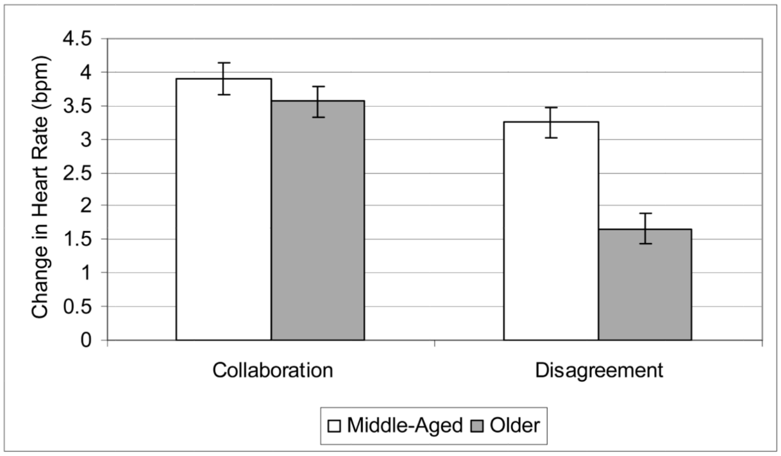

Figure 4.
Heart rate reactivity (task mean – baseline) during interaction tasks.

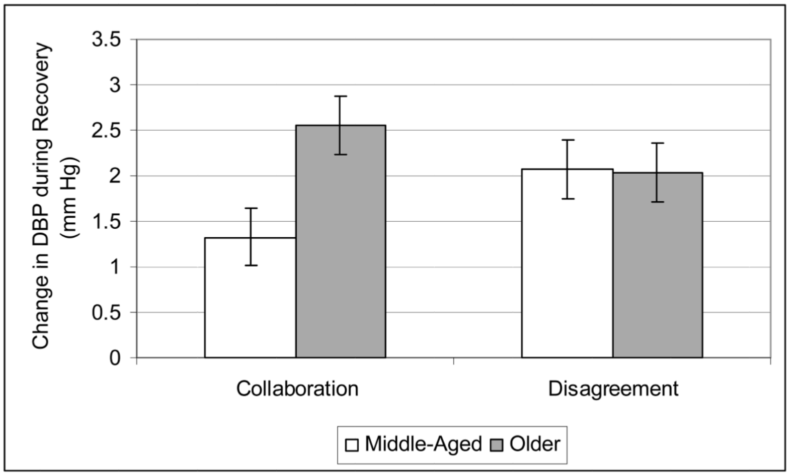

Figure 5.
Diastolic blood pressure (recovery period mean – baseline) during recovery period.

Table 1

Baseline Levels of Cardiovascular Function

	Women		Men							
	Middle-Aged	Older	Middle-Aged	Older	Age Effect		Sex Effect		Sex x Age	
Measure	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	*F*	eta2	*F*	eta2	*F*	eta2
SBP (mm Hg)	108.2 (1.2)	122.8 (1.1)	118.2 (1.1)	125.5 (1.1)	83.49**	.219	30.86**	.094	10.42**	.034
DBP (mmHg)	66.5 (.71)	69.5 (.70)	73.9 (.72)	75.4 (.71)	9.15**	.030	99.64**	.251		
CO (l/min)	5.9 (.16)	4.7 (.17)	5.9 (.17)	5.5 (.18)	22.25**	.091	8.17*	.035	5.75*	.025
TPR	1265 (57)	1761 (60)	1340 (55)	1562 (58)	41.42**	.157			5.40*	.024
HR (bpm)	69.4 (.81)	71.5 (.80)	67.8 (.82)	67.8 (.80)			13.19**	.043		
PEP (msec)	101.1 (1.9)	94.5 (2.0)	98.0 (2.3)	94.8 (2.4)	4.23*	.018				
RSA	5.70 (.10)	4.85 (.11)	5.24 (.10)	4.81 (.11)	37.86**	.146	5.79*	.025	4.08*	.018

SBP = systolic blood pressure; DBP = diastolic blood pressure; CO = cardiac output; TPR = total peripheral resistance; HR = heart rate; PEP = pre-ejection period; RSA = respiratory sinus arrhythmia

* $p<.05$,

** $p<.001$, degrees of freedom range from 1 and 284 to 1 and 181

Table 2

Task Main Effects on Cardiovascular Reactivity

Measure	**Disagreement Mean (SE)**	**Collaboration Mean (SE)**	***F***	**eta-squared**
Task Period Reactivity				
SBP (mm Hg)	9.3 (.40)	4.5 (.35)	119.81**	.297
DBP (mmHg)	5.6 (.21)	3.4 (.19)	77.04**	.213
CO (l/min)	.34 (.04)	−.09 (.05)	50.56**	.210
TPR	12.5 (16.0)	73.8 (16.8)	8.98**	.047
HR (bpm)	2.5 (.15)	3.7 (.17)	43.93**	.134
PEP (msec)	−1.89 (.58)	−.29 (.59)	5.35*	.027
RSA	.016 (.03)	−.144 (.04)	16.16**	.074
Recovery Period				
SBP (mm Hg)	5.2 (.36)	4.2 (.37)	4.67*	.016

SBP = systolic blood pressure; DBP = diastolic blood pressure; CO = cardiac output; TPR = total peripheral resistance; HR = heart rate; PEP = pre-ejection period; RSA = respiratory sinus arrhythmia

* $p<.05$,

** $p<.001$, degrees of freedom range from 1 and 284 to 1 and 181

Table 3

Significant Age Main Effects on Cardiovascular Reactivity

Measure	Middle-aged Mean (SE)	Older Mean (SE)	*F*	eta-squared
Task Period Reactivity				
SBP (mm Hg)	6.1 (.42)	7.7 (.43)	6.60*	.023
CO (l/min)	.045 (.053)	.202 (.052)	4.51*	.023
TPR	71.2 (17.9)	15.0 (18.4)	4.82*	.026
HR (bpm)	3.6 (.18)	2.6 (.18)	13.80**	.046
Recovery Period				
SBP (mm Hg)	3.7 (.40)	5.7 (.40)	12.47**	.042
CO (l/min)	−.24 (.055)	−.04 (.056)	6.33*	.032
HR (bpm)	2.1 (.18)	1.2 (.17)	13.78**	.046
RSA	−.345 (.05)	−.189 (.05)	4.85*	.024

SBP = systolic blood pressure; CO = cardiac output; TPR = total peripheral resistance; HR = heart rate; RSA = respiratory sinus arrhythmia

* $p<.05$,

** $p<.001$, degrees of freedom range from 1 and 284 to 1 and 181