

2013

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Recommended Citation

Campo, Rebecca A. and Uchino, Bert N. (2013) "Humans' Bonding with their Companion Dogs: Cardiovascular Benefits during and after Stress," *The Journal of Sociology & Social Welfare*: Vol. 40: Iss. 4, Article 13.

DOI: <https://doi.org/10.15453/0191-5096.3769>

Available at: <https://scholarworks.wmich.edu/jssw/vol40/iss4/13>

Humans' Bonding with their Companion Dogs: Cardiovascular Benefits during and after Stress

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This study examined whether having one's companion dog present during and after stress posed similar cardiovascular benefits as having a close friend present, even when the relationship quality for both the companion dog and friend was highly positive. Positive aspects of relationship quality for participants' dog and friend were not associated with one another, suggesting that these relationships exist independently. Additionally, compared to participants with a close friend present, those with their dog present had lower heart rate and diastolic blood pressure ($p's < .05$) while undergoing the stressors, and tended to have lower heart rate and systolic blood pressure ($p's < .09$) when recovering from stressors. This study indicates that even when relationship quality is similarly high for companion dogs and friends, dogs may be associated with greater reductions in owners' cardiovascular reactivity to stress, particularly if there is a potential for evaluation apprehension in the human friendships. These findings support the value of the human-companion animal relationship in promoting human welfare.

Key words: *bonding, companion dogs, cardiovascular health, stress*

Repetitive, exaggerated cardiovascular reactivity to psychological stress may influence the development and progression of cardiovascular disease, and more generally, lead to pathophysiological consequences such as metabolic changes, increased inflammation, and immunosuppression (Player, King, Mainous, & Geesey, 2007; Rosengren et al., 2004; Treiber et al., 2003). Research indicates that human social support may buffer cardiovascular responses to stress (Cohen & Wills, 2001). The current study examined whether having one's companion dog present during and after stress posed similar cardiovascular benefits as having a close friend present, even when the relationship quality for both the companion dog and friend was highly positive. Positive aspects of relationship quality for participants' dog and friend were not associated with one another, suggesting that these relationships exist independently. Additionally, compared to participants with a close friend present, those with their dog present had lower heart rate and diastolic blood pressure ($p's < .05$) while undergoing the stressors, and tended to have lower heart rate and systolic blood pressure ($p's < .09$) when recovering from stressors. This study indicates that even when relationship quality is similarly high for companion dogs and friends, dogs may be associated with greater reductions in owners' cardiovascular reactivity to stress, particularly if there is a potential for evaluation apprehension in the human friendships. These findings support the value of the human-companion animal relationship in promoting human welfare.

Journal of Sociology & Social Welfare, December 2013, Volume XL, Number 4

1985; Uchino, Cacioppo, & Kiecolt-Glaser, 1996) by changing psychological processes (i.e., stress appraisals, emotions) that enable one to cope more efficiently (Blascovich & Mendes, 2000; Lazarus & Folkman, 1984). However, social support's effectiveness to do so may depend on the quality of the relationship (i.e., positive, negative, or ambivalent quality) since not all close relationships are purely positive (Campo et al., 2009; Uchino, Holt-Lunstad, Uno, & Flinders, 2001). Likewise, research has shown that support from individuals with whom we have a positive relationship quality, compared to those with an ambivalent relationship quality (i.e., consists of positive and negative aspects, more prevalent than purely negative relationship quality), is associated with the lowest levels of cardiovascular reactivity during stress (Holt-Lunstad, Uchino, Smith, & Hicks, 2007; Uno, Uchino, & Smith, 2002).

Like human social support, human-companion animal relationships are associated with health benefits that exist after controlling for physical exercise (Serpell, 1991). Additionally, individuals with companion animals have reduced cardiovascular responses to stress compared to those without companion animals (Allen, Blascovich, & Mendes, 2002; Allen, Shykoff, & Izzo, 2001). Other research has shown that interacting with one's companion dog is associated with beneficial neuroendocrine changes in individuals, such as increases in dopamine, oxytocin, and B-endorphin, and decreases in cortisol, a stress hormone (Odendaal, 2000). Importantly, research has found no difference between owners and non-owners in terms of tobacco use, body mass index, or social economic status (i.e., income or education) that may explain such benefits.

Similar to humans' positive relationship quality, the attachment felt with one's companion animal may be a driving component behind many of the psychological and health benefits seen with human-companion animal relationships, including reduced cardiovascular responses to stress. Attachment with one's companion animal is associated with lower rates of depression and anxiety, and higher rates of happiness and self-esteem (Crawford, Worsham, & Swinehart, 2006). However, few studies have examined owners' attachment or relationship quality to their companion animals as a mechanism of the physical health benefits (Krause-Parello, 2008; Nagaswa, Mogi, & Kikusui, 2009; Winefield, Black, & Chur-Hansen,

2008). Research has shown that attachment behavior (e.g., animal-initiated gazing) and high satisfaction with one's companion animal is associated with owners' increased oxytocin levels compared to owners who did not have similar associations with their companion animals (Nagaswa et al., 2009). This is important in human health because oxytocin may be a mechanism for the stress buffering effects of social support (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003).

It should be noted that the benefits derived from human-companion animal relationships are not limited to the psychological and physical health outcomes between an individual and his or her companion animal. Rather, companion animals have also made significant contributions to aiding in social welfare issues. In hospital settings, therapy dog visits can help alleviate pain and distress in chronic pain patients and increase well-being in accompanying family members (Marcus et al., 2012). In psychiatric settings, animal-assisted therapy (AAT) has been successfully used in patients struggling with depression, loneliness, addiction, schizophrenia, and phobias (Dimitrijevic, 2009). AAT can also help individuals who have difficulties with human relationships become more responsive during therapy sessions. In family therapeutic settings, inquiring about the family's pet can ease tension and provide an opening to more difficult conversation topics (Dimitrijevic, 2009; Walsh, 2009). Furthermore, there are a variety of animal-assisted activity (AAA) programs that exist for improving children's reading and communication skills, decreasing loneliness in assisted living facilities, increasing motivation in physical rehabilitation sessions, and increasing empathy and prosocial behaviors in children with severe conduct disorders (Walsh, 2009).

The main purpose of this study was to compare the cardiovascular benefits of having one's companion animal or close friend present during and while recovering from stressors. Furthermore, considering the robust finding that positive human relationship quality is associated with cardiovascular benefits during stress, we wanted to compare these effects specifically for individuals who were attached to their companion animal and had a close friend of positive relationship quality. We predicted that cardiovascular responses would be at least equivalent when comparing participants who had

their companion animal present to those who had their close friend present.

Methods

Participants

A sample of individuals with companion dogs ($N = 162$) were recruited from the community and the University of Utah to participate in the study. The study was advertised in Utah mainstream and alternative newspapers, and flyers were posted throughout the Salt Lake City vicinity. Participants were excluded if they had pre-existing hypertension or cardiovascular disease, used cardiovascular prescription medications, or had a Body Mass Index > 35 . Inclusion criteria were that the participant had had their companion dog and same-sex best friend for at least 2 years in order to ensure that the relationships were not new. Participation was limited to dogs because past research has shown that, after controlling for physiological and psychosocial variables, dogs, compared to other types of companion animals, made a significant contribution to 1-year survival of patients who had been hospitalized for myocardial infarction (Friedmann & Thomas, 1995). This does not mean that other types of companion animals are not associated with health benefits (Allen et al., 2001; Castelli, Hart, & Zasloff, 2001; McConnell, Brown, Shoda, Stayton, & Martin, 2011); rather, we limited our sample to dogs because it helped us minimize any differences due to characteristics associated with different types of companion animals. Additionally, using only owners as participants, instead of including non-owners, may have limited the study's generalizability, but the intent was to compare the benefits of dogs with close friends, without confounding existing differences between owners and non-owners. The study was approved by the University's Institutional Review Board and all participants gave informed consent.

Study Design

This was a 3 (Support Condition: Dog, Friend, Alone) X 2 (Stressor Type: Active- or Passive-Coping Task) factorial study design. The support condition was a between-participants factor, to which participants were randomly assigned. The stressor was a within-participants factor, with the order of

occurrence counterbalanced. A priori power calculations indicated that a sample size of 165 would be sufficient for moderate effect size ($r = .30$), with power = .82 for between-subjects effects, power = .89 for within-subjects effects, and power = .82 for between-within interactions at 5% significance level.

Psychosocial Measures

Relationship quality. Prior to randomization to the support condition, participants' relationship quality (see dog and human relationship quality measures below) with their dog and same-sex best friend was assessed to ensure that neither consisted of negative or ambivalent relationship quality (Uchino et al., 2001). No participants needed to be excluded due to their relationship quality. The Companion Animal Bonding Scale (CABS) and the Pet Attitude Scale (PAS) assessed the relationship quality between the participant and his or her companion dog. The CABS (Poresky, Hendrix, Mosier, & Samuelson, 1987) measures self-reported behavior that is indicative of the bond an owner has with his or her companion animal and the PAS (Templer, Salter, Dickey, Baldwin, & Veleber, 1981) measures the favorableness of attitudes towards companion animals. Chronbach alphas for the CABS ranged from 0.76 to 0.82 in two study samples of adults and parents and 0.93 for the PAS in an undergraduate sample (Poresky et al., 1987; Templer et al., 1981). Construct validity was confirmed in Poresky (1987) by correlating the CABS with the PAS scale ($r = 0.31, p < .001$), suggesting these measures assess similar, but not redundant aspects of attitudes toward pets. Additionally, since a validated questionnaire does not exist that allows one to simultaneously assess both human and companion animal relationship quality, we adapted the Social Relationship Inventory (SRI) (Campo et al., 2009) by only focusing on emotional support, instead of including other types of support functions (e.g., instrumental support). The SRI assessed how important, helpful, and upsetting the dog and friend are when the participant needs emotional support (i.e., provides emotional comfort, relieves stress, or uplifts one's mood). In an undergraduate sample, reported Chronbach alphas were .69 and .80 for the positivity and negativity subscales, and it was correlated with the support ($r = 0.76, p < .001$) and conflict ($r = 0.50, p < .001$) subscales of the Quality of Relationship Inventory (Pierce, Sarason, Sarason, Solky-Butzel, & Nagle, 1997).

Psychological variables. Participants' psychological experience was captured with variables that research has indicated are relevant to stress responses (Cacioppo & Petty, 1986; Lazarus & Folkman, 1984), such as emotions, perceived threat and coping appraisals, and evaluation apprehension. Emotional responses were assessed with a measure that conceptualizes positive and negative affect as independent dimensions (i.e., high negative affect does not imply low positive affect) according to guidelines of Barrett and Russell (1998). Specifically, affect is viewed as an interaction of activation (activated or deactivated) and valence (pleasant or unpleasant). This results in four categories of affect: pleasant-activated (determined, attentive, strong), unpleasant-activated (distressed, nervous, jittery), pleasant-deactivated (calm, at ease, relaxed), and unpleasant-deactivated (bored, tired, sluggish). This measure was completed after baseline, each stressor, and the recovery periods. (I don't understand this sentence.) Perceived threat of the stressor and appraisal of coping ability (Feldman, Cohen, Hamrick, & Lepore, 2004) were assessed prior to each stressor. Evaluation apprehension (i.e., feeling threatened, disturbed, evaluated by the presence of one's companion dog or friend) (Guerin, 1989) was completed after each stressor (i.e., the alone condition did not complete this measure).

Stressors

The stressors were active-coping and passive-coping tasks that are standard laboratory challenges used in psychophysiological research (Sherwood, 1993). Active-coping tasks simulate types of stressors over which an individual has the ability to mentally or physically influence the outcome (e.g., prepare oneself for an upcoming job interview). Passive-coping tasks simulate types of stressors over which an individual has no control of the outcome (e.g., watching a loved one deliver a bad speech). The active-coping stressor consisted of a 5-minute mental arithmetic task in which the participant was asked to subtract out loud by 7's starting with a three-digit number (e.g., starting with 732, subtract by 7's). The participant was instructed that the goal was to get to zero as quickly as possible, but without making any mistakes or the experimenter would verbally alert him/her for every mistake made. The

passive-coping stressor was a cold pressor task that consisted of the participant holding a frozen ice pack to his or her forehead for 2 minutes. Participants were told not to remove the ice pack until the experimenter informed him/her that it could be removed.

Cardiovascular Measures

Systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) were measured continuously during the baseline, the stressors, and the recovery periods with a Dinamap Model 8100 monitor (Critikon Corporation, Tampa, FL). The Dinamap uses the oscillometric method to estimate blood pressure (Epstein, Huffnagle, & Bartkowski, 1991). Means of SBP, DBP, and HR for each period were averaged across minutes to increase the reliability of these assessments.

Procedure

All procedures were conducted in the participants' homes due to University regulations that only service animals were allowed on campus and to help ensure that the companion dogs were more at ease than they would have been in a university laboratory. This helped minimize issues related to atypical or negative dog behavior that might have distracted participants, and it helped increase the ecological validity of the findings. Participants were randomly assigned to one of the support conditions for the entire study: (a) companion dog present, (b) close friend present, or (c) alone during the study. The close friend was the same-sex best friend that the participants had previously rated on relationship quality. Prior to the study session, participants were asked to identify a room in their home that was free from potential distractions (i.e., phone, TV, other people). If the participant was assigned to the alone or friend condition, then his/her companion dog was kept out of the room or the home. This did not adversely affect the experiment, since none of the dogs that were put in a separate room or outside of the home reacted negatively.

Upon beginning the study, a blood pressure cuff was placed on the participant, and after a 10-minute baseline assessment of cardiovascular responses, the source of support (if assigned

to dog or friend condition) was introduced into the room. In the dog condition, the participant was informed that he or she may pet his/her dog if desired, taking care not to move excessively due to the blood pressure readings. In the friend condition, the friend sat close by and was informed that he or she could provide supportive behaviors if desired, but was asked not to provide answers to the arithmetic task. This helped to maintain equivalency between the dog condition and the friend condition. Participants in the alone condition remained alone throughout the study. The order of the consecutive stressors (i.e., math task, cold pressor) was counter-balanced across the study support conditions (dog, friend, alone) and each stressor was followed by an 8-minute recovery period in which the dog or friend remained present.

Results

Participant Demographics

Data were collected on 162 participants; 3 participants were excluded for failure to follow experiment instructions, resulting in a final N of 159 for analyses. The majority of our participants were Caucasian (89%) and female (75.5%), with an average age of 30 years old, and a median household income bracket of \$35,000 to \$55,000. The average length of participants' relationship with companion dog and friend was 5.6 years and 9.5 years, respectively.

Math Performance

A one-way ANOVA did not reveal any differences among the support conditions for the percentage of correct subtractions nor number of attempted subtractions (all p 's $> .1$). This suggests that any potential differences in psychosocial or physiological responses were not due to group differences in effort or performance.

Psychosocial Outcomes

Relationship quality. Participants' scores on the CABS and PAS indicated high levels of bonding and favorable attitudes towards their companion dogs (Table 1). Additionally, the SRI indicated high positive relationship quality with both the dog and friend. Participants felt that their dogs and friends were helpful, not upsetting, and important when needing emotional

support. A comparison of the SRI ratings for dogs and friends revealed that dogs were rated as more important than friends when needing emotional support ($t(154) = -2.89, p = .004$); however, there were no differences between dogs and friends on being helpful or not upsetting during emotional support.

Table 1. Correlations and Descriptive Statistics for Relationship Quality Measures

Measures	1	2	3	4	5	6	7	8
CABS ^a	-							
PAS ^b	.68***	-						
SRI Dog-Important ^c	.54***	.68***	-					
SRI Dog-Upsetting ^c	-.16	-.28**	-.25**	-				
SRI Dog-Helpful ^c	.56***	.69***	.56***	-.32***	-			
SRI Friend-Important ^c	-.03	-.09	.05	.17*	-.05	-		
SRI Friend-Upsetting ^c	.10	.08	.07	.20*	.03	.00	-	
SRI Friend-Helpful ^c	-.03	-.07	.05	.05	-.06	.48***	-.18*	-
M	4.04	4.33	5.59**	1.88	4.83	5.36**	1.81	4.80
SD	.74	.43	.71	.92	1.13	.70	.98	.87
Scale Range	1 - 5	1 - 5	1 - 6	1 - 6	1 - 6	1 - 6	1 - 6	1 - 6

Note. M = means, SD = standard deviation. ^aCompanion Animal Bonding Scale (Poresky et al., 1987). ^bPet Attitude Scale (Templer et al., 1981). ^cSocial Relationship Inventory (Campo et al., 2009). Listwise N = 148. * $p < .05$. ** $p < .01$. *** $p < .001$.

Bivariate correlations were conducted to examine the relationship among the different relationship quality measures (Table 1). As expected, positive aspects of the SRI for one's dog (i.e., importance & helpfulness during emotional support) were positively correlated with the PAS and CABS, and negatively correlated with SRI dog-upsetting. Notably, the SRI positive ratings for friends were not significantly correlated with the positive relationship aspects for dogs. This suggests that individuals can have positive relationship quality with their dogs, independently of their friend's relationship quality. In other words, it is not likely that individuals who bond with their dogs do so because they have difficulty with their human relationships or vice versa.

Unless specified, the following psychological variables were analyzed with 3 (Dog, Friend, Alone) X 2 (Stressor: Math Task, Cold Pressor) Analysis of Covariance (ANCOVAs) and controlled for baseline values. Descriptive statistics for the psychological variables by stressor type are reported in Table

2.

Pretask coping appraisals. To analyze the pretask appraisals of stress and coping resources, we calculated an appraisal ratio following the guidelines of Feldman et al. (2004). An ANOVA revealed a main effect for stressor type, $F(1, 152) = 57.95, p < .0001, \eta^2 = .28$. Overall, participants appraised the math task as more threatening ($M = .63, SE = .04$) given their coping resources than the cold pressor ($M = .37, SE = .02$). However, no significant effects involving the support conditions were found. Thus, all participants viewed the math task as more stressful than the cold pressor.

Emotional responses. Analyses were conducted on changes (i.e., Task - Baseline) in emotional responses (i.e., unpleasant-deactivation, unpleasant-activation, pleasant-deactivation, pleasant-activation) to the stressors and recovery from the stressors. For emotional responses to the stressors, there were no significant effects for stressor type or support condition. However, for recovery from the stressors, there was a significant stressor main effect for unpleasant-activation ($F(1, 150) = 3.78, p = .05, \eta^2 = .03$). Specifically, participants had a larger decrease in unpleasant-activation (i.e., feeling distressed, nervous, and jittery) during recovery from the cold pressor ($M = -.26, SE = .03$) than during recovery from the math task ($M = -.17, SE = .03$). Additionally, there was a significant support condition main effect ($F(2, 150) = 3.35, p = .04, \eta^2 = .04$). Follow-up comparisons revealed that those with their dog present had a larger decrease in unpleasant-activation during recovery ($M = -.30, SE = .04$) than those with their friend present ($M = -.19, SE = .05; p = .07$) or who were alone ($M = -.15, SE = .05; p = .02$). There was no significant interaction between type of stressor and support-member condition.

Evaluation apprehension. Next, the evaluation apprehension felt with the presence of one's dog or friend during the stressors was analyzed. The 'alone' participants did not complete this measure, as there was no one present to potentially increase evaluation apprehension (i.e., the experimenter was out of participants' view). A significant main effect for stressor type indicated that participants felt more evaluated ($F(1, 104) = 24.99, p < .0001, \eta^2 = .19$), disturbed ($F(1, 105) = 12.27, p = .001, \eta^2 = .11$), and threatened ($F(1, 103) = 7.29, p = .008, \eta^2 = .07$) during the math task than during the cold pressor.

Additionally, a significant main effect for support condition indicated that participants with their dog present felt less evaluated ($F(1, 104) = 17.05, p < .0001, \eta^2 = .14$) and less threatened ($F(1, 103) = 5.14, p = .03, \eta^2 = .05$) than those with a friend present.

These main effects were qualified by a significant Support Condition X Stressor Type interactions for feeling evaluated ($F(1, 104) = 37.22, p < .0001, \eta^2 = .26$), disturbed ($F(1, 105) = 5.39, p = .02, \eta^2 = .05$), and threatened ($F(1, 103) = 7.29, p = .008, \eta^2 = .07$). Specifically, during the math task, participants with their dog present felt less evaluated ($p < .0001$) and threatened ($p = .01$) than those with their friend present (Table 2). The interaction for feeling disturbed revealed that participants with their friend present felt more disturbed during the math task than during the cold pressor ($p < .0001$). These results indicate that during the most stressful task (math), participants with their dog present felt less evaluated about their ability to handle the stressor than those with a friend present did.

In summary of the psychological outcomes, the support conditions did not alter participants' emotional responses while undergoing the stressor. However, during recovery from the stressors, participants with their dog present had a larger decrease in unpleasant-activation affect (i.e., distressed, nervous, jittery) than those with their friend present or who were alone. Additionally, we found that participants with a friend present felt more evaluation apprehension compared to those with their dog present, particularly during the math task, which was reported to be more stressful than the cold pressor.

Cardiovascular Responses

ANCOVAs (Support Condition X Stressor Type) were also used to analyze cardiovascular responses (SBP, DBP, & HR) during the stressors and the recovery periods following the stressors. For this purpose, change scores were computed (i.e., Task - Baseline) and the baseline average was included as a covariate. Descriptive statistics for the cardiovascular variables by stressor type are reported in Table 2. *Cardiovascular reactivity during stressors.* Analyses of cardiovascular reactivity during the stressors revealed significant main effects for type of stressor for DBP ($F(1, 150) = 3.93, p = .05, \eta^2 = .03$) and HR ($F(1, 150) = 14.32, p < .0001, \eta^2 = .09$). In both cases, cardiovascular

reactions were higher to the math task (DBP $M = 6.24$, $SE = .52$; HR $M = 7.72$, $SE = .51$) than to the cold pressor (DBP $M = 3.55$, $SE = .42$; HR $M = .92$, $SE = .39$). Furthermore, significant main effects for support condition were found for DBP ($F(2, 150) = 6.51$, $p = .002$, $\eta^2 = .08$) and HR ($F(2, 150) = 4.70$, $p = .01$, $\eta^2 = .06$).

Table 2. Means of Psychological and Cardiovascular Variables

Variables	Alone	Dog	Friend
<i>Math Task Reactivity</i>			
Appraisal Ratio	.63 (.06)	.62 (.05)	.63 (.06)
Threat	--	1.04a (.06)	1.27b (.07)
Evaluation	--	1.51a (.12)	2.78b (.13)
Disturbed	--	1.43 (.12)	1.74 (.13)
Unpleasant-Deactivation	-.41 (.09)	-.50 (.08)	-.41 (.09)
Unpleasant-Activation	.46 (.12)	.40 (.11)	.54 (.12)
Pleasant-Deactivation	-.87 (.14)	-.99 (.13)	-1.13 (.14)
Pleasant-Activation	.31 (.10)	.36 (.09)	.36 (.10)
SBP Δ	7.01 (1.39)	9.54 (1.24)	9.23 (1.37)
DBP Δ	3.62a (.95)	6.23b (.84)	8.86c (.93)
HR Δ	6.81 (.92)	6.35 (.82)	10.02 (.91)
<i>Cold Pressor Reactivity</i>			
Appraisal Ratio	.38 (.03)	.38 (.03)	.37 (.03)
Threat	--	1.04 (.02)	1.02 (.02)
Evaluation	--	1.61 (.13)	1.71 (.14)
Disturbed	--	1.33 (.09)	1.22 (.10)
Unpleasant-Deactivation	-.35 (.09)	-.43 (.08)	-.50 (.09)
Unpleasant-Activation	.18 (.11)	.08 (.09)	.11 (.10)
Pleasant-Deactivation	-.85 (.15)	-.67 (.14)	-.71 (.15)
Pleasant-Activation	.11 (.11)	.27 (.10)	.23 (.11)
SBP Δ	4.11 (1.09)	5.73 (.97)	4.01 (1.07)
DBP Δ	2.62 (.76)	3.51 (.68)	4.52 (.75)
HR Δ	.27 (.70)	.69 (.62)	1.81 (.69)
<i>Math Task Recovery</i>			
Unpleasant-Deactivation	-.16 (.09)	-.35 (.08)	-.17 (.09)
Unpleasant-Activation	-.09 (.06)	-.29 (.05)	-.12 (.06)
Pleasant-Deactivation	-.21 (.11)	-.08 (.10)	-.23 (.11)
Pleasant-Activation	-.07 (.09)	-.02 (.08)	-.17 (.09)
SBP Δ	-.58 (.80)	.16 (.72)	2.05 (.82)
DBP Δ	-.96 (.70)	.04 (.59)	.69 (.67)
HR Δ	-1.34 (.68)	-.55 (.61)	1.07 (.70)
<i>Cold Pressor Recovery</i>			
Unpleasant-Deactivation	-.08 (.09)	-.19 (.09)	.06 (.09)
Unpleasant-Activation	-.21 (.06)	-.30 (.05)	-.26 (.05)
Pleasant-Deactivation	.07 (.11)	.09 (.11)	-.08 (.11)
Pleasant-Activation	-.04 (.09)	-.08 (.09)	-.15 (.10)
SBP Δ	.63 (.89)	.94 (.80)	.59 (.90)
DBP Δ	-.19 (.63)	.52 (.57)	-.25 (.64)
HR Δ	-1.11 (.69)	.33 (.62)	-.06 (.71)

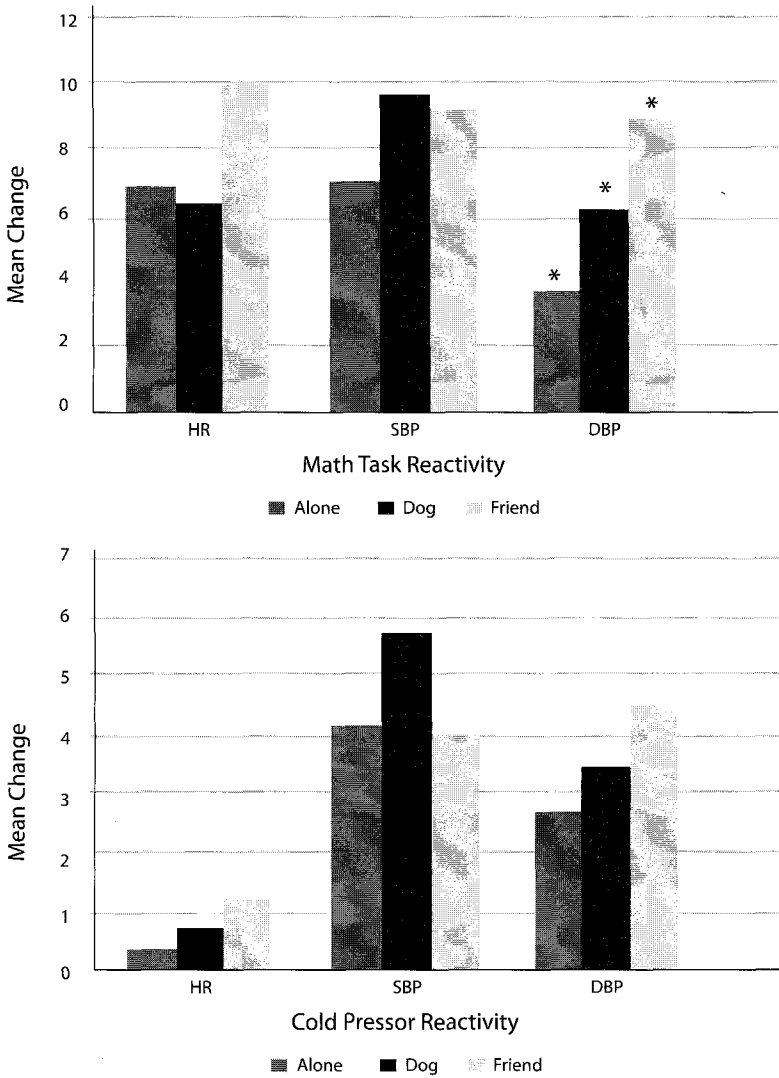
Note. The four affect variables and cardiovascular variables are changes scores (Task – Baseline). Values in parentheses represent standard errors. Dashes indicate variable was not measured for the Alone condition. SBP=systolic blood pressure, DBP=diastolic blood pressure, HR=heart rate. Means in the same row that do not share subscripts differ at $p < .05$. $N=159$; Alone $n=49$, Dog $n=61$, Friend $n=49$.

Participants with their dog present had lower DBP and HR reactivity (Dog: DBP $M = 4.87$, $SE = .63$; HR $M = 3.52$, $SE = .58$) than those with their friend present (Friend: DBP $M = 6.69$, $SE = .69$; HR $M = 5.91$, $SE = .64$; $p < .05$). The dog condition and alone condition (Alone: DBP $M = 3.12$, $SE = .71$; HR $M = 3.54$, $SE = .65$) did not differ from one another, although the friend condition had higher DBP and HR reactivity than the alone condition ($p < .05$). The DBP main effects were qualified by a significant Support Condition X Stressor Type interaction ($F(2, 150) = 2.97$, $p = .05$, $\eta^2 = .04$; Figure 1). Follow-up mean comparisons revealed that, during the math task, those with their dog present had lower DBP reactivity than those with their friend present ($p < .05$). Participants who were alone had lower DBP reactivity than those who had their dog or friend present (p 's $< .05$). No significant effects were found for SBP.

Cardiovascular recovery after stressors. Analyses of cardiovascular responses during the recovery periods from the stressors did not reveal significant main effects for support condition or stressor type. However, there was a significant Support Condition X Stressor Type interaction for SBP ($F(2, 149) = 3.81$, $p = .02$, $\eta^2 = .05$, Figure 2) and a trend interaction for HR ($F(2, 149) = 2.42$, $p = .09$, $\eta^2 = .03$, Figure 2). Follow-up mean comparisons revealed that, during recovery from the math task, those with their dog present tended to have lower SBP ($p = .08$) and HR ($p = .09$) than those with their friend present. The dog present condition did not differ from the alone condition. Additionally, participants with their friend present tended to have higher SBP ($p = .08$) and HR ($p = .09$) than those who were alone.

In summary, during the most stressful task (math), those with their dog present had lower DBP reactivity than those with a friend present. Additionally, across the stressor tasks, participants with their dogs present had lower HR reactivity than those with their friends present. Furthermore, during the recovery period from the math task, there were trends for participants with their dog present to have lower SBP and HR than those with their friend present. These findings suggest that, compared to friends, companion dogs are associated with more cardiovascular benefits for their owners while experiencing stress, as well as aiding in quicker cardiovascular

Figure 1. Cardiovascular Reactivity Means during the Math and Cold Pressor Tasks.

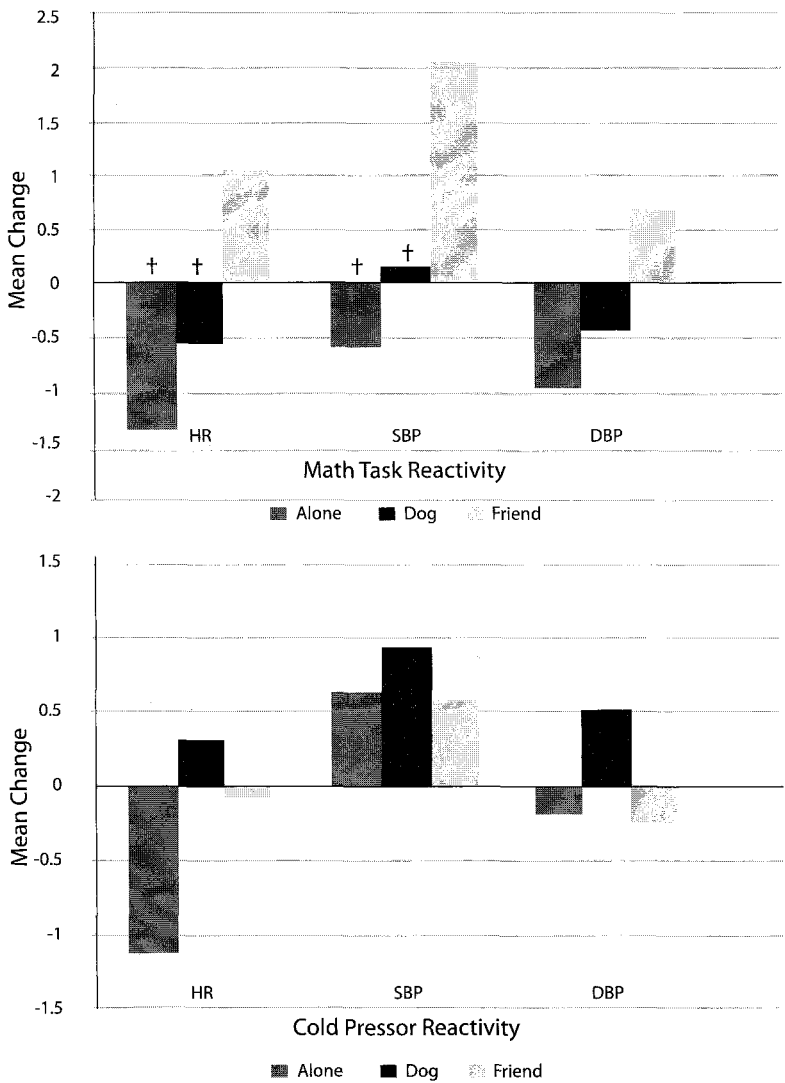


*p < .05

recovery from stress. Next, for exploratory purposes we examined whether the significant findings of feeling evaluated and threatened (evaluation apprehension) during the math task explained the relationship between support condition and DBP reactivity. That is, the presence of a close friend may have

been more stressful than beneficial because of evaluation apprehension concerns (Cacioppo & Petty, 1986; Guerin, 1989).

Figure 2. Cardiovascular Recovery Means after the Math and Cold Pressor tasks.



$p < .09$

Mediation Analysis

For mediation analysis, we used the non-parametric bootstrapping procedure of Preacher and Hayes (2008) for multiple mediation. This approach tests the total indirect effect of an independent variable (support condition) on a dependent variable (cardiovascular reactivity) through a mediator or set of mediators (feeling evaluated and threatened), and has the capability to test the specific indirect effects if there are multiple mediators in a set. Interpretation is accomplished by determining whether zero is contained within the 95% confidence intervals. The statistical advantages of this method are that: (1) multiple mediators can be tested simultaneously; (2) it does not rely on a normal sampling distribution; (3) it can be used with relatively small sample sizes; and (4) the number of inferential tests is minimized, therefore reducing the likelihood of Type 1 errors (Preacher & Hayes, 2008).

We examined whether feeling threatened and evaluated, as a set or individually, mediated the relationship between support condition (dog, friend) and DBP reactivity to the math task. This relationship was examined for DBP reactivity because this was found to be a significant Support Condition X Stressor Type interaction. The alone condition was excluded from these analyses as they did not complete the evaluation apprehension measure. The total and direct effects of support condition on DBP reactivity during the math task were 3.59, $p = .009$ and 5.37, $p = .001$, respectively. The total indirect effect through both mediators (feeling threatened and evaluated) was significantly from zero (point estimate = -1.78, 95% BCa bootstrap CI: -3.51 to -0.46). Therefore, as a set, feeling threatened and feeling evaluated mediated the relationship between support condition and DBP reactivity to the math task. Furthermore, examination of the specific indirect effects indicated that only feeling evaluated (a_1b_1 path) was a significant specific mediator (point estimate = -1.79, 95% BCa bootstrap CI: -3.49 to -0.43). In summary, these results suggest that participants with a friend present had greater DBP reactivity to the math task than those with a companion dog present because they felt more evaluated by having their friend present.

Discussion

The main purpose of this study was to examine whether having one's companion dog present during and after stress posed similar cardiovascular benefits as having a close friend present, even when the relationship quality for both the dog and friend was similarly positive. Our results indicated that the presence of a companion dog was associated with lower cardiovascular responses during stressors (i.e., DBP & HR) and trends for lower cardiovascular responses during recovery (i.e., SBP & HR) than having a friend present. The interactions for reactivity (i.e., DBP) and recovery (i.e., SBP & HR trends) revealed this was particularly true during the math task. Moreover, mediation tests indicated that participants with a friend present may have had higher cardiovascular reactivity (i.e., DBP) during the math task because of evaluation apprehension concerns, a finding that has been demonstrated in other research (Cacioppo & Petty, 1986; Guerin, 1989). Unexpectedly, the alone participants' responses were generally comparable to those with a dog present (i.e., except for DBP math reactivity). Guided by the stress buffering literature, we had expected the participants in the alone condition to have the highest levels of reactivity. An explanation may be that those who were alone did not feel distressed because just knowing that their dog was nearby (i.e., room or outside), without the presence of a potentially evaluating friend, made these participants have similar cardiovascular responses as those with the dog present in the room.

In examining emotional responses, we found a trend for participants with their dogs present to have a larger decrease in unpleasant-activation emotions (i.e., feeling distressed, nervous, and jittery) during recovery than those with a friend present and significantly larger decrease than participants who were alone. Additionally, they felt less evaluated and threatened during the math task than those with a friend present. However, there were no differences in other emotions, such as higher positive emotions in the dog condition compared to the other conditions. This is surprising considering that many owners claim to have intense emotional bonds with their companion dogs (Cohen, 2002; Collis & McNicholas, 1998). Similarly, interactions with their animals make people

happier, less lonely, more relaxed, secure, and affectionate (Barba, 1995). We know of no other experimental studies that have examined emotional processes associated with the presence of one's companion animal during stress. However, the lack of results is consistent with social support research that has been unable to find that emotional states differed as a function of support conditions (Gerin, Pieper, Levy, & Pickering, 1992; Lepore, Allen, & Evans, 1993). The emotional measure we used in this study may not have been appropriate for capturing the positive emotions that are associated with the bond between an individual and his/her companion animal. Future studies will need to explore how best to capture this emotional experience with one's companion animal.

Uniquely, this study simultaneously examined individuals' relationship quality with their companion animal and a close friend. As expected, participants reported high levels of bonding with their dogs, and both their friends and dogs were helpful and important when needing emotional support. Interestingly, the ratings for importance of one's dog during emotional support were significantly higher than the ratings for friends. This may be due to these relationships fulfilling different aspects of emotional support. Likewise, Bonas, McNicholas, and Collis (2000) found that companion animals (i.e., mainly dogs) scored higher than humans for fulfilling alliance, nurturance, and companionship needs. Human-animal relationships may be characterized by less variability than human friendships (i.e., friends may become too busy in their own lives to be supportive) and many individuals report their companion animals to be sources of unconditional love. We also found that the positive aspects of relationship quality (i.e., SRI-importance, SRI-helpful) for participants' dogs and friends were not related to one another. This suggests that individuals who value their relationships with their companion animals, or perceive it as a highly positive one, may not be supplementing for a lack of human support. In fact, companion animals can help foster new human relationships as the presence of one's dog while walking or shopping may be associated with increased interactions with strangers. Considering this, it may be possible for individuals to have the best of both worlds: a close bond with one's companion animal and supportive close friends.

A limitation of our study is that the participants were healthy and young. These findings should be tested in older adults and populations with special needs, such as chronically ill or disabled individuals. Existing research has shown that companion animals can help decrease loneliness and daily stress as well as lower depression rates in such vulnerable populations as those living with HIV/AIDS (Castelli et al., 2001), with disabilities, and who are elders (Garrity, Stallones, Marx, & Johnson, 1989; Steffens & Bergler, 1998). This is evidence that companion animals are psychologically beneficial in such vulnerable populations; theoretically, such benefits should carry over to effect physical health outcomes.

In summary, our study indicates that even when relationship quality is similarly positive for companion dogs and close friends, dogs may provide more cardiovascular benefits during stress and while recovering from stress. Particularly in stressful circumstances where there is potential for evaluation, having a friend present may actually make it more stressful. Although it is not always possible to have one's dog present during stressors, these findings indicate that dogs are also associated with cardiovascular benefits afterwards. For example, after a hard day at work, our companion animals may help us rewind, both mentally and physically. Such findings also have important implications for the psychological and physical well-being of a society that experiences significant levels of stress. Stress can lead to the development and/or progression of diseases (e.g., cardiovascular, infectious diseases, diabetes, depression, etc.) by directly contributing to physiological changes or, indirectly, by increasing health behaviors associated with disease risk and poor mental health outcomes. Our relationships with our companion animals can reduce stress levels and buffer the stress-related changes that occur in the body (i.e., increased blood pressure, inflammation, & stress hormones). Furthermore, they may encourage individuals to engage in healthy behaviors to cope with stress, such as choosing to walk the dog instead of attempting to cope through more maladaptive behaviors (e.g., alcohol, drug use, overeating, etc.). Such benefits gained with our companion animal relationships may be reflected on a society level through reductions in stress-related diseases (e.g., cardiovascular, infectious diseases, diabetes, etc.) and improvements in psychological

well-being. Consequently, society holds a mutually beneficial and rewarding relationship with companion animals—we provide shelter and care for them and, in turn, the emotional bonds we share help reduce our stress and the development of stress-related diseases.

Acknowledgement: We would like to thank the participants, their companion dogs and friends for participating in this study. This study was supported by the National Institutes of Health under a Ruth L. Kirschstein National Research Service Award (F31 HL081963-01) from the National Heart, Lung, Blood Institute awarded to the first author. Research Support: NIH NRSA F31 HL081963-01.

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