Cardiovascular Reactivity and the Presence of Pets, Friends, and Spouses: The Truth About Cats and Dogs

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Objective: The purpose of this study was to examine the effects of the presence of friends, spouses, and pets on cardiovascular reactivity to psychological and physical stress. **Methods:** Cardiovascular reactivity was examined among 240 married couples, half of whom owned a pet. Mental arithmetic and cold pressor were performed in one of four randomly assigned social support conditions: alone, with pet or friend (friend present for non-pet owners), with spouse, with spouse and pet/friend. **Results:** Relative to people without pets, people with pets had significantly lower heart rate and blood pressure levels during a resting baseline, significantly smaller increases (ie, reactivity) from baseline levels during the mental arithmetic and cold pressor, and faster recovery. Among pet owners, the lowest reactivity and quickest recovery was observed in the pet-present conditions. **Conclusions:** People perceive pets as important, supportive parts of their lives, and significant cardiovascular and behavioral benefits are associated with those perceptions. **Key words:** cardiovascular reactivity, social support, pets, blood pressure.

SBP = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index; CV = cardiovascular; MANCOVA = multivariate analysis of covariance; MAT = mental arithmetic task; CP = cold pressor; ACE = angiotensin converting enzyme.

INTRODUCTION

Numerous laboratory and community-based studies have focused on the supportive role of others in buffering cardiovascular reactivity to psychological stress. Review papers (1, 2) summarize this literature. In some studies, social support proved benign, in others, potentially harmful in terms of cardiovascular reactivity to demanding tasks. Generally, however, when potentially supportive others can be considered nonevaluative, a benign effect has resulted (3, 4).

Although many have focused on the definition and measurement of social support as it relates to health (5, 6), most have implicitly assumed human social support. Recently, however, several studies have documented a beneficial supportive role of pets. For example, compared with their counterparts without pets, elderly individuals with pets appear buffered from the impact of stressful life events and make fewer visits to physicians (7). Pet owners with AIDS report lower depression morbidity than those without pets (8). Service dogs generally have a positive influence on the well being, self-esteem, and community integration of people with disabilities (9).

Regarding cardiovascular health, pet ownership is associated with increased postmyocardial infarction survival (10, 11). Relative to supportive friends, the presence of pets results in significantly lower blood pressure and heart rate reactivity during demanding task performance (3). The presence of pet dogs reduced blood pressure of children reading aloud (12). Even talking to pets, compared with people, is associated with lower cardiovascular responses (13). Finally, pet ownership, but not ACE inhibitor therapy, attenuates reactivity to psychological stress (14). We based our past research (3) on the notion that the perceived evaluative or nonevaluative nature of potentially supportive others determines whether social support actually buffers the pathogenic effects of stress, especially in situations naturally evoking evaluation apprehension. We reasoned that the buffering effects of social support may depend on a relationship between the specific need for support evoked by a particular stressor and the functions provided by available supporters (15). We demonstrated that the presence of a loved pet compared with that of a close human friend can provide the kind of nonevaluative social support critical to buffering cardiovascular responses during potentially stressful task performance (3). Although studies have demonstrated that people can also provide nonevaluative support (4, 16), most were designed to insure those in the supportive role could not be judgmental (eg, concurrently listening to white noise through headphones).

Here we sought to extend our past research. Part of this extension includes a research design that integrates naturally occurring correlational data with experimental methodology. This was accomplished by using both pet-owner and non–pet-owner samples. Within the former, we randomly assigned participants

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to experimental conditions, manipulating various levels of the presence of one's beloved pet. This manipulation allowed us not only to compare the buffering effects of the presence of pets to the presence of friends but also to the presence of spouses and the joint presence of spouses and pets. These inclusions enabled us to determine the socially supportive effects of pets compared not only with "best" human friends but also with intimate others within the pet-owner sample. In addition, because pet dogs and cats are equally popular (there are over 50 million of each in the US), we extended the current study to include pet cats and their owners. The stereotype of the aloof, impersonal behavior of cats suggested that the potentially stress-buffering effects of dogs and cats might differ. Similarly, we randomly assigned members of the non–pet-owner sample to conditions paralleling those in the pet-owner sample. For this group, we substituted the presence of a close human friend for the pet.

This study also extends past research by examining cardiovascular measures at resting or baseline levels, reactivity (ie, changes from baseline) during the tasks, and recovery (ie, return to baseline levels) following the tasks. Together with the expanded comparison groups within the pet-owner sample and the inclusion of a non–pet-owner sample, the examination of cardiovascular measures during all three periods allows us to disentangle the supportive effects of pet ownership from the presence of pets. In addition, because we wanted to learn about perceptions, we assessed cognitive appraisals of stress and coping (17). Finally, because we wanted to test the influence of pets in both active and passive coping situations, we included MAT, an active coping task, and CP, a passive coping task.

In summary, we addressed several research questions in two studies, identical in design and method except for the type of pet owned by participants (cats or dogs). First, do pet owners differ in cardiovascular basal or resting activity, reactivity to demanding task performance, and recovery from task performance levels compared with non-pet owners? Second, to what degree are cardiovascular responses during and recovery from performance of a demanding task related to the source of social support provided, eg, spouse, close friends (pet or human), and their joint presence? Third, to what extent does the presence of others influence appraisals of tasks as challenging or threatening, and how is performance affected by the source of social support present?

METHODS

Overview

We used identical methods and procedures for the cat and dog studies. Each study includes couples living together who either owned or did not own a pet. In each study, participants completed several questionnaires and, while we recorded cardiovascular measures, performed two tasks commonly used in cardiovascular reactivity research. We counterbalanced tasks and participants performed each in one of four randomly assigned social support conditions: alone, with pet/friend (pet present for pet owners, friend present for non-pet owners), with spouse, and with spouse and pet/friend.

Participants

The cat and the dog studies included 120 married couples each (males: mean age = 42, SD = 0.9; females: mean age = 41, SD = 0.9). Because heterosexual couples served as participants, half of all participants were males. All participants were healthy and normotensive (blood pressure < 140/90) and none took any cardiovascular medications. All participants were employed full time outside their homes and each received $25.00 for participation. Half of the couples in each study had a single pet, and the other half had no pets and had not had one for at least 5 years. Each non–pet-owning participant identified a same-sex close friend who was available for the experiment, selected by the member who was assigned to the experimental condition requiring the presence of a friend. We did not specify what "close" indicated except to say that the friend should be someone with whom the participant socialized often at home and elsewhere. We recruited couples through local radio announcements and posted notices in community areas.

Settings

Before the experiment, which took place in their homes, participants arranged to be home alone and to power off potentially distracting electronic devices (eg, stereos, telephones). The main reason for visiting homes is that animals are not welcome in hospital or university laboratories. However, we also believe that the home is an ecologically appropriate environment in which to study social support. A quiet, closed-door room was chosen for the experiment, and only individuals and pets appropriate to the experimental condition were allowed inside. All participants, friends, spouses, and pets were familiar with the room because they had been in it many times before. Participants typically described the rooms as dens, living rooms, family rooms, or libraries, and all had comfortable chairs and pleasant surroundings. The same (female) experimenter was present throughout data collection for all participants in both studies. Although she was not blind to study conditions, she followed a carefully scripted routine.

Measures

Self-report. Before the experiment, participants completed the Pet Attitude Questionnaire (18), the Relationship Closeness Inventory (19), the Cook-Medley Hostility Scale (20), the Interpersonal Support Evaluation List (21), the Multidimensional Anger Inventory (22), and a general demographics questionnaire. We obtained challenge and threat self-reports before each task by means of a single-item measure with a dichotomous response.

Physiological. Cardiovascular measures (heart rate, SBP, and DBP) were automatically recorded once each minute throughout the experiment with a portable Propaq monitor (Model 106 EL, Protocol Systems, Inc., Denver, CO), one used widely by hospitals in critical care and emergency settings (23, 24). Before using this instrument, we tested it against 100 blood pressure readings by a nurse practitioner and found 97% agreement in readings within 2 mm Hg.

Behavioral. We recorded number of attempts and errors during the math task to index performance. Because a constant interval for the cold pressor was required of all participants, no performance data were gathered during this task.

Procedures

After obtaining informed consent and collecting the completed questionnaires, the experimenter attached the Propaq blood pressure cuff to participants. Instructions to sit quietly and rest were then given to participants and 10 minutes of baseline heart rate and blood pressure data were recorded. This was followed by an instruction period during which participants listened to tape-recorded instructions about performing the upcoming task (MAT or CP, depending on the counterbalanced order assignment of tasks). Specifically, the MAT involved 5 minutes of rapid serial subtraction by steps of three from a four-digit number and the CP task consisted of a 2-minute immersion of a hand in ice water, which was maintained between 2 and 4°C (25). After each task, there was a 15-minute rest period. Cardiovascular data were automatically recorded and stored once per minute throughout the rest and task periods. Any potential source of support (pets, spouses, friends) was in the room from the beginning of the home visit. The 10-minute recorded baseline was taken in the presence of support 10 minutes after the blood pressure cuff was attached (and operational).

During task performance, the experimenter stayed behind (out of the sight of) the participant performing the tasks. Because we wanted and used a naturalistic setting, the dog or cat roamed the room freely in the pet condition and the spouse and/or friend sat on a sofa or chair approximately 3 feet away from the participant at a 90-degree angle, allowing easy eye contact with the participant in the human support conditions. Participants, friends, and spouses were told that the experiment was about "social support and reactions to stress" and that they could be supportive during task performance in any way they chose.

RESULTS

We analyzed each study (dog and cat) separately. However, for ease in presentation and because we did not observe any significant differences on any of our measures between dog and cat owners, we combined the two studies and specified the study as a random factor using the PROC MIXED procedure available in SAS (26).[1]

Self-Report Measures

To determine any demographic or dispositional differences in our sample related to quasi-experimental variables (ie, gender and pet ownership), we conducted a series of mixed models using gender and pet ownership as the primary independent variables, the study (cat or dog) as a random factor, and the various prestudy surveys as the dependent variables. No statistically significant differences were found by pet ownership for couples' average age, body mass, education, or income (all p values $> .30$). In addition, pet ownership was unrelated to the presence of children in the home ($\chi^2 < 1$).

We conducted several analyses to examine group differences on other self-report measures. Analyses of pet attitudes revealed a main effect for pet ownership and gender as well as a significant interaction: pet ownership ($F(1,475) = 150.70$, $p < 0.001$), gender ($F(1,475) = 5.55$, $p < .02$), gender by pet ownership ($F(1,475) = 5.24$, $p < .02$). Not surprisingly, pet owners reported more positive pet attitudes than non-pet owners ($M = 14.53$, 9.95, respectively) and women reported more positive pet attitudes than men ($M = 12.68$, 11.80, respectively). The gender by pet-ownership interaction was due to men without pets reporting significantly less positive attitudes than women without pets, whereas men and women with pets did not differ in their pet attitudes. We also observed a significant main effect of pet ownership on the closeness inventory ($F(1,475) = 324.08$, $p < 0.001$), no main effect for gender, but a significant interaction. People with pets reported closer relationships ($M = 21.4$) than people without pets ($M = 17.0$).

Analyses of the Cook-Medley Hostility Scale and the Multidimensional Anger Inventory (MAI) revealed no significant main effects. However, for both scales, the gender by pet-ownership interaction was significant: Cook-Medley ($F(1,475) = 9.76$, $p < .002$), the MAI ($F(1,475) = 8.18$, $p < .004$). Post hoc analysis revealed that women with pets reported lower aggressiveness/cynicism ($M = 9.7$) than women without pets, men with pets, or men without pets ($M = 13.1$, 13.0, 12.9, respectively); women with pets had the lower reported anger ($M = 63.2$) than any other group ($M = 80.4$, 78.8, 73.6). The Interpersonal Support List (ISEL) yielded a significant main effect for pet ownership ($F(1,475) = 7.68$, $p < .006$) and a significant pet ownership by gender interaction ($F(1,475) = 19.57$, $p < .0001$). Women with pets reported more social support ($M = 33.2$) than women without pets, men with pets, or men without pets ($M = 28.5$, 28.9, 28.5, respectively).

Because of the differences by pet ownership on pet attitudes and the relationship closeness inventory, participants' mean scores on these measures were used as covariates in all subsequent analyses. Because of the similarity of interaction effects and the likely possibility of correlations among the Cook-Medley, MAI, and ISEL scores, we conducted a factor analysis with varimax rotation including all items from these measures. The factor analysis yielded two factors with eigenvalues exceeding 1.00. The first factor consisted of the ISEL items, and the second factor included the Cook

[1] Separate analyses of dog and cat studies are available on request.

Medley subscales and the MAI items. Cronbach's alpha confirmed that the ISEL items were highly related ($\alpha = .96$), as were the Cook Medley subscales and MAI items ($\alpha = .98$). The latter were combined into an index best characterized as temperance. Consequently, we included the ISEL total score and the temperance index as covariates for the main analyses.

Challenge/threat reports. Before the MAT and the CP, participants appraised the task as challenging or threatening. We used these responses as the outcome variable in a series of sequential logistic regression analyses in which we added several factors on each of four ordered steps. The difference between the −2 log likelihood model fit (as measured by χ^2) of the preceding model and the subsequent model indicates the incremental explanatory effects of the subsequent model (ie, with the inclusion of additional factors). Each model began with the inclusion of the covariates on the first step. The second step included the covariates plus pet ownership. The third step added the presence-of-others factor. The presence-of-others factor consisted of three dummy coded variables representing the four categories of presence of others. For the fourth step, three interaction terms were entered to represent the pet ownership by presence-of-others interaction. There were no effects of gender nor did gender interact with any of the independent variables. Therefore, for ease of presentation, men and women were combined to examine pretask challenge/threat appraisals.

Before beginning the MAT, the participants indicated whether they thought it would be challenging or threatening. The first model, the covariates alone, was significant ($\chi^2(5, N = 480) = 35.46$, $p < .0001$). Including pet ownership resulted in a significant increase in model fit ($\chi^2(1, N = 480) = 36.28$, $p < .0001$). Pet owners before the math task were more likely to report challenge than nonpet owners. On the third step, including the presence-of-others factors also increased model fit ($\chi^2(3, N = 480) = 34.84$, $p < .0001$). Specifically, participants who were to perform the math task alone were more likely to report challenge than participants about to perform the task in the presence of others. On the last step, we included the pet ownership by presence-of-others interaction, which also significantly increased model fit ($\chi^2(3, N = 480) = 88.63$, $p < .0001$). The nature of the interaction (see Table 1) was such that pet owners in the presence of their pet were significantly more likely to report challenge compared with pet owners in presence of their spouse, their spouse and pet, or alone. A different pattern emerged among non-pet owners. They were more likely to report challenge if they were alone compared with those in the presence of a supportive other.

Before beginning the CP task, participants appraised the task as challenging or threatening. The initial analysis with just the covariates yielded a significant model ($\chi^2(5, N = 480) = 38.77$, $p < .0001$). Adding the pet-ownership factor improved model fit ($\chi^2(1, N = 480) = 5.56$, $p < .02$). Consistent with the challenge/threat reports preceding the MAT, pet owners were more likely to report challenge responses than non-pet owners. The addition of the presence-of-others factors significantly improved model fit ($\chi^2(3, N = 480) = 165.75$, $p < .0001$). Contrary to the MAT results, participants in the presence of supportive others were more likely to report challenge than participants who were alone. The interaction term also was significant ($\chi^2(3, N = 480) = 7.45$, $p < .05$). Because almost all participants (97%; see Table 1) reported challenge before the cold pressor task in the presence of others, the only condition that differed between pet owners and non-pet owners was the alone condition, in which pet owners were more likely to report challenge than non-pet owners.

Cardiovascular Responses

Data reduction and analytic strategy. We calculated mean HR, SBP, and DBP values for each rest and task period. Using these mean values, reactivity scores for each variable were created by subtracting the average value for the rest period from the average value for the task period. Our main analytic strategy involved a series of analyses using MANCOVAs with the three cardiovascular reactivity values as the dependent variables; pet ownership, presence of others, and their interaction as the independent variables; couple (nest-

TABLE 1. Percentage of Participants Whose Pretask Appraisal Ratings of the Math and Cold Pressor Task Indicated Challenge

Presence of Others	Pre-math		Pre-Cold Pressor	
	Pet Owners	Non-Pet Owners	Pet-Owners	Non-Pet Owners
Alone	51.7	71.7	65.0	22.6
Pet/friend	96.7	11.7	100.0	100.0
Spouse	38.7	16.7	96.6	100.0
Pet/friend plus spouse	69.0	20.0	96.8	90.0

ed within pet ownership) as a within-subjects variable; and the same covariates as indicated above. The couple factor accounts for the dependency of the dyads within the experimental design. Partial η^2 is reported for each significant main effect as an estimate of the strength of association between the independent and dependent variables. We chose partial η^2 to provide a conservative estimate of the effect size (27). Because a mixed model cannot be specified in a MANCOVA, we included the study factor as a between-subjects variable in the initial analysis. However, following each significant multivariate effect, we then conducted univariate analyses that specify the study as a random effect using the PROC MIXED procedure.

To calculate the speed in cardiovascular recovery, we determined the time interval following the task when each participant's increase in CV responses was equivalent to half of their total increase in CV responses exhibited during the task. To obtain this threshold value for each participant, we first calculated delta values for HR, SBP, and DBP by taking the first minute of recovery after each task (mental arithmetic and cold pressor) and subtracting the last minute of the baseline. We then calculated the threshold value by dividing delta values by two. The first 20-second interval of the recovery period that equaled or fell below the identified threshold value for that person was identified as the criterion interval or half-delta ($\Delta/2$ HR, $\Delta/2$ SBP, or $\Delta/2$ DBP).

For example, if a person exhibited a heart rate of 100 during the first minute after arithmetic and the participant's resting heart rate was 60, the threshold value to reach $\Delta/2$ would be 20 (ie, $(100 - 60)/2$). If the participant had a heart rate of 80 or less by time interval 5 minutes 20 seconds, then his or her $\Delta/2$ HR would be 5.33. These $\Delta/2$ (HR, SBP, and DBP) values were submitted to a MANCOVA with the same independent variables and covariates as the main analyses. In addition, to control for the possibility that greater increases during the task are accounting for all of the variance in faster recovery, we also included CV responses during the stressor as covariates.

Baseline differences. To test for differences in baseline cardiovascular responses, we conducted a MANCOVA using the average SBP, DBP, and HR responses from the first baseline period as the primary dependent variables. Table 2 provides the MANCOVA results summary and Figure 1 depicts the mean resting cardiovascular responses with standard errors. A significant multivariate effect for pet ownership was found ($p < .001$). Pet owners exhibited significantly lower resting HR, SBP, and DBP than non-pet owners. The gender multivariate effect was also significant ($p < .001$). The mixed model analyses yielded significant differences between men and women for resting blood pressure but not resting heart rate (SBP, $F(1,234) = 14.44$, $p < .0002$; DBP, $F(1,234) = 19.47$, $p < .0001$;

TABLE 2. Summary Table of Results From MANCOVAs With HR, SBP, and DBP Responses[a]

Task	Partial η^2	λ	$df_{/df}$	Multivariate F	p
A. Baseline					
Pet	.03	.93	3/229	5.29	.001
Gender	.05	.89	3/229	9.43	.0001
Pet × gender	.04	.90	3/229	8.47	.0001
B. Mental arithmetic					
Pet	.18	.55	3/214	58.95	.0001
Gender	.02	.94	3/214	4.52	.004
Presence of others	.36	.11	9/520	81.14	.0001
Pet × gender	.02	.94	3/214	4.43	.005
Pet × presence of others	.36	.13	9/520	74.91	.0001
Gender × presence of others	.07	.84	9/520	4.41	.0001
Pet × gender × PO	.04	.91	9/520	2.37	.012
C. Cold pressor					
Pet	.06	.86	3/214	11.81	.0001
Gender	.00	.99	3/214	1.01	.39
Presence of others	.30	.27	9/520	41.61	.0001
Pet × gender	.01	.97	3/214	2.40	.07
Pet × presence of others	.14	.67	9/520	10.47	.0001
Gender × presence of others	.04	.90	9/520	2.46	.01
Pet × gender × presence of others	.02	.96	9/520	1.00	.43

[a] All analyses include pet attitudes, closeness inventory, support scale, and the temperance index as covariates. Baseline analyses use HR, SBP, and DBP averages across the 10 minutes of the first baseline period. Mental arithmetic and cold pressor tasks use CV reactivity during the tasks and also include baseline cardiovascular reactions as covariates. Partial η^2 is calculated as $1 - \lambda^{1/s}$, where $s = 2.43$ (27).

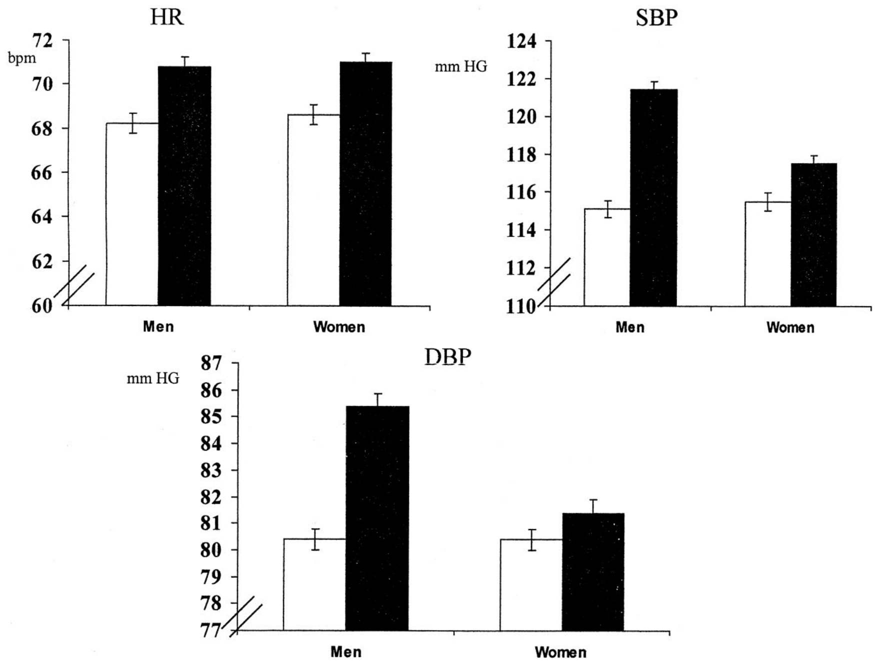

Fig. 1. Means and standard errors of resting cardiovascular responses by gender and pet ownership.

HR, $F(1,234) = 0.49$, $p < .48$). Women exhibited significantly lower resting blood pressure than did men.

These main effects are qualified by a significant multivariate pet ownership by gender interaction ($p < 0.0001$). Follow-up simple effects tests among non-pet owners revealed that men exhibited significantly higher blood pressure than women, whereas among pet owners, resting HR, SBP, and DBP did not significantly differ between men and women. Due to these resting baseline differences, all subsequent analyses using cardiovascular reactions control for baseline responses.

Cardiovascular reactivity during mental arithmetic. The first MANCOVA using the reactivity data during mental arithmetic tested for order effects. The order in which participants completed the experiment (ie, MAT vs. CP first) did not yield a significant main effect nor did it interact with pet ownership or the presence-of-others factor. Therefore, the order variable was omitted from all subsequent analyses. After controlling for the covariates, a significant multivariate effect was found for pet ownership ($p < .0001$; see Table 2, part b, for summary of MANCOVA effects). The mixed model analyses revealed that all three CV responses were significant (HR, $F(1,219) = 168.94$, $p < .0001$; SBP, $F(1,219) = 41.25$, $p < .0001$; DBP, $F(1,219) = 57.26$, $p < .0001$). The main effect for pet ownership was such that pet owners exhibited lower HR, SBP, and DBP reactivity than non-pet owners during the math task. The multivariate main effect for the presence of others was also significant ($p < .0001$) and all cardiovascular variables contributed to the multivariate effect (HR, $F(3,219) = 234.36$, $p < .0001$; SBP, $F(3,219) = 272.97$, $p < .0001$; DBP, $F(3,219) = 136.80$, $p < .0001$). Post hoc analyses revealed that the presence of just a spouse resulted in significantly greater reactivity than any other condition. The gender main effect was also significant ($p < .004$). The mixed model analyses revealed that only HR reactivity, not BP, differed by gender ($F(1,219) = 10.42$, $p < .001$), with women exhibiting greater HR reactivity during the MAT than men.

These main effects are qualified by the pet ownership by presence-of-others multivariate interaction ($p < .0001$). Results of the mixed model analyses confirmed significant contribution of all cardiovascular variables to the interaction (HR, $F(3,219) = 160.07$, $p < .0001$; SBP, $F(3,219) = 184.15$, $p < .0001$; DBP, $F(3,219) = 180.85$, $p < .0001$). The means and standard errors are depicted in Figure 2. Post hoc analyses revealed that the alone condition did not differ by pet ownership; however, the support conditions differed dramatically by pet ownership. Among non-pet owners, no differences were found between the different support conditions (ie, friend, spouse, friend and spouse). In contrast, among pet owners, the presence of the pet and spouse resulted in significantly more reactivity than with just the pet present but significantly less reactivity than with just the spouse present. Therefore, the pet ownership by presence-of-others interaction was primarily driven by the presence of a pet

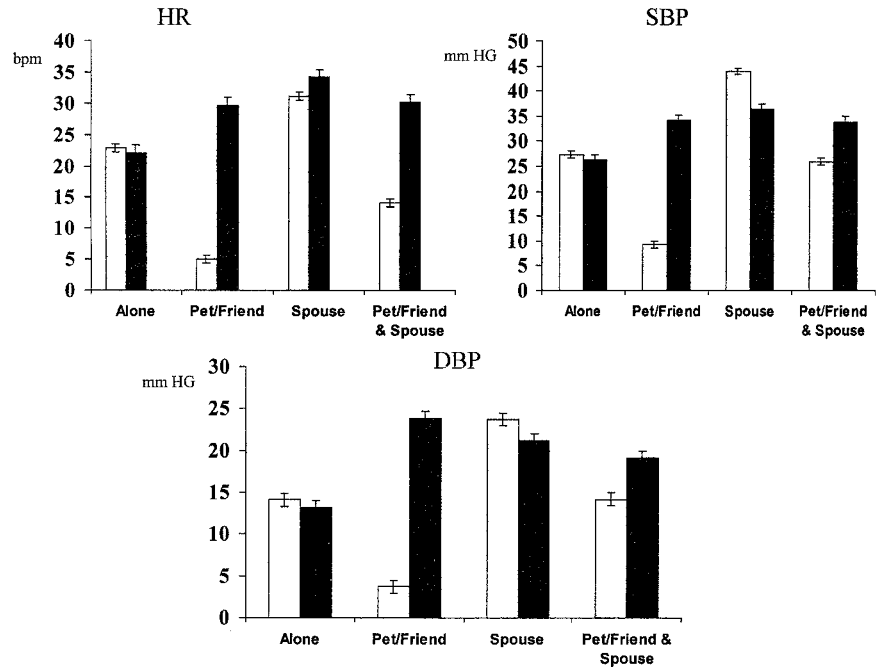

Fig. 2. Means and standard errors of cardiovascular reactivity during mental arithmetic by pet ownership and presence of others.

for pet owners, which resulted in significantly lower reactivity than any other condition.

Cardiovascular reactivity during cold pressor. The MANCOVA using the reactivity data during the cold pressor task yielded two significant main effects, pet ownership ($p < .0001$) and presence of others ($p < .0001$) (see Table 2, part c, for a summary of the MANCOVA). Pet owners exhibited significantly lower blood pressure during the cold pressor task than non-pet owners (HR, $F < 1$; SBP, $F(1,219) = 21.85$, $p < .0001$; DBP, $F(1,219) = 30.45$, $p < .0001$). The presence-of-others multivariate main effect yielded significant differences on all three cardiovascular variables (HR, $F(1,219) = 124.46$, $p < .0001$; SBP, $F(1,219) = 65.08$, $p < .0001$; DBP, $F(1,219) = 24.36$, $p < .0001$). The nature of the main effect was such that the alone condition resulted in significantly higher cardiovascular reactivity than the other three conditions. The multivariate main effect for gender was not significant.

Again, the pet ownership by presence-of-others multivariate interaction was significant. Means and standard errors are depicted in Figure 3. The mixed model analyses yielded significant contribution from the three cardiovascular variables (HR, $F(3,219) = 21.89$, $p < .0001$; SBP, $F(3,219) = 7.57$, $p < .0001$; DBP, $F(3,219) = 5.84$, $p < .0007$). Among non-pet owners, post hoc tests revealed significantly larger CV responses in the alone condition vs. the presence-of-supportive-others conditions, which did not differ from each other. Similar to non-pet owners, pet owners also exhibited the greatest increases in cardiovascular reactivity during the cold pressor task when alone; however, the presence of a pet or a pet plus spouse resulted in significantly lower cardiovascular reactivity than did the presence of just the spouse.

Cardiovascular recovery following mental arithmetic. We again employed a MANCOVA to examine the speed of recovery following mental arithmetic by pet ownership, presence of others, and gender. The time to half-delta ($\Delta/2$: reaching the midpoint of reactivity following a task) yielded a significant multivariate effect for pet ownership ($p < .0001$) and presence of others (see Table 3, part a, for a summary of the MANCOVAs). Pet owners recovered faster than did non-pet owners following mental arithmetic and the alone condition resulted in longer recovery than the support conditions.

These main effects are qualified by a significant two-way interaction between pet ownership and presence of others. Means and standard errors are depicted in Figure 4. Post hoc analysis revealed that, among non-pet owners, the friend plus spouse condition resulted in significantly slower recovery than any other condition. Among pet owners, the slowest blood pressure recovery was in the presence of spouses, which was significantly slower than the other three conditions. HR recovery was significantly quicker in the pet and pet plus spouse condition compared with the alone or just spouse condition. Therefore, among pet owners, the presence of their pet following mental

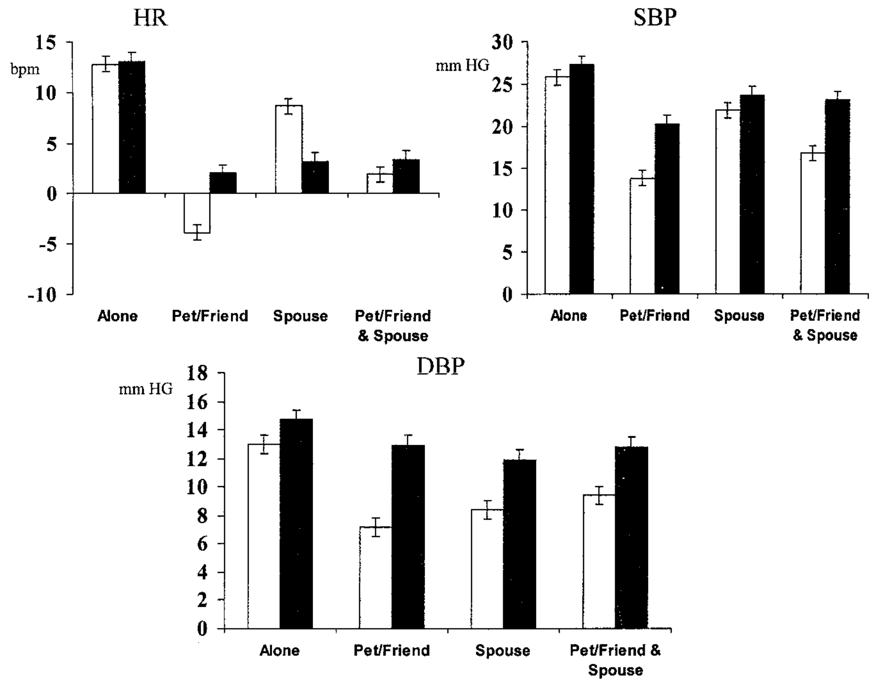

Fig. 3. Means and standard errors of cardiovascular reactivity during cold pressor task by pet ownership and presence of others.

arithmetic resulted in quicker recovery compared with the presence of spouses or alone. Among non-pet owners, the analogous friend-present condition did not result in significantly quicker recovery.

Cardiovascular recovery following cold pressor. To test for differences in the speed of cardiovascular recovery following the cold pressor task, the first MANCOVA included time to half-delta ($\Delta/2$). After controlling for the covariates, pet ownership was not significant (see Table 3, part b, for summary of MANCOVA). The multivariate main effects for the presence of others and gender were significant. Only $\Delta/2$ HR contributed significantly to the multivariate main effect for presence of others ($\Delta/2$ HR, $F(3,239) = 3.14$, $p < .03$; $\Delta/2$ SBP, $F(3,239) = 1.48$, $p < .22$; $\Delta/2$ DBP, $F(3,239) = 0.53$, not significant). Post hoc analyses revealed that $\Delta/2$ HR was reached faster in the presence of a supportive other (pet/friend, spouse, or pet/friend plus spouse) than when alone. The gender effect was a function of faster recovery among the female participants compared with the male participants.

Again, the pet ownership by presence-of-others interaction was significant ($p < .001$). The recovery data are presented in Figure 5. Post hoc analyses revealed that, among non-pet owners, the alone condition resulted in significantly longer $\Delta/2$ HR than the supportive other conditions. In addition, $\Delta/2$ SBP was longer when a spouse was present than when a friend or a friend and a spouse were present. Among pet owners, no significant differences were found among conditions in time to $\Delta/2$ HR. The condition that resulted in the longest blood pressure recovery was the alone condition, which was significantly longer than the spouse or spouse plus pet conditions (which did not differ from each other). The quickest recovery occurred in the pet present condition, which was significantly shorter than the spouse or spouse plus pet conditions.

Behavioral Measures

Attempts during MAT. The number of attempts during the math task was used as the dependent variable in a mixed model, as specified above. Two main effects (pet ownership and the presence of others) were significant. The main effect for pet ownership ($F(1,219) = 12.15$, $p < .0006$) revealed that people with pets made more attempts during the math task ($M = 54.8$) than people without pets ($M = 51.6$). The main effect for presence of others ($F(3,219) = 5.31$, $p < .002$) revealed significant differences between the four presence-of-others conditions such that participants made significantly more attempts when their spouse was present than when in any other condition. Again, the pet ownership by presence-of-others interaction was significant ($F(3,219) = 5.76$, $p < .0008$). The means are shown in Table 4. Post hoc tests among pet owners revealed that the presence of the spouse resulted in significantly more attempts than any other condition. Among non-pet owners, the conditions did not significantly differ from each other.

TABLE 3. Summary Table of Results from MANCOVAs with Δ/2 HR, SBP, and DBP[a]

Task	Partial η^2	λ	df_1/df_2	Multivariate *F*	*p*
A. Recovery after MAT					
CV Covariates					
Baseline HR	.01	.97	3/211	2.09	.10
Baseline SBP	.00	.98	3/211	1.70	.17
Baseline DBP	.01	.97	3/211	2.48	.06
MAT HR	.04	.90	3/211	7.62	.0001
MAT SBP	.02	.95	3/211	3.89	.01
MAT DBP	.02	.96	3/211	2.97	.03
Independent variables					
Pet	.07	.82	3/211	15.17	.0001
Gender	.00	.98	3/211	1.59	.19
Presence of others	.04	.90	9/514	2.47	.009
Pet × gender	.02	.94	3/211	4.55	.004
Pet × presence of others	.06	.85	9/514	3.87	.0001
Gender × presence of others	.03	.92	9/514	1.92	.05
Pet × gender × presence of others	.06	.88	9/514	2.99	.002
B. Recovery after cold pressor					
CV covariates					
Baseline HR	.01	.97	3/211	2.12	.10
Baseline SBP	.02	.95	3/211	3.91	.01
Baseline DBP	.00	.99	3/211	0.93	.42
CP HR	.06	.88	3/211	9.72	.0001
CP SBP	.00	.99	3/211	0.69	.56
CP DBP	.02	.96	3/211	3.01	.03
Independent variables					
Pet	.00	.99	3/211	0.13	.94
Gender	.04	.91	3/211	6.75	.0002
Presence of others	.04	.90	9/514	2.43	.01
Pet × gender	.00	.99	3/211	0.96	.41
Pet × presence of others	.09	.77	9/514	6.33	.0001
Gender × presence of others	.03	.92	9/514	1.91	.05
Pet × gender × presence of others	.07	.83	9/514	4.40	.0001

[a] All analyses include pet attitudes, closeness inventory, support scale, temperance index, and baseline CV means as covariates. CV responses during the math (Table 3, part A) or cold pressor task (Table 3, part B) were also included as covariates. We have included the results of the CV covariates in the table to allow for examination of the effects of CV covariates on our recovery measure.

Errors during MAT. The number of errors during the math task was used as the dependent variable in a mixed model as specified above. Two main effects (pet ownership and the presence of others) were significant. The main effect for pet ownership ($F(1,219) = 93.56$, $p < .0001$) demonstrated that people with pets made significantly fewer errors during the math task ($M = 7.1$) than people without pets ($M = 13.1$). The main effect for presence of others ($F(3,219) = 220.80$, $p < .0001$) revealed significant differences between the four presence-of-others conditions such that participants made the fewest errors when alone or with their pet/friend present and significantly more errors in the presence of their spouse and pet/friend and significantly more still when just their spouse was present. Again, the pet ownership by presence-of-others interaction was significant ($F(3,219) = 85.93$, $p < .0001$). The means are shown in Table 4. Post hoc tests revealed that, among pet owners, the presence of a pet (ie, pet or pet plus spouse) resulted in fewer errors than any other condition. Among non-pet owners, the highest accuracy rates were found in the alone condition.

DISCUSSION

Our major findings demonstrate that pets can buffer reactivity to acute stress as well as diminish perceptions of stress. First, relative to nonowners, we found that people with pets had significantly lower resting HR, SBP, and DBP; exhibited significantly lower HR, SBP, and DBP reactivity during the mental arithmetic task, and returned to baseline levels more quickly. A growing body of literature has implicated the duration of cardiovascular recovery following stressor exposure as a risk factor for essential hypertension (28). However, because the optimal analytic strategy for examining cardiovascular recovery has not been well estab-

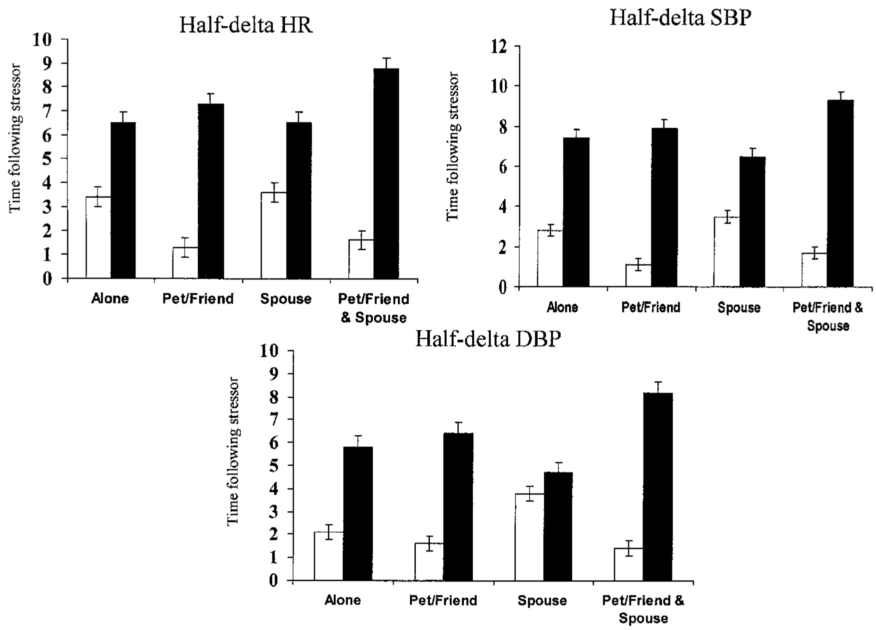

Fig. 4. Means and standard errors of recovery time to Δ/2 following mental arithmetic by pet ownership and presence of others.

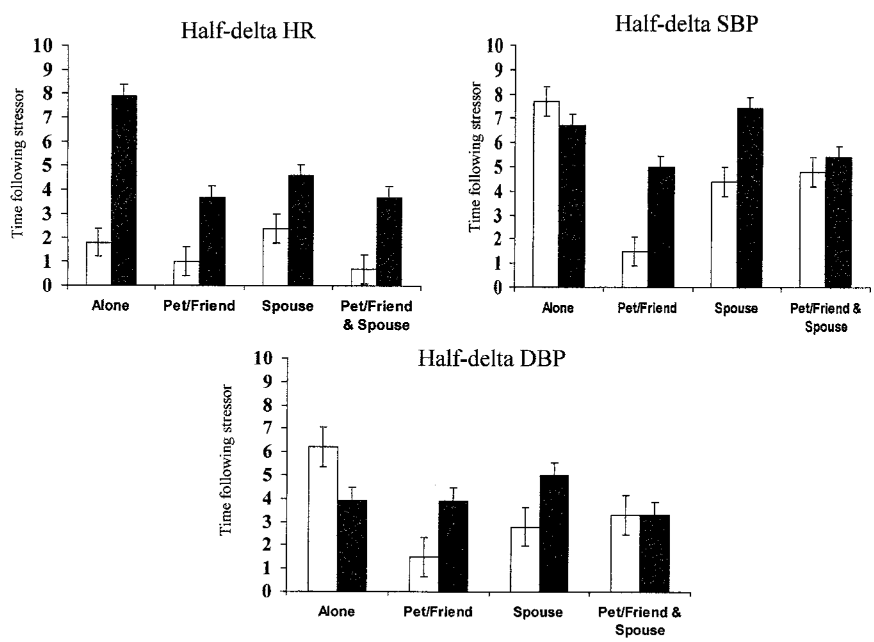

Fig. 5. Means and standard errors of recovery time to Δ/2 following cold pressor task by pet ownership and presence of others.

lished (29), we utilized extant data analytic techniques combined with our own analytic strategies to create an index of recovery that considers speed and time of cardiovascular recovery following the stressors.

Second, our findings indicate that non-pet owners had the lowest reactivity when they performed mental arithmetic alone and the highest reactivity in the presence of their spouses. Pet owners also had the highest reactivity with their spouses present, but their lowest reactivity occurred in the presence of their pets. In addition, pet owners were faster than nonowners at mental arithmetic, and the pet-present experimental condition was associated with the fewest errors, duplicating the mental arithmetic results reported in another pet-focused reactivity study (14). Perhaps the most interesting finding regarding presence of others and reactivity, however, was in the condition that included both pet and spouse. Although the presence

TABLE 4. Rates of Attempts and Errors During Mental Arithmetic by Pet Ownership and Presence of Others[a]

Presence of Others	Pet Owners	Non-Pet Owners
Attempts		
Alone	55.7_b	48.8_a
Pet/friend	52.9_b	51.6_a
Spouse	60.1_a	52.9_a
Pet/friend plus spouse	50.1_b	53.0_a
Errors		
Alone	7.0_b	6.9_c
Pet/friend	1.4_d	12.3_b
Spouse	16.7_a	16.8_a
Pet/friend plus spouse	2.9_c	16.2_a

[a] Different subscript letters refer to significant differences between column means. Means are adjusted for covariates.

of only a spouse elicited large BP and HR responses to mental arithmetic, the addition of the pet produced significantly diminished reactivity. Finally, during the cold pressor task (a nonevaluative, passive coping-type task), pet support was once again associated with the lowest reactivity, although the presence of spouses and/or friends was not as detrimental as during the mental arithmetic task.

Third, we found that pet owners were more likely to report challenge responses before the MAT than non-pet owners. Specifically, pet owners in the presence of their pet were significantly more likely to report challenge than those who were in any of the other experimental conditions, whereas non-pet owners were more likely to report challenge when alone than when in the presence of others.

This study replicates and extends our earlier work regarding friends, pets, and reactivity (3). Again, unlike other reactivity studies (4, 16, 30), we found that being alone was associated with lower reactivity than being with a friend. Both of our studies, however, were conducted in participants' homes in comfortable, familiar surroundings, and we do not know if a typical laboratory environment would produce different results. But we also do not know the influence of a laboratory environment in the studies cited above and if similar experiments would have different results in home surroundings.

Nevertheless, our study results have findings similar to past work (4, 31–35). Specifically, we have demonstrated that friends (albeit of another species) are associated with diminished reactivity. The work of Christenfeld et al. (35), which suggests that the nature of the support can influence its effectiveness, provides an explanatory framework for our findings. Similar to Christenfeld et al. (35), who contrasted reactivity differences elicited by friends and strangers, we examined differences elicited by different types of friends. We have demonstrated that the support of others can buffer physiological responses to stress but that the nature and species of such others is critical. In this respect, our results support the social support reactivity hypothesis (2), which postulates that the presence of others reduces health risks by attenuating harmful physiological responses to stressors. We speculate that one reason pets appear to elicit such calm responses is that they encourage the positive-feeling states that social support theorists (5, 21) have suggested may enhance a person's ability to handle stress. Although, to our knowledge, no established questionnaires exist to assess how pet ownership relates to emotional state, anecdotal reports of how people feel about being with pets often include words such as "happiness, " "laughter," and "relaxation." Although their owners often describe pets as providing a distraction from stress, we feel confident that our results were not so influenced because pet-owning participants remained engaged in the arithmetic task and actually outperformed the non-pet owners.

In recent years, the effect of the presence of others (friends and strangers, manipulated to be supportive or nonsupportive) on reactivity has been addressed in several laboratory studies (16, 35–38). Overall, these studies conclude that being alone during a stressful task elicits greater reactivity than does the presence of others who are nonevaluative. We agree with this conclusion. However, although the methodology of our current study has much in common with these previous investigations, important differences exist. For example, in several of the studies cited above, great care was taken to create a benign social environment and minimize evaluation potential and interaction between the observer and the participant under stress (eg, friends and strangers wore headphones to block out mental arithmetic responses of the participants). In contrast, our study did not attempt to manipulate opportunities for evaluation and instead instructed friends and spouses to just "be there as support." Similar to the observers in previous studies, our friends and spouses cheered the participants on, nodding their heads and making encouraging gestures. Although we did not mention to participants' friends whether touch was allowed, no participants or observers attempted to touch each other. A major departure in our study, of course, was the presence of what we regard as naturally occurring nonevaluative others in the form of participants' pets. In addition, although we examined the effect of same-sex best friends, we also included (presumably) best friends of the opposite sex (spouses).

A central research question regarding the presence of others is the level of familiarity of observer to the participant. Fontana et al. (16) demonstrated that observers in friend and stranger conditions elicited similar reactivity to stress among participants and concluded that familiarity is not important when evaluation apprehension is minimized. Our findings, however, suggest that, when evaluation apprehension is not minimized, participant's perceptions of potentially supportive others may be at least as important as familiarity. In our study, non-pet owners had the lowest reactivity to stress when they were alone rather than when in the company of supportive friends or spouses. They also reported being challenged when they were alone and threatened in the presence of others. The field location of our study and nature of our equipment, however, meant that the alone condition included the presence of the experimenter. Although the experimenter remained out of view of the participant, the participant was certainly aware of her presence but was undoubtedly less affected by it than by the social makeup of other conditions. After the experiment, many participants commented that, because they did not know the experimenter (and in all likelihood would never see her again), they felt less threatened by her presence than by that of their friends and spouses. For our participants, although spouses and friends may have meant well and tried to provide support, they were not perceived as nonevaluative.

While the idea of a pet as social support may appear to some as a peculiar notion, our participants' responses to stress combined with their descriptions of the meaning of pets in their lives suggest to us that social support can indeed cross species. In informal conversations, pet owners repeatedly told us that they talked to and confided in their pets and that having a pet nearby made them "feel better." We believe such reports indicate a need for a social support measure that could accurately assess and describe the meaning of pets in their owners' lives relative to other (human) sources of support.

Applications of the findings in this study are limited by our focus on a healthy population and by the lack of randomization to pet ownership. Although we know that pet owners and non-pet owners did not differ in terms of several personality, social support, and demographic measures, we do not know if there is some other important overarching characteristic associated with pet ownership that we have not identified. However, in a recent reactivity and pet study, we documented that random assignment to pet ownership can influence reactivity in a manner consistent with what we report here (14). We contend, however, that, because pet ownership is widespread and voluntary, it is also important to study individuals who have made their own choices about pets. Although this study has limitations and raises several questions about causality, we believe we have demonstrated clearly that people perceive their pets as important, supportive parts of their lives and that significant cardiovascular and behavioral benefits are associated with those perceptions.

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REFERENCES

1. Lepore SJ. Problems and prospects for the social support-reactivity hypothesis. Ann Behav Med 1998;20:257–69.
2. Uchino B, Cacioppo JT, Kielcolt-Glaser JK. The relationship between social support and physiological processes: a review with emphasis on underlying mechanisms and implications for health. Psychol Bull 1996;119:488–531.
3. Allen K, Blascovich J, Tomaka J, Kelsey RM. Presence of human friends and pet dogs as moderators of autonomic responses to stress in women. J Pers Soc Psychol 1991;61:582–9.
4. Kamarck TW, Manuck SB, Jennings JR. Social support reduces cardiovascular reactivity to psychological challenge: a laboratory model. Psychosom Med 1990;54:42–58.
5. Cohen S, Syme SL. Social Support and Health. San Diego (CA): Academic Press; 1985.
6. Shumaker SA, Czajkowski SM. Social Support and Cardiovascular Disease. New York (NY): Plenum; 1994.
7. Siegel JM. Stressful life events and use of physician services among the elderly: the moderating role of pet ownership. J Pers Soc Psychol 1990;58:1081–6.
8. Siegel JM, Angulo FJ, Detels R, Wesch J, Mullen A. AIDS diagnosis and depression in the multicenter AIDS cohort study: the ameliorating impact of pet ownership. AIDS Care 1999;11:157–69.
9. Allen K, Blascovich J. The value of service dogs for people with severe ambulatory disabilities. A randomized controlled trial. JAMA 1996;275:1001–6.
10. Friedmann E, Katcher AH, Lynch JJ, Thomas SA. Animal companions and one-year survival of patients after discharge from a coronary care unit. Public Health Rep 1980;95:307–12.
11. Friedmann E, Thomas SA. Pet ownership, social support, and one-year survival after acute myocardial infarction in the Cardiac Arrhythmia Suppression Trial (CAST). Am J Cardiol 1995;76:1213–7.
12. Friedmann E, Katcher AH, Thomas SA, Lynch JJ, Messent PR. Social interaction and blood pressure: influence of companion animals. J Nerv Ment Dis 1983;171:461–5.
13. Lynch JJ. The Language of the Heart. New York (NY): Basic Books; 1985.
14. Allen K, Shykoff B, Izzo JL Jr. Pet ownership, but not ACE inhibitor therapy, blunts home blood pressure responses to mental stress. Hypertension 2001;38:815–20.
15. Cohen S, Wills TA. Stress, social support, and the buffering hypothesis. Psychol Bull 1984;98:310–57.
16. Fontana AM, Diegnan T, Villeneuve A, Lepore S. Nonevaluative social support reduces cardiovascular reactivity in young women during acutely stressful performance situations. J Behav Med 1999;22:75–91.
17. Tomaka J, Blascovich J, Kibler J, Ernst JM. Cognitive and phys-

iological antecedents of threat and challenge appraisal. J Pers Soc Psychol 1997;73:63–72.
18. Templer DI, Salter CA, Dickey S, Baldwin R. The construction of a pet attitude scale. Psychol Rec 1981;31:343–8.
19. Berscheid E, Snyder M, Omto AM. The relationship closeness inventory: assessing the closeness of interpersonal relationships. J Pers Soc Psychol 1989;57:792–807.
20. Cook WW, Medley DM. Proposed hostility and phariasic-virtue scales for the MMPI. J Appl Psychol 1954;38:414–8.
21. Cohen S, Hoberman HM. Positive events and social supports as buffers of life change to stress. J Appl Soc Psychol 1983;13: 99–125.
22. Siegel JM. The multidimensional anger inventory. J Pers Soc Psychol 1986;51:191–200.
23. van Horn R. Noninvasive blood pressure performance: a standardized method for quantifying motion artifact tolerance. Biomed Instrument Measure. In press.
24. Amoore JN. A simulation study of the consistency of oscillometric blood pressure measurements with and without artefacts. Blood Press Monit 2000;5:69–79.
25. Long PM, Green WA. Physiological changes occurring over different temperatures of the cold pressor test. Psychophysiology 1995;32:S51.
26. Latour D, Latour K, Wolfinger RD. Getting Started with PROC Mixed Software. Cary (NC): SAS Institute, Inc.; 1994.
27. Tabachnick BG, Fidell LS. Using Multivariate Statistics. New York (NY): Harper Collins College Publishers; 1996.
28. Schuler JL, O'Brien WH. Cardiovascular recovery from stress and hypertension risk factors: a meta-analytic review. Psychophysiology 1997;34:649–59.
29. Christenfeld N, Glynn LM, Gerin W. On the reliable assessment of cardiovascular recovery: an application of curve-fitting techniques. Psychophysiology 2000;37:543–50.
30. Anthony JL, O'Brien WH. An evaluation of the impact of social support manipulations on cardiovascular reactivity to laboratory stressors. Behav Med 1999;25:78–87.
31. Edens JL, Larkin KT, Abel JL. The effect of social support and physical touch on cardiovascular reactions to mental stress. J Psychosom Res 1992;36:371–81.
32. Snydersmith MA, Cacioppo JT. Parsing complex social factors to determine component effects: I. Autonomic activity and reactivity as a function of human association. J Soc Clin Psychol 1992;11:263–78.
33. Gerin W, Milner D, Chawla S, Pickering TG. Social support as a moderator of cardiovascular reactivity in women: a test of the direct effects and buffering hypotheses. Psychosom Med 1995; 57:16–22.
34. Glynn LM, Christenfeld N, Gerin W. Gender, social support, and cardiovascular responses to stress. Psychosom Med 1999;61: 234–42.
35. Christenfeld N, Gerin W, Linden W, Sanders M, Mathur J, Deich JD, Pickering TG. Social support effects on cardiovascular reactivity: is a stranger as effective as a friend? Psychosom Med 1997;59:388–98.
36. Lepore SJ, Allen KA, Evans GW. Social support lowers cardiovascular reactivity to an acute stressor. Psychosom Med 1993; 55:518–24.
37. Lepore SJ. Cynicism, social support, and cardiovascular reactivity. Health Psychol 1995;14:210–6.
38. Kors DJ, Wolfgang L. Evaluation interferes with social support: effects of cardiovascular stress in women. J Soc Clin Psychol 1997;16:1–23.