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LONELINESS, PSYCHOSOCIAL STATES, BEHAVIOR, AND CARDIOVASCULAR PHYSIOLOGY: A 12-HOUR FIELD STUDY

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

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2001

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The current study is part of an ongoing research program focused on understanding psychological and physiological mechanisms underlying the health risk associated with loneliness. In a laboratory component that preceded the present study, lonely students exhibited higher levels of total peripheral resistance (TPR), diminished cardiac output, and smaller increases in sympathetically mediated cardiac responses to a series of acute stressors than did the nonlonely. In the 12-hour field study reported here, an experience sampling methodology was employed to monitor students' cardiovascular, psychosocial, and behavioral state at 9 random times over the course of a day. We hypothesized that loneliness would predict elevated vascular resistance in the field as it had in the laboratory. We also hypothesized that the lonely would display less sympathetic reactivity to the active coping demands of everyday stressors as they had in the laboratory. In addition, we hypothesized that loneliness would predict higher stress ratings of everyday activities, and examined whether the lonely were more frequently exposed to stressful situations. We also examined whether the lonely would be with friends less frequently than the nonlonely. Moreover, we hypothesized that the lonely would show smaller cardiovascular benefits from being with others during stressful situations. In addition, we hypothesized that loneliness would predict more negative ratings of social interactions. Finally, we sought to replicate retrospective reports that the lonely did not differ from the nonlonely in the frequency of health-compromising behaviors. As hypothesized, loneliness predicted increased TPR. In regard to sympathetic responses to the active coping demands of everyday life, loneliness predicted diminished cardiac output, but did not predict differential pre-ejection period.
The lonely gave larger threat appraisals; appraisals did not predict TPR. The lonely and nonlonely did not differ in exposure to everyday stressors, nor did they spend less time with other people. However, the lonely rated themselves as less "close," more "distant," and more "distrustful" than the nonlonely during social interactions. Closeness predicted reduced TPR. The lonely did not engage in more frequent health-compromising behaviors than did the nonlonely. Future research should examine the critical aspects of social interactions in predicting cardiovascular activity in the lonely.
Dedicated to my husband, Ken, and our two children, Krysta and Jared,

with love and deep appreciation for the sacrifices you have made on my behalf.
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“Education is what survives when what has been learned has been forgotten” (B. F. Skinner, 1964). For this reason, I am grateful for having had the fortune of spending time close to many great minds during my graduate education at the Ohio State University. With this document culminating a career in graduate school, I want to thank my two advisers, John Cacioppo and Gary Berntson, for both challenging and supporting my intellectual development, and for patiently correcting my thinking and writing. I am grateful to former post-doctoral fellows, particularly Mary Burleson and John Ernst, for their willingness to discuss aspects of this work and to embark on related collaborative efforts. I am also thankful for the intellectual energy I derived from working alongside gifted colleagues, such as Kyle Smith, Ray Kowalewski, and Jeff Larsen. Finally, I would like to thank Kris Preacher for providing conceptual and practical support in the use of MLwiN software.

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TABLE OF CONTENTS

Abstract ......................................................................................................................................ii

Dedication ................................................................................................................................iv

Acknowledgments .................................................................................. v

Vita ...........................................................................................................................................vi

List of Tables ............................................................................................................................ix

Chapters:

1. Introduction .............................................................................................................1

   1.1 Background ......................................................................................................1

   1.2 Loneliness and total peripheral resistance .........................................................3

   1.3 Loneliness and cardiovascular reactivity ...........................................................4

   1.4 Loneliness and stress: Differential reactivity and
differential exposure.................................................................................................4

   1.4.1 Loneliness and cardiovascular activity in a social context.....................5

   1.4.2 Differential social exposure....................................................................6

   1.4.3 Interaction quality...................................................................................6

   1.5 Loneliness and health behaviors.................................................................7

   1.6 Physical activity, posture, talking, and consummatory behaviors...............8

   1.7 Individual differences in cardiovascular activity ..............................................9

   1.8 This study ........................................................................................................10

2. Method ............................................................................................................................11

   2.1 Participants ......................................................................................................11

   2.2 Procedure .........................................................................................................12

   2.3 Cardiovascular equipment and measures .........................................................14

       2.3.1 Ambulatory blood pressure assessment................................................14

       2.3.2 Ambulatory impedance assessment.......................................................15

   2.4 Diary measures...................................................................................................16

   2.5 Individual differences measures .......................................................................17

   2.6 Cardiovascular data preparation .......................................................................18

       2.6.1 Outlier and error detection ...................................................................18

   2.7 Diary data preparation ......................................................................................19

       2.7.1 Behavior ..............................................................................................20

       2.7.2 Cognitive appraisals ............................................................................21
2.7.3 Social interactions ................................................................. 21
2.7.4 Interaction ratings ................................................................. 21
2.7.5 Outlier detection ................................................................. 22
2.8 Preparation of the final datasets .................................................. 23
2.9 Data analytic strategy .............................................................. 23
2.9.1 Multilevel regression analyses ................................................ 23
2.9.2 Analyses of variance ............................................................ 24
2.9.3 Special considerations .......................................................... 25
3. Results .......................................................................................... 26
3.1 Covariates .................................................................................... 26
3.2 Does loneliness predict elevated vascular resistance? .................... 28
3.3 Does loneliness predict diminished cardiac responsivity? ............... 32
3.4 Do the lonely give higher stress ratings ......................................... 32
3.5 Are the lonely more frequently exposed to stressors? ...................... 32
3.6 Are the lonely less buffered from cardiovascular effects of stress? .. 35
3.7 Are the lonely less frequently with others? ..................................... 35
3.8 Do the lonely perceive social interactions more negatively? .......... 37
3.9 Do the lonely engage in more health-compromising behaviors? ...... 40
3.10 Gender differences in cardiovascular activity, social interactions, and health behaviors ................................................................ 42
4. Discussion ...................................................................................... 43
4.1 Loneliness and vascular resistance ............................................... 43
4.2 Loneliness and cardiovascular reactivity ........................................ 44
4.3 Loneliness and stress .................................................................. 44
4.4 Loneliness and cardiovascular activity in a social context ............... 45
4.5 Loneliness and social exposure .................................................... 45
4.6 Loneliness and interaction quality ................................................ 45
4.7 Loneliness and health behaviors .................................................. 47
4.8 Gender ......................................................................................... 48
4.9 Limitations of the current study ................................................... 48
4.10 Future Directions ....................................................................... 51

List of References ............................................................................. 55

Appendix: Experience Sampling Questionnaire .................................. 63
LIST OF TABLES

Table | Page
--- | ---
2.1 Factor solution of social interaction ratings | 22
3.1 Prevalence and frequency of behavioral variables (n = 1,051) | 27
3.2 Nonstandardized partial regression coefficients for covariates in base models with cardiovascular criteria | 29
3.3 Means (SDs) of cardiovascular variables as a function of loneliness group and gender | 30
3.4 Nonstandardized partial regression coefficients for loneliness, depression, and covaried loneliness and depression in models with cardiovascular criteria | 31
3.5 Means (SDs) of cardiovascular variables and cognitive appraisals as a function of loneliness group during active coping behaviors | 33
3.6 Means (SDs) of percentage of observations engaged in activities as a function of loneliness group and gender | 34
3.7 Means (SDs) of total daily number of interactants and social interactant endorsement rate (% of observations) as a function of loneliness group and gender | 36
3.8 Mean (SD) social interaction ratings as a function of loneliness group and gender | 38
3.9 Nonstandardized partial regression coefficients for loneliness, depression, and covaried loneliness and depression in models with psychological criteria ......................................................... 39

3.10 Means (SDs) of percentage of observations engaged in health-related behaviors as a function of loneliness group and gender ......................................................... 41
CHAPTER 1

INTRODUCTION

"What should young people do with their lives today?

Many things, obviously. But the most daring thing is to

create stable communities in which the terrible disease

of loneliness can be cured." - Kurt Vonnegut

Background

Loneliness is indeed a terrible condition. Lonely people not only report less happiness
with life, but tend also to exhibit hostility, pessimism, poor social skills, insecure attachment
styles, interpersonal distrust, and poor coping mechanisms (Berscheid & Reis, 1998; Ernst &
Cacioppo, 1999). This syndrome of psychological symptoms is of obvious concern in terms of
sufferers’ mental health, but the concern may extend to physical health. To the extent lonely
individuals find themselves socially isolated, they have increased risk for morbidity and mortality
from widespread causes, even after controlling for standard risk factors such as smoking, obesity,
sedentary lifestyle, and social status (Berkman & Syme, 1979; House, Landis, & Umberson,
1988). In their review of the relationship between social isolation and cardiovascular disease,
Rozanski et al. (1999) found significantly increased risk for cardiac events among initially
healthy populations who had smaller or less diverse social networks, less frequent social
interactions, and fewer people living with them (Rozanski, Blumenthal, & Kaplan, 1999).
Animal studies provide experimental evidence that social factors influence cardiovascular function and risk for disease. In animal models of social isolation, female cynomolgus monkeys separated from their social group were shown to exhibit increased heart rate, a known risk factor for coronary heart disease in both monkeys and human beings (Watson, Shively, Kaplan, & Line, 1995; Kaplan, Manuck, & Clarkson, 1987). Indeed, monkeys assigned to isolated housing developed significantly more advanced arteriosclerosis than those assigned to group housing, even though the groups did not differ in levels of plasma lipids (Shively, Clarkson, & Kaplan, 1989). The stress of social isolation was further shown to result in endothelial damage, an effect that is believed to initiate atherogenesis (Skantze, et al., 1998).

In humans, qualitative aspects of social relationships have also been shown to predict cardiovascular health. Krumholz et al. (1998), for instance, reported that a lack of emotional support increased the risk of fatal and nonfatal cardiovascular events after heart failure, especially among women. Among individuals who had experienced a myocardial infarction, emotional support was shown to be inversely and linearly related to the death rate (Berkman, Leo-Summers, & Horwitz, 1992). In fact, subjective measures of social relationships have been shown to be at least as important as objective measures of social isolation in predicting health consequences (Seeman, 1996; Uchino, Cacioppo, & Kiecolt-Glaser, 1996). This is a particularly important finding since loneliness is, by definition, a perceived (i.e., subjective) deficit in social relationship quantity or quality (Peplau & Perlman, 1982). In a direct assessment of the relationship between loneliness and health outcomes, Herlitz et al. (1998) reported that among 1,290 patients who underwent coronary artery bypass surgery, ratings of the statement, “I feel lonely,” predicted survival at 30 days and 5 years after surgery independently of preoperative factors known to increase mortality.
The mechanisms responsible for the link between loneliness and health are not yet known, but our initial laboratory testing of lonely and nonlonely individuals suggested one possibility, that lonely and nonlonely individuals differ in levels of autonomic (i.e., cardiovascular) activity. In this field study, we employed experience sampling methodology to collect information about psychosocial and behavioral states concurrently with various measures of cardiovascular activity. Experience sampling methodology (ESM), as the name implies, involves repeated momentary assessments of phenomena experienced in the natural environment. The primary advantage of the method, therefore, is its ecological validity. An additional advantage of ESM is its reliance on immediate reporting of activities, thoughts, and feelings, thereby reducing its vulnerability to the memory-related errors and biases typically associated with retrospective self-reports. Furthermore, of particular relevance for the present study, concurrent momentary assessments of self-report and ambulatory cardiovascular measures permit asking questions about the dynamic relationships among cardiovascular measures, events, thoughts, and feelings (Shiffman & Stone, 1998).

**Loneliness and total peripheral resistance.**

Vascular resistance and cardiac output jointly determine blood pressure. Thus, elevated blood pressure can be due to increased peripheral resistance, increased cardiac output, or both. Individual differences in vascular resistance and cardiac output responses to laboratory stressors exhibit temporal stability (Kasprowicz, Manuck, Malkoff, & Krantz, 1990) and postural stability (Sherwood & Turner, 1993). In fact, individual differences in the hemodynamic determinants of blood pressure may be more robust than individual differences in blood pressure itself (Sherwood & Turner, 1993). These differences may be significant in that elevated peripheral resistance can, over the long term, contribute to the development of hypertension, a condition well known to increase risk for cardiovascular events such as myocardial infarctions and strokes (Brown & Haydock, 2000).
During the laboratory component of the present study, we observed higher tonic levels of peripheral vascular resistance and lower tonic levels of cardiac output in the lonely than in the nonlonely (Cacioppo et al., in press). Of course, if tonic elevations in vascular resistance are characteristic of lonely individuals, this characteristic should generally also be evident in everyday life. Employing the same participants as in the laboratory component, we hypothesized that this indeed would be the case.

**Loneliness and cardiovascular reactivity**

Against a background of tonically elevated vascular resistance, the lonely showed smaller sympathetic cardiac responses to active coping tasks (Obrist, 1981) in a laboratory setting than did the nonlonely. That is, we observed smaller increases in heart rate and cardiac output, and smaller decreases in pre-ejection period among the lonely than the nonlonely during speech delivery and a mental arithmetic task. Because blood pressure levels were comparable for the lonely and nonlonely, control of blood pressure appeared to involve a greater vascular component (i.e., peripheral resistance) in the lonely and a greater cardiac component (i.e., heart rate, cardiac output) in the nonlonely. We hypothesized that this loneliness-related difference in the pattern of cardiovascular activity would characterize the responses of the same students to field stressors requiring active coping.

**Loneliness and stress: Differential reactivity and differential exposure**

In addition to differential cardiovascular reactivity to stress, loneliness may be associated with differential ratings of the stressfulness of everyday activities. What we observed in the laboratory was that although the lonely did not differ from the nonlonely in their retrospective reports of the frequency of past (or present) stressful life events, they reported greater levels of perceived stress (Cacioppo et al., 2000). In the field, we hypothesized that the lonely would appraise their everyday circumstances as more threatening. Cognitive appraisals reflect stress by taking into consideration both the perceived demands of the situation and one's perceived ability
to meet those demands (Blascovich & Tomaka, 1996). That is, we hypothesized that the appraisals of the lonely would reflect their perception that they were less capable than the nonlonely of coping with the situations encountered over the course of the day.

Independent of the cardiovascular and cognitive responses of the lonely to everyday stressors, loneliness may be associated with differential exposure to stress. We evaluated the possibility that the lonely engaged in different types or frequencies of potentially stressful everyday activities than did the nonlonely. To the extent the lonely are more frequently exposed to stressors, differences in cardiovascular responses could exact a larger cumulative toll.

**Loneliness and cardiovascular activity in a social context.** Previous research indicates that cardiovascular activity is influenced by the social context. For example, when times alone were contrasted with contexts in which adult participants were with family, friends, or strangers, ambulatory systolic and diastolic blood pressure levels were lowest in the family context and highest in the stranger context (Spitzer, Llabre, Ironson, Gellman, & Schneiderman, 1992). Similarly, interactions with a significant other predicted significantly lower ambulatory systolic blood pressure than that exhibited during other one-on-one interactions, or during times not interacting (Gump, et al., 2001).

Moreover, cardiovascular responses to stress are influenced by the presence of others. For example, young adult women showed smaller increases in blood pressure to a threatening mental stressor when in the presence of a partner than when alone (Kamarck, Manuck, & Jennings, 1990). During an experimental procedure that included unstructured conversation and reunion with the partner or friend after separation, female participants interacting with a long-term romantic partner exhibited lower heart rates than females interacting with equally long-term best friends (Diamond, 2000). On the basis of these findings, we hypothesized that the presence of others, especially close social partners (e.g., friends) as opposed to less familiar partners, would buffer (i.e., reduce) cardiovascular activity and cardiovascular responses to stress in the
field. Ultimately, we wanted to know whether the lonely would experience as much of a benefit from the presence of others, in terms of cardiovascular activity, as would the nonlonely.

**Differential social exposure.** Even if the lonely benefit as much as the nonlonely from the presence of others, previous research suggests that they may not be with others as often as are the nonlonely. For example, Russell et al. (1980) found that loneliness measured with the revised UCLA loneliness scale (R-UCLA) was positively correlated with self-reported amount of time spent alone each day and negatively correlated with number of close friends. More recently, Bell (1993) reported that lonely individuals have fewer friends, fewer close friends, and are less likely to have a romantic partner. Lonely individuals also tend to avoid social situations and to prefer solitude (Burger, 1995; Nurmi, Toivonen, Salmela-Aro, & Eronen, 1996). We therefore predicted that lonely individuals in our study would report fewer social interactions, and that this could result in reduced day-to-day benefits of social interactions on cardiovascular activity.

**Interaction quality.** Qualitative differences in social interactions may also impact on the cardiovascular benefit of being with others. Holt-Lunstad et al. (submitted), for example, found that ambulatory blood pressure levels were highest when participants were interacting with individuals about whom they felt ambivalent (high positive and high negative feelings), independent of the role these individuals played in participants’ lives (e.g., family member, spouse, friend, roommate, coworker). Hostility during social interactions has been associated with elevated ambulatory blood pressure, at least in men (Guyll & Contrada, 1998; Smith & Allred, 1989), and with greater vascular resistance during interpersonal stressors (Davis, Matthews, & McGrath, 2000). On the other hand, empathy during discussion of an emotional personal problem predicted lower heart rate and lower heart rate variability during the interaction (Conforti, 1999).
The primary complaint of the lonely is that their social interactions lack the level of intimacy they desire (Segrin, 1998; Williams & Solano, 1983). Ironically, despite their desire for more intimate relationships, they tend to be more distrustful (Rotenberg, 1994) and inhibited (Horowitz & French, 1979; Jones, Hobbs, & Hockenbury, 1982) in their social interactions. Lonely individuals are generally considered low in social skills (Buhrmester, Furman, Wittenberg, & Reis, 1988; Riggio, Watring, & Throckmorton, 1993), and they seem acutely aware of their social ineptitude, giving themselves more negative ratings during interactions with strangers (Christensen & Kashy, 1998) or established friends and roommates (Wittenberg & Reis, 1986; Duck, Pond, & Leatham, 1994). Whether these negative impressions of social relationships are causes or consequences of loneliness is not clear, but these findings suggest that, regardless of the type of social partner (e.g., stranger, friend), lonely individuals are more likely than nonlonely individuals to perceive their relationships and interactions as less satisfying or meaningful. We therefore hypothesized that momentary reports of perceived social interaction quality would be more negative among the lonely than the nonlonely.

**Loneliness and health behaviors.**

An additional explanation for cardiovascular differences between the lonely and nonlonely could involve poorer health behaviors by the lonely. In the laboratory component of this study, the lonely and nonlonely did not differ in frequency or amount of weekly exercise, nor in alcohol, tobacco, and caffeine consumption, but the lonely did report slightly greater use of recreational drugs. However, these results were based on retrospective reports; on-line momentary reports of such behaviors were expected to provide a more accurate representation of actual health-related behaviors. To the extent health habits are being established during the college years, health-compromising behaviors could, over the long term, pose significant health risks.
Physical activity, posture, talking, and consummatory behaviors

In field studies, analyses of cardiovascular activity during psychological and emotional states should consider, and statistically control for, cardiovascular effects of various physical states (Carels, Sherwood, & Blumenthal, 1998). Mild to moderate levels of physical activity, for example, result in increased heart rate and vasoconstriction in peripheral, inactive tissues (e.g., kidneys, skin). Vascular resistance in active muscle tissue, on the other hand, is reduced due in part to the local release of vasodilatory substances, and permits increased blood flow with relatively modest increases in blood pressure (Berne & Levy, 1997). A postural change, such as shifting from lying down to standing, results in a rapid increase in total peripheral resistance, and a decrease in stroke volume accompanied by a gradual increase in heart rate, that in combination produce only a slight decrease in cardiac output and a slight increase in blood pressure. These changes are effected within a minute of the postural change, and are as quickly reversed with a return to a supine posture (Levick, 1995).

Among other behaviors that may have cardiovascular consequences, talking and consumption behaviors are prevalent in everyday life. Talking rapidly increases heart rate and blood pressure (Liehr, 1992; Tardy, Thompson, & Allen, 1989), although these effects appear to be moderated by the affective content of speech rather than the motor efforts involved in generating speech (Linden, 1987). Eating and drinking alcohol have been observed to increase diastolic blood pressure and decrease heart rate if tested within four hours of ingestion (Sheffield, et al., 1997), although some have observed heart rate to increase after eating (Smith, Clark, & Gallagher, 1999). Tobacco and caffeine use produce acute increases in systolic and diastolic blood pressure, and tobacco also increases heart rate (Green, Kirby, & Suls, 1996; James & Richardson, 1991; Sheffield, et al., 1997). The increased blood pressure observed in response to caffeine consumption has been shown to arise from increased vascular resistance (Pincomb, Sung, Lovallo, & Wilson, 1993). In the current study, to permit statistical control of the
cardiovascular effects of physical states, participants were asked at each timepoint to indicate their posture, physical activity, whether they were talking, and whether they were or had ingested food, alcohol, caffeine, or nicotine.

**Individual differences in cardiovascular activity**

In addition to physical activity and consummatory behaviors that could obscure the relationship between cardiovascular activity and psychosocial states, several individual difference variables were also included as covariates in analyses involving cardiovascular activity. Body mass index (BMI) and a parental history of hypertension (PHT) are frequently taken into consideration in estimations of health risks because of their known influence on cardiovascular activity. BMI has strong associations with elevated blood pressure, and to lipid abnormalities (i.e., higher levels of low-density lipoproteins and triglycerides and lower levels of high-density lipoproteins) that may contribute to cardiovascular health risk (Rabkin, et al., 1997). PHT has been associated with elevated blood pressure and, among males, with higher vascular resistance at rest and in response to psychological stress (Sherman, McCubbin, & Matenga, 1998; Marrero, al’Absi, Pincomb, & Lovallo, 1997).

Depression, like loneliness, involves relational problems, including poor social skills and difficulty forming meaningful relationships with others (Segrin, 1998). Correspondingly, depression and loneliness are correlated (Russell, Peplau, & Cutrona, 1980), so we employed depression as a covariate to determine the unique contribution of loneliness in predicting psychosocial variables, and whether depression moderated the influence of loneliness. In terms of cardiovascular activity, major depression has been associated with elevated systolic and diastolic blood pressure, as well as increased heart rate, diminished pre-ejection period, and diminished heart rate variability (Light, Kothandapani, & Allen, 1998). On the other hand, subclinical depressive symptoms have been associated with either no effect on blood pressure (Paterniti, et al., 1999) or with diminished diastolic blood pressure (Shinn, 1999; Moser et al., 1999).
We examined whether loneliness made a unique contribution in predicting cardiovascular activity beyond what was predicted by depression, and whether depression moderated the effects of loneliness.

For completeness, we also considered gender differences in the relationship between loneliness and psychosocial and cardiovascular variables. Loneliness tends to be experienced at least as intensely in males as in females (Borys and Perlman, 1985). Similarities in self-reported loneliness intensity, however, may not be reflected in similar psychological and physiological processes in males and females. For example, perceived quality of social support was inversely related to systolic blood pressure in female undergraduate students, but not in male students (Linden, Chambers, Maurice, & Lenz, 1993). Therefore, separate analyses were performed to whether gender moderated the effects of loneliness on psychosocial and cardiovascular variables.

This Study

In review, therefore, this study examined the following questions:

1. Does loneliness predict elevated vascular resistance in the field as it did in the laboratory?

2. Does loneliness predict diminished cardiac responsiveness (i.e., heart rate, cardiac contractility, cardiac output) to the active coping demands of everyday stressors as it did in the laboratory?

3. Does loneliness predict higher stress ratings of everyday activities?

4. Are the lonely and nonlonely differentially exposed to stressors?

5. Do the lonely benefit less than the nonlonely from the cardiovascular buffering effects of being with others?

6. Are the lonely less likely to be with friends? Do they perceive their interactions with others more negatively?

7. Do the nonlonely engage in more health-compromising behaviors than the nonlonely?
CHAPTER 2

METHOD

Participants

Participants were 135 undergraduate students (83% Caucasian, 7% African-American, 7% Asian, Asian American, or Pacific Islander, 3% other or undeclared) at the Ohio State University. Students were screened and recruited to represent the lower (total score ≤28; 22 males, 22 females), middle, (total score ≥33 and <39; 23 males, 23 females), and upper quintile (total score ≥46; 23 males, 22 females) of scores on the R-UCLA Loneliness Scale. Inclusion criteria for participation were that participants (a) score no higher than 13 on the 13-item version of the Beck Depression Inventory; (b) had a body mass index (BMI) no greater than 27; (c) were enrolled in at least 6 credit hours in the quarter during which they were to be tested; (d) were not first-quarter freshmen during the quarter they were tested; (e) were not last-quarter seniors; (f) were not speech or needle phobic; (g) were not married or living with a significant other; (h) were U.S. citizens, and (i) scored no more than 8 on a 12-point lie scale (included to determine the credibility of participants' responses; approximately 8% of students were excluded on this basis). At the time of recruitment, students' mean age was 19.2 (SD = 1.0) and they had completed at least one and, on average, 3.2 (SD = 2.8) academic quarters at this university. 52% were freshmen, 32% were sophomores, 8% were juniors, and the remaining 8% were seniors or fifth-year students.
Before being accepted as participants, students were advised regarding the time-consuming nature of the study, and were informed that, to reflect the importance of maintaining compliance during the entire study, payment would be distributed across the days of the study. For their participation in the study, participants received $30 for completing day 1, $25 for completing each of days 2 and 3, $20 for completing each of days 4-8, and a $20 bonus for completing the study, totaling $200 for the entire study. All 135 participants completed Day 1 of the study, and 134 completed Day 2, the day upon which this study is based.

Procedure

Participation in the study involved a laboratory component on Day 1, an ambulatory cardiovascular component with diaries on Day 2, salivary cortisol assessment with diaries on Day 3, and diaries on Days 4-8. Participants were scheduled so that the ambulatory cardiovascular monitoring occurred on a Monday, Tuesday, Wednesday, or Thursday to maintain relatively consistent daily routines across students. Ambulatory study day did not differ by loneliness group or gender ($X^2 < 4, p's > .2$).

On Day 1 of the study, participants completed a laboratory cardiovascular reactivity protocol (results reported elsewhere) in the General Clinical Research Center at the Ohio State University Medical Center. This protocol took place in the late afternoon and was followed by participants' completing a battery of psychological tests (results reported elsewhere). Participants then spent the night at the Ohio State University Medical Center.

The next day, Day 2 of the study, all participants were awakened at approximately 7 am. A blood sample was obtained from the indwelling catheter inserted the prior day, then the catheter was removed and participants could shower. While eating a breakfast of their choice, participants were asked to complete a small packet of psychological inventories. After breakfast, usually between 8:00 and 8:30 a.m., ECG spot electrodes were applied in a standard lead II configuration, and impedance band electrodes were applied as detailed in Sherwood, Allen, et al.
Briefly, the two inner voltage electrodes encircled the base of the neck just above the pre-sternal notch, and the thorax at the xiphisternal junction (or below the bra line in females). The two outer current electrodes were applied so as to maintain a distance of at least 3 cm from the voltage electrodes. The distance between the front and back voltage electrodes was measured for use in computing stroke volume. At this point, experimenters verified the functionality of the ambulatory impedance unit by connecting the ECG/ZCG cable leads to the unit and connecting the unit to an on-site computer programmed to provide a visual display of signal quality. When functionality of the ambulatory impedance unit was confirmed, a final step was to attach a blood pressure cuff to the participant's non-dominant arm, connect the cuff to the ambulatory blood pressure monitor, and confirm the functionality of this unit.

For the ambulatory study, participants were asked to initiate cardiovascular data collection and make a diary entry whenever signaled. A watch (suspended from a cord worn around the neck to enhance audibility) signaled the participant with a beeping sound at 9 random times over the course of the day. The first beep always occurred at 9:30 am and the final beep occurred before 9 pm; no 2 beeps were closer than 45 minutes apart.

Prior to leaving the Medical Center to resume their normal everyday activities, participants were trained how to respond to a watch beep. Participants were instructed that, upon being signaled, they were to be seated, take out one of the provided diaries, initiate cardiovascular

---

1 Several measures were taken to minimize the obtrusiveness of the ambulatory equipment, both to the participant and to observers. The air supply hose for the blood pressure cuff was inconspicuously draped down the inside of the participant's shirt before emerging to connect to the blood pressure unit worn in a pouch on a belt around the waist. The four cables leading from the four impedance electrode bands and the three cables leading from the ECG spot electrodes were also draped inside the participant's shirt before emerging to connect to the impedance unit worn in a separate pouch on a belt around the waist. Excess cable length was bound in rubber bands and tucked out of sight into the pouch. Both pouches (blood pressure unit and impedance unit) were so situated on the participant's waist as to maximize comfort and minimize interference with movement. Approximately the first 60 participants tested had a respirometer applied below the bottom voltage electrode; this was determined to be unnecessary in later participants in light of demonstrations of valid respiratory estimations derived from impedance signals (Ernst, Litvack, Lozano, Cacioppo, & Berntson, 1999).
data collection from each ambulatory instrument, and complete the diary while minimizing body motion. To provide a reliable estimate of cardiovascular activity, the impedance unit was programmed to collect 4 minutes of data upon triggering. To provide a reliable estimate of blood pressure, participants were asked to initiate a first blood pressure reading at the beginning of the collection epoch and a second reading upon encountering a written instruction midway through the diary booklet.

All participants were provided with an instruction card detailing the procedure they were to follow upon being signaled and outlining how to respond in the event of unusual circumstances like driving, taking an exam, or arguing. In these circumstances, participants were instructed to initiate ambulatory data collection and complete a diary as soon as possible after the event. Participants were also given simple trouble-shooting instructions, including how to adjust the blood pressure cuff should it slip from its original position during the day and how to re-attach an ECG electrode or lead should it come off (a spare spot electrode was provided in case one needed to be replaced). This instruction card included contact information in the event of equipment problems. In addition, participants were asked to avoid vigorous exercise and showering while wearing the ambulatory units.

Participants returned to the General Clinical Research Center by 9 pm of Day 2 to turn in that day’s diaries and have a nurse detach the ambulatory units and remove all electrodes. In return, participants were given diaries and salivary cortisol collection tubes to be used the following day (results to be reported elsewhere).

**Cardiovascular Equipment and Measures**

**Ambulatory blood pressure assessment.** The SpaceLabs ambulatory blood pressure monitor (Model 90207, SpaceLabs Medical, Inc., Redmond, Washington, USA) was used to track systolic (SBP), diastolic (DBP), and mean blood pressure (MAP) via a noninvasive, oscillometric method. Validation of the unit has been provided by Groppelli, Omboni, Parati, & Mancia
Data collection was initiated by the participant depressing a pressure sensitive button on the face of the unit. The visual display on the face of the unit was disabled by the experimenter to prevent participants from viewing their blood pressure readings. Each blood pressure reading was automatically time-stamped by the unit and enabled experimenter verification of participant compliance. Data was downloaded to a personal computer after the participant returned the unit at the end of the day.

**Ambulatory impedance assessment.** The ambulatory impedance unit employed in this study (World Wide Medical Instruments, Inc.) enables the collection and storage of entire electrocardiogram and impedance signals for later off-line editing and artifact detection. Validation of the unit has been reported by Nakonezny, et al. (2001).

For each participant, the device was programmed to collect the electrocardiogram signal (ECG), impedance signal (ZCG), the first derivative of the impedance signal (dZ/dt), and basal thoracic impedance (Z₀) at a sampling frequency of 500 Hz. Data collection was initiated by the participant manually depressing a button on the face of the unit. Also on the face of the unit, a steadily flashing red indicator light verified data collection in process, and an intermittently flashing yellow indicator light signified data transfer to disk (a PCMCIA flashcard). Each 4-minute epoch of cardiovascular data was automatically time-stamped by the unit and enabled experimenter verification of participant compliance. Data was downloaded to a personal computer after the participant returned the unit at the end of the day.

The myocardial measures of interest were heart rate (HR), pre-ejection period (PEP), respiratory sinus arrhythmia (RSA), and stroke volume (SV). HR is a measure of heart beats per min and was quantified as the number of R-spikes in the ECG waveform in each minute. PEP is a time interval used to measure myocardial contractility and decreases in duration with increased sympathetic activation of the heart (Cacioppo, et al., 1994). PEP was quantified as the time interval in msec from the onset of the ECG Q-wave to the B-point of the dZ/dt wave (Sherwood,
Allen, et al., 1990). RSA is a measure of changes in heart period associated with respiration. At respiration frequencies between .12 and .40 Hz, RSA reflects parasympathetic influences on the heart (Cacioppo, et al., 1994). It was derived by spectral analysis (fast-Fourier transform) of an interbeat interval time-series calculated from ECG following procedures specified by Berntson, et al. (1997). RSA is associated with respiration, which is transduced into changes in neural activity. Hence, we also measured respiration by deriving the impedance pneumographic signal from the dZ/dt signal (Ernst, Litvack, Lozano, Cacioppo, & Berntson, 1999) to insure any effects on RSA were not secondary to differences in respiration. SV is a measure of how much blood is ejected from the left ventricle with each beat of the heart. This was derived using the Kubicek equation applied to the Zo and dZ/dt waveforms:

\[ SV = \rho_b \left( \frac{L}{Z_0} \right)^2 \times LVET \times \left| \frac{dZ}{dt_{\max}} \right|, \]

where \( \rho_b \) = blood resistivity, \( L \) = distance between recording electrodes, \( Z_0 \) = mean thoracic impedance, \( LVET \) = left ventricular ejection time, and \( \left| \frac{dZ}{dt_{\max}} \right| \) = absolute value of the maximum rate of voltage change in the impedance signal (Kubicek, et al., 1966). These measures were scored using software developed in our laboratory (ANS Suite, version 5.2.1). Cardiac output (CO; l/min) was defined as HR \( \times \) SV. Total peripheral resistance (TPR; dyne-sec*cm \(^{-5}\)) was derived using the formula, MAP/CO \( \times \) 80. All myocardial measures were ensemble-averaged into 1-minute periods (Kelsey & Guethlein, 1990), and were verified or edited prior to analyses.

**Diary Measures**

We used Teleform software (Cardiff Software, Inc.) to design and create a detailed paper-and-pencil diary to capture participants' social, emotional, cognitive, and physical state at the time of each beep of the watch. A sample diary can be found in the Appendix. Diary format consisted primarily of closed-ended questions (multiple options) requiring participants to check the appropriate response. However, some items and questions were open-ended. This included the first items in the diary in which participants provided the time they started filling out the diary.
and the time they finished filling out the diary. This information enabled experimenters to calculate how long it took the participant to complete a diary and to time-match diaries with corresponding cardiovascular data.

Participants’ physical states were determined by responses to questions about their posture (choice of sitting, upright, lying down, walking, running, exercising; question #1, Appendix), food intake (currently and since last diary entry; questions #1 and #9, Appendix), tobacco use (question #1, Appendix), whether they had been talking (question #1, Appendix), alcohol intake (how recent and how much; question #11, Appendix), and caffeine intake (how recent and how much; question #12, Appendix).

Participants’ activities were determined by their response to an open-ended question asking them “What was the main thing you were doing?” (question #1, Appendix). Participants were also asked a series of questions to assess how they felt about their main activity. Responses were given on a 5-point “not at all” to “very” continuum (question #3, Appendix), and included the questions, “how demanding is this activity?” and “how well can you meet the demands of this activity?”

Social context was determined by asking participants with whom they were interacting. Some of the choices included no one, significant other, roommate, and a choice of male and/or female friend (see question #5, Appendix, for a complete listing of choices). Participants were also asked how they felt about the person or persons with whom they were interacting; these 16 items (e.g., comfortable, distant, affectionate) were rated on a 5-point scale from “not at all” to “very” (question #10, Appendix).

Individual Difference Measures

Medical history and vital health information obtained by nurses at the beginning of participation in the study provided data regarding participants’ parental history of hypertension and participants’ heights and weights from which body mass index was calculated (weight in
kg/height in \( m^2 \)). Surveys completed by participants during the recruitment phase of the study provided measures of depression. Loneliness was assessed at both time points using the revised UCLA (R-UCLA) Loneliness Scale (Russell, Peplau, & Cutrona, 1980). Loneliness scores were temporally reliable (\( r_g (135) = .77, p < .01 \)). Nevertheless, loneliness decreased slightly from recruitment to laboratory testing (\( M = -1.6, SD = 7.7 \)), and participants differed greatly in the extent of this change (range = -29 to +20). The strategy for dealing with this change is described in the data analysis section below.

**Cardiovascular data preparation**

Of the 134 participants outfitted with an ambulatory blood pressure unit, 124 (93%) provided usable ambulatory blood pressure data (\( M = 7.8 \) assessments, \( SD = 1.6 \)). The amount of usable data did not differ by loneliness group, \( F (2, 118) = 1.151, p = .32 \), or gender, \( F (1, 118) = 2.06, p = .15 \). Due to equipment problems, only 113 (84%) of the participants were outfitted with an ambulatory impedance cardiograph unit, and 103 (91%) of these provided ambulatory electrocardiogram and impedance data. However, technical difficulties, excessively noisy signals, and one participant with a marked cardiac arrhythmia resulted in usable impedance data from only 81 participants (\( M = 6.9 \) assessments, \( SD = 2.2 \)). The amount of usable impedance data did not differ by loneliness, \( F (2, 75) = 2.404, p = .10 \), or gender, \( F (1, 75) = 1.221, p = .27 \).

**Outlier and error detection.** The SpaceLabs monitor records zeros for unsuccessful blood pressure readings due to technical difficulties (inadequate cuff pressure, movement during reading) and automatically makes another attempt at a blood pressure reading. All successful blood pressure readings, therefore, were accepted unless the values were deemed artifactual as defined by criteria outlined by Marier, Jacob, Lehoczky, and Shapiro (1988): \( \text{SBP} < 70 \text{ mmHg or}\) \( > 250 \text{ mmHg, DBP} < 45 \text{ mmHg or} > 150 \text{ mmHg, SBP/DBP} < 1.065 + (.00125*DBP) \) or > 3. No artifacts were found in either the SBP or the DBP data. Data were therefore averaged across the 2
readings taken at each timepoint to increase reliability. SBP, DBP, and MAP values were then evaluated for between-subjects outliers. Using a cutoff of three standard deviations, one SBP observation was deleted.

The impedance data were averaged across the 4 minutes in each epoch to produce mean values of each cardiovascular measure at each timepoint. The averaged MAP and CO values were used to calculate one TPR value for each epoch. Artifactual HR and CO values were defined as those exceeding maximal exercise values in college students: HR > 192 and CO > 20 (Blomqvist & Saltin, 1983). Neither HR values nor CO values exceeded these maximums. HR, RSA, PEP, CO, and TPR values were then evaluated for between-subject outliers. Using a cutoff of three standard deviations, four HR (in three participants), three RSA (in three participants), two PEP (in two participants), three CO (in two participants), and two TPR observations (in two participants) were deleted.

Diary data preparation

The 134 participants who undertook the diary component of the study provided 1,081 of a possible 1,206 diary entries (90%). Because we were interested in maximizing the temporal coherence of diary and cardiovascular data and minimizing the degree of retrospection, diaries that were missing start or end times, or took longer than 25 minutes to complete (a time limit determined on the basis of the frequency distribution of the time taken to complete a diary), were considered invalid. Invalid diary entries accounted for 15% of total entries (30 entries), leaving a final sample of 1,051 valid entries from 134 participants. On average, participants provided 7.8 (SD = 1.4) valid diaries (87% return rate). Valid diary return rate did not differ by loneliness group, $F (2, 128) = 2.583, p = .08$ ($M_{nonlonely} = 8.1, M_{control} = 8.0, M_{lonely} = 7.5$), or by gender, $F (1, 128) = 1.765, p = .19$ ($M_{males} = 8.0, M_{females} = 7.7$).
**Behavior.** Two independent raters performed an initial categorization of the main activity participants reported engaging in at the time they were beeped. Using the categorization scheme outlined by Csikszentmihalyi (1984), activities were classified into sixteen subcategories of three main categories—productive, maintenance, or leisure. Interrater agreement on classification into the subcategories was 80%. In a discussion of their differences, raters agreed upon a final set of twenty-one subcategories that retained Csikszentmihalyi’s (1984) three main activity categories. Productive activities included subcategories such as classwork, studying, job-related activities, other occasions involving writing, typing, or listening, and activities related to participation in this study (e.g., completing a diary, checking sensor placement, etc.). Maintenance activities included eating, personal care, transportation, chores and errands, rest and sleeping, and waiting. Leisure activities included “real” socializing (e.g., all conversations, partying, talking on the phone), “virtual” socializing (e.g., email, instant messenger, personal letters), watching television, listening to music, art and hobbies, reading for pleasure, thinking, computer activities (e.g., games, Web surfing), and other leisure activities (e.g., doing nothing, attending a movie, pleasure shopping). Using these categories, interrater agreement reached 92%. Consensus was achieved with a final discussion of categorization discrepancies. Because some of the activity subcategories were infrequently endorsed, they were grouped to form a final set of 7 activity types for further analysis. These were (1) school work, (2) other productive activities (job, meetings, writing/typing not related to classwork or socializing), (3) transportation, chores, and errands, (4) other maintenance activities (eating, personal care, waiting, rest and napping), (5) socializing, real or virtual, (6) watching television, and (7) other leisure activities (listening to music, art and hobbies, reading, thinking, computer activities, other). The number of endorsements of each activity category was summed across the day within participant, and endorsement rate was calculated as a percent of the total observations available for each participant.
In addition, certain activity subcategories were considered to entail active coping. These activities were classwork, studying, job-related activities, personal care, chores and errands, socializing, sports and games, art and hobbies, and computer activities. The subset of observations involving these activities were employed to evaluate loneliness differences in cardiovascular responsivity to behaviors requiring active coping.

**Cognitive appraisals.** In response to the main activity in which they were engaged at the time they were beeped, participants' responses to the item "how demanding is the activity?" served as an index of primary appraisals, and participants' responses to the item, "how well can you meet the demands of this activity?" indexed secondary appraisals. Cognitive appraisals were calculated as the ratio of primary appraisal to secondary appraisal (Tomaka, Blascovich, Kelsey, & Leitten, 1993).

**Social interactions.** Because some of the possible interactants were infrequently endorsed, they were grouped to form a set of 9 interaction partner categories. These were (1) alone, (2) roommate, (3) male friend, (4) female friend, (5) male and/or female friend, (6) coworkers and/or neighbors, (7) classmates and/or teachers, (8) acquaintances and/or strangers, and (9) all other possible partners. The number of endorsements of each interactant category was summed across the day within participant, and endorsement rate was calculated as a percent of the total observations available for each participant.

**Interaction ratings.** The sixteen indicators of participants' ratings of the quality of their social interactions were submitted to a maximum likelihood factor analysis with oblique rotation that resulted in a 3-factor solution. As can be seen in Table 2.1, the first factor loaded on items related to interpersonal distance, the second factor on items related to interpersonal closeness and familiarity, and the third factor on items related to interpersonal distrust and insincerity. The
factors exhibited modest to moderate intercorrelations ($r_{12} = -.26, r_{13} = .63, r_{23} = -.13$). The four highest loading items on each factor were summed to produce a score for "distance," "closeness," and "distrust".

<table>
<thead>
<tr>
<th>Item</th>
<th>Distance</th>
<th>Closeness</th>
<th>Distrust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distant</td>
<td>.888</td>
<td>-.02</td>
<td>-.05</td>
</tr>
<tr>
<td>Disconnected</td>
<td>.807</td>
<td>-.02</td>
<td>.02</td>
</tr>
<tr>
<td>Closed off</td>
<td>.649</td>
<td>-.02</td>
<td>.201</td>
</tr>
<tr>
<td>Cautious</td>
<td>.399</td>
<td>-.06</td>
<td>.281</td>
</tr>
<tr>
<td>Sharing</td>
<td>-.08</td>
<td>.777</td>
<td>.105</td>
</tr>
<tr>
<td>Affectionate</td>
<td>-.004</td>
<td>.754</td>
<td>.09</td>
</tr>
<tr>
<td>Supported</td>
<td>-.07</td>
<td>.751</td>
<td>-.06</td>
</tr>
<tr>
<td>Understood</td>
<td>-.07</td>
<td>.671</td>
<td>-.103</td>
</tr>
<tr>
<td>Intimate</td>
<td>.04</td>
<td>.613</td>
<td>.008</td>
</tr>
<tr>
<td>Involved</td>
<td>-.126</td>
<td>.605</td>
<td>.04</td>
</tr>
<tr>
<td>Uninhibited</td>
<td>.151</td>
<td>.486</td>
<td>-.02</td>
</tr>
<tr>
<td>Comfortable</td>
<td>-.220</td>
<td>.399</td>
<td>-.269</td>
</tr>
<tr>
<td>Distrustful</td>
<td>-.02</td>
<td>-.02</td>
<td>.757</td>
</tr>
<tr>
<td>Dishonest</td>
<td>-.05</td>
<td>.006</td>
<td>.710</td>
</tr>
<tr>
<td>Phony</td>
<td>.05</td>
<td>-.02</td>
<td>.600</td>
</tr>
<tr>
<td>Conflicted</td>
<td>.113</td>
<td>.09</td>
<td>.520</td>
</tr>
</tbody>
</table>

1Bolded loadings indicate the items summed to produce scores for the corresponding scale.

Table 2.1: Factor solution of ratings of social interactions.

Outlier detection. All continuous diary variables were evaluated for between-subjects outliers. Values that exceeded three standard deviations were deleted, and degrees of freedom were adjusted accordingly.
Preparation of the final datasets.

Blood pressure or impedance data (EKG, ZCG, or both) were available for 1000 observations, but only 484 observations from 72 participants had both blood pressure and cardiac output data enabling the calculation of TPR. Corresponding diary data were available for all but one of these observations; the resulting 483 observations comprised the large, unmodified cardiovascular data set. More stringent criteria were then applied to create a data subset. First, because the blood pressure and cardiac output values used to calculate TPR were obtained from separate ambulatory units, we imposed a limit on the discrepancy permitted between the times data were collected on each unit. Based on the frequency distribution of the time discrepancy, cardiovascular data were considered invalid if there was a greater than 10-min interval between blood pressure and impedance data collection (13 invalid observations on this basis). Second, to maintain coherence between diary and cardiovascular data, data were considered invalid if the time interval between diary entry and impedance data collection was unknown or exceeded 25 minutes (16 invalid observations on this basis). Finally, data were considered invalid when diary completion time was unknown or exceeded 25 minutes (14 observations on this basis). This left a final subset of 441 observations from 70 participants. The mean number of observations per participant was 6.3 (SD = 2.4). The number of complete observations did not differ by loneliness group, $F(2, 64) = 1.469, p = .24$, or gender, $F(1, 64) = .863, p = .36$.

Data analytic strategy

Multilevel regression analyses. The data subset ($n = 441$) was used to evaluate the relationships among loneliness, momentary states, and cardiovascular activity. In this study, repeated assessments of diary measures and cardiovascular variables ("Level 1") are nested within participants ("Level 2"). In consideration of the hierarchically nested data structure, momentary data were examined using a multilevel linear regression technique (see Kreft & de Leeuw, 1998; Schwartz & Stone, 1998). We used MLwiN software (version 1.1), a multilevel...
modeling program for Windows® (Institute for Education, University of London). Prior to analyses, all continuous Level 1 predictor variables were centered around the grand mean to reduce multicollinearity (e.g., high negative correlation between slope and intercept) and produce more stable parameter estimates (Kreft & de Leeuw, 1998).

A major advantage of a multilevel regression approach is that it does not require participants to have data at each measurement occasion, a concern in our study because participants varied in the number of observations they provided. Unlike repeated-measures analyses of variance that exclude participants from the analysis if they are missing data on any occasion, a multilevel approach takes advantage of all available data to generate parameter estimates.

Another advantage of a multilevel model is that it enables treating lower order (i.e., Level 1) regression parameters as random coefficients. In a random-coefficients model, regression coefficients are considered to originate from a population distribution of possible coefficients, and the mean and variance of these coefficients can then be modeled as a function of higher order (i.e., Level 2) predictors. For example, in a regression model with only a Level 1 predictor (e.g., affect), we can address the question, “Is TPR higher when participants report low positive affect?” If the Level 1 slope is allowed to vary between subjects (i.e., a random-slope model), we can add a Level 2 predictor (e.g., loneliness), and its cross-level interaction with affect to address the question, “Are differences in the relationship between positive affect and TPR predicted by differences in loneliness?” Fixed effects of Level 1 predictors are reported unless otherwise stated.

Analyses of variance. All valid diary data (n = 1,051) were used to examine the relationship between loneliness and participants' social, emotional, and behavioral states. Diary variables involving event frequencies (e.g., activities, social interactions) were aggregated within-
subject and then submitted to two-factor (Loneliness: nonlonely, middle, lonely; Gender: male, female) between-subjects analyses of variance. These analyses were done with SPSS (version 10.0).

Special considerations. Loneliness scores at the time of recruitment were the basis for grouping participants as low, middle, and high in loneliness, so this was the score used as a predictor variable in analyses. However, because loneliness scores changed between recruitment and ambulatory testing, and because participants differed in the degree of change, we employed the loneliness change score as a covariate in all analyses in which loneliness was a factor or a predictor variable.

Because we were interested in the unique contribution of loneliness in predicting psychosocial and cardiovascular measures, and because loneliness and depression are typically correlated, all analyses employed depression scores as a covariate. Depression was also tested as a moderator of the relationship between loneliness and cardiovascular or psychosocial variables.

Diary analyses were based on all valid data (n = 1,051). Analyses involving cardiovascular variables focused on the subset of data that resulted from the time-matching criteria described above (n = 441). If a result was found significant in the data subset, then the analysis was repeated in the large, unmodified dataset (n = 483) for confirmation. Statistical significance was set at p < .05 unless otherwise stated. In multilevel regression analyses, effect sizes were calculated as the proportion of variance explained by the addition of predictor variables to base models.
CHAPTER 3

RESULTS

Covariates

The impact of posture, exercise, nicotine (smoking), caffeine, eating, and talking on cardiovascular activity was assessed by performing a series of multilevel regression analyses. The prevalence and frequency of these behaviors are listed in Table 3.1. In this study, participants were specifically asked to be seated prior to cardiovascular data collection, so we did not expect pronounced residual postural effects. In fact, analyses of variance revealed that mean levels of cardiovascular activity did not differ between prone, sitting, and upright postures. Walking, however, differed from these postures and was therefore dummy-coded to contrast cardiovascular levels with those in stationary postures. Walking, exercise, and caffeine consumption in the previous two hours each showed a significant relationship to all cardiovascular variables except TPR; each of these behaviors was associated with elevated HR, diminished PEP (enhanced sympathetic activity), diminished RSA (diminished vagal activity), increased CO, and elevated SBP, DBP, and MAP. Elevated heart rate was also predicted by smoking and talking behaviors. Alcohol and drug use were rarely reported, and were not correlated with any of the cardiovascular variables.

Separate multilevel analyses for each between-subject covariate indicated a statistically significant effect of parental history of hypertension on TPR and PEP, explaining 8% of the between-subject variance in TPR, and 15% of the between-subject variance in PEP. BMI
<table>
<thead>
<tr>
<th>Occasions/participant (%)</th>
<th>Participants (%) with frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt;=3</td>
</tr>
<tr>
<td><strong>Posture</strong></td>
<td></td>
</tr>
<tr>
<td>lying down</td>
<td>11.7</td>
</tr>
<tr>
<td>sitting</td>
<td>60.3</td>
</tr>
<tr>
<td>standing</td>
<td>17.3</td>
</tr>
<tr>
<td><strong>Physical Activity</strong></td>
<td></td>
</tr>
<tr>
<td>walking</td>
<td>9.7</td>
</tr>
<tr>
<td>exercising</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Talking</strong></td>
<td>30.5</td>
</tr>
<tr>
<td><strong>Ingestion</strong></td>
<td></td>
</tr>
<tr>
<td>nicotine</td>
<td>1.5</td>
</tr>
<tr>
<td>caffeine</td>
<td>4.1</td>
</tr>
<tr>
<td>food</td>
<td>9.9</td>
</tr>
<tr>
<td>alcohol</td>
<td>.2</td>
</tr>
<tr>
<td>recreational drugs</td>
<td>.2</td>
</tr>
<tr>
<td><strong>Behavior</strong></td>
<td></td>
</tr>
<tr>
<td>school work</td>
<td>20.9</td>
</tr>
<tr>
<td>other productive work</td>
<td>7.9</td>
</tr>
<tr>
<td>transportation, errands, etc.</td>
<td>16.8</td>
</tr>
<tr>
<td>other maintenance activity</td>
<td>13.0</td>
</tr>
<tr>
<td>socializing, real or virtual</td>
<td>14.6</td>
</tr>
<tr>
<td>watching TV</td>
<td>11.2</td>
</tr>
<tr>
<td>other leisure activity</td>
<td>14.0</td>
</tr>
<tr>
<td><strong>Social setting</strong></td>
<td></td>
</tr>
<tr>
<td>alone</td>
<td>44.5</td>
</tr>
<tr>
<td>roommate</td>
<td>15.4</td>
</tr>
<tr>
<td>male friend</td>
<td>13.4</td>
</tr>
<tr>
<td>female friend</td>
<td>13.3</td>
</tr>
<tr>
<td>friend (male and/or female)</td>
<td>23.0</td>
</tr>
<tr>
<td>coworkers and/or neighbors</td>
<td>4.0</td>
</tr>
<tr>
<td>classmates and/or teachers</td>
<td>12.4</td>
</tr>
<tr>
<td>acquaintances and/or strangers</td>
<td>9.6</td>
</tr>
<tr>
<td>other</td>
<td>6.5</td>
</tr>
</tbody>
</table>

Table 3.1: Prevalence and frequency of behavioral variables (n = 1,051).
predicted SBP, explaining 8% of the between-subject variance in SBP. Depression did not have a significant main effect on any of the cardiovascular variables, and no gender differences were seen on this measure ($M_{males} = 4.3, M_{females} = 5.5, t = -1.703, p > .09$).

In combination, depression and the within- and between-subject covariates with significant main effects comprised base models for all analyses in which cardiovascular variables served as criteria. Controlling for all other covariates, depression emerged as a significant predictor of RSA. Regression weights for covariates in each base model are listed in Table 3.2. The intra-class coefficient (ICC) is also included in Table 3.2, and refers to the proportion of variance in each cardiovascular variable that is between-subjects. The balance of the variance is within-subject. Each cardiovascular variable has substantial variance (range = 45-65% between-subject variance) to be explained at each level of this hierarchically structured data.

**Does loneliness predict elevated vascular resistance?**

Mean daily levels of cardiovascular activity are presented in Table 3.3 as a function of loneliness group and gender. As hypothesized, and consistent with laboratory findings, greater loneliness was associated with higher TPR levels in the field, explaining 12% of the between-subject variance in TPR. Loneliness also predicted lower CO and explained 12% of the between-subject variance in CO. Partial regression weights for loneliness are presented in Table 3.4. Interestingly, although depression did not have a main effect on TPR, it appeared to suppress the relationship between loneliness and TPR. As can be seen by the partial regression weights for loneliness and depression in Table 3.4, the main effect of loneliness on TPR was smaller than the effect with depression partialled, and only approached statistical significance ($p < .06$).

Depression did not interact with loneliness to predict TPR. Nor did gender interact with loneliness to predict TPR. These findings were replicated in the larger dataset ($n = 483$).
### Table 3.2: Nonstandardized partial regression coefficients for covariates in base models with cardiovascular criteria.

<table>
<thead>
<tr>
<th></th>
<th>Intercept</th>
<th>Walking</th>
<th>Exercise</th>
<th>Smoking</th>
<th>Caffeine</th>
<th>Talking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SE</td>
<td>SE</td>
<td>SE</td>
<td>SE</td>
<td>SE</td>
<td>SE</td>
</tr>
<tr>
<td>SBP</td>
<td>101.12</td>
<td>10.59</td>
<td>3.04</td>
<td>1.29**</td>
<td>6.15</td>
<td>2.75**</td>
</tr>
<tr>
<td>DBP</td>
<td>74.53</td>
<td>1.22</td>
<td>2.24</td>
<td>1.14*</td>
<td>4.82</td>
<td>2.30*</td>
</tr>
<tr>
<td>MAP</td>
<td>90.66</td>
<td>1.23</td>
<td>3.42</td>
<td>1.13**</td>
<td>4.71</td>
<td>2.27*</td>
</tr>
<tr>
<td>TPR</td>
<td>999.61</td>
<td>48.20</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CO</td>
<td>7.53</td>
<td>.37</td>
<td>.44</td>
<td>.25</td>
<td>.81</td>
<td>.51</td>
</tr>
<tr>
<td>HR</td>
<td>79.09</td>
<td>3.10</td>
<td>5.12</td>
<td>1.57**</td>
<td>9.33</td>
<td>3.10**</td>
</tr>
<tr>
<td>PEP</td>
<td>116.51</td>
<td>2.40</td>
<td>-3.31</td>
<td>2.09</td>
<td>-10.43</td>
<td>4.14**</td>
</tr>
<tr>
<td>RSA</td>
<td>6.18</td>
<td>.16</td>
<td>-.41</td>
<td>.15*</td>
<td>-1.12</td>
<td>.30**</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Hypertensive parent</th>
<th>BMI</th>
<th>Depression</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>cont'd.</td>
<td>Beta</td>
<td>SE</td>
<td>Beta</td>
<td>SE</td>
</tr>
<tr>
<td>SBP</td>
<td>-</td>
<td>-</td>
<td>1.05</td>
<td>.46*</td>
</tr>
<tr>
<td>DBP</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.03</td>
</tr>
<tr>
<td>MAP</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.05</td>
</tr>
<tr>
<td>TPR</td>
<td>152.63</td>
<td>67.24*</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CO</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.02</td>
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<tr>
<td>HR</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.37</td>
</tr>
<tr>
<td>PEP</td>
<td>9.52</td>
<td>3.36**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>RSA</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-.05</td>
</tr>
</tbody>
</table>

SBP = systolic blood pressure (mm Hg); DBP = diastolic blood pressure (mm Hg); MAP = mean arterial pressure (mm Hg); TPR = total peripheral resistance (dyne-sec*cm-5); CO = cardiac output (liters/min); HR = heart rate (beats/minute); PEP = pre-ejection period (msec); RSA = respiratory sinus arrhythmia (natural log transform).

ICC = intra-class coefficient

* p < .05, one-sided; ** p < .01, one-sided

Table 3.2: Nonstandardized partial regression coefficients for covariates in base models with cardiovascular criteria.
<table>
<thead>
<tr>
<th></th>
<th>Nonlonely</th>
<th>Control</th>
<th>Lonely</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All (n=21)</td>
<td>Males (n=10)</td>
<td>Females (n=11)</td>
</tr>
<tr>
<td>SBP</td>
<td>127.6 (9.6)</td>
<td>131.9 (9.2)</td>
<td>123.7 (8.4)</td>
</tr>
<tr>
<td>DBP</td>
<td>75.6 (7.5)</td>
<td>73.3 (7.9)</td>
<td>77.7 (6.7)</td>
</tr>
<tr>
<td>MAP</td>
<td>92.4 (7.0)</td>
<td>92.1 (7.5)</td>
<td>92.7 (6.9)</td>
</tr>
<tr>
<td>TPR</td>
<td>975.6 (275.4)</td>
<td>953.8 (309.6)</td>
<td>995.4 (254.0)</td>
</tr>
<tr>
<td>CO</td>
<td>8.3 (2.3)</td>
<td>8.6 (2.6)</td>
<td>7.9 (2.0)</td>
</tr>
<tr>
<td>HR</td>
<td>82.7 (8.7)</td>
<td>77.8 (7.0)</td>
<td>87.1 (7.9)</td>
</tr>
<tr>
<td>PEP</td>
<td>114.3 (12.8)</td>
<td>110.0 (6.0)</td>
<td>118.3 (16.1)</td>
</tr>
<tr>
<td>RSA</td>
<td>5.86 (.89)</td>
<td>6.27 (.61)</td>
<td>5.49 (.96)</td>
</tr>
</tbody>
</table>

SBP = systolic blood pressure (mm Hg); DBP = diastolic blood pressure (mm Hg); MAP = mean arterial pressure (mm Hg); TPR = total peripheral resistance (dyne-sec*cm^-5); CO = cardiac output (liters/min); HR = heart rate (beats/minute); PEP = pre-ejection period (msec); RSA = respiratory sinus arrhythmia (natural log transform)

Table 3.3: Means (SDs) of cardiovascular variables as a function of loneliness group and gender.
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Loneliness Changes</th>
<th>Loneliness</th>
<th>Depression</th>
<th>Loneliness Changes</th>
<th>Loneliness</th>
<th>Depression</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Beta</td>
<td>SE</td>
<td>Beta</td>
<td>SE</td>
<td>Beta</td>
<td>SE</td>
</tr>
<tr>
<td>SBP</td>
<td>.054</td>
<td>.169</td>
<td>-.002</td>
<td>.102</td>
<td>-.011</td>
<td>.237</td>
</tr>
<tr>
<td>DBP</td>
<td>-.183</td>
<td>.126</td>
<td>-.006</td>
<td>.077</td>
<td>.026</td>
<td>.180</td>
</tr>
<tr>
<td>MAP</td>
<td>-.066</td>
<td>.130</td>
<td>.023</td>
<td>.079</td>
<td>.051</td>
<td>.182</td>
</tr>
<tr>
<td>TPR</td>
<td>-1.451</td>
<td>4.608</td>
<td>5.309</td>
<td>2.794*</td>
<td>-1.072</td>
<td>6.818</td>
</tr>
<tr>
<td>CO</td>
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<td>.037</td>
<td>-.035</td>
<td>.023</td>
<td>.015</td>
<td>.055</td>
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<tr>
<td>HR</td>
<td>.012</td>
<td>.062</td>
<td>.103</td>
<td>.098</td>
<td>.367</td>
<td>.222</td>
</tr>
<tr>
<td>PEP</td>
<td>-.498</td>
<td>.236*</td>
<td>-.275</td>
<td>.142*</td>
<td>-.514</td>
<td>.334</td>
</tr>
<tr>
<td>RSA</td>
<td>-.026</td>
<td>.017</td>
<td>-.019</td>
<td>.010*</td>
<td>-.047</td>
<td>.024*</td>
</tr>
</tbody>
</table>

1 Three sets of multilevel analyses were performed to produce these partial regression weights: the first set employed loneliness scores as predictor, holding loneliness changes constant; the second set employed depression scores as predictor; the third set employed loneliness and depression scores as simultaneous predictors, holding loneliness changes constant.

SBP = systolic blood pressure (mm Hg); DBP = diastolic blood pressure (mm Hg); MAP = mean arterial pressure (mm Hg); TPR = total peripheral resistance (dyne-sec*cm^-2); CO = cardiac output (liters/min); HR = heart rate (beats/minute); PEP = pre-ejection period (msec); RSA = respiratory sinus arrhythmia (natural log transform);

* p < .05; ** p < .01; ^ p < .06

Table 3.4: Nonstandardized partial regression coefficients for loneliness, depression, and covaried loneliness and depression in models with cardiovascular criteria1.
In addition, loneliness tended to predict lower PEP, but this relationship was not evident when depression was held constant. However, holding loneliness constant, loneliness changes were a significant predictor of PEP. PEP decreased with temporal increases in loneliness, suggesting increased sympathetic activation.

**Does loneliness predict diminished cardiac responsivity?**

Table 3.5 presents mean levels of HR, PEP, CO, and TPR for each loneliness group during the performance of a subset of behaviors deemed to entail active coping. Consistent with our laboratory results, loneliness predicted lower cardiac output \( (b = -.08, SE = .03, z = -2.6) \), explaining 6.3% of the between-subject variance in CO during the performance of these behaviors. Unlike our laboratory results, loneliness did not predict differential changes in HR or cardiac contractility (as indexed by decreases in PEP). TPR, on the other hand, continued to exhibit a positive relationship with loneliness. Loneliness did not predict any of the other cardiovascular variables, nor did gender interact with loneliness to predict any of the cardiovascular variables during the performance of these behaviors.

**Do the lonely give higher stress ratings?**

Also included in Table 3.5 are mean cognitive appraisal ratios. As hypothesized, loneliness was a significant predictor of higher cognitive appraisals during active coping behaviors \( (b = .008, SE = .004, z = 2.0) \). Cognitive appraisals did not predict any of the cardiovascular variables.

**Are the lonely more frequently exposed to stressors?**

The prevalence and frequency of each category of activity is presented in Table 3.1. None of the activity categories differed in endorsement rate by loneliness group. Table 3.6 provides the activity endorsement rate as a function of loneliness group and gender. A significant
Table 3.5: Means (SDs) of cardiovascular variables and cognitive appraisals as a function of loneliness group during active coping behaviors.
Table 3.6: Means (SDs) of percentage of observations engaged in activities as a function of loneliness group and gender.
A covariate effect, however, indicated that loneliness changes were associated with socializing frequency. A significant correlation revealed that socializing frequency decreased with temporal increases in loneliness ($r (134) = - .22, p = .011$).

**Are the lonely less buffered from cardiovascular effects of stress?**

We hypothesized that being with a friend or roommate would be associated with lower cardiovascular activity. Our data, however, revealed that TPR and CO were not differentially affected by the presence of a friend or roommate during behaviors involving active coping or otherwise. The presence of a friend predicted higher SBP ($b = 1.94, SE = .81, z = 2.39$), but this association did not differ as a function of loneliness. Furthermore, loneliness did not predict differential effects of the presence of a friend or roommate on levels of any of the cardiovascular variables.

**Are the lonely less frequently with others?**

Table 3.1 lists the prevalence and frequency of interactions with partners in each of the social categories. Social interactions were reported by all of the participants on at least one occasion, for a total of 561 occasions (53% of all possible occasions). Contrary to hypotheses, the lonely reported a similar percentage of observations engaged in social interactions as did the nonlonely. Specifically, the rate of interactions with friends, which was hypothesized to be lower among the lonely, did not differ among loneliness groups. The endorsement rate of each category of interactant is presented in Table 3.7 as a function of loneliness group and gender. Gender and loneliness did not interact to predict the endorsement rate of social interactant categories. However, a significant covariate effect indicated that loneliness changes were associated with percentage of observations engaged in social interactions. The proportion of time engaged in interactions tended to decrease with temporal increases in loneliness, $r (134) = - .163, p = .053$. 

35
<table>
<thead>
<tr>
<th></th>
<th>All (n = 44)</th>
<th>Nonlonely (n = 23)</th>
<th>Females (n = 21)</th>
<th>Control Males (n = 23)</th>
<th>Females (n = 23)</th>
<th>All (n = 44)</th>
<th>Nonlonely Males (n = 22)</th>
<th>Females (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of male interactants</td>
<td>10.9 (21.4)</td>
<td>13.6 (24.9)</td>
<td>8.0 (17.2)</td>
<td>19.8 (37.7)</td>
<td>19.1 (26.6)</td>
<td>20.6 (47.0)</td>
<td>14.5 (17.8)</td>
<td>15.7 (16.5)</td>
</tr>
<tr>
<td>Number of female interactants</td>
<td>11.3 (19.6)</td>
<td>9.0 (18.9)</td>
<td>13.8 (20.5)</td>
<td>20.6 (37.6)</td>
<td>17.0 (26.8)</td>
<td>24.0 (46.0)</td>
<td>14.9 (20.2)</td>
<td>16.7 (25.5)</td>
</tr>
<tr>
<td>Total number of interactants</td>
<td>21.7 (38.5)</td>
<td>21.6 (42.5)</td>
<td>21.8 (34.6)</td>
<td>40.0 (74.5)</td>
<td>35.3 (52.3)</td>
<td>44.6 (92.6)</td>
<td>28.3 (34.7)</td>
<td>30.8 (39.5)</td>
</tr>
<tr>
<td>% of observations interacting</td>
<td>50.4 (22.1)</td>
<td>52.0 (23.9)</td>
<td>48.6 (20.5)</td>
<td>53.8 (19.9)</td>
<td>49.6 (17.6)</td>
<td>57.9 (21.4)</td>
<td>53.7 (23.5)</td>
<td>56.5 (23.0)</td>
</tr>
<tr>
<td>% alone</td>
<td>49.2 (20.7)</td>
<td>48.9 (22.3)</td>
<td>49.6 (19.4)</td>
<td>42.7 (21.3)</td>
<td>47.2 (19.5)</td>
<td>38.3 (22.5)</td>
<td>41.5 (22.7)</td>
<td>41.4 (23.7)</td>
</tr>
<tr>
<td>% with roommate</td>
<td>14.2 (16.8)</td>
<td>13.6 (15.9)</td>
<td>14.8 (18.1)</td>
<td>15.9 (16.4)</td>
<td>15.5 (16.0)</td>
<td>16.3 (17.1)</td>
<td>16.1 (21.6)</td>
<td>16.7 (20.9)</td>
</tr>
<tr>
<td>% with male friend</td>
<td>13.2 (17.6)</td>
<td>20.5 (20.3)</td>
<td>5.3 (9.2)</td>
<td>12.9 (13.9)</td>
<td>18.9 (15.2)</td>
<td>6.8 (9.4)</td>
<td>14.1 (19.1)</td>
<td>22.7 (21.0)</td>
</tr>
<tr>
<td>% with female friend</td>
<td>14.8 (17.3)</td>
<td>11.6 (15.7)</td>
<td>18.3 (18.6)</td>
<td>12.2 (14.2)</td>
<td>10.0 (11.7)</td>
<td>14.4 (13.1)</td>
<td>13.0 (18.6)</td>
<td>7.4 (10.7)</td>
</tr>
<tr>
<td>% with friend (male +/- female)</td>
<td>23.9 (21.3)</td>
<td>27.3 (23.8)</td>
<td>20.3 (18.0)</td>
<td>21.5 (17.2)</td>
<td>24.1 (16.4)</td>
<td>18.8 (17.9)</td>
<td>23.6 (22.8)</td>
<td>27.6 (20.6)</td>
</tr>
<tr>
<td>% with co-workers and/or neighbors</td>
<td>4.6 (10.3)</td>
<td>4.6 (9.2)</td>
<td>4.6 (11.6)</td>
<td>3.4 (9.4)</td>
<td>2.1 (4.7)</td>
<td>4.7 (12.5)</td>
<td>4.2 (9.1)</td>
<td>4.5 (7.0)</td>
</tr>
<tr>
<td>% with classmates and/or teachers</td>
<td>9.4 (12.9)</td>
<td>10.7 (14.4)</td>
<td>8.0 (11.2)</td>
<td>12.2 (11.7)</td>
<td>12.3 (12.5)</td>
<td>12.0 (11.1)</td>
<td>15.8 (19.1)</td>
<td>12.5 (13.9)</td>
</tr>
<tr>
<td>% with acquaintances and/or strangers</td>
<td>6.8 (10.1)</td>
<td>7.5 (8.9)</td>
<td>6.1 (11.5)</td>
<td>11.0 (15.0)</td>
<td>7.0 (9.8)</td>
<td>15.1 (18.2)</td>
<td>10.8 (14.3)</td>
<td>13.5 (15.2)</td>
</tr>
<tr>
<td>% with other interactant</td>
<td>5.8 (11.1)</td>
<td>6.5 (12.5)</td>
<td>5.0 (9.6)</td>
<td>7.0 (13.7)</td>
<td>4.3 (6.9)</td>
<td>9.6 (18.0)</td>
<td>6.7 (12.7)</td>
<td>5.0 (9.7)</td>
</tr>
</tbody>
</table>

Table 3.7: Means (SDs) of total daily number of social interactants and social interactant endorsement rate (% of observations) as a function of loneliness group and gender.
Do the lonely perceive social interactions more negatively?

Table 3.8 lists the means of the interpersonal distance, closeness, and distrust scales as a function of loneliness group and gender. Consistent with our hypothesis that the lonely would find their social interactions less satisfying, loneliness predicted greater feelings of distance from social partners. Depression scores also predicted feelings of distance, but when depression and loneliness were simultaneously entered into the equation, loneliness, but not depression, continued to predict interpersonal distance. In combination with loneliness changes, loneliness explained 2.4% of the variance in interpersonal distance beyond that explained by depression. Partial regression weights are included in Table 3.9.

Loneliness also predicted lower interpersonal closeness ratings, but only when depression was held constant. Holding depression constant, loneliness, in combination with loneliness changes, explained an additional 5.2% of the variance in closeness ratings. Interpersonal distrust ratings were higher among the lonely, but loneliness was not a significant predictor of distrust ratings when depression was held constant. See Table 3.9 for partial regression weights.

Loneliness and depression did not interact to predict interpersonal distance, closeness, or distrust. Nor did gender interact with loneliness to predict distance, closeness, or distrust ratings.

Interestingly, TPR was predicted by interpersonal closeness ($b = -29.65$, $SE = 14.86$, $z = -2.00$); closeness ratings accounted for 1% of the within-subject variance in TPR. However, variance in the relationship between interpersonal closeness and TPR was not predicted by loneliness or gender. Nor did closeness mediate the effect of loneliness on TPR. Holding closeness constant, the influence of loneliness on TPR was still significant ($b = 8.89$, $SE = 3.90$, $z = 2.28$).
Table 3.8: Mean (SD) social interaction ratings as a function of loneliness group and gender.

<table>
<thead>
<tr>
<th></th>
<th>All (n = 44)</th>
<th>Nonlonely Males (n = 23)</th>
<th>Nonlonely Females (n = 21)</th>
<th>Control Males (n = 23)</th>
<th>Control Females (n = 23)</th>
<th>Lonely Males (n = 22)</th>
<th>Lonely Females (n = 22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>interpersonal distance</td>
<td>1.3 (.4)</td>
<td>1.4 (.5)</td>
<td>1.3 (.3)</td>
<td>1.6 (.5)</td>
<td>1.6 (.5)</td>
<td>1.7 (.6)</td>
<td>1.7 (.7)</td>
</tr>
<tr>
<td>interpersonal closeness</td>
<td>2.8 (.9)</td>
<td>2.6 (1.0)</td>
<td>3.0 (.7)</td>
<td>2.6 (.8)</td>
<td>2.6 (.9)</td>
<td>2.6 (.6)</td>
<td>2.5 (.7)</td>
</tr>
<tr>
<td>interpersonal distrust</td>
<td>1.1 (.2)</td>
<td>1.2 (.2)</td>
<td>1.1 (.1)</td>
<td>1.2 (.3)</td>
<td>1.2 (.3)</td>
<td>1.3 (.3)</td>
<td>1.2 (.3)</td>
</tr>
</tbody>
</table>
Three sets of multilevel analyses were performed to produce these partial regression weights: the first set employed loneliness scores as predictor, holding loneliness changes constant; the second set employed depression scores as predictor; the third set employed loneliness and depression scores as simultaneous predictors, holding loneliness changes constant.

* p < .05; ** p < .01

Table 3.9. Nonstandardized partial regression coefficients for loneliness, depression, and covaried loneliness and depression in models with psychological criteria.
Do the lonely engage in more health-compromising behaviors?

All valid diary data (n = 1,051) were used to perform a series of analyses of variance. Although health-compromising and promoting behaviors were infrequently endorsed (see Table 3.1), loneliness groups did not differ in the frequency with which they slept, ate, exercised, or consumed caffeine, alcohol, or recreational drugs (see Table 3.10). However, the nonlonely reported drinking significantly more caffeine than did the control and lonely groups, $F(2, 98) = 4.615, p = .012$ ($M_{\text{nonlonely}} = .4, M_{\text{control}} = .2, M_{\text{lonely}} = .2$). Gender did not interact with loneliness to predict the endorsement rate of health behaviors.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Nonlonely</th>
<th></th>
<th></th>
<th>Control</th>
<th></th>
<th></th>
<th>Lonely</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All (n = 44)</td>
<td>Males (n = 23)</td>
<td>Females (n = 21)</td>
<td>All (n = 46)</td>
<td>Males (n = 23)</td>
<td>Females (n = 23)</td>
<td>All (n = 44)</td>
<td>Males (n = 22)</td>
<td>Females (n = 22)</td>
</tr>
<tr>
<td>smoking</td>
<td>2.4 (8.3)</td>
<td>3.7 (10.9)</td>
<td>1.1 (3.6)</td>
<td>1.5 (5.6)</td>
<td>1.9 (7.2)</td>
<td>1.0 (3.4)</td>
<td>.6 (3.8)</td>
<td>0</td>
<td>1.1 (5.3)</td>
</tr>
<tr>
<td>ingesting caffeine</td>
<td>5.2 (9.3)</td>
<td>4.9 (9.6)</td>
<td>5.6 (9.1)</td>
<td>3.7 (8.9)</td>
<td>3.4 (11.0)</td>
<td>4.0 (6.6)</td>
<td>3.3 (8.2)</td>
<td>3.8 (9.9)</td>
<td>2.8 (7.7)</td>
</tr>
<tr>
<td>eating</td>
<td>10.7 (11.1)</td>
<td>8.8 (10.5)</td>
<td>12.8 (11.6)</td>
<td>9.4 (11.1)</td>
<td>5.3 (6.9)</td>
<td>13.5 (13.0)</td>
<td>9.8 (11.1)</td>
<td>10.1 (10.3)</td>
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<tr>
<td>ingesting alcohol</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>.5 (2.5)</td>
<td>.6 (2.7)</td>
<td>.5 (2.4)</td>
</tr>
<tr>
<td>ingesting recreational drugs</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>.2 (1.6)</td>
<td>.5 (2.3)</td>
<td>0</td>
<td>.3 (1.7)</td>
<td>0</td>
<td>.5 (2.4)</td>
</tr>
<tr>
<td>exercising</td>
<td>2.2 (6.2)</td>
<td>2.1 (7.4)</td>
<td>2.2 (4.8)</td>
<td>3.9 (8.5)</td>
<td>3.2 (7.4)</td>
<td>4.7 (9.5)</td>
<td>2.9 (7.4)</td>
<td>4.6 (9.4)</td>
<td>1.2 (4.0)</td>
</tr>
<tr>
<td>sleeping</td>
<td>6.0 (9.4)</td>
<td>6.0 (10.9)</td>
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<td>2.8 (5.3)</td>
<td>3.5 (5.9)</td>
<td>2.1 (4.5)</td>
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Table 3.10: Means (SDs) of percentage of observations engaged in health-related behaviors as a function of loneliness group and gender.
Gender differences in cardiovascular activity, social interactions, and health behaviors.

Two sex differences in cardiovascular activity emerged, both anticipated on the basis of past research. First, females had significantly higher HR than males ($b = 5.54$, $SE = 1.79$, $z = 3.10$), accounting for 16% of the between-subject variance in HR. Second, females had significantly lower SBP than males, ($b = -6.28$, $SE = 1.92$, $z = -3.27$); sex explained 16% of the between-subject variance in SBP.

Three gender differences were noted in the endorsement rate of social interactant categories. Female interaction partners were more frequently reported by females than by males (17% vs. 9.7% of observations), $F(1, 127) = 7.084, p < .01$, and male interaction partners were more frequently reported by males than by females (20.7% vs. 5.9% of observations), $F(1, 127) = 35.438, p < .001$. In addition, males reported interacting with a friend, either male or female or both, more frequently than did females (26.3% vs. 19.6% of observations), $F(1, 127) = 4.36, p < .05$.

In examinations of gender differences in interaction ratings, gender predicted greater closeness ratings by females than by males ($b = .39$, $SE = .13$, $z = 3.06$), and explained 13% of the variance in interpersonal closeness. Feelings of distance and distrust did not differ as a function of gender. The only significant gender difference in health-related behaviors was that females reported eating more frequently than did males, $F(1, 127) = 4.603, p = .034$ ($M_{\text{female}} = 11.9\%$ vs. $M_{\text{male}} = 8.0\%$ of observations).
CHAPTER 4

DISCUSSION

Social isolation, whether assessed in quantitative or qualitative terms, has been shown to increase risk for disease (Rozanski, et al., 1999; Uchino, et al., 1996). Similarly, loneliness, a perceived state of social deprivation, has been associated with poor survival after coronary artery bypass surgery (Herlitz, et al., 1998). To the extent loneliness is a cardiovascular health risk, we have hypothesized that it may manifest in patterns of cardiovascular activity that suggest pathways to disease. In the laboratory, we observed that lonely participants exhibited chronically higher levels of total peripheral resistance than the nonlonely (Cacioppo, et al., in press). Over the long term, increased vascular resistance contributes to hypertension, suggesting a mechanism linking loneliness and cardiovascular health. The purpose of the current study was to examine the generalizability of our laboratory findings in regard to loneliness-related differences in cardiovascular activity, and to better understand the role of participants’ thoughts and behaviors in explaining any cardiovascular differences.

Loneliness and vascular resistance. Our first hypothesis was that the increased peripheral resistance exhibited by the lonely in the laboratory would be evident in their everyday life. In support of this hypothesis, elevated levels of total peripheral resistance were observed in the field, just as they had been in the same participants in the laboratory. Interestingly, depression appeared to suppress the relationship between loneliness and vascular resistance, as loneliness had its greatest influence on vascular resistance when depression was held constant. Although
this effect suggests that depression might predict reduced vascular resistance, our exclusionary criteria restricted the range of depression scores, and may therefore have impeded our ability to detect vascular effects of depression.

**Loneliness and cardiovascular reactivity.** In the laboratory, we observed, in addition to higher levels of peripheral resistance, smaller increases in sympathetic cardiac activity (i.e., smaller decreases in pre-ejection period and smaller increases in cardiac output) in response to acute psychological stressors, stressors deemed to require active coping (Obrist, 1981). We therefore examined the possibility that everyday behaviors requiring active coping would elicit smaller sympathetically mediated cardiac activity in the lonely than the nonlonely. This hypothesis was partially supported in that loneliness predicted smaller cardiac output during behaviors requiring active coping. We failed to observe a significant change in pre-ejection period during the performance of these behaviors, possibly because we measured cardiovascular activity while participants were seated quietly, not while they were performing the behavior. This may have contributed to the finding that loneliness did not predict higher levels of pre-ejection period (i.e., less sympathetic influence on cardiac contractility) during the performance of behaviors requiring active coping.

**Loneliness and stress.** Consistent with our hypothesis that the lonely view their world as a more threatening place, loneliness predicted higher appraisal ratings of potentially demanding situations, situations thought to require active coping. However, cognitive appraisals did not predict cardiovascular activity in these situations, possibly because of a restricted range of appraisal ratios. On average, stress ratings on this particular day did not exceed the midpoint on both primary and secondary appraisal scales, and cognitive appraisal ratios did not exceed 1.67 on a scale that permitted ratios as high as 5 (i.e., primary appraisal = 5, secondary appraisal = 1).
Our hypothesis that the lonely and nonlonely would experience differential exposure to stress was not borne out in the frequency with which participants engaged in potentially stressful daily activities. The everyday activities of lonely students showed a remarkable similarity to that of nonlonely students.

**Loneliness and cardiovascular activity in a social context.** We had hypothesized that the presence of supportive others would reduce cardiovascular responses to stressful situations. In fact, the presence of a friend or roommate did not influence cardiovascular activity during behaviors thought to require active coping, nor did loneliness moderate this relationship. However, the low stress of the situations in which participants found or placed themselves may have contributed to our inability to detect these relationships.

**Loneliness and social exposure.** Contrary to hypotheses that the lonely would spend less time socializing and more time alone than the nonlonely, the lonely and nonlonely did not differ in the frequency of social interactions over the course of the day. Nor did they differ in the frequency with which they interacted with various social partners. For instance, time spent with friends, which we had hypothesized might buffer the cardiovascular effects of everyday stressors, was no different among the lonely than the nonlonely. However, participants who had become lonelier between recruitment and ambulatory testing were more likely to report reduced rates of social interactions than participants whose loneliness had not increased over time, a finding that is consistent with previous research linking loneliness with less frequent social interactions (Burger, 1995; Nurmi, Toivonen, Salmela-Aro, & Eronen, 1996; Russell, et al., 1980).

**Loneliness and interaction quality.** In terms of subjective measures, the lonely were indeed “exposed” to more stress than the nonlonely. Not only did they appraise their daily activities as more threatening, they rated their social interactions less positively than did the nonlonely. Consistent with our hypothesis that the lonely would rate their interactions more negatively, the lonely gave themselves lower closeness ratings and higher distance and distrust
ratings during social interactions. Furthermore, interpersonal closeness ratings predicted lower levels of vascular resistance. Although loneliness did not moderate the strength of the relationship between closeness ratings and vascular resistance, the fact that the lonely gave chronically lower closeness ratings suggests that the lonely did not benefit from the buffering effects of social interactions on vascular resistance to the extent experienced by the nonlonely. That is, to the extent close social relationships reduce cardiovascular responses (Gump, et al., 2001), the lower closeness ratings given by the lonely suggest that their cardiovascular responses (i.e., peripheral resistance) may not be reduced to the extent seen in the nonlonely.

Depressed individuals, like the lonely, tend to report less intimacy during social interactions than do the nondepressed (Nezlek, Imbrie, & Shean, 1994). Therefore, it was surprising to see that depression suppressed the influence of loneliness on closeness ratings. However, Nezlek et al. (2000) found that the depressed report less intimacy only during interactions with close friends, not with less intimate social partners (Nezlek, Hampton, & Shean, 2000). On the other hand, the lonely, relative to the nonlonely, give more negative ratings to interactions with both close friends and strangers (Christensen & Kashy, 1998; Duck, Pond, & Leatham, 1994; Williams & Solano, 1983). This distinction may have contributed to the apparent suppressive effect of depression on loneliness-related differences in interaction ratings. Further investigation is needed to better understand the role of depression in moderating the effect of loneliness on perceptions of social interactions.

In addition to less closeness, the lonely reported greater interpersonal distance during interactions, suggesting that the lonely were more cautious and withholding in their social interactions. Moreover, the lonelier participants became between recruitment and testing, the greater their distance ratings. Interpersonal distrust was also predicted by loneliness, suggesting that the lonely felt less authentic and honest in their interactions. This effect appeared redundant with that of depression; although both loneliness and depression had main effects on distrust
ratings, neither had significant effects when both were simultaneously entered in the regression
equation. Nevertheless, the main effect of loneliness on distrust is consistent with Rotenberg’s
(1994) finding that lonely students (only females were tested) displayed increasingly less trust
than the nonlonely while interacting with an experimental confederate during a prisoner’s
dilemma game. In addition, in the present study, the tonically higher distrust ratings given by the
lonely were augmented during interactions with casual social partners (e.g., co-workers and
neighbors) relative to interactions with other social partners. However, distance and distrust
ratings did not predict vascular resistance levels. Thus, to the extent distance and distrust could
be considered negative aspects of an interaction, and closeness a positive aspect, it was the lack of
positivity, not the presence of negativity, that proved to be the more important aspect of social
interactions in predicting cardiovascular activity.

Moreover, positive interactions are important in reducing the risk of loneliness. Rook
(2001), for instance, found that loneliness was predicted primarily by a lack of positive social
exchanges (e.g., helpful, supportive), whereas depression was predicted primarily by a greater
number of negative social exchanges (e.g., conflictual, hurtful) in a sample of older adults. In
addition, although negative social exchanges were seen to have a stronger short-term influence
(on mood, for example) than positive social exchanges, positive exchanges were shown to offset
the effects of negative exchanges over the long-term, diminishing tendencies toward increasing
loneliness (Rook, 2001). Thus, the positive aspects of social interactions could be of crucial
importance for both the physical and psychological outcomes associated with loneliness.

Loneliness and health behaviors. Finally, the lonely and the nonlonely did not differ in
the rate at which they reported engaging in health-compromising or health-promoting behaviors.
This is consistent with these participants’ retrospective self-reports made at the recruitment stage
of the study. Nevertheless, because loneliness is a risk factor for substance abuse (Jensen et al.,
1994; Sadava & Pak, 1994; Stacy et al., 1995), it is interesting to observe that only the lonely
reported alcohol use during this day. Clearly, this observation requires authentication with a larger sample of individuals and/or days. The extent to which this finding is borne out could help explain the health risk associated with loneliness.

Gender

Loneliness did not appear to differentially affect males and females in this study, whether physiologically, behaviorally, or psychologically. However, several gender differences were noted. First, consistent with previous research (Stoney, Davis, & Matthews, 1987), systolic blood pressure was higher in males than in females, and heart rate was higher in females than in males. Also consistent with past research indicating that females exhibit greater heart rate reactivity to psychological stressors than do males (Stoney, Davis, & Matthews, 1987), cognitive appraisals predicted greater heart rate increases among females than males.

Second, both males and females interacted more frequently with their own sex than with the opposite sex, a finding that is not surprising if for no other reason than college housing meant others of their own sex were more readily available for social interactions. However, females reported greater closeness ratings during social interactions than did males. This is consistent with prior research (Shaver, Furman, & Buhrmester, 1985) that found male undergraduates described their friendships in less positive terms than did females over the duration of the first year of college.

Limitations of the current study

One of the disadvantages of our study was our inability to verify the accuracy of participants’ reported diary entry times, and hence our inability to verify the concurrency of diary entries and cardiovascular data recordings. Kamarck et al. (1998) employed an electronic device for diary entries, each of which was time-stamped and could therefore be precisely matched with cardiovascular data. Although we were careful, in introducing participants to the procedure, to
emphasize the importance of accuracy in self-reports, we can not rule out the possibility that some participants may have fabricated times and given highly retrospective and/or inaccurate self-reports. However, it is unlikely that fabricated times matched electronically time-stamped cardiovascular data, suggesting that our time-matching criteria probably eliminated flagrant disregard for appropriate procedure. Nevertheless, future studies of this sort would do well to reduce compliance problems and enhance data reliability by using electronic diaries that prompt participant response and register temporal delays.

Another concern pertained to our measures of participants' behaviors. Participants endorsed a variety of activities performed concurrently with the one "main" activity on which analyses were based, introducing "noise" that could have obscured relationships between behavior and cardiovascular activity that might have differentiated the lonely from the nonlonely. The lack of loneliness-related behavior differences may also have been attributable to the fact that results were based on only one day, and in this case, an unusual day in participants' lives. It is easy to understand that, sporting electrodes and wires and ambulatory data collection units, participants may have been more self-conscious than usual and restricted their activities accordingly. Indeed, a recent study reported that men and women were significantly less physically active, as measured with triaxial accelerometers, during an ambulatory monitoring day than they were on a regular working day (Costa, Cropley, Griffith, & Steptoe, 1999). Some of the participants in our study reported that their day was atypical, usually because they avoided going to class or leaving their room for any reason. More importantly for our purposes, however, was whether loneliness influenced restriction of activity. Based on exit interviews, participants' reports of activity restriction did not indicate any loneliness-related differences in the tendency to curtail normal activities. A more comprehensive understanding of the lifestyle differences of the lonely and nonlonely awaits examination of the additional six days of diaries completed by these participants. Weekends, for example, may be more telling than relatively scripted school days in
terms of loneliness-related differences in choices of activities and social interactions. That is, the lonely may spend less time socializing than the nonlonely during weekends. In addition, they may spend more time interacting in larger groups and less time in dyadic interactions than do the nonlonely, thereby reducing the likelihood that they will have intimacy needs satisfied.

Finally, as is the case with all regression techniques, the regression coefficients derived in this study are estimates of population effects based on our particular sample. Replication using an independent sample is therefore important to enhance confidence in the reliability of these estimates. Replication is even more important when dealing with complex multilevel models. Although complex models may more nearly resemble reality, they are also more susceptible to small changes in the system that could lead to unstable parameter estimates (Kreft & de Leeuw, 1998).

Of course, the regression approach we used in this study cannot be used to infer causation. For example, the link between loneliness and elevated peripheral resistance could be bi-directional or could be attributable to a third factor that gives rise to both loneliness and increased peripheral resistance. A bi-directional model might consider that elevated peripheral resistance could elicit, even if on a subconscious level, compensatory changes in behavior to minimize further tension-related increases in peripheral resistance. One means to reduce tension could be to minimize potentially stressful social interactions. Thus, although this change in behavior reduces the probability of having to deal with social conflict, it also reduces the probability of having one’s intimacy needs met, hence the risk of loneliness.

A third-factor model might consider social anxiety the origin of both loneliness and elevated peripheral resistance. Socially anxious individuals tend to exhibit poor social skills, are much more tense and nervous in social interactions, and sometimes avoid interactions completely (Segrin, 1998). Social anxiety, therefore, could be the origin of loneliness, at least in some people. Although the link between social anxiety and vascular resistance has not been explored,
anxiety in the form of phobias, panic disorder, and generalized anxiety disorder increases risk for cardiac events such as coronary artery disease and myocardial infarctions (Rozanski, Blumenthal, & Kaplan, 1999). This raises the possibility that social anxiety, as a category of anxiety disorders, may have distinct cardiovascular consequences. The extent to which social anxiety contributes to elevated peripheral resistance could therefore help account for the association between loneliness and vascular resistance.

Future Directions

The results of the current study demonstrate that elevated vascular resistance was not limited to the laboratory, but was evident in everyday life. This would be expected if elevated vascular resistance plays a role in the development of hypertension in the lonely. In fact, we recently found, in a small sample of older adults, that aging predicted increased systolic blood pressure among lonely, but not nonlonely adults (Cacioppo, et al., submitted). Additional support for the idea that loneliness leads to blood pressure increases via increased vascular resistance requires a longitudinal study to track changes in loneliness and cardiovascular activity. Such a longitudinal project is currently underway to monitor cardiovascular developments and changes in loneliness in an aging population.

Given the provocative finding in the current study linking interpersonal closeness ratings with loneliness and vascular resistance, additional research is needed to determine the critical dimensions of interaction quality in predicting loneliness and/or cardiovascular activity. Currently, we are experimentally evaluating the role of interpersonal distrust in mediating the effects of loneliness on psychological and cardiovascular responses during a prisoner's dilemma situation modeled after that of Rotenberg (1994). Although distrust did not predict cardiovascular activity during social interactions in the present study, our measure of distrust did not provide evidence that an interaction partner had behaved in an untrustworthy fashion. In the prisoner’s
dilemma protocol, participants are exposed to a confederate that behaves either cooperatively or not, and the consequences on their ratings of their confederate partner, their behavioral response, and their cardiovascular activity will be evaluated as a function of loneliness.

A similar issue to that of the critical dimensions of interaction quality is the multi-dimensional nature of loneliness (Hawkley, Browne, Ernst, Burleson, & Cacioppo, unpublished manuscript). Loneliness can arise for a multitude of reasons, and its emotional, social, and behavioral manifestations may be equally diverse. Greater specificity in defining loneliness should provide greater specificity in predicting its consequences. Our laboratory is therefore continuing its efforts to develop a multi-dimensional loneliness scale that more precisely reflects the multi-faceted nature of loneliness. Loneliness may also vary in its temporal nature: some individuals may be chronically lonely, while others may experience loneliness as a transitory state. It would be reasonable to expect that transient loneliness would not be equivalent to chronic loneliness in its impact on physical or psychological health.

Further work is also needed to better understand the mechanisms that are responsible for increased vascular resistance in the lonely. In the present study, tonically elevated vascular resistance was not accompanied by higher blood pressure among the lonely, but by lower cardiac output. One mechanism that may help explain this pattern of results is reduced beta-adrenoceptor responsivity in the lonely. In high-hostile males, phasic increases in vascular resistance in response to stressors were due to reduced vascular receptor responsivity to beta-adrenergic activation (isoproterenol), not to enhanced responsivity to alpha-adrenergic activation (phenylephrine) (Suarez, Sherwood, & Hinderliter, 1998). Whereas alpha-adrenergic activation produces vasoconstriction, beta-adrenergic activation produces vasorelaxation, suggesting that the cardiovascular risk associated with hostility may be diminished counteractive dilation of vessels and, consequently, inadequate management of the sympathetically mediated increase in cardiac
output that typically accompanies stressful encounters. A similar process may be at work among
the lonely on a more chronic basis. Specifically, we found a tendency toward increased \( \beta_1 \)-
mediated cardiac sympathetic activity (i.e., decreased PEP) in the lonely, but the lack of
differences in blood pressure suggests that \( \alpha_1 \)- and/or \( \beta_2 \)-mediated vascular sympathetic responses
resulted in a net deficit in vasodilation in the lonely relative to the nonlonely.

In addition, increased vascular resistance could be due to diminished flow-mediated
dilation of the vasculature. Evidence suggests that the \( \alpha_2 \)-adrenergic vasodilatory response is
partly mediated by nitric oxide, a vasodilatory substance synthesized by the endothelium upon
increased blood flow (Dawes, Chowienczyk, & Ritter, 1997). Individuals with low endothelium-
dependent arterial dilation (EDAD) responses to increased brachial artery flow exhibited
increased vascular resistance responses but not significantly different blood pressure or cardiac
output responses than high EDAD responders during a variety of active and passive laboratory
stressors (Sherwood, Johnson, Blumenthal, & Hinderliter, 1999). Interestingly, in monkeys,
social stress (i.e., socially unstable housing conditions) was sufficient to produce a significant
degree of damage to endothelial cells in the descending thoracic aorta, an effect that was
attributed to \( \beta_1 \)-mediated sympathetic activity as damage was greatly reduced by \( \beta_1 \)-blockade
(Skantze et al., 1998). Similarly, the social stress of loneliness in the current study tended to
predict greater sympathetic cardiac activation (\( \beta_1 \)-mediated) that increased with temporal
increases in loneliness. To the extent this activation damages the endothelium and reduces
vasodilatory capacity, \( \beta_1 \)-mediated endothelial damage may help explain the origins of increased
vascular resistance in the lonely. A longitudinal study would be helpful in determining whether
increased vascular resistance in the lonely is in fact preceded by exaggerated beta-adrenergically
mediated cardiovascular activity.
Notably, holding loneliness constant, loneliness changes between recruitment and testing did not predict increases in vascular resistance, suggesting that vascular resistance levels had stabilized at a higher level among the lonely at the time of recruitment into the study. Roughly half of our sample was recruited during their first quarter at college, a particularly vulnerable transition time (see, for example, Cutrona, 1982, and Shaver, Furman, & Buhrmester, 1985) when cardiovascular physiology might have been undergoing adjustments to students' new physical, social, and emotional environments. Yet even in our predominantly freshman sample, it is plausible to expect physiological adjustments to have reached a plateau by the time participants were tested in the second academic quarter or later, concomitantly with the gradual recovery of stability in other aspects of students' lives.

Whether alleviation of loneliness is eventually reflected in a recovery of pre-college patterns of cardiovascular activity is a question that needs to be addressed in a longitudinal study parallel to those of Cutrona (1982) and Shaver et al. (1985), who examined loneliness and the social adjustment process during a freshman year at college. For good or ill, the patterns of cardiovascular activity established during college years may be as stable as the behavior patterns often established during these critical years. To the extent this is true, it reinforces Kurt Vonnegut's admonition to "create stable communities" and reduce the risk of loneliness and its psychological and physical health consequences.
LIST OF REFERENCES


56


58


APPENDIX

EXPERIENCE SAMPLING QUESTIONNAIRE
Experience Sampling Questionnaire

Date: ____________ Beep #: ____________

Timed beeped: ____________ AM ____________ PM

Time started to fill out: ____________ AM ____________ PM

1. When you were beeped...

Where were you? __________________________________________

What was your posture? ____________ (Circle one)

- ____________ sitting
- ____________ upright
- ____________ lying down
- ____________ walking
- ____________ running
- ____________ exercising

How many people were within sight? ____________

Who were they? __________________________________________

What was the main thing you were doing? __________________________________________

What else were you doing? __________________________________________

What was the main thing you were thinking? __________________________________________

What else were you thinking? __________________________________________

If you are anticipating an event outside of your normal routine, what is it? __________________________________________

Please check all of the following that describe what you were doing and thinking when you were beeped (items are listed alphabetically).

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<th>DOING</th>
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<td>Attending a social gathering</td>
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<td>Drinking coffee, tea, or other caffeine drink</td>
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<td>8.</td>
<td>Driving</td>
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<td>9.</td>
<td>Eating. What were you eating?</td>
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<td>10.</td>
<td>Engaging in a group activity</td>
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Participant ID # 0131
1. (cont'd) When you were beeped...

Please check all of the following that describe what you were doing and thinking when you were beeped (listed alphabetically).

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2. When you were beeped, was the main thing you were doing...

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<th>VERY</th>
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The next question is to be answered only if you were interacting with another person or persons when you were beeped. In other words, if you were alone or were not interacting with the individuals present (such as during a class lecture), you can omit this question.

10. When you were beeped, with how many males and/or females were you interacting?

- Males
- Females

When you were beeped, how did you feel about the person or persons with whom you were interacting?

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11. Have you consumed any alcohol in the past 2 hours?

- O No  
- O Yes Please write in how many glasses you had in the last 2 hours: _______

12. Have you consumed any caffeine in the past 2 hours?

- O No  
- O Yes Please write in how many cups you had in the last 2 hours: _______

Any comments? (Please use the reverse side of this page.)
4. When you were baped, were you in physical pain or discomfort?

I) Yes
II) No

5. With whom did you have the experience?

I) A teacher
II) A priest
III) A relative
IV) A doctor
V) A friend
VI) A family member
VII) A stranger
VIII) A professional person

6. When did you have the experience?

I) Early childhood
II) Late childhood
III) Teenage years
IV) Adult years
V) Elderly years

7. What was the experience like?

I) Scary
II) Terrible
III) Unforgettable
IV) Intense
V)life shattering

8. How did you feel about the experience?

I) Terrified
II) Confused
III) Shocked
IV) Scared
V) Frightened
VI) Terrified

9. What did you do or think when the experience occurred?

I) Nothing
II) Run
III) Hide
IV) Talk
V) Cry
VI) Fight
VII) Try to resist
VIII) Do nothing

10. How did the experience affect you?

I) Had no effect
II) Made you feel better
III) Made you feel worse
IV) Made you feel anxious
V) Made you feel stressed
VI) Made you feel resistant
VII) Made you feel confident
VIII) Made you feel frustrated

11. What was your general mood during the experience?

I) Happy
II) Sad
III) Angry
IV) Excited
V) Nervous
VI) Confused
VII) Relax
VIII) Content

12. Did you experience any physical sensations?

I) Yes
II) No

13. Were there any other people present during the experience?

I) Yes
II) No

14. How long did the experience last?

I) A short time
II) A long time

15. Did you have any physical effects after the experience?

I) Yes
II) No

16. How did you feel about the experience after it had occurred?

I) Terrified
II) Confused
III) Shocked
IV) Scared
V) Frightened
VI) Terrified
VII) Uncomfortable
VIII) Terrified
For the next three questions, you'll be asked to classify people into different categories, such as friend, family member, etc. Some will fit several categories, depending on the situation. Within the context of the situation when you were beeped, choose the ONE category which best describes your relationship with each person with whom you were interacting.

6. When you were beeped, whom were you interacting with? Check all that apply. (M=male, F=female)
   - No one
   - Family members / relatives
   - Significant other
   - Roommate
   - Pet
   - Other (please describe)

How were you interacting?
   - In person
   - By phone
   - By email
   - By letter
   - Other

8. When you were beeped, what were you feeling?

   Very slightly not at all
   - A little
   - Moderately
   - Quite a bit
   - Extremely

   - Interested
   - Hostile
   - Ashamed
   - Active
   - Distressed
   - Enthusiastic
   - Inspired
   - Afraid
   - Excited
   - Proud
   - Nervous
   - Determined
   - Upset
   - Irritable
   - Scared
   - Jittery
   - Guilty
   - Alert
   - Attentive
   - Strong
   - Left out
   - Bored

9. Since you were last beeped, did you...
   Please check all of the following that describe what you have done or thought since you were last beeped (items are listed alphabetically).

   DONE
   - Argue or fight
   - Attend a social gathering
   - Dance
   - Discuss a personal problem with someone
   - Draw, paint, or do other visual art
   - Drink alcohol
   - Drink coffee, tea, or other caffeine drink