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Personal Mastery is Associated with Reduced Sympathetic Arousal in Stressed Alzheimer Caregivers

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Abstract

Objectives—Spousal caregivers of Alzheimer's Disease patients are at increased risk for cardiovascular disease, possibly via sympathetic response to stressors and subsequent catecholamine surge. Personal mastery (i.e., belief that one can manage life's obstacles) may decrease psychological and physiological response to stressors. This study examines the relationship between mastery and sympathetic arousal in elderly caregivers, as measured by norepinephrine reactivity to an acute psychological stressor.

Design—Following assessment for mastery and objective caregiving stressors, caregivers underwent an experimental speech task designed to induce sympathetic arousal.

Setting—Data was collected by a research nurse in each caregiver's home.

Participants—Sixty-nine elderly spousal Alzheimer caregivers (mean age = 72.8 years) who were not taking β-blocking medication.

Intervention—Participants delivered a brief speech in response to vignettes depicting stressful situations.

Measurements—Mastery was assessed using Pearlin's Personal Mastery scale and Alzheimer patient functioning was assessed using the Clinical Dementia Rating Scale, Problem Behaviors Scale, and Activities of Daily Living Scale. Plasma norepinephrine assays were conducted using pre- and post-speech blood draws.

Results—Multiple regression analyses revealed that mastery was significantly and negatively associated with norepinephrine reactivity ($B = -9.86$, $t(61) = -2.03$, $p = .046$) independent of factors theoretically and empirically linked to norepinephrine reactivity.

Conclusions—Caregivers with higher mastery had less norepinephrine reactivity to the stressor task. Mastery may exert a protective influence that mitigates the physiological effects of acute stress, and may be an important target for psychosocial interventions in order to reduce sympathetic arousal and cardiovascular stress among dementia caregivers.

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Keywords

Dementia; Caregiving; Sympathetic Arousal; Mastery; Stress; Coping

Introduction

Extensive research suggests that providing in-home care to a spouse diagnosed with Alzheimer's Disease (AD) can take a considerable toll on the caregiver's health [1]. Along with increased risk for psychiatric morbidity, such as depression and anxiety [2], the chronic stress associated with caregiving enhances mortality risk [3], possibly due to the deleterious effects of stress on cardiovascular health [4, 5]. Particularly, caregiving has been associated with increased risk for hypertension [4] and coronary artery disease [6]. In a 6-year longitudinal study, Shaw and colleagues [4] compared AD caregivers with non-caregiving controls on risk for developing hypertension. Results indicated that individuals providing care for a spouse with AD had a 67% greater risk of manifesting hypertension than similar individuals not providing such care. In a more recent study, Mausbach and colleagues found that greater distress among caregivers was associated with significantly reduced time for developing cardiovascular disease [7].

While direct causes for impaired cardiovascular health in elderly caregivers remain unclear, a possible mechanistic explanation may involve heightened sympathetic arousal as evidenced by increased circulating catecholamines [8]. It is well-established that acutely stressful situations activate the sympathetic nerves, resulting in an upsurge of circulating plasma and norepinephrine (NE) [9, 10]. In turn, catecholamines can produce physiological changes such as increased metabolism, heart rate, and blood pressure [11]. Caregiving (especially for cases in which caregivers experience high disparity between amount of care responsibilities and time for respite) has been associated with elevated levels of circulating plasma catecholamines which might predispose to hypertension [12]. Furthermore, a recent study by Mausbach and colleagues found that NE response to acute stressors is amplified in caregivers high in depressive symptomology, which the authors attributed to possible coping skills deficits and/or distorted cognitive appraisals [13].

An emerging body of research has linked stress-induced catecholamine surge to hemostatic reactivity. Research investigating the procoagulant molecule fibrin D-dimer, the final degradation product from activated coagulation and fibrinolysis systems [14], has supported the relationship between elevations in plasma catecholamine concentration and D-dimer [15]. For instance, Wirtz and colleagues [16] found that NE activity independently predicted D-dimer response to an acute stressor task in healthy, adult men. Moreover, several studies that elicited sympathetic activation through catecholamine infusions in vivo produced increases in various markers of coagulation [17]. Such evidence linking catecholamine surge to hypercoagulability suggests that excessive sympathetic arousal in response to stressful events in daily living may predispose to both hypertension and vascular occlusion.

The potential association between the stress of AD caregiving and cardiovascular impairment for an examination of the psychosocial factors that may reduce sympathetic reactivity to acute stressors. Identification of these psychosocial resource factors may help scientists and practitioners more adequately identify targets for interventions that may, in turn, reduce such harmful levels of physiological arousal. According to the Transactional Model of stress [18], individuals faced with stressful environmental stimuli (e.g., dementia caregivers) make both primary and secondary appraisals of these stimuli. With primary appraisals, an individual evaluates the significance of the stressor to his/her well-being. With secondary appraisals, the individual evaluates the controllability of the stressor and his/her perceived ability to cope with

it. Therefore, within this model, stressors deemed "threatening" and uncontrollable would likely exhibit the greatest psychological and physiological response to stress.

Indeed, one major characteristic of anxiety is the perceived lack of control over one's surroundings and circumstances [19]. In contrast, individuals appraising stressors as controllable are theoretically believed to exhibit an attenuated response to stressors. Consistent with this concept, personal mastery, or the belief that one possesses control over life's obstacles [20], has been inversely related to symptoms of anxiety [21]. Recent research also suggests that mastery is associated with both psychiatric and physical health outcomes. For example, mastery appears to reduce the effects of stress on psychiatric morbidity [22] and may be related to increased β_2-adrenergic receptor sensitivity [23] and decreased mortality risk [24]. Whether mastery has similar protective effects against elevated catecholamine response associated with sympathetic arousal from acutely stressful events has yet to be investigated.

The present study aimed to further understand possible psychosocial protectors against caregiving-related stress associated with CVD risk in elderly spousal caregivers of AD patients. Due to a growing body of research outlining the positive psychological and physiological effects of personal mastery, it seemed plausible that mastery may have similar protective effects against excessive sympathetic arousal. Therefore, the purpose of this specific study was to determine the relationships among personal mastery, caregiver strain, and sympathetic arousal in elderly caregivers, as measured by NE reactivity to an acute stressor task.

Methods

Participants

Sixty-nine spousal caregivers of AD patients agreed to participate in a study of psychobiologic responses to stress. Participants were recruited through referrals from the University of California, San Diego (UCSD) Alzheimer's Disease Research Center (ADRC), media advertisements, community support groups, health fairs, and presentations by agencies providing services to AD caregivers. All participants provided written informed consent for this protocol, approved by the UCSD Institutional Review board.

All caregivers provided in-home care to their spouse diagnosed with AD and were of a mean age of 72.8 years (range = 51–88). Participants taking β-blocking or anticoagulant medication, or who had blood pressure exceeding 200/120 mmHg at the time of recruitment were excluded. Use of antihypertensive medication other than β-blockers (e.g. angiotensin-converting enzyme inhibitors, angiotensin II antagonists, calcium channel blockers, and diuretics) was noted. Due to extreme resting NE levels ($z > 4.0$) and NE reactivity ($z < -4.0$), one participant's data was excluded from analyses, yielding a final sample size of 68 individuals.

Procedures

All data were collected in each caregiver's home by a research nurse, who administered structured assessments of: a) caregiver general physical and psychological health, b) severity of the AD patient's dementia, c) AD patient problem behaviors, and d) the type and degree of assistance the caregiver provided. Following assessment of demographic and psychosocial constructs, the nurse inserted a venous indwelling catheter into the caregiver's forearm in preparation for the experimental stress task. Caregivers were then instructed to rest while seated comfortably for 20 minutes. The first blood sample was drawn promptly after this resting period.

Participants were randomly presented with one of two stressor vignettes, which previous studies have found to elicit analogous reactivity [25]. Caregivers spent 3 minutes mentally preparing to give a speech responding to the vignette, and then spent an additional 3 minutes

delivering it. One vignette required the participant to defend him or herself against false accusations of shoplifting [26] while the other required the participant to argue with a disreputable automobile repairman over unreasonable costs. Directly following the speech, blood was drawn once again.

Measures

Norepinephrine Levels—Blood samples were stored in −80° freezer until assay. A catechol-o-methyltransferase (COMT)-based radioenzymatic assay with a preconcentration step was done to extract norepinephrine from 1 mL plasma and was then concentrated in 0.1 mL of dilute acid, a technique 10 times as sensitive as standard catecholamine assays [27].

Mastery—Mastery was assessed using a 7-item instrument developed by Pearlin and Schooler [28]. This instrument asks participants to rate statements such as "I can do just about anything I really set my mind to do," on a 4-point scale. Ratings were summed to obtain an overall mastery score (7=low mastery; 28=high mastery).

Dementia Severity of the AD Patient—The Clinical Dementia Rating (CDR) scale [29] provides a global assessment of dementia severity, as measured by six behavioral and cognitive domains: memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care. AD patients received a rating of 0–4 (0=healthy; 4=severe dementia) on each of the six dimensions, and the overall dementia severity score represented the average rating across these dimensions. By definition, because inclusion criteria required a diagnosis of dementia, there were no care recipients with CDR scores of zero.

Patient Problem Behaviors—Caregivers rated the frequency of 14 patient problematic behaviors, such as disturbing caregiver's sleep, bowel or bladder "accidents," threatening others, and use of foul language [30]. Frequency of behaviors was rated on a 4-point scale as follows: 1 = no days; 2 = 1–2 days; 3 = 3–4 days; 4 = 5 or more days. A total problem behaviors score was obtained by averaging scores of the 14 items.

Patient Daily Dependency—Pearlin's 15-item measure of Activities of Daily Living (ADL)[30] was used to assess the number of activities for which the AD patient depends on the caregiver. Activities such as eating, bathing, taking medications, and using the restroom are rated based on the patient's dependency on the caregiver for assistance: 0 = not applicable; 1 = not at all; 2 = somewhat; 3 = quite a bit; 4 = completely. Item rankings were summed to obtain a total ADL score.

Statistical Analysis

Given that zero-order correlations indicated large associations between conceptually similar measures of caregiver stress (r = .461–.607, Table 2), an aggregate component score was formed using principal component analysis (PCA) with varimax rotation in order to reduce potential problems of multicollinearity in regression analyses. The aggregate component score was derived from three measures of stressors related to caregiving (i.e., CDR, problem behaviors, and ADLs), previously categorized by Pearlin and colleagues [30] as objective "primary stressors." The resulting component (i.e., "primary stress") was saved as a z-score (i.e., mean = 0, SD = 1).

Hierarchical linear regression was used to assess the unique contribution of mastery over other factors theoretically and empirically linked to NE reactivity. For this analysis, NE reactivity was quantified by subtracting resting (baseline) NE from post-speech NE. In step 1 of our regression analysis, resting NE levels were entered to account for their relationship to reactivity and to control for possible ceiling effects. Age, sex, and usage of antihypertensive medication

were entered in step 2, reflecting demographic and physiological characteristics related to NE reactivity. Step 3 involved entering the principal component capturing primary stressors. Finally, personal mastery was entered in step 4 of the regression analysis. As recommended by Kraemer and Blasey [31], independent variables were centered around the mean prior to conducting our regression analysis in order to generate meaningful regression coefficients and to reduce multicollinearity. Sex was centered as +0.5 (men) and −0.5 (women), and linear variables were centered at their means as follows: resting NE (405 pg/ml), age (72 years), and mastery (average mastery score = 19).

Results

Caregiver demographic characteristics are presented in Table 1 and bivariate correlations between study variables are presented in Table 2. The majority of participants were female (66%) and Caucasian (93%) with a median yearly household income of $40,398. Forty-six percent of caregivers reported using at least 1 antihypertensive medication (excluding β-blockers). Means for indexes of objective primary stressors were as follows: mean AD patient CDR score was 2.5 (±0.9) indicative of mild to moderate cognitive impairment, mean problem behaviors score was 1.9 (±0.5), and mean ADL score was 10.4 (±7.8). Caregiver mastery scores ranged from 14 to 25 (mean = 19.0).

As anticipated, PCA analysis of patient CDR, problem behaviors, and ADL yielded a single component solution representing “primary stressors” of caregiving. Given that this component had an eigenvalue of 1.96 (compared to .58 for the next highest component) and explained 65.4% of the variance, the single component solution was considered a parsimonious characterization of the data with reasonable practical significance. Factor loadings of each scale on the primary stressor component were as follows: CDR = .78; problem behaviors = .84; and ADL = .81.

Results of the regression analysis are presented in Table 3. In Step 1, resting NE levels were not significantly associated with NE reactivity. The addition of demographic and physiological covariates in step 2 (age, sex, and use of antihypertensive drugs) indicated that the usage of antihypertensive drugs was the only covariate significantly associated with NE reactivity (B = 58.92, t(63) = 2.45, P = .017). In step 3, prior to the addition of mastery in the full model, the regression revealed that the primary stressors component was significantly and positively associated with NE reactivity (B = 28.79, t(62) = 2.40, p = .019). As anticipated, the addition of mastery in the final step of the regression model revealed a significant association between mastery and NE reactivity (B = −9.86, t(61) = −2.03, p = .046) such that participants endorsing greater mastery experienced less reactivity in response to an acutely stressful event. As a whole, the final prediction model accounted for 26.7% (adjusted R^2 = .20) of the total variance in NE reactivity (F(6,61) = 3.70; p = 003). Mastery uniquely accounted for 5% of the variance in NE reactivity, above and beyond the effects of the other factors.

Notably, with the addition of mastery in the fourth step of the regression model, primary stressors declined in significance (i.e., B = 28.79, p = .019 to B = 19.4, p = .129), raising the possibility that mastery might mediate the relationship between primary stressors and NE reactivity. Mastery exhibited a moderate association with the primary stressor component was r = −.42, p < .001, suggesting that caregivers’ sense of personal mastery declines as their stressors increase. Although the cross-sectional nature of the data prohibits causal hypotheses, in the interests of gaining further understanding for future prospective studies, a Sobel test [32] of meditation was used to explore the possibility that mastery might mediate the relationship between primary stressors and NE reactivity. The test of the indirect effect of primary stress on NE reactivity as mediated by mastery exhibited a trend in the direction of significance (B indirect = 9.41, standard error [SE]: 5.53, z =1.70, p = 0.089). Moreover, in order to consider

a moderating model, the interaction between mastery and primary stressors was also tested, but was non-significant.

Discussion

The current study provides evidence for a possible protective effect of personal mastery on sympathetic arousal, as measured by NE reactivity to a psychological stressor task. Specifically, caregivers who believed they had greater control over their life circumstances demonstrated reduced sympathetic arousal to an acute stressor. An increasing body of literature suggests that AD caregivers experience sympathetically-mediated vascular changes that place them at increased risk for CVD [9, 15]. Despite this growing body of literature, little research has examined resilience factors that may protect caregivers from these negative physiological consequences.

AD caregivers are faced with stressful challenges on a daily basis related to their loved one's decline in mental functioning, problem behaviors, and need for basic care (e.g., eating, toileting). For example, handling problems involving an AD spouse's procedural forgetfulness of mundane tasks or wandering out of the house, to name a few, can produce great levels of stress, thereby triggering frequent sympathetic activation. These findings suggest that high mastery can also contribute to the attenuation of catecholamine spillover resultant from sympathetic activation. Indeed, as seen in the final step of our regression model (Table 3), caregivers evidenced an average NE increase of approximately 68 pg/ml in response to the psychological stress task, and the regression coefficient for mastery allows one to quantify the effects of mastery on NE reactivity. Specifically, the current findings suggest that increasing mastery scores by approximately 1 standard deviation (i.e., 2.4 points) would yield approximately a 33% reduction in NE reactivity (24 pg/ml). Furthermore, given that the mastery scale has a range of 21 points, a hypothetical increase from the lowest to the highest possible mastery score would yield an average predicted reduction in NE reactivity of over 200 pg/ml.

The significant association between mastery and reduced sympathetic arousal is consistent with Lazarus' Transactional model of stress [18]. That is, persons who appraise themselves as incapable of managing stressors (i.e., low mastery) are expected to have greater physiologic arousal driven by increased sympathetic arousal. In contrast, those who appraise themselves as capable of managing stressors (i.e., high in mastery) may either perceive the event as less threatening or experience a greater subjective sense of control, thereby resulting in less physiologic arousal. To place this concept into context, imagine a caregiver who has just realized that her AD spouse has wandered out of the house. She may feel overwhelmed and under-prepared, eliciting stress, and thus arousal. Alternatively, she may approach the situation with confidence stemming from either an internalized sense of control or preparedness from previous education on handling such a scenario. Indeed, significant negative correlations were found between mastery and the primary stressors component, as well as with its three individual contributing measures. A caregiver demonstrating this type of perceived sense of control is unlikely to appraise the situation as highly unmanageable, and may circumvent a strong physiological response.

Application of this theory suggests that healthcare professionals could potentially intervene with caregivers at a cognitive or behavioral level in order to alter their perceived sense of control. Specifically, providing caregivers with skills for handling stressful situations may build mastery and thus reduce their risk for cardiovascular impairment. In view of this, several studies have demonstrated the efficacy of psychoeducational interventions aimed at increasing perceived control over stressful situations [33, 34]. For instance, a 16-month longitudinal study found that mastery increased while psychological distress decreased significantly compared to

control groups after participating in a perceived control intervention [33]. Furthermore, Coon and colleagues [35] found that caregivers participating in either an anger or depression management class (AMC and DMC, respectively) adhering to a cognitive-behavioral model experienced a significant increase in perceived caregiving self efficacy compared to those in a waitlisted control group. The AMC included relaxation and assertiveness training and role-play for potentially frustrating scenarios while the DMC focused on increasing life satisfaction by instilling problem-solving techniques and behavioral activation. Overall, it appears that providing AD caregivers with cognitive and/or behavioral skills to manage daily caregiving stressors can help increase mastery, which in turn may potentially reduce the effect of caregiving-related stress and its accompanying physiological response.

Previous literature suggests that sustained sympathetic arousal can potentially trigger downregulation of β_2-adrenergic receptors [9], leading to impaired vasodilation. This is due to the fact that healthy β_2-adrenergic receptor functioning is essential for vascular smooth muscle relaxation and vasodilation [36]. Blunted β_2-adrenergic receptor sensitivity may lead to impaired vasodilation, possibly contributing to the development of hypertension [37]. Interestingly, the results of this study build upon previous research demonstrating a positive relationship between personal mastery and peripheral blood mononuclear cell (PBMC) β_2-adrenergic receptor sensitivity [23]. In that study, caregivers reporting high mastery demonstrated increased β_2-adrenergic receptor sensitivity, which may be due to a reduction in catecholamine surge elicited by stress. Therefore, high personal mastery, which the present study found to be related to decreased NE reactivity, may possibly decrease one's risk for hypertension.

Although results support the hypothesis that there is indeed a negative relationship between mastery and NE reactivity, the cross-sectional design of this study does not allow for causal explanation or assumption of potential downstream health outcomes. However, a body of literature provides some support for a link between sustained sympathetic arousal and risk for negative cardiovascular events such as atherosclerosis [10], thrombosis [38] and hypertension [39]. Future research examining the direct relationship between sympathetic reactivity to acute stress and cardiovascular events would confirm this conjecture.

In summary, AD caregivers who reported having a high sense of mastery demonstrated reduced NE reactivity to an acute stressor task compared to their low-mastery counterparts. These results are consistent with the Transactional model of stress [18], and suggest that psychosocial interventions which build mastery may have beneficial physiologic or health outcomes. Indeed, our results provide further support for mastery's previously demonstrated protective effects on physiologic outcomes, including β_2-adrenergic receptors and the fibrinolysis marker PAI-1 [40], among other known psychosocial and physiological benefits. Further research examining the long term outcomes of reduced frequency arousal and catecholamine surge in stressed populations would reveal the magnitude of this effect.

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Table 1

Participant Characteristics

Age, M (SD), y	72.8 (8.8)
Gender, n (%)	
Male	23 (34)
Female	45 (66)
Ethnicity, n (%)	
Caucasian	63 (93)
Non-Caucasian	5 (7)
Education n (%)	
Less than high school	1 (1.5)
High school	21 (30.9)
Some college	15 (22.1)
College graduate	31 (45.6)
Yearly Household Income, median, $	40,398*
Antihypertensive Drug Use n (%)	
Present	31 (46)
Absent	37 (54)
Resting NE, M(SD) , pg/ml	404.7 (191.8)
Post-Speech NE, M(SD) , pg/ml	502.3 (203.7)
BMI, M(SD)	25.4 (4.9)
Patient CDR, M(SD)	2.5 (0.9)
Patient Problem Behaviors M(SD)	1.9 (0.5)
Patient ADL M(SD)	10.4 (7.8)
Personal Mastery, M(SD)	18.9 (2.4)

Note. NE=Norepinephrine; BMI=Body Mass Index; CDR=Clinical Dementia Rating; ADL=Activities of Daily Living.

*10 participants declined to disclose yearly household income information; therefore data is based on 58 participants.

Table 2

Spearman Correlations Among Study Variables

Variable	1	2	3	4	5	6	7	8	9
1. NE (rest)									
2. NE (speech)	.822**								
3. NE Reactivity	−.121	.418**							
4. Age	.231	.259*	.067						
5. Sex	−.207	−.297*	−.139	−.418**					
6. Antihypertensive Use	.132	.299*	.291*	.214	−.282*				
7. CDR	−.027	.179	.344**	.077	.078	−.153			
8. Problem Behaviors	−.096	−.096	.057	−.222	.343**	−.307*	.494**		
9. ADL	−.078	−.055	.024	−.206	.355**	−.373**	.461**	.607**	
10. Mastery	.048	−.067	−.290*	.027	−.181	.195	−.339**	−.361**	−.348

Note. NE=Norepinephrine; CDR=Clinical Dementia Rating score; ADL=Activities of Daily Living

* $p \leq .05$

** $p \leq .01$

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Table 3

Regression Model Predicting Change in Plasma Norepinephrine

	df	ΔF	*p*	ΔR^2	Entered Variables	*B*	*β*	*p*
Step 1	1,66	1.12	.295	.017	Intercept	97.59		
					NE Rest	−.07	−.13	.295
Step 2	4,63	3.13	.032	.128	Intercept	72.33		
					NE Rest	−.11	−.21	.088
					Age	.95	.09	.517
					Sex	14.30	.07	.594
					Drug	58.92	.30	.017
Step 3	5,62	5.76	.019	.073	Intercept	68.28		
					NE Rest	−.10	−.20	.093
					Age	.89	.08	.531
					Sex	29.59	.14	.268
					Drug	73.32	.38	.003
					Stressors	28.79	.30	.019
Step 4	6,61	4.14	.046	.050	Intercept	67.81		
					NE Rest	−.10	−.20	.092
					Age	.78	.07	.573
					Sex	32.56	.16	.213
					Drug	75.28	.39	.002
					Stressors	19.38	.20	.129
					Mastery	−9.86	−.25	.046
		R^2 = .27; Adjusted R^2 = .20						

Note. NE = Norepinephrine; Drug = Antihypertensive drug use; Stressors = Caregiver primary stressors. Intercept corresponds to the predicted NE reactivity to the acute stress task for a caregiver (regardless of sex) where resting NE was centered at 405 pg/ml, age was centered at 72 years, and Mastery was centered at 19.