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Research Article

Emotion Recognition and Reactivity in Persons With Neurodegenerative Disease Are Differentially Associated With Caregiver Health

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Abstract

Background and Objectives: Motivated by the high rates of health problems found among caregivers of persons with neurodegenerative disease, we examined associations between deficits in two aspects of care recipients' socioemotional functioning and their caregivers' health.

Research Design and Methods: In 2 studies with independent samples (N = 171 and 73 dyads), caregivers reported on care recipients' emotion recognition and emotional reactivity. Caregiver health was assessed using both self-report measures (Studies 1 and 2) and autonomic nervous system indices (Study 2).

Results: Lower emotion recognition in care recipients was linearly associated with worse self-reported health, faster resting heart rate, and greater physiological reactivity to an acoustic startle stimulus in caregivers. These effects held after accounting for a variety of risk factors for poor caregiver health, including care recipients' neuropsychiatric symptoms. Emotional reactivity showed a quadratic association with health, such that the lowest and highest levels of emotional reactivity in care recipients were associated with lower self-reported health in caregivers.

Discussion and Implications: Results shed light on the unique associations between two aspects of care recipients' emotional functioning and caregivers' health. Findings suggest potential ways to identify and help caregivers at heightened risk for adverse health outcomes.

Keywords: Dementia, Empathy, Stress, Social support, Autonomic nervous system responding

Caregiving is a positive experience for many individuals (Roth, Fredman, & Haley, 2015). However, caregivers of close relational partners with neurodegenerative disease experience more health problems than other caregiving subgroups due to the unique and chronic stresses of providing care to an individual with neurodegenerative disease, in conjunction with the health risk factors associated with aging (Dassel, Carr, & Vitaliano, 2017; Vitaliano, Murphy, Young, Echeverria, & Borson, 2011; Vitaliano, Zhang, & Scanlan, 2003). Specific stressors have been shown to contribute to caregivers' health problems, including care recipients' neuropsychiatric symptoms (Allegri et al., 2006) and cognitive impairments (Schulz, O'Brien, Bookwala, & Fleissner, 1995), the demands of attending to care recipients' activities of daily living (Razani et al., 2007), and caregivers' loss of social support (Kiecolt-Glaser, Dura,

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Speicher, Trask, & Glaser, 1991). Less attention has been paid to the ways that basic aspects of care recipients' socioemotional functioning affect caregiver health.

Neurodegenerative diseases, especially frontotemporal dementia (FTD), can produce pronounced deficits in key aspects of emotional functioning (Levenson, Sturm, & Haase, 2014; Sturm, Haase, & Levenson, 2016). For example, individuals can lose their ability to recognize others' emotions (emotion recognition) and their ability to generate emotional responses (emotional reactivity). When care recipients no longer recognize emotions or fail to react emotionally, this removes an important source of social connection and support from caregivers' lives, increasing feelings of social isolation, and adding to the stress of caregiving (Brown et al., 2018; Chen et al., 2017). To illustrate, imagine experiencing sadness in response to the death of a family friend, while your closest loved one does not recognize your grief or does not react to the loss. These emotional deficits could be extremely upsetting, frustrating, and stressful for caregivers.

Deficits in care recipients' emotional functioning may also "get under the skin" affecting caregivers' autonomic nervous system (ANS) responding. "Still face" paradigms used in developmental psychology exemplify how a lack of emotional engagement from a previously responsive partner can affect ANS physiology. In these paradigms, when a parent maintains a neutral facial expression, babies undergo almost immediate stress, shrieking, and blubbering as their sympathetic adrenal medullary pathway increases ANS arousal and their hypothalamic pituitary adrenal axis releases cortisol (Kemeny, 2003; Mesman, van IJzendoorn, & Bakermans-Kranenburg, 2009). Similarly, adults show increased physiological stress responses when their partner is emotionally disengaged (Heffner et al., 2006). Moreover, a number of studies suggest that ANS reactivity to stressors is lower for individuals with high-quality relational partners whose emotional functioning is intact (Brown, Beckes, Allen, & Coan, 2017; Thorsteinsson & James, 1999). Relational partners may exert even more powerful influences on physiological responding in late life, given that the deleterious effects of negative social interactions increase with age (Hakulinen et al., 2016).

Physiological responding in the ANS plays an important role in linking stressors to poor health. Stressors activate ANS and other physiological systems, and the chronic activation of these systems can lead to poor health (Cohen, Janicki-Deverts, & Miller, 2007). Resting ANS activity such as higher resting heart rate (Greenland et al., 1999) and blood pressure (Vasan et al., 2001) can indicate heightened risk for cardiovascular disease and nonspecific mortality risk. Heightened ANS responses following an acute stressor are indicative of increased physiological stress reactivity (Lepore, Miles, & Levy, 1997), which can lead to increases in blood pressure and atherosclerotic buildup in arterial walls (Kamarck et al., 1997). Thus, it is reasonable to expect that changes in care recipients' emotional functioning can adversely affect their caregiver's resting ANS physiology, ANS reactivity, and health. Yet, no studies, to the best of our knowledge, have examined how particular aspects of care recipients' emotional functioning are related to caregivers' health or ANS physiology, or compared the adverse effects of care recipients' emotional functioning with other well-established risk factors for poor caregiver health. Identifying specific stressors related to caregiver health could lead to earlier interventions that are more narrowly targeted, efficient, and effective, thereby reducing some of the huge societal burden associated with neurodegenerative disease.

Current Studies

We conducted two studies examining whether caregivers' reports of care recipients' emotion recognition and emotional reactivity are associated with self-report and ANS indicators of caregivers' health. Caregivers completed an assessment of care recipient's emotional functioning that has been previously linked to objective care recipient emotional behaviors (validated in a dissertation; Ascher, 2012). In Study 1 (N = 177), caregivers provided self-reports of their own health. In Study 2, an independent sample of caregivers (N = 73) provided self-reports of their own health and, in addition, ANS indices of their health (i.e., resting heart rate, resting blood pressure, and ANS reactivity in response to an acoustic startle stimulus) were obtained in a laboratory study. Across studies, we hypothesized that lower emotion recognition and lower emotional reactivity in care recipients would be associated with worse health in caregivers even when controlling for the effects of other well-established risk factors for poor health, including care recipients' neuropsychiatric symptoms and cognitive decline, caregiving demands associated with care recipients' instrumental activities of daily living, and caregivers' social support from friends and family.

Study 1: Design and Methods

Participants

Care recipients with neurodegenerative diseases (N = 177) were recruited from the Memory and Aging Center at the University of California, San Francisco (UCSF) between 2004 and 2013 as part of an ongoing study of the impact of neurodegenerative diseases on emotional functioning. Care recipients underwent neuropsychological and neuroimaging testing and were diagnosed using standard criteria for a number of neurodegenerative diseases. The sample included 80 individuals diagnosed with FTD, 53 with Alzheimer's disease (AD), and 44 with neurodegenerative diseases that primarily impact motor functioning (Motor), such as corticobasal syndrome, progressive supranuclear palsy, and amyotrophic lateral sclerosis. Each care recipient's primary caregiver was identified and also recruited for participation in the study. Caregivers were either spouses/significant others (N = 151), siblings (N = 11), adult children (N = 13), or friends (N = 2) who self-identified as playing a primary role

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in providing care to a community-dwelling care recipient. The sample was predominately Caucasian, with approximately 88% of care recipients and caregivers identifying as Caucasian, 5% Asian, 4% Latino, 2% Black or African American, and 1% mixed race. Additional sample characteristics are presented in Table 1.[1]

Measures

All measures were completed within 3 months of the care recipient evaluation. All procedures were approved by the UC Berkeley Committee for the Protection of Human Subjects.

Care Recipient Diagnosis

Care recipients underwent neuropsychological and neuroimaging testing and were diagnosed using standard criteria for a number of neurodegenerative diseases, which fall into three categories (AD, FTD, and Motor). For analyses, the diagnostic category was dummy coded (with FTD as the reference group).

Care Recipient Cognitive Impairment

One hundred fifty-two care recipients' cognitive impairment was assessed using the Mini-Mental State Examination (MMSE; M = 22.73, SD = 5.99), a well-validated measure for assessing global cognitive impairment (Folstein, Folstein, & McHugh, 1975).

Caregivers' Reports of Care Recipients' Emotional Functioning

Caregivers reported on their care recipient's emotional functioning using two 10-item subscales from the Caregiver Assessment of Socioemotional Functioning (Ascher, 2012). For the *emotion recognition* subscale, caregivers rated the extent to which care recipients were able to recognize and understand each of 10 emotions (i.e., amusement, anger, disgust, embarrassment, fear, guilt, joy, pride, sadness, shame) over the past month (e.g., "Please rate the participant's behavior in the past month for: recognizes and understands when others are feeling angry"). For the *emotional reactivity* subscale, caregivers rated the extent to which care recipients expressed each of the same 10 emotions (listed previously) over the past month (e.g., "Please rate the participant's behavior in the past month for: expresses anger"). For both subscales, responses ranged from 0 (*not at all*) to 4 (*a lot*) with a "don't know" option. Responses were averaged, and scale reliabilities were high (recognition: Cronbach's alpha = .97, M = 1.93, SD = 1.08; reactivity: Cronbach's alpha = .85, M = 1.71, SD = .62).

Caregivers' Self-Reported Health

In Study 1, caregivers completed the well-validated Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36; Ware & Sherbourne, 1992), a self-report questionnaire assessing eight health domains. Subscales were averaged, with higher scores indicating better health (M = 71.57 SD = 15.58).

Care Recipients' Neuropsychiatric Symptoms

At UCSF, 99 care recipients' neuropsychiatric symptoms were assessed via a structured interview conducted by a nurse using the Neuropsychiatric Inventory (M = 23.8, SD = 21.62), a well-validated measure of neuropsychiatric symptoms (Cummings, 1997).

Statistical Analyses

To test associations between care recipients' emotion recognition and caregivers' health, three linear regression models were constructed with caregivers' health as the dependent variable. In the first model, care recipients' emotion recognition served as the predictor variable. In the second model, we added care recipients' diagnosis and care recipients' cognitive impairment (MMSE) as covariates to the first model. In a third model, we added care recipients' total score on the neuropsychiatric inventory as an additional covariate to the second model.

Next, to test the association between care recipients' emotional reactivity and caregivers' health, we repeated the analysis described previously, replacing care recipients' emotion recognition with care recipients' emotional reactivity as a predictor variable in each of the three regression models. Finally, in exploratory analyses, we examined the curvilinear association between care recipients' emotional reactivity and caregivers' health. This exploratory

Table 1. Demographic Data for Care Recipients and Caregivers

Group	*n*	Age	M:F	Cognitive impairment (MMSE)
Study 1 FTD care recipients	80	63.52 (7.88)	43:37	24.23 (5.61)
Study 1 AD care recipients	53	63.54 (8.61)	28:25	21.72 (5.63)
Study 1 Motor care recipients	44	67.31 (6.55)	23:21	24.15 (6.29)
Study 1 caregivers	177	62.04 (11.58)	74:103	—
Study 2 FTD care recipients	35	65.94 (7.90)	19:16	25.17 (3.24)
Study 2 AD care recipients	16	59.56 (15.87)	8:8	23.83 (4.30)
Study 2 Motor care recipients	22	64.32 (10.75)	12:10	24.33 (6.59)
Study 2 caregivers	73	64.05 (11.04)	29:44	—

Note: AD = Alzheimer's disease; FTD = frontotemporal dementia; MMSE = Mini-Mental State Examination.

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analysis was motivated by the possibility that, in addition to underexpressivity, overexpressivity (e.g., inappropriate laughter, angry outbursts) can be difficult for caregivers and could contribute to health problems. We used three polynomial hierarchical regression models, with caregiver health as the dependent variable. In the first model, care recipients' emotional reactivity was entered in the first step, and the quadratic effect of care recipients' emotional reactivity (emotional reactivity squared) was entered in the second step. In the second model, we added care recipient diagnosis (coded as above) and cognitive impairment in the first step of the model as covariates. In the third model, we added care recipients' total score on the neuropsychiatric inventory as an additional covariate in the first step of the model.

Results

Care Recipients' Emotion Recognition and Caregivers' Self-Reported Health

Lower care recipients' emotion recognition (predictor variable) was associated with lower caregivers' health (dependent variable), β = .28, $t(167) = 3.77$, $p < .001$. This association remained significant when we added diagnosis and cognitive impairment (MMSE) as covariates, β = .29, $t(139) = 3.50$, $p = .001$. Finally, when we added care recipients' neuropsychiatric symptoms to the model, lower care recipients' emotion recognition and fewer care recipients' neuropsychiatric symptoms were both independently associated with lower caregiver health, β = .31, $t(71) = 2.68$, $p = .009$ and $\beta = -.40$, $t(71) = -3.41$, $p = .001$, respectively. Table 2 presents adjusted results from the final model.

Care Recipients' Emotional Reactivity and Caregivers' Self-Reported Health

Care recipients' emotional reactivity was not significantly associated with caregivers' health, β = .05, $t(173) = 0.61$, $p = .54$, even after we included care recipients' diagnosis and cognitive impairment as covariates, β = .03, $t(145) = 0.34$, $p = .73$.

Results from exploratory curvilinear analyses revealed a significant change in R^2 with the addition of the quadratic effect $F(1, 172) = 7.55$, $p = .007$, such that the lowest and highest levels of care recipients' emotional reactivity were associated with lower caregivers' self-reported health, β = −.21, $t(172) = -2.75$, $p = .007$.[2] This effect remained significant when diagnosis and cognitive impairment were included as covariates, β = −.22, $t(144) = -2.73$, $p = .007$, $F(1, 144) = 7.45$, $p = .007$.[3] Finally, when care recipients' neuropsychiatric symptoms were included, emotional reactivity (curvilinear) and neuropsychiatric symptoms (linear) were both independently predictive of caregivers' health, β = −.34, $t(74) = -3.53$, $p = .001$ and β = −.49, $t(74) = -4.87$, $p < .001$, respectively. Tables 2 and 3 display adjusted results from the final models.

Preliminary Discussion

Results from Study 1 revealed that caregivers' reports of care recipients' emotional functioning were related to caregivers' self-reported health independently of care recipients' neuropsychiatric symptoms. Specifically, low levels of care recipients' emotion recognition were linearly associated with lower caregiver health. For care recipients' emotional reactivity, we found evidence for a curvilinear relationship with high and low levels of emotional reactivity associated with lower caregiver health. Study 1 was limited in that both measures of care recipients' emotional functioning and caregiver health were based on caregivers' reports (thus, associations may have been inflated by common method variance). To address these issues, in Study 2, we reexamined this association in an independent sample adding more objective ANS indices of caregivers' health and additional covariates.

Study 2: Design and Methods

Participants

An independent sample of care recipients with neurodegenerative disease ($N = 73$) and their caregivers ($N = 73$) were recruited, evaluated, and diagnosed between 2013 and 2016 using the same methodology as Study 1. Diagnoses included FTD ($n = 35$), AD ($n = 16$), and other diagnoses (primarily motor; $n = 22$). Caregivers were either spouses/significant others ($n = 65$) or siblings, adult children, or friends ($n = 8$). The sample was predominately Caucasian (80%; 9% Asian, 2% Latino, 2% Black or African American, and 7% other race). Additional sample characteristics for Studies 1 and 2 are presented in Table 1.

Apparatus

ANS physiology was monitored using a BIOPAC polygraph, and data acquisition and analysis software written by Robert W. Levenson. The program calculated second-by-second averages for the following measures: (a) heart rate—measured as the interbeat interval (IBI) of successive R waves; (b and c) finger pulse transit time and amplitude; (d) ear pulse transmission time; (e) skin conductance level; (f) systolic blood pressure; and (g) diastolic blood pressure. See Supplementary Section 1 for additional details regarding physiological measures. Although the device used to measure second-by-second blood pressure during the reactivity task is a reliable indicator of blood pressure changes over time, it is not a reliable measure of absolute blood pressure levels (Remmen et al., 2002). Thus, at the

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Table 2. Adjusted Results From Full Models Examining Associations Between Care Recipients' Emotional Reactivity and Caregivers' Subjective Health

	Study 1: subjective health					Study 2: subjective health				
Step	*B*	*SE*	β	ΔR^2	ΔF	*B*	*SE*	β	ΔR^2	ΔF
1				.27***	5.52				.39**	3.77
Care recipient diagnosis (AD)	−7.13	3.98	−0.22			0.22	0.22	0.14		
Care recipient diagnosis (Motor)	−7.68	4.41	−0.19			−0.16	0.17	−0.12		
Care recipient cognitive impairment (MMSE)	0.17	0.28	0.06			0.00	0.02	0.03		
Care recipient neuropsychiatric symptoms	−0.37	0.08	−0.52***			—	—	—		
Care recipient emotional reactivity (linear)	3.44	1.74	0.21			0.12	0.08	0.20		
Caregiving demands for iADLs	—	—	—			−0.14	0.07	−0.26		
Social support (not from care recipient)	—	—	—			0.30	0.22	0.19		
Caregiver comorbid health conditions	—	—	—			−0.31	0.11	−0.35**		
2				.11**	12.49				.03	1.87
Care recipient diagnosis (AD)	−7.62	3.71	−0.23*			0.23	0.21	0.14		
Care recipient diagnosis (Motor)	−6.87	4.12	−0.17			−0.20	0.17	−0.15		
Care recipient cognitive impairment (MMSE)	0.17	0.26	0.06			0.00	0.02	−0.02		
Care recipient neuropsychiatric symptoms	−0.35	0.07	−0.49***			—	—	—		
Care recipient emotional reactivity (linear)	2.18	1.66	0.14			0.14	0.09	0.23		
Care recipient emotional reactivity (quadratic)	−4.32	1.22	−0.34**			−0.07	0.05	−0.18		
Caregiving demands for iADLs	—	—	—			−0.15	0.07	−0.29*		
Social support (not from care recipient)	—	—	—			0.23	0.22	0.14		
Caregiver comorbid health conditions	—	—	—			−0.33	0.11	−0.37**		

Note: AD = Alzheimer's disease; iADL = instrumental activities of daily living; MMSE = Mini-Mental State Examination.
*p < .05. **p < .01. ***p < .001.

Table 3. Intercorrelations Between Study 2 Variables

	1	2	3	4	5	6	7	8	9	10	11
1. Emotion recognition	1										
2. Emotional reactivity	.35**	1									
3. Self-reported health	.43**	.18	1								
4. Resting heart rate (IBI)	.32**	−.02	.44**	1							
5. Resting systolic blood pressure	.04	.06	−.16	−.26+	1						
6. Resting diastolic blood pressure	−.11	−.03	−.21	−.27*	.56**	1					
7. Physiological reactivity	−.27*	−.09	.03	.12	−.12	−.01	1				
8. Specific health conditions	−.12	.21	−.24+	−.32*	.16	.21	−.2	1			
9. Cognitive impairment	−.03	−.23+	.11	.18	.03	.04	.01	−.10	1		
10. Activities of daily living	−.39**	−.01	−.33**	−.18	.01	−.11	.04	−.04	−.37**	1	
11. External social support	.21+	.11	.27*	.37**	.01	.09	.04	−.09	.26*	−.17	1

Note: IBI = interbeat interval.
+p < .1. *p < .05.**p < .01.

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beginning of the laboratory protocol, caregivers' resting systolic and diastolic blood pressure were also measured using a single reading from a GE medical systems Dynamap Pro 100–400 Patient Monitor.

Procedure

Within 3 months of the UCSF evaluation of the care recipient, the caregiver completed questionnaires and visited the Berkeley Psychophysiology Laboratory at the University of California, Berkeley, to participate in a comprehensive assessment of emotional functioning (Levenson et al., 2008). Following consent, caregivers' resting systolic and diastolic blood pressures and hearing were measured. All caregivers could hear at least an 80 dB stimulus at 4,000 Hz. Next, caregivers were seated in an experimental room, and physiological sensors were attached. For the present study, we used data from an unanticipated startle trial where participants were told to relax and watch the screen. An "X" appeared on the screen for a 60-s pretrial rest period along with the instructions to "watch the X, please." After 60-s, a startle stimulus (a 115-dB, 100-ms burst of white noise, akin to a gunshot) was presented without warning using hidden speakers located behind the participant. The "X" remained on the screen for another 60 s following the startle stimulus.

Measures

For Study 2, we obtained a number of measures using the same methods described for Study 1, including care recipients' diagnosis (AD, Motor, FTD), cognitive impairment (M = 24.65, SD = 4.63), and caregivers' reports of care recipients' emotional functioning (emotion recognition: Cronbach's alpha = .77, M = 2.52, SD = 1.15; and emotional reactivity: Cronbach's alpha = .96, M = 1.66, SD = 0.70). Additionally, we obtained the measures described below.

Caregivers' Self-Reported Health

Caregivers completed: (a) several subscales related to physical health from the SF-36, including physical functioning, pain, and role limitations due to physical health problems, and (b) three individual items assessing perceived general health and health change: (i) "In general would you say your health is …" 1 (*poor*) to 5 (*excellent*); (2) "Compared to one year ago: How would you rate your health in general now?" on a scale of 1 (*much worse*) to 5 (*much better*); and (3) "Do you feel your health has suffered because of your involvement with the participant?" on a scale of 0 (*never*) to 4 (*nearly always*).

To control for Type I error related to having multiple dependent measures, we computed a single health measure by normalizing all inventories and the three health items (inverting when appropriate) and averaging to produce a composite score in which higher scores indicated better health. This composite measure was moderately reliable (Cronbach's alpha = .67). Because this composite had not been used previously in the literature, we also conducted independent analyses for each subscale and health item when effects were significant (Supplementary Section 2).

Caregivers' ANS Health Indices

To obtain a measure indicative of *resting heart rate*, we averaged the IBIs that occurred during the 20-s period preceding the onset of the acoustic startle, with longer (higher) IBIs reflecting slower heart rate. For *resting systolic and diastolic blood pressure*, we used the single measure obtained prior to the start of the assessment of emotional functioning.

To obtain measures of *ANS reactivity* to the unanticipated startle, we first computed a single composite measure of ANS reactivity (Gross & Levenson, 1997) to reduce the Type I error associated with multiple physiological measures. For each physiological measure, we extracted the final 20 s of the rest period preceding the acoustic startle (these were most distant from initial instructions) and the 15 s immediately following the startle (sufficient to incorporate the full ANS response to the startle) to form a time series of 35 values. We then normalized each of these time series inverted the values for IBI, finger pulse transmission time, and ear pulse transmission time, and computed an average for each second. In this composite measure, higher values were associated with greater physiological activation. A reactivity score was then computed by subtracting the average of the 20-s rest period from the 15-s poststartle period. When effects were significant, we also examined results for each channel independently for exploratory purposes (Supplementary Section 1).

Caregiver Social Support

We used an adapted version of the Lubben Social Network Scale that assessed social support from friends, neighbors, or family members other than the care recipient (Lubben, 1988). Caregivers were asked three items (e.g., How many relatives, friends, neighbors, other than the participant do you feel you can call on for help with chores, transportation, etc.?), and responded on a scale of 0 (*0*) to 5 (*9+*). Responses were averaged, with higher scores reflecting greater social support (M = 1.28, SD = 0.37).

Caregiving Demands for Care Recipient's Instrumental Activities of Daily Living

Instrumental activities of daily living (iADLs) were measured by an adapted version of the Lawton–Brody iADL Scale (Lawton & Brody, 1969). Specifically, caregivers were asked, "In the past month, how much did you help the participant with the activities listed below?" and they responded on a scale of 1 (*not at all*) to 5 (*always*) for each of eight activities (e.g., food preparation, responsibility for own medications). Responses were averaged, with higher scores reflecting greater caregiving demands for care recipient's iADLs (M = 2.67, SD = 1.21).

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Comorbid health conditions were operationalized as the number of specific health conditions endorsed by caregivers, including heart conditions, lung disease, diabetes, stroke, kidney and liver problems, and cancer ($M = 0.63$, $SD = 0.72$).

Statistical Analyses

In our primary analyses, we used linear regressions to examine associations between care recipient emotion recognition and several dependent variables: (a) self-reported health, (b) resting heart rate, (c) resting systolic blood pressure, (d) resting diastolic blood pressure, and (e) ANS reactivity to an acute stressor. For each dependent variable, we first ran a linear regression with care-recipient emotion recognition as the predictor. If an association was found, we included Study 2 covariates in the model to assess the robustness of the association. Study 2 covariates included patient diagnosis (as coded in Study 1), cognitive impairment (MMSE), caregivers' demands for iADLs, social support, and comorbid health conditions.

Next, for each of the five dependent variables listed previously, we followed the analytic strategy used in Study 1 and conducted a polynomial hierarchical regression to test the quadratic association with care recipient emotional reactivity. If an association was found, we included Study 2 covariates in the model to assess the robustness of the association.

Results

Preliminary Analyses

Table 4 displays correlations between all variables. Caregivers responded with increased ANS activation to the acoustic startle; a repeated-measures analysis of variance comparing the prestartle physiological composite to the poststartle physiological composite was significant, $F(1, 72) = 50.95$, $p < .001$, partial $\eta^2 = .41$ ($M_{\text{prestartle}} = -0.16$, $SD = 0.31$), ($M_{\text{poststartle}} = 0.17$, $SD = 0.42$). We also examined correlations between caregivers' self-reported health and the ANS measures. Caregivers with better self-reported health had slower resting heart rate, $r(59) = .44$, $p < .001$, but no associations were found between self-reported health and resting systolic blood pressure, $r(57) = -.16$, $p = .22$, diastolic blood pressure, $r(57) = -.21$ $p = .11$, or physiological reactivity to the acoustic startle stimulus, $r(65) = .03$, $p = .79$.

Care Recipients' Emotion Recognition and Caregivers' Health

Caregivers' Self-Reported Health

As in Study 1, lower care recipients' emotion recognition was associated with worse caregivers' health, $\beta = .43$, $t(66) = 3.82$, $p < .001$, even after including all Study 2 covariates in the model, $\beta = .34$, $t(42) = 2.27$, $p = .028$.

Table 4. Adjusted Results From All Models Where Care Recipients' Emotion Recognition Significantly Predicted Caregivers' Health and ANS Variables

	Study 1: subjective health			Study 2: subjective health			Study 2: resting heart rate			Study 2: ANS reactivity		
	B	*SE*	β	*B*	*SE*	β	*B*	*SE*	β	*B*	*SE*	β
Care recipient emotion recognition	4.89	1.82	.31**	0.18	0.08	.34*	41.75	19.21	.36*	−0.14	0.06	−.43*
Care recipient diagnosis (AD)	−6.98	3.81	−.21	0.24	0.20	.15	−22.88	48.55	−.07	0.04	0.15	.04
Care recipient diagnosis (Motor)	−6.54	4.43	−.16	−0.29	0.18	−.22	−33.82	46.64	−.11	0.03	0.13	.03
Care recipient cognitive impairment	0.21	0.28	.08	0.01	0.02	.04	5.52	4.26	.19	−0.02	0.01	−.21
Care recipient neuropsychiatric symptom	−0.28	0.08	−.40**	—	—	—	—	—	—	—	—	—
Caregiving demands for iADLs	—	—	—	−0.07	0.07	−.13	3.59	17.69	.03	−0.06	0.05	−.18
Social support (not from care recipient)	—	—	—	0.29	0.21	.18	74.93	51.83	.21	0.01	0.15	.01
Caregiver comorbid health conditions	—	—	—	−0.21	0.11	−.24	−34.18	26.87	−.18	−0.14	0.08	−.26

Note: AD = Alzheimer's disease; ANS = autonomic nervous system; iADL = instrumental activities of daily living.
*$p < .05$. **$p < .01$. ***$p < .001$.

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Associations between care recipients' emotion recognition and caregivers' health were similar across the individual self-reported health subscales (Supplementary Section 2).

Caregivers' ANS Health Indices

For *resting heart rate*, lower care recipients' emotion recognition was significantly associated with faster caregivers' resting heart rate, $\beta = .32$, $t(64) = 2.69$, $p = .009$, even after including all Study 2 covariates in the model, $\beta = .36$, $t(40) = 2.17$, $p = .036$. We did not find any associations between care recipients' emotion recognition and caregivers' *resting systolic blood pressure*, $\beta = .04$, $t(62) = 0.32$, $p = .75$, or *resting diastolic blood pressure*, $\beta = -.11$, $t(62) = -0.89$, $p = .38$.

For *ANS reactivity*, lower care recipients' emotion recognition (predictor variable) was significantly associated with greater caregivers' ANS reactivity to the acoustic startle, $\beta = -.27$, $t(71) = -2.36$, $p = .021$, even after including all Study 2 covariates in the model, $\beta = -.43$, $t(43) = 2.47$, $p = .018$.

Care Recipients' Emotional Reactivity and Caregivers' Health

Caregivers' Self-Reported Health

Following the analytic strategy used in Study 1, a polynomial hierarchical regression revealed a marginally significant change in R^2 for the addition of the quadratic effect of emotional reactivity $F(1, 65) = 3.38$, $p = .071$, such that lowest and highest levels of care recipients' emotional reactivity were marginally associated with worse caregivers' health, $\beta = -.22$, $t(65) = -1.84$, $p = .071$. However, when covariates were included in the model, the quadratic effect was not statistically significant, $F(1, 42) = 1.86$, $p = .179$.

Caregivers' ANS Health Indices

There were no significant curvilinear relationships between care recipients' emotional reactivity and any of caregivers' ANS health indices, including resting heart rate, $\beta = -.02$, $t(64) = -0.12$, $p = .90$, systolic blood pressure, $\beta = .05$, $t(62) = 0.45$, $p = .65$, diastolic blood pressure, $\beta = -.03$, $t(62) = -0.23$, $p = .82$, or ANS reactivity, $\beta = -.09$, $t(71) = -0.77$, $p = .45$.

Discussion and Implications

In the present study, we examined associations between caregivers' reports of two aspects of care recipients' emotional functioning, emotion recognition and emotional reactivity, and caregivers' health. Results from two independent samples indicate that lower emotional recognition in care recipients was associated with worse self-reported health in caregivers. Similar results were also found when using more objective ANS health indices in Study 2, with lower emotion recognition in care recipients associated with faster resting heart rate and greater ANS reactivity to an unanticipated acoustic startle in caregivers.[4] Although additional research is needed to examine specific psychological pathways (e.g., loneliness, subjective stress) through which care recipients' emotion recognition deficits link to worse caregiver health, these findings lend support to theories that suggest emotion recognition plays a central role in reducing a partner's arousal in response to stressors (Paivio & Laurent, 2001). Caregivers of persons with emotion recognition deficits may be especially vulnerable to the increasing health risks posed by social and emotional stressors that come with age (Charles & Luong, 2013) because they lose the stress-buffering support of a close relational partner while facing the added stressor of providing care to an individual who can no longer recognize emotions. Although older adults typically employ interpersonal strategies to protect themselves from negative emotional arousal (e.g., retaining only their closest, most supportive relationships and using strategies to de-escalate negative interactions; Rook & Charles, 2017) these kinds of strategies may prove futile when one's closest relational partner loses the ability to recognize emotions. Thus, additional research is also needed to examine whether care recipient emotional deficits have a more deleterious effect on older caregivers.

Findings for care recipients' emotional reactivity were not as clear-cut. We found some evidence for a curvilinear relationship between care recipients' emotional reactivity and caregivers' self-reported health, suggesting that care recipients who over- or underexpress emotions have caregivers with worse subjective health. However, this curvilinear effect was less robust, becoming nonsignificant in Study 2 after including covariates, and was not observed for objective ANS measures. Nonetheless, it makes sense that when it comes to emotional reactivity, too much or too little can both have downsides. A number of challenging symptoms in care recipients (e.g., inappropriate laughter) can be viewed as indicative of high levels of emotional reactivity. Similarly, research suggests that forms of underexpression of emotion in care recipients (e.g., apathy) are also associated with worse caregiver outcomes (e.g., Landes, Sperry, Strauss, & Geldmacher, 2001). Although atypical emotional reactivity may be difficult for caregivers, changes in emotional reactivity may not have the same degree of interpersonal influence as changes in emotion recognition. Whereas emotion recognition deficits will likely be noticed during interpersonal interactions (e.g., when caregivers' emotions go unrecognized), emotional reactivity deficits can occur outside of interpersonal interactions (e.g., lack of disgust reactivity leading to eating rotten food). More research is needed to understand fully the adverse effects of disease-related alterations in care recipients' emotional reactivity on caregivers' health. The associations are likely more complex than those of emotion recognition (including possible differences associated with different emotions; e.g., high levels of care recipients' amusement may have different effects than high levels of care recipients' anger).

Importantly, lower emotion recognition in care recipients was associated with worse health in their caregivers, even

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after including other risk factors in our models (care recipients' diagnosis, cognitive impairments, neuropsychiatric symptoms, caregiving demands associated with care recipients' iADLs, caregivers' social support). Moreover, care recipients' emotional functioning and neuropsychiatric symptoms were both independently associated with caregivers' health, suggesting that differences in basic aspects of care recipients' emotional functioning, as well as more pathological neuropsychiatric symptoms, can each take a toll on caregivers' health. Care recipients' emotion recognition, however, appeared to be a better predictor of caregivers' health than caregiving demands associated with care recipients' iADLs, caregivers' social support from people other than the care recipient, and care recipients' cognitive impairments. These findings suggest that care recipients' emotional functioning is an important risk factor for caregivers' health problems, above and beyond the effects of these other well-established risk factors.

The Value of Caregivers' Reports of Care Recipients' Emotional Functioning

Taken together, these findings underscore the value that caregivers' reports of care recipients' emotional functioning have for explaining some of the individual differences in caregivers' health. Previous research suggests laboratory measures of care recipients' emotional functioning are useful for predicting adverse caregiver outcomes (Brown et al., 2018; Chen et al., 2017). Despite their utility, laboratory assessments of care recipients' emotional functioning can be quite labor- and time-intensive and typically require additional equipment and expertise. Compared to laboratory assessments, caregivers' reports have the advantage of being based on viewing emotional functioning in natural environments and over longer periods of time. Moreover, caregivers' reports can be easily implemented into large-scale epidemiological and population-based studies, which may provide more generalizable findings than those associated with laboratory studies that do not use representative samples. Importantly, in the current study, caregivers' reports showed specificity of prediction, with reports of care recipients' emotion recognition having different associations with caregivers' health than reports of care recipients' emotional reactivity. These findings highlight the value of asking caregivers more differentiated questions about multiple aspects of care recipients' emotional functioning.

Strengths and Limitations

Strengths of the current studies include using two independent samples of participants encompassing a diverse set of neurodegenerative diseases; assessing multiple aspects of care recipients' emotional functioning (emotion recognition, emotional reactivity); comparing emotional functioning to other well-established risk factors for poor caregiver health; and including both self-report and objective measures of caregivers' health. Limitations include the use of caregivers' reports of emotional functioning, which may introduce bias, and the cross-sectional design, which prevents the determination of causal and temporal relationships. These limitations leave open the possibility that caregivers' health (and other factors) may affect caregivers' reports of care recipients' emotional functioning, which could influence the strength of observed associations. Although the well-established impact of neurodegenerative diseases on emotional functioning (e.g., Rankin et al., 2006) suggests care recipients' emotional deficits lead to declines in caregivers' health, the other direction of causal influence is certainly plausible. For example, lower levels of caregivers' mental health predict earlier care recipient mortality (Lwi, Ford, Casey, Miller, & Levenson, 2017). Future research should directly address the direction of causality using longitudinal designs and assess factors that might moderate associations between care recipients' emotional functioning and caregivers' health such as relationship type (e.g., child vs spouse), gender, coresidence with care-recipient, age, and cultural background (e.g., cultures that differ in their views regarding familial roles and responsibilities).

Conclusions

Our findings point to robust linear associations between deficits in care recipients' emotion recognition and poor caregivers' health (whether measured by self-report or ANS indices). We also found less robust curvilinear relationships between care recipients' emotional reactivity and caregivers' self-reported health such that highest and lowest levels of care recipients' emotional reactivity are associated with poor caregivers' self-reported health, but not caregivers' physiological responding. These findings have both theoretical and practical implications. Findings are consistent with theories that suggest caregivers of loved ones with neurodegenerative diseases experience greater health problems due in part to specific stressors resulting from their partner's neurodegeneration. Findings highlight specific associations between particular aspects of care recipients' emotional functioning and caregivers' health and suggest the possibility of using this kind of information to identify and intervene to help caregivers who may be at heightened risk for adverse health outcomes. With the aging population and increasing prevalence of neurodegenerative diseases casting more people into the caregiver role, early detection of and intervention with caregivers at risk has the potential to ameliorate some of the staggering health consequences of caregiving.

Author Notes

[1]A subset of participants from the Study 1 sample (n = 154) were included in a previous study that examined the relationship between care recipients' empathic accuracy measured using a variety of objective laboratory tasks and caregiver depressive

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symptoms (Brown et al., 2018). None of the current analyses regarding caregiver ratings of recipient emotional functioning, reported health, or caregiver ANS measures have been reported in other publications.

[2]This curvilinear pattern of association was similar across some positive and negative emotions (e.g., joy, $\beta = -.15$, $t(169) = -1.86$, $p = .065$ and anger, $\beta = -.16$, $t(173) = -2.21$, $p = .028$).

[3]For consistency, we examined whether there was a quadratic effect of care recipients' emotion recognition on caregivers' self-reported health; this effect was nonsignificant, $\beta = .05$, $t(166) = 0.71$, $p = .48$.

[4]Care recipients' emotion recognition was not related to resting blood pressure. It is possible we did not find associations because both elevated and lowered blood pressure can be indicative of health problems. In addition, associations between care recipients' lack of emotion recognition and caregivers' blood pressure may only arise over time, following caregivers' longer-term exposure to stress. Alternatively, the lack of associations may result from blood pressure measures being based on a single reading (vs the typical practice of averaging multiple readings).

Supplementary Material

Supplementary data are available at *The Gerontologist* online.

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Conflict of Interest

None reported.

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