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Differences in cognitive performance between informal caregivers and non-caregivers

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Abstract

Extensive literature exists documenting the relationship between stress and cognition. Caregiving for an individual with Alzheimer's disease can be aunique and chronic stress experience due to the increasing dependency of the care-recipient as the disease progresses. The current study examines the relationship between stress and cognitive performance in 47 dementia caregivers compared to 47 noncaregiver control participants matched on age, gender, and education. Participants completed measures assessing stress (measured via the Perceived Stress Scale) and seven domains of cognition including episodic memory, working memory, executive functioning, attention, visuospatial processing, processing speed, and implicit memory. Results showed that caregivers had poorer performance than non-caregivers on certain measures of episodic memory, working memory, and executive functioning; while no significant differences were observed on measures of attention, visuospatial processing, processing speed, or implicit memory. In addition, when controlling for general stress, caregiver performance on measures of processing speed and visuospatial processing was also poorer than non-caregivers. By controlling for levels of general stress that may not be related to caregiving, these results show that differences in cognitive performance are unlikely to be explained by general stress alone.

Keywords

Caregivers; cognition; stress; Alzheimer's disease; dementia

Informal caregivers of persons living with chronic illnesses and disabilities experience circumstances considered to be inherently stressful in a role that may be prolonged over a period of years. Caregivers of individuals living with Alzheimer's disease (AD)/dementia face particularly unique challenges due to the progressive nature of the illness in which the care-recipient loses the ability to communicate, recognize loved ones, and provide basic care for oneself. Caregivers arguably are chronically stressed and given the amount of unpaid health services they provide to a growing population of persons with dementia, it is important to determine the adverse impacts that caregivers may experience as a result of stress. Caregivers do not only provide assistance with activities of daily living, such as bathing and transferring, they are also tasked with navigating the health care system, making

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medical decisions, and facilitating communication with formal care providers (Wolff et al., 2016). Moreover, caregivers simultaneously experience the loss of a relationship with a loved one, hence why they are often referred to as the concealed victims of the disease (Brodaty & Donkin, 2009; Clyburn et al., 2000; Zarit et al., 1985). Because informal caregivers provide approximately 17.7 billion hours of unpaid care services worth an estimated 220.2 USD billion (Alzheimer's Association, 2014), a value that greatly exceeds the national spending for home health care, examining caregiver functioning in the context of stress is a pertinent issue not only at the individual level, but at the societal level as well. The stress associated with caregiving can negatively impact a caregiver's health, well-being, and quality of life. Additionally, any interference with a caregiver's ability to provide effective support and care would create additional strain on the formal health care system at a crucial time when demand continues to increase (Gillespie et al., 2015). Furthermore, because the caregiving role requires complex organization and problem-solving skills, impaired cognitive functioning may impact the quality of care and safety of the care-recipient (Willis et al., 1992).

Substantial research exists that demonstrates the impact of stress on cognitive functioning (e.g., Arnsten, 2009; Bremner, 1999; Lupien et al., 2009; McEwen, 1998; McEwen & Magarinos, 1997; McEwen & Sapolsky, 1995). In particular, research has shown that chronic stress results in the over secretion of glucocorticoids, such as cortisol, and can potentially have long-lasting effects on the brain and body, such as impaired immune functioning, cardiovascular disease, and accelerated cognitive decline (Cacioppo et al., 1998; S. Lupien et al., 1994; S. J. Lupien et al., 2007, 2009; McEwen, 1998). In particular, studies have found that cumulative exposure to high levels of glucocorticoids result in damage to the hippocampus (Gianaros et al., 2007; S. J. Lupien et al., 2009, 2018; Marshall et al., 2015) and that greater levels of stress have been associated with smaller hippocampal volume (Zimmerman et al., 2016)

S. Lupien et al. (1994) found a relationship between high levels of cortisol in the hippocampus and impaired declarative memory. Group differences, however, were not found on non-declarative implicit memory measures. There is evidence to suggest that a double dissociation exists between the implicit and explicit memory systems, such that implicit memory assessments are not dependent on the medial temporal regions of the brain (e.g., Henson, 2003; Preston & Gabrieli, 2008; Schacter & Buckner, 1998; Voss & Paller, 2008). Research also suggests that there is a strong connection between the hippocampus and the frontal lobe (Preston & Eichenbaum, 2013; Thierry et al., 2000; Vertes, 2006) and that damage to the hippocampus can lead to downstream effects on other brain regions, along with the cognitive functions they support, such as working memory or processing speed (Cabeza et al., 2004; Nichols et al., 2006). This may indicate that stress can impact performance not only on purely hippocampal-dependent tasks, but also on tasks that are associated with the recruitment of the hippocampus.

Unlike the vast research available on the physical and psychological effects of informal caregiving, much less is known about the relationship between stress and cognitive functioning in caregivers. Mild stress has been shown to be associated with everyday memory failures, such as misplacing one's keys or forgetting to take medication (Mahoney et al., 1998). Chronic stress and caregiver burnout have been linked to impairments in processing speed, episodic memory, learning, and attention (Caswell et al., 2003; Mackenzie et al., 2007, 2009; Oken et al., 2011).

Mackenzie et al. (2007) examined cognitive functioning in 27 caregivers of palliative patients and found that caregivers exhibited impairments in attention regulation and learning/memory, however, no deficits were observed in working memory. In a follow-up study, Mackenzie et al. (2009) found that caregivers reported clinically significant levels of distress and burden and had poorer performance on measures of learning and episodic/working memory compared to noncaregiver control participants.

Vitaliano et al. (2005) found that spousal caregivers of individuals with dementia showed a significant decline in vocabulary ability compared to controls, with differences more pronounced among caregivers who reported greater hostility with their care recipient and possessed higher metabolic risk factors. Moreover, spousal caregivers, who are usually close in age to the care-recipient and may already process information at a slower rate due to the normal aging process, are also at risk for accelerated age-related cognitive decline (Caswell et al., 2003). Similarly, Caswell et al. (2003) found that caregivers of spouses with AD performed significantly worse on measures of processing speed and attention (measured via the digit symbol task) compared to age-matched spousal controls. As part of the same study, Vitaliano et al. (2009) longitudinally assessed digit symbol performance and found that individuals who provided care for an average of 44 months at Time 1 had a mean digit symbol score that was roughly 3.30 points lower than noncaregivers ($d = .29$), and caregivers scored approximately 4.50 points lower than controls at Time 3 ($d = .38$). De Vugt et al. (2006) also noted deficits in digit symbol and delayed recall performance. Likewise, in a telephone-based study using the Nurses' Health Study Cohort, Lee et al. (2004) found significant impairments in both immediate and delayed recall, verbal fluency, and digit-span backwards in female caregivers compared to noncaregivers.

In a cross-sectional study, Oken et al. (2011) investigated which aspects of cognition were most impacted by caregiver-related stress in a sample of 31 caregivers between the ages of 45–85, compared to 25 age-matched controls. Differences were observed between caregivers and noncaregivers on reaction time, attention, and executive functioning, but no differences were found on verbal memory performance. It is not entirely clear why these results are inconsistent with other research that has identified a link between stress and memory performance, however it may be necessary to include multiple measures of memory to determine which types of memory are most impacted by chronic stress.

Many explanations have been proposed to explain why long-term caregivers may have poorer cognitive performance than non-caregivers. Although the process of caregiving for an individual with AD may be a chronic stress experience, considerable individual differences exist. The discrepancy between the presence of stressful events and how people react to them is a fundamental principle underlying the stress process model (Haley et al., 1987; Lazarus & Folkman, 1984; Mittelman et al., 2004; Pearlin et al., 1990), a common theoretical framework used in caregiver research, which attempts to explain the various paths by which stress can differentially impact individuals. Within the model, caregiver stress is divided into four domains (in addition to the caregiver's background characteristics): primary stressors (e.g., stressors that arise directly from the care environment, such a problematic behaviors of the care-recipient and caregiver overload), secondary stressors (stressors that arise in domains outside of the care environment, such as role strains), mediators, and outcomes. Vitaliano et al. (2009) posit that as AD progresses and communication deficits in the care-recipient worsen, in conjunction with the caregiver's increasing isolation from normal social activities, the caregiver's environment can become less intellectually stimulating, which may further exacerbate cognitive decline. Moreover, this can also lead to depressive symptoms, which may serve as a mediator between caregiver status and poorer cognitive performance.

Despite evidence supporting the relationship between caregiving and poorer cognitive functioning, another line of research has demonstrated support for the healthy caregiver hypothesis, arguing that caregivers may have better outcomes compared to noncaregivers because healthier older adults are more likely to become and remain caregivers (Bertrand et al., 2012). High-intensity caregivers are believed to engage in more physical activity (e.g., bathing, assistance with mobility and transport) as part of their role (Bertrand et al., 2012; Fredman et al., 2008) and research has found that caregivers had lower rates of mortality and functional impairment compared to noncaregiver control participants (e.g., Fredman et al., 2010; O'Reilly et al., 2008; Roth et al., 2015). To investigate this in the context of cognition, Bertrand et al. (2012) tested performance on verbal learning and processing speed in 5,592 women over 65 who assisted a relative or friend with at least one ADL and/or IADL and found that continuous caregivers exhibited better cognitive performance than noncaregivers. However, the participants did not specify what their care responsibilities consisted of and whether they were primary, full-time caregivers. The participants were also required to assist with at least one ADL/IADL, which may suggest that the care-recipient could have maintained a significant level of functional independence. Furthermore, Pertl et al. (2015) used data from the Health and Retirement Study (HRS) to examine whether having a spouse with dementia was associated with poorer cognitive functioning. Although no differences were identified between caregivers and controls on any of the cognitive domains assessed, the HRS does not explicitly examine caregiving. Instead, it was presumed that participants who have (and live with) a spouse with dementia were caregivers, although it was unknown how much care the participants provided. A more recent study argued that sampling bias may overestimate the negative effects of caregiver stress that prior literature has identified. O'Sullivan et al. (2019) compared caregivers' cognitive performance to two demographically matched control samples and found that caregivers and noncaregivers exhibited comparable performance on multiple cognitive tests, with caregivers even outperforming control participants on tests of processing speed and reaction time despite scoring higher on measures of stress and depression. Overall, however, the evidence regarding cognitive performance in caregivers is mixed.

With the changing demographic of society and an increase in older adults developing age-related pathological illnesses, it is important to investigate the effects that diseases such as AD can have on the functioning of caregivers. Although research has found that caregivers exhibit worse cognitive performance compared to control participants, previous work examining cognition in caregivers has focused on a limited number of cognitive variables.

Thus, the aim of the current study is to extend prior work by examining performance in caregivers and noncaregiver control participants across seven domains of cognition.

Method

Participants

The current study included a sample of 47 individuals who served as primary, informal caregivers to an individual with AD/dementia and 53 control participants, 47 of which were matched on age, education, and gender to caregiver participants to form the final sample. Control participants and caregivers were recruited via Research Match, an online research registry, and CraigsList.com. Caregivers were also recruited through flyers and announcements made at caregiver support groups. Study information was also distributed at an adult day center and via certified home health aides at a large skilled nursing facility in New York City. Fordham University's Institutional Review Board approved all study protocol and procedures.

Inclusion criteria

Participants in the caregiver group were required to be the primary caregiver of an individual with AD/dementia still living in the community and spoke English as their primary language. Because age is an important predictor of cognition (e.g., Murman, 2015), participants under the age of 40 were not eligible to participate. Participants were excluded if the care-recipient resided in an assisted living or long-term care facility. Participants in the control group were matched to caregivers based on age, gender, and education. Control participants did not have (or previously have) a caregiver role for a disabled/ill family or friend and did not provide care for an individual in a nursing home (see Appendix A for an overview of measures completed by control participants). For both groups, the Mini Mental State Exam (MMSE; Folstein etal., 1975), an assessment of global cognitive functioning, was administered as a screening measure. There were no participants who exhibited cognitive impairment in the current sample (e.g., by obtaining a score of less than 24; Tombaugh & McIntyre, 1992).

Measures

Caregiver-specific measures—Data used in the current analysis are part of a larger study examining caregiving and cognition in the context of Pearlin et al.'s (1990) stress process model. Participants in the caregiving group responded to questions inquiring about caregiving history (e.g., length of time the person has been a caregiver), relationship to the care-recipient, hours of care provided per week, and use of/frequency of home health services. Based on the stress process model, caregivers were also administered questionnaires pertaining to primary stressors (e.g., health, behavior, and functional capacity of the care-recipient, caregiver overload, relational deprivation) and secondary stressors (e.g., family conflict, occupational and financial strain, role captivity, and loss of self). See Appendix B for full list of measures.

Perceived stress—The Perceived Stress Scale (PSS; Cohen et al., 1983) is a 10-item general stress measure that assesses the degree to which individuals appraise situations as uncontrollable, unpredictable, and overwhelming over the past month. Sample items included: "In the last month, how often have you been upset because of something that happened unexpectedly?" and "In the last month, how often have you felt confident about your ability to handle personal problems?" Participants responded to each statement on a 4-point scale ranging from 1 (never) to 4 (very often). In the current study, Cronbach's α = .90 in the caregiver subsample and α = .91 in the control subsample. In the overall sample, Cronbach's α = .90.

Cognitive outcomes

Working memory—The n-back test is a measure of working memory that was administered via PsyToolKit (Stoet, 2010, 2017), a psychological experiment software. In this task, participants were presented with a sequence of letters one at a time. As each letter appeared, the participant was asked to determine whether the stimulus shown is the same one that was presented *n* trials ago. In the first portion of the task, participants determined whether the target presented was the same as the one that was shown two letters prior (2-back task). The second portion of the task (3-back task) required the participant to discern whether the letter shown was the same as the target presented three letters prior. Twenty trials were administered in total for each part. Performance was assessed via reaction times (RTs), accuracy for each trial, and percentage of wrongly reported n-back items.

Episodic memory—Episodic memory was assessed via the Wechsler Memory Scale-Third Edition (WMS-III) word recall task (Wechsler, 1997). Participants were read a list of 12 unrelated words and were given 90 seconds to recall the words in any order. The same procedure was repeated with the same list of words three additional times. After four trials were completed, participants were then read a list of new words and were asked to recall the words in any order. The final trial instructed participants to recall as many words from the first list. The task was scored by summing the number of words correctly recalled on trials 1–4 (with higher numbers indicating better recall). Number of intrusions across trials 1–4 were also summed to form an overall score.

Attention—The Stroop Color-Word Interference Test was administered online via PsyToolKit (Stoet, 2010, 2017) to assess attention (e.g., Dunsky et al., 2017; Fahimi et al., 2018; MacLeod, 1992; McGuinness et al., 2010; Melara & Algom, 2003). In this task, participants were presented with a series of words printed in four colors and were asked to indicate the color of the ink in which the word is printed. Participants completed 100 trials (25 trials for each color) of congruent and incongruent targets. Performance was assessed via an interference score, which is the difference in the amount of time taken to correctly respond to congruent versus incongruent stimuli. According to Siegrest (1995), the Stroop Color-Word Interference Test exhibits high reliability (.88).

Processing speed—Processing speed was assessed via three measures: pattern comparison, letter comparison, and the Wechsler Adult Intelligence Scale - Fourth Edition (WAIS-IV) digit symbol task (Wechsler, 2008). Task administration of pattern and letter comparison followed the format as described in Salthouse and Babcock (1991). Participants were given two sheets of paper and were given 30 seconds per page to determine whether two patterns of lines were the same or different, with a total of 60 trials; participants were instructed to write the letter “S” if the two pairs were the same or a “D” if the two were different. The letter comparison task was then administered, and participants determined whether two strings of three, six, or nine letters were the same or different. As in pattern comparison, the letter “S” was used to indicate that the two pairs are the same or a “D” if they were different. Both comparison tasks were scored based on the number of correct responses minus the number of incorrect responses within the 30-second time limit.

In the WAIS-IV digit symbol task, participants were given a sheet of paper with a key located at the top. The key included numbers (1–9) with corresponding symbols. Participants were instructed to fill in the correct symbol below each digit within a −90 second time limit. The digit symbol task was scored by summing the number of correct items, with higher scores indicating better performance.

Executive functioning—The connections task (Salthouse et al., 2000), which is a variant of the trail making task, was comprised of two parts with two conditions each. Participants were given a sheet of a paper with 49 circles and were given 20 seconds to complete each condition. In the first condition of part A, the circles on the page were numbered from 1–49, and participants were instructed to draw lines to connect the numbers in ascending order. In condition 2 of part A, the task requirements were similar, and participants were presented with a sheet of letters and were instructed to connect letters in alphabetical order. In part B, participants were asked to connect alternating numbers and letters from lowest to highest (e.g., 1, A, 2, B, 3, C). The final condition of part B required participants to alternate between letters and numbers (e.g., A, 1, B, 2, C, 3). Participants’ scores were assessed by subtracting the number of correct connections minus the number of incorrect connections. Scores from both conditions in part A and both conditions in part B were averaged to form two composite variables, the ratio of conditions B/A was then calculated.

Visuospatial processing—Visuospatial processing was assessed using the mental rotation task (Shephard & Metzler, 1971) administered via PsyToolKit (Stoet, 2010, 2017). In this task, which consisted of 24 trials, three 3-dimensional stimuli were presented in each trial. A gray stimulus was presented at the top of the screen, and participants were asked to imagine what the image would look like if it was rotated. The angle of rotation of the image was increased for each trial (e.g., 0, 60,120, and 180 degrees). Two options were given, and participants were asked to choose the stimulus that matches the sample in gray. Performance was assessed via reaction time (change in reaction time from the shortest to the longest angle), as well as with a percent correct score, with higher scores indicating better performance.

Implicit memory—Implicit memory was assessed using the word-stem completion task, which is a measure of perceptual priming and incidental learning. This measure followed the format used by Roediger et al. (1992). In phase I (study phase), participants were presented with a list of 68 words and were instructed to read and construct a visual image of each word. Then, participants were asked to rate the pleasantness of each image on a scale from 0 (extremely unpleasant) to 7 (extremely pleasant). After all questionnaires and cognitive tasks were completed, participants were administered phase II (test phase) of the task and were presented with 34 word-stem puzzles. Each puzzle contained the first three letters of a possible word (with five possible completions) and participants were instructed to fill in the word-stems with the first word that comes to mind. Participants were not informed of any relation between the test phase and the study phase that occurred at the beginning of the study.

Procedure

The study was conducted at Fordham University as a part of a larger study. Testing sessions took approximately 90 minutes, in which participants were asked to complete questionnaires and a series of tasks measuring the cognitive abilities described above. For a full description of the tasks and questionnaires administered, please see Appendices A and B. All participants were compensated with a gift card to Amazon.com.

Data analysis plan

Prior to conducting data analyses, all variables were examined for normality and homogeneity. In terms of descriptive statistics, means and standard deviations or percentages were calculated for all demographic, cognitive, and questionnaire measures. Propensity score matching was used to match caregiver and control participants based on age, education, and gender. Mean group comparisons between control and caregiving groups were analyzed via *t*-tests and ANCOVAs.

Results

Propensity score matching

To ensure that groups could be compared at baseline, propensity score matching using the Propensity Score Matching R plug-in for SPSS Statistics 25.0 was used to match caregiver to control participants on age, education, and gender (Thoemmes, 2012). One-to-one nearest neighbor matching without replacement was used to match 47 controls to 47 caregiver participants. Based on prior literature, logistic regression and an *a priori* caliper of .25 standard deviations ($d = .25$) of the logit transformation of the propensity score was used to match participants (Stuart, 2010; Stuart & Rubin, 2008; Thoemmes & Kim, 2011). In order to determine the effectiveness of the propensity scores, the matched cases were assessed by examining two multivariate tests of covariate balance to assess group differences. Balance is assumed to be achieved when there are no significant differences between groups. The linear combination of variables using a X^2 distribution (Hansen & Bowers, 2008) were examined and showed that the covariates were well-balanced due to its nonsignificant result (X^2 (3) = .19, $p = .98$). Based on the standards proposed by Iacus et al. (2011), the second test compared the L statistic, a test that assesses covariate balance while including interaction effects. According to Thoemmes (2012), the L statistic should produce a value smaller in the matched sample than the unmatched sample. In the current analysis, the L statistic was reduced from an initial pre-matching value of .25 to .22, which suggests that the covariate balance had been improved following matching. Additionally, no covariates in the dataset displayed a large imbalance (> $d = 25$). Finally, standardized group mean differences on the propensity score were examined before ($d = .07$) and after matching ($d = .01$). According to Rubin (2001), standardized mean differences in propensity scores should be close to zero (d

< .20). Based on these guidelines, the results of the current propensity score analyses indicate well-matched groups.

Descriptive statistics

Sociodemographic variables—The overall sample consisted of 94 participants between the ages of 40–71 ($M = 52.94$, $SD = 6.66$). The mean age of the caregiving group was 53.00 years ($SD = 6.26$), and the control group had a mean age of 52.87 years ($SD = 7.11$). Within each group, 46.8% ($n = 22$) of the sample consisted of males and 53.2% ($n = 25$) were females. Independent samples *t*-tests were performed to assess differences between caregiver and control participants on age, gender, education, race/ethnicity, marital status, number of children and grandchildren, along with scores on the Perceived Stress Scale, and there were no significant differences between caregiver and control participants.

Demographic characteristics for caregiver participants—The caregiver sample identified as predominantly White (51.10%). Demographic information for caregiver participants is presented in Table 1. All caregiver participants reported residing with the care-recipient. Participants reported a mean of 4.77 ($SD = 4.05$) years spent in the caregiving role and provided an average of 65.82 ($SD = 54.87$) hours of care per week. Most of the caregiver participants reported being a child of the care recipient (85.1%, $n = 40$), while 7 participants (14.9%) reported being spousal caregivers. An independent samples *t*-test was conducted to determine if differences exist between child and spousal caregivers. No differences emerged on any measures.

Additionally, 38.30% ($n = 18$) of caregivers reported having a home health aide to assist with caregiving responsibilities. Of the caregivers who reported having a home health aide, the care recipients received approximately 45.35 ($SD = 50.84$) hours of home health care per week, with care ranging from one hour a week to 168 hours a week (24 hours a day, seven days a week). Independent samples *t*-tests were conducted to examine differences between caregivers of individuals who receive home health services and those who do not. The only significant finding was that caregivers of individuals with home health services reported worse care-recipient cognitive status compared to those who did not receive home health care ($t(45) = 2.38$, $p < .05$).

Demographic characteristics for control participants—Demographic information for control participants is presented in Table 1. Thirty-one (66%) participants identified as White. The remaining racial/ethnic background of the control participants consisted of thirteen (27.70%) Black or African American participants, two (4.30%) Hispanic/Latino participants, and one Asian (2.1%) participant.

Comparing caregiver and control participants—Table 2 summarizes the results of the independent samples *t*-tests used to examine differences between caregiver and control participants on cognitive performance. Results show that caregivers performed significantly worse than control participants on a number of cognitive tests. In the 2-back condition of the n-back test, caregivers had a fewer number of correctly identified items compared to controls. In the 3-back condition, caregivers had a higher percentage of wrongly reported items, a lower number of correctly identified items, and a slower reaction time compared to controls.

As seen in Table 2, caregivers also performed significantly worse on the WMS-III word recall subtest and the connections task. No significant group differences were identified on any of the processing speed tasks (pattern comparison, letter comparison, and digit symbol; *p*s = .90, .23, and .18, respectively), attention (stroop test; $p = .20$), visuospatial processing (mental rotation; $p = .38$), and implicit memory (word-stem completion test; $p = .39$). Although group differences were not significant, almost all of the relationships were in the direction hypothesized, with the exception of the stroop task – in which caregiver participants scored slightly higher, although the effect size was small ($d = .35$). Alternatively, for the three processing speed tasks measured via the pattern comparison, letter comparison, and digit symbol tasks, control participants exhibited higher mean scores with large effect sizes (*d*s = −1.17, −1.11, −.99, respectively). Control participants also scored higher on the mental rotation ($d = -.50$) and word-stem completion tasks ($d = -.18$), although the effect sizes were not large.

Analyses of covariates—To determine group differences while controlling for perceived stress, a series of ANCOVAs were conducted for each cognitive variable (See Table 3).

The results of the ANCOVAs yielded consistent findings with those reported from the *t*-tests above. Furthermore, after controlling for perceived stress, additional significant findings emerged. Although average reaction time on the 2-back test was not significant before controlling for perceived stress as covariate, significant differences emerged such that caregivers had a longer reaction time compared to controls, however, perceived stress was not a statistically significant predictor. When examining processing speed between caregiver and control participants, significant differences emerged only after controlling for perceived stress. For the pattern comparison, letter comparison, and digit symbol tasks, there were significant group differences with caregivers performing worse compared to control participants. Group differences were also identified on the mental rotation task, which assesses visuospatial processing with caregivers scoring lower than controls. Group differences also emerged on the Stroop test. However, caregivers scored higher than controls on this measure. There were no significant differences that emerged for average reaction time on the mental rotation task and performance on the word-stem completion test after controlling for perceived stress.

Discussion

In the current study, as expected, control participants exhibited better performance across multiple cognitive domains, such as working memory, episodic memory, and executive functioning. In addition, analyses showed consistent results with what was found in the original *t*-test analyses, although additional significant differences emerged after controlling for perceived stress. Caregivers performed worse on both conditions of the working memory task, as well as measures of processing speed, visuospatial processing, executive functioning, and episodic memory. Interestingly, caregiver and control participants did not differ on levels of stress as identified in previous studies (e.g., Oken et al., 2011). It is thus possible that the sample of caregivers included in the current study may have experienced less burden and stress compared to other populations of caregivers. Furthermore, by examining whether caregiver and control participants perform differently across various cognitive assessments, while controlling for levels of general stress, these results show that differences in performance cannot be explained by general stress alone, and that other factors that may perhaps be unique to the caregiving experience (e.g., sleep disruptions, decreased psychological well-being, lack of social support) may help to explain why caregivers performed more poorly.

These results are generally consistent with the little work that has been done on caregiving and cognitive functioning. It is unclear, however, why differences emerged on certain measures and not others. Mackenzie et al. (2007, 2009) found that caregivers exhibited poorer performance on measures of attention, learning, and episodic memory compared to a healthy normative sample, but, unlike the current study, they did not find differences in working memory performance. Furthermore, other studies have found that caregivers displayed poorer performance on processing speed, along with other measures such as verbal fluency, and short-term memory using the digit span backwards task, as compared to control participants (Caswell et al., 2003; De Vugt et al., 2006). The discrepancies between the current findings and prior research are only in terms of significance in the t-tests, and not effect sizes. The three measures of processing speed in the current study showed large effects (e.g., digit symbol performance yielded a Cohen's d of −.98, pattern comparison yielded a Cohen's d of −1.13, and letter comparison yielded a Cohen's d of −1.12), such that control participants outperformed caregiver participants and differences in processing speed measures did, in fact, emerge after controlling for perceived stress.

Additionally, an important point to consider are the various tasks used to operationalize different cognitive functions. Mackenzie et al. (2007, 2009) used the Ruff 2 & 7 Selective Attention Task and the WMS-III Working Memory Index, while Caswell et al. (2003) used the digit symbol task to simultaneously examine attention and processing speed performance. Moreover, working memory incorporates executive functioning processes and differences were also identified between caregiver and control participants on the connections task, a measure of executive functioning, in the current study. Executive functioning performance is associated with the pathways between the hippocampus and the dorsolateral prefrontal cortex, while processing speed performance is mainly associated with the structural integrity of white matter tracts in the frontal, parietal, and temporal cortices (Eckert et al., 2010;Turken et al., 2008). Although processing speed is an essential component that contributes to higher order functions such as working memory, it is possible that no differences initially emerged in the processing speed domain due to the reduced complexity of the tasks compared to the n-backtest. However, although this is a possible explanation for the current findings, the large effect sizes evident in the current sample point to an underpowered sample as a potential reason for the lack of significant relationships.

Previous research supports the impact of chronic stress on performance on complex cognitive measures, such as episodic memory tasks, which is associated with the hippocampus, and may also compromise prefrontal cortex functioning and working memory performance (Arnsten, 2009; Cabeza et al., 2004; Leszczynski, 2011). Thus, it is not surprising that differences were observed primarily on working memory, episodic memory, and executive functioning measures, with caregivers exhibiting worse performance on these measures. This is an important finding, and although examining the unique influences of caregiver stressors on cognition was beyond the scope of the current study, cognition in caregivers is an important topic that warrants further research given the complexity of responsibilities required to effectively carry out the caregiving role.

Limitations and future directions

Several limitations must be considered in interpreting study findings. Most notably, the sample size ($n = 47$ for each group) may have limited the study's power. Furthermore, cognitive functioning was assessed cross-sectionally, which does not allow for conclusions regarding how caregiving is associated with changes in cognition over time. Additionally, the conclusions drawn in the current study are limited by the characteristics of the caregiving sample. Data were only collected on whether caregivers were caring for an individual with Alzheimer's/dementia and not on specific type of dementia and thus, we were not able to determine whether cognitive performance varies across different types of dementia caregivers. Given the difficulty in recruiting caregivers to participate in research, the individuals who participated in the current study can be considered a specialized group of caregivers. That is, these caregivers are more likely to seek out research opportunities, thus this sample may not be representative of all dementia caregivers. Additionally, given that stress did not differ between caregiver and control participants, it is also possible that the current findings, along with caregiver levels of stress, could be overestimated as noted above, or perhaps underestimated compared to caregivers who do not utilize formal services or seek out resources. An additional limitation is that participants also exhibited better performance on the 3-back version of the n-back test compared to the 2-back condition. This is an unexpected finding, given that the 3-back test is more difficult and places greater constraints on working memory. It is possible that practice effects influenced n-back performance, such that participants gained increased familiarity with the measure and had a better understanding of the directions required, which is common in cognitive assessments (Goldberg et al., 2015). Future research should incorporate multiple measures of working memory to determine if the effects observed in the current study are specific to the n-back paradigm. Another limitation is the lack of adjustment of p-values to control for multiple comparisons in the analyses, which increases the risk of type I error; as a result, some of the significant findings reported may be due to chance. However, adjustments were not made in order to reduce type II errors, which are more common in studies with similarly small sample sizes. Not adjusting for multiple comparisons is a commonly used method to reduce type II error, due to the conservative nature of multiple comparison adjustments (Feise, 2002; Rothman, 1990). Additionally, adjustments are not needed if all comparisons are reported (Feise, 2002). Lastly, a majority of the cognitive assessments used in the current study do not have normative data to assess performance. Future research should include cognitive assessments that contain available normative data in order to determine if the differences observed between caregiver and control participants are clinically significant.

Conclusion

This study examined the differences between caregivers and noncaregivers on performance across seven domains of cognition. The results showed that caregivers performed significantly worse compared to control participants on multiple domains of cognition including working memory, episodic memory, and executive functioning. Furthermore, by controlling for levels of general stress that may not be related to caregiving, these results show that differences in performance cannot be explained by general stress alone, and that other factors (e.g., well-being, health behaviors, and levels of social support) may help to explain why caregivers performed more poorly. With the increasing older adult population, and the subsequent increase in age-related pathological illnesses, the number of individuals providing care to a loved one will continue to increase, and additional research is needed to further examine the possible effects of caregiving to identify mechanisms to target in intervention and support efforts.

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Appendix A.

Description of measures completed by control participants.

Domain	Variable	Description	Source
Screening	Mini Mental State Exam	Brief cognitive screening assessing global cognition across five domains	Folstein et al. (1975)
Depression	Center for Epidemiological Studies Depression Scale	Self-report questionnaire assessing depressive symptoms within the past week	Radloff (1977)
Social Support	ENRICHD Social Support Inventory	Questionnaire assessing perceived availability of emotional, informational, and practical support.	Mitchell et al. (2003)
Coping	Cope Inventory	Self-report questionnaire asking participants to report how they cope in stressful situations	Carver et al. (1989)
Perceived Stress	Perceived Stress Scale	Questionnaire assessing situational stress appraisal within the past month	Cohen et al. (1983)
Working Memory	N-back Test	Decide whether presented letter is the same as 2- or 3- trials back	Kirchner (1958), Stoet (2010, 2017)
Episodic Memory (immediate and delayed recall)	WMS-III Word-Recall Subtest	Number of words recalled across 5 trials of a word list	Wechsler (1997)
Attention	Stroop Color-Word Interference Test	Respond to color of ink that word is printed in	Stoet (2010, 2017)
Processing Speed	WAIS-IV Digit Symbol Test	Use a code legend to indicate the correct symbol underneath each digit	Weschler (2008)
Processing Speed	Pattern Comparison	Make same/different judgments of pairs of line patterns	Salthouse and Babcock (1991)
Processing Speed	Letter Comparison	Make same/different judgments of pairs of letter strings	Salthouse and Babcock (1991)

Domain	Variable	Description	Source
Executive Functioning	Connections	Connect circles in order (e.g., numerical order, alphabetical order, alternating between numerical and alphabetical order, and alternating between alphabetical and numerical order)	Salthouse et al. (2000)
Visuospatial Processing	Mental Rotation Task	Choose rotated stimulus that matches target stimulus	Shephard and Metzler (1971), Stoet (2010, 2017)
Implicit Memory	Word-Stem Completion Task	Phase I (study phase): Read word-list, construct visual image of each word, and rate the pleasantness of the image. Phase II (test phase): fill in word-stems	Roediger et al. (1992)

Appendix B.

Description of measures completed by caregiver participants.

Stress Domain (based on the stress process model; Pearlin et al., 1990)	Variable	Description	Source
Background and Context	Demographics	Self-report items assessing age, gender, race, marital status, highest level of education, and socioeconomic status	Pearlin et al. (1990)
Primary Stressors: Objective	Cognitive Status	Assesses cognitive impairment in care-recipient and their level of difficulty in carrying out specific tasks	Pearlin et al. (1990)
Primary Stressors: Objective	Problematic Behaviors	Frequency of problematic behaviors exhibited by the care-recipient over the past week	Pearlin et al. (1990)
Primary Stressors: Objective	Katz Index of Independence in Activities of Daily Living (ADLs)	Assesses care-recipients ability to carry out functions such as bathing, dressing, and feeding	Katz et al. (1963)
Primary Stressors: Objective	Lawton and Brody's Instrumental Activities of Daily Living (IADLs) Scale	Assesses care-recipients ability to carry out complex activities such as grocery shopping, food preparation, and financial management	Lawton and Brody (1969)
Primary Stressors: Subjective	Caregiver Overload	Assesses caregivers' energy level and amount of time it takes to complete daily activities	Pearlin et al. (1990)
Primary Stressors: Subjective	Relational Deprivation	Assesses loss related to intimacy exchange and activity deprivation due to care-recipient's illness	Pearlin et al. (1990)
Secondary Stressors: Role Strain	Family Conflict	Assesses level of disagreement within the family due to the seriousness/safety of the care-recipient, family members' attitudes toward the care-recipient, and family members' attitudes toward the caregiver	Pearlin et al. (1990)
Secondary Stressors: Role Strain	Financial Strain	Assessed via 3 items asking caregivers to report how their total household income has changed compared to prior to the onset of care, how their monthly expenses have changed since the onset of care, and how finances work out at the end of the month	Pearlin et al. (1990)
Secondary Stressors: Role Strain	Occupational Strain	Assesses conflict in providing care and maintaining employment	Pearlin et al. (1990)
Secondary Stressors: Role Strain	Modified Caregiver Strain Index	Assesses strain/burn related to caregiving responsibilities across five domains:	Thornton and Travis (2003)

		employment, financial, physical, social, and time	
Secondary Stressors: Intrapsychic Strain	Role Captivity	Assesses the extent to which caregivers feel trapped as a result of their role	Pearlin et al. (1990)
Secondary Stressors: Intrapsychic Strain	Loss of Self	Assesses loss of identity due to caregiving role	Pearlin et al. (1990)

Domain	Variable	Description	Source
Depression	Center for Epidemiological Studies Depression Scale	Self-report questionnaire assessing depressive symptoms within the past week	Radloff (1977)
Social Support	ENRICHD Social Support Inventory	Questionnaire assessing perceived availability of emotional, informational, and practical support.	Mitchell et al. (2003)
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Attention	Stroop Color-Word Interference Test	Respond to color of ink that word is printed in	Stoet (2010, 2017)
Processing Speed	WAIS-IV Digit Symbol Test	Use a code legend to indicate the correct symbol underneath each digit	Weschler (2008)
Processing Speed	Pattern Comparison	Make same/different judgments of pairs of line patterns	Salthouse and Babcock (1991)
Processing Speed	Letter Comparison	Make same/different judgments of pairs of letter strings	Salthouse and Babcock (1991)
Executive Functioning	Connections	Connect circles in order (e.g., numerical order, alphabetical order, alternating between numerical and alphabetical order, and alternating between alphabetical and numerical order)	Salthouse et al. (2000)
Visuospatial Processing	Mental Rotation Task	Choose rotated stimulus that matches target stimulus	Shephard and Metzler (1971), Stoet (2010, 2017)
Implicit Memory	Word-Stem Completion Task	Phase I (study phase): Read word-list, construct visual image of each word, and rate the pleasantness of the image. Phase II (test phase): fill in word-stems	Roediger et al. (1991)

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Table 1.

Demographic characteristics for caregivers (n = 47) and controls (n = 47).

	Caregivers			*Controls*		
Sociodemographic Variable	*%*	*M*	*SD*	*%*	*M*	*SD*
Sex (Male)	46.80			46.80		
Race/Ethnicity						
Asian	2.10			2.10		
Black or African American	27.70			27.70		
Hispanic or Latino	14.90			4.30		
White	51.10			66.00		
More than one	4.60			0.00		
Highest Level of Education						
Less than a High School Degree	2.10			2.10		
High School Degree or Equivalent	14.90			14.90		
Associate Degree	12.80			12.80		
Bachelor's Degree	36.20			36.20		
Graduate Degree	27.70			27.70		
Other Advanced Degree	6.40			6.40		
Subjective Health		1.72	0.54		1.57	0.61
Marital Status						
Married	34.00			44.70		
Widowed	0.00			0.00		
Divorced	8.50			6.40		
Separated	4.30			0.00		
Not Married, but in a committed relationship	14.90			6.40		
Single	38.30			42.60		
Number of Children		0.87	1.03		1.06	1.39
Number of Grandchildren		0.21	1.03		0.29	0.83
Employment						
Employed Full-Time	44.70			34.00		
Employed Part-Time	27.70			29.80		
Unemployed	8.50			12.80		
Retired	8.50			17.00		
Other	10.60			6.40		
Perceived Stress Scale		21.00	7.50		18.42	7.47
Length of Time as a Caregiver		4.77	4.05	n/a		
One year	23.40					
Two Years	14.90					
Three Years	12.80					
Four Years	10.60					
Five Years	6.40					
Six Years	6.40					

	Caregivers			Controls		
Sociodemographic Variable	***%***	***M***	***SD***	***%***	***M***	***SD***
Seven Years	4.30					
Eight Years	6.40					
Ten Years	2.10					
Twelve Years	6.40					
Fourteen Years	2.10					
Fifteen Years	4.30					
Hours Spent Caregiving Per Week		65.82	54.87	n/a		
Use of Home Health Aide (1 = yes)	38.30			n/a		
Home Health Aide Hours Per Week		21.52	41.28			
Receives Medicaid Compensation for Caregiving	12.80			n/a		

Table 2.

Independent samples t-test results comparing caregivers and controls on cognitive outcomes (n = 94).

	Caregivers		Control participants			
	M	*SD*	*M*	*SD*	*t*-test	Cohen's *d*
Working Memory						
N-Back: 2-Back Condition						
Percentage of items wrongly reported	1.58	0.29	1.25	0.33	4.67***	1.06
Number of items correctly identified	0.93	0.31	1.17	0.17	−4.53***	−.96
Average reaction time	1403.92	334.67	1118.80	297.36	4.37	.90
N-Back: 3-Back Condition						
Percentage of items wrongly reported	1.40	0.97	1.21	0.30	2.63**	.26
Number of items correctly identified	1.05	0.22	1.18	0.09	3.71***	−.77
Average reaction time	1188.55	337.26	963.60	244.48	−3.70***	.76
Episodic Memory						
WMS-III Word-Recall Subtest (Sum of Trials 1–4)	29.25	6.56	35.51	4.51	−5.39***	−1.11
WMS-III Word-Recall Subtest Intrusions (Sum of Trials 1–4)	0.27	0.24	0.22	0.28	0.62	.19
Attention						
Stroop Test	2.12	0.24	2.01	0.37	1.71	.35
Processing Speed						
Pattern Comparison	34.17	8.59	43.45	7.08	−5.71	−1.17
Letter Comparison	23.25	6.01	29.55	5.33	−5.37	−1.11
Digit Symbol	54.76	12.38	66.23	10.65	−4.81	−.99
Executive Functioning						
Connections	0.52	0.17	0.59	0.12	−2.18***	−.47
Visuospatial Processing						
Mental Rotation: Percent correct	79.61	7.95	83.32	6.63	−2.45	−.50
Mental Rotation: Average reaction time	3.55	0.17	3.52	0.17	0.86	.17
Implicit Memory						
Word-Stem Completion Test	10.46	3.78	11.17	4.06	−0.87	−.18

* $p < .05$

** $p < .01$

*** $p < .001$.

Table 3.

ANCOVA results controlling for perceived stress (n = 94).

	Caregivers			Control participants						
Measure	***M***	***Adjusted M***	***SD***	***M***	***Adjusted M***	***SD***	***F***	***p***	***Partial Eta Squared***	***d***
Working Memory										
N-Back: 2-Back Condition										
Percentage of items wrongly reported	1.57	1.57	0.29	1.25	1.25	0.35	20.12	**0.00**	0.21	.99
Perceived Stress							0.22	0.64	0.003	
Number of items correctly identified	0.93	0.93	0.31	1.17	1.17	0.17	19.14	**0.00**	0.18	−.95
Perceived Stress							0.06	0.80	0.001	
Average reaction time	1403.92	1413.39	334.67	1118.80	1109.33	297.36	21.46	**0.00**	0.19	.96
Perceived Stress							2.84	0.09	0.03	
N-Back: 3-Back Condition										
Percentage of items wrongly reported	1.40	1.40	0.37	1.21	1.22	0.30	6.38	**0.01**	0.07	.53
Perceived Stress							0.13	0.72	0.001	
Number of items correctly identified	1.06	1.06	0.22	1.18	1.18	0.09	12.11	**0.001**	0.12	−.71
Perceived Stress							1.15	0.29	0.01	
Average reaction time	1188.55	1192.00	337.26	963.60	960.15	244.48	14.05	**0.00**	0.13	.78
Perceived Stress							0.42	0.52	0.005	
Episodic Memory										
WMS-III Word-Recall Subtest (Sum of Trials 1–4)	29.26	29.10	6.56	35.51	35.70	4.51	31.57	**0.00**	0.26	−1.17
Perceived Stress							2.46	0.12	0.03	
WMS-III Word-Recall Subtest Intrusions (Sum of Trials 1–4)	0.27	0.27	0.24	0.22	0.22	0.28	0.37	0.55	0.01	.19
Perceived Stress							0.002	0.97	0.00	
Attention										
Stroop Test	2.13	2.12	0.24	2.01	2.02	0.37	2.41	0.12	0.03	.32
Perceived Stress							0.34	0.56	0.004	
Processing Speed										
Pattern Comparison	34.17	34.33	8.59	43.45	43.30	7.09	29.60	**0.00**	0.25	−1.13
Perceived Stress							1.30	0.26	0.01	
Letter Comparison	23.26	23.23	6.01	29.55	29.60	5.33	28.15	**0.00**	0.24	−1.12

	Caregivers			Control participants						
Measure	***M***	***Adjusted M***	***SD***	***M***	***Adjusted M***	***SD***	***F***	***p***	***Partial Eta Squared***	***d***
Perceived Stress							0.05	0.82	0.001	
Digit Symbol	54.80	54.82	12.39	66.23	66.17	10.66	21.79	**0.00**	0.19	−.98
Perceived Stress							0.08	0.77	0.001	
Executive Functioning										
Connections	0.53	0.53	0.17	0.60	0.60	0.12	4.70	**0.03**	0.05	−.47
Perceived Stress							0.03	0.85	0.00	
Visuospatial Processing										
Mental Rotation: Percent Correct	79.62	79.55	7.95	83.32	83.45	6.63	6.20	**0.01**	0.06	−.53
Perceived Stress							0.23	0.63	0.003	
Mental Rotation: Average reaction time	3.55	3.55	0.17	3.52	3.51	0.17	1.32	0.25	0.01	.23
Perceived Stress							3.00	0.09	0.03	
Implicit Memory										
Word-Stem Completion Test	10.47	10.42	3.79	11.17	11.22	4.06	0.93	0.34	0.01	−.20
Corrected Model							0.58	0.56	0.01	
Perceived Stress							0.42	0.52	0.01	

d = Cohen's *d*. Bolded *p*-values indicate significance.