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Cognitive Function and Sleep in Caregivers of Persons Living with Dementia

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Abstract

Poor sleep is prevalent among caregivers of persons living with dementia and increases their risk for cognitive impairment and decline. In this cross-sectional, correlational study, we compared the cognitive function scores of caregivers with poor sleep with the demographically adjusted normed scores of the National Institutes of Health Toolbox Cognition Battery. Caregivers completed a 14-day sleep diary. On average, caregivers (n = 28) were 65.14 (±10.08) years, female, and White. Their average crystallized cognitive function composite score was significantly higher and their average fluid cognitive function composite score was significantly lower than the normative scores. Caregivers performed significantly worse on the processing speed domain measure. Poor sleep may affect how caregivers, including highly educated caregivers, process and respond to information, thus can influence how they safely perform complex caregiving tasks. Health care providers should consistently assess caregivers' sleep and cognitive abilities to promptly identify changes and provide timely interventions.

Keywords

Alzheimer's disease; Fluid cognition; Crystallized cognition; Processing speed; Sleep onset latency; Sleep duration

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More than 11 million Americans provide unpaid care to someone living with Alzheimer's disease and related dementias (Alzheimer's Association, 2020). Caregivers are often not well-prepared especially as caregiving becomes progressively becomes more demanding with time (Skufca, 2017). As a result, caregiving redirects attention and resources needed for the caregivers' to sufficiently complete self-care (Tommis et al., 2009). While recent research has supported a healthy caregiver hypothesis where caregivers have better health outcomes than their non-caregiving peers (Roth et al., 2018), the research is robust regarding caregivers being at risk for and experiencing poor cognitive, physical, psychological, and cardiovascular health outcomes (Pinquart & Sorensen, 2003; Polenick et al., 2020; Schulz & Sherwood, 2008; Vitaliano et al., 2003; Wang et al., 2014).

For the majority of caregivers of persons living with dementia (PLwD), sleep disturbance is a significant health problem (Gao et al., 2019; Peng et al., 2019). Specific caregiver sleep continuity disturbances include long sleep onset latency (SOL) and wake after sleep onset (WASO), short sleep duration, low sleep efficiency (SE), and poor sleep quality compared to non-caregivers and recommended norms (Beaudreau et al., 2008; Fonareva et al., 2011; Gao et al., 2019; Rowe et al., 2008; Smyth et al., 2020). Sleep has numerous functions including the removal of potential neurotoxic metabolites that accrue while awake (Xie et al., 2013). While adequate sleep may actively facilitate normal cognitive function, inadequate sleep increases the risk for impaired cognitive function (Bubu et al., 2017; Fernandez-Mendoza et al., 2021). Frontal brain regions are disrupted with sleep deprivation (Drummond & Brown, 2001; Thomas et al., 2000) and there are lapses in attention due to sleep loss (Durmer & Dinges, 2005). Sleep-deprived persons respond slower on response inhibition and attention tasks compared to rested individuals (Renn & Cote, 2013). Moreover, prolonged sleep debt is associated with faster cortical thinning and lower clearance of metabolites like β-amyloid and tau (Gao et al., 2019; Holth et al., 2019; Lucey et al., 2018).

Cognitive dysfunction which involves declines in either or both fluid and crystallized cognitive abilities can impact a person's ability to perform everyday tasks competently (Willis et al., 1992). Fluid abilities are independent of previous knowledge and include domains, such as executive function, attention, memory, and processing speed (Flanagan & Dixon, 2014; Nisbett et al., 2012; Weintraub et al., 2013). Executive function involves the cognitive regulation of goal-directed activity (Weintraub et al., 2013); attention is the ability to maintain focus on a task while excluding other stimuli (Weintraub et al., 2013); memory is the ability to process, manipulate, store, and retrieve information (Weintraub et al., 2013); and processing speed is either the time taken to process a set amount of information or the quantity of information processed within a certain time (Weintraub et al., 2013). Crystallized abilities are an accumulation of knowledge and skills, which includes language and vocabulary (Flanagan & Dixon, 2014; Nisbett et al., 2012; Weintraub et al., 2013). Language is a system of established symbols used to communicate and vocabulary is the verbal component of language (Weintraub et al., 2013). When specifically examining caregivers' of PLwD cognitive function, research showed that they performed poorer than non-caregivers on fluid cognitive function domain measures of working memory (Mackenzie et al., 2009) and processing speed (De Vugt et al., 2006; Oken et al., 2011; Vitaliano et al., 2009). Compared to non-caregivers, caregivers' processing speed (Vitaliano et al., 2009) and vocabulary (Vitaliano et al., 2005) decreased more rapidly over time.

Furthermore, spousal caregivers had reduced cognitive functioning, speed of information processing, and verbal memory, compared with healthy matched controls (Falzarano & Siedlecki, 2021). While O'Sullivan et al. (2019) did not find any differences between caregivers and controls on working memory, immediate and delayed recall, and executive tasks, they found that caregivers had better reaction time, processing speed, and free recall. In addition, Bertrand et al. (2012) found that full-time caregivers had better memory and processing speed than non-caregivers.

Cognitive abilities enable caregivers to respond and react in the appropriate ways to caregiving situations and impairment in these domains can affect caregivers' ability to safely perform activities of daily living, and increase the risk for worsening quality of life for both the caregiver and PLwD (Johansson et al., 2012). Cognitive abilities influence people's ability to plan, execute, manage, and organize tasks, and declines in these abilities increase the risk of making errors during tasks like medication organization and administration (Lim & Sharmeen, 2018). Low verbal memory scores were associated with a decrease in caregiver competence and an increase in patient behavioral symptoms (De Vugt et al., 2006). Further, caregivers' higher executive dysfunctions were associated with poorer judgment about functioning changes in the care recipient (Dassel & Schmitt, 2008).

While research supports the association between sleep and cognitive function in middle and older-aged adults (Brewster et al., 2015; Bubu et al., 2017; Torossian et al., 2021), there still is a paucity of research specifically examining these associations in caregivers of PLwD with poor sleep and comparing their performance with normative scores. One study with 31 caregivers of PLwD found that sleep quality measured with the Pittsburgh Sleep Quality Index appeared to mediate the relationship between caregiving and attention and executive function tasks but not recall (Oken et al., 2011). Similarly, Caswell et al. (2003) found that distress (a composite of uplifts, burden, and sleep problems) mediated the relationship between caregiver status and processing speed. However, in secondary analysis, sleep, measured with a 4-item questionnaire, was not a mediator in the relationship between caregiver stress and a test of vocabulary (Vitaliano et al., 2005). These studies used questionnaires which does not provide a daily overview of caregivers' sleep or multiple sleep continuity variables. Given that cognitive dysfunction could affect caregivers' quality of life and health care utilization, and compromise their ability to provide care for themselves and the PLwD (De Vugt et al., 2006; Vitaliano et al., 2007), it is important to investigate caregivers' cognitive function in the presence of disrupted sleep.

Purpose

The purpose of this study was to compare the cognitive function of caregivers of PLwD who had poor sleep with the age, education, gender, race/ethnicity, and educational attainment adjusted normative scale scores for attention, working memory, processing speed, episodic memory, executive function, and language of the Cognitive Battery of the National Institutes of Health Toolbox, and to identify whether there are relationships among sleep continuity variables (i.e., SOL, WASO, SE, sleep duration, and sleep quality) and the individual and composite scores of the cognitive domains. We hypothesized that caregivers would have lower cognitive function compared to the age, education, gender, race/ethnicity, and educational attainment adjusted normative scale scores on the Cognitive Battery of the National Institutes of Health Toolbox, and that SOL and WASO would be negatively correlated with the individual and composite scores of the cognitive domains, and SE, sleep duration, and sleep quality would be positively correlated with the individual and composite scores of the cognitive domains.

Methods

Design and Sample

A cross-sectional, correlational study was conducted using baseline data from a randomized, prospective study of caregivers of PLwD (Improving Dementia Caregiver Sleep & the Effect of Heart Disease Biomarkers, AG039495, PI: M. Rowe). To be included in the study, the participants had to: have met the standard criteria for poor sleep/insomnia symptoms (reported time to fall asleep and/or time awake during the night is more than 30 min on at least 3 nights/week over a 6-month period of time), speak and understand English, deny the presence of chronic illness that requires frequent treatment/assessment, not have another diagnosed sleep disorder, such as sleep apnea or restless leg syndrome, not require aids to walk in the home at night, and have a cognitive status score of more than 25 based on the Telephone Interview for Cognitive Status (Brandt et al., 1988). The caregivers were recruited from the Eastern-Florida to Mid-Florida area. All data collection was done in the homes of the participants. The University of South Florida Institutional Review Board approved the study protocol, and all respondents provided informed consent before data collection. Additional details about the study protocol have been published elsewhere (Rowe, 2012).

Measures

Sleep was assessed with a sleep diary. Cognitive function was assessed using the Cognitive Battery of the National Institutes of Health Toolbox. Demographics were also assessed using an investigator-developed questionnaire.

Sleep Diary.—Caregivers completed a 14-day sleep diary which included: number of minutes they napped the previous day, bedtime, time taken to fall asleep, number of awakenings for themselves and the care-recipients, minutes awake during the night for themselves and the care-recipients, final wake-up time, out-of-bed time, sleep quality, and medications taken for sleep (Carney et al., 2012; Schutte-Rodin et al., 2008). From the data collected, the variables used were:

- SOL is the time from intention to fall asleep to actually falling asleep. Less than 31 min SOL would be consistent with normal sleep (Ohayon et al., 2017; Schutte-Rodin et al., 2008).
- WASO is the sum of minutes awake from sleep onset to the final awakening. Less than 31 min WASO would be consistent with normal sleep (Ohayon et al., 2017).
- Time in bed (TIB) is the time from getting into bed to getting out of bed.

- Total sleep time (TST) is the TIB that the individual was actually asleep. Between 420 and 540 min of TST would be consistent with normal sleep (Watson et al., 2015).
- SE is the percentage of time the individual is asleep while actually in bed. An 85% or greater would be consistent with normal sleep (Ohayon et al., 2017).
- Sleep quality represents how caregivers rated their quality of sleep, with a range from 1 to 5 with one representing very poor sleep and five representing excellent sleep.

Cognitive Battery of the National Institutes of Health.—The cognitive battery of the National Institutes of Health (NIH) Toolbox was used to test multiple cognitive abilities (Slotkin, Kallen, et al., 2012). The test was administered on the computer and was adapted to the participant's ability level. The fluid cognition composite consists of five measures (Heaton et al., 2014; Slotkin, Kallen, et al., 2012; Weintraub et al., 2013, 2014).

- Attention was measured with the NIH Toolbox Flanker Inhibitory Control and Attention Test. The NIH Toolbox Flanker Inhibitory Control and Attention Test required the participant to focus on a given stimulus while inhibiting attention to stimuli flanking it. Sometimes the middle stimulus pointed in the same direction as the "flankers" and sometimes it pointed in the opposite direction. Scoring was based on a combination of accuracy and reaction time. Higher scores indicate better performance (Slotkin, Kallen, et al., 2012; Weintraub et al., 2013).
- Working memory was evaluated using the NIH List Sorting Working Memory Test. The NIH Toolbox List Sorting Working Memory Test required the participants to sequence different visually and orally presented stimuli. Pictures of various foods and animals were displayed with both a sound clip and written text that named the item. First, participants were required to order a series of objects (either food or animals) in size order from smallest to largest. Then, participants were presented with pictures of both food and animals, and asked to report the food in size order, followed by the animals in size order. The number of items in each series is increased from one trial to the next and the test ends when the participant fails two trials of the same length. Participants were given credit for the total number of items correctly recalled and sequenced. Higher scores indicate better performance (Slotkin, Kallen, et al., 2012; Weintraub et al., 2013).
- Episodic memory was evaluated using the NIH Toolbox Picture Sequence Memory Test. For the NIH Toolbox Picture Sequence Memory Test, the participant recalled an increasingly lengthy series of illustrated objects and activities that were presented in a particular order on the computer screen. The participants were asked to remember the sequence of pictures that were demonstrated over two learning trials. Participants were given credit for each adjacent pair of pictures they correctly placed. Higher scores indicate better performance (Slotkin, Kallen, et al., 2012; Weintraub et al., 2013).

- Executive function was assessed using the NIH Toolbox Dimensional Change Card Sort Test. For the NIH Toolbox Dimensional Change Card Sort Test, two target pictures were presented that varied along two dimensions (e.g., shape and color). Participants were then asked to match a series of test pictures. Scoring was based on a combination of accuracy and reaction time. Higher scores indicate better performance (Slotkin, Kallen, et al., 2012; Weintraub et al., 2013).
- Processing speed was assessed using the NIH Toolbox Pattern Comparison Processing Speed Test. For the NIH Toolbox Pattern Comparison Processing Speed Test which assessed processing speed abilities, participants had to decide whether two side-by-side pictures were the same or different. Participants' raw score was the number of items correct in a 90 s period. Higher scores indicate better performance (Slotkin, Kallen, et al., 2012; Weintraub et al., 2013).

The crystallized cognition composite consists of two measures (Heaton et al., 2014; Slotkin, Kallen, et al., 2012; Weintraub et al., 2013, 2014).

- The language was assessed using: vocabulary comprehension (Picture Vocabulary Test) and oral reading decoding (Oral Reading Recognition Test). For the NIH Toolbox Picture Vocabulary Test, the participants were presented with an audio recording of a word and four photographic images on the computer screen and asked to select the picture that most closely matched the meaning of the word. In the NIH Toolbox Reading Recognition Test, the participants were asked to read and pronounce letters and words as accurately as possible. The test administrator scored them as right or wrong. Items for both tests are administered by computer adaptive testing. Higher scores indicate better performance (Slotkin, Kallen, et al., 2012; Weintraub et al., 2013).

In this study, we used the demographically adjusted scale score. This score was automatically calculated and provided through the NIH Toolbox platform. It compares the score of the caregiver to the scores of the participants in the NIH Toolbox nationally representative normative sample while adjusting for key demographic variables, age, gender, race (white, black, and other), ethnicity (Hispanic versus non-Hispanic), and educational attainment, collected during the Toolbox national norming study (Slotkin, Kallen, et al., 2012; Slotkin, Nowinski, et al., 2012).

Demographics.—Baseline data included gender, race, age, marital status, years of education, employment status, and relationship to the person with dementia.

Data Analyses

Data were analyzed with SPSS version 26 (Chicago, IL, USA). Descriptive statistics were conducted to describe the sample characteristics and the study variables. One sample t-test with effect sizes was used to compare the means of the caregivers on each of the fluid and crystallized cognitive domains, and the fluid, crystallized, and total cognitive function composites with the normative means adjusted for age, education, gender, race/ethnicity, and educational attainment. We also conducted bivariate correlations between the sleep continuity variables and the cognitive function outcomes.

Results

The sample included 28 caregivers. The mean age of the sample was 65.14 years (*SD* ± 10.08 years; range 44–83 years) with 15.14 (±2.53) years of education. Most were Caucasian and women. Most of the caregivers were wives or adult daughters caring for a person living with dementia with an average age of 80.21 (±7.51) years (Table 1). Caregivers had poor sleep as per the recruitment criteria with less than 7 h of sleep per night. They also had high amounts of wake after sleep onset, and lower than recommended sleep efficiency (Table 2).

For the total cognition composite, results of the one-sample t-test indicated that there were no significant differences between caregivers' scores and the normed scores ($t(27) = 0.91$, $p = .373$, Cohen's $d = 0.17$). However, for the crystallized and the fluid cognitive function composites, there were significant differences between the caregivers' scores and the norms (crystallized $t(27) = 4.20$, $p < .001$, Cohen's $d = 0.79$; fluid: $t(27) = -4.59$, $p < .001$, Cohen's $d = 0.87$) suggesting the caregivers performed significantly better than the norms on the crystallized composite tests and poorer than the norms on the fluid composite tests both with medium to large effect sizes (Table 3).

Comparing the specific tests for the crystallized cognitive domain, results of the one-sample t-test indicated that there were significant differences between caregivers' scores and the norms on the language domain tests (Picture Vocabulary: $t(27) = 2.70$, $p = .012$, Cohen's $d = 0.51$; Oral Reading: $t(27) = 4.54$, $p < .001$, Cohen's $d = 0.86$), implying that caregivers' had significantly higher scores than the norms on each of these language tests with a large effect size. On the fluid domain tests, results of the one-sample t-test indicated that there were significant differences between caregivers' scores and the norms on the processing speed domain (pattern comparison test: ($t(27) = -6.01$, $p = .001$, Cohen's $d = -1.14$) suggesting that caregivers performed significantly worse than the norms on this test of processing speed with a large effect size. While there were no significant differences between the norms and caregivers' episodic memory, executive function, working memory, and attention scores, there was a trend toward significance for the attention (Flanker: $t(27) = -1.91$, $p = .067$, Cohen's $d = -0.36$) and working memory (List Sort: $t(27) = 1.94$, $p = .062$, Cohen's $d = 0.37$) domains (Table 3).

Neither SOL, wake after sleep onset, time in bed, total sleep time, sleep efficiency nor sleep quality was significantly correlated with total cognitive function. We also did not observe any significant correlations between the sleep variables and the domains or composites of fluid and crystallized cognition.

Discussion

This study aimed to compare fluid and crystallized cognitive function (total and specific domains) between caregivers of PLwD with poor sleep and demographically adjusted population normative scale scores of the Cognitive Battery of the National Institutes of Health Toolbox, and examine bivariate correlations between sleep continuity and cognitive function variables. The results partially supported our hypotheses. We found that the scores of caregivers with poor sleep were significantly better than the demographically adjusted normative scores of the crystallized cognition composite and domain-specific tests. On the other hand, caregivers with poor sleep had significantly lower scores than the demographically adjusted normative scores of the fluid cognition composite; in particular, they performed significantly worse on the processing speed test. There was no correlation between the sleep continuity variables and the cognitive domains.

Our results pertaining to the crystallized composite were different from the study by Vitaliano et al. (2005) which reported that caregivers had lower scores than non-caregivers on a test of crystallized cognition. Crystallized cognition is associated with learning and knowledge over the lifetime, and continues to improve into late adulthood (Cattell, 1943). Our sample was highly educated with an average of 15 years of education, which could explain the significantly higher crystallized cognition scores. As it pertains to fluid cognitive function, our results were similar to studies that reported caregivers of PLwD having lower fluid cognition scores compared to non-caregivers (Falzarano & Siedlecki, 2021; Mallya & Fiocco, 2017), but different from Jütten et al. (2019) who found caregivers performed similarly to non-caregivers on fluid cognitive domain tests.

While, on average, caregivers reported spending at least 8 h in bed, they averaged about 6.5 h of sleep duration. Short sleep and chronic sleep loss contribute to sleep debt and increase the risk for caregivers to experience the cumulative effects of partial sleep deprivation, such as deficits and impairment in cognitive function (Jarraya et al., 2013; Scott et al., 2006; Van Dongen et al., 2003). A recent meta-analysis revealed that sleepers with less than 7 h sleep duration had a significantly increased relative risk of cognitive impairment and preclinical Alzheimer's disease (Bubu et al., 2017). Burke et al. (2018) found that individuals who experienced sleep disturbance had a 1.39 times higher risk of developing mild cognitive impairment compared to individuals without sleep disturbance. Poor sleepers also have cortical thinning in areas of their brains associated with mild cognitive impairment (Torossian et al., 2021). Furthermore, sleep problems affect the frontal cortex, which predominantly controls fluid cognitive tasks (Bugg et al., 2006), and in one study, fluid cognitive task scores predicted everyday function (Dassel & Schmitt, 2008). Moreover, performance in tests of processing speed predicted execution of tasks like medication management and independent completion of activities of daily living (Bertrand et al., 2012; Vitaliano et al., 2009) and executive function skills like problem-solving, attention, sequencing, and cognitive flexibility could influence the accuracy of subjectively reported activities of daily living (Dassel & Schmitt, 2008). Therefore, it is important to assess caregivers consistently for poor sleep patterns and intervene initially with non-pharmacological interventions like cognitive behavioral therapy for insomnia. Early intervention to improve poor sleep may protect their cognitive health and enable them to perform their caregiving tasks safely.

The lack of correlation between the sleep continuity and cognition variables could be due to all the caregivers having poor sleep and the study having a small sample (Hackshaw, 2008). Future research should examine sleep and cognitive function in caregivers across a continuum from good to poor sleep. While we did not assess napping in this study, future research should also consider examining napping as a sleep variable that could be associated with cognitive function. Objective and subjective sleep measures are not often congruent (Rowe et al., 2008; Torossian et al., 2021); therefore, it may be useful to examine whether the outcomes would be similar using objective sleep measures. Moreover, we did not assess the length of time caregivers had sleep disturbance or their sleep disturbance relative to when they began providing care. These factors may play a role in further understanding caregiver risk for poor sleep and worsening cognitive function. Future research with caregivers of PLwD should utilize larger sample sizes, and examine the relationship between sleep and cognitive function accounting for duration of sleep disturbance relative to the start of caregiving, and comparing caregivers with and without sleep disturbance.

In addition to the limitations mentioned above, the Cognitive Battery of the National Institutes of Health Toolbox is brief and does not test all the domains of cognition, however, it allows for the efficient assessment of the main aspects of cognition (Bauer & Zelazo, 2014). The test is a computer-adaptive test, and caregivers who may not be adept at using the computer may be intimidated; this may adversely affect their score. However, there are practice sections before the actual test so that the participant will understand how to perform the test. Few minority participants and sleep disparity issues related to factors, such as race and place of residence are also limitations. We also did not account for other variables, such as caregiver health conditions, medications, and employment status. Future studies should seek to recruit a more heterogeneous sample to increase the generalizability of the results and examine whether there are racial/ethnic differences in the cognitive outcomes.

In conclusion, this study highlights that caregivers with poor sleep had lower scores than normative scores on fluid cognitive function tests, with these lower scores occurring even among highly educated caregivers. Fluid cognition domains, like processing speed, predict a person’s ability to perform activities of daily living, execute cognitively complex tasks like medication management, and care for themselves and the PLwD (Bertrand et al., 2012; Vitaliano et al., 2009). Most caregivers support and care for the PLwD for many years (Alzheimer’s Association, 2020). The quality of life of both the PLwD and caregiver, and the ability to provide care at home depends upon the ability of the caregiver to adequately adapt and respond to the problems and needs of the patient (De Vugt et al., 2006). Effective care strategies depend on the cognitive abilities of the caregiver and given the complex and changing demands in the caregiving situation, suboptimal cognitive functioning, and poor sleep may affect daily caregiver functioning. Since many caregivers have sleep disturbance, and are at risk for poorer fluid cognitive function, health care practitioners should assess these elements in caregivers at the initial visit and on an ongoing basis in order to promptly identify changes and provide timely interventions.

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Table 1.

Sample Demographics.

Variables	N (%)
Caregiver	
Sex	
Male	5 (17.9)
Female	23 (82.1)
Race	
Caucasian	22 (78.6)
African-American	4 (14.3)
Ethnicity	
Hispanic	2 (7.1)
Relation to care recipient	
Spouse	14 (50)
Child	13 (46.4)
Other	1 (3.6)
Employment status	
Currently employed	8 (28.6)
Not currently employed	20 (71.4)
Care recipient	
Diagnoses	
Alzheimer’s disease	20 (71.4)
Vascular	4 (14.3)
Other	4 (14.3)

Table 2.

Sleep Continuity Means and Norms.

Sleep Continuity Variable	Mean (*SD*)	Norms[1]
Sleep onset latency	34.93 (20.56)	Less than 31 min
Wake after sleep onset	43.77 (25.13)	Less than 31 min
Time in bed	500.35 (45.24)	—
Total sleep time	395.94 (44.66)	420–540 min
Sleep efficiency	79.13 (6.78)	More than 85%
Sleep quality	3.03 (.51)	—

[1] The norms are based on the National Sleep Foundation and the American Academy of Sleep Medicine recommendations.

Table 3.

Means, Norms, and t-Test Values of Cognitive Function Domains and Composites.

Cognition	Normative Scale Scores[1]	Mean (*SD*)	99% CI (Lower, Upper)	*t*	Sig (2-Tailed)	Cohen's *d*
Total cognition composite	99.21	102.05 (16.56)	(−3.58, 9.26)	0.91	0.373	0.17
Fluid cognition composite	100.40	93.21 (8.28)	(−10.40, −3.97)	−4.59	<0.001	0.87
Crystallized cognition composite	98.21	112.81 (18.38)	(7.47, 21.73)	4.20	<0.001	0.79
Picture vocabulary (language)	100.06	108.36 (16.27)	(1.99, 14.61)	2.70	0.012	0.51
Flanker (attention)	99.34	95.84 (9.68)	(−7.35, 0.26)	−1.91	0.067	−0.36
List sorting (working memory)	99.46	103.90 (12.08)	(−0.25, 9.12)	1.94	0.062	0.37
Card sorting (executive function)	98.56	96.55 (10.83)	(−6.21, 2.19)	−0.98	0.334	−0.19
Pattern comparison (processing speed)	99.30	85.94 (11.76)	(−17.91, −8.80)	−6.01	0.001	−1.14
Picture sequence (Episodic memory)	100.34	99.73 (10.08)	(−4.52, 3.30)	−0.32	0.752	−0.06
Oral reading (language)	99.73	111.81 (14.06)	(6.62, 17.53)	4.54	<0.001	0.86

[1] The normative scale scores are the computerized scores for the Cognitive Battery of the National Institutes of Health Toolbox which automatically adjusts for age, gender, race (white, black, and other), ethnicity (Hispanic versus non-Hispanic), and educational attainment.