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Cognition and Functional Capacity: An Initial Comparison of Veteran and Non-Veteran Older Adults

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ABSTRACT

Introduction:

The U.S. Military Veterans aged 65 and older comprise an estimated 43% of the 22 million living Veterans in the United States. Veterans have high rates of physical, psychiatric, and social challenges, but it is not known whether Veteran status confers additional risk for cognitive or functional impairments in later life. Thus, this investigation specifically compared older Veterans with their non-Veteran peers in cognitive functioning and performance-based functional capacity.

Materials and Methods:

Participants ($N = 110$; 29 Veterans and 81 non-Veterans) were part of a larger longitudinal study on biopsychosocial functioning in independently living older adult residents of a Continuing Care Senior Housing Community. The University of California San Diego Institutional Review Board approved the study and all participants provided written informed consent. Participants provided demographic and mental health information and were administered a comprehensive neuropsychological battery. Functional capacity was assessed using the UCSD Performance-Based Skills Assessment-Brief (UPSA-B), which uses financial and communication role-plays to assess everyday functioning skills. Neuropsychological scores were appropriately normed prior to analysis. Multivariate Analyses of Variances with post hoc *t*-tests and an Analysis of Covariance were used to examine neuropsychological and functional capacity differences, respectively, between Veterans and non-Veterans.

Results:

Veterans did not differ from non-Veterans in educational attainment (16.4 years versus 15.5 years, $P = 0.110$), but they were significantly older (mean age 86.9 years $\pm$ 5.7, versus 81.74 years $\pm$ 6.53; $P < 0.001$) and were more likely to be male (X^2 [1, $N = 110$] = 62.39, $P < 0.001$). Thus, though neuropsychological norms already accounted for demographic differences in our participants, age and sex were controlled in the Analysis of Covariance predicting UPSA-B score from Veteran status. Results suggested that, compared to non-Veterans, Veterans had significantly worse performance in the list learning portion of a test of verbal memory (Hopkins Verbal Learning Test-Revised, Total Recall; $t = 2.56$, $P = 0.012$, $d = 0.56$). Veterans and non-Veterans did not significantly differ in performance on the delayed recall portion of the verbal learning test and did not differ on a cognitive screening test (Montreal Cognitive Assessment) or on measures of premorbid intellectual functioning (Wide Range Achievement Test-4 Reading), language (Boston Naming Test, Verbal Fluency), visual memory (Brief Visuospatial Memory Test-Revised), attention/working memory (WAIS-IV Digit Span), processing speed (WAIS-IV Digit Symbol Coding), executive function (Delis-Kaplan Executive Function System Trails and Color-Word Test), or functional capacity (UPSA-B). Because our examination of multiple outcomes might have inflated Type I error, we performed a post hoc adjustment of *P* values using Benjamini-Hochberg procedures and the group difference in verbal learning remained significant.

Conclusions:

Despite largely similar function in most domains, Veterans performed significantly more poorly in verbal list learning than their non-Veteran peers. Additional attention should be given to the understanding, assessment, and possible treatment of learning and memory differences in older Veterans, as this may be an area in which Veteran status confers additional risk or vulnerability to decline. This is the first study to compare objective neuropsychological and functional performance between older (age 65+) US Veterans and non-Veterans.

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The views expressed in these materials are those of the authors and do not reflect the official policy or position of the U.S. Government, the Department of Defense, or the Department of the Army.

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INTRODUCTION

Cognitive and functional changes are well documented in aging populations and can occur for a variety of modifiable and non-modifiable reasons such as changes in the central nervous system, medical and psychiatric conditions, substance use, and more.[1,2] Separately, a history of military service is associated with many conditions[3] that may adversely affect cognition. For example, compared to the general population, U.S. Veterans have higher rates of traumatic brain injury (TBI), depression, post-traumatic stress disorder (PTSD), substance use, and cerebrovascular risk factors (e.g., hypertension, hyperlipidemia, diabetes, obesity, tobacco use),[4–6] all of which could contribute to poor cognitive health in later life. For these reasons, in addition to other possible interactive factors (e.g., demographic differences in race and education in Veterans; level of premorbid functioning; deployment; combat exposure, toxin exposure; sleep),[7,8] it is highly plausible that older Veterans have poorer cognitive health and function in later life than older non-Veterans. To our knowledge, however, the 2 groups have never been formally compared in these domains.

Veterans aged 65 and older are an important group to study because they comprise approximately 50% of the estimated 17.5 million living Veterans in the United States.[9] As Vietnam-era Veterans of the Baby Boomer generation continue to age, the number of Veterans with cognitive impairment is expected to continue to rise.[10] Knowledge of cognitive or functional patterns of change in Veterans could help orient providers to screen for these changes and inform treatment planning.

The purpose of this exploratory investigation was to compare older, independently living Veterans with their non-Veteran peers in performance on a variety of neuropsychological tests and a performance-based measure of functional capacity. Data were collected from residents of a continuing care senior housing community (CCSHC). For the reasons described above, we expected that Veterans on the whole would be a more cognitively and functionally vulnerable group. We did not have *a priori* hypotheses regarding specific cognitive tests or areas of weakness.

METHODS

Participants

Participants were 110 older adults (29 Veterans and 81 non-Veterans) who were recruited as part of a larger longitudinal study on biopsychosocial functioning in residents of a CCSHC in San Diego County, CA. All 110 participants resided in the independent living sector of the community. Inclusion criteria were the following: (a) English-speaking, (b) aged 65 or older, (c) ability to complete written informed consent and study assessments, and (d) no known diagnosis of dementia or any other serious medical illness that would prevent participation in the entire study. Sample characteristics can be found in Table I.

PROCEDURES

The University of California San Diego Institutional Review Board approved the study and all participants provided written informed consent. Participants provided demographic and mental health information and were administered a comprehensive neuropsychological battery.

Measures

Neuropsychological performance

We administered the Wide Range Achievement Test, 4th edition (WRAT-4)[11] as an estimate of premorbid intellectual functioning and the Montreal Cognitive Assessment

TABLE I. Sample Characteristics

	Non-Veterans (n = 81)			Veterans (n = 29)					
Demographics	***n***	**Mean or %**	**SD**	***n***	**Mean or %**	**SD**	***t* or X^2**	***df***	***P***
Age	81	81.74	6.53	29	86.93	5.69	−3.79	108	**<0.001**
Sex							62.39	1	**<0.001**
Female	71	97%		2	3%				
Male	10	27%		27	73%				
Education (years)	81	15.57	2.49	29	16.41	2.23	−1.61	108	0.11
Self-reported race							1.88	1	0.17
White	71	72%		28	28%				
Non-white	10	91%		1	9%				
Self-reported ethnicity							0.73	1	0.40
Hispanic or Latino/a/x	2	100%		0	0%				
Non-Hispanic or Latino/a/x	79	73%		29	27%				
Marital status							2.49	1	0.11
Married/Cohabitating	31	66%		16	34%				
Single	50	79%		13	21%				
MoCA	81	23.81	3.39	29	23.34	3.74	0.61	105	0.54
WRAT-4 (standard score)	81	109.54	11.72	29	111.83	12.67	−0.88	108	0.38

Abbreviations: MoCA = Montreal Cognitive Assessment; WRAT-4= Wide Range Achievement Test, 4th edition.

(MoCA)[12] as a cognitive screening test. The Wechsler Adult Intelligence Scale, 4th edition (WAIS-IV)[13] Digit Span subtest and Delis-Kaplan Executive Function System (D-KEFS)[14] Visual Scanning subtest assessed attention and working memory.

The Boston Naming Test (BNT)[15] and the Letter Fluency (FAS) and Animal Fluency tests assessed language.[16] The Hopkins Verbal Learning Test-Revised (HVLT-R)[17] and Brief Visuospatial Memory Test-Revised (BVMT-R)[18] assessed verbal and visual learning and memory, respectively. The WAIS-IV Coding subtest and the D-KEFS Number Sequencing, Letter Sequencing, Color Naming, and Word Reading subtests assessed processing speed. The D-KEFS Letter-Number Switching, Color-Word Interference-Inhibition, and Color-Word Interference-Inhibition/Switching subtests assessed executive functioning. Neuropsychological scores were appropriately normed prior to analysis to account for demographic differences between participants.

Functional capacity

The UCSD Performance-based Skills Assessment–Brief (UPSA-B) was administered as a measure of objective performance-based functional capacity.[19] The UPSA-B uses role-play scenarios to demonstrate everyday functioning skills in 2 domains: finance and communication. Total scores on the UPSA-B range from 0 to 100, with higher scores indicating better performance.

Physical and emotional health

Given the known associations between physical and mental health and cognitive performance, we also included available measurements of participants' emotional functioning, sleep, and physical functioning. These included the Brief Symptom Inventory (BSI) Anxiety Scale[20]; the Perceived Stress Scale (PSS)[21]; the Patient Health Questionnaire-9 item questionnaire (PHQ-9)[22] assessing depressive symptom severity; the 36-Item Short Form Survey (SF-36),[23] including Mental and Physical Functioning indices of health status; the Pittsburgh Sleep Quality Index (PSQI)[24]; and the Cumulative Illness Rating Scale for Geriatrics (CIRS)[25] as an index of total illness burden. Participants' Body Mass Index (BMI), waist-to-hip ratio, and systolic and diastolic blood pressure were also assessed.

Statistical Analyses

Examination of differences in neuropsychological performance

To determine whether Veterans differed from non-Veterans in cognitive function, a total of 6 Multivariate Analyses of Variance (MANOVAs) were computed. For each MANOVA, Veteran status was entered as the one independent categorical variable and demographically adjusted cognitive scores within a domain were the dependent variables. Dependent variables were in the domains of Attention/Working Memory, Language, Verbal Memory, Visual Memory, Processing Speed, and Executive Function (see Table II). Each dependent variable was normally distributed and dependent variables were highly correlated. Assumptions regarding homogeneity of variance were met (Levene's Test of Equality of Variance and Box's M Test). Because our examination of multiple outcomes might have inflated Type I error, we calculated adjusted significance thresholds for each comparison, using Benjamini-Hochberg procedures with a false discovery rate of 0.05. In the case of a significant omnibus test, post-hoc independent samples *t*-tests and Cohen's *d* values were computed to better quantify group-based differences in performance on specific tests.

Examination of differences in functional performance

To evaluate whether Veterans differed from non-Veterans in performance-based functional capacity, we ran an Analysis of Covariance (ANCOVA). The dependent variable was total UPSA-B performance, and the primary independent variable was Veteran status. Covariates were age and sex. All testing assumptions were met.

"To explore potential group differences that could explain cognitive or functional differences," we compared Veterans and non-Veterans in our sample on available measures of emotional functioning, sleep, and physical functioning. ANCOVAs were computed with each health-related factor as the dependent variable, Veteran status as the primary independent variable, and the covariates of age and sex.

RESULTS

Demographically, Veterans did not differ from non-Veterans in educational attainment (16.4 years versus 15.5 years), but they were significantly older (mean age 86.9 years $\pm$ 5.7, versus 81.7 years $\pm$ 6.5; $P < 0.001$) and were more likely to be men (X^2 [1, $N = 110$] = 62.39, $P < 0.001$).

Examination of Differences in Neuropsychological Performance

Using the Benjamini-Hochberg adjusted significance levels that account for multiple comparisons, the overall MANOVAs revealed a significant main effect for Veteran status on verbal memory (F[2, 106.0] = 5.12, $P < 0.01$, $\eta_p^2 = 0.09$, a medium effect). Post-hoc *t*-tests suggested that, compared to non-Veterans, Veterans had significantly worse performance in immediate verbal list learning (HVLT-R, Total Recall; t = 2.56, $P = 0.01$, Cohen's $d = 0.56$, a medium effect). There was no significant difference between groups in delayed recall/retention of verbal information (HVLT-R, Retention %; t = –0.09, $P = 0.93$, $d = -0.02$). The other 5 MANOVAs revealed no significant effects of Veteran status on attention/working memory, language, visual memory, processing speed, or executive function. Differences between groups are listed in Table II.

TABLE II. Cognitive and Functional Performance in non-Veterans and Veterans

		Non-Veterans ($n = 81$)		Veterans ($n = 29$)					
Cognitive domain	**Tests in domain**	**Mean or %**	**SD**	**Mean or %**	**SD**	***df***	***F* or *t***	η_p^2 **or *d***	***P***
Attention/Working Memory						2,104	$F = 0.92$	$\eta_p^2 = 0.02$	0.40
	WAIS-IV Digit Span Total Scaled Score	10.31	2.59	10.93	3.09				
	D-KEFS Visual Scanning Scaled Score	11.21	2.59	10.89	3.07				
Language						3,106	$F = 2.43$	$\eta_p^2 = 0.06$	0.07
	Boston Naming Test T-Score	53.09	11.57	56.9	12.61				
	D-KEFS Letter Fluency (FAS) Total T-Score	44.99	8.86	44.86	9.14				
	D-KEFS Animal Fluency T-Score	47.52	10.88	43.59	11.81				
Verbal Learning/Memory						**2,106**	$\mathbf{F = 5.12}$	$\mathbf{\eta_p^2 = 0.09}$	**<0.01**
	HVLT-R Total Recall T-score	47.68	10.24	42.01	9.74		$\mathbf{t = 2.56}$	$\mathbf{d = 0.56}$	**0.01**
	HVLT-R Norms, Retention % T-score	42.17	16.23	42.47	13.58		$t = -0.09$	$d = -0.02$	0.93
Visual Learning/Memory						2,103	$F = 0.32$	$\eta_p^2 = 0.01$	0.73
	BVMT-R Total Recall T-Score	41.60	12.3	39.36	16.35				
	BVMT-R Delayed Recall T-Score	43.36	12.66	41.7	16.57				
Processing speed						5,99	$F = 1.68$	$\eta_p^2 = 0.08$	0.15
	WAIS-IV Digit Symbol Coding Scaled Score	13.38	3.25	12.39	2.78				
	D-KEFS Number Sequencing Completion Time Scaled Score	11.24	3.17	11.14	3.39				
	D-KEFS Letter Sequencing Scaled Score	11.09	2.92	10.90	3.44				
	D-KEFS Color Naming Scaled Score	9.95	3.15	10.54	2.80				
	D-KEFS Word Reading Scaled Score	10.33	2.47	9.89	2.41				
Executive function						3,100	$F = 1.14$	$\eta_p^2 = 0.04$	0.27
	D-KEFS Letter-Number Switching Completion Time Scaled Score	10.25	3.86	9.96	3.94				
	D-KEFS—Color Word Interference—Inhibition Scaled Score	10.85	3.02	10.56	3.80				
	D-KEFS—Color Word Interference—Inhibition/Switching Scaled Score	10.49	3.58	11.33	2.77				
Functional capacity									
	UPSA-B Total Score	75.50	12.32	74.57	13.90	1,105	$F = 3.85$	$\eta_p^2 = 0.04$	0.052

Abbreviations: BVMT-R= Brief Visuospatial Memory Test-Revised; D-KEFS = Delis-Kaplan Executive Function System; HVLT-R= Hopkins Verbal Learning Test-Revised; UPSA-B = UCSD Performance-based Skills Assessment- Brief; WAIS-IV= Wechsler Adult Intelligence Scale, 4th edition.

TABLE III. Comparison of Veteran and non-Veteran Emotional Functioning, Sleep, and Physical Functioning

	Non-Veterans ($n=81$)		Veterans ($n=29$)					
Measure	Mean or %	SD	Mean or %	SD	*df*	*F* or *t*	η_p^2	*P*
BSI Anxiety Scale	1.84	3.53	1.75	1.94	1,98	0.01	0.00	0.91
PHQ9 Severity Score	2.94	4.17	3.59	3.91	1,94	0.71	0.01	0.40
Perceived Stress Scale	11.9	5.81	13.23	5.11	1,93	0.48	0.01	0.49
SF-36 mental component	54.29	9.50	53.69	8.55	1,97	0.03	0.00	0.87
SF-36 physical component	40.71	11.03	41.30	11.08	1,97	2.22	0.02	0.14
PSQI Total Score	6.06	3.73	5.13	2.39	1,60	1.24	0.02	0.27
BMI	27.69	5.50	28.68	4.42	1,104	0.14	0.00	0.71
Waist-to-Hip Ratio	0.89	0.08	0.98	0.10	1,102	0.03	0.00	0.85
Systolic Blood Pressure	135.15	15.13	135.96	16.84	1,102	0.48	0.01	0.49
Diastolic Blood Pressure	74.58	8.84	76.25	10.19	1,102	0.39	0.00	0.53
CIRS—Total Severity Score	8.67	3.40	9.00	3.93	1,103	1.10	0.01	0.30

Abbreviations: BMI = Body Mass Index; BSI= Brief Symptom Inventory; CIRS = Cumulative Illness Rating Scale for Geriatrics; PHQ = Patient Health Questionnaire; PSQI = Pittsburgh Sleep Quality Index; SF-36 = 36-Item Short Form Survey.

Examination of Differences in Functional Performance

After controlling for age and sex in an ANCOVA, there was a small, non-significant effect of Veteran status on performance-based functional capacity ($F[1, 105] = 3.85$, $P = 0.052$, small $\eta_p^2 = 0.04$). Veterans had slightly poorer UPSA-B total scores than non-Veterans (1 point difference; 75.50 ± 12.32 versus 74.57 ± 13.90, respectively).

As a final step, we probed for health-related differences between Veterans and non-Veterans that might help explain the differences in HVLT-R verbal list learning described above. Veterans and non-Veterans did not significantly differ in the areas of emotional functioning, sleep, or physical functioning (all *P*-values >0.27; η_p^2 range = 0.00–0.02; see Table III).

DISCUSSION

To our knowledge, this is the first study to directly compare older US Veterans and non-Veterans in the areas of neuropsychological performance and performance-based functional capacity. Limited differences were found between the 2 groups, but one significant finding was that Veterans performed more poorly on verbal list learning than their non-Veteran peers. This indication of slightly worse list learning on a memory test, in the context of generally similar performances in other domains, suggests that learning and memory should be further explored in research on aging Veterans.

It is unclear why verbal learning/memory was selectively worse among Veterans compared to other cognitive domains. Early changes in verbal learning are common in healthy older adults and are predictive of later cognitive decline.[26–29] It is well established that military service can impact multiple dimensions of health and wellbeing, including cerebrovascular risk and psychiatric functioning,[5] both of which could theoretically underlie changes in learning and memory. Although we had limited information about participant health, we did not observe between-group differences in BMI, blood pressure, sleep, or illness burden to explain performance differences in list learning. There were also no differences in measured emotional functioning (e.g., anxiety, depression, perceived stress) that would explain our findings. However, we did not assess PTSD specifically, and accumulating data have linked PTSD to accelerated cognitive aging in Veterans and non-Veterans, with one explanation centering on the damaging effect of chronic stress on brain structures that underlie learning and memory.[30–33] Future studies would benefit from further characterization of PTSD and other mental health conditions in older Veterans.

The current sample is additionally limited in its characterization as primarily White and highly educated, thereby limiting the generalizability of the findings to the larger more racially and socioeconomically diverse older adult and/or Veteran population in the United States. It is also limited to a single facility, which may also limit generalizability. Because the sample was on average over 80 years old, we cannot rule out survivor effects. We also did not quantify duration or exposures of military service, which would be important to understand the impact of military service on cognitive health. It is also limited by its cross-sectional design; a subsequent longitudinal study will evaluate patterns of change between Veterans and non-Veterans over time. Nevertheless, this is one of the few studies to specifically focus on older Veterans who are several decades past military service, and to our knowledge is the only study to directly compare older US Veterans to non-Veterans in cognition or functional capacity. This group is important to continue to follow because as Vietnam-era Veterans continue to age, the number of older Veterans seeking treatment for cognitive difficulties is expected to continue to rise.[3]

Because late life is a time of risk for memory decline, future research should consider additional focus on neuropsychological assessment and treatment needs for aging

Veterans. Future investigations should consider long-term neuropsychological changes in the older Veteran population, particularly in the areas of learning and memory. It is valuable to continue to analyze military-service-based differences in later life to identify risk factors and relevant treatment targets that might prolong cognitive health and functional independence for our nation's Veterans.

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CLINICAL TRIAL REGISTRATION

Not applicable.

INSTITUTIONAL REVIEW BOARD (HUMAN SUBJECTS)

The UCSD Human Research Protections Program (IRB #170466) provided approval for this research.

INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE

Not applicable.

INDIVIDUAL AUTHOR CONTRIBUTION STATEMENT

JEM contributed to conceptualization, data curation, data analysis, and writing of the original draft. CAD, EEL, HCK, and AVK assisted with writing and revising of the original draft. DVJ contributed to conceptualization, methodology, investigation, writing (review and editing), project administration, and funding acquisition. EWT contributed to conceptualization, methodology, investigation, writing (review and editing), supervision, and project administration. All authors read and approved the final manuscript.

INSTITUTIONAL CLEARANCE

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CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY

The data that support the findings of this study are available on request from Dr Elizabeth Twamley, the senior author.

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