Journal of Racial and Ethnic Health Disparities (2019) 6:851–860
https://doi.org/10.1007/s40615-019-00584-x

Multiple Influences on Cognitive Function Among Urban-Dwelling African Americans

R. S. Wright[1] · S. R. Waldstein[2,3] · C. S. Gerassimakis[4] · M. R. Sprung[2] · D. L. Beatty Moody[2] · A. D. Taylor[2] · E. Al'Najjar[2] · J. M. McNeely[2] · Z. Zhang[5] · M. K. Evans[6] · A. B. Zonderman[6]

Received: 10 January 2019 / Revised: 14 March 2019 / Accepted: 18 March 2019 / Published online: 26 March 2019

Abstract

This study examined multiple influences on cognitive function among African Americans, including education, literacy, poverty status, substance use, depressive symptoms, and cardiovascular disease (CVD) risk factors. Baseline data were analyzed from the Healthy Aging in Neighborhoods of Diversity across the Life Span (HANDLS) study. Participants were 987 African Americans (mean age 48.5 years, SD = 9.17) who completed cognitive measures assessing verbal learning and memory, nonverbal memory, working memory, verbal fluency, perceptuo-motor speed, attention, and cognitive flexibility. Using preplanned hierarchical regression, cognitive performance was regressed on the following: (1) age, sex, education, poverty status; (2) literacy; (3) cigarette smoking, illicit substance use; (4) depressive symptoms; and (5) number of CVD risk factors. Results indicated that literacy eliminated the influence of education and poverty status in select instances, but added predictive utility in others. In fully adjusted models, results showed that literacy was the most important influence on cognitive performance across all cognitive domains ($p < .001$); however, education and poverty status were related to attention and cognitive flexibility. Depressive symptoms and substance use were significant predictors of multiple cognitive outcomes, and CVD risk factors were not associated with cognitive performance. Overall, findings underscore the need to develop cognitive supports for individuals with low literacy, educational attainment, and income, and the importance of treating depressive symptoms and thoroughly examining the role of substance use in this population.

Keywords Cognitive performance · Literacy · Dementia · African Americans · Poverty status · Education

Introduction

Cognitive function is an important predictor of functional independence and quality of life [1]. Cognitive dysfunction may emerge as early as middle age and predict future cognitive decline [2]. African Americans, in particular, are believed to be among the most vulnerable to cognitive dysfunction due, at least in part, to high rates of cardiovascular disease (CVD), impaired metabolic and vascular function, and related psychosocial and socio-demographic risk factors that both promote and interact with poor health [3, 4]. Multiple investigations have utilized between-group comparisons to contrast the cognitive performance of African Americans with the majority population, ignoring potential important knowledge gleaned from within-group analysis [5]. Indeed, surprisingly, few investigations have thoroughly examined sources of variability in cognitive performance among African Americans.

Existing explanatory models of cognitive function in the general population have focused on several primary influences including, but not limited to, socioeconomic indicators

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s40615-019-00584-x) contains supplementary material, which is available to authorized users.

✉ R. S. Wright
rsims@udel.edu

[1] School of Nursing, University of Delaware, Newark, DE, USA

[2] Department of Psychology, University of Maryland Baltimore County, Baltimore, MD, USA

[3] Geriatric Research Education & Clinical Center, Baltimore Veterans Affairs Medical Center, Baltimore, MD, USA

[4] Department of Behavioral Health and Nutrition, University of Delaware, Newark, DE, USA

[5] Christiana Care Value Institute, Newark, DE, USA

[6] Laboratory of Epidemiology and Population Sciences, National Institute on Aging Intramural Research Program, National Institutes of Health, Baltimore, MD, USA

such as educational attainment, literacy, poverty status, substance use, depression, and CVD risk factors and related chronic conditions [6–12]. In a comprehensive approach, Glymour and Manly posited that cognitive variability among African Americans is largely explained by a number of multilevel influences across the life course, including proximal mediators (e.g., physical health), distal mediators (e.g., psychological stress), and contextual factors including geographic segregation, migration patterns, socioeconomic position, discrimination, and group resources [13]. This model acknowledged that multiple complex and interrelated factors likely influence cognitive function. These (and other) researchers have also invoked a recent interpretation of the "brain battering hypothesis" that suggests the cumulative impact of various life-long exposures (e.g., low education, lower childhood socioeconomic status) may promote race-related disparities in brain health [14].

To date, empirical testing of multiple influences on cognitive function among African Americans has been limited. Studies have largely focused on predictor factors by category, such as education and literacy [11, 15], depression [16], cardiovascular health [17]. Accordingly, the primary aim of the present analysis was to examine multiple influences on cognitive function, including socioeconomic indicators, substance use, depressive symptoms, and CVD risk factors, in a large sample of socioeconomically diverse, urban-dwelling African Americans. Reviewed briefly below, each of these influences has previously been associated with cognitive performance in the general population, and/or within African Americans.

Socioeconomic indicators generally bear strong associations with cognitive function. For example, low levels of education have been associated with a higher incidence of dementia and more rapid cognitive decline [8]. Supported by both the brain-reserve [18] and cognitive-reserve hypotheses [19], this inverse relation has indeed been documented among African Americans [15]. Similarly, literacy has emerged as a stronger predictor of cognitive decline than years of education, and a primary predictor of poor cognitive outcomes in the older adult population [20]. These findings have been attributed to the likelihood that literacy more accurately reflects educational experience and quality [21, 22]. Among African-American elders specifically, literacy, a proxy of educational quality, has emerged as a stronger predictor of cognitive performance than age, sex, years of education, or acculturation [11]. It has been argued that disparate school experiences, including unequal distribution of school resources, variable teacher education, lower attendance due to required work, and shorter school years, both during and post-school school segregation, reduced the quality of education, as well as reading skills, for many African Americans [23, 24]. Lastly, research suggests that poverty has negative consequences for cognitive function, independently of the role of education [25]. Poverty is thought to consume a large proportion of mental resources, by imposing a mental load that drains attentional resources and reduces effort, thus leaving fewer resources for other tasks [10]. At least one investigation showed that African-American adults who reported childhood financial strain had lower levels of cognitive functioning than those who did not [26].

Substance use has been associated with poorer cognitive performance in the general population. In that regard, smoking and illicit drug use have been related to lower levels of cognitive function, cognitive decline, and dementia [6, 9, 27, 28]. However, few studies have examined whether these factors are correlates of cognitive function within African Americans.

Depression and depressive symptomatology have long been known to have a negative impact on cognitive function [29], although the patterns of cognitive dysfunction vary widely across studies [12]. Zahodne and colleagues found evidence that relations of depressive symptoms to cognitive outcomes differed by race, with African Americans' cognitive performance reflecting more vulnerability to negative effects of depression than their White counterparts, independently of age, education, reading level, income, and health [16].

Substantial evidence has shown that CVD risk factors, such as elevated blood pressure, glucose, and total cholesterol, and obesity, promote decrements in cognitive function and increase risk of cognitive decline and dementia [30–33]. Among African Americans, for whom CVD disparities are prominent [34], these conditions have previously been associated with lower levels of cognitive functioning [16, 35, 36].

Importantly, among previous studies that have examined correlates of cognitive function in the general population, very few have (a) focused specifically on African Americans, (b) explored a substantial breadth of cognitive domains, and (c) included a focus on multiple influences that tend to aggregate among individuals. Indeed, we are unaware of any study that has included all three of these important components to understand variability in African Americans' cognitive performance. Furthermore, we were interested in understanding whether potential influences on cognitive function, examined sequentially, added to, reduced, or replaced variance explained by other potential influences. Therefore, here we queried, in a sequential manner (adjusted for age and sex), the respective influences of the following (a) sociodemographic factors (education, poverty status); (b) literacy; (c) smoking, substance use; (d) depressive symptoms; and (e) CVD risk factors on multiple domains of cognitive function in a large, population-based sample of middle age and older African Americans.

Methods

Study Design

We conducted a cross-sectional analysis of baseline data from the Healthy Aging in Neighborhoods of Diversity across the

Life Span (HANDLS) study. Derived from area probability sampling, the HANDLS study is a multi-disciplinary, 20-year prospective epidemiological study designed to evaluate the influences of race and socioeconomic status on minority health, aging, and health disparities among a fixed cohort of 3720 African American and white urban-dwelling men and women, aged 30–64 years, from 13 neighborhoods in Baltimore City, MD. Participants were socioeconomically diverse based on household income above or below 125% of the poverty threshold. All participants provided written informed consent. The HANDLS protocol was approved by the Institutional Review Board at the National Institute of Environmental Health Sciences. Participants receive monetary compensation for their participation.

Data from the baseline study, conducted between 2004 and 2009, were examined. Baseline data were collected in two phases. In the first phase, residential dwellings were identified in the preselected census tracts. Eligible candidates were identified at doorstep interviews and invited to participate in the HANDLS study. After informed consent was obtained, a household survey and the first of two 24-h dietary recall questionnaires were administered to participants ($n = 3720$). The second phase involved collection of biomarkers, cognitive, psychosocial, medical, and physical performance assessments, and a second dietary recall ($n = 2799$; for further detail see [37]). The second phase was performed in mobile medical research vehicles (MRVs) parked in participants' neighborhoods to improve access and limit attrition.

Participants

Overall criteria for inclusion in the HANDLS Study were age 30 to 64 years at enrollment, ability to give informed consent to perform at least five of the study measures, and possession of a valid photo ID. Baseline exclusion criteria included pregnancy, history of cancer treatment within the past 6 months, or a history of acquired immune deficiency syndrome (AIDS). Additional exclusion criteria for this analysis included self-reported White race, history of stroke, transient ischemic attack (TIA), dementia, other neurological disease (e.g., Parkinson's disease, epilepsy, multiple sclerosis), HIV, heart failure, or renal dialysis. After exclusions, 987 African American participants remained from the sample of 2799 who had participated in both phases of wave 1, with complete data for all analyzed variables.

Measures

Age was measured in number of years. Sex was defined as female (0) or male (1). Educational attainment was defined as the total number of years of formal education.

Literacy The Wide Range Achievement Test-Revision 3 (WRAT-3) Letter and Word Reading subtest is an assessment of letter recognition and word pronunciation, used to estimate literacy levels for individuals aged 5 to 75 years [38].

Poverty Status Poverty status was dichotomized using the U.S. Census Bureau poverty thresholds for 2004 based on income, size of family, and related children under age 18 years [39]. Poverty status was defined as below the poverty threshold (< 125% of the poverty threshold; 1) or above the poverty threshold (≥ 125% of the poverty threshold; 0).

Cigarette Smoking and Substance Use Cigarette smoking and substance use, defined as marijuana, cocaine, or opiates use, were dichotomized as never used or ever used.

Depressive Symptoms Depressive symptoms were assessed with the Center for Epidemiological Studies-Depression Scale (CES-D), a 20-question self-report tool that was designed for and validated in nonclinical populations [40]. The total score was utilized in the analysis; higher total scores indicate greater depressive symptomatology.

CVD Risk Factors Height and weight were measured by a trained medical provider using standardized equipment for calculation of body mass index (BMI). Venous blood was obtained after an overnight fast and analyzed by Quest Diagnostics (Chantilly, VA). Serum total cholesterol (mg/dL) was assayed using a spectrophotometer (AU5400 Immuno Chemistry Analyzer; Olympus, Center Valley, PA). Glucose was measured using a spectrophotometer (AU5400 Immuno Chemistry Analyzer; Olympus, Center Valley, PA). Following 5 min of rest, in a seated position, brachial arterial blood pressure was auscultated to assess systolic and diastolic blood pressure (SBP, DBP). The average of two readings was calculated. Based on these assessments, a CVD risk variable was trichotomized as 0, 1, or 2+ CVD risk factors from the following list: BMI > 30 kg/m^2; total cholesterol ≥ 240 mg/dL; hypertension diagnosis based on mean BP > 140/90 mmHg, self-reported diagnosis of hypertension, or use of anti-hypertensive medications; and diabetes diagnosis based on fasting glucose ≥ 126 mg/dL, self-reported diagnosis of diabetes, or use of diabetes medications.

Cognitive performance was assessed with a neuropsychological test battery that assessed domains including nonverbal memory, verbal learning and memory, working memory, fluency, attention, and cognitive flexibility. All tests were administered by a trained examiner.

Nonverbal memory was assessed using the Benton Visual Retention Test-5th edition (BVRT) [41]. Scores utilized in the analysis were the total number of errors in designs, based on the BVRT manual criteria, so higher scores reflected lower performance levels.

The California Verbal Learning Test-II (CVLT-II) assessed verbal learning and memory [42]. Four scores from the CVLT-II were utilized in the analysis: total number correct, short delay total score, and long delay total score. Higher values of each score reflect better verbal learning and memory performance.

The Wechsler Adult Intelligence Scale–Third Edition (WAIS-III) Digit Span subscale assessed working memory, concentration, and auditory attention [43]. Both the forward and backward versions were administered. The total number of digits recalled for each version was utilized for the analysis.

The Animal Fluency Test measured spontaneous word generation within the animal category [44]. The Animal Fluency score utilized was the total number of unique animal words listed within a specified time frame. Higher scores reflect greater fluency.

Attention, cognitive flexibility, visual scanning, and visuomotor tracking were examined using the Trail Making Test (TMT), versions A and B [45]. The score utilized for each version reflects the length of time for completion, thus higher scores indicate lower performance.

Statistical Analysis

All statistical analyses were performed using R (V3.4.1) [46]. Hierarchical regressions, adjusted for age and sex, examined cross-sectional relations of the following: (1) education, poverty status; (2) literacy; (3) cigarette smoking and substance use; (4) depressive symptoms; and (5) CVD risk factors. Each cognitive measure was entered as a single outcome variable in separate hierarchical regressions.

Results

Sample Characteristics

The mean age of participants was 48.5 years (SD = 9.17); 56% of the sample was female. On average, most participants had attained a high school education and nearly half had a family income below the poverty threshold. Analysis of mean values showed that, on average, the sample had moderate levels of depressive symptomatology. At least one CVD risk factor was present in 69.8% of the sample. Full descriptive statistics are provided in Table 1.

Regression Findings

Table 2 shows findings for the fully adjusted models. Table 3 shows block 2 of the regression models to highlight the relative contribution of socioeconomic predictors, including literacy. Table 4 highlights the significant predictors by block for each cognitive outcome. Lastly, unstandardized coefficients, by block of entry, for all regression models can be found in the online supplement (supplementary Tables 1–9).

Nonverbal Memory For BVRT total errors, the contribution of education was significant in block 1 and WRAT-3 total score was significant in blocks 2, 3, 4, and 5 (see Table 4 and online supplement). In the fully adjusted model (see Table 2), higher WRAT-3 total scores ($p < .001$) were associated with fewer BVRT errors. In addition, greater depressive symptomatology ($p < .001$) was associated with more BVRT errors.

Verbal Learning and Memory For CVLT-II list A total correct, the contribution of education was significant in block 1. In blocks 2 through 5, the contributions of education and WRAT-3 were significant (see Table 4 and online supplement). The addition of CES-D in block 4 was also significant. In the fully adjusted model (see Table 2), higher WRAT-3 total scores ($p < .001$) and less depressive symptomatology ($p < .001$) were associated with more words recalled correctly. For CVLT-II short-delay recall, the contribution of education was significant in block 1. In blocks 2 and 3, the contributions of education and WRAT-3 were significant. The addition of CES-D in block 4 eliminated the contribution of education. In the fully adjusted model, WRAT-3 total scores ($p < .001$) were positively associated with performance ($p < .001$) while CES-D scores ($p < .001$) were negatively associated with performance. For long delay performance, the contribution of education in block 1 was eliminated by the addition of WRAT-3 in block 2, which was significant across blocks 2 through 5. The addition of depressive symptoms was significant in block 4 (Table 4 and online supplement). In the fully adjusted model (see Table 2), WRAT-3 performance ($p < .001$) was significantly and positively related to CVLT-II long-delay recall performance ($p < .001$) while CES-D scores were negatively related to performance ($p < .001$).

Working Memory For Digit Span Forward performance, the entry of WRAT-3 scores in block 2 eliminated the block 1 significance of education. In the fully adjusted model, higher WRAT-3 total scores ($p < .001$) and ever used a substance ($p < .001$) were associated with better performance. CES-D scores were inversely related ($p < .05$). For Digit Span Backward performance, the entry of WRAT-3 scores in the model eliminated the significance of block 1 education. In the fully adjusted model, higher WRAT-3 scores were positively associated with Digit Span Backward performance ($p < .001$) while higher CES-D scores were associated with poorer performance ($p < .01$).

Verbal Fluency For animal fluency, the influence of education in block 1 was eliminated by the addition of WRAT-3 in block 2. In block 3, substance use emerged as a significant predictor. In the fully adjusted model, higher WRAT-3 performance

Table 1 Sample characteristics ($N = 987$)

	M (SD)		M (SD)
Age (y)	48.50 (9.17)	BVRT total errors	6.69 (5.3)
Education (% less than HS)	32.52	CVLT short delay	6.59 (2.83)
Sex (% female)	56	CVLT long delay	6.7 (2.8)
Poverty status (% below poverty threshold)	46	CVLT total score	23.6 (6.0)
WRAT-3 total score	40.5 (7.65)	Digit span backward	5.15 (1.94)
CES-D total score	14.84	Digit span forward	6.97 (2.06)
% ever smoked cigarettes	69	Word fluency	18.07 (4.95)
% ever used illicit substance	54.71	Trail making A (s)	40.5 (30.07)
% with 0 CVD risk factors	30.19	Trail making B (s)	139.1 (85.36)
% with 1 CVD risk factor	31.2		
% with 2+ CVD risk factors	38.6		

HS high school, *WRAT-3* Wide Range Achievement Test-Revision 3, *CES-D* Center for Epidemiological Studies Depression Scale, *CVD* cardiovascular disease

($p < .001$) and having ever used a substance ($p < .05$) were associated with better performance.

Attention and Cognitive Flexibility For trails A, in block 1, poverty status was a significant contributor to performance across all blocks. In addition, the entry of WRAT-3 total scores and substance use was significant across all blocks. In the fully adjusted model, higher WRAT-3 scores ($p < .001$), being above the poverty threshold ($p < .05$), and having ever used a substance ($p < .05$) were associated with a shorter trails A completion time ($p < .001$). With respect to trails B performance, the contribution of education was significant across all blocks. The contribution of poverty status was significant in block 1 was eliminated by the addition of WRAT-3 in block 2, but re-emerged as significant in block 3 with the addition of substance use, which was also significant. In block 4, CES-D scores emerged as significant. In the fully adjusted model, greater educational attainment ($p < .001$), being above the poverty threshold ($p < .05$), higher WRAT-3 scores ($p < .001$), ever used a substance ($p < .05$), and lower CES-D scores ($p < .001$) were associated with a shorter time to complete trails B.

Discussion

In a large, population-based sample of middle age and older African Americans, the current study examined multiple influences of the following: (1) sociodemographic factors (education, poverty status), (2) literacy, (3) cigarette smoking and substance use, (4) depressive symptoms, and (5) CVD risk factors on multiple domains of cognitive function, with adjustment for age and sex. Findings showed a salient influence of literacy, with literacy emerging as the most prominent influence on cognition, and education and poverty status adding unique contributions that varied by cognitive measure.

Table 2 Unstandardized coefficients for cognitive outcomes regressed on standard adjustment variables, education, poverty status, literacy, substance use, and cardiometabolic risk factors

	BVRT	CVLT no. correct	CVLT short delay	CVLT long delay	DSF	DSB	Fluency	Trails A	Trails B
Age (years)	.14***	− 0.12***	− 0.08**	− 0.07***	− 0.01	− 0.01*	− 0.05**	.52***	2.15***
Sex	− 1.18***	− 1.99***	− 0.67***	− 0.77***	.02	.04	1.51***	4.25*	4.98
Poverty status	− 0.14	− 0.18	− 0.17	− 0.00	− 0.11	− 0.13	− 0.34	4.83*	10.31*
Education	− 0.50	1.36***	.35	.22	− 0.05	− 0.00	.30	− 1.49	− 23.58***
WRAT-3 total score	− 0.10***	.19***	.07***	.09***	.09***	.11***	.13***	− 0.38**	− 2.95***
Used cigs ever	− 0.20	− 0.19	.16	− 0.10	.001	− 0.02	− 0.47	− 0.29	.32
Used substances ever	− 0.25	.51	.14	.22	.49***	.18	.77*	− 4.28*	− 13.46*
CES-D score	.06***	− 0.09***	− 0.03***	− 0.03***	− 0.01*	− 0.02**	− 0.02	.09	.84***
CVD risk	.07	.30	.07	.16	− 0.06	− 0.02	.19	.87	4.58

CES-D Center for Epidemiological Studies-Depression, *SBP* systolic blood pressure, *BMI* body mass index, *WRAT-3* Wide Range Achievement Test-Revised, *CRP* C-reactive protein, *BVRT* Benton Visual Retention Test, *CVLT* California Verbal Learning Test, *DSF* digit span forward, *DSB* digit span backward

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Table 3 Unstandardized coefficients for cognitive outcomes regressed on age, sex, education, poverty status, and WRAT-3 total score

	BVRT	CVLT no. correct	CVLT short delay	CVLT long delay	DSF	DSB	Animal fluency	Trails A	Trails B
Age	.13***	− 1.80***	− 0.07***	− 0.06***	− 0.01	− 0.01*	− 0.05**	.55***	2.23***
Sex	1.40***	− 1.80***	− 0.56***	− 0.71***	.20	.13	1.64***	2.57	− 1.77
Poverty status	− 0.13	− 0.26	− 0.18	− 0.04	− 0.07	− 0.13	− 0.36	4.43*	9.63
Education	− 0.66	1.68***	.44*	.34	− 0.05	.04	.37	1.3	− 25.29***
WRAT-3 total score	− 0.11	.21***	.08***	.09***	.09***	.11***	.13***	− 0.41**	− 3.12***

CES-D Center for Epidemiological Studies-Depression, *SBP* systolic blood pressure, BMI body mass index, *WRAT-3* Wide Range Achievement Test-Revised, *CRP* C-reactive protein, *BVRT* Benton Visual Retention Test, *CVLT* California Verbal Learning Test, *DSF* digit span forward, *DSB* digit span backward

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

Depressive symptoms and substance use were associated with fewer domains of cognitive function. However, CVD risk factors explained no significant variability in cognitive function.

Sociodemographic Factors

Results from the fully adjusted models indicated that higher educational attainment was associated with better cognitive performance in the domains of attention and cognitive flexibility, while higher literacy was associated with better cognitive performance across all domains examined. Household incomes above the poverty threshold were associated with better attention and cognitive flexibility performance. Although the fully adjusted models showed that literacy was a consistent predictor of cognitive performance across all domains, the earlier models suggested a more complex pattern of associations, whereby literacy eliminated the influence of education and poverty status for select domains.

Findings for literacy were consistent with previous studies highlighting it as an important predictor of cognitive performance [11, 21], in addition to prior research showing that, particularly among African Americans, years of education are less valuable in explaining cognitive performance than literacy, a proxy of the quality of the educational experience [21, 22]. However, results demonstrating that higher educational attainment was associated with better attention and cognitive flexibility were also consistent with prior evidence of the cognitive benefits of attaining more education [19]. In terms of the relative importance of each of these variables, our findings demonstrated, in block 2, that literacy diminished the contribution of education on tests of nonverbal memory, working memory, and delayed verbal memory. Similarly, when literacy entered the model in block 2, it eliminated the influence of poverty status on working memory. These findings suggest that it is important to continue to consider both educational attainment and poverty status as unique and valuable contributors to cognitive performance; however, the focus on literacy as a proxy of educational quality is a vital focus in this population.

Depressive Symptoms

Greater depressive symptomatology was associated with poorer performance in the domains of nonverbal memory, short and delayed verbal memory, working memory, and attention and cognitive flexibility. These findings were consistent with prior evidence generally linking depression (symptomatology or diagnosis) to poor cognitive performance, or even frank impairment across multiple domains of cognitive function [12, 29]. Further, the consistency of our depression findings for African Americans is aligned with recent results from the normative study for the NIH Toolbox. Results of that investigation revealed evidence that relations of depressive symptoms to cognitive outcomes differed by race, with African Americans' cognitive performance reflecting more vulnerability to negative effects of depression than their White counterparts, independently of age, education, literacy, income, and health [16]. The present study adds to the limited body of knowledge about the unique influence of depressive symptomatology on cognitive performance among community-based African Americans and underscores the importance of depression screening and treatment within this population.

Substance Use

Prior research has shown that smoking and chronic illicit drug use are inversely associated with cognitive function [6, 9, 27, 28]. Our study revealed no significant relations of cigarette smoking to cognitive outcomes; however, having ever used an illicit drug was associated with greater fluency, attention, and cognitive flexibility performance. These unexpected associations between illicit drug use and cognitive function are not supported by prior studies. It is conceivable that these unexpected findings may, in part, reflect better metabolic profiles that are seen with select types of drug use, relative activation with current use, and/or stress-buffering effects. Importantly, we did not have information on quantity or frequency of smoking or substance use, nor did we identify substance

Table 4 Significant predictors by block for each cognitive outcome

		Block 1				Block 2	Block 3		Block 4	Block 5
Measure	Block	Age	Sex	Poverty status	Education	WRAT-3	Used cigs ever	Used substances ever	CES-D score	CVD risk
BVRT	1	•	•		•					
	2	•	•			•				
	3	•	•			•				
	4	•	•			•			•	
	5	•	•			•			•	
CVLT A total correct	1	•	•		•				•	
	2	•	•		•	•				
	3	•	•		•	•				
	4	•	•		•	•			•	
	5	•	•		•	•			•	
CVLT short delay	1	•	•		•					
	2	•	•		•	•				
	3	•	•		•	•				
	4	•	•			•			•	
	5	•	•			•			•	
CVLT long delay	1	•	•		•					
	2	•	•			•				
	3	•	•			•				
	4	•	•			•			•	
	5	•	•			•			•	
DSF	1	•			•					
	2					•				
	3					•		•		
	4					•		•	•	
	5					•		•	•	
DSB	1	•		•	•					
	2	•				•				
	3	•				•				
	4	•				•			•	
	5	•				•			•	
Animal fluency	1	•								
	2	•				•				
	3	•				•				
	4	•				•				
	5	•				•		•		
Trails A	1	•		•						
	2	•		•		•				
	3	•		•		•		•		
	4	•		•		•		•		
	5	•		•		•		•		
Trails B	1	•		•		•				
	2	•				•				
	3	•		•		•		•		
	4	•		•		•		•	•	
	5	•		•		•		•	•	

Block 1= age, sex, education, poverty status; block 2 = WRAT-3; block 3 = substance use; block 4 = CES-D; block 5 = cardiometabolic risk factors

Educ education, *WRAT-3* Wide Range Achievement Test-Revised, *CES-D* Center for Epidemiological Studies-Depression, *SBP* systolic blood pressure, *HbA1c* glycated hemoglobin, *TC* total cholesterol, *CRP* C-reactive protein, *BVRT* Benton Visual Retention Test, *CVLT* California Verbal Learning Test, *DSF* digit span forward, *DSB* digit span backward

abuse. Results suggest a need for more detailed examination of substance use and abuse in relation to African Americans' cognitive performance.

CVD Risk Factors

CVD risk factors showed no association with cognitive function, contrasting with prior research that showed significant relations of CVD risk factors to lower levels of cognitive performance among African Americans [17, 35, 36]. Despite the high prevalence of one or more CVD risk factors in our sample, lower literacy was the prominent correlate of lower cognitive performance. Here, null findings highlight the importance of examining multiple influences of cognitive function to fully understand the relative contribution of each factor. In this case, the contribution of literacy outweighed the contribution of health, suggesting a need to take a comprehensive view of predictors of cognitive function in African Americans.

Limitations

The current study has some limitations. First, temporal associations could not be determined in this analysis. Future analyses should examine relations of multiple influences to changes in cognitive function over time. Also, although the findings cannot be generalized to all African Americans, independent demographic analyses found that the HANDLS sample is representative of urban populations from US cities with similar population and racial distributions [47]. In addition, the absence of an analysis of individual CVD risk factors and the gross measure of substance use were limitations of the study. Determining relative risk from multiple measures with varying cutoffs and degrees of influence with respect to cognitive function would have limited the validity of our risk measurement. Lastly, while our study included a relatively extensive set of predictor variables, African-American elders have also been uniquely exposed to various stressors across the life course, such as racial micro- and macro-aggressions, discrimination, and early adverse experiences, that may have long-term influences on cognitive function. Our analysis did not include these potential influences. Despite these limitations, the examinations of an underrepresented population in the cognitive aging literature, as well as the breadth of sociodemographic, health, and cognitive measures included, are major strengths of the study.

Conclusions

Overall, our findings provide unique contributions to the limited literature on multiple influences on cognitive function in community-based African-American adults. Our findings partially support prior theoretical models that posit complex influences on cognitive outcomes for African Americans. Furthermore, the inclusion of this number of potential influences in a large study of African Americans is unprecedented. With respect to the important contribution of literacy, our findings were robust. It is apparent from our findings that cognitive performance is highly sensitive to the influence of literacy in African Americans, and that other cognitive effects typically seen in predominately White samples (e.g., poor cardiovascular health, poor health habits) may be muted by this salient predictor. One important future consideration that follows, then, is how individuals that have low literacy or have experienced a lower quality education can be supported with respect to their cognitive function. Thus, future research might explore cognitive training interventions tailored for individuals with lower literacy. However, our results further indicated a minor importance of other sociodemographic variables—education and poverty status—as determinants of cognitive performance within socioeconomically diverse African Americans. Findings for depressive symptomatology were consistent across several cognitive domains, which added support to the few studies that had previously reported relations of depressive symptoms to cognitive function among African Americans and highlight the importance of depression screening and treatment. Although substance use contributed unexpected relations to cognitive function, future research should include a more comprehensive assessment of these factors, including quantity and frequency of use. Furthermore, despite high rates of CVD risk among African Americans in general, these variables did not contribute to cognitive performance in our relatively healthy sample. Examining these relations over time may tell us more about the relative influence of CVD risk. Lastly, to capture the possible influence of discrimination and racism experienced by African Americans on cognitive performance, future research should examine various stressors utilizing validated surveys that capture a spectrum of events and exposures related to racial micro- and macro-aggressions, discrimination, and early adverse experiences.

Acknowledgments The authors wish to thank the HANDLS study participants for their contributions and the HANDLS staff for collection and availability of the data.

Funding This research was supported by the National Institute on Aging grants (Z01–AG000194) to Evans and Zonderman (R01 AG034161) to Waldstein; the Claude D. Pepper Older Americans Independence Center (P30 AG028747) to Magaziner, Katzel, and Ryan; and the National Institute of General Medical Sciences (P20 GM103446, P20 GM113125) and the state of Delaware to Wright.

Compliance with Ethical Standards

All participants provided written informed consent. The HANDLS protocol was approved by the Institutional Review Board at the National Institute of Environmental Health Sciences. Participants receive monetary compensation for their participation.

Conflict of Interest The authors declare that they have no conflict of interest.

References

1. Royall DR, Palmer R, Chiodo LK, Polk MJ. Declining executive control in normal aging predicts change in functional status: the Freedom House study. J Am Geriatr Soc. 2004;52(3):346–52.
2. Salthouse TA. When does age-related cognitive decline begin? Neurobiol Aging. 2009;30:507–14.
3. Go AS, Mozaffarian D, Roger VL, Benjamin EJ, Berry JD, Blaha MJ, … & Fullerton HJ. Heart disease and stroke statistics-2014 update. Circulation. 2014;129(3).
4. Young DR, He X, Genkinger J, Sapun M, Mabry I, Jehn M. Health status among urban African American women: associations among well-being, perceived stress, and demographic factors. J Behav Med. 2004;27(1):63–76.
5. Whitfield KE, Allaire JC, Belue R, Edwards CL. Are comparisons the answer to behavioral aspects of aging in racial and ethnic groups? J Gerontol Ser B Psychol Sci Soc Sci. 2008;63(5):P301–8.
6. Anstey KJ, von Sanden C, Salim A, O'Kearney R. Smoking as a risk factor for dementia and cognitive decline: a meta-analysis of prospective studies. Am J Epidemiol. 2007;166(4):367–78.
7. Awad N, Gagnon M, Messier C. The relationship between impaired glucose tolerance, type 2 diabetes, and cognitive function. J Clin Exp Neuropsychol. 2004;26(8):1044–80.
8. Chodosh J, Reuben DB, Albert MS, Seeman TE. Predicting cognitive impairment in high-functioning community-dwelling older persons: MacArthur studies of successful aging. J Am Geriatr Soc. 2002;50(6):1051–60.
9. Dregan A, Gulliford MC. Is illicit drug use harmful to cognitive functioning in the mid-adult years? A cohort-based investigation. Am J Epidemiol. 2012;175(3):218–27.
10. Mani A, Mullainathan S, Shafir E, Zhao J. Poverty impedes cognitive function. Science. 2013;341(6149):976–80.
11. Manly JJ, Byrd DA, Touradji P, Stern Y. Acculturation, reading level, and neuropsychological test performance among African American elders. Appl Neuropsychol. 2004;11(1):37–46.
12. McDermott LM, Ebmeier KP. A meta-analysis of depression severity and cognitive function. J Affect Disord. 2009;119(1):1–8.
13. Glymour MM, Manly JJ. Lifecourse social conditions and racial and ethnic patterns of cognitive aging. Neuropsychol Rev. 2008;18(3):223–54.
14. Del Ser T, Hachinski V, Merskey H, Munoz DG. An autopsy-verified study of the effect of education on degenerative dementia. Brain. 1999;122(12):2309–19.
15. Alley D, Suthers K, Crimmins E. Education and cognitive decline in older Americans: results from the AHEAD sample. Res Aging. 2007;29(1):73–94.
16. Zahodne LB, Nowinski CJ, Gershon RC, Manly JJ. Which psychosocial factors best predict cognitive performance in older adults? J Int Neuropsychol Soc. 2014;20(5):487–95.
17. Aiken-Morgan AT, Sims R, Whitfield KE. Cardiovascular health and education as sources of individual variability in cognitive aging among African Americans. J Aging Health. 2010;22:477–503.
18. Satz P. Brain reserve capacity on symptom onset after brain injury: a formulation and review of evidence for threshold theory. Neuropsychology. 1993;7(3):273–95.
19. Stern Y. Cognitive reserve. Neuropsychologia. 2009;47(10):2015–28.
20. Dotson VM, Kitner-Triolo MH, Evans MK, Zonderman AB. Effects of race and socioeconomic status on the relative influence of education and literacy on cognitive functioning. J Int Neuropsychol Soc. 2009;15:580–9.
21. Manly JJ, Schupf N, Tang MX, Stern Y. Cognitive decline and literacy among ethnically diverse elders. J Geriatr Psychiatry Neurol. 2005;18(4):213–7.
22. Sisco S, Gross AL, Shih RA, Sachs BC, Glymour MM, Bangen KJ, … & Manly JJ. The role of early-life educational quality and literacy in explaining racial disparities in cognition in late life. J Gerontol Ser B Psychol Sci Soc Sci. 2014;gbt133.
23. Anderson JD. The education of blacks in the south, 1860–1935. Chapel Hill: University of North Carolina Press; 1988.
24. Margo RA. Race and schooling in the south, 1880–1950: an economic history. Chicago: University of Chicago Press; 1990.
25. Cagney KA, Lauderdale DS. Education, wealth, and cognitive function in later life. J Gerontol Ser B Psychol Sci Soc Sci. 2010;57(2):P163–72.
26. Szanton SL, Thorpe RJ, Whitfield K. Life course financial strain and health in African Americans. Soc Sci Med. 2010;71(2):259–65.
27. Cadet JL, Bisagno V. Neuropsychological consequences of chronic drug use. Frontiers in Psychiatry. 2016;15(6):189.
28. Sabia S, Elbaz A, Dugravot A, Head J, Shipley M, Hagger-Johnson G, et al. Impact of smoking on cognitive decline in early old age: the Whitehall II cohort study. Arch Gen Psychiat. 2012;69(6):627–35.
29. Swan GE, Lessov-Schlaggar CN. The effects of tobacco smoke on cognition and the brain. In: Waldstein SR, Elias MF, editors. Neuropsychology of cardiovascular disease. New York: Psychology Press; 2015. p. 3–34.
30. Grant MM, Thase ME, Sweeney JA. Cognitive disturbance in outpatient depressed younger adults: evidence of modest impairment. Psychiatry. 2001;50:35–43.
31. Elias MF, Goodell AL, Robbins MA. In: Waldstein SR, Elias MF, editors. Neuropsychology of cardiovascular disease. New York: Psychology Press; 2015. p. 109–49.
32. Muldoon MF, Conklin SM. Effects of cholesterol and N-3 fatty acids on cognitive functioning, decline, and dementia. In: Waldstein SR, Elias MF, editors. Neuropsychology of cardiovascular disease. New York: Psychology Press; 2015. p. 150–83.
33. Marsland AL. Inflammation and preclinical neurocognitive decline. In: Waldstein SR, Elias MF, editors. Neuropsychology of cardiovascular disease. New York: Psychology Press; 2015. p. 238–64.
34. Koekkoek PS, Kappelle LJ, van den Berg E, Rutten GE, Biessels GJ. Cognitive function in patients with diabetes mellitus: guidance for daily care. Lancet Neurol. 2015;14(3):329–40.
35. National Center for Health Statistics US. (2016). Health, United States, 2015: with special feature on racial and ethnic health disparities.
36. Wright RS, Cole AP, Ali MK, Skinner J, Whitfield KE, Mwendwa DT. Examining the influence of measures of adiposity on cognitive function in middle age and older African Americans. Arch Clin Neuropsychol. 2016;31(1):23–8.
37. Evans MK, Lepkowski JM, Powe NR, LaVeist T, Kuczmarski MF, Zonderman AB. Healthy aging in neighborhoods of diversity across the life span (HANDLS): overcoming barriers to implementing a longitudinal, epidemiologic, urban study of health, race, and socioeconomic status. Ethn Dis. 2010;20(3):267–75.
38. Wilkinson GS. Wide Range Achievement Test—Revision 3. Wilmington, DE: Jastak Association; 1993.
39. U.S. Census Bureau: Social, Economic, and Housing statistics division (2014). Poverty Thresholds, 2004. http://www.census.gov/hhes/www/poverty/data/threshld/thresh04.html. Accessed January 2016.
40. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. Appl Psychol Meas. 1977;1(3):385–401.
41. Sivan AB. The Benton Visual Retention Test: fifth edition manual. Oxford: The Psychological Corporation, Harcourt Assessment, Inc.; 1991.
42. Delis DC, Kramer JH, Kaplan E, Kaplan BA. California verbal learning test—second edition manual. Adult version. San Antonio, TX: Psychological Corporation; 2000.

43. Wechsler D. Wechsler Adult Intelligence Scale—Revised. New York: Psychological Corporation; 1981.
44. Strauss E, Sherman EM, Spreen O. A compendium of neuropsychological tests: administration, norms, and commentary. New York: Oxford University Press; 2006.
45. Reitan RM. Trail making test: manual for administration and scoring. Tucson, AZ: Reitan Neuropsychology Laboratory; 1992.
46. R Core Team. R: a language and environment for statistical computing. R Foundation for statistical computing, Vienna, Austria. 2018. URL https://www.R-project.org/.
47. Lepkowski J. HANDLS Principal Cities Clusters Analysis. Unpublished internal document. Baltimore, MD: National Institute on Aging. 2011.