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The Associations Among Sociocultural Factors and Neuropsychological Functioning in Older American Indians: The Strong Heart Study

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Abstract

Objective.—Valid neuropsychological assessment is critical to the accurate diagnosis and effective treatment of diverse populations. American Indians and Alaska Natives experience substantial health disparities relative to the general U.S. population. Given the dearth of studies on neuropsychological health in this population, we aimed to characterize neuropsychological performance among older American Indians with respect to age, sex, education, income, and language use.

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Methods.—From 2010 to 2014, we recruited 818 American Indians aged 60 and older from the Cerebrovascular Disease and its Consequences in American Indians (CDCAI) study, who comprised all of the surviving members of a cardiovascular study (Strong Heart Study). This cohort from 11 tribes resided on or near their home reservations in three geographic regions (Northern Plains, Southern Plains, and Southwest). Using a cross-sectional design investigating potential vascular brain injury, we administered a brief, targeted neuropsychological and motor function assessments.

Results.—Higher scores on neuropsychological tests were associated with younger age, female sex, more education, higher income, and less Native American language use. Similar associations were found for the motor tests, although men had higher scores on both motor function tests. After accounting for other sociocultural and health factors, age, sex, education, income, and Native American language use all had significant associations to the test scores.

Conclusions.—Our findings may be used to guide research and inform clinical practice. The development of future normative studies for older American Indians will be more culturally appropriate when sociocultural factors are included.

Keywords

Neuropsychology; Cognitive Assessment; American Indians and Alaska Natives; Racial/ethnic Minorities; Culture; Aging

INTRODUCTION

As the U.S. population ages, valid neuropsychological assessment of older adults becomes increasingly critical. While neuropsychological assessment is often used to assist in the diagnosis and treatment of aging-related physical and mental illness (Castor et al., 2006; Centers for Disease Control and Prevention, 2003; Cook, McGuire, & Miranda, 2007; Gone & Trimble, 2012; Jaiyeola & Stabler, 2009; D. S. Jones, 2006; World Health Organization, 2002), the evidence base for interpreting such assessments in minority populations, particularly American Indians and Alaska Natives, is extremely limited (Verney, Bennett, & Hamilton, 2015). This population experiences a disproportionately high risk of serious health problems related to aging and cognitive decline including from hypertension, diabetes mellitus, hypercholesterolemia, and obesity (Ayala et al., 2001; Centers for Disease Control and Prevention, 2004; Gillum, 1995; Harwell et al., 2005; Hutchinson & Shin, 2014; Lee et al., 1990), compared with US general population (Ying Zhang et al., 2008). Yet most published studies of neuropsychological performance in American Indians and Alaska Natives have been hindered by methodological limitations including the recruitment of relatively small samples, the use of few neuropsychological measures, and have addressed either a single tribe or a select few tribes (Verney et al., 2015). Therefore, we report neuropsychological and motor performance in association with sociocultural factors among 818 American Indian elders in three different geographical regions. Our results are intended to guide future clinical and research information on cognitive decline and health among American Indians and Alaska Natives.

The extent to which culture influences cognitive assessments and the appropriate use of existing assessment tools in racial, ethnic, and cultural minority groups continue to be challenging and often controversial topics (Gopaul-McNicol & Armour-Thomas, 2002; Manly, 2005; Suzuki, Ponterotto, & Meller, 2001; Suzuki & Valencia, 1997; Valencia & Suzuki, 2001). Most standardized neuropsychological tests were designed for and normed to non-Hispanic White samples (Wong, 2000). The tests' lack of proper validation for minority populations might lead to misdiagnoses of cognitive impairment or deficits (Manly, 2006). In addition to the lack of studies and normative data of neuropsychological test performance of American Indians and Alaska Natives, little is known about the confounding factors that may affect the interpretation of the test performance. Demographic and sociocultural factors, such as education, socioeconomic status, language, and acculturation are associated with neuropsychological test performance yet are rarely accounted for in defining normative data for a population (Suzuki, Naqvi, & Hill, 2014). Even when test performance between or within a racial or ethnic group differs according to such factors, neuropsychological assessment is still critical for determining baseline performance levels from which to gauge subsequent cognitive change and decline; to understand cognition-related physical and mental health, including brain injuries and insults; and to guide diagnosis and treatment. Thus, for the interpretation of neuropsychological test of racial/ethnic and other minority populations, it is critical to understand the extent of the sociodemographic associations for those populations.

A brief overview of the unique history and sociocultural context of the American Indian and Alaska Native population contextualizes neuropsychological assessment with this population. American Indians and Alaska Natives collectively number 5.3 million people, comprising 1.7% of the U.S. population. The 573 federally recognized tribes (U.S. Department of the Interior: Indian Affairs, 2018) stem from ecologically diverse regions in the U.S. and have developed considerable variation in language, lifestyle, and cultural traditions. The American Community Survey codes 169 Native North American languages spoken at home with the number of speakers of these languages being estimated at less than half a million (U.S. Census Bureau, 2011).

Although significant variation in culture continues among tribes, in the context of the larger U.S. society, tribes share a sociopolitical history that has resulted in understudied and underserved populations (American Psychological Association, 2005). Due in part to this shared sociopolitical history, various sociocultural factors experienced by American Indians/Alaska Natives may also be associated with neuropsychological test performance including socioeconomic status, education, and language use. While they exist in all socioeconomic categories in the U.S., American Indians and Alaska Natives suffer disproportionately in terms of poverty, unemployment, and inadequate housing with many living in third-world poverty conditions (U.S. Census Bureau, 2010). Similarly, this population is represented across a wide-range of education levels, yet educational disparities are evident including a lower high school graduation rate compared to the general U.S. population (71% vs 80%). Further, the education of American Indians and Alaska Natives includes a traumatic and unique history: U.S. policies supported a system of government run boarding schools aimed at assimilating Native people through forced removal of children from families and tribes and through reported abuses of many Native schoolchildren (Lomawaima & McCarty, 2005). Older American Indians and Alaska Natives may have learned their tribal language first and English when starting school, and they may retain both languages throughout their lives leading to a possible confound of bilingualism in neuropsychological assessment (Bialystok, Craik, & Luk, 2008). Further, the majority of Native languages are either oral only languages or have very little written content resulting in the use of English-only assessments. Moreover, a long and continuing colonization process implemented through boarding schools, disempowerment, and relocation (American Psychological Association, 2005), as well the serious medical and research abuses experienced by Native communities (Hodge, 2012), have left many tribes and Native peoples mistrustful of U.S. institutions, including health, mental health, and research institutions as well as healthcare and research professionals.

This cross-sectional study investigated the neuropsychological and motor function test performance and their associations with sociocultural factors in a cohort of older American Indians as part of an ongoing, population-based cohort study. Our aims were to 1) characterize the neuropsychological and motor test performance among older American Indians; 2) examine the associations of sociocultural factors with test performance; and 3) investigate the impact of sociocultural factors on test performance. Our hypotheses were that the various sociocultural factors would each be associated with test performance and, after accounting for the other sociocultural and health factors, that age, sex, and Native American language use would have unique contributions to test performance. Because education and family income are closely linked (Glymour & Manly, 2008), we did not hypothesize unique contributions of these factors to test performance for these measures. Furthermore, as a part of a larger study of older American Indians, we did not set out to provide normative data for this population, yet this descriptive study and our findings may be helpful to clinicians and researchers working with Native populations. Our findings from examinations of basic associations between neuropsychological and motor functions with common socioeconomic factors may be used to evaluate whether these are similar or different factors that influence cognitive performance in other populations.

METHODS

Participants

The Cerebrovascular Disease and its Consequences in American Indians (CDCAI) study was a cross-sectional examination of vascular brain injury among a normative aging sample of 1,033 American Indians aged 60 and older (Suchy-Dicey et al., 2016). CDCAI recruited participants from survivors from 11 of the 13 tribes of the Strong Heart Study, a longitudinal, normative cohort of aging American Indians in the U.S. Central Plains, Northern Plains and Southwest (Lee et al., 1990) to investigate cardiovascular disease and its risk factors in American Indians. The original cohort recruited tribes from these regions to provide a sample of American Indians with diverse cultural practices, language, economic and cultural resources, and living conditions ranging from rural communities to communities close to large metropolitan centers. As part of the original Strong Heart Study enrollment criteria, participants were included if they maintained their tribal affiliation or community attachment and were fluent in English. Of the 1,033 older American Indians enrolled in the current study, 215 participants completed examinations but were removed from analyses because one community withdrew consent to use their data, leaving a total analytic sample of 818. Only those able to complete a brain magnetic resonance imaging (MRI) and other study examination procedures were eligible for inclusion. Participants were excluded if they had (1) prior surgery for a cerebral aneurysm; (2) an implanted cardiac pacemaker, defibrillator, or artificial heart; (3) contraindicating metal prostheses; (4) a cochlear implant, spinal cord stimulator, or other internal electrical device; (5) a history of employment as a metal worker (given the possibility of retained metal fragments, especially near the eyes); (6) a weight of 350 pounds or more; or (7) the physical or cognitive inability to complete study procedures (Suchy-Dicey et al., 2016). Tribal councils, the Indian Health Service, and Institutional Review Boards for the participating universities approved all study procedures, and all participants provided written informed consent.

CDCAI participants completed questionnaires on demographics, health behaviors, and language use. They self-reported year of birth, sex, marital status, education level, annual income, alcohol use, lifetime tobacco smoking (yes/no), current tobacco use (number of packs per year), and fluency in speaking their traditional Native (“tribal”) language. Because English-speaking capacity was an eligibility criterion to participate, Native language-speaking capacity represented bilingual status. One participant, who used a language other than English or a Native language at home, was excluded from analyses. Participants underwent cranial MRI, electrocardiograms, and physical function assessments; self-reported their clinical health and medical history; and submitted blood samples for laboratory assay (Suchy-Dicey et al., 2016).

Neuropsychological Assessments & Motor Function Tests

Since CDCAI participants were older and often frail, study procedures were subject to considerable time constraints. The battery of cognitive measures was selected to include instruments that were used in other large studies of MRI-defined vascular brain injury and that could be administered rapidly in community settings (Arnold et al., 2005; Rosamond et al., 1999). The brief neuropsychological battery included the Modified Mini Mental State (3MS) test, California Verbal Learning Test, Coding test, Controlled Oral Word Association, Finger Tapping Test (FTT), and Grip Strength Test.

The Modified Mini-Mental State (3MS), an expanded version of the Mini-Mental Status Examination, is a global cognitive screening measure developed to reduce ceiling effects and improve sensitivity to change over time (Teng & Chang Chui, 1987). It consists of 40 questions and is scored on a 100-point scale.

The California Verbal and Learning Test-II Short Form (CVLT-II SF) provides several indices of verbal learning and memory (Delis, Kramer, Kaplan, & Ober, 2000). A list of nine words from three semantic categories is presented over four learning trials, and participants are asked to repeat as many words as possible after each trial. Memory indices include short-term recall (30-second delay), long-term recall (10-minute delay), cued memory, and a recognition discriminability score.

The Coding Test is a subtest of the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV) (Wechsler, 2008) that measures visuospatial processing speed and working memory. Along with the 3MS, the Coding subtest (termed the Digit Symbol Test in previous WAIS versions) has been a primary screening measure for cognitive functioning used by the Community Health Survey (Lopez et al., 2003). Respondents are asked to pair a set of symbols with specific numbers (1–9) within a span of 120 seconds. Scoring is based on the total number of symbols coded correctly with a range from 0 to 135.

The Controlled Oral Word Association (COWA) is a widely used measure of phonemic verbal fluency that also provides an index of executive functioning (Benton & Hansher, 1976). In three successive 1-minute trials, participants are asked to say as many words as possible that begin with the letter F, then A, and finally S. A total score is derived from the summation of the three trials and may range from 0 to over 53.

The Finger Tapping Test (FTT) is a test of motor dexterity (Halstead, 1947) that has been used as an index of laterality and hemispheric dysfunction. Respondents are asked to tap the index finger as quickly as possible over five 10-second trials. We measured performance by using the Lafayette Finger Tapping instrument, model 32726 (Lafayette Instrument Company, 2002) and obtained a score by averaging the number of taps per trial for each participant.

The Grip Strength Test is a measure of gross physical strength that has been used as an index of laterality and hemispheric dysfunction (Reitan & Wolfson, 1993). We assessed grip strength in kg by using the Jamar Hydraulic Hand Dynamometer (Patterson Medical) and averaged the results of three trials for each hand.

Analytic Strategy

We performed descriptive analyses to determine means, standard deviations, counts, and percentages for all participant characteristics and for the raw scores of the neuropsychological cognitive tests; we stratified the cognitive results by age, sex, education level, socioeconomic status, and Native language use. Two-way ANOVA with F-test across ordered categories was used to assess effect size in association as well as statistical significance. Effect size from ANOVA models was reported as eta-squared (η^2), or the proportion of variability in the dependent variable (neuropsychological or functional test) that is explained by each independent variable (age, sex, education, income, or language). In the event that η^2 was calculated as <0.01, it was reported as 0.00; if the point estimate was very close to zero, the lower bound of the confidence interval was not reported. Linear regression models were then used to evaluate the degree of association of demographic and sociocultural variables with cognitive and physical functioning measures, independent of other *a priori* stated confounding factors. Such adjustments included age, sex, education, income, Native language speaking capacity, history of tobacco use, history of alcohol use, and self-reported diabetes, high blood pressure, prior coronary heart failure, prior heart attack, and prior stroke. All analyses were performed by using Stata v.11–13 (StataCorp, 2013).

RESULTS

Descriptive Analyses

The median age of participants was 72 years for women and 71 years for men, and most were women (67.8%) (Table 1). Educational attainment varied widely; notably, 20.9% of women and 17.5% of men reported an 11^{th} grade education or less. Household income was typically low, with 28.6% of all participants reporting annual household incomes under $10,000 and 19.3% reporting more than $35,000. Fluency in Native languages also varied widely with 32.0% reporting speaking "Not at all" to 26.7% speaking "Very well."

Participants reported a range of alcohol use from lifetime abstinence (24%) to a drink or more in the last week (8%). Approximately two thirds of the participants report smoking cigarettes with an average tobacco use of 11 packs per year for women and 19 for men. A majority of participants reported high blood pressure (73%) or diabetes (52%). Cardiovascular disease was also prevalent, with 8% reporting prior coronary heart failure and 8% prior stroke.

In neuropsychological and motor function raw test score summations, stratified by age categories (Table 2), the 3MS, CVLT-II SF indices, Coding, COWA, finger tapping, and Grip strength were all associated with age, with poorer testing performance being associated with older age (at $p \leq 0.005$ or less). Coding was most affected by age yielding a medium effect size ($\eta^2 = 0.18$) in decline across the age groups. Small effect sizes for age were found for the 3MS Total Score, all CVLT-II SF indices, COWA, and Finger tap ($\eta^2 = 0.02$ to 0.08).

In neuropsychological and motor function test score summations, stratified by sex (Table 3), women and men scored similarly on the 3MS with an average score of 84. Women scored higher on most of the CVLT-II SF indices then men, with a mean difference of 1.2 more words learned across the 4 trials, and small increases in the short delay free recall, long delay cued recall, and total recognition discriminability scores ($\eta^2 = 0.01$ for all CVLT-II SF indices). Men scored significantly higher than women on both motor tests, with a mean difference of almost 6 taps across the 5 FTT trials, and almost 14 kg higher grip strength.

Tables 4 presents neuropsychological test scores according to education, income, and Native language speaking capacity. All tests were associated with both education and income level. Higher categories of education or income were associated with better performance on neuropsychological tests. Education had the largest effects on 3MS, Coding, and COWA ($\eta^2 = 0.17$ to 0.19), while income had the largest effect on Coding ($\eta^2 = 0.11$). Most test scores were also associated with Native language use, with the exception of the CVLT-II SF Total Recognition Discriminability score and FFT. In general, more proficient speakers of Native languages performed less well on tests, including those related to non-verbal cognitive and physical functioning, such as Coding and grip strength (η^2 ranged from 0.02 to 0.07).

Compared with unadjusted results, adjustment for age, sex, education, income, Native language speaking capacity, smoking more than 100 cigarettes in lifetime, any lifetime alcohol use, and self-reported diabetes, high blood pressure, heart failure, heart attack, and stroke in models of 3MS, Coding, COWA, and CVLT-II SF short and long delay free recall tests did not alter our findings (Table 5). Older age, male sex, less education, lower income, and more Native speaking capacity were each associated with lower test scores, independent of other sociocultural and health factors. CVLT-II SF short and long delay free recall scores were also not associated with Native language speaking capacity.

DISCUSSION

This study aimed to characterize the neuropsychological and motor test performance among older American Indians. It includes the largest population-based normative aging sample of American Indians (*n*=818) assessed using standard tests of neuropsychological and motor performance. Participants aged 60 and older, completed neuropsychological tests of general cognitive functioning, verbal learning and memory, processing speed, and phonemic fluency, as well as motor function tests of dexterity and grip strength. All scores in both neuropsychological and physical functioning categories were associated with sex, age, socioeconomic, and sociocultural factors. Additionally, our findings highlight the range and distribution of test scores as well as socioeconomic and sociocultural factors in this population. Moreover, consistent with our hypotheses, age, sex, education, income, and Native American language use all had significant associations to the test scores after accounting for other sociocultural and health factors. Overall, our findings suggest that the group under study is one whose members may have multiple sociocultural factors associated with their individual neuropsychological test score rendering less confidence in the interpretation of the score when compared to normative data for diagnostic and treatment purposes. The significant associations between the neuropsychological and motor test performance and all demographic and sociocultural variables in addition to the lack of normative data underscore why researchers should be cautious when interpreting results from existing studies that have used these instruments, especially in clinical diagnosis. Our findings highlight the need to better understand the role of these factors in assessing cognitive functioning in this population.

Our study cohort represented a wide range of education levels, annual incomes, and language use. According to our adjusted mean scores (Table 5), participants who scored higher on neuropsychological and motor tests were younger, more educated, had higher incomes, and had less Native language speaking capacity after controlling for other sociocultural and health factors. Our findings of the associations of age, sex, education, income, and language with neuropsychological tests in older American Indians parallel similar associations reported in the neuropsychological testing literature with non-Hispanic White populations; such similar associations indicate that these measures tap into the same cognitive constructs for American Indians as they do for non-Hispanic White populations. Interestingly, the CVLT-II SF appeared to be less affected by sociocultural factors than the other tests. This variation may suggest that the CVLT-II SF is more culturally congruent with the American Indian population or that this is a finding specific to our sample. While our data may be of use to clinicians and researchers working with American Indians, we caution that this population is extremely culturally diverse, such that a single normative dataset has limited utility. Indeed, the deconstruction of race and education may provide more clarification of racial/ethnic group differences than the use of normative data for specific racial/ethnic groups (Manly, 2005).

Our study does not represent nor was designed to produce a normative study of neuropsychological test performance in older American Indians. Our CDCAI cohort is part of a larger longitudinal cardiovascular study, the Strong Heart Study, investigating the risk factors for cardiovascular and cerebrovascular disease. American Indians have elevated risks for these and related disease; thus, this is a sample at high risk for diseases that may affect cognitive performance. Approximately 25 years after the original Strong Heart Study, over 3000 participants did not survive to be assessed in the CDCAI study, thus, the data are susceptible to survivor bias. In addition, the American Indian population is diverse in culture, language, tribal governments and services across 573 tribes. While our sample includes 11 tribes from 3 geographic regions, it does not capture the diversity within the Native population overall. Further, our analyses aimed to investigate associations between a few select sociocultural factors (education level, income, language) and neuropsychological performance; the associations among combinations of demographic variables and neuropsychological performance remain unknown. Thus, our study investigated of the impact of sociocultural factors on neuropsychological scores that is needed prior to the development of appropriate normative data for older American Indians, as well as furthering the deconstruction of race in this population.

Differences in tests of cognitive function have consistently been found between older members of ethnic minority groups and older non-Hispanic Whites, even after accounting for education, sex, and other sociodemographic factors (Longebardi, Cummings, & Anderson-Hanley, 2000; Manly et al., 1998; Mindt, Arentoft, Coulehan, & Byrd, 2013). Similar to our findings, a study of a large community sample of multi-ethnic older individuals reported significant associations between cognitive tests and various sociodemographic indices including age, race/ethnicity, education, occupational status, household income, health insurance type, household size, place of birth, years, generation in the U.S., and presence of *APOE* ε4 allele (Fitzpatrick et al., 2015). Ethnic minority populations are vulnerable to misdiagnosis of neurocognitive disorders because available assessment tools are inadequately specific (Manly, 2006; Mindt et al., 2013). A better understanding of relevant demographic and sociocultural factors is essential to improving the accuracy of neuropsychological assessment in older American Indians.

Sociocultural Factors

Age.—Consistent with the vast literature on cognition and aging (e.g., Lezak, Howieson, Bigler, & Tranel, 2012), cognitive scores in our study sample declined with increasing age on the all cognitive and motor tests (Table 2). After adjusting for other social, demographic, cultural, and health variables, Coding was significantly associated with all levels of age group compared to the referent category (60–70 years), suggesting a steady decline in processing speed with age (Table 5). For the 3MS and COWA, the 60–69-year-old participants scored significantly higher than the 75–79 and 80+ year age groups. This pattern suggests a notable decline in general cognition and phonemic fluency after 75 years. However, after accounting for other confounding variables, both the CVLT-II SF short and long delay free recall evidenced no decline from the 60–69-year age group until 80+ years suggesting that verbal memory performance remained stable through 80 years for American Indians in our study (Table 5). This finding is in contrast to published norms on the CVLT

(Delis et al., 2000; Norman, Evans, Miller, & Heaton, 2000) and other verbal learning measures (Mitrushina et al., 2005), which have reported more prominent age effects than we observed in our sample. However, our cohort, which was derived from the parent Strong Heart Study, may be susceptible to selection and survival bias (Muller et al., Manuscript in preparation).

Sex.—No sex differences were found on the 3MS, Coding, COWA, or CVLT-II SF (see Table 3). Consistent with the extensive literature on sex differences in motor function tests (Mitrushina et al., 2005), men in our cohort scored higher than women on the FTT and Grip Strength tests (Table 3). In contrast to the unadjusted models for the Coding, COWA, and the CVLT-II SF short and long delay free recall, adjusting for other social demographic, cultural, and health variables resulted in differences by sex with women scoring significantly higher than men (Table 5).

Education.—Level of education showed a positive association with all neuropsychological and motor measures (Table 4). After adjusting for other social demographic, cultural, and health variables in the adjusted model, we determined that the 3MS, Coding, COWA, and CVLT-II SF short and long delay free recall tests were positively associated with education. In brief, those with higher education levels had higher scores than the referent category of "up to 11th grade" (Table 5). One exception was noted in which the referent category was similar to the highest education category, "BA/BS and beyond," suggesting that other confounding variables accounted for the difference reported in the unadjusted means (Table 4). Notable in our study is the large proportion of participants with less than a high school education, a factor that highlights the impact of education on the cognitive domains we assessed. Our findings on education are consistent with those from a smaller study of sociocultural factors and dementia in American Indians aged 60 and older (n=137) (Jervis et al., 2010). These authors found that better performance on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975), and the Dementia Rating Scale-Second Edition (Jurica, Leittan, & Mattis, 2001) was associated with higher education, non-receipt of Supplemental Social Security Income, and frequent healthcare needs. Also, older American Indians who attended American Indian boarding schools had better performance on the latter scale than did older American Indians who had not (Jervis et al., 2010).

The quality of education is also likely to affect test performance. For example, in older African Americans, the effects of race on most neuropsychological measures diminish after accounting for quality of education, as measured by reading achievement scores (Manly, Jacobs, Touradji, Small, & Stern, 2002). The educational histories of American Indians and Alaska Natives, especially those born before 1960, have been unique and sometimes highly traumatic. Their experiences were shaped by former U.S. policies, which instituted forced removal and relocation of Native children to military-style boarding schools or forced attendance at local day schools operated by the Bureau of Indian Affairs (Verney et al., 2015). Members of our study cohort, who attended primary and secondary school in the mid-twentieth century, had a wide range of educational backgrounds that were typically substandard relative to those of non-Hispanic Whites. This history likely influences neuropsychological performance in later life. Unfortunately, no research addressing the potential effects of educational quality on neuropsychological assessment has been conducted in American Indians or Alaska Natives.

Socioeconomic Status.—In contrast to our prediction that education and socioeconomic status would not yield significant associations with test scores for each factor when accounting for the other factor, both education and socioeconomic status were significantly associated with neuropsychological test scores after accounting for other sociocultural factors. Higher household income was associated with higher scores on all neuropsychological and motor measures (Table 4). As noted above, our study cohort collectively reported relatively low incomes, consistent with national data that demonstrate disproportionate levels of poverty and unemployment among American Indians. Low income among American Indians is associated with adverse home environments as well as negative geographic factors that can affect neuropsychological test performance (Suzuki, Naqvi, & Hill, 2013). In the adjusted model, the 3MS, Coding, and COWA tests were significantly associated with income; that is, individuals with higher income, >$35,000, achieved higher test scores than those in the lowest income category, <$10,000 per year (Table 5). However, verbal memory scores, as measured by the CVLT-II SF short and long delay free recall, remained similar from the referent category to the $20-$35,000 per year category. Income, after controlling for other confounding variables, had no effect on these verbal memory scores until those in the highest category were compared to those in the referent category.

Language.—Because fluency in English was a requirement for participation in the original Strong Heart Study, the ability to speak a Native language indicates at least a minimum level of bilingualism in our cohort. Native speaking capacity was associated with neuropsychological and motor measures, with the exception of the CVLT-II SF short delay free recall and total recognition discriminability scores and the FFT (Table 4). After adjusting for other social demographic, cultural, and health variables, we concluded that the associations between 3MS, Coding, and COWA tests with Native language use were those in the referent “not at all” Native language category compared to those in the “very well” category (Table 5). Interestingly, the CVLT-II SF short and long delay free recall tests were not associated with Native language use, even though this is a verbally oriented task (Table 5). All participants, regardless of Native language speaking capacity, performed similarly on a verbal memory test after we controlled for other sociodemographic, cultural, and health variables. Hence, bilingualism did not influence verbal memory performance in our study.

The inverse relationship between Native language ability and actual test performance, especially on the 3MS, Coding, and COWA, has at least two possible explanations: either the tests included unmeasured confounding factors, or are written in English are not well suited for speakers of Native languages- even those who are considered fluent in English. Bilingualism may offer cognitive advantages, including favorable executive functioning (Bialystok, Craik, & Luk, 2008; Prior & MacWhinney, 2010). Conversely, when they are tested in their non-dominant language, bilinguals may be at a disadvantage. This drawback does not mean that bilinguals, and in our sample, Native bilinguals, are slow to process or cognitively impaired. However, it does suggest that these tests may be less accurate for bilingual individuals. As noted above, American Indians and Alaska Natives vary widely in language use, and a vast majority of Native American languages are either exclusively oral or rarely written. Such a diversity of language-related issues presents a serious challenge to valid neuropsychological assessment in this population.

Limitations

This cross-sectional study has several limitations. First, the assessment tools we used may have questionable cultural congruence and have not been validated in American Indians; however, this study provides a better understanding of the demographic and sociocultural associations with test performance. The comprehensive nature of the larger study with various medical, MRI, and functional assessments and the advanced ages of study participants placed substantial time constraints on formal assessments and other data collection efforts. Furthermore, we were limited in the comprehensiveness of our test battery owing to the time limitations of the CDCAI study. Although our study population includes a well-defined and geographically diverse group of American Indians residing in 11 tribal communities in 3 U.S. regions, our results might not be representative of other tribal populations or individuals from younger age groups. Study recruitment was also limited to survivors of an ongoing 20+ year cohort; thus, selection pressures may affect our findings, notably through loss of the sickest or most incapacitated individuals (Muller et al., Manuscript in preparation).

Directions for Culturally Appropriate Future Research

Given the vast geographic and cultural diversity of American Indian and Alaska Native populations in general, the cultural considerations in working with these groups are substantial. Further, the long, complex history of Native peoples in North America has rendered many segments of the Native population marginalized, apprehensive, and vulnerable. Yet, the scientific literature on cognitive functioning among American Indians and Alaska Natives is sparse but essential (Verney et al., 2015). The success of future research on cognition in American Indians and Alaska Natives will depend on several factors. First, existing tests should be assessed for validity in this population. Our findings indicate that American Indians who commonly speak a Native language or who belong to the lowest categories of income and educational attainment perform below normative standards. Yet, importantly, their performance might reflect test bias due to sociocultural factors rather than actual functioning. Second, the diagnostic and predictive effectiveness of these tests should be thoroughly investigated with regard to sociocultural issues. Third, new cognitive test batteries or even brief screening protocols should be developed that are less influenced by sociocultural factors than current standardized tests and should incorporate existing technological advances such as information processing approaches and psychophysiological indices (Verney, Granholm, Marshall, Malcarne, & Saccuzzo, 2005). Information processing tasks that tap into early stages of cognitive processing should merge with a psychophysiological measure that reflects the cognitive process more directly, implicitly, and in a way that behavioral measures such as standardized testing measure processes favor (Verney & Ellwanger, 2014). For example, a measure of higher-order processing, the Wechsler Adult Intelligence Scale –Revised (WAIS-R), was compared to efficiency of early stages of information processing using a psychophysiological measure, pupillary dilation response, in conjunction with an information processing task, the visual backward masking task; this comparison was done in order to investigate the validity of this standardized IQ measure with ethnic minority and non-Hispanic White students. Documented differences between early- and higher-order processing suggest that a cultural component exists in this cognitive ability measure that could lessen researchers' confidence in the interpretation of the score of ethnic minority students (Verney, Granholm, Marshall, Malcarne, & Saccuzzo, 2005). Fourth, recent research on racial disparities in cognitive aging calls for a better understanding of the life course of individuals (Glymour & Manly, 2008; Manly & Mungas, 2015). That is, researchers need to know how early educational and socioeconomic factors affect cognition in later life. Native populations have faced and survived a variety of hardships and challenges in the U.S., and such early life experiences likely affect cognitive functioning in later life. Finally, we advocate the development of indigenous models of cognition, mental health, and dementia, which might lead to optimized, novel methods of cognitive and mental health assessment for American Indians and Alaska Natives. Indigenous methodologies (Smith, 2013) may be used to represent the knowledge and viewpoints of indigenous peoples, which may then drive the development of novel assessments that reflect their cultural values and priorities of assessing cognitive processes. In addition, current tests that measure creative problem solving (Kaufman, 2006), that are novel and limit the use of language, may reveal cognitive processes not tapped by standardized batteries. For example, the Porteus Maze Test (Porteus, 1965), which relies on planning and foresight, appeared useful among American Indian/Alaska Native adults (Gardiner, Tansley, & Ertz, 2002) as clinical samples excelled on this particular task in contrast to the individuals' low scores on other neuropsychological tests. Verney and colleagues (2015) offer other recommendations for conducting neuropsychological assessments in this population. The existing neuropsychological assessment industry is likely to face difficult circumstances when its current assessment products are utilized in American Indian populations.

Conclusions

This study characterized the neuropsychological and motor function assessments in older American Indians by investigating the associations among sociocultural factors and neuropsychological and motor test performance in a brief battery of standardized tests. We provide an overview of the sociocultural factors that must be considered when conducting such research, as well as suggestions for implementing this work with American Indians, Alaska Natives, and potentially other indigenous populations. Standard neuropsychological test performance in older American Indians are impacted by sociocultural factors. Nonetheless, these tools still have value for identifying individual cognitive strengths and weaknesses, for establishing baseline measures to gauge possible cognitive decline over time, and for understanding associations between neuropsychological assessments and physical and mental health-related diagnoses.

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Public Significance Statement

American Indians vary considerably in language, lifestyle, cultural traditions, and sociopolitical history; additionally, little is known about neuropsychological performance in this population. This study suggests that demographic and sociocultural factors are associated with neuropsychological test performance in older American Indians after accounting for other sociocultural and health factors. Clinical and research implications are offered as well as directions for culturally appropriate research in this population.

Table 1.

Selected participant characteristics (sample number, percentile)

		Female N=555	Male N=263
Age, categories	60–69 years	194 (35.0%)	86 (32.7%)
	70–74 years	165 (29.7%)	92 (35.0%)
	75–79 years	105 (18.9%)	55 (20.9%)
	80+ years	91 (16.4%)	30 (11.4%)
Education	Up to 11th grade	116 (20.9%)	46 (17.5%)
	Graduated HS	141 (25.4%)	69 (26.2%)
	Any college	221 (39.8%)	101 (38.4%)
	College (BA/BS) +	77 (13.9%)	47 (17.9%)
Annual Household Income	<$10,000	184 (33.2%)	67 (25.5%)
	$10–20,000	175 (31.5%)	59 (22.4%)
	$20–35,000	111 (20.0%)	64 (24.3%)
	>$35,000	85 (15.3%)	73 (27.8%)
Capacity to speak Native ("tribal") language	Not at all	178 (32.1%)	84 (32.1%)
	A little	147 (26.5%)	88 (33.6%)
	Moderately	73 (13.2%)	28 (10.7%)
	Very well	157 (28.3%)	62 (23.7%)
Alcohol use	Never drinker	175 (31.5%)	25 (9.5%)
	No drink in past year	312 (56.2%)	163 (62.0%)
	Last drink 1 mo.−1 year ago	23 (4.1%)	7 (2.7%)
	Last drink 1 week-1 mo. ago	19 (3.4%)	29 (11.0%)
	Last drink within past week	26 (4.7%)	39 (14.8%)
Tobacco use	Ever smoked >100 cigarettes	327 (58.9%)	213 (81.0%)
Tobacco use, pack years	Mean (SD)	11.0 (20.7)	19.3 (30.8)
High blood pressure	Self-report	408 (73.5%)	192 (73.0%)
Diabetes	Self-report	292 (52.6%)	134 (51.0%)
Congestive heart failure	Self-report	56 (10.1%)	10 (3.8%)
Heart attack		58 (10.5%)	52 (19.8%)
Stroke	Self-report	49 (8.8%)	20 (7.6%)

Notes: IQR = interquartile range.

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Table 2.

Test scores by age categories (raw score means and standard deviations)

Tests	Age Categories					
	60–69 years N=280	**70–74 years N=257**	**75–79 years N=160**	**80+ years N=121**	***η^2 (95% CI)***	***P-value***
3MS, Total Score	91.0 (6.31)	89.2 (9.3)	86.7 (9.2)	83.1 (12.1)	*0.08 (0.05, 0.12)*	*<0.001*
CVLT-II SF						
Total Learned, Words	23.5 (5.1)	22.7 (5.2)	22.3 (4.6)	20.9 (5.9)	*0.03 (0.01, 0.,05)*	*<0.001*
Short Delay Free Recall, Words	6.2 (1.9)	5.9 (2.0)	5.9 (2.0)	5.4 (2.3)	*0.02 (0.00, 0.03)*	*0.005*
Long Delay Free Recall, Words	5.8 (2.2)	5.5 (2.1)	5.4 (2.3)	4.7 (2.4)	*0.03 (0.01, 0.05)*	*<0.001*
Long Delay Cued Recall, Words	6.3 (1.0)	6.0 (2.0)	5.8 (2.0)	5.4 (2.2)	*0.02 (0.00, 0.04)*	*<0.001*
Total Recognition Discriminability, Score	2.6 (0.8)	2.7 (0.7)	2.5 (0.8)	2.4 (0.8)	*0.02 (0.00, 0.04)*	*<0.001*
WAIS Coding, Total Score	51.7 (14.0)	44.2 (15.3)	39.1 (13.8)	32.1 (14.4)	*0.18 (0.14, 0.23)*	*<0.001*
COWA, Correct words	27.0 (10.4)	25.3 (11.8)	21.0 (10.9)	20.7 (11.7)	*0.05 (0.02, 0.08)*	*<0.001*
Finger tap, Dominant hand	37.3 (9.3)	35.3 (10.2)	33.6 (10.0)	31.2 (9.3)	*0.04 (0.02, 0.07)*	*<0.001*
Grip strength, Dominant hand	26.8 (9.3)	25.9 (9.5)	23.5 (9.3)	19.9 (8.3)	*0.06 (0.03, 0.09)*	*<0.001*

Notes: 3MS= Modified Mini Mental State; Coding = WAIS -IV Coding; COWA = Controlled Oral Word Test; FTT = Finger Tapping Test; CVLT-II SF = California Verbal Learning Test – 2nd edition Short Form. P-values represent test from Analysis of Variance (ANOVA), with effect size given as eta-squared (η^2) with 95% confidence interval (95% CI).

Table 3.

Test scores by sex (raw score means and standard deviations)

	Female	Male		
	N=555	**N=263**	***η^2 (95% CI)***	***P-value***
3MSE, Total Cognitive Score	88.4 (9.4)	88.5 (9.06)	*0.00 (− , 0.01)*	*0.81*
CVLT-II Short Form				
Total Learned, Words	23.0 (5.0)	21.8 (5.5)	*0.01 (0.00, 0.03)*	*0.003*
Short Delay Free Recall, Words	6.1 (2.0)	5.6 (2.1)	*0.01 (0.00, 0.03)*	*0.003*
Long Delay Free Recall, Words	5.6 (2.3)	5.2 (2.2)	*0.01 (0.00, 0.02)*	*0.021*
Long Delay Cued Recall, Words	6.1 (2.0)	5.7 (2.1)	*0.01 (0.00, 0.02)*	*0.023*
Total Recognition Discriminability, Score	2.6 (0.7)	2.5 (0.8)	*0.01 (0.00, 0.03)*	*0.006*
WAIS Coding, Total Score	44.5 (16.3)	43.0 (14.8)	*0.00 (− , 0.01)*	*0.19*
COWA, Correct words	24.9 (11.4)	23.4 (11.4)	*0.00 (− , 0.02)*	*0.086*
Finger tap, Dominant hand	33.1 (9.4)	38.9 (9.9)	*0.07 (0.04, 0.11)*	*<0.001*
Grip strength, Dominant hand	20.5 (6.2)	34.0 (8.8)	*0.44 (0.39, 0.48)*	*<0.001*

Notes: 3MS= Modified Mini Mental State; Coding = WAIS-IV Coding; COWA = Controlled Oral Word Test; FTT = Finger Tapping Test; CVLT-II SF = California Verbal Learning Test – 2nd edition Short Form. P-values represent test from Analysis of Variance (ANOVA), with effect size given as eta-squared (η^2) with 95% confidence interval (95% CI).

Table 4.

Test scores by education, household income, and Native (“tribal”) language speaking capacity (raw score means and standard deviations)

	Education					
	Up to 11th grade N=162	**Graduated HS N=210**	**Any college N=322**	**College (BA/BS) + N=124**	***η^2 (95% CI)***	***P-value***
3MS, Total Score	80.8 (11.5)	88.8 (7.0)	90.3 (8.1)	92.5 (6.6)	*0.18 (0.13, 0.22)*	*<0.001*
CVLT-II SF						
Total Learned, Words	20.3 (5.9)	22.8 (4.3)	23.0 (5.3)	24.3 (4.5)	*0.06 (0.03, 0.09)*	*<0.001*
Short Delay Free Recall, Words	5.2 (2.3)	6.1 (1.8)	6.0 (2.1)	6.2 (1.9)	*0.03 (0.01, 0.05)*	*<0.001*
Long Delay Free Recall, Words	4.8 (2.6)	5.6 (2.0)	5.6 (2.2)	5.6 (2.2)	*0.02 (0.00, 0.04)*	*<0.001*
Long Delay Cued Recall, Words	5.3 (2.4)	6.1 (1.8)	6.1 (2.0)	6.2 (1.8)	*0.03 (0.01, 0.05)*	*<0.001*
Total Recognition Discriminability, Score	2.3 (0.9)	2.7 (0.6)	2.6 (0.8)	2.7 (0.7)	*0.04 (0.01, 0.06)*	*<0.001*
WAIS Coding, Total Score	31.9 (14.2)	43.6 (14.4)	46.3 (14.6)	54.6 (14.0)	*0.19 (0.14, 0.23)*	*<0.001*
COWA, Correct words	16.4 (8.8)	23.1 (10.0)	26.5 (11.2)	31.3 (11.3)	*0.17 (0.12, 0.21)*	*<0.001*
Finger tap, Dominant hand	31.8 (9.2)	34.6 (9.4)	35.8 (10.4)	37.9 (9.4)	*0.04 (0.01, 0.06)*	*<0.001*
Grip strength, Dominant hand	21.6 (8.8)	24.0 (8.9)	25.7 (9.2)	28.4 (10.7)	*0.05 (0.02, 0.08)*	*<0.001*
	Annual Household Income					
	<$10,000 N=251	**$10–20,000 N=234**	**$20–35,000 N=175**	**>$30,000 N=158**	***η^2 (95% CI)***	***P-value***
3MS, Total Score	85.2 (10.8)	87.6 (9.6)	90.6 (7.2)	92.2 (5.4)	*0.08 (0.05 (0.12)*	*<0.001*
CVLT-II SF						
Total Learned, Words	21.3 (5.7)	22.3 (5.3)	23.6 (4.5)	24.1 (4.5)	*0.04 (0.02, 0.07)*	*<0.001*
Short Delay Free Recall, Words	5.6 (2.3)	5.8 (1.9)	6.1 (2.0)	6.4 (1.7)	*0.02 (0.00, 0.04)*	*<0.001*
Long Delay Free Recall, Words	5.1 (2.5)	5.4 (2.1)	5.6 (2.1)	5.9 (2.0)	*0.02 (0.00, 0.04)*	*0.002*
Long Delay Cued Recall, Words	5.6 (2.2)	5.9 (2.0)	6.2 (1.9)	6.5 (1.7)	*0.02 (0.00, 0.05)*	*<0.001*
Total Recognition Discriminability, Score	2.5 (0.8)	2.5 (0.8)	2.6 (0.7)	2.7 (0.7)	*0.02 (0.00, 0.03)*	*0.007*
WAIS Coding, Total Score	37.4 (16.2)	43.4 (14.2)	47.4 (15.1)	51.6 (14.3)	*0.11 (0.07, 0.15)*	*<0.001*
COWA, Correct words	20.5 (11.2)	23.3 (10.8)	27.4 (11.4)	28.8 (10.5)	*0.08 (0.05, 0.12)*	*<0.001*
Finger tap, Dominant hand	32.7 (10.2)	33.4 (9.6)	37.0 (9.7)	39.0 (8.8)	*0.06 (0.03, 0.10)*	*<0.001*
Grip strength, Dominant hand	22.3 (9.3)	23.6 (8.6)	26.0 (9.2)	29.6 (9.7)	*0.08 (0.04, 0.11)*	*<0.001*

	Education					
	Up to 11th grade N=162	**Graduated HS N=210**	**Any college N=322**	**College (BA/BS) + N=124**	***η^2 (95% CI)***	***P-value***
	Native ("tribal") language speaking capacity					
	Not at all N=262	**A little N=235**	**Moderately N=101**	**Very well N=219**	***η^2 (95% CI)***	***P-value***
3MS, Total Score	90.3 (7.8)	89.0 (8.7)	88.4 (9.8)	85.4 (10.6)	*0.04 (0.02, 0.07)*	*<0.001*
CVLT-II SF						
Total Learned, Words	23.0 (5.0)	23.0 (4.8)	23.1 (5.1)	21.3 (5.8)	0.02 (0.00, 0.04)	<0.001
Short Delay Free Recall, Words	6.0 (2.0)	6.0 (2.0)	6.2 (1.9)	5.7 (2.1)	0.01 (− , 0.02)	0.14
Long Delay Free Recall, Words	5.6 (2.2)	5.7 (2.2)	5.5 (2.1)	5.1 (2.4)	0.01 (− , 0.03)	0.036
Long Delay Cued Recall, Words	6.1 (2.0)	6.3 (1.9)	5.9 (2.0)	5.6 (2.1)	0.02 (0.00, 0.04)	0.003
Total Recognition Discriminability, Score	2.6 (0.8)	2.6 (0.7)	2.6 (0.8)	2.5 (0.8)	0.00 (− , 0.01)	0.57
WAIS Coding, Total Score	47.4 (14.4)	46.5 (15.4)	44.2 (15.3)	37.1 (16.4)	0.07 (0.04, 0.11)	<0.001
COWA, Correct words	26.0 (11.6)	25.1 (10.9)	27.5 (12.3)	20.3 (10.4)	0.05 (0.02, 0.08)	<0.001
Finger tap, Dominant hand	35.5 (9.9)	35.0 (9.8)	34.6 (10.3)	34.6 (10.0)	0.00 (− , 0.01)	0.76
Grip strength, Dominant hand	25.8 (9.3)	26.2 (9.6)	24.1 (9.0)	22.6 (9.6)	0.02 (0.01, 0.05)	<0.001

Notes: 3MS= Modified Mini Mental State; Coding = WAIS-IV Coding; COWA = Controlled Oral Word Test; FTT = Finger Tapping Test; CVLT-II SF = California Verbal Learning Test – 2nd edition Short Form. P-values represent test from Analysis of Variance (ANOVA), with effect size given as eta-squared (η^2) with 95% confidence interval (95% CI).

Table 5.

Adjusted regression models for test scores by demographic and sociocultural characteristics

		3MS	WAIS Coding	COWA	CVLT-II SF short delay free recall	CVLT-II SF long delay free recall	Finger tap	Grip strength
		β(95% CI)	β(95% CI)	β(95% CI)	β(95% CI)	β(95% CI)	β(95% CI)	β(95% CI)
Age	70–74 years	−0.8 (−2.0, 0.5)	−6.2 (−8.4, −4.0)***	−0.8 (−2.6, 0.9)	−0.1 (−0.4, 0.3)	−0.2 (−0.5, 0.2)	−2.1 (−0.5, −3.7)**	−1.2 (−0.02,−2.3)*
	75–79 years	−2.1 (−3.7, −0.6)*	−9.8 (−12.3, −7.3)***	−3.8 (−5.8, −1.8)***	−0.1 (−0.45, 0.3)	−0.2 (−0.7, 0.3)	−3.3 (−1.4, −5.2)***	−3.0 (−1.6, −4.3)***
	80+ years	−4.6 (−6.7, −2.4)***	−15.1 (−18.0, −12.1)***	−3.0 (−5.4, −0.6)**	−0.6 (−1.0, −0.1)*	−0.8 (−1.3, −0.2)**	−5.0 (−2.9, −7.1)***	−4.7 (−3.3, −6.1)***
Sex	Male	−1.1 (−2.4, 0.1)	−3.1 (−5.1, −1.1)***	−2.7 (−4.3, −1.1)***	−0.6 (−1.0, −0.3)***	−0.6 (−1.0, −0.3)***	5.0 (3.5, 6.5)***	12.9 (11.7, 14.1)***
Education	Graduated HS	6.5 (4.5, 8.6)***	7.4 (4.5, 10.2)***	4.8 (2.8, 6.8)***	0.7 (0.3, 1.2)***	0.6 (0.1, 1.1)*	1.7 (−0.3, 3.6)	0.4 (−1.1, 1.8)
	Any college	7.8 (5.7, 9.9)***	9.3 (6.6, 12.0)***	7.8 (5.8, 9.8)***	0.6 (0.1, 1.0)*	0.6 (0.1, 1.0)*	2.3 (0.5, 4.2)*	2.1 (0.8, 3.4)**
	BA/BS +	9.3 (7.0, 11.5)***	16.5 (13.2, 19.8)***	11.6 (9.0, 14.2)***	0.6 (0.1, 1.2)*	0.4 (−0.3, 1.0)	3.1 (0.7, 5.4)*	3.2 (1.3, 5.0)***
Annual	$10–20,000	0.3 (−1.4, 2.0)	2.2 (−0.2, 4.6)	0.4 (−1.4, 2.3)	0.2 (−0.2, 0.5)	0.2 (−0.3, 0.6)	0.5 (−1.3, 2.3)	0.6 (−0.6, 1.8)
Household	$20–35,000	1.7 (0.0, 3.5)*	3.63 (0.86, 6.41)**	2.7 (0.5, 4.9)*	0.4 (−1.0, 0.8)	0.3 (−0.2, 0.8)	3.1 (1.1, 5.1)**	0.8 (−0.6, 2.1)
Income	>$35,000	2.6 (0.6, 4.2)**	4.34 (1.41, 7.26)***	2.7 (0.4, 4.9)*	0.6 (0.2, 1.1)**	0.6 (0.1, 1.1)*	3.6 (1.5, 5.7)***	2.1 (0.6, 3.6)**
Native	A little	−1.1 (−2.5, 0.2)	−0.8 (−2.9, 1.5)	−0.8 (−2.6, 0.9)	0.1 (−0.3, 0.4)	0.2 (−0.2, 0.5)	−0.4 (−2.0,1.2)	−0.2 (−1.3, 0.9)
Language	Moderately	−1.6 (−3.5, 0.4)	−2.03 (−5.07, 1)	1.8 (−0.92, 4.5)	0.3 (−0.2, 0.7)	0.0 (−0.5, 0.5)	0.3 (−1.9, 2.5)	−0.5 (−1.9, 0.9)
Capacity	Very well	−2.0 (−3.6, −0.4)**	−5.1 (−7.6, −2.6)***	−3.2 (−5.1, −1.2)***	0.0 (−0.4, 0.4)	−0.1 (−0.6, 0.3)	1.7 (−0.2, 3.6)	−1.0 (−2.3, 0.3)

Notes: Referent categories: Age = 60–69 years; Sex = female; Education = <11th grade; Annual household income; <$10,000; Native language speaking capacity = not at all. Models mutually adjusted: age categories (4 levels); sex; education categories (4 levels); income (4 levels); Native (tribal) language use (4 levels); smoking more than 100 cigarettes (lifetime); drinking alcohol (ever); and self-reported diabetes, high blood pressure, coronary heart failure, or stroke. 3MS= Modified Mini Mental State; Coding = WAIS-IV Coding; COWA = Controlled Oral Word Test; CVLT-II SF = California Verbal Learning Test – 2nd edition Short Form. Negative coefficients indicate a decrease in scores and positive values indicate an increase in scores. Significant P-values denoted using

* <0.05

** <0.01

*** <0.001