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Socioeconomic status and neuropsychological functioning: Associations in an ethnically diverse HIV+ cohort

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Abstract

Objective—There is limited research examining the relationship between socioeconomic status (SES) and neuropsychological functioning, particularly in racial/ethnic minority and HIV+ populations. However, there are complex associations between poverty, education, HIV disease, race/ethnicity, and health outcomes in the US.

Method—We explored these relationships among an ethnically diverse sample of 134 HIV+ adults using a standardized SES measure (i.e., the Hollingshead scale), a comprehensive NP test battery, and a functional evaluation (i.e., Patient's Assessment of Own Functioning Inventory and Modified Instrumental Activities of Daily Living Scale).

Results—Bivariate analyses showed that adult SES was significantly, positively correlated with neuropsychological performance on specific tests within the domains of verbal fluency, attention/concentration, learning, memory, processing speed, and executive functioning, and childhood SES was significantly linked to measures of verbal fluency, processing speed, and executive functioning. In a series of linear regressions, controlling for SES significantly attenuated group differences in NP test scores between racial/ethnic minority individuals and non-Hispanic white individuals. Finally, SES scores significantly differed across HIV-Associated Neurocognitive Disorder (HAND) diagnoses. In a binary logistic regression, SES was the only independent predictor of HAND diagnosis.

Conclusions—HIV+ individuals with lower SES may be more vulnerable to HIV-associated neuropsychological sequelae due to prominent health disparities, although the degree to which this is influenced by factors such as test bias remains unclear. Overall, our results suggest that SES is

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significantly linked to neuropsychological test performance in HIV+ individuals, and is an important factor to consider in clinical practice.

Keywords

neuropsychology; socioeconomic status; HIV; health disparities

Socioeconomic status (SES) is a construct that refers to one's social standing and differential access to economic resources (Jones & McMillan, 2001; Oakes & Rossi, 2003). It is often operationally defined as reflecting a combination of education, income, and/or occupation based on the "tripartite model of SES" (Duncan, Featherman, & Duncan, 1972; Gottfried, 1985; Hauser & Warren, 1997; Liberatos, Link, & Kelsey, 1988). Within the context of HIV disease, SES is an important consideration; there are complex associations between SES, race/ethnicity, and health outcomes in the U.S. that may have particularly salient implications for persons living with HIV/AIDS (PLWHA).

For instance, prominent health disparities exist among HIV+ racial/ethnic minorities in the U.S. Racial/ethnic minorities, including Latinas/os, are disproportionately impacted by HIV in terms of incidence, prevalence, morbidity, and mortality (CDC 2008b, CDC 2008b, Cargill & Stone, 2005; Chu & Selwyn, 2008, Heron & Smith, 2007; Heron et al., 2008; McGinnis et al., 2003; U.S. Census Bureau, 2006). Additionally, the U.S. now has one of the highest levels of income inequality among all industrialized nations, and racial/ethnic minorities have been strongly affected by these changes in SES distribution (Chevan & Stokes, 2000; Weeks, 2007). Racial/ethnic minorities are more likely to be living in poverty than non-Hispanic whites (US Census Bureau, 2007), and the median wealth among non-Hispanic white households is now 18 times higher than the median wealth of Hispanic/Latino households (Taylor et al., 2011), although poverty is more strongly linked to HIV than race/ethnicity (Denning & DiNenno, 2010).

The influence of SES on HIV disease is particularly salient. Individuals with lower SES have less access to quality medical care and are less likely to receive adequate medical treatment for HIV disease (Chu & Selwyn, 2008; Wood et al., 2002). This includes delayed initiation of HIV medication (Joy et al., 2008), which can lead to higher HIV plasma viral load levels and lower CD4 counts, both of which can affect neuropsychological functioning (Heaton et al., 2010). Lower SES individuals also have higher rates of HIV-related mortality (Cunningham et al., 2005). In light of these prominent health disparities, there is reason to suspect that HIV+ adults with low SES may be at particular risk for poor neuropsychological outcomes, although this has not yet been explored.

Neuropsychological functioning is a critical health outcome in HIV/AIDS, and the relationship between HIV disease and impaired neuropsychological test performance has been well documented. The HIV virus penetrates the CNS, triggering a cascade of events implicated in neuropathogenesis, particularly in frontostriatal circuitry, and neuropsychological and functional declines, including HIV-Associated Neurocognitive Disorders (HAND; Bell, 2004; Boisse, Gill, & Power, 2008; Grant et al., 1987; Hult, Chana, Masliah, & Everall, 2008; Ragin et al., 2004; Ragin et al., 2005; Thames et al., 2013a; Thompson et al., 2006; Woods et al., 2009). Although patterns of neuropsychological

impairment are variable, deficits are often reported in attention/working memory (Heaton et al., 1995; Odiase, Ogunrin, & Ogunniyi, 2007), executive functioning (Dawes et al., 2008; Reger, Welsh, Razani, Martin, & Boone, 2002), and processing speed (Heaton et al., 1995; Odiase, Ogunrin, & Ogunniyi, 2007; Reger, Welsh, Razani, Martin, & Boone, 2002; Simoni et al., 2010). While rates of HIV-Associated Dementia (HAD) have decreased, more individuals in the post-CART era exhibit milder forms of neuropsychological impairments, suggesting that neuropsychological outcomes remain a pertinent issue (Cysique & Brew, 2011; Foley, Ettenhofer, Wright, & Hinkin, 2008; Heaton et al., 2010).

Prior research suggests that sociocultural factors are associated with neuropsychological test performance in individuals with HIV. For instance, research shows that fewer years of education and poorer quality of education are related to worse neuropsychological test performance in this population (Heaton et al., 1995; Maj et al., 1994; Pereda et al., 2000; Ryan et al., 2005; Satz et al., 1993; Starace et al., 1998; Stern, Silva, Chaisson, & Evans, 1996). Lower levels of acculturation to majority culture have been associated with worse neuropsychological performance in both Latina/o and African American HIV+ adults (Arentoft et al., 2012; Manly et al., 1998b). HIV+ racial/ethnic minorities often obtain artificially depressed scores on neuropsychological tests and are more likely than their non-Hispanic white peers to be misclassified as cognitively impaired (Heaton et al., 2003; Ryan et al., 2005). This parallels the larger neuropsychology literature in which artificially depressed NP tests scores have been observed among racial/ethnic minorities across several clinical and healthy samples (Campbell et al., 2002; Heaton, Taylor, & Manly, 2003; Manly et al., 1998a), which is often adjusted in the normative data in order to improve test interpretation. However, there are also complex associations between SES and race/ethnicity in the U.S. that should be considered, and the relationship between socioeconomic status and neuropsychological functioning in adults remains understudied, particularly in the context of HIV disease

Despite the well-documented evidence that at least one socioeconomic factor (i.e., education) is strongly associated with neuropsychological test performance, few studies have examined the broader construct of SES in relation to neuropsychological performance in adults, and the current literature has several limitations. For instance, the relatively sparse literature has primarily focused on HIV- children (i.e., Mezzacappa et al., 2004; Noble, Norman, & Farah, 2005), and preliminary evidence suggests that childhood socioeconomic status is significantly related to neuropsychological functioning in adulthood among HIV- individuals (Kaplan, et al., 2001; Luo & Waite, 2005). This may be due, in part, to the cumulative impact of social disadvantage over the lifespan (Fiscella & Williams, 2004). However, less is understood about the relationship between adult SES and concurrent NP functioning, and no studies to date have systematically examined the relationship between these factors in HIV+ adults.

The extant literature on SES and neuropsychological functioning is also limited by its operational definitions of SES. SES tends to be idiosyncratically and/or inconsistently defined and has typically been assessed using non-standard SES measures, which limit the replicability and generalizability of previous findings. For example, across studies examining SES in HIV- individuals, education has been defined as the highest degree

ranked ordinally (i.e., 1–9; Schwartz et al., 2004), total years completed (Andel et al., 2007), or dichotomized as eight or more years versus less (Luo & Waite, 2005). Occupation has been assessed by degree of supervision and responsibility for decision-making in the longest-held job (Schwartz et al., 2004), the degree occupational complexity (i.e., ranked from 0–8, low to high complexity; Andel et al., 2007), or dichotomized "white-collar job" versus not (Luo & Waite, 2005). Income has been defined as household income (Schwartz et al., 2004), dichotomized as above or below poverty-level (Dotson et al., 2008), or grouped based on median split (Luo & Waite, 2005). In one study by our group, among HIV+ individuals, community-level income was examined using median zip code income (Rivera Mindt et al., 2008). Studies have also differed in their use of continuous or categorical SES scores, and whether or not composite scores across indices are computed. The lack of standard SES measurement leads to important differences in how socioeconomic status is defined. This variability prevents cross-study comparisons and may even account for discrepant findings in the literature. For example, some studies have found significant associations between socioeconomic status and neuropsychological functioning (Andel et al., 2007; Kaplan, et al., 2001; Luo & Waite, 2005; Schwartz et al., 2004) while others have not (Dotson et al., 2008; Rivera Mindt et al., 2004). Therefore, research that employs standardized, replicable SES measures is needed in order to improve our ability to compare results across samples and populations.

The current study sought to explore the role of socioeconomic status (SES) within an ethnically diverse (i.e., primarily Latina/o, of all racial backgrounds, and non-Hispanic white) HIV+ population. Specifically, this study evaluated both adult and estimated childhood SES levels using a standardized SES measure (i.e., the Hollingshead scale). Although there is currently no "gold-standard" measure of socioeconomic status, many disciplines use the Hollingshead scale in their research (Liberatos, Link, & Kelsey, 1988; Lynch & Kaplan, 2000; Shavers, 2007; Oakes & Rossi, 2003). This study also employed a well-validated, comprehensive neuropsychological test battery. We hypothesized that 1) both adult and childhood SES would be positively correlated with global and domain neuropsychological test performance, and that 2) in a series of regressions, after accounting for adult and childhood SES, race/ethnicity would not significantly predict global and domain neuropsychological test performance. Finally, 3) we predicted that SES would remain a significant predictor of clinical diagnoses of HIV-Associated Neurocognitive Disorders (HAND), and that individuals with a HAND diagnosis would have significantly lower SES scores compared to NP unimpaired individuals.

Method

Participants

This study examined 134 HIV+ adults who were enrolled in an ongoing, NIMH-funded study (PI: M. Rivera Mindt, PhD; K23 MH079718). Participants were recruited through community outreach in New York City, particularly the East Harlem area, and through self-referral. Participants were also referred from clinics and related research studies located at the Icahn School of Medicine at Mount Sinai (ISMMS) in New York City.

Included participants were HIV+ (confirmed by medical records), between the ages of 18–80, English-speaking, identified as Latina/o (of any racial background) or non-Hispanic white, and had been taking antiretroviral medications for at least the past 12 weeks. Participants who reported any of the following conditions which may potentially affect cognition were excluded: significant head trauma (as indicated by loss of consciousness for greater than one hour or any penetrating head injury), history of neurosurgery; severe psychiatric illness (i.e., schizophrenia, schizoaffective disorder, bipolar disorder, or psychotic disorder); significant co-morbid medical conditions (i.e., Parkinson's disease, lupus, epilepsy/seizure disorder; chronic obstructive pulmonary disease (COPD) requiring oxygen; multiple sclerosis; end stage renal disease requiring dialysis, stroke, brain cancer or tumor).

Procedure

Comprehensive neuropsychological evaluations were administered to all study participants. Participants were also interviewed regarding their socioeconomic status and demographic characteristics. CD4 lymphocyte counts and HIV plasma loads were assessed from blood samples collected as part of the medical evaluation. The study was approved by the Institutional Review Boards (IRB) at both ISMMS and Fordham University, and all participants provided written, informed consent.

Neuropsychological Evaluation—A comprehensive, three-hour neuropsychological test battery was administered to each participant and scored by trained psychometrists using standardized procedures and supervised by a board-certified clinical neuropsychologist (MRM). Neuropsychological functioning was assessed in the following seven domains:

1. Verbal fluency (Controlled Oral Word Association Test F-A-S; Animals)
2. Attention/working memory (WAIS-III Letter Number Sequencing, Paced Auditory Serial Addition Tests (PASAT)-50 item)
3. Learning (Hopkins Verbal Learning Test-Revised (HVLT-R), Brief Visuospatial Memory Test-Revised (BVMT-R)
4. Memory (HVLT-R, BVMT-R)
5. Executive functioning (Wisconsin Card Sorting Task-64 item version, Trailmaking Test—Part B)
6. Processing speed (Wechsler Adult Intelligence Scale-III (WAIS-III) Digit Symbol, WAIS-III Symbol Search Trailmaking Test—Part A)
7. Motor functioning (Grooved Pegboard)

For the primary analyses of this study, raw scores were used instead of demographically-corrected T-scores since many of these scores are education-corrected, which is a variable of interest in our investigation of SES. Instead, we statistically controlled for any significant associations between raw neuropsychological scores and other relevant covariates (e.g., age, gender; see Statistics section below). However, for assigning clinical diagnoses, demographically-corrected T-scores were used, from which domain and global NP T-scores

were computed. For more information on T-score calculations and the normative sources used, please see Arentoft et al., 2012.

Functional evaluation—Participant's everyday functioning was assessed using two self-report inventories.

Patient's Assessment of Own Functioning Inventory (PAOFI): The PAOFI is a 41-item questionnaire that assesses the frequency the individual's difficulties in everyday functioning as a result of cognitive functioning (i.e., difficulties with memory, language and communication, motor function, sensory-perception, higher-level cognitive functions; Chelune, 1986).

Modified Instrumental Activities of Daily Living Scale (IADL): Participants also completed a modified version of the original Lawton and Brody IADL scale (Heaton et al., 2004). This measures assesses current and highest level of independence in areas such as housekeeping, finances, grocery shopping, cooking, comprehension (i.e., reading material, TV), transportation, telephone use, home repair, bathing, dressing, shopping, laundry, and medication management.

Clinical Diagnoses—Participants were also assigned HIV-Associated Neurocognitive Disorder (HAND) diagnoses according to the Frascati criteria guidelines (see Antinori et al., 2007). Definitions of functional impairment were based on the specific guidelines put forth by Woods et al., 2004 and Blackstone et al., 2012, which are consistent with Antinori and colleagues. Briefly, individuals were not assigned a diagnosis (i.e., classified as neuropsychologically unimpaired) if they did not exhibit scored below the threshold of impairment (i.e., 2 or more NP domains > 1 SD below the mean). A diagnosis of asymptomatic neurocognitive impairment (ANI) was assigned if participants exhibited at least mild NP impairment i.e., 2 or more NP domains > 1 SD below the mean) without reporting functional decline. A diagnosis of mild neurocognitive disorder (MND) was assigned if participants exhibited at least mild NP impairment (i.e., 2 or more NP domains ≥ 1 SD below the mean) and decline in daily functioning (i.e., decline in 2 or more areas of everyday functioning, along with 3 or more significant elevations on the PAOFI (and 10 or more significant elevations on the PAOFI if BDI score was greater than 17). Finally, a diagnosis of HIV-Associated Dementia (HAD) was assigned if participants exhibited severe neuropsychological impairment (i.e., 2 or more NP domains ≥ 2 SD below the mean), and decline in daily functioning (i.e., decline in 2 or more areas of everyday functioning, along with 3 or more significant elevations on the PAOFI (and 10 or more significant elevations on the PAOFI if BDI score was greater than 17).

Socioeconomic and Demographic Evaluation—Participants completed a questionnaire designed for this study assessing their demographic background, including race/ethnicity, and socioeconomic characteristics relevant to the calculation of a Hollingshead score.

In order to estimate adult socioeconomic status, demographic characteristics relevant to the present study were coded as follows: Education was assessed as the total, complete years of

formal education. Education was coded based on the guidelines described by Heaton and colleagues (2004b), as is commonly done in the neuropsychology literature (Strauss, Sherman, & Spreen, 2006). Degrees/diplomas were coded as follows: high school = 12 years of education, associate's degree = 14, bachelor's degree = 16, master's degree = 18, and doctoral degree = 20 (e.g., Heaton, Miller, Taylor & Grant, 2004). For individuals who received a General Equivalency Degree (GED), education was coded as the total full academic years completed. The participant's occupational history was recorded, including their longest-held, most-recent, and highest-level jobs. Each of these occupations was coded using the Hollingshead, and the highest-ranked occupation was selected for computing the total Hollingshead SES score. The information obtained from the demographic questionnaire was used to compute a total adult SES score using the Hollingshead scale, which was developed based on a community-based epidemiological study conducted in New Haven, CT (Hollingshead, 1975), and is one of the most widely used and commonly cited SES measures in the literature (Cirino, 2002). The Hollingshead Index of Social Prestige (ISP) score is derived from the sum of the educational rank (ranked ordinally from 1 (less than seven years of education) to 7 (completing of MA/MS, MD, PhD, JD or other graduate/professional degree), then multiplied by three) and the occupational rank (ranked ordinally from 1 (which includes "farm laborers and menial service workers") to 9 ("higher executives, proprietors of large businesses, and major professionals") and multiplied by five). Possible scores range from 8 to 66, with higher scores reflecting higher SES. These scores are also classified into 5 levels of social strata, with lower levels reflecting higher social class. See Hollingshead, 1975, for more details.

In order to estimate childhood socioeconomic status, participants reported each parent's total years of education and/or degree obtained (as described above). They also reported each parents' primary occupation (while the participant was a child), including "under the table" work. If a parent changed jobs, the longest held job during childhood was selected. Parental education and occupation were ranked and summed (as described above) and then averaged for both parents in order to compute a Hollingshead score to estimate childhood SES. The custodial parent's Hollingshead score was used for single-parent households. If one or both parents' education/occupation were unknown (and the parent lived with/supported them), it was treated as missing data and omitted from the analyses.

For the purposes of describing the sample, participants also reported their current, annual household income as well as their estimated household income in childhood. Rather than ask participants to retrospectively estimate their parents' actual income (which is likely to be highly inaccurate), participants qualitatively ranked their household income during childhood as wealthy, middle income, below average, or poor/poverty level.

Psychiatric evaluation—Participants were also screened for the presence of substance abuse/dependence based on DSM-IV-TR criteria using the Composite International Diagnostic Interview (CIDI; World Health Organization, 1997). Current mood symptoms were measured using the Beck Depression Inventory-II (Beck, 1996).

Statistical Analyses

The Statistical Package for the Social Sciences (SPSS) Version 18.0 was used to analyze the results. A *p*-level of 0.05 was used to determine statistical significance. All variables were normally distributed with the exception of plasma HIV viral load, Trailmaking Test (parts A & B), Wisconsin Card Sorting Test-64 (WCST-64; perseverative responses and perseverative errors), and Grooved Pegboard (dominant and non-dominant hand), which were log transformed. We also explored the relationship between NP test scores and demographic variables unaccounted for in the SES measure, as well as virologic and psychiatric variables. Bivariate analyses showed that age was weakly but significantly correlated with Grooved Pegboard total time for the dominant hand (r=.20, p=.04). Independent samples T-tests showed that only Grooved Pegboard total time, non-dominant hand (t=.−2.16, p=.04) differed significantly by gender. BDI scores were weakly but significantly associated with scores on LNS (r=.−184, p <.05) and PASAT (r=.−23, p=.02), HVLT Total (r=.−23, p=.01), Trails A (r=.24, p<.01), and Grooved Pegboard Dominant Hand (r=.20, p=.03). Individuals with current substance abuse/dependence scored significantly worse on HVLT Total (20.10 ± 5.26, p< .01) and HVLT Delay (6.52 ± 2.48, p=.01), as well as on BVMT Total (16.00 ± 7.41, p<.05) and BVMT Delay (6.30 ± 3.06, p=.04) compared to those without substance abuse/dependence diagnoses (HVLT Total: 23.93 ± 5.01, HVLT Delay: 7.97 ± 2.37; BVMT Total: 19.41 ± 6.72, BVMT Delay: 7.77 ± 2.76). Therefore, age, gender, BDI score, and substance abuse/dependence diagnosis were entered in relevant analyses below as covariates. Plasma HIV viral load, current CD4 count, and nadir CD4 count were not significantly related to any neuropsychological test scores (all p's>.10) and therefore were not included in any analyses.

Pearson correlations and linear multiple regressions were computed as the primary method of analyses. Specifically, raw NP test scores were entered individually as dependent variables in a series of linear regression models. After accounting for any relevant covariates (i.e., age or gender, entered in Step 1 where applicable), adult SES (Step 1 or 2, depending on covariates) and estimated childhood SES (Step 2 or 3) were entered, followed by ethnicity (Step 3 or 4).

Results

Sample Characteristics

Table 1 summarizes the demographic and socioeconomic characteristics by ethnic group. On average, non-Hispanic white participants were significantly older, had more years of education, and had higher estimated socioeconomic status compared to Latina/o participants. Additionally, no Latina/o participants reported being homeowners, while 9% of non-Hispanic white participants reported owning a home. However, it is important to considering the study setting (i.e., NYC), where home ownership is disproportionately lower than other urban areas.

Across the entire sample, participants were 70% male, 74% Latina/o, and 26% non-Hispanic white. In terms of current SES, the mean Hollingshead SES score was 36.84 (*SD* = 12.85), which corresponds with the middle strata (or social class 3) of the Hollingshead's scale

(Hollingshead, 1975). Median household income was $11,052 (*IQR* = $12,900). Over half (58%) of our sample reported annual household income below poverty level (by household size, based on federal poverty guidelines; Department of Health and Human Services, 2012). In terms of estimated childhood SES (i.e., based on parents' estimated SES based on retrospective report), the mean Hollinghead score was 27.82 (*SD* = 14.41), which falls into the lower strata (or social class 4). The majority of participants' reported that their household was middle income or below average (71%) during childhood. Adult and estimated childhood SES scores were also significantly correlated with each other (r=.28, p<.01). Table 2 summarizes virological and psychiatric characteristics by ethnic group. In terms of virological characteristics, most participants were not severely immunosuppressed at the time of study evaluation. However, non-Hispanic white participants had significantly higher CD4 count and lower plasma HIV viral load compared to Latina/o participants, although groups did not differ on nadir CD4 count. There were also no differences in rates of CART medication regimens or route of HIV infection. Finally, there were no differences between groups on depression or substance use disorder diagnoses.

Prior to testing the study hypotheses, we also explored the relationship between the Hollingshead estimate of SES and other measures of (or linked to) SES in order to assess how strongly associated they were with the adult and childhood Hollingshead scores within this sample. Adult Hollingshead SES scores were significantly related to current annual income (r=.30, p<.01). Categorically, individuals living at or below the poverty level also had significantly lower mean adult SES scores (34.54 ± 13.19) compared to individuals currently living above poverty level (40.56 ± 12.10; t=2.31, p=.02). Homeowners had significantly higher adult Hollingshead SES scores (52.67 ± 4.04) compared to non-homeowners (36.48 ± 11.95, t =−2.34, p = .02).The mean parental Hollingshead SES score (i.e., estimated childhood SES) among participants who described their family income during childhood as "wealthy" was 39.79 (*SD* = 16.00), among those who described their family as "middle income," was 31.65 (*SD* = 13.93), "below average" was 24.17 (*SD* = 12.29), and "poor" was 21.30 (*SD* = 13.42, F= 5.41, p<.01).

Mean neuropsychological test raw scores for the overall sample and comparisons by ethnic group are reported in Table 3. Non-Hispanic white participants had significantly higher raw scores on measures of verbal fluency (FAS total), attention/working memory (WAIS-III Letter-Number Sequencing), learning (HVLT-R immediate recall), memory (HVLT-R delayed recall), processing speed (WAIS-III Digit Symbol, WAIS-III Symbol Search) and significantly lower raw scores on executive functioning (Trail Making Test Part B; all p's < .05) compare to Latinas/o participants. The groups did not significantly differ on motor functioning or other tests in the aforementioned domains (p > .05). Based on clinical diagnoses of HAND, 32% of the sample was NP unimpaired, 56% met criteria for ANI, 5% met criteria for MND, and 7% met criteria for HAD.

SES and Neuropsychological Test Performance

Bivariate analyses showed that adult SES was significantly, positively correlated with neuropsychological performance on specific tests within the domains of verbal fluency, attention/concentration, learning, memory, processing speed, and executive functioning (all

p's<.05). Estimated childhood SES was significantly positively correlated with one test within each of the domains of verbal fluency, learning, processing speed, and executive functioning (all *p*'s<.05).

As illustrated in Table 5, a series of hierarchical linear regression models were computed to predict neuropsychological test scores from SES scores and ethnicity. After accounting for any relevant covariates (i.e., age, gender, depression diagnosis, or substance use disorder diagnosis, entered in Step 1 where applicable), adult SES (Step 1 or 2, depending on covariates) and estimated childhood SES (Step 2 or 3) were entered, followed by ethnicity (Step 3 or 4). Results showed that adult SES significantly predicted 5–17% of the variance on tests of verbal fluency, attention/working memory, learning, memory, and processing speed (all *p*'s < .05). Adult SES did not significantly predict executive functioning or motor functioning (*p*'s > .05). Estimated childhood SES accounted for an additional 5–7% of the variance on tests of verbal fluency, processing speed, and executive functioning (*p*'s < .05). After accounting for both adult and childhood SES, ethnicity did not account for a significant amount of the variance in neuropsychological test performance on any of the measures.

Clinical Diagnoses

We then examined HIV-Associated Neurocognitive Disorder (HAND) diagnoses across the sample in order to determine whether or not SES played a unique role in clinical diagnoses that utilize demographically-corrected NP T-scores. HAND diagnoses were available for a subset of participants with sufficient data, including self-report of functional status (*N* = 126). We compared SES—as well as other demographic, virological, and psychiatric characteristics—across each level of HAND diagnosis (Table 6). In terms of SES, results showed that NP unimpaired individuals had the highest SES scores, followed by MND, then ANI, and finally HAD. On average, there was over a 12 point difference in SES scores between NP unimpaired individuals and individuals with HAD.

Lastly, we computed a binary logistic regression in order to examine the odds of receiving a HAND diagnosis based on SES, while also accounting for the possible influence of covariates that significantly differed across diagnostic category (i.e., age, BDI score) to predicting presence or absence of HAND diagnosis (i.e., NP unimpaired individuals vs. individuals with any HAND diagnosis). For ease of interpreting the odds ratio, NP unimpaired was coded as 1 and all HAND diagnoses (i.e., ANI, MND or HAD) were coded as 0. The results of this regression revealed that adult SES (*B*=0.04, *SE*=0.02, *p*=.02) was the only significant predictor of HAND diagnosis (x^2=9.54, *p*=.02). Neither age (*B*=0.02, *SE*=0.03, *p*=.52) nor BDI score (*B*=.−0.02, *SE*=0.02, *p*=.32) was significant. The odds ratio (OR) for SES was 1.04 (95% CI [1.00–1.08], Wald x^2=5.97, *p*=.02).

Discussion

Although some studies have reported associations between sociocultural factors (i.e., education, quality of education, and acculturation) and neuropsychological test performance in HIV+ individuals (e.g., Arentoft et al., 2012; Heaton et al., 1995; Manly et al., 1998b; Pereda et al., 2000; Ryan et al., 2005; Satz et al., 1993), there is limited research examining

the relationship between SES and neuropsychological functioning, particularly among racial/ethnic minority and HIV+ populations. Considering that HIV disproportionately affects lower SES and racial/ethnic minority individuals (US Census Bureau, 2007) and HIV can negatively impact neurocognition, the present study sought to examine the relationship between SES on neuropsychological test performance in a primarily Latina/o HIV+ cohort. In a sample of 134 HIV+ participants, our findings showed that adult SES, as measured by the Hollingshead scale, significantly predicted scores on tests in almost all neuropsychological domains, except motor functioning. Adult SES was more strongly associated with neuropsychological test performance than estimated childhood SES, although childhood SES was significantly linked to some measures of verbal fluency, learning, and executive functioning in bivariate analyses. Childhood SES was the only significant predictor of one measure of executive functioning (i.e., WCST Perseverative Errors) in the regression analyses. This is generally consistent with previous results suggesting that childhood SES may be linked to neuropsychological functioning—particularly frontal lobe functions—which may persist in adulthood, although only one test was significantly associated with childhood SES in each domain (Kaplan, et al., 2001; Luo & Waite, 2005).

Regression analyses showed that both childhood and adult SES combined significantly predicted between 6–18% of the variance on tests of verbal fluency, attention/working memory, processing speed, learning, memory, and executive functioning. Importantly, after accounting for SES, ethnicity did not significantly predict performance on any neuropsychological domains. These results likely support the growing body of literature suggesting that the prefrontal cortex may be particularly vulnerable to environmental stressors, which can include low SES, given the degree to which this region is developing and physiologically influenced by experience during the childhood years (Brito & Noble, 2014). It is also consistent with recent research reporting that structural changes (i.e., reduced cortical thickness) in the prefrontal cortex were correlated with SES (Lawson, Duda, Avants, Wu, & Farah, 2013), and suggests that there may be key periods in the developmental trajectory when adverse environmental effects can have particularly deleterious long-term health consequences.

This study also examined SES levels across individuals by HAND diagnosis. The results revealed that mean adult SES scores significantly differed across HAND diagnosis; SES scores were highest among NP unimpaired individuals and lowest among individuals diagnosed with HAD. Interestingly, individuals with ANI and MND did not significantly differ on SES scores. While our study design precludes causal interpretations, it is possible that adults with lower SES are most vulnerable to the neurocognitive effects of HIV (which is discussed in more detail below). In addition, the minimal differences between SES scores among individuals in the ANI and MND diagnostic categories may support some criticisms of the Frascati criteria. Specifically, some contend that individuals in the ANI and MND diagnostic categories may differ more in their level of *insight* into their deficits than their actual deficits. ANI and MND diagnoses differ only in regard to functional abilities, as they both require mild (i.e., at least one SD below the mean) cognitive deficits in at least two domains. Therefore, when functional deficits are self-reported—which is relatively common

—the only difference between these categories is that individuals who deny any deficits in daily functioning would be diagnosed with ANI while those who endorse such difficulties would be diagnosed with MND (Valcour et al., 2011).

In a binary logistic regression, including all significant covariates, only adult SES remained a significant predictor of HAND diagnosis. For each 1-point increase in SES score, individuals were 1.05 times more likely to be diagnosed as NP unimpaired than to be diagnosed with any form of HAND. To put this finding into context, there is roughly a 10-point difference between each level of Hollingshead 5 proposed social stratas (i.e., scores <20 comprise the lowest social strata, 20–29 = strata 2, 30–39 = strata 3, 40–54 = strata 4, 55 and above = strata 5). Therefore, individuals in a higher social strata (i.e., roughly a 10 point difference in Hollingshead score) are over 10 times more likely to be diagnosed as NP unimpaired than to be diagnosed with an HIV-associated neurocognitive disorder compared to their peers in a social strata just one level lower. It is also important to note that HAND diagnoses were made using normed T-scores, which already correct for education (i.e., one component of SES). Thus, even after partially accounting for SES, the relationship between SES and HAND remained robust. Furthermore, these results suggest that even small differences in SES may have negative repercussions, and that an invididual in a lower social strata is at significantly greater risk of developing neurocognitive impairment compared to a peer just one social strata higher.

Overall, our results suggest that SES may be driving the differences in neurocognitive performance between Latina/o and non-Hispanic white HIV+ participants in this sample. The reasons why HIV+ individuals with low SES may be more vulnerable to HIV-associated neuropsychological sequelae are likely complex and multifactorial. However, this relationship is likely influenced by factors that are related to neurocognitive functioning as well as factors that are unrelated to neurocognitive functioning, and these distinctions may not always be mutually exclusive. For example, an older individual may perform worse on a computerized test of processing speed due to age-related slowing (i.e., a factor related to neurocognitive functioning) as well as lack of familiarity with computers (i.e., a factor unrelated to neurocognitive functioning). Similarly, in our study, there are many SES-related factors that could impact neurocognitive function. Disparities in healthcare access and quality may predispose those with low SES to experience worse neurocognitive outcomes (as discussed in greater detail in the introduction section). Moreover, environmental factors associated with lower SES such as poorer quality housing, poorer nutrition, greater amount of environmental toxin exposure, and higher rates of other chronic and infectious diseases (Lee & Paxman, 1997; Fernald & Adler, 2010; Gruenewald et al., 2009; Moffet et al., 2009) may also place these individuals at increased risk. But other factors that are unrelated to neurocognitive functioning are likely to play a role as well. Particularly in our sample, which is largely comprised of individuals from racial/ethnic minority backgrounds, it remains unclear how much of the variance accounted for by SES reflects genuine cognitive impairment and how reflects test bias and contextual factors such as stereotype threat (Thames et al., 2013b). These are important issues that still need to be disentangled. Additionally, the relationship between SES and neuropsychological test performance should be more thoroughly explored in other samples—including neurologically healthy adults and

other clinical populations with notable health disparities—in order to better understand these associations.

There were also a few unexpected findings that warrant discussion. First, biological variables (i.e., plasma HIV viral load, CD4 count, and nadir CD4 count) were not associated with neuropsychological test performance in this sample. Overall, the sample did not have advanced HIV disease or immunosuppression; and very few individuals in our sample had progressed to AIDS. While significantly more individuals exhibited cognitive deficits (i.e., over half of our sample received a HAND diagnosis), relatively few received more severe diagnoses, such as HAD. Therefore, our results suggest that among individuals with relatively well-controlled HIV, SES factors are more strongly linked to neuropsychological test performance than HIV disease-related factors, and therefore may be an important factor to consider in clinical practice. Future research should explore how these results may differ in a cohort with more advanced HIV disease. An SES-matched HIV-negative cohort should also be included in future studies. Second, it was somewhat surprising that the association between adult and childhood SES scores was relatively weak (r = .28). While prior research does suggest a stronger association between childhood and adult SES, other groups have also observed weaker associations and some have even found that SES is more variable than expected over time. For instance, a 14-year longitudinal study examining children's SES trajectories reported that the correlation between mean family income in the last year of the study and change in family income over the course of 14 years was relatively weak (r = −0.36; Chen et al., 2007). This is particularly noteworthy given the comparatively shorter timespan. Also of note, while we did not find strong associations between self-reported childhood and adult SES scores, our study did find more robust and consistent associations between adult SES scores and neurocognitive functioning. Thus, it is also possible that self-report of current (adult) SES may be a more reliable and valid measure. More research will be needed to assess this issue. Fortunately, our study represents one step toward a better understanding of these relationships.

However, our study is not without limitation. The SES measure used, the Hollingshead scale, has not been updated in several decades. Therefore, the occupational rankings may not reflect current employment statistics and the economic climate, and may fail to capture generational shifts in occupations and earning potential. However, in our sample, Hollingshead SES scores were significantly associated with inherently related variables such as income, poverty, and homeownership. In our population, an SES measure that did not rely on income was desirable, as the majority of our sample was not currently working due to medical disability and therefore reported a low, restricted income. For example, 58% of participants reported an annual household income below poverty level. The Hollingshead scale considers an individual's education and occupation, but not income, and current unemployment did not negate our calculation of occupational status, as highest adult occupation score was used. Moreover, this is likely applicable to other populations with serious medical or mental illness that have similarly high levels of current unemployment. However, it is unclear how these results may differ in other samples with different socioeconomic characteristics, including samples with a higher percentage of working individuals, and samples with a wider range of SES scores. Future studies may wish to

explore the comparative utility of other SES measures. This study also relied on self-reported adult SES data and retrospective childhood SES data. Self-report and retrospective recall may be inaccurate or incomplete, and can be affected by factors ranging from perceived social desirability to neurological status. Therefore, longitudinal exploration of SES measures and neuropsychological test performance is needed to examine the influence and stability of childhood SES, which may also help establish causality. Information on Hepatitis C virus was not available; therefore, its potential impact could not be assessed. Finally, samples sizes were unequal across ethnic groups.

Despite these limitations, this study has a number of important strengths. It is the first study to systematically examine the utility of SES in predicting neuropsychological performance within a predominantly racial/ethnic minority and relatively impoverished, neurologic (HIV) population. It is also the first study to examine both adult and childhood SES estimates and neuropsychological performance among HIV+ participants. To date, SES has been inconsistently defined and examined across studies, and has not been examined using a standard SES measure like the Hollingshead scale. This has limited the generalizability of past research and impeded the ability to compare results or sample SES characteristics across studies. Therefore, this study provides an initial, systematic investigation of SES using a clearly-defined SES measure that can be easily replicated in future studies.

This study also suggests that SES may be a more salient predictor of neuropsychological test performance than ethnicity. In fact, after accounting for SES, ethnicity was no longer a significant predictor. This has several important implications. First, it suggests that neuropsychological assessment may move toward exploring the impact of more significant, conceptually-linked sociocultural factors, such as SES. Future research will need to further explore the degree to which test bias affects the relationship between SES and NP, and normative corrections for SES may considered in the future. Second, given the prominent health disparities evident in the HIV/AIDS epidemic, it is likely that at least some of the variance in this relationship reflects cognitive dysfunction. This relationship may also be bidirectional. Research shows that lower SES individuals are disproportionately affected by HIV/AIDS (Denning & DiNenno, 2010) and are less likely to receive adequate medical treatment for HIV disease (Chu & Selwyn, 2008; Wood et al., 2002). Many HIV+ individuals become unemployed (Rabkin, McElhiney, Ferrando, Van Gorp, & Lin, 2004) which, in turn, typically reduces SES.

Overall, this study represents an important first step towards a better understanding of the relationship between SES and neuropsychological performance and paves the way for future research in this area. It highlights the prominent health disparities that exist in HIV, and suggests that the relationship between SES and NP performance may have important implications for the diagnosis of HAND. Over time, more thorough exploration of SES and neuropsychological performance may lead to improved clinical care through more accurate norms and increased diagnostic accuracy.

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Table 1

Demographic and Socioeconomic Characteristics of the Study Sample (N = 128)

	Non-Hispanic white (*n* = 35)		Latina/o (*n* = 99)		
	M or %	***SD***	***M or %***	***SD***	***Statistic***
Age	51.17	9.85	46.29	6.90	t=3.07**
Education (years)	14.63	3.01	11.92	2.55	t=5.15**
Gender (% Male)	80%		67%		x^2=2.20
Adult SES score	47.71	11.78	32.90	10.85	t=6.67**
Childhood SES score	36.54	14.04	24.60	13.23	t=3.94**
	Mdn or %	*IQR*	*Mdn or %*	*IQR*	*Statistic*
Current Income (Adult)	$18,000	$24,000	$9,366	$11,210	U=.−2.86**
Current Income (Adult) (% below poverty level)	37%		66%		x^2=6.84**
Estimated Family Income Level (Childhood)					x^2=4.00
Wealthy	6%		5%		
Middle Income	56%		37%		
Below Average	22%		32%		
Poor & Below Poverty	16%		26%		

[a] Mdn=median, IQR=Inter Quartile Range

[b] $\log_{10}$ transformed,

† $p < .10$,

* $p < .05$,

** $p < .01$

Table 2

Virological and Psychiatric Characteristics of the Study Sample (N = 128)

	Non-Hispanic white (*n* = 34)		Latina/o (*n* = 94)		
Virological	***Mdn or %***	***IQR***	***Mdn or %***	***IQR***	***Statistic***
CD4 count	606	510	420	422	U=.−2.35*
CD4 (% ≥ 200)	97%		85%		x^2=3.17†
Nadir CD4	160	135	164	208	U=0.01
Plasma HIV[b] viral load	1.68	0	1.68	1.31	U=.−2.86**
CART Category	92%		90%		x^2=0.07
Route of HIV infection					
Sexual	81%		85%		x^2=2.74
Injection Drug	14%		6%		
Transfusion/Blood-exposure	5%		3%		
Unknown	0%		6%		
Psychiatric	*M or %*	*SD*	*M or %*	*SD*	*Statistic*
Substance Abuse/Dependence	21%		17%		x^2=0.26
BDI score	14.00	10.79	10.07	9.71	t = 1.94†

[a] median,

[b] log10 transformed,

† $p < .10$,

* $p < .05$,

** $p < .01$

Table 3

Samples Means and Group Differences between Non-Hispanic White and Latina/o Participants on Neuropsychological Raw Scores and SES variables (N = 128)

	non-Hispanic White (*n* = 34)		Latina/o (*n* = 94)		
	Mean	***SD***	***Mean***	***SD***	***t***
Verbal Fluency					
COWAT (FAS) Total	42.94	13.61	33.20	11.29	3.91**
Animals Total	19.84	4.52	17.84	5.37	1.69
Attention/Working Memory					
WAIS-III LNS	9.79	3.45	8.27	2.39	2.73*
PASAT	7.63	3.62	6.88	3.02	1.09
Learning					
HVLT-R Total	25.97	4.88	22.14	5.02	3.81**
BVMT-R Total	20.59	7.49	17.96	6.72	1.86†
Memory					
HVLT-R Delay	8.76	2.29	7.30	2.41	3.01**
BVMT-R Delay	8.06	2.98	7.22	2.82	1.44
Processing Speed					
WAIS-III Digit Symbol	66.91	13.69	61.08	14.58	1.98*
WAIS-III Symbol Search	29.69	6.65	25.52	7.44	2.80*
Trails A[a]	1.45	0.13	1.51	0.16	−1.89†
Executive Functioning					
WCST Perseverative Responses[a]	1.07	0.32	1.06	0.28	0.18
WCST Perseverative Errors[a]	1.07	0.28	1.03	0.27	0.57
Trails B[a]	1.83	0.17	1.94	0.19	−2.81*
Motor					
Grooved Pegboard Dominant Hand[a]	1.91	0.09	1.89	0.10	0.81

	non-Hispanic White (*n* = 34)		Latina/o (*n* = 94)		
	Mean	***SD***	***Mean***	***SD***	***t***
Grooved Pegboard Non-Dominant Hand[a]	1.94	0.09	1.94	0.10	−0.17

[a] log transformed;

† $p < .10$,

* $p < .05$,

** $p < .01$

Table 4

Correlations between SES Estimates and Neuropsychological Raw Scores (N = 128)

	Adult SES	Childhood SES
Verbal Fluency		
COWAT (FAS) Total	.27**	.19†
Animals Total	.14	.31**
Attention/Working Memory		
WAIS-III LNS[b]	.31**	.14
PASAT[b]	.25*	−.02
Learning		
HVLT Total[b,c]	.40**	.29**
BVMT Total[c]	.20*	.13
Memory		
HVLT Delay[c]	.39**	.15
BVMT Delay[c]	.21*	.13
Processing Speed		
WAIS-III Digit Symbol	.18*	.09
WAIS-III Symbol Search	.26**	.16
Trails A[a,b]	−.15†	−.22*
Executive Functioning		
WCST Perseverative Responses[a]	−.03	.03
WCST Perseverative Errors[a]	.13	.25*
Trails B[a]	−.22*	−.12
Motor		
Grooved Pegboard - Dominant Hand[a,b,d]	−.01	−.06
Grooved Pegboard - Non-Dominant Hand[a,e]	.06	−.05

[a] log transformed, after controlling for

[b] BDI,

[c] substance abuse/dependence,

[d] age,

[e] gender

† $p < .10$,

* $p < .05$,

** $p < .01$

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Table 5

Multiple Regression Analyses for SES Estimates and Ethnicity Predicting Neuropsychological Raw Scores (N = 128)

	Adult SES			*Childhood SES*			*Ethnicity*		
	R^2_Δ	β	*SE β*	R^2_Δ	β	*SE β*	R^2_Δ	β	*SE β*
Verbal Fluency									
COWAT (FAS) Total	.09	.31**	.11	.02	.12	.10	.03	−6.71†	3.78
Animals Total	.05	.09†	.05	.07	.10*	.04	<.01	−1.31	1.53
Attention/Working Memory									
WAIS-III LNS[b]	.08	.06**	.02	<.01	<.−01	.02	<.01	−.56	.75
PASAT[b]	.03	.04	.03	.02	−.03	.02	<.01	−.62	.89
Learning									
HVLT Total[b,c]	.14	.15**	.04	.04	.07†	.04	.02	−1.88	1.35
BVMT Total[c]	.05	.13*	.06	.01	.06	.05	<.01	−1.13	2.00
Memory									
HVLT Delay[c]	.17	.08**	.02	<.01	.01	.02	<.01	−.38	.65
BVMT Delay[c]	.08	.06**	.02	.02	.02	.02	<.01	.17	.81
Processing Speed									
WAIS-III Digit Symbol	.03	.19	.12	<.01	.17	.13	<.01	−2.91	4.31
WAIS-III Symbol Search	.09	.17**	.06	<.01	.05	.05	<.01	−1.27	1.98
Trails A[a,b]	<.01	<.−01	<.01	.05	<.−01*	<.01	<.01	.02	.04
Executive Functioning									
WCST Perseverative Responses[a]	<.01	<.−01	<.01	<.01	<.01	<.01	<.01	<.01	.09
WCST Perseverative Errors[a]	<.01	<.01	<.01	.06	<.01*	<.01	.01	.07	.08
Trails B[a]	.03	<.−01†	<.01	.01	<.−01	<.01	.01	.06	.06
Motor									
Grooved Pegboard Dominant Hand[a,b,d]	<.01	<.01	<.01	<.01	<.01	<.01	<.01	−.02	.03
Grooved Pegboard Non-Dominant Hand[a,e]	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.02	.03

[a] log transformed, after controlling for

[b] BDI,

[c] substance abuse/dependence,

[d] age,

[e] gender

† $p < .10$,

* $p < .05$,

** $p < .01$

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Table 6

Demographic, Socioeconomic, Virological, and Psychiatric Characteristics by HAND Diagnosis (N=126)

	NPU	***ANI***	***MND***	***HAD***		
Demographic / SES	*M (SD) or %*	*M (SD) or %*	*M (SD) or %*	*M (SD) or %*	*Statistic*	*LSD*
Age	48.57 (8.76)	47.75 (7.64)	37.93 (5.52)	46.86 (4.58)	F=3.31*	*NPU***,*ANI***>*MND* *MND*>*HAD**
Education (years)	13.41 (2.89)	12.36 (2.68)	12.5 (1.87)	10.33 (3.74)	F=3.29**	*NPU***,*ANI**>*HAD*
Gender (% Male)	73%	66%	83%	67%	x^2=1.29	
Adult SES score	41.10 (14.06)	33.99 (10.55)	38.33 (12.80)	29.56 (15.88)	F=3.77**	*NPU*>*ANI****HAD**
Childhood SES score	28.71 (14.85)	25.73 (12.82)	28.42 (10.36)	27.38 (26.48)	*F=0.33*	
	Mdn (IQR) or %	*Mdn (IQR) or %*	*Mdn (IQR) or %*	*Mdn (IQR) or %*	*Statistic*	*LSD*
Income	$12,500 (11,337)	$11,052 (13,090)	$10,050 (19,017)	$10,080 (21,628)	K=0.99	
Income (% below poverty level)	53%	58%	75%	63%	x^2=0.85	
Estimated Family Income (Childhood)					x^2=11.65	
Wealthy	0%	8%	0%	0%		
Middle Income	51%	37%	33%	37%		
Below Average	31%	34%	16%	13%		
Poor	18%	21%	50%	50%		
Virological	*Mdn (IQR) or %*	*Mdn (IQR) or %*	*Mdn (IQR) or %*	*Mdn (IQR) or %*	*Statistic*	*LSD*
CD4 count	571 (441)	417 (479)	345 (173)	467 (239)	K=2.33	
CD4 (% ≥ 200)	87%	88%	83%	100%	x^2=1.44	
Nadir CD4	160	135	164	208	K=1.31	
Plasma HIV[a] viral load	1.68 (0.18)	1.68 (0.85)	1.68 (1.15)	1.97 (1.97)	K=1.26	
CART Category	96%	85%	100%	89%	x^2=3.11	
Psychiatric	*M (SD) or %*	*M (SD) or %*	*M (SD) or %*	*M (SD) or %*	*Statistic*	
Substance Abuse/Dependence	10%	19%	17%	50%	x^2=7.38†	

	NPU	*ANI*	*MND*	*HAD*		
BDI score	9.29 (9.23)	10.21 (9.57)	20.17 (9.37)	17.78 (14.77)	$F = 3.63^{*}$	*NPU<MND*HAD* ANI<MND*HAD**

NPU = NP Unimpaired, ANI = Asymptomatic Neurocognitive Impairment, MND = Mild Neurocognitive Disorder, HAD = HIV-Associated Dementia

[a] $\log_{10}$ transformed,

$^{\dagger}p < .10$,

$^{*}p < .05$,

$^{**}p < .01$