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UNDERSTANDING THE NEUROPSYCHOLOGICAL PROFILE OF HIV+ PARTICIPANTS WITH LOW LITERACY: ROLE OF THE GENERAL ABILITY MEASURE FOR ADULTS (GAMA)

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Abstract

The WRAT-3 Reading subtest (WRS) may be inappropriate in diseases having disproportionate impact on populations with educational disadvantages (i.e., HIV/AIDS). To understand how low literate individuals would perform on an IQ test requiring minimal education, the General Ability Measure for Adults (GAMA) was studied. HIV+ participants completed WRS, GAMA, and neuropsychological tests. Participants with low WRS (<80 SS) but higher GAMA (≥80 SS) had significantly better overall neuropsychological functioning than those with <80 SS on both tests. The GAMA may be a useful test when disparities in educational quality render reading-based measures of IQ a poor surrogate of premorbid function.

Keywords

Ethnicity; HIV; Literacy; Neuropsychological testing; Premorbid IQ; Quality of education

INTRODUCTION

Estimation of premorbid intellectual functioning is an essential part of interpreting neuropsychological performance following brain injury and disease. Oftentimes prior neuropsychological assessment is non-existent, which necessitates the use of premorbid indicators to determine the presence or degree of injury or disease-induced impairment. The

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neuropsychological research literature has studied various estimation methods including the “best performance” method, the use of actuarial or demographic regression formulas, and measuring cognitive functions assumed to be resistant to disease or injury. The latter method includes assessing reading ability to predict premorbid functioning.

Using reading level as a premorbid indicator is predicated on reading’s high correlation with IQ in the general population, its greater resistance to dementia than vocabulary tests, and its supposed reliance on previous knowledge rather than current cognitive functioning (Franzen, Burgess, & Smith-Seemiller, 1997; Nelson & McKenna, 1975). Several reading tasks have been studied including The National Adult Reading Test (NART) (Nelson & McKenna, 1975), The North American Adult Reading Test (NAART) (Spreen & Strauss, 1991), and versions of the Wide Range Achievement Test – Reading Recognition subtest (WRAT) (Jastak & Wilkinson, 1984). The WRAT Reading subtest unlike the NART (or NAART) includes regularly, as well as irregularly, spelled words. The WRAT Reading subtest is routinely used for assessing premorbid intelligence because it is well normed and easy to administer. It also provides a corresponding grade level for reading ability.

The National NeuroAIDS Tissue Consortium (NNTC) is a multi-site, longitudinal observational study of advanced HIV patients that utilizes a comprehensive neuropsychological battery and includes the WRAT-3 Reading subtest to estimate premorbid intelligence (Woods et al., 2004). Within this consortium, the Manhattan HIV Brain Bank (MHBB) site has a predominantly racial/ethnic minority cohort in which 41% of its participants have <an eighth-grade reading level and 56% have reading levels which are ≥ 2 years lower than their stated educational level (Ryan et al., 2005). Thus, it provides a laboratory in which the effects of neurologic disease on a low-literacy cohort can be examined. In the MHBB cohort we have observed individuals whose performance on the WRAT-3 Reading subtest is indicative of premorbid intellectual functioning in the mentally retarded range despite clinical presentations, as well as work and social histories, that are not suggestive of mental retardation (nor do these individuals report dyslexia, remedial reading, or any other condition that could account for a very low reading level). Thus, we suspect that a poor quality of education is responsible for very low reading levels in this cohort, and sought to assess intellectual functioning using a measure that would be less dependent on verbal abilities or education.

The MHBB is not the only group in which discrepancy in education and reading levels has been reported; it has been seen in research settings with other racial/ethnic minority cohorts (Manly, Jacobs, Touradji, Small, & Stern, 2002; O’Bryant, Schrimsher, & O’Jile., 2005; O’Bryant et al., 2007). These studies have led to a suggestion that reading ability should be used as a proxy for educational level (Manly et al., 2002). While reading ability is likely to be a better approximation of the number of years of education completed for racial/ethnic minorities, it may also have limitations in completely eradicating neuropsychological test biases, and addressing the issue of estimating premorbid intelligence.

Foremost among these limitations is the fact that reading ability has a variable relationship to intellectual functioning across racial/ethnic populations, and that there is over-representation of racial/ethnic minorities at the lowest levels of literacy (NCES, 2007). For racial/ethnic minorities, educational inequities (i.e., teacher training, school district spending on students, and student/teacher ratio, etc.) are confounded with reading ability. Given inequities in educational quality and funding, reading ability does not appear to have the same relationship to intellectual functioning in racial/ethnic minorities that has been reported in predominantly non-Hispanic White samples (Johnstone et al., 1996; Wiens, Bryan, & Crosson, 1993). Race/ethnicity has been found to be a significant predictor of the relationship between reading and IQ, and adds incrementally more variance to the model (beyond the WRAT Reading subtest) (Kareken, Gur, & Saykin, 1995). The incremental variance that race/ethnicity contributes to

the relationship between reading and IQ likely reflects access to a quality education; a factor that can differ by race/ethnicity but is due to sociopolitical forces. Thus, while using educational level may be biased toward overestimating racial/ethnic minorities' abilities, using reading level could potentially underestimate abilities for some, given inadequate teaching resources. Use of a test that is less dependent on education would be ideal in understanding expected neuropsychological functioning in individuals with low literacy.

The General Ability Measure for Adults (GAMA) assesses intellectual functioning using abstract designs, thereby limiting reliance on verbal comprehension (Naglieri & Bardos, 1997). It was specifically designed for individuals with limited educational experiences and/or verbal skills. Given these features of the GAMA, it may be an appropriate measure of intellectual functioning for a racially and ethnically diverse urban cohort who have likely experienced a poor quality of education.

The GAMA consists of four types of problems: matching, reasoning by analogy, sequencing, and mental construction. "Matching" requires the individual to choose which of six options is identical to the target stimulus in shape, color, and configuration. "Analogies" demands that the individual recognize the relationship between two figures and then determine which of six options mimics the same conceptual relationship to the target stimulus. In "Sequences" the color, shape, and location of the abstract design changes in a logical sequence. The individual must understand the pattern of change and choose the option that fits the pattern. "Construction" has the individual decide how several target shapes can be put together to produce one of the six options. Thus, the individual has to analyze and synthesize the spatial characteristics of the target shapes to mentally construct the correct design.

The psychometric properties of the GAMA reveal adequate internal consistency, as well as test-retest reliability. Validity studies revealed that individuals performed similarly on the GAMA as on other tests of intellectual functioning (Naglieri & Bardos, 1997). GAMA correlated .74 with WAIS-R PIQ, .65 with WAIS-R VIQ, and .75 with WAIS-R FSIQ. Notably, these correlations are higher than those of the WRAT-3 Reading subtest with the WAIS-R (despite similar racial/ethnic composition in the normative groups). The WRAT-3 manual reports that the reading subtest correlated .63 for WAIS-R VIQ, .31 for PIQ, and .53 for FSIQ (Wilkinson, 1993).

Both the WRAT-3 and the GAMA were standardized to match the 1990 US Census. The WRAT-3 standardization sample was comprised of 49.3% women and 50.7% men; the GAMA had 54.3% women and 45.7% men. The racial/ethnic composition of the GAMA and the WRAT-3 normative groups were similar. Racial/ethnicity breakdown was 71.7% White, 13.6% African American, 10.7% Hispanic, and 3.9% Other for the WRAT-3; and 76.3% White, 12.5% African American, 7.8% Hispanic, and 3.4% Other for the GAMA. Age groups for the WRAT-3 varied from age 5 to age 75 whereas the GAMA ranged from 18 to 96 years. While the WRAT-3 did not stratify by education level, the GAMA included five educational levels (less than 9 years education completed, 9–12 years completed without graduating, high school graduate or GED, some college including vocational programs and 2-year colleges, and a bachelor's degree or more). The WRAT-3 test manual states that the standardization sample is representative of the US population with regard to SES whereas the GAMA makes no mention of SES characteristics of its normative sample.

Using a cross-sectional design, the present study examined the comparability of the GAMA and the WRAT-3 Reading subtest among a predominantly racial/ethnic minority cohort with advanced HIV disease. The study's aim was to determine how the GAMA performed relative to the WRAT-3 Reading test at varying levels of literacy, and also to examine how the GAMA and the WRAT-3 Reading test related to neuropsychological domains at different levels of

literacy. We hypothesized that participants with low literacy would perform better on the GAMA than on the WRAT-3 Reading subtest, and that the GAMA would more strongly correlate with neuropsychological functioning than the WRAT-3 among a cohort characterized by low literacy. Additionally, we hypothesized that participants with low literacy (WRAT-3 reading scores <80 SS), but GAMA scores within normal limits (>80 SS), would perform better on neuropsychological domains than individuals whose performance was low (<80 SS) on both tests.

METHOD

Research participants

The 95 study participants were derived from the Manhattan HIV Brain Bank (MHBB; R24MH59724), a longitudinal observational study that includes biannual neurologic, neuropsychologic, and psychiatric examinations of exclusively HIV participants. MHBB participation eligibility criteria include (1) advanced HIV disease or another disease without effective therapy,¹ or (2) a CD4 count ≤ 50 cells/mm³ for at least a 3 month period of time, or (3) substantive risk for imminent mortality in the judgment of the participant's primary physician. (For further inclusion criteria see Ryan et al., 2005.) Selection criterion for this study was having completed the GAMA in addition to the neuropsychological battery.

The MHBB participants all gave consent for post-mortem organ donation for research purposes. All participants were English speaking. Hispanic participants were mainly of Dominican and Puerto Rican descent and all were dominant English speakers. Participants were excluded from this study analysis if they reported dyslexia, remedial reading assistance, or were known to have another condition (i.e., CMV retinopathy, blindness) that confounded or prevented their reading. Data reported in this manuscript were obtained in compliance with the Mount Sinai School of Medicine IRB.

Procedure

Laboratory values—Current absolute CD4 count and HIV plasma RNA were obtained either through blood draw and laboratory analysis, or via clinical chart review. "Current" is defined as the closest laboratory measures to the neuropsychological test battery. All participants had a urine toxicology screen at the time of neuropsychological assessment.

Psychiatric interview—The Psychiatric Research Interview for Substance and Mental Disorders (PRISM) (Hasin et al., 1996) was administered to assess for substance use disorders.

Income—We used data from the 2000 U.S. Census Bureau report to obtain a proxy for income level, as self-reported income was not ascertained. Tables listing median household income per zip code by ethnicity were utilized (U.S. Census Bureau, 2000).

Reading level—The Reading Recognition subtest of the Wide Range Achievement Test - Version 3, WRAT-3 (Wilkinson, 1993) was administered to assess reading level. Participants were asked to pronounce words, and if they were unable to correctly pronounce 10 consecutive words, to name letters. Words are listed in order of decreasing familiarity and increasing phonological complexity. Grade-equivalent scores were derived by age-based normative values from the WRAT-3 manual. The WRAT-3 reading grades were quantified from pre-kindergarten through eighth grade. Beyond an eighth-grade reading level, participants were

¹Indicator conditions include progressive multifocal leucoencephalopathy; lymphoma (systemic or CNS); disseminated mycobacterium avium-intercellulare; wasting (>30% of lean body mass); AIDS dementia complex; CMV end organ disease; viscera Kaposi's sarcoma; congestive heart failure; or serum albumin <3.2 g/dl.

assigned a twelfth-grade reading level for “high school” and 13 years for “post high school” reading levels as we have done in our previous work (Ryan et al., 2005).

We operationalized “low literacy” as <80 SS (or $<$ eighth-grade reading level) and divided the cohort on this basis.

General Ability Measure for Adults (GAMA)—The GAMA (Naglieri & Bardos, 1997) consists of four subtests that utilize abstract, colorful designs to assess matching to a sample, reasoning by analogy, mental construction, and recognizing a visual sequence. The GAMA is self-administered and has a multiple choice format; the time limit is 25 minutes. The four subtests are combined into an IQ score ($M = 100$, $SD = 15$).

Alphabet writing—Alphabet writing, a component of the HIV Dementia Scale (Power, Selnes, Grim, & McArthur, 1995), was used to study participants’ ability to write the letters of the alphabet without errors. Alphabet writing has been shown to be a predictor of reading (Bruck, Genesee, & Caravolas, 1997).

Neuropsychological battery—Participants were administered the NNTC neuropsychological test battery which assessed a broad range of cognitive abilities sensitive to HIV impairment (Woods et al., 2004). Specific tests included the Trailmaking Test – Parts A and B (TMT-A and TMT-B, respectively), Grooved Pegboard Test – Dominant and Nondominant Hands (GPDH and GPNH, respectively); Hopkins Verbal Learning Test (HVLTL), Brief Visuospatial Memory Test-Revised (BVMTR), WAIS-III Digit Symbol, WAIS-III Symbol Search, WAIS-III Letter Number Sequencing, Controlled Oral Word Association Test (FAS), Paced Auditory Serial Attention Test (PASAT), and the Wisconsin Card Sorting Test-64 card version (WCST-64). To investigate prevalence of impairment across domains, we assigned T-scores using the following published norms: Heaton et al. (1991) for GPDH, GPNH, TMT-A, and TMT-B; Gladsjo et al. (1999) for FAS; Benedict et al. (1998) for HVLTL; Benedict (1997) for BVMTR; Wechsler (1997) for the WAIS-III subtests; Diehr et al. (2003) for PASAT; and Kongs et al. (2000) for the WCST-64. The PASAT and FAS provide racial/ethnicity corrections for non-Hispanic Whites and African Americans (Diehr et al., 2003; Gladsjo et al., 1999). All of the tests except the BVMTR and the WAIS-III tests corrected for education.

The individual tests were also grouped according to domains (Woods et al., 2004) as indicated in the Appendix. Domain scores were derived from the mean *T*-scores of the individual tests in that particular domain with the Global domain score derived from the mean of all the individual neuropsychological test *T*-scores.

RESULTS

Demographic and medical characteristics

A total of 95 participants (47% male) were studied. Of the participants, 44% were African American, 32% were non-Hispanic White, and 24% were Hispanic. Mean age was 49.4 years ($SD = 7.7$). A total of 78% had AIDS and the remainder had no documentation of a $CD4 < 200$ cells/mm³ or an AIDS-defining illness (CDC, 1992). Median $CD4$ count was 315 cells/mm³ and median log plasma HIV RNA was 1.88 copies/mL. Absolute $CD4$ count was drawn a mean of 2.54 days ($SD = 3.32$) from the GAMA and NP battery (with 70% of the participants having labs drawn the same day). There were no significant differences in $CD4$ or plasma HIV RNA across the racial/ethnic groups. Participants mainly identified intravenous drug use (IDU) as their HIV risk factor (37.9%) with homosexual/bisexual risk the next highest category (30.5%). Comparison of mean education and reading levels revealed that African American and Hispanic participants had significantly lower education, $F(2, 92) = 7.3$, $<.01$, and reading grade

levels, $F(2, 92)=9.3$, $p<.001$, than non-Hispanic Whites, but not compared to each other (see Table 1). Hispanic participants were significantly younger ($M = 45.8$ years, $SD = 6.1$) than the African Americans ($M = 50.3$ years, $SD = 7.3$) and the non-Hispanic Whites ($M = 50.9$ years, $SD = 8.6$) $F(2, 92)=35.17$, $p<.05$.

WRAT-3 Reading and GAMA

For the sample, the mean WRAT-3 Reading standard score was 88.5 ($SD = 17.8$), and the mean GAMA standard score was 90.0 ($SD = 12.9$). The GAMA and the WRAT-3 Reading subtest were significantly correlated ($r = .50$, $p<.01$). WRAT-3 Reading was more highly correlated with education ($r = .72$, $p<.01$) and income ($r = .56$, $p<.01$) than the GAMA ($r = .26$, $p<.05$; $r = .40$, $p<.05$, respectively). Fisher's z transformation revealed that the WRAT-3 Reading correlation with education was significantly stronger (z diff=4.35, $p<.001$) than that of the GAMA and education. There was no significant difference in the correlation of the tests with income.

Comparison by reading levels (<eighth-grade reading vs $\geq$ eighth grade)

In our sample, a SS of <80 on the WRAT-3 Reading test was equivalent to < eighth-grade reading level. While 2% of the cohort had < eighth-grade education, 38% had < eighth-grade reading level as assessed by the WRAT-3 Reading subtest. Table 2 displays the sample's medical and demographic information by reading level (< eighth-grade vs $\geq$ eighth grade). Among participants who had < eighth-grade reading level, their mean education level was 10.9 years ($SD = 2.4$) and their median household income per zip code was \$21,810. Both African American and Hispanic participants were more likely than non-Hispanic Whites to have < eighth-grade reading level ($\chi^2 = 11.6$, $df = 1$, $p<.01$; $\chi^2 = 6.09$, $df = 1$, $p<.05$). Of the participants with < eighth-grade reading level, 53% were unable to write the alphabet without making an error (not including self-corrected errors).

Correlations between the WRAT-3 Reading subtest and the GAMA with specific neuropsychological domains varied by reading level (< eighth grade vs $\geq$ eighth grade) as depicted in Table 3. Among low-literate participants (< eighth-grade reading) the WRAT-3 Reading subtest was not significantly correlated with any of the neuropsychological domains. Reading had small to medium-sized correlations with motor, processing speed, working memory, learning, and global neuropsychological functioning among participants with $\geq$ eighth-grade reading. Both groups exhibited more robust correlations with the GAMA and the largest correlations were with the processing speed and global neuropsychological domains.

Comparison of reading levels and GAMA test performance

We divided the sample into quartiles based on WRAT-3 Reading SS. As shown in Table 4, participants scoring in the lowest quartile of WRAT-3 Reading scores had significantly less education, $F(3, 91)=26.42$, $p=.000$, and as expected, lower reading SS, $F(3, 91)=283.4$, $p=.000$, than the other groups. Notably, their GAMA scores were significantly higher than their WRAT-3 scores, $t(23)=-6.40$, $p<.001$. In contrast, participants in the highest quartile of WRAT-3 Reading scores had GAMA scores that were significantly lower than their WRAT-3 scores, $t(21)=5.47$, $p<.001$. In the highest and lowest WRAT-3 reading quartiles, there were no differences in HIV indices of CD4 and HIV RNA. Participants in the middle quartiles of reading function scored equivalently on the WRAT-3 and the GAMA.

In order to assure that better performance on the GAMA in the lowest WRAT-3 quartile was not solely an artifact, we also separated the group into quartiles based on GAMA performance. As shown in Table 5, both participants scoring in the lowest GAMA quartile as well as those scoring in the second GAMA quartile had significantly less education than participants in the third GAMA quartile, $F(3, 91)=4.50$, $p<.01$. Additionally participants in the lowest GAMA

quartile had significantly lower reading SS, $F(3, 91)=12.74, p=.000$, than the other groups. In regards to WRAT-3 and GAMA performance, the first three quartiles showed equivalent performance on the two tests, but the participants in the highest GAMA quartile exhibited significantly better performance on the GAMA, $t(20)=2.69, p<.05$, relative to the WRAT-3 (Table 5). No differences in CD4 or HIV RNA were detected.

GAMA, reading level, and global neuropsychological test performance

The GAMA ($r=.64, p<.0001$) and the WRAT-3 Reading tests ($r=.41, p<.0001$) were each significantly correlated with global neuropsychological functioning; using Fisher's z transformation, the GAMA correlation with global neuropsychological functioning was significantly stronger ($z \text{ diff} = 2.19, p < .05$). Additionally, all of the GAMA subtests were significantly correlated with the neuropsychological domain scores ($rs=.2-.60$), with the exception of the GAMA construction subtest and the working memory domain.

Neuropsychological functioning by low reading levels and GAMA test performance

To understand whether a difference in neuropsychological test performance existed based on WRAT-3 and GAMA scores, we compared participants with both WRAT-3 reading levels and GAMA scores that were <80 SS ($n=15$) to participants with low (<80 SS) WRAT-3 reading levels but higher GAMA scores (≥ 80 SS) ($n=19$). The two groups did not significantly differ in age, HIV risk factor (i.e., IDU, sexual risk, or blood products), substance use disorders (either within the past 12 months or at any time in their lives), presence of an illicit urine toxicology screen, or HIV disease indices (CD4 and plasma HIV RNA).

As shown in Table 6, the participants with low WRAT and low GAMA scores performed worse on every neuropsychological domain and significantly lower on global neuropsychological functioning, $t(32)=-2.56, p<.05$, and processing speed, $t(32)=-3.19, p<.01$. There were also trends toward worse functioning in learning and executive functioning. The participants with ≥ 80 GAMA SS (but low WRAT-3 scores, <80 SS) exhibited normal T-score domain performance on processing speed, working memory, and fluency.

DISCUSSION

The present study compared reading ability and a test of nonverbal intellectual functioning (that was less reliant on education) to assess their relationship to each other and to global and domain-specific neuropsychological function among a predominantly racial/ethnic cohort in which more than a third of participants had $<$ eighth-grade reading level. Consistent with our hypotheses, the GAMA correlated more strongly with global neuropsychological functioning than reading ability. Participants with the lowest literacy (mean reading grade score = fourth grade) achieved GAMA scores that were significantly higher than their reading scores. Among those with $<$ eighth-grade reading level, WRAT-3 reading scores were not significantly associated with neuropsychological domain scores whereas GAMA scores were, and across the sample the GAMA was found to be less confounded by education. While participants with low WRAT and low GAMA scores (both <80 SS) had uniformly impaired average T-scores on neuropsychological domains, those with low WRAT-3 ability (<80 SS) but GAMA scores within normal limits (>80 SS) performed significantly better on global neuropsychological functioning and processing speed.

The results demonstrate that the GAMA and the WRAT-3 Reading test function differently in low-literate participants. For instance, those who perform at the lowest level of literacy would be labeled as falling in the "mentally retarded" range of intellectual functioning (if using reading scores to estimate their IQ), whereas this same group performed in the "low average" range on the GAMA. Notably, their GAMA scores were only 1 standard deviation below

participants with the highest level of literacy (mean WRAT-3 SS = 113; $SD = 4$) whereas their WRAT-3 scores were 3 standard deviations less. Higher GAMA compared to reading scores among low-literate participants is consistent with the report of stronger visuo-perceptual skills relative to language- or reading-related abilities among both illiterate, indigenous adults unexposed to an educational system (Ostrosky-Solis, Ramirez, & Ardilla, 2004) and pre-literate, low-SES, African American kindergarteners (Noble, Norman, & Farah, 2005).

Our study findings also suggest that using reading scores to understand premorbid functioning could lead to inaccurate interpretations about the lack of disease-related effects because some low-literate individuals may exhibit a “floor effect.” As we demonstrated, separating patients with low WRAT scores (<80 SS) by GAMA scores (<80 SS versus ≥ 80 SS) revealed differences in performance on neuropsychological domains that were unrelated to HIV disease indices or other risk factors (age, means of HIV risk, or substance use disorders). Thus, the GAMA may help distinguish individuals who demonstrate solely low literacy from those with longstanding poor cognitive functioning across measures.

While the GAMA shows promise in understanding the abilities of low-literate individuals, current research has yet to determine the best way to assess cognitive functioning of racial/ethnic minorities that may have received a poor quality of education. Manly (2005) has noted that most neuropsychological tests do not tap the full potential of cognitive skills and strategies of racial/ethnic minorities, and our results support this observation. Although neuropsychological tests are vulnerable to sociodemographics (Byrd et al., 2006; Heaton et al., 1991; Heaton, Taylor, & Manly, 2001; Manly et al., 1998, 2004), most tests were designed for use with a non-Hispanic White population and have been normed primarily with this group (Manly, 2005). This is especially problematic in a disease like HIV, where racial/ethnic minorities are disproportionately affected.

It is imperative that clinicians be mindful of the higher likelihood that racial/ethnic minorities were raised in a low-SES environment, and understand that SES impacts reading. Low SES comprises not only low family income, but also lower maternal/caregiver education level, limited or poor-quality community resources in terms of schools, libraries, etc., and fewer and/or poor-quality home literacy materials and experiences (Brooks-Gunn, Duncan, Klebanov, & Sealander, 1993; Fazio, Naramore, & Connell, 1996; Hoffman & Llagas, 2003; Nettles & Perna, 1997). Given these factors, SES is highly predictive of the quantity and quality of children's early reading experiences (Bradley, Corwyn, Pipes McAdo, & Garcia Coll, 2001; Raz & Bryant, 1990; Whitehurst, 1997). There are also qualitative differences in the early home literacy experiences of African Americans. African Americans are more likely to have rich oral storytelling experiences (Ball, 1992), but are less likely to engage in daily storybook reading (Federal Interagency Forum on Child and Family Statistics, 2003). Additionally, their first experiences with text may occur as environmental forms of print, such as trademarks, which can often have unconventional spellings (Craig & Washington, 2004). Thus, the circumstances that contribute to low literacy are multi-faceted, and yet these circumstances are not routinely inquired about in the clinical interview nor are they factored into interpreting the neuropsychological profile. Similarly, experiences such as early exposure to print versus oral storytelling among low-literate people are not considered.

In trying to understand the quality of education in our own cohort, we found and previously reported that 56% of our cohort has a reading level that is at least 2 years discrepant from their educational level, suggesting that a sizable portion of our cohort has received a poor quality of education. Disentangling the effect of poor educational quality from HIV-related effects on cognitive functioning is very challenging given the dearth of information about normative neuropsychological performance in low-literate individuals. Besides normative data, understanding cognitive reserve in low-literate people is also important.

Education (De Ronchi et al., 2002; Satz et al., 1993; Stern, Silva, Chaisson, & Evans, 1996;) and verbal IQ (Basso & Bornstein et al., 2000; Farinpour et al., 2003) have been found to be markers of cognitive reserve in HIV. However, these measures may not be reliable markers of cognitive reserve for HIV+ racial/ethnic minorities who have received a poor quality of education. For instance, among healthy racial/ethnic minority elders, literacy (not education) was the most sensitive predictor of verbal memory decline (Manly, Touradji, Tang, & Stern, 2003). Among low-literate individuals it is unclear what the best predictor of cognitive reserve is. The GAMA may be the best predictor of cognitive reserve for low-literate individuals, because performance on it is less dependent on education (Noble et al., 2005; Ostrosky-Solis et al., 2004) and it has “ecologic relevance” for this group as they have may have relied more on visuo-perceptual ability than literacy to negotiate the world. Longitudinal studies of HIV-related neurocognitive impairment in low-literate individuals would help to increase understanding of the utility of literacy versus visuo-perceptual processing as a marker of cognitive reserve.

Whether low literacy and low GAMA scores signify lower cognitive reserve and greater vulnerability to the effects of HIV or whether low scores on both tests denote poorer premorbid cognitive functioning remains to be determined. While there is some evidence of an HIV-related pattern of impairment in NP domain scores among the group who had <80 SS on both tests (i.e., significantly lower speed of processing and a trend toward lower learning and executive functioning), a longitudinal study following individuals pre and post seroconversion would determine the significance of both low WRAT and low GAMA scores.

A limitation of this study is the assumption that HIV does not affect the GAMA. Investigation of how the GAMA performs relative to neuropsychological tests in a seronegative control group of low-literate people is needed in order to judge its ultimate utility. Despite not knowing HIV's effect on the GAMA, our finding that a subgroup of low-literate people had GAMA scores that were within normal limits was consistent with these participants' present and historical functional levels. The GAMA was also more strongly correlated with global neuropsychological functioning than the WRAT-3 reading test. Taken together, the GAMA appears to provide valuable information for understanding individuals who may have had ineffective instruction, and it should be considered in a neuropsychological evaluation when reading scores are <80 SS. As this study demonstrates, identifying an accurate premorbid estimation method for individuals whose low literacy is secondary to a poor quality of education would be a significant contribution to neuropsychological research.

We also recommend further study of phonological awareness skills, the building blocks of reading. Phonological awareness skills in kindergarteners are a better predictor of reading in adolescence than kindergarten reading ability (MacDonald & Cornwall, 1995). Noble, Farah, and McCandliss (2006) suggest that phonological awareness interacts with SES in the development of reading ability. At lower phonological awareness levels, children from lower-SES environments had worse reading ability, suggesting that a higher-SES environment and its accompanying resources can facilitate reading. More than half of our participants with < eighth-grade reading level were unable to write the alphabet flawlessly, and likely have deficient phonological awareness skills. Thus, future study of the relationship between alphabet writing and phonological awareness in low-literate adults may help to provide more specific information about the nature of their literacy deficiencies such that they can be quantified more precisely.

Currently it is unclear what constitutes impairment among individuals with low literacy, as well as what constitutes a clinically meaningful decline in cognitive functioning. Being able to identify cognitive impairment and decline in low-literate individuals is particularly important in HIV given the disproportionate effect of the virus on racial/ethnic minorities who are

vulnerable to receiving a poor quality of education. In fact, HIV may be one of the most challenging diseases in which to distinguish disease-related effects from poor education because, for some individuals, HIV can cause only subtle neuropsychological impairment or may not cause any impairment at all (given advances in combination antiretroviral treatment). Despite the backdrop of this challenge, we were able to distinguish low-literate individuals based on their GAMA performance and show differences in overall neuropsychological functioning. These findings highlight the need for further refinement of neuropsychological assessment techniques with low-literate individuals; work, in HIV populations, that will require a heretofore unprecedented understanding of the interplay of social/environmental factors and neurobiology.

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APPENDIX

Neuropsychological domains

Domain	Tests	Norms
Global	Mean T-score of all NP Tests	As indicated below
Motor	Grooved Pegboard, DH Grooved Pegboard, NDH	Heaton et al., 1991
Processing Speed	Trailmaking Test, A	Heaton et al., 1991

Domain	Tests	Norms
Working Memory	WAIS-III Digit Symbol	Wechsler, 1997
	WAIS-III Symbol Search	
	WAIS-III Letter Number Sequencing	Wechsler, 1997
	PASAT	Diehr et al., 2003
Learning	Brief Visual Memory Test - Total Recall	Benedict et al., 1997, 1998
Memory	Hopkins Verbal Learning Test - Total Recall	
	Brief Visual Memory Test - Delayed Recall	Benedict, 1997, 1998;
	Hopkins Verbal Learning Test - Delayed Recall	
Fluency	FAS	Gladso et al., 1999
Executive Functioning	Trailmaking Test, B	Heaton et al., 1991
	WCST Perseverative Responses	Kongs et al., 2000

Table 1

Education level and reading grade

	African American (N = 42)		Hispanic (N = 23)		Non-Hispanic White (N = 30)		F	p
	M	SD	M	SD	M	SD		
Education	12.1	2.3	11.9	2.8	14.3	2.9	7.3	<.01 ^I
Reading Grade	7.8	3.4	8.7	3.8	11.3	3.3	9.3	<.001 ^I

^I _{NHW>AA&H.}

Table 2
Demographic and medical status by reading level

Variable	<Eighth-grade reading level (N = 36)	≥ Eighth-grade reading level (N = 59)
Mean Age	48.7	49.3
Mean Years of Education	10.9	13.9 **
African American (%)	22 (61%) **	20 (34%)
Hispanic (%)	10 (28%) *	13 (22%)
Non-Hispanic White (%)	4 (11%) ^I	26 (44%)
Median Household Income per Zip Code (mean)	\$21,810	\$36,375 **
IDU Risk	50%	31%
Median CD4	378	406
Median log RNA	2.71	2.74

^I AA>NHW, H>NHW.

**
 $p < .01$

*
 $p < .05$

Table 3

Correlations of WRAT-3 Reading and General Ability Measure for Adults with neuropsychological domains by reading level

	<Eighth-grade reading		≥Eighth-grade reading	
	WRAT-3	GAMA	WRAT-3	GAMA
Global	−.06	.52 **	.33 *	.60 **
Motor	−.19	.24	.28 *	.49 **
Processing Speed	−.25	.59 **	.30 *	.59 **
Working Memory	.14	.15	.33 *	.39 **
Learning	.14	.39 *	.31 *	.40 **
Memory	.16	.39 *	.13	.40 **
Fluency	.11	.37 *	−.02	.26
Executive Functioning	−.24	.38 *	.25	.51 **

**
 $p < .01$

*
 $p < .05$.

Table 4
Participant characterization by WRAT-3 reading quartiles

	Education <i>M</i> (<i>SD</i>)	Reading Grade <i>M</i> (<i>SD</i>)	CD4	HIV log RNA	WRAT-3 SS <i>M</i> (<i>SD</i>)	GAMA SS <i>M</i> (<i>SD</i>)
Quartile 1 (<i>N</i> = 24)	10.3 ¹ (2)	4.3 ¹ (1)	385	3.03	67 (9)	84 ² (12)
Quartile 2 (<i>N</i> = 25)	12.1 (2)	7.7 (2)	339	2.72	81 (3)	83 (11)
Quartile 3 (<i>N</i> = 24)	13.3 (2)	12.0 (1)	413	2.66	96 (5)	95 (11)
Quartile 4 (<i>N</i> = 22)	15.6 (2)	13.0 (0)	459	2.46	113 (4)	99 ³ (12)

¹ Quartile 1 < Quartiles 2, 3, & 4, *p* < .001.
² Quartile 1 GAMA > WRAT Reading, *p* < .001.
³ Quartile 4 GAMA < WRAT Reading, *p* < .001.

Table 5
Participant characterization by General Ability Measure for Adults quartiles

	Education <i>M</i> (<i>SD</i>)	Reading grade <i>M</i> (<i>SD</i>)	CD4	HIV log RNA	GAMA SS <i>M</i> (<i>SD</i>)	WRAT-3 SS <i>M</i> (<i>SD</i>)
Quartile 1 (<i>N</i> = 24)	11.7 (3)	6.08 ¹ (3)	272	2.95	74 (5)	76 (14)
Quartile 2 (<i>N</i> = 30)	12.2 (2)	8.8 (4)	416	2.39	87 (3)	84 (14)
Quartile 3 (<i>N</i> = 20)	14.4 ² (3)	11.3 (3)	452	2.69	95 (2)	100 (18)
Quartile 4 (<i>N</i> = 21)	13.3 (3)	11.1 (3)	441	3.08	108 (8)	99 ³ (15)

¹ Quartile 1 < Quartiles 2,3,4, *p* < .01.
² Quartile 3 > Quartiles 1, 2, *p* < .01.
³ Quartile 4 GAMA > WRAT Reading, *p* < .05.

Table 6

Neuropsychological domain scores

	Low WRAT Low GAMA (<i>N</i> = 15) <i>M</i> (<i>SD</i>)	Low WRAT High GAMA (<i>N</i> = 19) <i>M</i> (<i>SD</i>)
Global	31.9* (7.4)	37.5 (5.5)
Motor	32.2 (10.7)	35.9 (8.6)
Processing Speed	33.4** (6.8)	41.9 (8.4)
Working Memory	37.0 (11.0)	40.3 (7.1)
Learning	26.8 (9.9)	31.6 (6.2)
Memory	28.1 (10.9)	32.7 (7.4)
Fluency	39.2 (7.6)	43.0 (9.9)
Executive Functioning	33.4 (8.8)	38.3 (6.4)

Neuropsychological domain scores in Low WRAT & Low GAMA (<80 SS) versus Low WRAT (<80 SS) and Higher GAMA (≥80 SS).

**
 $p < .01$

*
 $p < .05$.