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Cognitive Functioning and Driving Simulator Performance in Middle-aged and Older Adults with HIV

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Abstract

Nearly half of people living with HIV experience cognitive deficits that may impact instrumental activities of daily living. As the number of people aging with HIV increases, concerns mount that disease-related cognitive deficits may be compounded by age-related deficits, which may further compromise everyday functions such as driving. In this cross-sectional pilot study, during a 2.5-hour visit, 26 middle-aged and older adults (40+ years) were administered demographic, health, psychosocial, and driving habits questionnaires; cognitive assessments; and driving simulator tests. Although CD4+T lymphocyte count and viral load were unrelated to driving performance, older age was related to poorer driving. Furthermore, poorer visual speed of processing performance (i.e., Useful Field of View) was related to poorer driving performance (e.g., average gross reaction time). Mixed findings were observed between driving performance and cognitive function on self-reported driving habits of participants. Implications for these findings on nursing practice and research are posited.

Keywords

aging; driving; HIV; instrumental activities of daily living; neuropsychology

By 2015, nearly half of people living with HIV (PLWH) in the United States will be 50 years of age or older (Kirk & Goetz, 2009). Aging of the HIV population is a testament of

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the ability of combination antiretroviral therapy (cART) to reduce mortality and improve quality of life. Yet, even with improved health, concerns remain that people aging with HIV are at risk for microbial translocation, systemic and chronic inflammation, immune senescence, vascular comorbidities, and oxidative stress, all of which may account for the elevated cognitive deficits found in middle-aged and older adults with HIV compared to their uninfected counterparts (Vance, Fazeli, Moneyham, Keltner, & Raper, 2013).

HIV and Cognition

Many studies have shown that individuals with HIV, especially as they age, exhibit lower cognitive performance than uninfected individuals in the domains of speed of processing, psychomotor speed, executive functioning, and learning and memory (Lojek & Bornstein, 2005; Valcour, Paul, Neuhaus, & Shikuma, 2011; Vance, Fazeli, & Gakumo, 2013). The cognitive deficits in HIV reflect a dysfunction of the frontal-subcortical brain circuitry (Lojek & Bornstein, 2005). Although cART has dramatically improved life expectancy and reduced the incidence of HIV-associated dementia (HAD), more subtle forms of HIV-associated neurocognitive disorders persist as individuals continue to age with HIV (Vance, Fazeli, Moneyham et al., 2013). In fact, approximately 50% of people with HIV experience some form of cognitive deficit; the more subtle form (asymptomatic neurocognitive impairment) is the most common (Heaton et al., 2010).

Although it is promising that severe forms of cognitive deficits in HIV are less prevalent today, there remains a growing concern that even subtle cognitive deficits in the aforementioned domains will adversely affect instrumental activities of daily living (IADL) tasks such as driving (Marcotte et al., 2004). In fact, with the potential synergistic effect of aging and HIV on cognitive functioning (Vance, Fazeli, & Gakumo, 2013), examining driving abilities in people aging with HIV is particularly relevant, as the ability to drive safely has significant quality of life and public health implications. Driving is perhaps one of the most cognitively complex everyday activities, involving the ability to successfully negotiate ones' environment on the road by making quick decisions and attending and reacting to various stimuli. Given that in HIV the most pronounced and prevalent cognitive deficits are found in measures of speed of processing, and these functions directly underlie the ability to drive safely, this area requires further examination, especially given that 29% of adults with HIV have indicated a decreased driving ability (Marcotte, Heaton, Reicks, Gonzalez, & Grant, 2000).

HIV and Driving

While examining driving in HIV is a relatively new research area, Marcotte and colleagues have conducted several seminal studies on this topic. One study examined HIV-associated cognitive deficits and performance on a personal computer (PC) -based driving simulator as well as specific cognitive predictors of simulator performance in adults with HIV ($N = 68$; $M_{\text{age}} = 37.0$; Marcotte et al., 1999). They found that participants with cognitive deficits were more likely to fail the driving simulator protocol than cognitively "normal" participants, particularly with regard to number of simulator accidents. Further, they found that poor executive functions, attention, speed of processing, complex perceptual/motor, and simple motor abilities were the most consistent predictors of poor performance on the simulations. Self-reported crash history was not related to simulator performance, which may speak to the poor predictive validity of self-report crash data, and/or the ecological validity of the driving simulation (Marcotte et al., 1999). A later study by Marcotte et al. (2004) examined individuals with ($N = 40$; $M_{\text{age}} = 41.3$) and without ($N = 20$; $M_{\text{age}} = 42.5$) HIV on driving simulations, on-road driving, Useful Field of View[®] (UFOV[®]) performance (a computerized test of visual speed and attention), and overall cognitive performance.

Comparisons between three groups (the HIV-infected individuals with cognitive deficits, the HIV-infected cognitively normal group, and the uninfected group) revealed that the HIV-infected group with cognitive deficits had worse performance on all driving outcomes and UFOV[®] than the HIV-infected cognitively normal group and the uninfected group, who performed similarly. Cognitive performance and the driving simulations were independent predictors of on-road driving performance, explaining 48% of the variance, suggesting the unique predictive value of both indices. Another study by Marcotte et al. (2006) assessed HIV-infected ($N = 42$; $M_{\text{age}} = 42.0$) and uninfected ($N = 21$; $M_{\text{age}} = 42.5$) individuals on cognitive measures and found that those with HIV performed significantly worse than the uninfected group on the UFOV[®] test. Further, poor UFOV[®] performance was related to higher self-reported accidents in the previous year. Altogether these findings suggest that: (a) individuals with HIV who had some evidence of cognitive deficits exhibited poorer driving outcomes compared to HIV-infected individuals without such deficits and uninfected controls, and (b) cognition was an important predictor of real-world crash risk and should be considered by clinicians when making assessments of driving risk in those with HIV. While these earlier studies have significant implications, the relatively young mean ages limited their generalizability to older adults with HIV, who as a group have been observed to have poor UFOV[®] compared to younger adults with HIV and older adults without HIV (Vance, Fazeli, & Gakumo, 2013).

Purpose

Given that there is an increasing prevalence of adults aging with HIV who are at risk for developing cognitive deficits that may impair driving ability and other IADLs, further research is needed to examine driving performance in this at-risk population. In fact, many demographic and mental and physical health factors endemic to this clinical population can negatively impact cognitive functioning, which may indirectly impact driving outcomes (Vance, Fazeli, Moneyham et al., 2013). Thus, the purpose of this descriptive cross-sectional pilot study was to build on existing research and examine driving simulator performance in an older sample of adults with HIV than in prior studies. Aim 1 was to examine relationships between demographic and mental and physical health variables and driving simulator outcomes. Aim 2 was to examine relationships between cognitive and everyday functioning measures and driving simulator outcomes. Aim 3 was to examine relationships between demographic and mental and physical health variables, cognitive measures, and driving simulator outcome measures and self-reported driving habits in older adults with HIV.

Method

Participants

The University of Alabama at Birmingham's Institutional Review Board for Human Subjects reviewed and approved this study prior to recruitment and enrollment. Participants were recruited via flyers in a university-affiliated HIV clinic. From this, 51 patients called the research office and were screened over the phone. Exclusion criteria included being homeless ($n = 0$), being younger than 40 years of age ($n = 3$), being diagnosed for less than 1 year (to control for reactive depression that often accompanies an initial HIV diagnosis; $n = 1$), having any severe neuromedical co-morbidities ($n = 4$; i.e., Alzheimer's disease, dementia, mental retardation, schizophrenia, bipolar disorder), being pregnant ($n = 0$), inability to speak and understand English ($n = 0$), currently undergoing chemotherapy or radiation ($n = 0$), being legally blind or deaf ($n = 0$), or having a past brain injury with loss of consciousness greater than 30 minutes ($n = 0$). Many of these criteria were included to reduce the confounder of non-HIV-related cognitive deficits and/or to make the results more generalizable to the larger HIV community. In addition, as this was a driving performance and driving habits study, participants were also required to be a currently licensed driver in

order to control for potential poor driving simulator performance due to a lack of recent driving experience ($n = 6$ did not meet this criterion). Furthermore, all participants had to have been currently treated at the clinic in order to perform a medical chart extraction to gather most current CD4+T lymphocyte cell counts and HIV plasma viral loads that corresponded most closely to study visits ($n = 12$ did not meet this criterion). From this, 26 participants met eligibility criteria and completed the assessments. Participants were compensated \$50 for their time.

Procedure

After the 10-minute telephone screening, participants who met the inclusion/exclusion criteria were scheduled for a 2.5-hour visit. The study was explained and participants signed an institutional review board approved Use of Human Subjects consent form. Participants were administered demographic and mental and physical health instruments, a driving questionnaire, a comprehensive cognitive battery covering a range of cognitive domains (e.g., memory, speed of processing, psychomotor), and everyday functioning measures including two PC-based driving simulations.

Instruments

Measures

Demographic questionnaire—This measure was used to gather information on age (date of birth – date of interview), gender, sexual orientation, race/ethnicity, years of education (1 = *grade 1*, 12 = *high school diploma/GED*, 14 = *associate's degree*, 16 = *bachelor's degree*, 18 = *master's degree*, 20 = *doctoral degree*); work status (hours worked for pay each week); and household income before taxes (0 = *less than \$10K*, 1 = *\$10K - \$20K*, etc). These data were used to describe the sample and provide a context in which to interpret the findings.

Health questionnaire—Based on the health instrument used in the Cardiovascular Health Study (1989), this measure was used to determine common co-morbidities (e.g., hypertension, diabetes, heart disease) participants identified as having; from this, the total number of co-morbidities was calculated. Likewise, participants reported prescribed medications; from this, the total number of medications was calculated. Participants were also asked to report their most recent CD4+T lymphocyte count and viral load. Medical chart extraction from the clinic was also performed to gather these data. Surprisingly, participants were quite accurate in recalling their most recent CD4+T lymphocyte count ($r = 0.84$, $p < .001$) but not their viral load ($r = -0.34$, $p = 0.11$). For analyses, only the clinical values from medical chart extraction were used.

Centers for Epidemiological Studies (CES) – Depression Scale—The CES-Depression Scale (Radloff, 1977) was used because depression and depressive symptomatology can negatively impact cognition. Participants indicated on a 4-point Likert-type scale how often they felt a certain way over the previous week related to a verbal symptom of depression for each of the items. These were tallied to form a composite score that could range from 0 to 60, with higher scores indicating more depressive symptomatology. Cronbach's alpha is very good at 0.88 (Clark, Mahoney, Clark, & Eriksen, 2002).

Far visual acuity—Participants had to have relatively normal far visual acuity to drive and participate in our study. Participants' corrected distance visual acuity was measured via a standard eye chart and expressed as log minimum angle of resolution. The measure is face valid and is the gold standard of vision research (Vance et al., 2006).

Addiction Severity Index—Because substance use can impact cognition, the Addiction Severity Index, a widely used gold standard measure, was used to quantify alcohol and drug use. Several items were used to determine type, frequency, and severity of substance use from which established composite scores were calculated. Higher scores indicated greater alcohol and drug use. Composites for alcohol use ($r = 0.88$) and drug use ($r = 0.89$) displayed good inter-rater reliability (McLellan et al., 1992).

Simplified Medication Adherence Questionnaire—cART medication adherence was measured using this 6-item instrument that assessed how consistently a patient took his or her medication (e.g., *Over the past 3 months, how many days have you not taken any medicine at all?*). A composite score was computed; lower scores indicated better adherence. Two questionnaires were not completed because those participants were not prescribed cART. The questionnaire has good overall inter-observer agreement (88.2%) and has been validated with virological outcomes (Knobel et al., 2002).

Cognitive Measures

Useful Field of View (UFOV®)—The UFOV® test has been shown to be predictive of on-road driving performance in clinical and non-pathological populations. The UFOV® test is a touch-screen computerized visual attention and visual speed of processing measure with four subtests that increase in complexity and decrease in stimuli presentation time based on participant performance (Edwards et al., 2005). The first subtest measured gross visual attention and had participants attend to a central target on the screen and then identify if the target was a car or truck. The second subtest measured divided attention and included the central identification from Subtest 1 with the addition of a peripheral localization target in one of eight locations surrounding the central identification target. The third subtest was the same as the second, but distractors (triangles) filled the area between the central identification task and the peripheral localization task, tapping into participants' selective attention abilities. Subtest 4 was the same as Subtest 3 with the addition of a more challenging central identification task where participants were instructed to determine whether the objects were the same or different. In each subtest, a double staircase method was used to determine the presentation speed in which participants correctly completed the task 75% of the time. The optimal presentation speed for each of the four subtests in milliseconds was the outcome; higher scores indicated poorer visual attention and visual speed of processing. Additionally, a sum of the four subtests was used to create a composite score for this measure. Test-retest reliability was quite high and ranged from 0.74 to 0.81 (Edwards et al., 2005).

Complex Reaction Time—The Complex Reaction Time test is a measure of everyday speed as the tasks involve responding to street signs (Ball et al., 2002). The test is computerized and uses a mouse response mode. Participants were shown various street signs (e.g., a pedestrian, a left or right arrow) and asked to respond when they saw a sign that did not have a red slash. If they saw an arrow street sign without a slash, they were instructed to move the mouse as quickly as possible in the direction the arrow was pointing. If they saw any other street sign without a red slash (i.e., pedestrian, bicycle), they were told to click their mouse as quickly as possible. The task alternated presentation of signs between 3 and 6 signs at a time. Scores for this measure included a 3-sign and 6-sign average reaction time in seconds, with higher scores reflective of slower reaction time in the context of responding and attending to street signs. An average reaction time was also created for this measure. The test-retest reliability for this measure was modest, at $r = 0.56$ (Ball et al., 2002), and may have been in part due to the variable nature of reaction time.

Letter comparison—Speed of processing was measured with this commonly used pencil-and-paper test. In the version we used, 192 pairs of letters containing three (e.g., HLV, HLX), six (e.g., NLCVZL, NLCVZL), or nine (e.g., SLNFZHMBQ, SLHFZNMBQ) segments were presented to participants. Participants were timed to mark whether the segments were the *same* or *different* and to denote this by writing either an “S” or “D” between the segments as quickly as possible. The score was the total number of correct responses; higher scores indicated faster speed of processing (Salthouse, 1991).

Pattern comparison—Speed of processing was also measured with this commonly used pencil-and-paper test. In the version we used, 96 pairs of patterns containing three, six, or nine line segments were presented to participants. Participants were timed to mark whether the segments were the *same* or *different* and to denote this by writing either an “S” or “D” between the segments as quickly as possible. The score was the total number of correct responses; higher scores indicated faster speed of processing (Salthouse, 1991).

Hopkins Verbal Learning Test - Revised (HVL - R)—Memory was measured with this commonly used instrument. The test started by playing an audiotape, which contained 12 words that were semantically related; 4 were animals (e.g., lion), 4 were shelters (e.g., cave), and 4 were stones (e.g., emerald). After the participant had heard the audiotape, three learning/free-recall trials were administered. The score was the total number of words recalled in all three trials; higher scores indicated better memory. Over a 9-month period with older adults, test-retest reliability was stable ($r = 0.50$), a value similar to other gold standard measures of memory such as the California Verbal Learning Test and the Logical Memory subtest of the Wechsler Memory Scale-Revised (Rasmusson, Bylsma, & Brandt, 1994).

Finger Tapping Test (FTT)—Psychomotor ability was measured using the FTT. The participant was instructed to use an index finger to tap on a button attached to a device as many times as possible for 10 seconds; the device automatically counted the number of taps within those 10 seconds. A total of 10 trials were conducted; 5 for the right and 5 for the left hand. The score was the average number of taps across the 10 trials; higher scores indicated better psychomotor ability. Test-retest reliability for this test ranged from 0.86 to 0.94 (Lezak, 1995).

Trails A—Attention, visuospatial tracking, and perceptual motor speed were measured by Trails A. In this commonly used pencil-and-paper test, participants were instructed to connect randomly scattered numbers on a paper in sequence (e.g., 1-2-3-4 etc.) and to do so as quickly and accurately as possible. The score was the amount of time (seconds) needed to complete the task; lower scores indicated better cognitive performance. This test has been used in HIV research and has good sensitivity to age-related cognitive declines (Lezak, 1995).

Trails B—Trails B measured executive functioning, as well as attention, visuospatial tracking, and perceptual motor speed. Similar to Trails A, in this commonly used pencil-and-paper test, participants were instructed to connect randomly scattered numbers and letters on a paper in sequence (e.g., 1-A-2-B-3-C etc.) and to do so as quickly and accurately as possible. The score was the amount of time (seconds) needed to complete the task; lower scores indicated better cognitive performance. This test has also been used in HIV research and has good sensitivity to age-related cognitive deficits (Lezak, 1995).

Everyday Functioning Measure

Timed Instrumental Activities of Daily Living Test (TIADL)—The ability to perform instrumental activities of daily living (IADLs) was measured using the TIADL (Owsley, Sloane, McGwin, & Ball, 2002). In this objective measure, participants were given five tasks to perform and they were evaluated on the accuracy and speed in which the tasks were completed. The tasks included identifying ingredients on cans of food, reading instructions on medicine bottles, using a phone book to look up a specific number, locating food items on a shelf, and counting out correct change. Time (seconds) required to complete the task was recorded; a maximum time limit of 2 minutes was set a priori in case participants could not complete the task (3 minutes was used as the maximum time limit for looking up a number in a phone number). A time penalty was added to the time required to complete the task if it was not performed accurately. Accuracy was also assessed using pre-established guidelines (completed without errors, completed with minor errors, completed with major errors). Each of the tasks was transformed to z-scores (i.e., mean set to zero), which allowed them to be equally weighted and then summed to form an overall composite score; lower scores indicated better IADL functioning. Test-retest reliability for the TIADL is good ($r = 0.64$; Owsley et al., 2002).

Driving Measures

Mobility questionnaire—Self-reported driving habits were assessed using the mobility questionnaire. Participants indicated the quality of their own driving (1 = *excellent*; 5 = *poor*), number of days out of 7 driven per week, number of miles driven in a 7-day week, total number of accidents during the previous 2 years as the driver, and the total number of times pulled over by the police in the previous 2 years as the driver (Vance et al., 2006).

Driving simulator—Participants completed two PC-based driving simulations using the STISIM computer program (Rosenthal, Parseghian, Allen, & Stein, 1995). The hardware on this simulator consisted of a steering wheel, a horn, turn signals, accelerator and brake pedals, sound system, adjustable car seat, and 3 monitors (one with front view and two adjacent monitors reflecting the right and left side views giving the driver a 100 degree field of view). The center monitor displayed the speedometer, and rear view mirrors were placed appropriately providing a view of the road behind the driver. In order to familiarize the participants to the simulator and to reduce potential novelty that may have confounded performance, participants underwent an adaptation or practice drive that lasted approximately 7 minutes. During the adaptation drive, participants practiced reaching and maintaining the speed limit, making turns, using the brakes, stopping at stop signs, and generally becoming familiar with the simulator. There were also two reaction time tasks that participants practiced during adaptation. The first was a gross reaction time task that required participants to press the brake pedal immediately when a large (not a standard) stop sign was shown on the center screen. The second was a divided attention reaction time task requiring participants to press a button to the right of the steering wheel as soon as they noticed a red arrow flash on the right screen, and the same procedure for the left side. When the adaptation terminated, participants were instructed to ask any final questions because the experimenter would not be able to talk to them or answer questions during the actual driving test. In addition to maintaining the speed limit, the experimenter stressed the importance of driving as one would normally on the real road.

The driving simulation consisted of 13.98 miles of city and country driving and took participants approximately 20–30 minutes to complete depending on speed; all participants were instructed to adhere to the speed limit signs. In addition to the aforementioned gross and divided attention reaction time tasks, participants were given instructions during the drive via the computer speakers (e.g., *turn right/left at the next intersection*). Also,

numerous scenarios were embedded in the protocol that required participants to use aggressive driving maneuvers to maintain safety for themselves and other cars/pedestrians (e.g., a biker pulls out in front of their car, a car drives toward them in their lane).

Outcome variables for the simulation consisted of: (a) average gross reaction time, (b) lowest reaction time, (c) average divided attention reaction time, (d) lowest divided attention reaction time, (e) total number of 18 divided attention reaction time tasks that were correctly completed, (f) number of crashes, (g) number of pedestrians hit, (h) total time of drive (seconds), (i) percentage of total drive time over the speed limit, and (j) percentage of total drive time out of lane. Note that, for the divided attention task, if participants missed (did not attend to) any of the 18 trials, a time of 5 seconds was automatically given for this trial. Thus, the divided attention average was created including these 5 seconds, when applicable. Given that the goal of our pilot study was to examine cognitive predictors of individual outcomes, participants were not classified as passing or failing the simulation, but instead the unique predictors of each of the driving outcomes were examined.

Results

Data Analysis

Data were analyzed using SPSS 19.0. There were no missing data. Basic descriptive and bivariate statistics (i.e., Pearson's *r* correlations) were used to examine patterns of relationships between study variables; alpha was set at .05. Due to the small sample size, no alpha inflation corrections were used.

Background Characteristics of the Sample

As seen in Table 1, more than half (58%) of the sample were 50 years or older with a mean age of 51 years. The majority of participants were male (65%), heterosexual (54%), and African American (65%). Most participants had at least a high school education (88%) and were currently unemployed (80%). On average, participants had six ($SD = 2.42$) medical conditions and were prescribed seven ($SD = 3.66$) medications. The mean of depressive symptoms for the sample was a CES-D score of 17 ($SD = 12.89$), which is borderline high (16 or higher is indicative of depression; Katz et al., 1996). Nearly 50% of adults with HIV have experienced medically documented depressive symptomology (Vance, Mugavero, Willig, Raper, & Saag, 2011), so our sample was reflective of the larger HIV population. The far visual acuity score reflected that participants had relatively normal vision; a score around 0 was considered normal or 20/20 (Vance et al., 2006). In general, the substance use scores were low, with alcohol use being endorsed more than other drugs.

Regarding HIV, participants had been diagnosed with HIV for an average of nearly 16 years. The mean CD4+T lymphocyte cell count was high at 628 cell/mm³; this was well within the normal immunological range, which indicated that ours was a relatively healthy sample. In addition, 21 of 26 (80%) had an undetectable viral load, which indicated excellent viral suppression. Of those who had a detectable viral load, two were not prescribed cART. Concerning the cognitive and everyday functioning variables, there was a wide range of functioning within the sample with some individuals performing 2 or 3 standard deviations below and above the mean; this indicated that some participants were experiencing successful cognitive aging and some were not. Furthermore, when using demographically-based norms for these cognitive tests, it was clear that a few participants were performing well above the norms; as can be seen, only a handful of participants scored above the 70th percentile which indicated excellent cognitive functioning (i.e., Trails A ($n = 2$; 8%), Trails B ($n = 5$; 19%), HVLIT ($n = 0$; 0%), and FTT dominant hand ($n = 1$; 4%) and non-dominant hand ($n = 1$; 4%)). However, many of the participants were performing well

below the demographically-based norms; as can be seen, several participants scored below the 30th percentile which indicated poor cognitive functioning (i.e., Trails A ($n = 10$; 38%), Trails B ($n = 16$; 62%), HVLT ($n = 3$; 11%), and FTT dominant hand ($n = 0$; 0%) and non-dominant ($n = 0$; 0%)).

As seen in Table 2, there were also a wide range of scores for driving simulator outcomes and self-reported driving habit variables. On average, there were 2.5 collisions during the driving simulation and 0.35 pedestrian hits. In general, most participants rated their driving as *excellent* or *very good* as indicated by a mean of 1.54. Participants drove, on average, 5.35 days and 123 miles a week.

Aim 1: Demographic/Mental Health/Physical Health and Driving Simulator Outcomes

As seen in Table 3, few relationships were significant. Older age was associated with slower (lowest) divided attention reaction time and average divided attention reaction time. Surprisingly, higher income was associated with slower (lowest) gross reaction time. Finally, more reported drug use was associated with lower (faster) average gross reaction time.

Aim 2: Cognition/Everyday Functioning and Driving Simulator Outcomes

As seen in Table 4, better (i.e., lower score) UFOV[®] performance was associated with faster (lowest) gross reaction time, faster average gross reaction time, and faster average divided attention reaction time. Better Complex Reaction Time performance and better memory performance (HVLT-R) were associated with better driving simulator performance via lower percent of drive time spent outside the lane. Better Letter Comparison performance was associated with better driving simulator performance through lower percentage of drive time spent over the speed limit. Better executive performance (Trails B) was associated with faster average divided attention reaction time. Finally, better TIADL performance was associated with lower percentage of drive time spent outside the lane.

Aim 3: Associations to Self-Reported Driving Habits

As seen in Table 5, self-rated driving quality was not related to any of the study variables; however, there was little variance in this variable as most reported their driving as *very good* or *excellent*. This finding was in line with research by Ross, Dodson, Edwards, Ackerman, and Ball (2012), which found that the large majority of older adults rated their driving as *very good* or *excellent*, regardless of objective evidence of negative driving outcomes within the previous 5 years. More days driven out of 7 was associated with fewer medications taken, less drug use, lower CD4+T lymphocyte count, and better attention and perceptual motor speed performance (Trails A). More miles driven in a 7-day week was associated with higher income, fewer medications taken, worse UFOV[®] performance, slower (lowest) gross reaction time, and higher number of pedestrians hit in the driving simulator. More accidents in the previous 2 years were associated with slower (lowest) gross reaction time and higher total number of collisions in the driving simulator.

Discussion

When integrating the three study aims, it appears that some of the findings may be mixed regarding tacit expectations but, in general, increased age and poorer UFOV[®] performance were found to be related to slower reaction times in the driving simulator. This is a concern given a prior study of adults with HIV ($n = 78$; ages 20 to 70 years) where increasing age was significantly associated with poorer UFOV[®] performance ($r = .38$, $p < .01$; Vance, Fazeli, & Gakumo, 2013). Those findings were aligned with HIV studies reported by

Marcotte et al. (1999, 2004), as well as the older adult driving literature (Ball, Edwards, Ross, & McGwin, 2010).

Despite this, those with poorer UFOV[®] performance reported significantly more miles driven during the week. This finding was at odds with a large amount of literature where the opposite has been found (Ross et al., 2009; Vance et al., 2006), which may suggest that older adults with HIV who have poorer visual speed of processing may be placing themselves and others at risk, and may not be aware that they, themselves, are at risk (Vance, Fazeli, Moneyham et al., 2013). In fact, in both Ross et al.'s (2012) and our study, people generally rated their driving as *good*, *very good*, or *excellent*; perhaps the internal acceptance of perceived driving quality prevented the individual from accurately monitoring driving ability and the possible need to reduce or restrict driving. Another explanation for this finding could be that participants with poorer UFOV[®] performance also had poorer executive functioning and thus were making poorer decisions about their driving behaviors; given the interrelatedness of cognitive domains, this is a reasonable hypothesis and worth investigating further. This finding was also supported by the significant association with more miles driven during the week and slower (lowest) gross reaction time and more pedestrian hits in the simulator.

An alternate interpretation of the association with more miles driven per week and poorer simulator outcomes may be that those who drove less in the real world were more cautious (e.g., compensating) in the simulator because it was relatively more novel to them, than to someone who drove frequently. This interpretation is questionable, however, because those with slower (lowest) reaction times and more collisions in the driving simulator reported more actual on-road accidents within the previous 2 years. While there was a low range in the simulator and self-reported crashes variables, the fact that an association between the two emerged was, nonetheless, a salient finding in our study and supported the validity and applicability of simulator outcomes to on-road driving. However, it is important to note that the results related to more self-reported days driven per week positively correlated with worse UFOV[®] performance, worse gross reaction time, and more pedestrian hits should be interpreted with caution as they were not typical of the literature. It is possible that the results were invalid or inconclusive due to the small sample size of our pilot study. Further, this finding could be due to the relatively young sample size ($M_{age} = 51.23$, $SD = 6.17$) when compared to studies in much older adults without HIV, which found that poorer UFOV[®] performance was related to a reduction in driving (Ross et al., 2009 [$M_{age} = 70.96$]; Vance et al., 2006 [$M_{age} = 71.47$]). Also, despite poor UFOV[®] performance, compared to a much older sample, perhaps the sample in our study may not have had the option of reducing driving due to daily life demands that required driving. Finally, as is consistent with real-world driving outcome literature (Ball et al., 2010), better cognitive performance in speed of processing (Complex Reaction Time, UFOV[®]), executive functioning (Trails B), memory (HVLT-R), and better everyday functioning (TIADL) were also associated with better driving simulator performance outcomes. The lack of association with psychomotor speed (FTT) was consistent with cART-era findings demonstrating that this domain may be spared with well-controlled HIV therapy (Al-Khindi, Zakzanis, & van Gorp, 2011).

Concerning the demographic, mental health, and physical health variables, several associations with driving are worth considering. Driving more days per week was associated with higher income. This finding was consistent with other literature and may reflect work status or income needed to support fiduciary requirements (e.g., gas, insurance) to drive (Marottoli et al., 1993). Additionally, more days driven per week was also associated with taking fewer medications and faster psychomotor speed (Trails A), which is intuitive; those who are healthier, as indicated by taking fewer medications, and have better psychomotor speed may drive more. Some findings from our study are less clear, namely the findings

that: (a) more drug use was associated with better average reaction time in the simulator, which could reflect stimulant use; (b) increased drug use and lower CD4+T lymphocyte counts were associated with more days driven; and (c) higher income was related to reaction time. As these three findings were inconsistent with established literature, they should be interpreted with care and may reflect alpha inflation from the numerous tests conducted or the small sample size.

Implications for Nursing Practice and Research

Our findings have at least two important implications for nurses in practice and research. First, given that nearly half of adults with HIV experience cognitive deficits (Heaton et al., 2010), nurses working with older adults with HIV must be aware of the prevalence of cognitive deficits in this population that can affect everyday functioning, including driving, which could threaten their safety and the safety of others. If cognitive deficits are suspected, appropriate referrals to a psychologist or neurologist should be considered (Vance, Fazeli, Moneyham et al., 2013).

Second, because UFOV[®] performance is the single best predictor of passing or failing an on-road driving assessment beyond vision and other cognitive measures in older adults (Myers, Ball, Kalina, Roth, & Goode, 2000), it is important to examine how this cognitive ability can be improved in this population. In a study of normal community-dwelling older adults, 10 hours of specifically designed computerized speed of processing training was found to improve UFOV[®] performance, which translated to safer driving simulator performance (Roenker, Cissell, Ball, Wadley, & Edwards, 2003) and an almost 50% reduction in at-fault state-reported crashes across 6 years (Ball et al., 2010). Furthermore, Vance, Fazeli, Ross, Wadley, and Ball (2012) delivered the speed of processing training to middle-aged and older adults with HIV compared to the control group, those who received the training not only significantly improved their UFOV[®] performance but the training translated into improved performance on a measure of everyday functioning (i.e., TIADL). This suggested that older adults with HIV might experience beneficial outcomes from training, but further research is needed.

Limitations and Strengths

Some limitations and strengths of the study are noteworthy. The major limitations were the small sample size and lack of a younger HIV-infected group or an uninfected comparison group, all of which prevented more sophisticated statistical analyses and comparisons. Even so, it is important to note that driving simulator studies often use small numbers of participants due to the inherent cost of collecting and processing driving simulation data (e.g., average sample size = 30; Rapoport & Baniña, 2007). The major strengths include: (a) the use of a well-established, psychometrically cognitive battery of tests; (b) the inclusion of a much older sample of adults with HIV compared to previous HIV driving simulator studies; and (c) the inclusion of novel measures examining driving performance in this clinical population, including self-rated driving habits.

Conclusion

As adults age with HIV, many will experience cognitive deficits that may predispose them to poorer driving performances. In fact, adults with HIV experiencing cognitive deficits may be unaware of their own cognitive deficits (Vance, Fazeli, Moneyham et al., 2013). Likewise, as found in our study and others, many who exhibit poor driving performance as measured by driving simulator outcomes may not be aware of their driving deficits and may actually consider themselves to be good or excellent drivers. Fortunately, studies do show that some cognitive abilities (i.e., visual attention and visual speed of processing) associated

with driving can be improved in middle age and older adults with HIV (Vance, Fazeli, & Gakumo, 2013), so this technique may improve driving safety in adults with HIV as they age.

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References

- Al-Khindi T, Zakzanis KK, van Gorp WG. Does antiretroviral therapy improve HIV-associated cognitive impairment? A quantitative review of the literature. *Journal of the International Neuropsychological Society*. 2011; 17:1–14. [PubMed: 21083962]
- Ball KK, Berch DB, Helmers KF, Jobe JB, Leveck MD, Marsiske M, Willis SL. Effects of cognitive training interventions with older adults: A randomized controlled trial. *Journal of the American Medical Association*. 2002; 288(18):2271–2281. [PubMed: 12425704]
- Ball KK, Edwards JD, Ross LA, McGwin G. Cognitive training decreases motor vehicle collision involvement of older drivers. *Journal of the American Geriatrics Society*. 2010; 58:2107–2113. [PubMed: 21054291]
- Cardiovascular Health Study. Manual of operations. Seattle, WA: University of Washington Coordinating Center; 1989.
- Clark CH, Mahoney JS, Clark DJ, Eriksen LR. Screening for depression in a hepatitis C population: The reliability and validity of the Center for Epidemiologic Studies Depression Scale. *Journal of Advanced Nursing*. 2002; 40(3):361–369. [PubMed: 12383188]
- Edwards JE, Vance DE, Wadley V, Cissell GM, Roenker DL, Ball KK. The reliability and validity of the Useful Field of View test scores as administered by personal computer. *Journal of Clinical and Experimental Neuropsychology*. 2005; 27:529–543. [PubMed: 16019630]
- Heaton RK, Clifford DB, Franklin DR Jr, Woods SP, Ake C, Vaida F, Grant I. HIV-associated neurocognitive disorders persist in the era of potent antiretroviral 24 therapy. *Neurology*. 2010; 75:2087–2096. [PubMed: 21135382]
- Katz MH, Douglas JM Jr, Bolan GA, Marx R, Sweat M, Park MS, Buchbinder SP. Depression and use of mental health services among HIV-infected men. *AIDS Care*. 1996; 8(4):433–442. [PubMed: 8863914]
- Kirk JB, Goetz MB. Human immunodeficiency virus in an aging population, a complication of success. *Journal of the American Geriatrics Society*. 2009; 57(11):2129–2138. [PubMed: 19793157]
- Knobel H, Alonso J, Casado JL, Collazos J, Conzlez J, Ruiz I, Ocampo A. Validation of a simplified medication adherence questionnaire in a large cohort of HIV-infected patients: The GEEMA Study. *AIDS*. 2002; 16(2):605–613. [PubMed: 11873004]
- Lezak, MD. *Neuropsychological assessment*. 3rd ed.. New York, NY: Oxford University Press; 1995.
- Lojek E, Bornstein RA. The stability of neurocognitive patterns in HIV infected men: Classification considerations. *Journal of Clinical and Experimental Neuropsychology*. 2005; 27:665–682. [PubMed: 16019643]
- Marcotte, T.; Heaton, R.; Reicks, C.; Gonzalez, R.; Grant, I. HIV-related neuropsychological impairment and automobile driving. Poster presented at the 28th annual meeting of the International Neuropsychological Society; Denver, CO. 2000 Feb.
- Marcotte TD, Heaton RK, Wolfson T, Taylor MJ, Alhassoon O, Arfaa K, Grant I. The impact of HIV-related neuropsychological dysfunction on driving behavior. *Journal of the International Neuropsychological Society*. 1999; 5:579–592. [PubMed: 10645701]
- Marcotte TD, Lazzaretto D, Scott JC, Roberts E, Woods SP, Letendre S. Visual attention deficits are associated with driving accidents in cognitively-impaired HIV-infected individuals. *Journal of Clinical and Experimental Neuropsychology*. 2006; 28:13–28. [PubMed: 16448973]

- Marcotte TD, Wolfson T, Rosenthal TJ, Heaton RK, Gonzalez R, Ellis RJ, Grant I. A multimodal assessment of driving performance in HIV infection. *Neurology*. 2004; 63:1417–1422. [PubMed: 15505158]
- Marottoli RA, Ostfeld AM, Merrill SS, Perlman GD, Foley DJ, Cooney LM Jr. Driving cessation and changes in mileage driven among elderly individuals. *Journal of Gerontology: Social Sciences*. 1993; 48(5):S255–S260.
- McClellan AT, Kushner H, Metzger D, Peters R, Smith L, Grissom G, Argeriou M. The fifth edition of the Addiction Severity Index. *Journal of Substance Abuse Treatment*. 1992; 9(3):199–213. [PubMed: 1334156]
- Myers RS, Ball KK, Kalina TD, Roth DL, Goode KT. The relationship of Useful Field of View and other screening instruments to on-road driving performance. *Perceptual and Motor Skills*. 2000; 91(1):279–290. [PubMed: 11011899]
- Owsley C, Sloane M, McGwin G Jr, Ball K. Timed Instrumental Activities of Daily Living Tasks: Relationship to cognitive function and everyday performance assessments in older adults. *Gerontology*. 2002; 48:254–265. [PubMed: 12053117]
- Radloff LS. The CES-D Scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*. 1977; 1:385–401.
- Rapoport MJ, Baniña MC. Impact of psychotropic medications on simulated driving: A critical review. *CNS Drugs*. 2007; 21(6):503–519. [PubMed: 17521229]
- Rasmusson DX, Bylsma FW, Brandt J. Stability of performance of the Hopkins Verbal Learning Test. *Archives of Clinical Neuropsychology*. 1994; 10(1):21–26. [PubMed: 14588448]
- Roenker DL, Cissell GM, Ball KK, Wadley VG, Edwards JD. Speed of processing and driving simulator training result in improved driving performance. *Human Factors*. 2003; 45(2):218–233. [PubMed: 14529195]
- Rosenthal, TJ.; Parseghian, Z.; Allen, RW.; Stein, AC. STISIM: The low-cost driving simulator. Hawthorne, CA: Systems Technology, Inc.; 1995.
- Ross LA, Clay OJ, Edwards JD, Ball K, Wadley VG, Vance DE, Joyce JJ. Do older drivers at-risk for crashes modify their driving over time? *Journals of Gerontology: Psychological Sciences*. 2009; 64(2):163–170.
- Ross LA, Dodson J, Edwards JD, Ackerman ML, Ball KK. Self-rated driving and driving safety in older adults. *Accident Analysis and Prevention*. 2012; 48:523–527. [PubMed: 22664719]
- Salthouse TA. Mediation of adult age differences in cognition by reductions in working memory and speed of processing. *Psychological Science*. 1991; 2(3):179–183.
- Valcour V, Paul R, Neuhaus J, Shikuma C. The effects of age and HIV on neuropsychological performance. *Journal of the International Neuropsychological Society*. 2011; 17(1):190–195. [PubMed: 21144102]
- Vance DE, Fazeli PL, Ross LA, Wadley V, Ball K. Speed of processing training with middle-age and older adults with HIV: A pilot study. *Journal of the Association of Nurses in AIDS Care*. 2012; 23(6):500–510. [PubMed: 22579081]
- Vance DE, Fazeli PL, Gakumo CA. The impact of neuropsychological performance on everyday functioning between older and younger adults with and without HIV. *Journal of the Association of Nurses in AIDS Care*. 2013; 24(2):112–125. [PubMed: 22943982]
- Vance DE, Fazeli PL, Moneyham L, Keltner NL, Raper JL. Assessing and treating forgetfulness and cognitive problems in adults with HIV. *Journal of the Association of Nursing in AIDS Care*. 2013; 24(1S):S40–S60.
- Vance DE, Mugavero M, Willig J, Raper JL, Saag M. Aging with HIV: A cross-sectional study of comorbidity prevalence and clinical characteristics across decades of life. *Journal of the Association of Nurses in AIDS Care*. 2011; 22(1):17–25. [PubMed: 20471864]
- Vance DE, Roenker DL, Cissell GM, Edwards JD, Wadley VG, Ball KK. Predictors of driving exposure and avoidance in a field study of older drivers from the state of Maryland. *Accident Analysis and Prevention*. 2006; 38:823–831. [PubMed: 16545765]

Key Considerations

- Older adults with HIV who have poorer visual speed of processing may be placing themselves and others at risk and may not be aware of the risk.
- Nurses working with older adults with HIV should be aware of the prevalence of cognitive deficits in this population that can affect everyday functioning, including driving. Assessing for cognitive deficits and using performance-based measures of IADLs such as driving should be considered.
- UFOV[®] performance can be improved in those aging with HIV, and has been shown to improve driving in community-dwelling older adults without HIV infection, suggesting that older adults with HIV may experience similar beneficial outcomes, but further research is needed.

Table 1Sample Description ($N = 26$)

Variables	<i>M (SD)</i>	<i>n (%)</i>	Range
Demographics Variables			
Age (years)	51.23 (6.17)		41.4 – 67.07
Gender (number of Men)		17 (65.4%)	
Race (number Caucasian)*		8 (30.8%)	
Sexual Orientation (number Heterosexual)		14 (53.8%)	
Years of Education	13.04 (2.03)		8 – 18
Employment (number Unemployed)		5 (19.2%)	
Income**	2.08 (1.16)		1 – 5
Mental/Physical Health Variables			
Total Number of Co-morbidities	6.00 (2.42)		2 – 10
Total Number of Medications	7.19 (3.66)		1 – 14
CES-Depression Score	16.85 (12.89)		1 – 52
Far Visual Acuity***	−0.03 (0.12)		−0.10 – 0.50
Alcohol Use	0.26 (0.61)		0 – 2.77
Drug Use	0.03 (0.05)		0 – 0.23
Years with HIV	15.92 (7.18)		3.27 – 29.47
Number (%) Taking cART		24 (92.3%)	
cART Medication Adherence	2.08 (2.41)		0 – 8
CD4+ Lymphocyte Count (clinic values) [†]	628.81 (342.86)		54 – 1,333
Viral Load (clinic values) [‡]	4,502.96 (15,307.17)		20 – 71,500
Cognitive Variables			
UFOV® Total (milliseconds)	659.65 (384.93)		94 – 1,940
Complex Reaction Time (seconds)	1.75 (0.52)		1.10 – 3.08
Letter Comparison (number correct)	48.73 (11.35)		25 – 72
Pattern Comparison (number correct)	34.42 (5.19)		24 – 45
HVLT-R Memory (number correct)	27.77 (4.79)		19 – 35
Finger Tapping Test (average number taps)	46.04 (6.59)		34.10 – 62.30
Trails A (seconds)	32.98 (7.41)		19.82 – 54.09
Trails B (seconds)	83.36 (32.89)		37.25 – 161.44
Everyday Functioning Variable			
TIADL	0.00 (0.63)		−0.97 – 1.69

Notes

* All others were African American except 1 who was Hispanic;

** For income, 1 = \$0 – \$10,000 and 8 = above \$70,000;

*** For far visual acuity, the LogMar score is reported where lower values = better visual acuity, and 0.00 = 20/20 vision.

[†] = cell/mm³.

[‡] = copies/ml.

cART = combination antiretroviral therapy; CES = Centers for Epidemiological Studies; HVLT-R = Hopkins Verbal Learning Test - Revised; TIADL = Timed Instrumental Activities of Daily Living; UFOV[®] = Useful Field of View. All cognitive data are raw values.

Table 2Driving Simulator Outcomes and Self-Reported Driving Habits for the Sample ($N = 26$)

Driving Simulator Outcome Variables	<i>M (SD)</i>	Range
Lowest Gross Reaction Time (seconds)	0.90 (0.21)	0.52 – 1.33
Average Gross Reaction Time (seconds)	1.01 (0.20)	0.63 – 1.41
Total Number of Collisions	2.50 (1.24)	0 – 5.00
Total Number of Pedestrians Hit	0.35 (0.63)	0 – 2.00
Total Number of Correct Divided Attention Responses	12.38 (3.67)	3.00 – 18.00
Total Drive Time (seconds)	1491.34 (275.78)	1251.37 – 1877.39
% of Total Drive Time Over the Speed Limit	66.94 (14.48)	7.97 – 79.95
% of Total Drive Time Out of Lane	5.29 (2.47)	2.19 – 10.26
Lowest Divided Attention Reaction Time (seconds)	1.16 (0.23)	0.80 – 1.73
Average Divided Attention Reaction Time (seconds)	2.79 (0.67)	0.52 – 1.33
Self-Report Driving Habit Variables	<i>M (SD)</i>	Range
Self-Rated Driving Quality*	1.54 (0.58)	1 – 3
Number of Days out of 7 Driven Per Week	5.35 (2.23)	1 – 7
Number of Miles Driven in Average 7-day Week	123.08 (145.61)	0 – 700
Total Number of Accidents in Previous 2 Years	0.46 (0.86)	0 – 3
Total Number of Times Pulled Over in Previous 2 Years	0.27 (0.45)	0 – 1

Notes.

* For Self-Rated Driving Quality, 1 = Excellent, 5 = Poor. Time is represented in seconds.

Table 3

Aim 1: Correlations Between Demographic, Mental Health, and Physical Health Variables and Driving Simulator Outcomes ($N = 26$)

Variables	Lowest Gross RT (sec)	Avg. Gross RT (sec)	Total # Collisions	Total # Pedestrians Hit	Total # Correct DA Responses	Total Drive Time (sec)	% of Drive Time Over Speed Limit	% of Drive Time Out of Lane	Lowest DA RT (sec)	Average DA RT (sec)
Demographic Variables										
Age	.34	.30	.18	.05	-.33	.12	.02	-.08	.49*	.45*
Education	-.11	-.14	-.01	.08	-.17	.10	.09	-.36	.32	.17
Income	.41*	.35	.11	.18	.04	.19	.17	-.24	.24	.07
Mental/Physical Health Variables										
Number of Co-morbidities	-.29	-.20	-.20	.13	.00	.10	-.05	-.05	-.17	-.02
Number of Medications	-.29	-.33	-.27	-.36	-.12	.08	-.18	-.29	.06	.14
CES Depression	-.31	-.23	-.06	.23	.11	.07	.18	.07	-.25	-.03
Visual Acuity	-.36	-.23	-.11	.18	.14	.04	.15	.32	-.16	.01
Alcohol Use	-.20	-.20	-.01	.12	.20	-.04	.25	-.18	.03	-.05
Drug Use	-.38	-.43*	-.31	-.12	-.10	.18	-.07	-.05	-.05	.14
Years with HIV	.23	.31	.18	.14	.04	-.14	.26	.25	.22	.14
Medication Adherence	.21	.17	-.08	-.27	.23	.17	.10	-.18	-.02	-.21
CD4+ Count (clinic values) [†]	-.16	-.20	-.16	-.26	-.10	.23	-.01	-.32	-.29	.09
Viral Load (clinic values) [‡]	-.21	-.18	-.16	-.12	.21	-.05	.16	-.13	.03	-.11

Notes.

* $p < 0.05$;

** $p < 0.01$,

[†] = cell/mm³,

[‡] = copies/ml.

CES = Centers for Epidemiological Studies; DA = Divided Attention; RT = Reaction Time; sec = seconds.

Table 4

Aim 2: Correlations Between Cognitive and Functional Variables and Driving Simulator Outcomes ($N = 26$)

Variables	Lowest Gross RT (sec)	Avg. Gross RT (sec)	Total # Collisions	Total # Pedestrians Hit	Total # Correct DA Responses	Total Drive Time (sec)	% of Drive Time Over Speed Limit	% of Drive Time Out of Lane	Lowest DA RT (sec)	Average DA RT (sec)
Cognitive Variables										
UFOV® Total	.43*	.40*	.05	.30	-.27	-.02	.23	.32	.06	.41*
Complex Reaction Time	.21	.31	.21	.08	.15	.12	.26	.42*	-.04	.02
Letter Comparison	-.18	-.13	-.10	.03	-.03	-.23	-.40*	.02	-.13	-.26
Pattern Comparison	-.23	-.16	-.08	.04	.02	-.12	-.18	-.23	-.21	-.23
HVLT-R Memory	-.15	-.28	-.30	-.24	.04	.24	-.25	-.40*	.00	-.15
Finger Tapping Test	.01	-.01	.12	.21	.17	-.06	.17	-.10	.08	-.12
Trails A	-.13	-.12	-.03	-.03	-.35	-.11	.26	-.27	-.06	.36
Trails B	.19	.28	.21	.06	-.23	-.12	.19	.33	.08	.42*
Everyday Functioning										
Variable										
TIADL	.10	.08	-.14	.08	.01	-.13	.39*	.06	-.09	.11

Notes.

* $p < 0.05$;

** $p < 0.01$.

DA = Divided Attention; HVLT-R = Hopkins Verbal Learning Test - Revised; RT = Reaction Time; TIADL = Timed Instrumental Activities of Daily Living; UFOV® = Useful Field of View.

All cognitive data were analyzed using raw values.

Table 5
Aim 3: Correlations Between Study Variables and Self-Reported Driving Outcomes ($N = 26$)

Variables	Self-rated Driving Quality	Days Driven Out of 7	Miles Driven in 7-day Week	Accidents in Previous 2 Years	Pulled Over in Previous 2 Years
Demographic Variables					
Age	.05	-.08	.04	-.10	-.17
Education	-.09	.16	.17	-.15	.08
Income	-.12	.30	.61**	.20	-.12
Mental/Physical Health Variables					
Number of Co-morbidities	.00	-.26	-.35	-.10	.15
Number of Medications	-.18	-.43*	-.51**	.10	.04
CES-Depression	.28	-.14	-.03	.25	.15
Alcohol Use	-.24	.09	-.12	-.18	-.14
Drug Use	.18	-.47*	-.24	.12	-.06
Years with HIV	-.20	.00	.39	-.03	-.07
Medication Adherence	-.19	-.03	.15	.20	.14
CD4+ T Cell Count (clinic values)	.15	-.47*	-.29	.05	.14
Viral Load (clinic values)	-.13	-.35	-.20	-.16	-.18
Cognitive Variables					
UFOV® Total	.21	-.14	.52**	.37	.09
Complex Reaction Time	.23	.04	.04	.37	-.07
Letter Comparison	-.18	.34	.03	-.01	.20
Pattern Comparison	-.21	.19	.00	-.32	.33
HVLT-R Memory	-.18	-.27	-.03	.04	.12
Finger Tapping Test	-.02	.10	.29	-.10	.27
Trails A	.22	-.50**	-.30	-.11	.19
Trails B	-.08	-.23	-.13	.08	-.04
Everyday Functioning Variable					
TIADL	-.09	-.31	.22	-.24	-.21
Driving Simulator Variables					

Variables	Self-rated Driving Quality	Days Driven Out of 7	Miles Driven in 7-day Week	Accidents in Previous 2 Years	Pulled Over in Previous 2 Years
Lowest Gross RT	.20	.23	.42*	.42*	-.04
Average Gross RT	.15	.27	.39	.35	-.06
Total Number Collisions	.33	.21	.16	.38*	.04
Total Number Pedestrian Hits	.13	.17	.46*	-.01	-.06
Total Number Correct DA Responses	-.16	.13	-.08	.08	.07
Total Drive Time (seconds)	.11	.06	-.17	.08	.15
% of Drive Time Over Speed Limit	.17	-.11	.09	.03	.06
% of Drive Time Out of Lane	.06	.21	.28	.17	-.11
Lowest DA RT	.15	.07	.17	.10	-.17
Average DA RT	.23	.23	.12	-.03	.10

Notes.

* $p < .05$;

** $p < .01$

$\dot{t}$ = cell/mm³,

$\dot{x}$ = copies/ml.

HVLT-R = Hopkins Verbal Learning Test - Revised; TIADL = Timed Instrumental Activities of Daily Living; UFOV[®] = Useful Field of View; DA = Divided Attention; RT = Reaction Time.
All cognitive data were analyzed using raw values.