Impact of HIV-associated Neurocognitive Impairment On Driving Simulator Performance: A pilot study

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Abstract

HIV-infection often results in neurocognitive impairment (NCI). Cognitive domains such as executive functioning, and attentional abilities are frequently affected, both of which are implicated in the functional task of driving. This pilot study measured the impact of HIV-associated NCI on driving performance in a sample of lay drivers in South Africa. 25 lay drivers (12 HIV-positive, 13 HIV-negative) completed a neuropsychological test battery, self-reports of functional abilities, and driving assessments consisting of (a) driving history questionnaires (detailing previous accidents and experience), (b) the Useful Field of View (UFOV) task, and (c) three driving simulator tasks (examining, respectively, divided attention, crash avoidance, and navigational abilities). On the basis of neuropsychological tests, NCI was detected in two HIV+ participants. HIV+NCI participants did not report greater difficulty with activities of daily living, and did not perform more poorly on measures related to on-road driving. In the Divided Attention task, the HIV+NCI group demonstrated significantly more frequent lane crossing (p = .007) than the groups without NCI. In the Challenge Drive, the HIV+ groups took significantly longer to complete the task than HIV- group (p = .016). Analyses detected no significant between-group differences on the Virtual City task. Although the generalisability of these findings is limited by sample size, they are significant enough, both in terms of potential clinical impact and in terms of consistency with similar previous research, to suggest that further research should be conducted to draw better-informed conclusions regarding the impact of HIV-associated NCI on driving in South Africa.

Keywords: HIV-infection, HIV-associated neurocognitive impairment, driving, driving simulator

Impact of HIV-associated Neurocognitive Impairment On Driving Simulator Performance: A pilot study

South Africa has the world's largest population of people living with HIV/AIDS (PLWHA), estimated at 6.4 million persons (Hemellar, Gouws, Ghys, & Osmanov, 2006; Simbayi et al., 2014). The introduction of combination antiretroviral therapy (cART) has transformed HIV from a terminal to a chronic illness, a fact that has particular implications for those millions of PLWHA in South Africa (Heaton et al., 2011; Mahungu, Rodger, & Johnson, 2009). Among HIV-positive individuals, even those on cART, more than half exhibit symptoms of central nervous system (CNS) injury (Heaton et al., 2010; Joska et al., 2011).

CNS injury frequently results in neurocognitive impairment (NCI) (Grant, 2008; Heaton et al., 2010). PLWHA with clinical levels of NCI may be diagnosed with HIV-associated Neurocognitive Disorders (HAND). The term HAND describes three conditions of increasing severity: Asymptomatic Neurocognitive Impairment (ANI), Mild Neurocognitive Disorder (MND), and HIV-associated Dementia (HAD) (Antinori et al., 2007). Even individuals with ANI, the mildest form of HAND, may present with impairment in everyday functioning. Often, this functional impairment manifests as difficulty obtaining employment and impaired driving performance (Mind Exchange Working Group, 2013).

There is scant data, however, about the functional impact of HAND on PLWHA in South Africa, where clade C of HIV predominates (Habib et al., 2013; Joska et al., 2011). Hence, there is a critical need for investigations focusing on the behavioural consequences of the cognitive impairment often associated clade C of the virus. A study that assesses the effects of HIV-associated NCI on a particular functional task, such as driving, in South Africa can be of great importance. The findings of such a study could inform public health policies and vocational suitability of HIV-positive people in the workplace, thus adding considerably to the body of knowledge regarding PLWHA in South Africa.

Epidemiology and Functional Effects of HAND and the Impact of cART

Globally, the epidemiology and clinical presentation of HAND has shifted since the introduction of cART (Heaton et al., 2011). For instance, cART has greatly improved medical morbidity and life expectancy in PLWHA. Furthermore, in the

post-cART era, some cognitive domains (viz., executive functioning, visuospatial processing, and attentional abilities) may be affected more severely than others by HIV infection (Grant et al., 2005; Grant, 2008; Heaton et al., 2011).

Most research investigating the epidemiology and functional effects of HAND has emerged from North America, where clade B of the virus predominates (Robertson & Hall, 2007). Prevalence estimates for HAND in this region approximate 52%. The cognitive domains of learning and executive functioning are most severely implicated by this HIV-associated NCI (Heaton et al., 2010). Although few studies have focused on the prevalence of HAND in South Africa, where clade C predominates (Joska, Fincham, Stein, Paul, & Seedat, 2010; Witten, Thomas, Westgarth-Taylor, & Joska, 2015), prevalence rates have been estimated between 23.5% and 42.4%, suggesting that HIV-associated NCI is also common among PLWHA in South Africa (Joska et al., 2011; Joska et al., 2012). Patterns of HIV-associated NCI here are similar to those in North America, with the domains of executive functioning, learning and psychomotor processing being the most compromised.

HIV and Driving: Cognitive Domains and Performance of HIV-positive Persons

Because driving is a complex activity of daily living, and requires integration of a wide range of cognitive abilities, intact performance within the cognitive domains of executive function, visuospatial processing, and attention is integral to the ability to drive safely. For instance, lapses of attention are commonly associated with driving accidents (Vance, Fazeli, Ball, Slater, & Ross, 2014). Additionally, intact visuospatial abilities allow drivers to interpret and integrate visual information on the road, allowing them to drive safely and to avoid hazards and accidents. Furthermore, driving success relies on multi-tasking, which is dependent on executive function, planning, decision-making, and judgement (Marcotte & Scott, 2009). Considering the centrality of these functions to driving, it follows that HIV-associated NCI may result in impaired driving performance.

Published studies investigating driving in HIV-positive populations have emerged from the United States. Marcotte et al. (1999) were the first to report on the association between driving ability and HIV infection. They aimed to answer the fundamental question: Is driving impairment present in HIV-positive individuals? Their sample comprised only seropositive participants (N = 68). Each participant was classified as either neurocognitively impaired (n = 32) or unimpaired (n = 36), based

on measures of functional ability, clinical and laboratory data, and a global neuropsychological performance score. Outcome measures included performance on two computer-based driving simulations (participants had to perform typical driving tasks, e.g., changing lanes and passing other cars) and data from a driving history questionnaire (detailing incidents of accidents and miles driven in the past year). Results indicated that participants with NCI performed more poorly on the simulations than unimpaired participants: They were more likely to fail simulation tasks, with a higher rate of accidents across emergency or high-risk situations. NCI participants did not, however, differ from unimpaired participants in their incidence of reported accidents over the previous year. The authors attributed this discrepancy to the fact that individuals with impaired driving ability may have been driving less frequently, or may have ceased driving altogether.

Marcotte et al.'s (1999) study established an important relationship between impaired driving performance and HIV-associated NCI, and highlighted the need for further investigation. For instance, their study did not provide comparisons to driving performance in an HIV-negative control group. It was also limited in its ability to extrapolate driving simulator performance to on-road performance: At the time, existing driving simulations had not been found to be predictive of typical on-the-road driving, and so their ecological validity was questionable.

Marcotte et al. (2004) attempted to address these limitations. Their study included both HIV-positive and HIV-negative individuals, and again used a multi-modal assessment of driving performance. This time, however, the Useful Field Of View (UFOV) task, which assesses participants' visual processing speed, and divided and selective attention, and on-road testing, which assesses participants' ability to perform traffic checks, maintain lane position and speed, and yield when appropriate, were used alongside the measures used by Marcotte et al. (1999). The authors confirmed that a subset of individuals who were HIV-positive and had NCI were at higher relative risk for impaired driving performance. For instance, HIV-positive participants with NCI had significantly more accidents and performed more poorly on the simulator navigation task than HIV-positive and HIV-negative cognitively intact participants.

This result confirmed the suggestion made initially by Marcotte et al. (1999): HIV infection itself does not confer risk for impaired driving performance. Rather, NCI associated with HIV infection confers that risk. This 2004 study made important

progress in characterising the relationship between HIV-associated NCI and driving. Furthermore, its wide-ranging multimodal method allowed for an assessment of driving performance that was more reflective of real-world performance than the Marcotte et al. (1999) study. Together, these studies confirmed that NCI associated with HIV infection could compromise driving performance.

Rationale

The increased effectiveness of cART means that PLWHA have a longer life expectancy. However, even in the post-cART era, HIV-associated NCI continues to affect complex functional abilities such as driving performance. Despite the prevalence of HIV infection and HAND in South Africa (Joska et al., 2011; Joska et al., 2012), and despite studies emerging from the United States suggesting that a subset of HIV-positive individuals with NCI are likely to demonstrate impaired driving performance (Marcotte et al., 2004; Marcotte et al., 1999), no published study has investigated the association between HIV-associated NCI and driving performance in a South African sample.

The variable neurovirulence of clade B and clade C of HIV may mean that the pattern of NCI associated with each of these clades is different (Paul, Sacktor, Cysique, Brew, & Valcour, 2009; Rao et al., 2008; Witten et al., 2015). Thus, the risk conferred by HIV-associated NCI for driving performance might also differ.

It is important to understand the specific effects HIV-associated NCI has on functional abilities such as driving performance. Knowledge of these effects will inform decisions on, for instance, the vocational suitability of HIV-positive individuals and public safety regulations regarding safe driving performance standards. In addition, it will add to the growing body of South African literature regarding the functional consequences of HIV-associated NCI.

Specific Aims and Hypotheses

This study assessed the impact of HIV-associated NCI on driving performance (both on road and in a simulator) in a sample of South African lay drivers. The study addressed two primary aims, each of which was associated with at least one specific hypothesis.

The first aim was to determine the relationship between HIV-associated NCI and measures related to on-road driving performance. The first hypothesis related to

this aim was that participants who were HIV-positive with NCI would report poorer driving histories (indicated by higher accident rates and less frequent driving) than (a) participants without HIV-associated NCI and (b) cognitively unimpaired HIV-negative controls. The second hypothesis related to this aim was that participants who were HIV-positive with NCI would be assigned higher risk scores on tests of visual attention (as assessed by the UFOV task) than (a) participants without HIV-associated NCI and (b) cognitively unimpaired HIV-negative controls.

The second aim was to determine the relationship between HIV-associated NCI and driving simulator performance. The broad hypothesis here was that participants with HIV-associated NCI would perform more poorly on driving simulator tasks than (a) participants without HIV-associated NCI and (b) cognitively unimpaired HIV-negative controls.

Methods

Design and Setting

This was a cross-sectional pilot study. Participants were South African motor vehicle drivers assigned to three groups: HIV-positive with NCI (HIV+NCI; $n = 2$), HIV-positive without NCI (HIV+NCN; $n = 10$), and HIV-negative controls without NCI (HIV-; $n = 13$).

The study sites were Town II Clinic in Khayelitsha, and Groote Schuur Hospital (GSH). Participants completed consent documents, self-report assessments of functioning and instrumental activities of daily living, and neuropsychological testing at the former venue, and measures relating to on-road driving performance and driving assessments at the latter venue.

Participants

Recruitment. This study is linked to an on-going study being conducted by the HIV Mental Health Research Unit (Gouse et al., 2016; Joska et al., 2012). Study staff at Town II Clinic attempted to contact forty people who were involved in that study. Thirty-four of them were unreachable. One person had moved to the Eastern Cape. Five people were contactable and invited by telephone to participate in this study. One of them did not meet the inclusion criteria. The remaining four participants met the inclusion criteria, and agreed to participate in this study. HIV-negative control participants, and the remainder of the HIV-positive participants, were recruited from Town II Clinic.

Inclusion criteria. All participants had to (1) be licensed motor vehicle drivers, or unlicensed drivers who had driven at least once in the last month; (2) be between the ages of 20 and 50 years; (3) have conversational fluency in English; and (4) have completed at least 7 years of formal education successfully. HIV-positive participants had to have been on cART for at least 1 month.

Exclusion criteria. These included (1) Head injury with loss of consciousness for more than 30 minutes; (2) a neurologic disorder not related to HIV infection; (3) infections that can affect the CNS; (4) current or past psychotic disorder; and (5) current substance abuse/dependence.

All HIV-positive participants had a confirmed diagnosis of HIV determined by an Elisa test conducted at a Department of Health primary health care clinic. NCI was determined using a Global Deficit Score (GDS; Carey et al., 2004) of ≥0.5 based on a comprehensive neuropsychological assessment. The GDS has strong predictive validity (Carey et al., 2004) at a cut-off score of ≥0.5 for NCI. GDS detects NCI across varying impairment patterns in different cognitive domains.

Those in the HIV- group had a confirmed HIV negative diagnosis as determined by a certificate from a Department of Health primary health care clinic within the month prior to enrolment.

Materials and Measures

Sociodemographic questionnaire. Research assistants at Town II Clinic administered standard sociodemographic questionnaires to all participants (Appendix A). These questionnaires gathered information about the participant's age, level of education, and employment status.

Neuropsychological test battery. Although previous neuropsychological data was available for some of HIV-positive participants, all participants completed a gold standard neuropsychological test battery to confirm their cognitive status. This battery consisted of standardized neuropsychological tests, each of which had demonstrated reliability and validity for assessing NCI in clinical populations (Grant, 2008; Lezak, 2004; Strauss, Sherman, & Spreen, 2006). This battery has been used successfully in previous studies of South African HIV-positive individuals (Cross, Combrinck, & Joska, 2013; Joska et al., 2010; Robbins et al., 2014).

The battery, which took approximately 2 hours to administer, consisted of the following tests that assessed function in the following cognitive domains: (1): *Language:* Semantic Fluency (fruits and vegetables, and animals) and Action Fluency

tests (Borkowski, Benton, & Spreen, 1967); (2) *Executive functioning*: Trail Making Test (TMT) Part B (Reitan, 1992), Wisconsin Card Sorting Test (WCST) (Heaton, Chelune, Talley, Kay, & Curtiss, 1981); (3): *Attention/working memory:* Paced Auditory Serial Addition Test (Gronwall, 1977), Wechsler Adult Intelligence Scale III (WAIS-III) Digit Span (Wechsler, 1997); (4): *Speed of information processing:* WAIS-III Digit Symbol-Coding and Symbol Search (Wechsler, 1997), TMT Part A (Reitan, 1992); (5) *Learning and memory:* Hopkins Verbal Learning Test-Revised (HVLT-R) (Brandt & Benedict, 2001), Brief Visuospatial Memory Test-Revised (BVMT-R) (Benton, Hamsher, & Sivan, 1994); (6): *Motor functioning:* Finger Tapping (Halstead, 1947; Reitan & Davison, 1974) and Grooved Pegboard Test (Kløve, 1963).

Patient's Assessment of Own Functioning Inventory (PAOFI). This measure (Appendix B) assessed reports of behavioural difficulties in everyday life that may be associated with NCI (Chelune, Heaton, & Lehman, 1986). The PAOFI includes 33 items, covering the domains of memory, language and communication, use of hands, intellectual functioning, and work, on which participants rate the degree of everyday behavioural difficulties. Participants respond to each item with a score of between 1 (almost always experiencing difficulty with a particular task) and 6 (almost never experiencing difficulty with a particular task). A total score is calculated by summing the scores of each individual item. Lower total scores indicate more everyday behavioural difficulties. This measure has not been used in previous studies investigating HIV-associated NCI in South Africa. It has, however, been used in studies investigating this area in the USA (Blackstone et al., 2012; Heaton et al., 2004), and in one study investigating HIV-associated NCI and driving (Marcotte et al., 1999).

Lawton Instrumental Activities of Daily Living Scale. This measure of activities of daily living (Appendix C) assessed participants' ability to complete daily tasks such as food preparation, medication adherence, and laundry (Lawton & Brody, 1969). For each of the eight items, participants can respond with a score of between 0 (unable to perform the task independently) and 2 (able to fully complete the task without any assistance). Participants received a total score of between 0 and 16, with a score of 13 or less suggesting functional impairment. This scale has been used in South Africa previously, and demonstrated validity for detecting functional impairment associated with activities of daily living (Joska et al., 2016).

Blood draw. Participants in the HIV+ groups had blood drawn by a study doctor at GSH. The GHS NHLS laboratory assayed samples for CD4 count and viral load.

Driving History and Habits Questionnaire. This questionnaire (Appendix D) provides information on driving history (e.g., number of previous motor vehicle accidents) and recent habits (e.g., number of kilometres driven in the last month). The questionnaire has been used in previous studies investigating HIV-associated NCI and driving in the USA (Marcotte et al., 2004; Marcotte et al., 1999). It was adapted for use in South Africa for this study.

Useful Field of View (UFOV) task. The UFOV task is a computer-based measure of visual processing speed, divided attention, and selective attention (Visual Resources, 1998). Impaired UFOV performance is found in individuals with various neurological disorders, and has predictive validity for future driving accidents (Wood & Owsley, 2014). Participants sat in front of a computer monitor and were instructed to respond by selecting the correct option on the screen with their finger. For each of the three tasks, an empty 1 x 1-inch square with a white border was presented in the centre of a black screen, followed by the presentation of a white stimulus inside this box. The stimulus presentation time was adjusted in each task independently depending on how quickly participants responded. Stimulus presentation durations ranged from 16 milliseconds to 500 milliseconds (i.e., stimulus presentation duration could reach 16 milliseconds for participants with quick response times). After the stimulus was presented, a black and white mask screen covered the screen for 500 milliseconds until the presentation of the next stimulus.

In task one (visual processing speed), either a car or a truck was presented in the central square. The participant was asked to determine which vehicle was presented. In task two (divided attention), the car or truck was presented again in the central square. In addition, a car was presented on a spoke at a particular angle from the central stimulus. These spokes were at angles of 0°, 45°, 90°, 135°, 180°, 225°, 270° or 315°. Participants had to identify whether the car or the truck was presented in the central square, and select the position at which the car on the periphery appeared. Task three (selective attention) was identical to task two, except that the stimulus on the periphery was now embedded among 47 small triangular distractors. Participants had to identify which stimulus was presented in the centre, and at which angle the car on the periphery appeared. The presentation of the stimuli and positioning of the

periphery stimuli were random. The UFOV task took approximately 15-minutes to complete.

The programme assigned a risk level for driving-related problems, ranging from very low to very high, based on performance on the three tasks. The UFOV has demonstrated reliability and validity coefficients of sufficient magnitude to be appropriate for use in clinical evaluations (Edwards et al., 2005). This is the first time it has been used in a South African study.

Driving simulator assessment. Participants then completed three interactive driving simulations, on a vSIMC200 driving simulator (TMI Systems Technology, Johannesburg, South Africa) that is modelled on the performance of a VW Polo 1.4. The simulator has three side-by-side monitors providing a 180° field of view. Simulator assessments took approximately 1.5 hours to complete. The three driving tasks were designed for previous studies investigating driving simulator performance to reflect real-world driving situations and scenarios (Marcotte et al., 2004; Marcotte et al., 1999). Before beginning their formal assessment, participants were given the chance to complete two 6-minute acclimation drives. After each of these, they took a 6-min break. This structure of presentation sought to minimize the effect of novelty on performance, as well as reduce the chances of simulator sickness occurring.

Simulation 1: Divided Attention. Participants were required to drive down a straight 2-lane road, maintain a constant speed of 100km/h, maintain appropriate lane position, and respond to divided attention tasks. These tasks required responding to cues that appeared on the two side screens of the simulator. When a diamond appeared, no response was required and participants continued driving. When a triangle pointing either left or right appeared, participants had to respond by indicating in that direction. When a ‘hooter’ icon appeared, participants had to press the hooter on the steering wheel. The primary outcomes of this task were standard deviation of lateral position on the road, response accuracy on the tasks, and speed deviation.

Simulation 2: Challenge Drive. This task most closely replicated normal driving conditions. It consisted of a 15-minute drive along multilane highways and congested city streets. Participants were instructed to drive to a location as quickly as possible, preferably within 10-minutes (a countdown timer was displayed on the screen). Participants were given instructions from an automated voice, and were subjected to a number of unexpected challenges (e.g., other cars braking suddenly or

other cars trying to drive into the back of them). The primary outcomes were completing the task and task duration. Other outcomes included number of crashes and road traffic violations.

Simulation 3: Virtual City. This task assessed navigational abilities in a five-by-six block virtual city consisting of residential and commercial sections bisected by a park. Participants were required to find the most efficient route to a designated location (the BP garage) while obeying all traffic signs, including one-way roads. They were allowed to consult the map freely. Upon arrival at the target location, they were required to drive back to the starting point. Participants were first given the map and asked to plot their intended route, by marking it out with a coloured pen, to the designated location and then for their return trip. The time taken to plot each of these routes was recorded. After this, participants were placed at an intersection and instructed to begin the task. Participants were given 20 minutes to complete the task. If they were successful, the task terminated as they arrived back at their starting location. If they were unsuccessful, I ended the task after the designated time period. For scoring purposes, participants unable to complete the task were assigned scores of 1 block greater than the highest score generated by the remainder of the cohort (thus including them in the analyses, but not giving their scores excessive weight). The primary outcomes were completing the task and the number of blocks driven to reach the target location and return to the starting location. The optimal number of blocks for this is 22. Other outcomes included road traffic violations.

Virtual City questionnaire. At the end of the Virtual City task, a Virtual City questionnaire (Appendix E) was administered to all participants. Participants answered qualitative questions about the task and their previous, if any, experience with using maps. This questionnaire was designed for the purposes of this study.

Simulator Sickness Questionnaire (SSQ). This measure (Appendix F) assessed whether participants were experiencing any symptoms of simulator sickness (e.g., nausea or dizziness), and the severity of the associated symptoms (ranging from none to severe) (Kennedy, Lane, Berbaum, & Lilienthal, 1993). In previous studies, participants with higher SSQ scores have been found to be more likely to drop out. A particular score (or range of scores) that results in participant dropout has not been established, however, overall, the symptom for nausea was most strongly correlated with participant dropout (Balk, Bertola, & Inman, 2013). In this study, the SSQ was administered to all participants on two occasions: First, before participants had begun

the driving simulator assessment, and for a second time after participants had completed that assessment.

Procedure

The study followed the University of Cape Town's ethical guidelines for conducting research involving human participants. Ethical approval was granted by the Health Sciences Human Research Ethics Committee (Appendix G) and the Department of Psychology Research Ethics Committee (Appendix H).

Study administrators contacted potential participants either by telephone or directly at Town II Clinic, and asked them to participate in this study. At Town II Clinic, study administrators obtained written informed consent (Appendix I) from all participants. Trained neuropsychological test administrators administered neuropsychological tests, the PAOFI, and the Lawton Instrumental Activities of Daily Living Scale.

At GSH, participants in the HIV+ groups had blood drawn in a clinic room. All participants then entered the testing room where they completed the Driving History and Habits Questionnaire. After this, they completed the UFOV and then the first administration of the SSQ. The two 6-minute acclimation drives took place, with a 6-minute break after each. During the breaks, participants were encouraged to walk around outside the testing room, and were offered light refreshments. Participants then commenced the driving simulator assessment. First they completed the Divided Attention task, then the Challenge Drive, and finally the Virtual City task. After the Virtual City task, participants were responded to the Virtual City questionnaire.

If, at any point, participants began to experience symptoms of simulator sickness, they were instructed to stop driving. Participants took a short break outside of the testing room in attempt to alleviate these symptoms. After this they could decide if they felt well enough to complete the assessment, or if they would like to terminate their session.

At the conclusion of the driving simulator assessment, I administered a second SSQ. Finally, participants were debriefed, thanked, and provided with compensation.

Statistical Analyses

I analysed the data using SPSS version 23. For all analyses, I set the threshold for statistical significance at .05. One-way ANOVAs and independent-sample *t*-tests were used to analyse data related to continuous outcome variables, and Fisher's Exact test was used to analyse data related to categorical outcome variables. For each

analysis, appropriate effect size estimates were calculated, and interpreted following convention (e.g., for Cohen's *d*, 0.20-0.30 = small; 0.50 = medium; > 0.80 = large; Cohen, 1988).

To calculate GDS, raw scores from each of the neuropsychological tests in the battery were converted to *T*-scores using demographically adjusted normative data obtained from on-going studies in the HIV Mental Health Research Unit (Gouse et al., 2016; Robbins et al., 2014). These *T* scores allow for the calculation of GDS for each individual test. GDS for each test is then averaged to produce a single GDS that is indicative of global cognitive functioning. An overall GDS of ≥0.5 was indicative of HIV-associated NCI. Participants with GDS of ≥0.5 were assigned to the HIV+NCI group. HIV-positive participants with GDS of <0.5 were assigned to the HIV+NCN group, and HIV-negative control participants with GDS of <0.5 were assigned to the HIV- group.

All analyses began with inspection of the descriptive statistics. I took care to ensure that the assumptions underlying all statistical tests utilised here were fulfilled. When these assumptions were violated, non-parametric tests were used. Following this inspection of descriptive statistics, a series of one-way ANOVAs tested for between-group differences in terms of certain demographic characteristics (e.g., age and years of education); neuropsychological test performance; scores on the PAOFI, Lawton Instrumental Activities of Daily Living Scale, Driving History and Habits Questionnaire, UFOV, SSQ; and, finally, on driving simulator performance. If the omnibus test detected a significant between-group difference after the appropriate correction for inflated familywise error, post-hoc pairwise comparisons sought to determine more specifically where the differences lay.

Initial analyses sought to establish the similarity of the three groups in terms of age, years of education, and sex distribution. These also sought to establish whether there was a difference in self-report data for daily functioning and activities of daily living as established by particular questions on the PAOFI and the Lawton Instrumental Activities of Daily Living Scale. For the HIV+ groups, biomedical data was compared to establish whether their was a difference between the HIV+NCN and HIV+NCI groups.

A one-way ANOVA sought to confirm the significant between-group differences in GDS. A series of one-way ANOVAs tested the prediction that

participants in the HIV+NCI group reported significantly more compromised everyday functioning than participants in the HIV- and HIV+NCN groups. Outcome variables were derived from responses to the PAOFI and the Lawton Instrumental Activities of Daily Living Scale. An independent samples *t*-test tested whether there was a difference in CD4 count and viral load in the HIV+NCN group and the HIV+NCI group.

The main analyses sought to determine whether there was a difference in measures related to on-road driving performance and driving simulator performance in the three groups.

Hypothesis 1. A series of one-way ANOVAs tested the prediction that participants in the HIV+NCI group drove significantly less frequently than participants in the other two groups, as well as the prediction that participants in the HIV+NCI group had significantly more driving accidents than those the HIV- and HIV+NCN groups. Outcome variables were derived from responses to the Driving History and Habits Questionnaire. These included: years routinely driving a car, days per week driving, kilometres driven in the last month, minor accidents in the last year and in a person's lifetime, major traffic accidents in the last year and in a person's lifetime, and close calls (instances where drivers needed to swerve or slam on brakes to avoid an accident) in the last year and in a person's lifetime.

Hypothesis 2. A Fisher's Exact test tested the prediction that there would be a significant association between risk scores on the UFOV and belonging to the HIV+NCI group. The outcome variable for this task was the assigned risk score (based on performance on the three UFOV tasks) which could range from very low to very high. A series of one-way ANOVAs tested whether there were between-group differences in response times for each of the three UFOV tasks (namely, visual processing speed, divided attention and selective attention).

Hypothesis 3. A series of one-way ANOVAs tested the prediction that participants in the HIV+NCI group would perform more poorly than participants in the HIV+NCN and HIV- groups on driving simulator tasks. These investigations covered all three-simulator tasks, with these outcome variables being the subject of study.

For the Divided Attention task, outcome variables included: lane crossing (crossing into the opposite lane of the road), road edge excursions (driving off the edge of road), distance from centre line of the road, response accuracy (i.e., correct

responses, incorrect responses, missed responses), exceeding the speed limit (by less than 10km/hr, between 10 and 20km/hr or more than 20km/hr), under speeding (by less than 10km/hr, between 10 and 20km/hr or more than 20km/hr) and mean speed and standard deviation for the task.

For the Challenge Drive, outcome variables included: completing the task, duration of the task, crashes, driving through a red light, ignoring stop streets, and exceeding the speed limit.

For the Virtual City task, outcome variables included completing the task, number of blocks driven (a total score representing the number of blocks driven to the target location and back to the starting point), driving through a red light, ignoring stop streets and exceeding the speed limit (by less than 10km/hr, between 10 and 20km/hr or more than 20km/hr). Additional outcome variables were derived from responses to the Virtual City questionnaire. These included: using a map before, time to plan the route to the BP petrol station, and time to plan the route back to the starting location.

Results

Sample Characteristics

Table 1 presents data regarding the sample's characteristics with regard to age, education, sex distribution, general intellectual functioning, activities of daily living, and biomedical variables. Regarding general intellectual functioning, the analyses detected the expected (given the method of group constitution) significant between-group difference for GDS. Post-hoc pairwise comparisons indicated there were significant differences between the HIV- and HIV+NCI groups, $t(22) = -4{,}86$, $p < .001$, Cohen's $d = 0.46$, and between the HIV+NCN and HIV+NCI groups, $t(22) = -4.17$, $p < .001$, Cohen's $d = 2.79$.

Regarding demographic characteristics, the groups were well matched: Analyses detected no significant between-group difference for age, for years of successfully completed education, or for sex distribution.

Regarding activities of daily living, the groups were again well matched: Analyses detected no significant between-groups differences with regard to either the PAOFI questions that addressed behaviours possibly related to driving or the total score on the Lawton Instrumental Activities of Daily Living Scale. The average

scores for each group were above clinical cut-offs, suggesting that none of the participants were impaired with regard to their activities of daily living.

Regarding the biomedical data of the HIV+ groups, analyses detected no significant differences with regard to CD4 count or viral load.

Table 1
Sample Characteristics (N = 25)

	Group					
Variable	HIV- (*n* = 13)	HIV+NCN (*n* = 10)	HIV+NCI (*n* = 2)	*F* / *t*	*p*	ESE
Age (years)[a]	34.46 (7.66)	39.10 (3.81)	40.00 (5.65)	1.83	.184	0.19
Education (years)	11.31 (1.03)	10.80 (1.14)	12.00 (1.41)	1.25	.099	0.10
Sex[b]				-	.841	0.22[c]
Men (*n*)	8 (62%)	7 (70%)	2 (100%)	-	-	-
Women (*n*)	5 (38%)	3 (30%)	0	-	-	-
GDS	0.07 (0.10)	0.13 (0.14)	0.50 (0.00)	11.82	< .001**	0.52
PAOFI						
Q27[d]	5.62 (0.77)	6.00 (0.00)	6.00 (0.00)	-	-	-
Q28	5.77 (0.83)	6.00 (0.00)	6.00 (0.00)	0.44	.650	0.04
Q32[d]	5.39 (0.96)	6.00 (0.00)	6.00 (0.00)	-	-	-
IADLS	15.77 (0.83)	16.00 (0.00)	16.00 (0.00)	0.44	.650	0.04
Biomedical data						
CD4	-	418.80 (478.50)	478.50 (245.37)	0.43	.676	0.33
VL[e]	-	20.00 (0.00)[f]	20.00 (0.00)	-	-	-

Note. Means are presented with standard deviations in parentheses. ESE = effect size estimates (in this case, η_p^2). GDS = Global Deficit Score; PAOFI = Patient's Own Assessment of Functioning; IADLS = Lawton Instrumental Activities of Daily Living Scale; CD4 = CD4 cell count; VL = viral load.
[a]Values calculated using the Brown-Forsythe test. [b]Fisher's Exact test performed.
[c]ESE in this case = Cramer's *V*.
[d]For PAOFI Q27 and Q32, the results of the Levene's test of homogeneity of variance were significant and non-parametric tests could not be conducted because some groups had standard deviations of zero.
[e]For VL, a *t*-test could not be conducted because both groups had standard deviations of zero.
[f]Data were analysed for 9 of the original 10 participants in the HIV+NCN group. The data from one participant (a 41-year-old HIV-positive man with 11 years of education) were excluded from this analysis on the basis of a statistical decision; his VL was more than three standard deviations greater than the mean.
*$p < .05$. **$p < .001$.

Measures Related to On-Road Driving Performance

Driving Habits and History Questionnaire. Table 2 presents descriptive statistics for the outcome variables derived from this questionnaire, as well as the results of a series of one-way ANOVAs investigating potential between-group differences with regard to those variables. As the Table shows, there were no significant between-group differences. Perusal of the data suggested that participants generally reported that they drove fairly regularly and a considerable number of kilometres in a month. Participants also generally reported a history of very few accidents and infrequent close calls. Participants in the HIV+NCN group generally reported to have driven considerably more kilometres per month than participants in the HIV- and HIV+NCI groups.

Table 2

Driving Habits and History Questionnaire: Descriptive statistics and between-group comparisons (N = 24)

	Group					
Variables	HIV- (n = 12)[a]	HIV+NCN (n = 10)	HIV+NCI (n = 2)	*F*	*p*	*ESE*
Years routinely driving a car	8.83 (8.33)	11.10 (11.02)	7.50 (3.54)	0.22	.808	0.20
Days per week driving	3.83 (2.04)	4.90 (2.23)	6.50 (0.71)	1.73	.203	0.14
Kilometres driven per month	732.50 (1228.85)	1619.00 (3028.22)	700.00 (707.11)	0.49	.620	0.04
Minor accidents in the last year	0.25 (0.45)	0.20 (0.42)	0 (0)	0.30	.747	0.03
Minor accidents in lifetime	0.92 (1.44)	0.30 (0.48)	0 (0)	1.18	.326	0.10
Major traffic accidents in the last year	0 (0)	0 (0)	0 (0)	-	-	-
Major traffic accidents in lifetime	0.25 (0.45)	0.10 (0.32)	0 (0.00)	0.61	.552	0.06
Close calls in the last year	4.33 (6.87)	5.70 (8.19)	2.50 (3.54)	0.20	.823	0.02
Close calls in lifetime	51.75 (142.12)	18.60 (36.66)	10.50 (13.44)	0.33	.726	0.03

Note. ESE = effect size estimate (in this case, η_p^2).

[a]Data were analysed for 12 of the original 13 participants in the HIV- group. The data from one participant (a 20-year-old HIV-negative man with 12 years of education) were excluded from this analysis on the basis of a statistical decision; certain responses were more than two standard deviations greater than the mean.

Useful Field of View (UFOV) task. Table 3 presents data regarding the UFOV risk score classifications. The results of a Fisher's Exact test suggested there was no association between group assignment and UFOV risk score, $p = .237$, Cramer's $V = .465$. Regarding the performance of three groups on each of the three tasks on the UFOV (visual speed processing, divided attention and selective attention), the analyses detected no significant between-group differences for any of them, Fs < 2.10, ps > .548 η_p^2s < .17.

Table 3
UFOV Task: Risk scores (N = 24)

	Group		
Risk category	HIV- (n = 12)[a]	HIV+ NCN (n = 10)	HIV+ NCI (n = 2)
Very low	6	3	0
Low	3	3	0
Moderate to low	1	2	1
Moderate to high	2	0	1
High	0	2	0
Very High	0	0	0

Note. UFOV = Useful Field of View.
[a]Data were analysed for 12 of the original 13 participants in the HIV- group. The data from one participant (a 44-year-old HIV-negative man with 13 years of education) were excluded from this analysis because a technical error by the researcher prevented him from completing this task.

Driving Simulator Assessment

As noted earlier, the driving simulator assessment consisted of three tasks: Divided Attention, Challenge Drive, and Virtual City. One participant, a 32-year-old woman with 11 years of education in the HIV+NCN group, experienced such severe simulator sickness that she was unable to complete the entire assessment. Her data were recorded and analysed for the Divided Attention task and the Challenge Drive, but not for the Virtual City task.

Divided Attention task. Table 4 presents descriptive statistics for the outcome variables derived from this task, as well as the results of a series of one-way ANOVAs investigating potential between-group differences with regard to those variables. The analyses detected no significant between-group differences except for lane crossing. A series of post-hoc pairwise comparisons conducted on the data for that outcome variable detected a significant difference between the HIV- and

HIV+NCI groups, $t(1.88) = -3.29$, $p = .044$, Cohen's $d = 1.78$. There were no other between-group differences in that regard, ts < 1.30, ps > .106, ds < 5.65[1].

The ANOVAs did detect a trend toward significance for two other outcome variables (road-edge excursion and distance from centre line of the road), however. For road-edge excursion, post-hoc pairwise comparisons detected significant differences between (a) the HIV- and the HIV+NCN groups, $t(22) = 1.85$, $p = .044$, Cohen's $d = 0.68$, and (b) the HIV- and the HIV+NCI groups, $t(22) = 1.99$, $p = .034$, Cohen's $d = 0.58$. For distance from centre line, post-hoc pairwise comparisons detected a significant difference between the HIV+NCN and the HIV+NCI group, $t(22)$, = -2.28, $p = .033$, Cohen's $d = 3.26$. That series of post-hoc comparisons detected no other significant between-group differences, ts < 1.68, ps > .107, ds < .86.

Challenge Drive. Table 5 presents descriptive statistics for the outcome variables derived from this task, as well as the results of a series of inferential statistical analyses investigating potential between-group differences with regard to those variables. The analyses detected no significant between-group differences.

One of the one-way ANOVAs did detect a trend toward significance for the duration variable, however. A series of post-hoc pairwise comparisons examining those data detected a significant difference between the HIV- and HIV+NCN groups, $t(22) = -2.56$, $p = .018$, Cohen's $d = 1.13$, but no other significant between-group differences, ts < 0.41, ps > .329, ds < 1.02.

An independent samples t-test examining the data for duration variable between the HIV- group and the HIV+NCN and HIV+NCI groups combined (thus forming one HIV+ positive group) detected a significant difference between the groups, $t(23) = -2.60$, $p = .016$, Cohen's $d = 1.04$.

Virtual City task. Table 6 presents descriptive statistics for the outcome variables derived from this task, as well as the results of a series of inferential statistical analyses investigating potential between-group differences with regard to those variables. The analyses detected (a) no statistically significant association between completing the task and belonging to a particular group, (b) no statistically significant association between completing the task and having used a map before, and (c) no other significant between-group differences, or strong trend toward any such differences.

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[1] This large effect size, despite the analyses detecting no statistically significant association, is reflective of the small sample size of the HIV+NCI group ($n = 2$).

Table 4
Driving Simulator Divided Attention Task: Descriptive statistics and between-group comparisons (N = 25)

	Group					
Outcome variable	HIV- (n = 13)	HIV+NCN (n = 10)	HIV+NCI (n = 2)	F	p	η_p^2
Lane crossing[a]	14.23 (19.98)	6.50 (6.70)	49.00 (12.73)	6.19	.007**	0.36
Road edge excursions[a]	23.39 (34.11)	5.50 (6.62)	4.50 (0.71)	3.48	.061	0.12
Distance from centre line of the road	0.47 (0.21)	0.36 (0.09)	0.64 (0.03)	3.12	.064	0.22
Response						
Correct	25.15 (4.06)	25.40 (5.48)	27.50 (2.12)	0.22	.802	0.02
Incorrect	0.39 (0.65)	0.60 (1.90)	0.50 (0.71)	0.07	.927	0.01
Missed	4.46 (3.93)	4.00 (4.59)	2.00 (2.83)	0.31	.741	0.03
Speed limit exceeded by:						
< 10 km/hr	0.77 (1.92)	1.00 (2.16)	1.50 (2.12)	0.13	.883	0.01
10-20 km/hr	0.46 (1.39)	0.40 (1.26)	0.50 (0.71)	0.01	.992	< 0.01
> 20km/hr	0.08 (0.28)	0.40 (1.26)	0.00 (0.00)	0.49	.622	0.04
Under speed by:						
< 10km/hr	10.31 (24.21)	0.90 (1.37)	4.00 (4.24)	0.79	.465	0.07
10-20 km/hr	9.62 (22.96)	0.50 (0.85)	1.50 (2.12)	1.95	.184	0.07
> 20km/hr[a]	4.07 (9.21)	0.10 (0.32)	1.00 (1.41)	1.00	.153	0.08
Speed						
Mean	86.24 (9.23)	81.32 (16.18)	92.23 (0.65)	0.84	.445	0.07
Standard deviation	14.05 (2.72)	13.70 (2.98)	15.26 (1.58)	0.26	.772	0.02

[a]Values calculated using the Welch test.
**p < .001.

Table 5
Challenge Drive: Descriptive statistics and between-group comparisons (N = 25)

	Group					
Outcome variable	HIV- (n = 13)	HIV+NCN (n = 10)	HIV+NCI (n = 2)	F	p	ESE
Completed the task[a]	69.2% (n = 9)	80% (n = 8)	50% (n = 1)	-	.679	0.18[b]
Duration (ms)	1122.15 (202.95)	1484.10 (202.96)	1377.50 (567.81)	3.34	.054	0.23
Car collision	0.77 (0.60)	1.10 (0.88)	0.50 (0.71)	0.88	.430	0.07
Drive through red light	1.00 (1.08)	1.20 (1.03)	1.00 (1.41)	0.10	.902	0.01
Ignore stop street	0 (0)	0 (0)	0 (0)	-	-	-
Speed limit exceeded < 10 km/hr[c]	4.46 (4.70)	2.80 (4.64)	9.50 (13.44)	0.41	.730	0.12
Speed limit exceeded 10-20 km/hr[c]	0.85 (1.34)	0.40 (0.84)	7.00 (9.90)	0.82	.612	0.37
Speed limit exceeded > 20 km/hr	0.08 (0.28)	0.00 (0.00)	1.50 (2.12)	-	-	-

Note. ESE = effect size estimate (in this case, η_p^2). ms = milliseconds.
[a]Fisher's exact test performed.
[b]Effect size in this case = Cramer's *V*.
[c]Values calculated using the Brown-Forsythe test.

Table 6
Virtual City: Descriptive statistics and between-group comparisons (N = 24)

Outcome variable	Group HIV- (*n* = 13)	HIV+NCN (*n* = 9)[a]	HIV+NCI (*n* = 2)	*F*	*p*	*ESE*
Completed the task[b]	23.1% (*n* = 3)	10% (*n* = 1)	50% (*n* = 1)	-	.315	0.27[c]
Number of blocks driven	43.62 (5.61)	43.70 (7.28)	40.00 (8.49)	0.29	.749	0.03
Drive through red light	5.54 (4.16)	8.90 (17.41)	7.50 (4.95)	0.24	.789	0.02
Ignore stop street	0 (0)	0 (0)	0 (0)	-	-	-
Speed limit exceeded by:						
< 10km/hr	1.08 (2.75)	0.20 (0.63)	3.00 (4.24)	1.38	.273	0.11
10km/hr -20km/hr[d]	0.54 (1.33)	0.10 (0.32)	3.00 (4.24)	0.80	.608	0.26
> 20km/hr	0.39 (0.96)	0.00 (0.00)	1.50 (2.12)	-	-	-
Used a map before[e]	41.7% (*n* =5)[f]	44.4% (*n* = 4)	0%	-	.685	0.25[g]
Time (in mins) used to plan route:						
To BP station	1.27 (0.62)[f]	1.00 (1.07)	2.70 (3.25)	1.96	.167	0.10
From BP station	0.85 (3.72)[f]	0.56 (0.28)	0.34 (0.00)	2.59	.101	0.10

Note. ESE = effect size estimate (in this case, η_p^2).
[a]Data were analysed for 9 of the original 10 participants in the HIV+NCN group. The data from one participant (a 32-year-old HIV+ woman with 11 years of education) were excluded from this analysis because she did complete the Virtual City task.
[b]Fisher's exact test performed.
[c]ESE in this case = Cramer's *V*.
[d]Values calculated using the Brown-Forsythe test.
[e]Fisher's exact test performed.
[f]Data were analysed for based on 12 of the original 13 participants in the HIV- group. The data from one participant (a 44-year-old HIV-negative man with 13 years of education) were excluded from this analysis because he did not complete the Virtual City questionnaire.
[g]ESE in this case = Cramer's *V*.

Simulator Sickness Questionnaire (SSQ). A series of 3 (Group: HIV-, HIV+NCN, HIV+NCI) x (Time: assessment before simulator, assessment after simulator) repeated-measures ANOVAs investigated between-and-within group differences regarding the data for each SSQ item at each administration. These analyses were conducted for the data from 24 participants because one participant (a 32-year-old woman with 11 years of education in the HIV+NCN group) experienced such severe simulator sickness that she was unable to complete the second administration of the SSQ.

The analyses detected no significant main effects of Group for any of the SSQ items, *Fs* < 12.15, *ps* > .087, η_p^2 < .20. The analysis did, however, detect a number of statistically significant main effects of Time: fatigue, $F(2,21) = 12.14$, $p = .002$, $\eta_p^2 = .37$; , fullness of head, $F(2,21) = 4,62$, $p = .044$, $\eta_p^2 = .18$; blurred vision, $F(2,21) = 7.30$, $p = .013$, $\eta_p^2 = .26$); and vertigo, $F(2,21) = 12.14$, $p = .002$, $\eta_p^2 = .36$. For all of these items, participants reported more severe feelings of the symptom in the second administration of the questionnaire. The analyses detected no significant interaction Group x Time interaction effects, *Fs* < 2.41, *ps* > .087, η_p^2 < .21.

Discussion

This study set out to determine the impact of HIV-associated NCI on driving performance (both on-road and in a simulator) of South African lay drivers. To achieve these aims, I recruited a group of HIV-positive participants and a matched group of HIV-negative controls. I then, on the basis of neuropsychological test results, assigned some of the HIV-positive participants to a neurocognitively impaired group, and the rest to a neurocognitively unimpaired group. Then, I tested the following hypotheses: (1) Participants who were HIV-positive with neurocognitive impairment (i.e., those in the HIV+NCI group) would report poorer driving histories (indicated by higher accident rates and less frequent driving) than participants without HIV-associated NCI (i.e., those in the HIV+NCN group) and cognitively unimpaired HIV-negative controls; (2) HIV+NCI participants would be assigned higher risk scores on a task assessing visual attention (the UFOV task) than participants without HIV-associated NCI and cognitively unimpaired HIV-negative controls; and (3) HIV+NCI participants would perform more poorly on driving simulator tasks than participants without HIV-associated NCI and cognitively unimpaired HIV-negative controls.

It is necessary to note an important caveat before I continue to discuss study findings. The sample size for the study as a whole (N = 25), and specifically, the sample size of the HIV+NCI group (n = 2) group, is small. Consequently, interpretation of the statistical analyses data is limited. Hence, I will discuss statistically significant results and also comment on trends (p = .05 to p = .07) in the data.

To help address the study's first major aim (i.e., that related to on-road driving performance), participants completed two measures related to on-road driving performance, the Driving History and Habits Questionnaire and the UFOV task. I hypothesised that, on the questionnaire, HIV+NCI participants would report poorer driving histories as indicated by higher accident rates, fewer kilometres driven per month, fewer days of driving in a given week, and higher frequencies of close calls while driving. This hypothesis was disconfirmed, but it is consistent with findings from a previous study (Marcotte et al., 1999). Marcotte et al. (1999) suggested that the similarity they observed between HIV+NCI participants and HIV+NCN participants in terms of incidences of reported accidents could be attributed to HIV+NCI participants driving less frequently than HIV+NCN participants. Clearly, in the current study, this interpretation cannot hold: There were no significant between-group differences in driving frequency. Perusal of the data suggested that, however, on average, HIV+NCN participants drove considerably more kilometres per month than HIV+NCI

participants. These lower driving distances might serve as a protective factor against the likelihood, in HIV+NCI participants, of having a motor vehicle accident. Despite this though, the effect size for the between-group comparison was small, and so even with a larger sample, it is unlikely that there would be a statistically significant between-group difference in the number of kilometres driven per month.

Further to the study's first major aim, I hypothesised that HIV+NCI participants would perform more poorly on the UFOV task, an assessment of visual attention, than participants in the other two groups. This hypothesis was also disconfirmed. There was no significant association between the assigned risk score (an overall score assigned according to performance on the three tasks of the UFOV ranging from very low to very high) of the UFOV and having HIV-associated NCI. However, two HIV+NCN participants were assigned a UFOV risk score of 'high' (indicative of slower response times on the three tasks, and thus compromised visual processing speed, divided and selective attention). This finding is consistent with that of Marcotte et al. (2006), who reported that the HIV-positive individuals in their sample performed more poorly than their HIV-negative controls on the UFOV, and that this compromised performance could not be attributed to cognitive impairment alone (Marcotte et al., 2006). It is therefore possible that HIV-positive individuals, regardless of whether or not they are cognitively impaired or not, perform more poorly on the UFOV.

This finding is inconsistent, however, with that of Marcotte et al. (2004), who reported that HIV-positive individuals with NCI in their sample performed more poorly than their unimpaired HIV-positive participants and HIV-negative controls on the visual processing speed task and divided attention task on the UFOV. In that study, it was suggested that HIV-associated NCI, rather than HIV-infection alone, confers a risk to visual attention, evidenced by slower visual processing speed and poorer divided attention on the UFOV.

The second, and major, aim of this study was to investigate the relationship between HIV-associated NCI and driving simulator performance. To address that aim, I tested the hypothesis that participants in the HIV+NCI group would perform more poorly on three driving simulator tasks (Divided Attention, Challenge Drive, and Virtual City) than participants in the HIV+NCN and HIV- groups. Regarding the Divided Attention task, this hypothesis was partially confirmed. Although analyses detected no significant between-group differences with regard to the outcome variables of response accuracy and speed deviation, it did detect such differences with regard to lateral position on the road. Specifically, I observed that participants in the HIV+NCI group had much higher rates of lane crossing than those in the other two groups. Moreover, the analyses suggested a trend for HIV+NCI participants to

be farther away from the centre line of the road than participants in the HIV+NCN group. This difficulty in maintaining lane position is consistent with a report from Marcotte et al. (1999), who also found that their HIV-positive participants with NCI tended to swerve significantly more than their HIV-positive unimpaired participants.

The current analyses also detected a trend, on the Divided Attention task, for participants in the HIV- group to leave the road edge more frequently than participants in the HIV+ groups. This trend is somewhat surprising, particularly considering that, on average, HIV- participants drove more than 20km/hr below the speed limit more frequently than HIV+ participants. The standard deviation for the HIV- group was very large, indicating that some of the participants in the HIV-group had high incidences of road edge excursions. The high incidence rate of these individuals pulled the distribution of road edge excursions for the HIV- group away from the rest of the HIV-participants, resulting in a higher mean value than was representative of all of the participants in this group. Hence, the between-groups comparison for road edge excursion included this exaggerated mean value, and detected a trend that was in fact an artefact of small sample size.

Regarding the Challenge Drive task, the hypothesis that participants in the HIV+NCI group would perform more poorly than those in the HIV+NCN and HIV- groups was disconfirmed. HIV+NCI participants did not exceed the speed limit, or break traffic regulations, or crash with other cars more frequently, than HIV+NCN or HIV- participants. Moreover, there was no significant association between completing the Challenge Drive and group membership. These non-significant findings are inconsistent with previous literature in the field. Previous studies that also assessed driving simulator performance using this task found that HIV-positive participants with NCI had more crashes than HIV-negative unimpaired participants and HIV-positive unimpaired participants (Marcotte et al., 2004; Marcotte et al., 1999). This discrepancy might be attributable to the low incidence of reported on-road accidents across the three groups. If participants demonstrated crash avoidance in their driving histories, it is possible that they were able to employ similar crash avoidance strategies on the Challenge Drive task, which is most similar to normal driving conditions.

Further regarding data from the Challenge Drive task, analyses detected a trend for participants in the HIV- group to complete the task much more quickly than participants in the HIV+NCN and HIV+NCI groups. This trend has not been found in previous studies using the Challenge Drive. Hence, it is not clear whether this finding is an artefact of the sample size, or indicative of a possible association between HIV-infection and slower completion time on the Challenge Drive. Further analyses indicated that when comparing the HIV- group

and the HIV+ group as a whole (both the HIV+NCN and HIV+NCI groups), the HIV- group was still found to complete the task more quickly than the HIV+ group. This further supports the possible association between HIV-infection and slower completion time on the Challenge Drive. This association is consistent with the findings of a previous study investigating HIV-infection and information processing speed (Fellows, Byrd, & Morgello, 2014). Fellows et al. (2014) reported that HIV-positive individuals tend to exhibit slower information processing speed than HIV-negative individuals, which is evident across multiple cognitive domains. Hence, this study revealed that this slower information processing speed might be implicated in the functional task of driving in HIV-positive individuals.

Regarding the Virtual City task, the hypothesis that HIV+NCI participants would perform more poorly than HIV+NCN and HIV- participants (as indicated by having more difficulty navigating to the BP garage and back, and thus being less likely to complete the task within the given time limit) was disconfirmed. Instead, the HIV+NCI group had the highest completion rate for this task. Furthermore, on average, participants in that group chose the most efficient routes to reach their destination.

This set of findings is inconsistent with those from a previous study utilising the Virtual City task (Marcotte et al., 2004). In that study, HIV-positive participants with NCI drove a similar number of blocks to reach the BP garage to unimpaired HIV-positive and unimpaired HIV-negative participants, but on returning, they drove for many more blocks than HIV-positive unimpaired and HIV- negative unimpaired participants. Marcotte et al. (2004) attributed this pattern of data to HIV-positive participants with NCI struggling to mentally rotate the map of the Virtual City. Whether this was true for the current sample is unclear.

What is clear, however, is that participants in the HIV+NCI group exceeded the speed limit more frequently than did those in the HIV+NCN and HIV- groups on the task. This might mean that their successful completion of the task and efficiency in reaching the destination was associated with breaking laws in order to do so. However, the sample size constrains the generalisability of this association.

In addition to these two primary aims of the study, the analyses tried to account for between-group differences, or lack thereof, by investigating self-report data regarding everyday functioning and activities of daily living, biomedical data for HIV+ participants, and symptoms of simulator sickness.

Regarding self-report data on functional abilities and activities of daily living, there were no significant between-group differences. Although participants assigned to the

HIV+NCI group performed significantly more poorly on standardised neuropsychological tests, their capacity for behavioural tasks and activities of living and performance on the driving simulator did not appear to be similarly compromised, at least in relation to those in the HIV- and HIV+NCN groups. Previous studies investigating the relationship between HIV-associated NCI and everyday functioning have found that this cognitive impairment is associated with greater difficulty on behavioural tasks and increased dependence in completing activities of daily living (Heaton et al., 2004). Additionally, there were no differences between the two HIV+ groups in terms of biomedical data (i.e., HIV-associated NCI was not associated with higher viral load or lower CD4 count).

Another secondary analysis considered whether the occurrence of simulator sickness might have been more prominent in a particular group. This was not the case. Participants in all three groups experienced symptoms of fatigue, fullness of head (referring to having many thoughts at a time, feeling that one's head is filled with ideas/concerns), blurred vision, and vertigo as being worse in the second (post-simulator) administration of the SSQ. Previous literature regarding simulator sickness in driving studies has found worse symptoms of simulator sickness to be associated with higher dropout rates (Balk et al., 2013). This association was only evident to a limited degree in this study. One participant dropped out of the study because she experienced such severe simulator sickness that she was unable to continue the assessment. Although she did not complete the second administration of the SSQ, she reported nausea and dizziness as her reasons for stopping the assessment. Both of these are symptoms measured on the SSQ, with nausea being most strongly associated with participant dropout (Balk et al., 2013).

Limitations and Directions for Future Research

Interpretation of the current data, and generalisability of the findings, are severely limited by sample size. The conclusions drawn regarding the impact of HIV-associated NCI on driving simulator performance are based on two participants, and it would be premature to generalise these to the South African population at large. To make more informed conclusions, a bigger sample with sufficient power needs to be considered. A power analysis for a three-group design using a medium effect size ($f = 0.4$), $\alpha = .05$, and a minimum desired power of .80, revealed that a sample size of 60 would be adequate (Faul, Erdfelder, Lang, & Buchner, 2007).

Another limitation of this study revolves around ability to predict on-road driving performance. The multimodal assessment of driving behaviour used in this study is regarded

as one of the most informative laboratory-based approaches (Marcotte et al., 2004). However, it still cannot replicate the experience of driving on the roads of South Africa. Future research should continue to develop this multimodal approach so that it is as close to on-road driving as possible. Furthermore, future research may consider the addition of an on-road driving evaluation, as was used by Marcotte et al. (2004).

A third limitation is the possibility for test-retest effects in a subgroup of the HIV+ participants. Four of the twelve HIV+ participants were recruited from a previous study in the HIV Mental Health Research Unit where they had completed neuropsychological testing. While administering the neuropsychological battery a second time controlled for the influence of aging or NCI degeneration over time, the test-retest effects may have influenced their neuropsychological data. Future research can avoid this by ensuring that all participants are being administered neuropsychological test batteries for the first time, or that all participants have similar prior exposure to neuropsychological testing.

Conclusion

This pilot study is the first in a programme of research focusing on the impact of HIV-associated NCI on driving performance in South Africa. Considering the prevalence of HIV in South Africa, generating knowledge regarding the functional implications of HIV-associated NCI offers wide-reaching and long-term benefits to the lay population, medical professionals and researchers in South Africa and the world at large. It is necessary to ascertain whether patterns of compromised driving simulator performance, and likely, driving, related to HIV-associated NCI that have been found in the United States are also present in the South African population. In this study, HIV+NCI participants demonstrated poorer performance on a subset of outcome measures for the Divided Attention simulator task than HIV+NCN and HIV- participants. In addition to this, HIV+ participants (both HIV+NCN and HIV+NCI) completed the Challenge Drive slower than HIV- participants. However, the small sample size limited statistical analyses, and definitive conclusions cannot be drawn at this point in time. Nonetheless, this study provides an important starting point for research investigating the functional implications of HIV-associated NCI on driving practices in South Africa.

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Appendix A

Sociodemographic Form

I am going to ask you some questions about yourself. Please answer honestly.

1. PGWC Folder Number: _____
   Get from clinic chart/folder

2. What is your SA ID? ☐☐☐☐☐☐☐☐☐☐☐☐☐
   ☐ Tick if patient does not know his/her SA ID

3. How old are you? _____

4. What is your date of birth? ☐☐ / ☐☐ / ☐☐☐☐
   Day / Month / Year

5. Where were you born? _____ Province _____ Country

6. What is your gender? *(Tick One)*
   - ☐ FEMALE
   - ☐ MALE
   - ☐ Transgender

7. What is your home language? *(Tick One)*
   - ☐ isiXhosa
   - ☐ isiZulu
   - ☐ English
   - ☐ Afrikaans
   - ☐ Other: _____

8. What is the highest level of education you have completed? *(Tick One)*
   - ☐ None
   - ☐ Grade 1/Sub A
   - ☐ Grade 2/Sub B
   - ☐ Grade 3/Std 1
   - ☐ Grade 4/Std 2
   - ☐ Grade 5/Std 3
   - ☐ Grade 6/Std 4
   - ☐ Grade 7/Std 5
   - ☐ Grade 8/Std 6
   - ☐ Grade 9/Std 7
   - ☐ Grade 10/Std 8
   - ☐ Grade 11/Std 9
   - ☐ Grade 12/Std 10
   - ☐ Tertiary (university/ Technikon/degree)

9. Are you currently working? *(Tick One)*
   - ☐ Yes **If YES, complete 9a – 9c**
   - ☐ No **If NO, skip to 9e**

   9a. What is your employment status? *(Tick One)*
   - ☐ Employed full-time
   - ☐ Employed part-time
   - ☐ Self-employed
   - ☐ Informal job/hawker

   9b. What type of work do you do? *(Tick One)* Specify: _____

   9c. Do you work night shifts? *(Tick One)*
   - ☐ Yes **If YES, complete 9d**
   - ☐ No **If NO, skip to 10**

9d. What hours is your shift? From: _____ To: _____

9e. How long has it been since you last worked? _____ Months _____ Years ☐ Never worked

10. What is your current monthly household income? *(Tick one)*
- ☐ 0 – 1500 Rand
- ☐ 1551 – 5000 Rand
- ☐ Greater than 5000 Rand

11. How long have you lived in Cape Town? _____ Months _____ Years

12. Which best describes your current relationship status? *(Tick one)*
- ☐ Single (never married)
- ☐ Customary Union
- ☐ Living with someone (in relationship)
- ☐ Married
- ☐ Separated
- ☐ Divorced
- ☐ Widow/widower

13. What type of dwelling best describes where you live? *(Tick one)*
- ☐ Shack/ Wendy house/backyard dwelling
- ☐ Rent private room
- ☐ Own/family house
- ☐ Hostel
- ☐ Other: _____

14. How many rooms are in your home? _____

15. How many people sleep in the same ROOM at night? _____

16. How many people sleep in the same HOUSE at night? _____

17. Do you have any children?
- ☐ Yes **If YES, complete 17a**
- ☐ No **If NO, skip to 18**

17a. How many? _____

18. Which of the following do you have in your house? *(Tick all that apply)*
- ☐ Running water/tap water
- ☐ Own electricity box
- ☐ Access to electricity
- ☐ Inside Toilet
- ☐ Radio
- ☐ Television
- ☐ DVD player

19. Who gives you money to buy things like food, cooking oil, etc? *(Tick all that apply)*
- ☐ At least one person living in the house has a job
- ☐ At least one person living in the house has a pension
- ☐ At least one person in the house has a grant
- ☐ No one living in the house has a grant, pension, or job

20. In the past month (30 days), how often have you and your family gone without enough food to eat? *(Tick one)*
- ☐ More than 6 times
- ☐ 4 – 6 times
- ☐ 2 – 3 times

- ☐ One time
- ☐ Never

21. What is your racial background? *(Tick all that apply)*
- ☐ Black
- ☐ Coloured
- ☐ Asian
- ☐ White
- ☐ Mixed ancestry
- ☐ Other: _____

22. What is your religious background? *(Tick one)*
- ☐ Christian
- ☐ Rastafarian
- ☐ Moslem
- ☐ Traditional Religion
- ☐ Other: _____

23. What is your citizenship status? *(Tick one)*
- ☐ South African citizen
- ☐ Asylum seeker
- ☐ Refugee
- ☐ Economic migrant
- ☐ Other:

24. Have you spent any part of the last year outside of Cape Town?
- ☐ Yes **If YES, complete 24a**
- ☐ No **If NO, skip to 25**

24a. Where: _____ How long (in weeks): _____

25. Are you currently receiving any of the following? *(Tick all that apply)*
- ☐ Disability grant
- ☐ Pension
- ☐ Child care grant
- ☐ Other grant: _____
- ☐ Not Applicable

26. Have you ever received any of the following? *(Tick all that apply)*
- ☐ Disability grant
- ☐ Pension
- ☐ Child care grant
- ☐ Not Applicable
- ☐ Other grant: _____

27. How do you get to this clinic? *(Tick one)*

- ☐ Walk less than 30-minutes
- ☐ Walk more than 30-minutes
- ☐ Take public transportation **If selected, go to 27a**
- ☐ Use my own transportation

27a. How much did you pay for transport to come to the clinic? R _____

28. Did you have to take time off work today to come to the clinic? *(Tick one)*

- ☐ Yes
- ☐ No
- ☐ Not currently employed

29. Did you have to pay for someone to watch your child to come to the clinic today? *(Tick one)*

- ☐ Yes
- ☐ No
- ☐ Do not have children

30. In the past year, have you seen any of the following people to talk about your emotions, mental health or use of alcohol and/or drugs? *(Tick all that apply)*

- ☐ Psychologist
- ☐ Social Worker
- ☐ Doctor
- ☐ Nurse
- ☐ Pastor
- ☐ Traditional Healer
- ☐ Other: _____
- ☐ Has not seen anyone

Appendix B

Patient's Assessment of Own Functioning Inventory (PAOFI)

NPPAOFI NP6

Study No. | Visit No. | Date | Staff I.D. | Data Entry Only

PATIENT'S ASSESSMENT OF OWN FUNCTIONING

INSTRUCTIONS TO PARTICIPANTS: Please answer each of the following questions by circling the number that best describes your response to each of the following statements. There is no right or wrong answer. Express how you have been feeling lately. It will tell us more about your daily functioning and any problems you might be having in your daily living.

Manner of Inventory Administration:

[ ] Participant read and answered items independently. **[ ] Items read by examiner.**

[ ] Examiner read items, and marked verbal given answers. **[ ] Examiner marked answers given verbally.**

SCALE I: MEMORY

	Almost Always	Very Often	Fairly Often	Once In A While	Very Infrequenty	Almost Never
1. How often do you forget something that has been told you within the last day or two?	1	2	3	4	5	6
2. How often do you forget events which have occurred in the last day or two?	1	2	3	4	5	6
3. How often do you forget people whom you met in the last day or two?	1	2	3	4	5	6
4. How often do you forget things that you knew a year or more ago?	1	2	3	4	5	6
5. How often do you forget people whom you knew or met a year or more ago?	1	2	3	4	5	6
6. How often do you lose track of time, or do things either earlier or later than they are usually done or are supposed to be done?	1	2	3	4	5	6
7. How often do you fail to finish something you start because you forgot that you were doing it? (Include such things as forgetting to put out cigarettes, turning off the stove, etc.)	1	2	3	4	5	6
8. How often do you fail to complete a task that you start because you have forgotten how to do one or more aspects of it?	1	2	3	4	5	6
9. How often do you lose things or have trouble remembering where they are?	1	2	3	4	5	6
10. How often do you forget things that you are supposed to do or have agreed to do (such as putting gas in the car, paying bills, taking care of errands, etc.)?	1	2	3	4	5	6

SCALE II: LANGUAGE AND COMMUNICATION

	Almost Always	Very Often	Fairly Often	Once In A While	Very Infrequenty	Almost Never
11. How often do you have difficulties understanding what is said to you?	1	2	3	4	5	6
12. How often do you have difficulties recognizing or identifying printed words?	1	2	3	4	5	6
13. How often do you have difficulty understanding reading material which at one time you could have understood?	1	2	3	4	5	6
14. Is it easier to have people show you things than it is to have them tell you about things?	1	2	3	4	5	6
15a. When you speak, are your words indistinct or improperly pronounced?	1	2	3	4	5	6
15b. If this happens, how often do people have difficulty understanding what words you are trying to say?	1	2	3	4	5	6
16. How often do you have difficulty thinking of the names of things?	1	2	3	4	5	6
17. How often do you have difficulty thinking of the words (other than names) for what you want to say?	1	2	3	4	5	6
18. When you write things, how often do you have difficulty forming the letters correctly?	1	2	3	4	5	6
19. Do you have more difficulty spelling, or make more errors in spelling, than you used to?	1	2	3	4	5	6

SCALE III: USE OF HANDS

	Almost Always	Very Often	Fairly Often	Once In A While	Very Infrequenty	Almost Never
20. How often do you have difficulty performing tasks with your right hand (including such things as writing, dressing, carrying, lifting, sports, cooking, etc.)?	1	2	3	4	5	6
21. How often do you have difficulty performing tasks with your left hand?	1	2	3	4	5	6

SCALE IV: SENSORY-PERCEPTUAL

	Almost Always	Very Often	Fairly Often	Once In A While	Very Infrequenty	Almost Never
22. How often do you have difficulty feeling things with your right hand?	1	2	3	4	5	6

NPPAOFI NP6

Study No. | Visit No. | Data Entry Only

	Almost Always	Very Often	Fairly Often	Once In A While	Very Infrequenty	Almost Never
23. How often do you have difficulty feeling things with your left hand?	1	2	3	4	5	6
24a. Lately do you have more difficulty than you used to in seeing all of what you are looking at, or all of what is in front of you (in other words, are some areas of your vision less clear or less distinct than others)?	1	2	3	4	5	6

	To The Right	To The Left	Cannot Tell Whether One Side Is Worse Than The Other
24b. If you are having this kind of trouble with your vision, is it more difficult to see things located to your right or to your left?	1	2	3

SCALE V: HIGHER LEVEL COGNITIVE AND INTELLECTUAL FUNCTIONS

	Almost Always	Very Often	Fairly Often	Once In A While	Very Infrequenty	Almost Never
25. How often do your thoughts seem confused or illogical?	1	2	3	4	5	6
26. How often do you become distracted from what you are doing or saying by insignificant things which at one time you would have been able to ignore?	1	2	3	4	5	6
27. How often do you become confused about (or make a mistake about) where you are?	1	2	3	4	5	6
28. How often do you have difficulty finding your way about?	1	2	3	4	5	6
29. Do you have more difficulty now than you used to in calculating or working with numbers (including managing finances, paying bills, etc.)?	1	2	3	4	5	6
30. Do you have more difficulty now than you used to in planning or organizing activities (i.e., deciding what to do and how it should be done)?	1	2	3	4	5	6
31. Do you have more difficulty now than you used to in solving problems that come up around the house, at your job, etc.? (In other words, when something new has to be accomplished, or some new difficulty comes up, do you have more trouble figuring out what should be done and how to do it?)	1	2	3	4	5	6
32. Do you have more difficulty than you used to in following directions to get somewhere?	1	2	3	4	5	6

	Almost Always	Very Often	Fairly Often	Once In A While	Very Infrequenty	Almost Never
33. Do you have more difficulty than you used to in following instructions concerning how to do things?	**1**	**2**	**3**	**4**	**5**	**6**

34. Do you think you are as "bright" now as you were before your accident or present illness?

Yes..... 1
No..... 2
I don't know..... 3

SCALE VI: WORK

35. Are you presently holding a job?

Yes, Full-time..... 1
Yes, Part-time..... 2
No..... SKIP TO QUESTION 39 3

36. What kind of job do you have, and briefly describe your duties:

_____
_____
_____

37. What is your salary per month: _____

38. On your job how much supervision is being given to you now?

I am closely observed and supervised in almost everything I do..... 1
There is a supervisor around most of the time, but supervision is not really constant..... 2
I receive only occasional supervision, though there may be more when a new job is given or after a job is completed. 3
I usually receive supervision only when being given a new job to do, or after a job has been completed..... 4
I function very much on my own at work..... 5
I am self-employed..... 6

39. Are you a student?

Yes, Full-time..... 1
Yes, Part-time..... 2
No..... SKIP QUESTIONS 40 & 41 3

40. Are you currently taking regular academic courses or special education courses?

All special education courses 1
Mostly special education courses 2
About an equal number of each type of course..... 3
Mostly regular academic courses..... 4
All regular academic courses..... 5

41. What is your approximate grade point average in regular academic courses only (i.e., leaving out grades in special education courses)?

Better than 3.7 (A)..... 1
3.0 to 3.6 (B to A minus)..... 2
2.0 to 2.9 (C to B minus)..... 3
1.0 to 1.9 (D to C minus)..... 4
Less than 1.0 (F)..... 5

Appendix C

Lawton Instrumental Activities of Daily Living Scale

THE LAWTON INSTUMENTAL ACTIVITIES OF DAILY LIVING SCALE- MODIFIED FOR SOUTH AFRICA

"Compared to your ability to do these things AT YOUR BEST, have you had any problems…"

Using a telephone or cell phone	
* Can use a phone and dial numbers	2
* Dials with difficulty OR uses speed dial ONLY.	1
* Answers telephone, but does not dial..	0

Laundry	
* Does laundry completely…	2
* Launders small items, rinses socks, underwear, etc.	1
* All laundry must be done by others.	0

Shopping	
* Able to go to the shops and buy things on own.	2
* Shops on own for one or two items ONLY.	1
* Needs to be accompanied on any shopping trip OR cannot shop..	0

Mode of transport	
* Travels alone on public transportation or able to drive.	2
* Travels on public transportation when assisted or accompanied by another.	1
* Does not travel at all OR needs ambulance OR wheelchair	0

Food preparation	
* Prepares, and serves adequate meals without help.	2
* Able to heat a meal or make something uncooked (e.g. sandwich) ONLY..	1
* Needs to have meals prepared and served OR cannot use any kitchen appliances	0

Responsibility for own medications	
* Is responsible for taking medication in correct dosages at correct time..	2
* Takes responsibility if medication is prepared in advance in separate dosages (e.g pill boxes).	1
* Is not capable of dispensing own medication.	0

Housekeeping and appliances	
* Does most things around the house and can use a toaster, kettle, stove, or television without help.	2
* Needs help with using a toaster, kettle, stove or television…	1
* Does not participate in any housekeeping OR cannot use any appliances without help	0

Ability to manage finances	
* Manages money alone (Pays rent and bills, goes to bank); collects and keeps track of income.	2
* Manages small money matters, but needs help with banking , major purchases, etc.	1
* Incapable of handling money.	0

Maximum score= 16. For non-applicable items, score "2". A score of 13 or less is suggestive of possible functional impairment.

Appendix D

Driving History and Habits Questionnaire

DRIVING HISTORY AND HABITS QUESTIONNAIRE

INSTRUCTIONS TO PARTICIPANT: Please answer the following questions regarding your driving experience and the habits you may have when driving. For some questions you will just be able to indicate the corresponding number of your response. For other questions, you will need to provide in a number, date or brief explanation.

1. Have you ever driven a car?
No…. EXPLAIN WHY NOT _____ STOP …….. 0
Yes ……..1

2. At what age did you start driving (even if you did not have a driver's licence)?
_____YEARS

3. In your lifetime, how many years have you *routinely* driven a car? _____YEARS

4. Are you currently driving?
No…WHEN DID YOU STOP DRIVING? (MM/YYYY) _____ ...SKIP TO QUESTION 6…0
Yes ……...1

5. If you are currently driving, are you driving less lately?
No …….. SKIP TO QUESTION 7 ……0
Yes….. WHEN DID YOU CUT BACK ON DRIVING? (MM/YYYY)_____ ……...1

6. If you are not driving or are driving less lately, please choose from the following answers to explain why. (CIRCLE ALL THAT APPLY).
No driver's license ……....0
License is suspended ……....1
Do not own a car……2
Car doesn't run…….....3
I am less confident due to slowed reactions, difficulty concentrating, etc ……...4
Do not feel safe due to medical condition……...……..5
Physician's recommendation ……....6
Relative's concern…….7
Lack of money…….....8
Other: Explain _____ ……..9

7. When was the last time you drove? (Choose only one answer)
Today ……...1
Within the last week ……...2
More than one week ago but within the last month ……....3
One month to six months ago ……...4
Six months to twelve months ago ……5
More than one year ago ……....6

For items 8-15, please just consider your driving over the past 12 months. If you have not driven in the last year, please answer the questions in terms of the last 12 months that you were driving.

8. How many days per week did you drive (0-7 days)? _____ DAYS

9. When you drove, about how many kilometers round trip was your usual trip?
_____KMS

10. About how many kilometres per month did you drive? _____KMS

11. Overall, how safely/carefully do you feel you drove over the past 12 months?

Very safely…….....1
Above average……...2
Average…….....3
Somewhat dangerously……...4
Dangerously ……..…...5

12. When driving in residential or commercial areas, where the speed limit is 60km/h, and there isn't any traffic or congestion, which range best fits your average driving speed?

Less than 50km/h……...1
51-60km/h…….....2
61-70km/hr…….....3
71-80km/hr…….....4
Greater than 80km/hr…….....5

13. When driving on the highway, where the speed limit is 100km/her, and there isn't any traffic or congestion, which range best fits your average driving speed?

Less than 90km/h……...1
91-100km/h…….....2
101-110km/hr…….....3
111-120km/hr…….....4
Greater than 120km/hr…….....5

14. Which statement below best describes your music listening habits while driving ('music' includes anything on CDs, radios, iPod, other music players):

I did not listen to music or talk radio while driving……...1
I chose one thing (CD, radio station, playlist, etc.) before I begin driving and did not change the music until at a safe stop. ……...2
I would listen to one thing for a while but would change the music while driving if I wanted to listen to something different……...3
I changed my music constantly while driving…….…….…...4

15. When another driver or pedestrian did something to significantly frustrate or anger you, how were you most likely to react?

I did nothing…….1
I muttered something to myself……...2
I shouted at the person (without cursing) ……...3
I cursed the person or made an obscene gesture I intended for them to see/hear
I honked my horn at them……...4
I followed them closely/tailgated them or cut them off…….....5

Use the scale on the right to answer questions 16-24. Circle the number that best answers each question. Remember to think about your driving over the past 12 months, or your driving during the last 12 months when you were driving.	**Within the last 12 months**					
	Never	Rarely	Half of the	Frequently	Almost	Always
16. How often did you wear your seatbelt while driving?	**1**	**2**	**3**	**4**	**5**	**6**
17. How often did you eat or drink (non-alcoholic beverages) while driving?	**1**	**2**	**3**	**4**	**5**	**6**
18. How often did you smoke cigarettes while driving?	**1**	**2**	**3**	**4**	**5**	**6**
19. How often did you race other drivers?	**1**	**2**	**3**	**4**	**5**	**6**
20. Often often did you pass other cars in no-passing lanes?	**1**	**2**	**3**	**4**	**5**	**6**
21. How often did you 'cut it close' at intersections with traffic lights that were already yellow or were about to turn red?	**1**	**2**	**3**	**4**	**5**	**6**
22. How often did you talk on a cellphone while driving? *(if never circle '1' and skip to question 24)*	**1**	**2**	**3**	**4**	**5**	**6**
23. If you talked on a cell phone while driving, how often did you use a hands-free device?	**1**	**2**	**3**	**4**	**5**	**6**
24. How often did you text message while driving?	**1**	**2**	**3**	**4**	**5**	**6**

For each of the items below, you should first consider your driving over your lifetime, and then over the last 12 months that you were driving.	In y our lifetime (including the last 12 months)	Within only the last 12 months that you were driving
25. How many minor traffic accidents (i.e. no injuries and no significant car damage) have you had in which you were the driver (even if it wasn't your fault)?		
25a. How many of these minor traffic accidents occurred while you were under the influence of alcohol or drugs (even if you didn't get a DUI)?		
26. How many major traffic accidents (i.e. injuries and/or significant car damage) have you had in which you were the driver (even if it wasn't your fault)?		
26a. How many of these major traffic accidents occurred while you were under the influence of alcohol or drugs (even if you didn't get a DUI)?		
27. How many 'close calls' (i.e. instances where you had to swerve or slam on your brakes to avoid an accident) have you had in which you were the driver (even if it wasn't your fault)?		
27a. How many of these 'close calls' occurred while you were under the influence of alcohol or drugs (even if you didn't get a DUI)?		
28. How many total moving violations/traffic tickets (not parking) have you had?		
28a. How many of these tickets occurred while you were under the influence of alcohol or drugs (even if you didn't get a DUI)?		
29. How many times did you drive while you were intoxicated or high from alcohol or drugs?		
30. How many DUIs have you had (i.e. 'Drunk driving' arrests, 'driving under the influence')?		

Appendix E

Virtual City questionnaire

VIRTUAL CITY QUESTIONNAIRE

1) Have you used a map before? …….YES/ NO
    a. If yes, did that map help you to get to your destination? ….. YES/NO
2) Was the map for this task clear? …….YES/NO
    a. If yes, why were you not able to find the BP garage?

        _____

    b. If no, what was not clear about this map?

        _____

3) Could you identify the one-way streets on the map? ……...……YES/NO
4) Could you identify the street names on the map? …….…...……YES/NO
5) Could you identify the park on the map? ……..…...……YES/NO
6) What was the most difficult thing about the Virtual City task for you?

    _____

    _____

    _____

Appendix F

Simulator Sickness Questionnaire (SSQ)

Instructions: Circle how much each of the symptoms below is affecting you right now.

1. General discomfort	None	Slight	Moderate	Severe
2. Fatigue	None	Slight	Moderate	Severe
3. Headache	None	Slight	Moderate	Severe
4. Eye strain	None	Slight	Moderate	Severe
5. Difficulty focusing	None	Slight	Moderate	Severe
6. Salivation increasing	None	Slight	Moderate	Severe
7. Sweating	None	Slight	Moderate	Severe
8. Nausea	None	Slight	Moderate	Severe
9. Difficulty concentrating	None	Slight	Moderate	Severe
10. Fullness of head*	None	Slight	Moderate	Severe
11. Blurred vision	None	Slight	Moderate	Severe
12. Dizziness with eyes open	None	Slight	Moderate	Severe
13. Dizziness with eyes closed	None	Slight	Moderate	Severe
14. Vertigo**	None	Slight	Moderate	Severe
15. Stomach awareness***	None	Slight	Moderate	Severe
16. Burping	None	Slight	Moderate	Severe

*Fullness of head refers to feeling as if one's head if full of thoughts

**Vertigo is experienced as loss of orientation with respect to vertical upright.

*** Stomach awareness is usually used to indicate feelings of discomfort which is just short of nausea.

Appendix G

Faculty of Health Sciences Human Research Ethics Committee Ethics Approval

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6626
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

18 July 2016

HREC REF: 253/2016

Dr H Gouse
Psychiatry & Mental Health
J-Block, GSH

Dear Dr Gouse

PROJECT TITLE: THE IMPACT OF HIV ASSOCIATED NEUROCOGNITIVE IMPAIRMENT ON DRIVING SIMULATOR PERFORMANCE- LINKED TO 596/2014 (BSc Honours Candidate Ms J Standish-White)

Thank you for your response to the Faculty of Health Sciences Human Research Ethics Committee dated 12 July 2016.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30th July 2017.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval before the research may occur.

The HREC acknowledge that the student, Julia Standish-White will also be involved in this study.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

Appendix H

Psychology Department Ethics Approval

From: Lauren Wild <lauren.wild@uct.ac.za>

Subject: Re: Psychology Ethics approval for Honours research project

Date: 25 July 2016 at 2:43:24 PM SAST

To: Julia Standish-White <julia.standish.white@gmail.com>

Dear Julia

Many thanks for submitting the documentation. You now have ethical approval from the Psychology Department for your study. I would just suggest correcting a couple of minor typing errors in the consent form (see the attachment for details).

Kind regards

Lauren

Appendix I
Consent Form

PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM

TITLE OF STUDY: Impact of HIV-associated Neurocognitive Impairment on driving simulator performance in South Africa

PRINCIPAL INVESTIGATOR: Dr. Hetta Gouse

ADDRESS: Department of Psychiatry and Mental Health, J-block, Groote Schuur Hospital, Anzio Road, Observatory, 7925. Telephone: 021-404 2164/021-4045225

We would like to invite you to take part in a study because you can drive a car and are either healthy and have had a recent negative HIV test, or because you previously tested positive for HIV. Please take some time to read over the information about this study. It is your choice whether you want to participate, it is entirely voluntary. If you say no, this will not affect you negatively in any way. It will not affect services you are receiving at the clinic. You are also free to withdraw from the study at any point, even if you do agree to take part.

If you have any questions or are confused about anything, please ask the study staff or doctor any questions about any part of this study that you do not fully understand. It is very important that you feel fully satisfied in your understanding of what participating in this study requires.

What is this research study all about?

Chronic conditions such as HIV may affect the way some people's brains work and result in problems such as poorer thinking skills, forgetfulness and poor planning ability – these problems together are known as 'neurocognitive impairment'. We are conducting a research study to determine whether drivers with HIV-associated neurocognitive disorders may experience difficulty with thinking (for example, whether they have trouble making decisions or paying attention), and if this might affect their driving performance. The results of this study may lead to better understanding of the cognitive problems that people with this chronic condition have, and rehabilitation for these cognitive problems and their impact on everyday functioning.

In this study, we will be assessing three groups of people: (1) HIV-positive people who previously performed lower than expected on neuropsychological testing; (2) HIV-positive people who performed within the normal range of neuropsychological testing, and (3) healthy HIV-negative. You are being asked to participate because you are a driver who falls into one of these three groups. Sixty people will participate in this study.

If you fall into group 1, it means that you previously had some cognitive symptoms. Because of that, and
to ensure that you understand what we will require from you we will ask you some questions after we have explained the study to you to see if we need someone you know to co-sign consent with you to participate in the study. Also, it must be highlighted that <u>HIV itself is not a risk factor for poorer driving performance, but that neurocognitive impairment found in a subpopulation of people living with HIV/AIDS is the risk factor. Again, of those with impairment, only certain persons may also exhibit impaired driving.</u>

If you agree to participate the following will happen: We will do a brief medical examination. You will be asked to complete some questionnaires, do some tasks using a pencil and paper to see how well you are thinking, do some tasks on a computer, and drive a driving simulator (see the picture on the next page). The driving simulator has a steering wheel and pedals like a normal car; you just drive on a computer screen. The first part of the study will be at Town II clinic where you will do a cognitive assessment. The second part of the study will require you to go to Groote Schuur Hospital where you will complete the driving simulator part of the study. Altogether it will take approximately 6 hours (including breaks) and you will be compensated R600 for participation. We will provide you with refreshments during the research activities.

More specifically:

1. Your assessment will include a brief medical examination.
2. Your assessment will include an evaluation of your thinking and your ability to perform everyday tasks (approximately 3 hours).
3. You will also complete a test administered on a computer-based driving simulator that assesses your driving skills (approximately 2 hours). The driving simulator looks like this:

4. Your assessment will include questions about your mood and how you are able to complete daily tasks. You will be asked to complete a questionnaire regarding your driving history and a self-evaluation questionnaire regarding your performance before and after the simulator test (approximately 20 minutes).

This study has been approved by the Human Research Ethics Committee of the Faculty of Health Sciences of the University of Cape Town. This study will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki, South African Guidelines for Good Clinical Practice and the Medical Research Council (MRC) Ethical Guidelines for Research.

Will you be compensated for participation and are there any costs involved?
You will be compensated R600 for participating in the study for your time and transport costs. There is no cost to you for participation in this study.

What are the possible risks and discomforts?

Participation in this study may include some risks or discomforts such as:

1. If we notice that your cognitive performance is below what we expect it to be, or that you are making driving errors we will tell you about it and counsel you on how to improve your driving. This may also mean that you have cognitive symptoms associated with your chronic condition that may affect your daily functioning. If you also present with cognitive symptoms we will inform your study buddy. We would strongly recommend that you follow-up with your doctor at the clinic and would be prepared to give your doctor a report should you request it. You may be advised to stop driving.

2. Motion sickness while completing the driving simulation. In order to minimize the risk of motion sickness, you will be slowly trained to adapt to the driving simulator. In the event that you continue to experience motion sickness, you will be offered the opportunity to take a break or stop the testing. In the unlikely event of this happening you will still be compensated for your participation.

3. The emotional stress of completing the simulations, neurobehavioral assessments or answering the questionnaires. Should you find this assessment particularly stressful, Dr. Gouse or her associates will consult with you about terminating the assessment and/or appropriate referrals.

4. Despite every possible safeguard, there always exists the potential for loss of private information, or violation of confidentiality, which will be addressed below.

5. You can contact the Human Research Ethics Committee of the Health Sciences Faculty of the University of Cape Town 021-4066338 if you have any concerns or complaints that have not been adequately addressed by your study doctor.

6. Unforeseeable risks: Because this is an investigational study there may be some risks that are currently unknown. If the study doctors learn of any new risks during the course of this study, you will be notified immediately.

By signing this consent, you agree that the results of your interviews, exams and/or other tests will be available to study investigators conducting this research. Should you have any questions you can contact Dr. Hetta Gouse on 021 404 5225 or Ms. Michelle Henry on 021 650 1804.

Who will have access to your medical records?

The information collected about you will be treated as confidential and protected, and only the study staff will have access to it. If we write about this work, we will not identify you personally and only group data will be published. Only the research study team will have full access to the information. Upon your request and with your permission study information can be made available to your personal physician.

Is the information that you provide confidential?
All research study staff are instructed to keep all of your study information confidential. They are not allowed to discuss it with your employer of occupational health provider. They are only allowed to discuss it with the research study staff.

To protect against a violation of confidentiality, all of your study information, including tests and assessments on paper, tablet computer and simulator will be identified by a unique ID number. No personal and identifiable information will be kept in the tablet, simulator or on paper forms that you complete.

A list matching participant names with ID numbers will be kept in a separate locked file drawer in a locked office at the University of Cape Town.

These and all records generated from this study will only be available to research study staff. Institutional personnel may access it as part of routine audits. This information will only be available to research study staff. Study results will be reported only as a group. This way, no individual participant can be identified.

Despite careful safeguards, information regarding your history, drug use or medical diagnosis may become known outside of the research setting, although such an event is extremely unlikely.

Research information will not be shared with your physician without your consent. You should however understand that this agreement does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research.

How will you benefit from study participation?
Should we find that you have cognitive risk factors you will be alerted to it and you can choose to share the information with your personal physician. Other than that you will not receive any direct benefit from these procedures. However, the new knowledge gained from this research may help you and others in the future.

What are the alternatives to participating in this study?
The alternative to participating in this study is not to participate.

Can you withdraw from, or be removed from the study?
Participation in this study is entirely voluntary. You may refuse or withdraw participation at any time. Likewise, your participation may be discontinued without your consent if you fail to comply with study procedures, if the investigator or the sponsor cancels the study, or if, in the investigator's clinical judgment, discontinuance is in your best interest.

Would you be interested in being contacted for further studies?
With your consent we would like to use your information to determine if you are eligible for other related studies that Dr. Gouse or her associates are conducting. If you are eligible, you may be informed about these studies. Whether or not you choose to become involved in those studies will not affect your continued involvement in this study. If you decide to enroll in other studies, you will sign a separate consent form. Note that if you choose to participate in other

studies conducted by Dr. Gouse or her associates, data collected during those assessments or procedures may be shared with this study.

Please tick this box if you would like to be contacted for further studies ☐

Information and Consent Summary

Ensure that each participant clearly understands each of the following points:

- As a participant in the study, one study visit wil be at Town II clinic and the other at Groote Schuur Hospital. At Town II you will:
    - Allow the study counsellor to assess your cognitive skills and ability to perform everyday tasks (approximately 3 hours).
    - Allow the research staff to access your clinic medical record.
- As a participant in the study, at the driving assessment visit at Groote Schuur Hospital, you will:
    - Allow the study staff to do a short neuromedical exam.
    - Allow the study staff to administer an assessment of your driving skills (approximately 2 hours) on a computer-based driving simulator.
- Everything you share during the visits is confidential. Only those people involved in this research study will see your answers to the questions. The clinic staff will not have access to your answers.
- Your participation in this study is completely voluntary.
- Your participation or decision not to participate in the study WILL NOT affect your care at this clinic.
- You can withdraw from the study at any time without any penalty and you can continue receiving care at this clinic.
- You will receive R600 for participating in this study.

DECLARATION BY PARTICIPANT

PARTICIPATION IN RESEARCH STUDY

By signing below, I _____ agree to take part in a research study entitled:

"The impact of HIV-associationed neurocognitive disorders on simulator performance."

I declare that:

- I have read or had read to me this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions and all my questions have been adequately answered.
- I understand that taking part in this study is voluntary and I have not been pressured to take part.
- I may choose to leave the study at any time without penalty or prejudice in any way.
- I may be asked to leave the study before it has finished, if the study doctor or researcher feels it is in my best interests, or if I do not follow the study plan as agreed.

Signed at (*place*) _____ on (*date*) _____ 20___.

_____

Signature/Fingerprint of participant

DECLARATION BY INVESTIGATOR/STUDY COORDINATOR

I *(name)* _____declare that:

- I explained the information in this document to _____
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above.

Signed at (*place*) _____ on (*date*) _____ 20___.

_____

Signature of investigator/study coordinator