

UC San Diego

UC San Diego Electronic Theses and Dissertations

Title

Script generation and multitasking in HIV-1 infection : implications for everyday functioning

Permalink

<https://escholarship.org/uc/item/5q0098nv>

Author

Scott, James Cobb

Publication Date

2009

Peer reviewed|Thesis/dissertation

UNIVERSITY OF CALIFORNIA, SAN DIEGO

SAN DIEGO STATE UNIVERSITY

Script Generation and Multitasking in HIV-1 Infection: Implications for
Everyday Functioning

A dissertation submitted in partial satisfaction of the requirements for the degree of
Doctor of Philosophy

in

Clinical Psychology

by

James Cobb Scott, M.S.

Committee in charge:

University of California, San Diego

Professor Thomas D. Marcotte, Chair
Professor Robert K. Heaton, Co-Chair
Professor Igor Grant
Professor Steven Paul Woods

San Diego State University

Professor Paul E. Gilbert
Professor Scott C. Roesch

2009

The Dissertation of James Cobb Scott is approved, and it is acceptable in
quality and form for publication on microfilm and electronically.

Co-Chair

Chair

University of California, San Diego

San Diego State University

2009

TABLE OF CONTENTS

Signature Page.....	iii
Table of Contents.....	iv
List of Figures.....	vii
List of Tables.....	viii
Acknowledgements.....	x
Vita.....	xii
Abstract.....	xv
Introduction.....	1
Neuropsychology of HIV-1 Infection.....	1
Functional Impact of NP Impairment in HIV-1 Infection.....	2
Script Generation.....	6
Multitasking.....	10
Specific Aims.....	15
Aim 1.....	15
Aim 2.....	16
Aim 3.....	16
Methods.....	18
Participants	18
Procedure.....	19
Neuropsychological Battery & Questionnaires.....	20
Script Generation Task.....	25
Multitasking Test.....	28

Data Analyses.....	30
Inter-rater Reliability.....	30
Study Analyses.....	31
Results.....	36
Distribution Characteristics of Everyday Action Measures.....	36
Demographic and Disease Effects on Everyday Action Measures.....	39
Everyday Action Performance in HIV+ and HIV- Participants.....	39
Neuropsychological Status and Everyday Action Results.....	40
Relationship between Neuropsychological Measures and Everyday Action Performance.....	42
Relationship of Everyday Action Performance to Manifest Everyday Functioning.....	43
Discussion.....	48
Psychometric Properties of the Experimental Tests.....	48
Impact of HIV Disease on Script Generation and Multitasking.....	51
Effects of Neuropsychological Impairment.....	56
Associations with Traditional Neuropsychological Tests.....	57
Implications for Everyday Functioning.....	61
Confounding Factors.....	66
Limitations, Summary, and Future Directions.....	67
Appendices.....	89
Appendix A: General Instructions and Introduction for the Everyday Action Battery.....	89
Appendix B: Administration Instructions for the Script Generation Task.....	90

Appendix C: Administration Instructions for the Multitasking Task.....	93
Appendix D: Example Examiner Scoring Sheets for Script Generation.....	99
Appendix E: Script Generation Recognition Items and Frequency Ratings..	100
Appendix F: Examiner Scoring Sheets for Multitasking.....	105
Appendix G: Everyday Functioning Surveys Given to Participants.....	111
Appendix H: Everyday Skills Survey.....	116
References.....	118

LIST OF FIGURES

Figure 1: Comparisons of Multitasking and Script Generation error variables in the HIV-, HIV+ NP-Normal, and HIV+ NP-Impaired groups.....	86
Figure 2: Multitasking Overall Score by group.....	87
Figure 3: ROC Curve: Multitasking Overall Score predicting the presence of IADL dependence.....	88

LIST OF TABLES

Table 1: Hypothesized effects on Script Generation and Multitasking tests relative to controls.....	71
Table 2: HIV disease and medical characteristics of the HIV+ sample (n = 60).....	72
Table 3: Intraclass correlations for 10 HIV-seronegative pilot participants enrolled prior to the study.....	73
Table 4: Demographic and psychiatric characteristics of the study sample.....	74
Table 5: Participant performance characteristics of Script Generation and Multitasking measures for the combined sample (n = 86).....	75
Table 6: Intercorrelations between variables of the Script Generation and Multitasking tests in the HIV- healthy comparison group (n = 26).....	76
Table 7: Intercorrelations between variables of the Script Generation and Multitasking tests in the HIV+ group (n = 60).....	77
Table 8: Script Generation performance in the HIV+ and HIV- healthy comparison samples.....	78
Table 9: Multitasking performance in the HIV+ and HIV- healthy comparison samples.....	79
Table 10: Comparisons of neuropsychologically (NP) normal and NP-impaired HIV+ groups on the Multitasking measure.....	80
Table 11: Correlations between neuropsychological performance and Script Generation and Multitasking variables in the HIV- group (n = 26).....	81
Table 12: Correlations between neuropsychological performance and Script Generation and Multitasking variables in the HIV+ group (n = 60).....	82
Table 13: Effect sizes for Script Generation Total Errors and Multitasking Overall Score with overall cognitive functioning and demographic, HIV disease, and psychiatric characteristics in the HIV+ sample (n = 60).....	83
Table 14: Demographic, HIV disease, and psychiatric characteristics of the HIV+ participants classified by IADL status (means and percentages).....	84

Table 15: Nominal logistic regression model predicting dependence in instrumental activities of daily living (IADL) by neuropsychological (NP) global deficit score (GDS), current major depression diagnosis, and Overall Score on the Multitasking test.....	85
-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the contribution of many dedicated and bright individuals who have helped along the way with project development, study recruitment, and general guidance and supervision. I can say with confidence that your multitasking skills are completely intact and are to be commended.

I would like to acknowledge the support of Ofilio Vigil for his help in administering and double-scoring many of these protocols, as well as sticking with this project through two years of feast or famine participant recruitment. He should also be acknowledged for somehow managing to prevent himself from laughing every time he asked whether “wash the car” was part of the script for getting in a car accident.

I would also like to acknowledge Drs. Brian Schweinsburg, Katie Carey, and David Moore for early feedback on test development. In addition, the HNRC PAR core was instrumental in recruiting and scheduling participants. My wife, Dr. Amy Carroll-Scott, was also a constant source of patience, support, and encouragement along the way, as well as an excellent editor. I would also be remiss to not thank my father and brother for their emotional and (at times) financial support through the long years of grad school.

Finally, I would like to acknowledge the collective guidance and mentorship of my dissertation committee. Your feedback and support have been invaluable throughout the many steps of this project, and I will undoubtedly use the lessons I have learned in its execution for many years to come.

This research was also supported by Developmental Award-759 from the Core Support Program for AIDS Research and by the 2007 Benton-Meier Scholarship from the American Psychological Association.

VITA

- 1999 Bachelor of Arts, Wesleyan University
- 1999 – 2001 Research Associate, San Francisco Veteran's Affairs Medical Center, San Francisco, CA
- 2000 – 2003 Contract Research Associate, San Francisco Veteran's Affairs Medical Center, San Francisco, CA
- 2001 – 2003 Research Associate/ Study Coordinator, University of California, San Francisco, Department of Anesthesia, San Francisco, CA
- 2006 Master of Science, San Diego State University
- 2003 – 2008 Graduate Student Researcher, HIV Neurobehavioral Research Center, University of California, San Diego, Department of Psychiatry, San Diego, CA
- 2008 – 2009 Predoctoral Intern (Clinical Psychology and Neuropsychology), VA Connecticut Healthcare System, Psychology Service, West Haven, Connecticut
- 2009 Doctor of Philosophy, San Diego State University/ University of California, San Diego Joint Doctoral Program in Clinical Psychology

PUBLICATIONS

Neylan, T.C., Jasiukaitis, P.A., Lenoci, M.A., Scott, J.C., Metzler, T.J., Weiss, D.S., et al. (2003). Temporal instability of auditory and visual event related potentials in posttraumatic stress disorder. *Biological Psychiatry*, 53, 216-25.

Marcotte, T.D. & Scott, J.C. (2004). The assessment of driving abilities. *Advances in Transportation Studies: An International Journal*, December, 79-90.

Marcotte, T.D., Scott, J.C., Lazaretto, D., & Rosenthal, T.J. (2004). Long-term stability of standard deviation of lateral position in neurocognitively normal and impaired individuals. *Advances in Transportation Studies: An International Journal*, December, 57-65.

Woods, S.P., Scott, J.C., Sires, D.A., Grant, I., Heaton, R.K., Tröster, A.I., & The HNRC Group. (2005). Action (verb) fluency: Test-retest reliability, normative standards, and construct validity. *Journal of the International Neuropsychological Society*, 11, 408-415.

Woods, S.P., Scott, J.C., Conover, E., Marcotte, T.D., Heaton, R.K., Grant, I., & The HNRC Group (2005). Test-retest reliability of component process variables within the Hopkins Verbal Learning Test - Revised. *Assessment*, 12, 96-100.

Woods, S.P., Scott, J.C., Dawson, M.S., Morgan, E.E., Carey, C.L., Heaton, R.K., Grant, I., & The HNRC Group. (2005). Construct validity of Hopkins Verbal Learning Test-Revised component process measures in an HIV-1 sample. *Archives of Clinical Neuropsychology*, 20, 1061-1071.

Scott, J.C., Woods, S.P., Patterson, K.A., Morgan, E.E., Heaton, R.K., Grant, I., Marcotte, T.D., & The HNRC Group. (2006). Recency effects in HIV-associated dementia are characterized by deficient encoding. *Neuropsychologia*, 44, 1336-1343.

Woods, S.P., Delis, D.C., Scott, J.C., Kramer, J.K., & Holdnack, J.A. (2006). The California Verbal Learning Test - second edition: Test-retest reliability, practice effects, and reliable change indices for the standard and alternate forms. *Archives of Clinical Neuropsychology*, 21, 413-420.

Woods, S.P., Morgan, E.E., Dawson, M., Scott, J.C., Grant, I., & The HNRC Group. (2006). Action (verb) fluency predicts dependence in instrumental activities of daily living in persons infected with HIV-1. *Journal of Clinical and Experimental Neuropsychology*, 28, 1030-1042.

Marcotte, T.D., Lazzaretto, D., Scott, J.C., Roberts, E., Woods, S.P., Letendre, S., Grant, I., & The HNRC Group. (2006). Visual attention deficits are associated with driving accidents in cognitively-impaired HIV-infected individuals. *Journal of Clinical and Experimental Neuropsychology*, 28, 13-28.

Scott, J.C., Woods, S.P., Matt, G.E., Meyer, R.A., Heaton, R.K., Atkinson, J.H., & Grant, I. (2007). Neurocognitive effects of methamphetamine: A critical review and meta-analysis. *Neuropsychology Review*, 17, 275-297.

Marcotte, T.D., Rosenthal, T.J., Roberts, E., Lampinen, S., Scott, J.C., Allen, R.W., & Corey-Bloom, J. (2008). The contribution of cognition and spasticity to driving performance in multiple sclerosis. *Archives of Physical Medicine and Rehabilitation*, 89, 1753-1758.

Woods, S.P., Scott, J.C., Fields, J.A., Poquette, A., & Tröster, A.I. (2008). Executive dysfunction and neuropsychiatric symptoms predict lower health status in Essential Tremor. *Cognitive and Behavioral Neurology*, 21, 28-33.

Morgan, E.E., Woods, S.P., Scott, J.C., Childers, M., Marquie Beck, J., Ellis, R.J., Grant, I., Heaton, R.K., & The HNRC Group. (2008). Predictive validity of demographically-adjusted normative standards for the HIV Dementia Scale. *Journal of Clinical and Experimental Neuropsychology*, 30, 83-90.

Iudicello, J.E., Woods, S.P., Weber, E., Dawson, M.S., Scott, J.C., Carey, C.L., Grant, I., & The HNRC Group. (2008). Cognitive mechanisms of switching in HIV-associated category fluency deficits. *Journal of Clinical and Experimental Neuropsychology*, 30, 797-804.

Marcotte, T.D., & Scott, J.C. (2008). Evolution of neuropsychological issues in HIV-1 infection during the HAART era. In K. Goodkin, P. Shapshak, and A. Verma (Eds.). The Spectrum of Neuro-AIDS Disorders: Pathophysiology, Diagnosis, and Treatment (pp. 29-40). Washington, DC: ASM Press.

Marcotte, T.D. & Scott, J.C. (2009). Neuropsychological performance and the assessment of driving behavior. In I. Grant & K.M. Adams (Eds.) Neuropsychological Assessment of Neuropsychiatric and Neuromedical Disorders, 3rd Edition (pp. 652-687). New York: Oxford University Press.

Gonzalez, R., Vassileva, J., & Scott, J.C. (2009). Neuropsychological consequences of drug abuse. In I. Grant & K.M. Adams (Eds.). Neuropsychological Assessment of Neuropsychiatric and Neuromedical Disorders, 3rd Edition (pp. 455-479). New York: Oxford University Press.

Scott, J.C., & Marcotte, T.D. (in press). Everyday impact of HIV-associated neurocognitive disorders. In T.D. Marcotte & I. Grant (Eds.). Neuropsychology of everyday functioning. New York: Guilford Publications, Inc.

Marcotte, T.D., Scott, J.C., Kamat, R., & Heaton, R. K. (in press). Neuropsychology and the prediction of everyday functioning. In T.D. Marcotte & I. Grant (Eds.). Neuropsychology of everyday functioning. New York: Guilford Publications.

Woods, S.P., Iudicello, J.E., Scott, J.C., & Grant, I. (in press). Neuropsychological assessment methods in mental disorders research: Illustrations from methamphetamine dependence. In S. Wood, N. Allen, & C. Pantelis (Eds.) Handbook of Neuropsychology of Mental Illness. Cambridge: Cambridge University Press.

ABSTRACT OF THE DISSERTATION

Script Generation and Multitasking in HIV-1 Infection: Implications
for Everyday Functioning

by

James Cobb Scott, M.S.

Doctor of Philosophy in Clinical Psychology

University of California, San Diego, 2009
San Diego State University, 2009

Professor Thomas D. Marcotte, Chair
Professor Robert K. Heaton, Co-Chair

It is well established that 30-50% of persons infected with HIV-1 exhibit neuropsychological impairment. A subset of individuals with HIV-associated neurocognitive impairment experience related deficits in "real world" functioning (i.e., independently performing instrumental activities of daily living [IADL]). While performance-based tests of everyday functioning are reasonably sensitive to HIV-associated IADL declines, questions remain regarding the extent to which these tests'

highly structured nature fully captures the inherent complexities of daily life. Script generation and multitasking are two constructs that may be of particular relevance to the prediction of everyday functioning in HIV, which ostensibly requires the efficient generation and execution of script-based action schemas to achieve specific goals, as well as the ability to plan, prioritize, and manage multiple activities.

The present study examined script generation and multitasking performance in 60 individuals with HIV-1 infection (HIV+) and 26 demographically comparable seronegative healthy adults (HIV-). HIV+ individuals demonstrated worse overall multitasking performance and an elevated number of script generation errors as compared to the HIV- sample. Within the HIV+ sample, script generation errors and multitasking impairments were modestly associated with deficits on standard clinical measures of executive functions, episodic memory, and information processing speed, providing preliminary evidence for convergent validity. More importantly, multivariate prediction models revealed that multitasking, but not script generation, deficits were uniquely predictive of dependence in IADL, independent of depression and global cognitive impairment. Classification accuracy statistics showed that multitasking provided excellent sensitivity (86%) but modest specificity (57%) in predicting IADL declines. Taken together, these data indicate that the assessment of multitasking ability may ultimately provide an important adjunct to traditional neuropsychological testing in the evaluation of everyday functioning in HIV+ individuals. Findings may also inform the development of compensatory strategies to minimize the functional impact of cognitive deficits in persons living with HIV infection.

INTRODUCTION

Neuropsychology of HIV-1 Infection

A convergence of multidisciplinary scientific evidence indicates that HIV-1 infection is associated with neuropathophysiology in frontal-subcortical systems (e.g., Aylward et al., 1993; Glass et al., 1993; Heaton et al., 1995). Although HIV-1 does not productively infect neurons, wide-spread neuronal and glial pathology is nevertheless common, particularly in the basal ganglia and the fronto-striato-thalamo-cortical circuits (e.g., Langford, Everall, & Masliah, 2005). HIV-related structural and functional alterations in cerebral white matter, cortical gray matter, and deep gray matter structures (e.g., basal ganglia) have also been demonstrated via neuroimaging techniques (Jernigan et al., 1993; Stout et al., 1998). Furthermore, the amount of postmortem dendritic simplification, particularly in the frontal cortex and basal ganglia, has been found to be strongly related to the degree of *in vivo* HIV-associated neurocognitive impairment (Cherner et al., 2002; Masliah et al., 1997; Moore et al., 2006).

Approximately 30% to 50% of individuals infected with HIV-1 demonstrate neuropsychological (NP) impairment (Grant et al., 1987; Heaton et al., 1995; Reger, Welsh, Razani, Martin, & Boone, 2002). Commensurate with its prominent frontostriatal neuropathogenesis, the NP sequelae of HIV-1 infection are commonly found in domains that are highly dependent upon these circuits, such as working memory, learning, motor skills, speed of information processing, and executive functioning (e.g., Becker et al., 1995; Durvasula, Miller, Myers, & Wyatt, 2001; Heaton et al., 1995; Martin et al., 2001; Reger et al., 2002). By way of contrast,

accelerated forgetting, intrusion errors, dysnomia, and dyspraxia are less commonly observed in HIV disease. While cognitive decline can occur at any disease stage, it is more prevalent and severe in advanced, symptomatic stages of HIV disease (Heaton et al., 1995; Reger et al., 2002; Scott et al., 2006). In line with this finding, the cognitive impairment seen in HIV infection has been associated with HIV disease markers, such as reduced CD4 cell counts (e.g., Becker et al., 1997) and elevated levels of viral burden in the cerebrospinal fluid (CSF; Ellis et al., 1997, 2002) and plasma (e.g., Marcotte et al., 2003).

Functional Impact of NP Impairment in HIV-1 Infection

Of particular relevance to this study, research to date clearly indicates that a subset of HIV-infected individuals with cognitive impairment also experience related deficits in everyday, “real world” functioning. These declines are not universal and are generally only evident in more complex everyday tasks, known as instrumental activities of daily living (IADL), such as financial management, meal preparation, and medication management. Declines in basic activities of daily living, such as bathing, grooming, and dressing, are typically the result of advance physical symptoms, and a cognitive etiology is only evident in severe HIV-associated dementia. Notably, researchers have consistently demonstrated associations between NP impairment and everyday functioning in HIV-infected individuals even after controlling for medical symptoms. Moreover, even the mildest forms of HIV-associated neurocognitive disorders can have substantial effects on the everyday life of affected individuals. These functional impairments have significant implications for both HIV-infected

individuals and society as a whole, including reducing the available workforce, increasing health-related costs, and potentially spreading drug resistant strains of virus with inadequate medication adherence (Marcotte, Heaton, & Albert, 2005). Given that the neurocognitive deficits associated with HIV are more likely to be subtle, especially in the era of highly active anti-retroviral treatment (HAART), assessing complex IADL functioning is of increasing importance.

A number of studies have shown strong associations between HIV-associated neurocognitive impairment and reports of functional difficulties. The cognitive impairment associated with HIV has been correlated with increased rates of unemployment and complaints of job performance difficulties (Albert et al., 1995; Heaton et al., 1994b, 2004), with deficits in the cognitive domains of memory, set-shifting/cognitive flexibility, and psychomotor speed being associated with unemployment (van Gorp, Baerwald, Ferrando, McElhiney, & Rabkin, 1999). HIV-associated cognitive impairment has also been associated with poor driving ability, a reduction in amount of driving, and increased accident rates in a subset of individuals (Marcotte et al., 1999, 2000, 2004).

Several studies have also demonstrated a strong link between HIV-related cognitive compromise and nonadherence to antiretroviral medications (Lovejoy & Suhr, in press). Specifically, poorer medication adherence in HIV-infected individuals, as measured by self-report and electronic monitoring technology (i.e., MEMS caps), has been associated with NP deficits in memory, psychomotor processing, and particularly executive dysfunction (Ettenhofer et al., 2009; Hinkin et al., 2002, 2004; Woods et al., 2009). These findings have tremendous clinical implications because

suboptimal adherence (i.e., below 90%-95% of doses taken) decreases the drug concentrations, increases the risk of developing drug resistance, lowers the likelihood of viral suppression, and increases the risk for progression to AIDS (Bangsberg et al., 2001; Chesney et al., 2000). Moreover, deviations from the prescribed dosing instructions may lead to development of a drug-resistant strain of the virus (Wensing et al., 2005; Hinkin et al., 2002).

Although neuropsychological tests have consistently been associated with interference in everyday functioning, they have, at best, limited face validity as measures of real world functioning (Marcotte, Heaton, & Albert, 2005). In addition, most NP measures lack thorough investigations into their ecological validity, and NP test scores alone are unlikely to account for a large amount of variance in everyday functioning (Chaytor & Schmitter-Edgecombe, 2003; Sbordone, 1997). Thus, researchers have recently begun to develop objective, functional tests that more accurately mimic the real world environment (e.g., standardized tests of medication management; Albert et al., 1999) while still remaining sensitive to disease related changes in cognitive abilities.

HIV-associated cognitive deficits have been associated with impairments in such laboratory-based functional measures, which have in turn been related to several aspects of real world outcomes. Albert et al. (1999) found that HIV-infected individuals with impairments in memory, psychomotor speed, and executive functions evidenced performance decrements on a structured task of medication management ability in which participants were required to follow label information and correctly pour different medications. In a series of studies, Heaton and colleagues (1996, 2004)

have shown associations between HIV-related cognitive impairment and poor performance on standardized measures of vocational performance, such as work samples. Notably, HIV-infected individuals without NP impairment in these studies performed similarly to HIV seronegative participants, suggesting these functional declines, as mentioned above, are not universal. In the latter study (Heaton et al., 2004), the relationship between NP impairment and a comprehensive functional battery was also investigated, including standardized instruments designed to assess grocery shopping, cooking, financial management, and medication management. Cognitively impaired HIV+ participants performed significantly worse on all functional measures when compared to non-impaired HIV+ participants. Impairments in executive functioning, learning, verbal abilities, and attention/working memory were most predictive of performance on these functional measures.

While direct functional tests specifically tailored for HIV-infected individuals are reasonably sensitive to IADL impairments associated with HIV infection (e.g., Heaton et al., 2004), questions remain regarding the extent to which these tests' highly structured nature fully captures the various cognitive functions involved in successful functional execution, including the environmental demands and complexities of daily life. It has long been noted that IADL functioning can still be impaired despite normal functioning in the laboratory, even on objective measures of functional ability (Burgess, Alderman, Evans, Emslie, & Wilson, 1998; McKibbin, Brekke, Sires, Jeste, & Patterson, 2004). For example, 36% of HIV-infected individuals in the study by Heaton and colleagues (2004) performed adequately on such structured functional tasks in the laboratory, but nevertheless reported being dependent in IADL. This

discrepancy may be due to, among other possibilities (e.g., psychiatric factors), impairment in the ability to maintain a course of action in the face of competing alternatives in daily life situations (i.e., multitasking) or an inability to generate complex, sequential action plans (i.e., script generation), tasks that are not measured by standard NP and functional tests.

To this end, Burgess (2000) has proposed that individuals with frontostriatal pathology, such as those with HIV, are at increased risk for IADL dependence in part due to executive dysregulation, including difficulties generating, organizing, planning, and executing action plans. Despite their potential importance, no prospective studies have examined the effects of HIV disease on these executive components of everyday action. Accordingly, the aim of the present study is to gather data regarding the effects of HIV-1 infection on multitasking and the generation and evaluation of script-based action schemas. As such, novel, conceptually-driven constructs that consider these previously unmeasured cognitive processes and factor in the contributions of prefrontostriatal systems may help elucidate the functional implications of HIV-associated neurobehavioral deficits and their mechanisms (Burgess et al., 2006; Woods & Grant, 2005). Ultimately, such information may even enhance the development of appropriate compensatory strategies to minimize the impact of neuropsychological deficits on the daily lives of persons living with HIV infection.

Script Generation

Shallice (1982) has proposed that the successful performance of IADLs depends on one's ability to generate, sequence, and implement "scripts" of daily

responsibilities, which are complex, sequential action plans derived from mental representations of activities. These sequential action plans are enacted when a high-level goal passes activation to its individual component actions and sub-goals. As such, scripts provide templates for a wide range of routine individual and social activities and are considered integral to goal-directed behavior. In Norman and Shallice's (1986) model of schema activation, two qualitatively distinct processes determine which action sequences (which they refer to as "schemas") will be activated: the Contention Scheduling (CS) system, an automatic process involved in more routine action sequence selection, and the Supervisory Attentional System (SAS), which modulates operations when situations are non-routine. Thus, in novel, infrequent, or decision-making situations, the SAS system modulates, potentially via fronto-striato-thalamo-cortical loops, the lower-level CS system as it selects between a series of action sequences (Shallice, 1988). Similarly, Grafman and colleagues (1991, 1995) have proposed that the structure of a script is similar to lexical or semantic knowledge representations, in which individual items are linked by associative rules to form a network. Grafman's model diverges from Norman and Schallice's, however, in storing these knowledge representations in the prefrontal cortex as basic conceptual units of 'managerial knowledge'. Thus, damage to frontal systems would lead to a degradation in the representation of scripts in Grafman's model, while in the Norman and Shallice model, the impairment observed would be attributable to deficient organization and processing of sequential information. In both models, however, script generation and sequencing are the logical first step in the conceptual formation of an

action plan, and impairment in either could lead to deficient ability in the actual execution of action sequences.

Implicit in these models of script generation is the significant contribution of executive functions; thus, script generation and sequencing are widely theorized to depend on the prefrontal cortex and basal ganglia (e.g., Shallice, 1988). The prefrontal cortex is involved in the encoding and retrieval of action knowledge, such as the conditional and temporal relations between component actions (Sirigu et al., 1995). A great deal of empirical evidence suggests that script generation depends largely on the integrity of frontostriatal regions and is therefore highly sensitive to frontal systems dysfunction. A number of studies have shown impairment on script generation tasks in patients with prefrontal lesions (e.g., Godbout, Cloutier, Bouchard, Braun, & Gagnon, 2004; Sirigu et al., 1995). Findings have consistently shown that individuals with prefrontal lesions display adequate performance in generating the relevant actions required for a script, but are deficient in sequencing and prioritizing script events and often have trouble with boundaries of scripts (i.e., ending scripts before or after their designated endpoint). Neuroimaging techniques with normal individuals further illustrate the crucial role of the prefrontal cortex, showing activation during the performance of sequential ordering tasks in the prefrontal cortex, particularly in right dorsolateral and medial regions (Partiot, Grafman, Sadato, Wachs, & Hallett, 1995; Partiot, Grafman, Sadato, Flitman, & Wild, 1996), and showing bilateral middle and inferior frontal involvement on tasks of script evaluation and sequencing (Crozier et al., 1999; Knutson, Wood, & Grafman, 2004). Lesion studies of patients with prefrontal damage have also shown impairments in the cognitive skills required for

planning and steering a course of action (e.g., Chevignard et al., 2000; Eslinger and Damasio, 1985), skills conceptually related to script generation. In this regard, studies have shown that impairment in the ability to generate a course of action may influence one's ability to carry out the intended sequence towards a goal (e.g., Zalla, Plaisart, Pillon, Grafman, & Sirigu, 2001).

The involvement of the basal ganglia is theorized to be integral in script generation for manipulating action knowledge and building up action sequences (Shallice, 1988). Grafman (2002) has proposed that the basal ganglia process the visuomotor 'commands' originating from the prefrontal cortex and integrate them to form a coherent set of actions relevant to a particular situation. Commensurate with these theories, patients with Parkinson's disease (PD), a disorder affecting regions of the basal ganglia, evidence decrements in organizing and prioritizing script elements, as well as difficulties inhibiting irrelevant intrusions, but perform adequately in generating the required elements of a script (Godbout & Doyon, 2000; Zalla et al., 1998, 2000). These deficits are important because organizing and prioritizing script elements in relation to one's overall goal is critical to planning behavior, as successful adaptive behavior requires the capability of modifying the ongoing plan, as well as assigning appropriate priority to each plan element.

Given HIV's predilection for the frontal cortex and basal ganglia, together with the results from studies noted above, it is surprising that script generation has not been previously examined in HIV infection, especially when one considers that distinct subregions of the basal ganglia and specific prefrontal areas, both of which are implicated in script generation, are also connected by parallel striato-thalamo-cortical

loops (e.g., Alexander, DeLong, & Strick, 1986), which may be damaged by HIV. Although no studies have specifically examined script generation in HIV infection, Woods et al. (2005) reported deficient performance on a test of action (verb) fluency in an HIV-infected sample, which they theorized reflected inefficiencies in the process of searching for, accessing, and retrieving mental representations of actions. Woods and colleagues (2006) also found that action fluency possessed excellent discriminative validity in predicting IADL dependence and independence within an HIV+ group. In addition, their HIV+ IADL dependent sample displayed difficulties inhibiting the generation of irrelevant actions. If one presumes that deficient generation of verbs and difficulty avoiding irrelevant actions might interfere with effective generation of script sequences, then it is reasonable to hypothesize that HIV infection might also lead to difficulties in script generation, which may lead to errors in the actual functional execution of scripts. Therefore, one might expect a disruption of the generation and organization of script action sequences in HIV, as well as related dysfunction in IADL.

Multitasking

Everyday situations that require the organization, structuring, and prioritizing of goal-related behavior are also prone to disruption from cognitive impairment. Burgess (2000) termed these situations “multitasking,” and noted that they make demands upon different cognitive processes than those assessed with traditional executive functioning tests (e.g., the Wisconsin Card Sorting Test [WCST]). This discrepancy is reflected in the fact that some patients who show impairments in such

situations in everyday life perform normally on traditional tests of executive functioning (e.g., Shallice & Burgess, 1991). While most people experience occasional lapses in their ability to multitask, neurologically healthy individuals appear to be able to successfully organize and structure goal related behaviors in everyday life. For example, cooking alone involves increased cognitive demands on organization, structuring, and prioritizing: deciding upon a recipe, consideration of ingredient amounts, execution of effective cooking techniques, timing of preparation and cooking, dealing with any interruptions, and monitoring and evaluation at each cooking stage. Yet most neurologically normal individuals can carry this act out with some success. On the other hand, given the nature of everyday task demands such as cooking, it is clear that a deficit in the ability to multitask can be a profound problem that can potentially threaten independent living.

Similar to its importance in script generation, the prefrontal cortex is thought to be critical in multitasking ability (e.g., Dreher, Koechlin, Tierney, & Grafman, 2008). In multitasking, however, one is required not only to plan and organize based on temporal and conditional associations between actions, but also to maintain this conditional and temporal information in working memory, along with other information such as the immediate environmental stimuli, goals, and sub-goals. In fact, a number of deficits could potentially lead to impairment in multitasking ability. Planning deficits that impact an individual's ability to organize appropriate and/or sequential action plans could complicate initial encoding, and ultimately impede successful execution. Since successful multitasking requires the ability to interrupt an ongoing activity and switch to a new one, deficits in set-shifting could profoundly

affect whether or not a course of action is continued or interrupted. Finally, a failure to monitor one's output could result in errors of repetition, intrusion, or omission.

Shallice & Burgess (1991) developed the Six Elements Test (SET) as a measure of multitasking, creating similar demands as everyday life situations and accessing executive processes commonly used in such situations but poorly assessed in traditional neuropsychological evaluations. This task has not been previously examined in HIV infection, but evidence from other similar clinical populations suggests a critical role for prefrontal systems in multitasking. A subset of patients with frontal lobe lesions have shown profound deficits on the SET and similar measures that seem to reflect many of their difficulties in daily life. Such multitasking deficits have been shown to occur despite minimal impairment on a range of traditional executive functioning tasks, including those of executive abilities previously shown to be sensitive to frontal lobe dysfunction, such as verbal fluency or performance on the WCST (e.g., Alderman, Burgess, Knight, & Henman, 2003; Burgess, 2000; Gouveia, Brucki, Malheiros, & Bueno, 2007). Similar results have also been reported in patients with selective vascular lesions of the basal ganglia (Thoma, Koch, Heyder, Schwarz, & Daum, 2008) and individuals with traumatic brain injuries (Levine, Stuss, Milberg, Alexander, Schwartz, & McDonald, 1998). Patients with prefrontal lesions who do show deficits on the SET characteristically display an elevated number of rule-breaks and/or a low number of tasks attempted. These errors are within the context of a normal work rate, suggesting that these individuals either get "stuck in set," plan inefficiently, or both. Furthermore, deficits on the SET have been documented in

depressed (Channon & Green, 1999) and schizophrenic (Evans, Chua, McKenna, & Wilson, 1997) patients showing evidence of executive dysfunction.

The ecological validity of the SET is supported by a study examining the association between caregiver or relative responses (for a mixed etiology neurological sample) on the Dysexecutive Questionnaire (DEX), reflecting twenty of the most common complaints of dysexecutive symptoms, and performance on a battery of neuropsychological tests. A factor analysis revealed that, of all the tests given, only the SET was related to the DEX “intentionality” factor, which involved everyday deficits in planning and decision-making that would be expected to interfere with multitasking ability (Burgess, Alderman, Evans, Emslie, & Wilson, 1998). These results provide evidence that performance on the SET is associated with everyday functional difficulties, and that the difficulties that some patients experience in everyday life may not be captured by traditional executive functioning tasks.

The SET and its shortened versions (i.e., Greenwich Test), however, have their shortcomings. They are comprised of tasks that may have little functional relevance for everyday functioning in neurological populations, such as dictation, bead counting, and object naming. Moreover, the rules of these tests are set up such that participants are not likely to complete any of the subtasks unless they get ‘stuck in set’ and do not switch to any other subtasks. Thus, the optimal performance on the SET entails spending approximately one-sixth of the allotted time on each subtask. While this assesses one’s ability to plan his or her time accordingly and carry out one’s formulated plan, it does not assess an individual’s ability to work efficiently within the time constraints given for each subtask or evaluate the ability to set priorities. In

addition, it does not present the opportunity truly multitask between different projects (i.e., simultaneously attend to two separate tasks). The multitasking test developed for this proposal improves upon these previous versions by employing tasks shown to be relevant to the everyday functioning of individuals with HIV (e.g., Heaton et al., 2004), while also allowing more participant-initiated task switching, prioritization, and time management. For example, one's best approach to the proposed multitasking test is to take advantage of the "heating time" in the cooking tasks to do other subtask portions, and to make phone calls whenever a short amount of time is available to do so.

In summary, the prefrontal cortex, basal ganglia, and circuits connecting the two brain regions are integral for the organization of everyday actions, and damage to any of these brain structures could cause deficits in either multitasking or the generation of script-based action schemas, potentially causing real world deficits that are not captured by common laboratory measures, and thus perhaps not typically appreciated by clinicians or researchers. Therefore, the aim of the present study is to assess these constructs, their relationships with other neurocognitive constructs, and their relationships with 'real world' functional implications in HIV disease.

SPECIFIC AIMS

Aim 1: To clarify the nature and extent of the effects of HIV-1 infection on the executive components of everyday action (i.e., script generation and multitasking), in an effort to further characterize the pattern of cognitive deficits observed in HIV-infected individuals.

Rationale

Given the evidence suggesting the sensitivity of multitasking and script generation tasks to frontal systems dysfunction, the primary aim of the present study is to assess these constructs in HIV-1 infection, a disease in which cognitive impairment is commonly attributed to prefrontal-striatal circuit neuropathophysiology.

Hypotheses

HIV-infected individuals will show poorer performance on novel experimental measures of script generation and multitasking relative to demographically comparable HIV seronegative comparison participants (see Table 1 for a comprehensive outline of the hypothesized effects). Given previous research in patients with prefrontal lesions and Parkinson's disease, disorders that have a similar neurocognitive profile to HIV, it is anticipated that: 1) an analysis of script generation performance by HIV-infected persons will reveal increased sequencing errors and intrusion errors (in contrast, repetitions and boundary errors are not expected); and 2) HIV-infected persons will show a lower overall summary score, increased errors, and

fewer multitasks attempts on the multitasking test relative to healthy comparison participants, reflecting inefficiencies in the ability to multitask.

Aim 2: To investigate the association between the executive components of everyday action and neuropsychological functioning in persons with HIV infection.

Rationale

The second aim of the present study is to systematically explore the construct validity of script generation and multitasking. Analyses will be performed separately in HIV-infected individuals and neurologically healthy controls, per the methodological recommendations of Delis et al. (2003).

Hypotheses

Worse performance on measures of script generation and multitasking will be associated with worse performance on traditional measures of executive functioning, memory, and processing speed in HIV infection and seronegative comparison subjects.

Aim 3: To investigate the association between the executive components of everyday action and instrumental activities of daily living (IADLs).

Rationale

It has been demonstrated that HIV-associated neurocognitive impairment is associated with declines in instrumental activities of daily living (IADLs), including failures to adhere to complex medication regimens. However, while it is often theorized that effective functioning in daily life requires the efficient generation, organization, planning, and execution of action plans, this association has not been empirically examined in HIV infection. The third aim of the present study is therefore to examine how well performance on these tasks predicts self-reported dependence in activities of daily living in HIV-infected individuals. Given the critical importance of successful medication adherence in HIV-infection, an exploratory analysis will also examine the relationship between these constructs and self-reported medication adherence.

Hypotheses

In HIV-infected participants, worse performance on both everyday action tests will be associated with increased self-reported IADL dependence. In addition, measures of script generation and multitasking are expected to be more sensitive to IADL impairment than traditional functional measures.

METHODS

Participants

Using a cross-sectional, static-group comparison design (Campbell & Stanley, 1963), the proposed study examined 60 persons with HIV-1 infection (HIV+), as determined by enzyme linked immunosorbent assays (ELISA) and a Western Blot confirmatory test, and a comparison sample of 26 healthy, HIV seronegative volunteers (HIV-). Selected participants were among those already being evaluated through standard protocols for the various longitudinal studies conducted at the HIV Neurobehavioral Research Center (HNRC), an NIMH-funded center for the study of the prevalence, features, course, and pathogenesis of HIV involvement in the central nervous system (CNS).

Individuals were excluded who: (1) were not fluent in English; (2) reported histories of major neuromedical confounds, including active CNS opportunistic infections, seizure disorders, head injuries with loss of consciousness greater than 15 minutes, intracranial neoplasms, multiple sclerosis, and cerebrovascular accidents (CVAs); (3) had histories of severe psychiatric disorders, including psychosis; (4) met *DSM-IV* criteria for any substance-related disorder (e.g., methamphetamine abuse or dependence) within one year of evaluation (as diagnosed by a structured clinical diagnostic interview); and/or (5) tested positive for recent illicit substance use (i.e., non-prescribed stimulants, opiates, benzodiazepines, barbiturates, sedatives, etc.) as measured by urine toxicology or tested positive for alcohol on a breathalyzer test, both of which were conducted at the time of evaluation.

Procedure

After providing written formal consent, each participant was administered a comprehensive neuropsychological assessment in the context of a larger full-day evaluation that also included a neuromedical examination and a brief psychiatric evaluation. Data were utilized from neuromedical examinations (e.g., CDC staging, CD4 lymphocyte counts, antiretroviral information, and plasma and CSF viral loads, when available), NP testing (i.e., NP test results, neurobehavioral screening interview, and self-report questionnaires regarding cognitive complaints and activities of daily living), and psychiatric evaluations (e.g., Beck Depression Inventory, structured clinical diagnoses of mood and substance use disorders) that were already conducted as part of an individual's participation in other studies. Thus, basic characterization of the study sample was provided as part of the ongoing HNRC studies. Table 2 provides a summary of HIV disease information for the HIV+ study sample.

After completing the standard HNRC NP test battery and questionnaires (see below), all participants in the study were administered the two experimental tests of interest: script generation and multitasking. These two measures will be discussed in further detail below. Of note, both tasks offered unstructured situations with clear scoring criteria but only a few rules, thus potentially more accurately mirroring the demands that individuals experience in everyday life. The lead author and a trained psychometrist administered and scored the test battery in accordance with standardized procedures. The examiner was blinded to the participant's HIV status. Each battery was double-scored to ensure accuracy, and any discrepancy in scoring was resolved with the assistance of a third rater. The battery was predominantly

administered at the end of a participant's day of testing, although some participants (31%) requested to return on another day to complete this battery. All additional assessments were completed within 1 week of a participant's initial visit, and participants were again administered a breathalyzer and urine toxicology screen on the day of testing. There were no significant differences in the proportion of individuals in the HIV+ (63%) and HIV- (73%) groups who returned for testing on a separate day.

Neuropsychological Battery & Questionnaires

The NP battery was constructed to provide a relatively brief, but nonetheless robust assessment of the cognitive domains that are affected by HIV-spectrum diseases. Thus, it included tests that are purported to be sensitive to the frontal-subcortical deficits associated with HIV infection and utilized the most comprehensive normative data available, correcting for age, sex, education, and ethnicity differences when indicated and possible. Specifically, the following tests (within seven cognitive domains) overlapped between a majority of the HNRC batteries, and therefore the data for each participant on these tests were used for the purpose of this study: (1) verbal fluency (Controlled Oral Word Association Test [COWAT-FAS; Benton, Hamsher, & Sivan, 1994; Gladsjo et al., 1999], action fluency [Piatt et al., 1999], and animal fluency [Gladsjo et al., 1999]); (2) speed of information processing (WAIS-III Digit Symbol and Symbol Search subtests [Heaton, Taylor, & Manly, 2002; Psychological Corporation, 1997] and Trail Making Test Part A [TMT, Reitan, 1979; Heaton, Grant & Matthews, 1991]); (3) learning (Hopkins Verbal Learning Test – Revised [HVLTR; Benedict, Schretlen, Groninger, & Brandt, 1998] Total Trial 1-3 Recall and Brief

Visuospatial Memory Test – Revised [BVMT-R; Benedict, 1997] Total Trial 1-3 Recall); (4) memory (HVLt-R Delayed Recall, BVMT-R Delayed Recall); (5) executive functions (Wisconsin Card Sorting Test [WCST 64-item version; Kongs, Thompson, Iverson, & Heaton, 2000] perseverative responses, Halstead Category Test [Heaton et al., 1991; Reitan & Wolfson, 1993], and TMT Part B [Reitan, 1979; Heaton et al., 1991]); (6) attention and working memory (Paced Auditory Serial Addition Test [PASAT; Diehr et al., 2003; Gronwall, 1977; Gronwall & Sampson, 1974]); (7) motor (Grooved Pegboard Test [Heaton et al., 1991; Kløve, 1963]) dominant and nondominant hand performances). Participants also received the Tower of London-Drexel Version (Culbertson & Zillmer, 1999), a measure of planning and problem solving, in order to examine the association of this measure with the multitasking test. The Wide Range Achievement Test-version 3 (WRAT-3; Wilkinson, 1993) and -version 4 (WRAT-4; Wilkinson & Robertson, 2006) Reading subtests were also administered as an estimate of premorbid verbal intellectual functioning. 30 participants received the WRAT-3 as part of their neuropsychological assessment, while 56 participants received the WRAT-4, although there was not a significant difference in the proportion of individuals who received each measure in the HIV+ and HIV- groups ($p > .10$). All NP tests were administered and scored by trained psychometrists in accordance with the procedures outlined within their respective test manuals.

Using the best available published normative data, raw scores for each test were converted to demographically corrected T-scores. Clinical ratings of NP status were performed for all participants according to the guidelines developed by Heaton

and colleagues (1994a) and operationalized in Woods et al. (2004). Considered the most sensitive and accurate approach for determining NP impairment, clinical ratings have been shown to be highly reliable in a variety of systemic and neurological conditions, including HIV (Heaton et al., 1995). Ratings were conducted by clinical neuropsychologists who had undergone extensive training in using the clinical rating system, and all raters were blinded to the participant's HIV serostatus. The clinical ratings system has demonstrated excellent inter-rater reliability $K = 0.84$ (Heaton et al., 1994a; Woods et al., 2004). Clinical ratings were assigned using a scale ranging from one (*above average*) to nine (*severely impaired*), which is based in large part on the T-score descriptive ranges proposed by Heaton, Grant, and Matthews (1991). Ratings were assigned for each of the seven cognitive domains and for global NP status, with more importance afforded to impaired test scores. A rating of five was used to indicate definite mild cognitive impairment (Heaton et al., 1995). Participants had to exhibit impairment in two or more domains in order to be classified as having global NP impairment (see Woods et al., 2004 for further details). This rating system offers the advantage of weighting patterns of mild deficits while minimizing the impact of superior scores on a global estimate of functioning. In addition, it allows the rater to adjust for performances that may be attributable to factors other than acquired brain dysfunction (e.g., cultural disadvantage and developmental disabilities).

In addition to the clinical ratings, an objective summary score based on the comprehensive NP battery was used to indicate overall NP impairment. This automated, actuarial approach calculates a Global Deficit Score (GDS), which weights the NP data in a similar manner to clinical ratings by considering both the number and

the severity of deficits in an individual's performance throughout the test battery, giving relatively less weight to performances within and above normal limits (Heaton et al., 1994, 1995). The GDS is computed by converting demographically corrected T-scores on individual NP measures to deficit scores ranging from 0 (*no impairment*) to 5 (*severe impairment*). The deficit scores for each test are then averaged to create the GDS measure. The GDS has demonstrated strong diagnostic power in detecting the presence of HIV-related NP impairment (Carey et al., 2004). The GDS has also previously been associated with biological markers of HIV-associated immunosuppression, including CD4 count and CSF viral load (Gonzalez et al., 2003).

As part of the NP evaluation, participants also completed self-report questionnaires to assess their mood state and their degree of independence in completing everyday activities. Each participant was administered the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) and the Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1981) in order to assess the degree of mood symptoms and acute affective distress, respectively, within the sample. The BDI-II is a 21-item questionnaire assessing various aspects of depression, including mood, vegetative, and somatic symptomatology. Fifteen of the current study participants who were enrolled in the California NeuroAIDS Tissue Network (CNTN) study received the first edition of the BDI (Beck, 1987), as this version was administered in their study protocol. The POMS is a 65-item, self-report measure of current mood states on which participants rate various adjectives (e.g., "unhappy") on a five-point Likert-type scale ranging from 0 (*not at all*) to 4 (*extremely*). The POMS

includes items relating to six subscales (i.e., Tension, Depression, Anger, Vigor, Confusion, and Fatigue) and a Total Mood score. Higher scores on both the BDI and POMS indicate greater affective distress.

In order to assess self-reported (i.e., manifest) everyday functioning outside of the laboratory, participants were asked to complete questionnaires regarding their current level of everyday functioning. The Activities of Daily Living skills questionnaire is a modified version of the Lawton and Brody Activities of Daily Living measure (Lawton & Brody, 1969), which assesses a participant's degree of independence in performing a variety of tasks involved in independent living, ranging from self-hygiene, grocery shopping, and performing housework to managing finances and adhering to medications. For each activity, the participant separately rates his/her current level of functioning and highest previous level of functioning. In addition, participants completed questionnaires assessing the frequency that they performed the activities assessed in the measure of multitasking (see Appendices G and H for more details).

The operationalization of IADL dependence for this study was informed by recent recommendations for determining functional impairment in diagnosing HIV-associated neurocognitive disorders (Antinori et al., 2007) and is generally consistent with guidelines outlined by the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., American Psychiatric Association, 1994). IADLs were defined as the subset of questionnaire items involving areas of functioning that were unlikely to reflect physical limitations due to medical complications. As such, basic ADLs (e.g., bathing, dressing) were not considered in determination of IADL dependence; similarly, the

child care and employment items were not considered as these items might be confounded by physical problems and medicolegal factors (Heaton et al., 2004). Individuals were classified as *IADL-dependent* if their self-rated current level of functioning was reported to be lower than their highest level of functioning for at least two of the following items (see Heaton et al., 2004, and Woods et al., 2006): (1) housekeeping; (2) finances; (3) groceries; (4) cooking; (5) transportation; (6) telephone use; (7) home repairs; (8) shopping; (9) laundry; and (10) medication management. Individuals with IADL declines that were attributed solely to physical limitations (e.g., ambulation disabilities) were not classified as IADL-dependent.

In addition, participants completed the ACTG Interview of Antiretroviral Medication Use (Chesney et al., 2000) or the Neuromedical Medications Adherence questionnaire, both assessing antiretroviral medication adherence, in order to examine the associations between the proposed tasks and self-reported medication adherence. In line with prior recommendations (e.g., Chesney et al., 2000), participants were classified as *non-adherent* if they reported taking less than 95% of prescribed medication doses.

Script Generation Task

Participants were administered a script generation task based on tasks and administration procedures previously described by Godbout & Doyon (2000), Sirigu et al. (1995, 1996), and Zalla et al. (2000). Briefly, participants were presented with a series of 6 daily activities and asked to generate and organize the necessary steps for completing each task (see Appendix B, D, and E for more specifics of this task). Five

scripts were chosen from a normative study of frequency in engaging in daily scripts by Rosen and colleagues (2003), including: (1) going shopping for a meal; (2) attending a dentist's appointment; (3) preparing to leave the house in the morning; (4) getting into a car accident; and (5) doing the laundry. An additional script, 'getting a new medication prescription filled,' was created for this study in order to provide an action sequence relevant to the daily activities of HIV-infected individuals. The remaining five scripts were chosen from the normative set in order to cover a range of novelty and complexity while also potentially having ecological relevance for clinical populations.

The examiner defined each action sequence with the overall purpose or goal and the script's starting point and ending point. Instructions were given verbally and then displayed on a cue card that remained visible throughout the task (in order to minimize demands on retrospective memory). For example, for *Preparing to leave the house in the morning*, the examiner stated: "You need to get up in the morning to go to work or attend an appointment. Tell me, in order, all of the things you need to do, starting when you go to sleep the night before and stopping when you leave the house." The examiner then offered an example to ensure that participants understood the task requirements. This example proceeded as: "For example, if I asked you to tell me all of the things you would need to do if you decided to go out to dinner starting when you decide to go out to dinner and stopping when you leave the restaurant, you could say 'Decide on a restaurant, get dressed, travel to the restaurant, give your name to the host, be seated, look at the menu, and so on.'"

After each script instruction, the examiner recorded all of the participant's responses in the order specified. Note that each sequence of responses was timed (to assess verbal output rate) but had no time limit. The examiner then read the participant's responses out loud and confirmed with the participant that the responses were correct and the sequences were in the desired order. When generated events were similar, such as "take a shower" and "take a bath," these were classified as belonging to the same action category (Sirigu et al., 1995). The scoring and administration of this task is described in further detail in Appendix B and D.

Performance on Script Generation was measured by the following variables: (1) Sequencing Errors (physically impossible or inconsistent); (2) Repetitions; (3) Intrusions (irrelevant to the script); (4) Total Errors (sum of 1, 2, and 3); and (5) Script Boundary Errors (e.g., participant ends a script before or extends a script beyond the prescribed endpoint) (Godbout & Doyon, 1995, 2000). In addition, the total number of script elements that participants did not generate from among the top five most frequently generated actions for each script (i.e., from a normative sample; Rosen et al., 2003) were summed to give a measure of script elements omitted. Previous research has shown that approximately five to seven actions per script are consistently generated by 80% of participants (Rosen et al., 2003; J. Grafman, personal communication, November 28, 2006), and the present results were generally consistent with this estimate. The total number of actions generated and mean generation time (total time/number of actions) were also calculated to be used as potential confounding variables (i.e., to determine whether findings might be due to reduced fluency). In addition, participants were read a list of 10 actions for each

sequence – five that belonged in the sequence and five that did not belong – and asked to respond “Yes” or “No” to whether each action belongs in a sequence (see Appendix E). These items provided a measure of recognition for the semantic content of scripts, which has been shown to be dissociable from script generation and sequencing and is perhaps more dependent on the integrity of temporal lobe structures (Cosentino, Chute, Libon, Moore, & Grossman, 2006; Partiot et al., 1996). The five actions that belong in the sequence were drawn from the ten most frequently generated actions in each sequence from the normative data of Rosen et al. (2003). Participants were also asked to rate the frequency that they perform the given tasks on a scale from 1 (*never*) to 5 (*very frequently*) to ensure that groups did not differ in everyday familiarity with the scripts.

Multitasking Test

A modified version of the Six Elements Test (SET), developed by Shallice and Burgess (1991), was used to assess multitasking. The assessment in this study, however, was modified to include tasks that possess more face validity and relevance to the daily functioning of individuals living with HIV-1 (cf. the SET included such tasks as bead separation and dictation, which may have little functional relevance). Participants were given 12 minutes to complete as much of the following four tasks as possible: (1) Cooking (meal preparation); (2) Advanced Finances; (3) Medication Management (pill dispensing); and (4) Telephone Communication. The first three tasks were adapted from Heaton et al. (2004), and their scoring and administration is described in Appendix C and F. The last task is a new functional measure created for

this application based on a test item from the UCSD Performance Based Skills Assessment (UPSA) created by Patterson et al. (2001). In this item, participants were asked to make three phone calls: one to a pharmacy, one to their doctor, and one to a credit card company. They were required to look up the number in a fictional address book, dial the number, and leave a message with the required information.

Points were awarded at each step of each of the four tasks for correct execution. Overall instructions for the test were based on those of the Six Elements Test and Greenwich Test (see Burgess, Veitch, de Lacy Costello, & Shallice, 2000). Participants were told that they would not be able to complete all four tasks in the 12-minute time limit, and indeed, no participants were able to complete all four tasks in this study. In order to minimize demands on retrospective memory for task instructions, the instructions for all parts of the multitasking test remained visible on cue cards for participant referral. Participants were told that they could perform the four tasks in any order and return tasks as often as they wished, but that they must attempt at least part of each of these four tasks. However, the participants were instructed to complete the phone call to the credit card company before beginning the financial task. In addition, they were told that they would run out of pills for one medication in the medication management task, and that when they figured out which medication it was, they would need to call the pharmacy with the information to request a refill. Thus, two automatic switches were built into the test itself, while other switches between tasks were participant initiated. These task switches made it so that participants could not complete any task from beginning to end without switching to another. The examiner assigned the cooking and advanced finances tasks explicit

importance by telling the participant that these tasks were their ultimate goals, and that they would receive more credit for completing them. Thus, if these tasks were completed, participants received bonus points. Of note, the method for getting the most points (i.e., doing the most items) on the multitasking test was to take advantage of the pauses in the cooking task to do other tasks, and to do the financial management task ahead of the medication management task due to its increased point value.

For the multitasking test, participants received one point for each step they completed in each task, creating an Overall Score that assessed how much of the total task they were able to complete (out of 70 possible points). In addition to the Overall Score, a number of qualitative variables and error types were examined, including number of: (1) Repetitions; (2) Intrusions (performing irrelevant task steps); (3) Other Errors (rule violations + other various errors in the execution of the tasks); (4) Total Errors (sum of 1, 2, and 3); (5) Task Switches; (6) Tasks Attempted (out of four); and (7) Simultaneous Task Attempts (i.e., multitasks).

Data Analyses

Inter-rater Reliability

Given the somewhat open-ended nature of the tasks themselves (i.e., guided by the participant with little input from the examiner while carrying them out), and the fact that scoring required some degree of judgment on the part of the examiner, the inter-rater reliability of the two tests was examined prior to recruiting study participants. The two tests of script generation and multitasking were administered by the lead author (JCS) to 10 healthy, HIV-seronegative participants while a trained

psychometrist observed and independently scored the performance of the participants. Note that these 10 pilot participants were not enrolled in the healthy comparison group for the main study sample (i.e., they were not included in other analyses). Intraclass correlations (ICCs) were calculated from the two independently determined scores for each of the indices on the tests in order to ensure adequate reliability ($ICC \geq 0.7$) across examiners. In line with the recommendations of Shrout and Fleiss (1979), two-way random-effects ICCs for consistency were conducted. As shown in Table 3, results of these analyses indicated that the measures showed good-to-excellent inter-rater reliability, with intraclass correlations ranging from 0.84 to 0.99 for individual indices.

Study Analyses

For each of the hypotheses associated with Aim 1, a series of independent samples *t* tests were conducted to examine potential between-group differences on the dependent variables of interest. The unbiased Cohen's *d* statistic was also used to assess the effect sizes of the group comparisons. For those variables that were not normally distributed (Kolmogorov-Smirnov *p*-values < .01), such as the various error variables, Wilcoxon Rank Sums tests were used to conduct between-group comparisons. The study sample ($N = 60$; $n = 26$) provided sufficient statistical power (0.87) to detect medium-to-large ($d = 0.65$) univariate effect sizes for the analyses in Aim 1 with a critical alpha of .05 (Erdfelder, Faul, & Buchner, 1996). One HIV+ participant displayed an abnormally large number of intrusions (13) on script generation and was therefore classified as an outlier (> 3.5 SDs from the mean).

Analytical results did not change appreciably with the exclusion of this participant, and therefore he/she was not excluded from the primary analyses. One HIV- participant was excluded from analyses of Multitasking, as he/she had an invalid administration and represented an outlier (> 3.5 *SDs* from the mean), generating only 5 points and evidencing an abnormally large number of errors.

Chi-square tests were used to assess group differences in the proportion of impaired participants in the HIV+ and HIV- samples, as assessed by the NP battery. Participants were organized into two groups based on their global NP deficit score, as NP-normal ($GDS \leq 0.49$) and NP-impaired ($GDS > 0.49$). Potential discrepancies in multitasking and script generation performance in these two groups were then examined, as previous studies have found significant differences in laboratory measures of everyday functioning between NP impaired and NP normal HIV-infected individuals (e.g., Heaton et al., 2004; Marcotte et al., 1999, 2004). As above, group differences between on the dependent variables of interest were examined with *t* tests and Wilcoxon Rank Sums tests (for nonparametric variables), with Cohen's *d* statistic providing a measure of effect size.

For Aim 2, correlational analyses were conducted to assess the hypothesis that NP measures of memory, speed of information processing, and executive functions would be associated with performance on the novel measures of everyday action organization. *Z* scores were created from individual measures within each neurocognitive domain (based on means and standard deviations from the whole sample), selected on an *a priori* conceptual basis, which were then averaged to generate putative composite measures of cognitive functioning within that domain. A

Pearson product-moment coefficient or Spearman's *rho* (depending on the distribution of the variables being analyzed) were then used to examine the associations between these mean *z* scores and indices from the script generation and multitasking tests in the HIV+ and HIV- groups separately, potentially providing evidence of convergent validity. For memory, the specific measures used were: (a) HVLT-R Delayed Recall; and (b) BVMT-R Delayed Recall. For speed of information processing, the measures used were: (a) WAIS-III Digit Symbol; (b) WAIS-III Symbol Search; and (c) the Trailmaking Test, Part A. For executive functions, the measures used were: (a) WCST-64 perseverative responses; (b) the Trail Making Test, Part B; and (c) the Stroop Color-Word Test (incongruent trial; Golden, 1978). The study sample (HIV+ = 60; HIV- = 26) provided sufficient power (0.96 and 0.70, respectively) to detect medium-to-large ($r = 0.40$) univariate effect sizes for these within-group analyses (Erdfelder, Faul, & Buchner, 1996). In addition, correlational analyses were conducted to examine the associations between measures of action fluency and script generation, given their potential relationship and the previous findings of Woods and colleagues (2005, 2006). Furthermore, correlations were examined between the Tower of London-Drexel Version (Culbertson & Zillmer, 1999), a measure of planning and problem solving, and the measure of multitasking.

To address Aim 3, multiple regression procedures were used to test the hypothesis that, in HIV+ subjects, worse performance on cognitive measures of everyday action organization would be associated with increased self-reported functional dependence, conceptualized as the summed total severity of declines reported in current versus past functioning on all of the IADL items (range = 0 to 29)

(see Woods et al., 2008). Moreover, a series of independent samples *t* tests and Wilcoxon Ranked Sums tests (for nonparametric variables) were used to determine if IADL dependent (binary) subjects demonstrated poorer everyday action performance than IADL independent subjects. Logistic regression analyses were used to examine the influence of performance on these everyday action tests on IADL status (binary), as well as self-reported medication adherence (binary). Regression models also accounted for the influence of depression (i.e., current diagnosis), given that depression has been associated with cognitive complaints in HIV-infected individuals (e.g., Carter, Rourke, Murji, Shore, & Rourke, 2003). In addition, regression models included and thus statistically controlled for demographic characteristics that could influence everyday action performance and represent confounding factors.

For those variables demonstrating significant between-group differences, receiver-operating characteristic (ROC) curves were conducted to assess their predictive validity in classifying participants in the IADL Dependent and Independent groups (see Zweig & Campbell, 1993 for a review). Next, descriptive classification accuracy statistics (i.e., hit rate, sensitivity, specificity, positive and negative predictive values) were generated for these variables using an optimal cutpoint that balanced sensitivity and specificity. These statistics provide an additional means of evaluating the clinical significance of potential research findings and provide a descriptive index of how effectively sample groups are classified on the basis of a particular criterion (e.g., a test score cutoff).

In addition, given the novel nature of these measures, a series of exploratory correlational analyses were conducted to examine the properties of the two measures

of everyday action organization, using either a Pearson product-moment coefficient or Spearman's *rho*, depending on the distribution of the variables being analyzed.

Correlational analyses were conducted separately in the two participant samples to examine the influence of demographic variables (i.e., age and education) on script generation and multitasking performance. In addition, correlational analyses were used to examine the intercorrelations of the script generation and multitasking variables.

Exploratory correlational analyses were also conducted in the HIV+ group to measure the association between performance on the two everyday action tests and HIV-disease variables (e.g., viral load, CD4 counts).

RESULTS

Table 4 provides a summary of demographic and psychiatric information for the total study sample. Individuals with HIV infection did not differ from the healthy comparison group in mean age, years of education, gender, ethnicity, or average WRAT Reading scaled scores (all p values $> .10$). Consistent with prior studies, HIV+ participants were more likely to be unemployed than the HIV- participants. HIV+ participants were similar to the HIV- healthy comparison sample in lifetime diagnoses of substance dependence ($p = .986$) and current major depression diagnoses ($p = .347$), although HIV+ participants had a trend-level finding for higher lifetime major depression diagnoses ($p = .052$) and endorsed greater levels of current affective distress on the POMS ($p = .018$) and BDI/BDI-II ($p = .003$) scales. Significant differences remained on the BDI-II between HIV+ and healthy comparison participants ($p = .02$) even when comparing the cognitive-affective scales (i.e., parceling out items that could be influenced by medical symptoms). On average, however, HIV+ participants reported a mild level of depressive symptoms on the BDI/BDI-II, with 22% reporting depressive symptoms at levels that are generally considered to be clinically significant (i.e., greater than or equal to 15 for BDI and greater than or equal to 17 for BDI-II). Moreover, only 10% of HIV+ participants were given a diagnosis of current depression via structured interview.

Distribution Characteristics of Everyday Action Measures

Table 5 summarizes the range of scores for each of the everyday action organization variables of interest. While the table indicates that many error variables

were somewhat restricted in their ranges, the overall scores and total error scores show considerable variability in performance. All error variables from the measure of script generation were non-normally distributed and positively skewed (i.e., most participants evidenced few errors). Overall score from the multitasking test displayed a normal distribution, while task switches and simultaneous task attempts evidenced non-normality. Error variables from the multitasking test were also non-normal and positively skewed (i.e., most participants evidenced few errors).

Tables 6 and 7 indicate the Spearman's *rho* intercorrelations between the variables of interest from the script generation and multitasking tests, with analyses conducted in the HIV+ and HIV- healthy comparison groups separately. In the HIV- group (shown in Table 6), script generation total errors were positively associated with each script generation error type (all $ps < .05$), but had the largest correlation with intrusions ($p < .001$). Script boundary errors were positively associated with script generation intrusions and total errors ($ps < .05$; note that boundary errors were not included in the total error variable). Multitasking overall score was negatively correlated with script generation repetitions, multitasking other errors, and multitasking total errors (all $ps < .05$) and positively correlated with task switches and simultaneous task attempts ($ps < .01$). Multitasking task switches and simultaneous task attempts were both negatively correlated with script generation repetitions ($ps < .05$). Finally, multitasking total errors were strongly and positively associated with multitasking other errors ($p < .001$), and multitasking task switches were strongly and positively associated with simultaneous task attempts ($p < .001$).

In the HIV+ group (Table 7), similar correlations emerged within each measure, but a slightly different pattern of associations was revealed between the two measures. Script generation total errors were positively associated with script generation repetitions ($p < .05$) and again had the largest correlation with intrusions ($p < .001$). Script boundary errors were positively associated with script generation repetitions ($p < .05$), intrusions ($p < .001$), and total errors ($p < .001$). In contrast to the associations in the HIV- group, multitasking overall score was negatively correlated with script generation intrusions, total errors, and script boundary errors (all $ps < .05$). In addition, overall score on the multitasking measure was negatively correlated with multitasking other errors and multitasking total errors ($ps < .05$) and positively correlated with task switches and simultaneous task attempts ($ps < .01$). All multitasking errors were significantly positively correlated with each other (all $ps < .05$). Also unlike the HIV- group, multitasking other errors and total errors were both positively associated with script boundary errors ($ps < .05$). Multitasking simultaneous task attempts were negatively correlated with script generation intrusions ($p < .05$). Finally, multitasking total errors were strongly associated with multitasking other errors ($p < .001$), and multitasking task switches were strongly associated with simultaneous task attempts ($p < .001$), though to a lesser degree than in the HIV- group.

Demographic and Disease Effects on Everyday Action Measures

In the HIV- group, exploratory analyses examining the influence of demographic variables on script generation and multitasking performance revealed that gender was associated with overall score on the multitasking test, such that women achieved more points on the test [$M = 36.5$, $SD = 8.2$ vs. $M = 30.4$, $SD = 6.5$; $t(23) = 2.2$ $p = .050$]. In addition, education was associated with script boundary errors ($\rho = -.40$, $p = .049$), such that individuals with increasing education performed fewer errors on this task. Analyses within the HIV+ group showed that script generation total errors were positively correlated with age ($\rho = .27$, $p = .039$), such that older individuals demonstrated increased errors. In addition, in the HIV+ group, education was positively associated with overall score on the multitasking test ($r = .26$, $p = .045$) and number of simultaneous task attempts ($\rho = .30$, $p = .018$), indicating better performance and increased multitasks with higher years of education. No HIV disease variables were associated with any variable from the script generation or multitasking measures.

Everyday Action Performance in HIV+ and HIV- Participants

Comprehensive descriptive statistics for Script Generation are displayed in Table 8. As can be seen from this table, the HIV+ and healthy comparison groups did not differ in terms of script elements omitted, repetitions, sequencing errors, or identification of relevant script elements upon recognition. However, the HIV+ group exhibited a significantly greater number of total (overall) errors ($p = .005$), intrusions that were irrelevant to the scripts ($p = .008$), and script boundary errors (i.e., either

ending the script before or after the designated endpoint; $p = .013$). The significant group differences in these errors remained even after reading the script back to participants and asking for changes (all p values $< .05$). Effect sizes for the significant results were generally medium, ranging from 0.55 to 0.73. In terms of self-reported frequency of performing the script activities in everyday life (e.g., “how often do you get a new prescription filled?”), HIV+ participants endorsed getting a prescription filled more frequently (2.8 vs. 3.3, $p = .014$), while the HIV- sample endorsed leaving the house to go to work or attend an appointment more frequently (4.8 vs. 4.4, $p = .044$). However, the mean of both groups corresponded to leaving the house “frequently,” and this rating was not associated with any script generation variable in the HIV+ group (all $ps > .10$).

Comprehensive descriptive statistics for the Multitasking test are presented in Table 9. As shown in this table, HIV+ participants demonstrated a significantly lower overall score ($p = .028$), switched between tasks less frequently ($p = .015$), and had significantly fewer simultaneous task attempts (i.e., multitasks; $p = .028$). Moreover, HIV+ participants exhibited a greater number of total errors ($p = .0003$), which primarily consisted of other errors ($p < .0001$). In contrast, the groups did not differ in the number of intrusions, repetitions, or tasks attempted (p values $> .10$). Effect sizes for the significant results were medium-to-large, ranging from 0.54 to 1.01.

Neuropsychological Status and Everyday Action Results

Among the 60 HIV+ participants, 18 (30%) were classified as NP-impaired and 42 (70%) were classified as NP-normal. The NP-impaired participants did not

significantly differ from the NP-normal HIV+ participants in age, education, gender, ethnicity, HIV disease variables (e.g., CD4 nadir, AIDS diagnosis), or lifetime diagnoses of substance dependence or depression (all p values $> .10$). NP-impaired participants evidenced significantly more sequencing errors [$\chi^2(1) = 5.57, p = .017; d = 0.59$] in script generation when compared to NP-normal participants, although no other script generation variables were significantly different between the NP-impaired and NP-normal HIV+ participants (results not shown).

Table 10 presents the results of Wilcoxon Ranked Sums tests, t tests, and effect sizes for the comparison of the NP-normal and NP-impaired participants on the multitasking test. As the table indicates, NP-impaired participants performed significantly worse on the multitasking overall score ($p = .006$), and evidenced an elevated number of intrusions ($p = .013$), other errors ($p = .015$), and total errors ($p = .005$). In addition, NP-impaired participants were significantly less likely to attempt multitasks ($p = .031$), although they evidenced a similar number of switches between tasks ($p > .10$). Figure 1 presents the mean number of each error type in the HIV-healthy comparison, HIV+ NP-normal, and HIV+ NP-impaired groups in order to illustrate the increasing numbers of errors across these groups. Similarly, Figure 2 presents the overall score on the multitasking test across these groups, demonstrating a stair-step pattern of results.

Relationship between Neuropsychological Measures and Everyday Action Performance

Because of the high degree of collinearity between script generation intrusions and total errors in both groups (see Tables 6 and 7), intrusion errors were not examined in the correlations of script generation and the neurocognitive domain z scores. As shown in Table 11, in the HIV- group, the memory z score was significantly correlated with script generation repetitions ($p = .034$) and boundary errors ($p = .016$). In addition, the executive functions z score was also significantly associated with repetitions ($p = .012$) and script boundary errors ($p = .029$). Within the HIV+ group, as shown in Table 12, the speed of information processing ($p = .049$), memory ($p = .024$), and executive functions ($p = .046$) z scores were all significantly correlated with sequencing errors, while the speed of information processing z score was also significantly correlated with script boundary errors ($p = .017$). Action fluency total was associated with script boundary errors in the HIV+ group only ($p = .034$).

Because of the high degree of collinearity between multitasking other errors and total errors in both groups (see Tables 6 and 7), other errors were excluded from the correlational analyses of the association between multitasking variables and neurocognitive domain z scores. As shown in Table 11, correlational analyses within the HIV- group revealed significant associations between the speed of information processing z score and multitasking task switches ($p = .020$) and simultaneous task attempts ($p = .005$). In addition, in the HIV- group, the executive functions z score was associated with multitasking overall score ($p = .020$), task switches ($p = .006$), and simultaneous task attempts ($p = .006$). Within the HIV+ group, as displayed in Table

12, correlational analyses revealed significant relationships between the speed of information processing z score and multitasking overall score ($p = .005$) and simultaneous task attempts ($p = .004$). Significant correlations were found for the memory z score and multitasking overall score ($p = .001$), intrusions ($p = .031$), total errors ($p = .0004$), and simultaneous task attempts ($p = .004$). Significant relationships were found between the executive functions z score and multitasking intrusions ($p = .032$) and total errors ($p = .008$). Multitasking repetitions and task switches were not associated with any cognitive domain z score. Moreover, no variable from the Tower of London-Drexel was associated with any multitasking variable.

Relationship of Everyday Action Performance to Manifest Everyday Functioning

Based on the responses of the 60 HIV+ participants on the IADL questionnaire, 14 participants (23.3%) met criteria for IADL-dependence, while 46 (76.7%) were deemed IADL-independent. Table 14 displays the demographic, disease, and psychiatric characteristics of the IADL-dependent and IADL-independent groups. As shown in the table, the IADL-dependent and IADL-independent subgroups were generally comparable for demographic characteristics, HIV disease severity, and estimated premorbid verbal IQ (as measured with the WRAT 3/4; all $ps > .10$). As might be expected from previous research (e.g., Heaton et al., 2004), the IADL-dependent group had a significantly higher rate of NP impairment ($p = .039$), endorsed greater affective distress on both the POMS ($p = .003$) and the BDI/BDI-II ($p = .0006$), and had a higher proportion of current major depression diagnoses ($p = .007$), although they did not differ in proportion of individuals with lifetime substance

dependence diagnoses ($p = .449$). The groups also did not differ in their prior “best” level of functioning ($p = .234$).

The variable assessing overall IADL decline severity was not significantly correlated with any script generation variable (all $ps > .10$). However, IADL decline severity was negatively correlated with overall score on the multitasking test at a trend level (Spearman’s $\rho = -0.24$, $p = .063$), such that greater decline in IADL severity was associated with a worse overall score on the Multitasking test. IADL decline severity was also correlated with number of task switches on the multitasking test at a trend level (Spearman’s $\rho = -0.22$, $p = .093$), such that greater IADL decline was associated with a lower number of task switches. When groups were divided by IADL status, analyses revealed that there was a trend for IADL-dependent individuals to display more sequencing errors [$\chi^2(1) = 3.19$, $p = .074$; $d = 0.41$] on the script generation task. However, IADL-dependent individuals were not significantly different from IADL-independent individuals on any other script generation variable (all $ps > .10$). On the multitasking test, IADL-dependent individuals displayed a lower overall score [$t(58) = 2.35$, $p = .022$], but no other variables were significantly different between the groups.

Table 15 presents the results of a logistic regression analysis that attempted to predict IADL status among HIV+ participants from the overall score from the multitasking test while also accounting for the effects of NP impairment (GDS) and depression (current diagnosis). The model was significant [$R^2 = .22$; $\chi^2(3) = 14.29$, $p = .002$], although only depression diagnosis and overall score on the multitasking test provided significant, unique contributions to the prediction model. Of note, there were

no significant differences on the multitasking test in HIV+ individuals with and without a current diagnosis of depression [$t(58) = 0.16, p = .870$], and the BDI/BDI-II Total Score was not significantly correlated with the overall score on the multitasking test ($r = -.039, p = .769$). In order to assure that the multitasking overall score accounted for a significant amount of variance after accounting for the effects of depression, a hierarchical logistic regression was also conducted, with current depression diagnosis in the first step and multitasking overall score in the second step. In the first step, the model with only depression accounted for a significant amount of variance [$R^2 = .09; \chi^2(1) = 5.93, p = .02$], while in the next step, the inclusion of multitasking overall score resulted in a significant increase in the proportion of IADL variance explained [$R^2 = .20, R^2 \text{ change} = .11; \chi^2(2) = 7.18, p = .007$].

As shown in Figure 3, an ROC curve revealed that overall score on the multitasking test was superior to chance in classifying IADL status (area under the curve [AUC] = 0.69, $SE = 0.07, p = .03$). A cut-point of 27 on the multitasking test was chosen as providing a reasonable balance between sensitivity and specificity for predicting IADL status. The overall hit rate for this cutoff was 65%, with excellent sensitivity (i.e., the proportion of IADL-dependent participants with overall scores on multitasking below this cutoff = 86%) and negative predictive power (i.e., the proportion of multitasking overall scores above cutoff produced by the IADL-independent sample = 88%). However, the specificity (i.e., the proportion of IADL-independent participants with multitasking overall scores above this cutoff = 57%) and positive predictive power (i.e., the proportion of multitasking overall scores below

cutoff produced by the IADL-dependent sample = 38%) values were somewhat more modest.

With regards to the prediction of self-reported adherence, 13 individuals were classified as *non-adherent*, 46 individuals were classified as *adherent*, and 1 participant was excluded from further analyses due to missing data. This classification variable was first examined for associations with HIV disease variables in order to provide evidence for the construct validity of this classification. Analyses showed that individuals classified as *adherent* had somewhat higher, although non-significant, current CD4 counts than participants classified as *non-adherent* [544.6 vs. 389.5; $\chi^2(1) = 1.11, p = .140; d = -0.57$]. However, there were no differences in viral load. Thus, the construct validity of this classification may be limited, and analyses may be affected by the small size of the *non-adherent* group. Nonetheless, individuals who were classified as *non-adherent* evidenced a lower overall score of the multitasking test at a trend level [24.5 vs. 29.0; $t(57) = 1.81, p = .076$] compared to *adherent* individuals.

Given the utility of the multitasking overall score in predicting IADL dependence, a *post hoc* exploratory analysis was also conducted to examine the potential differences between unemployed and employed individuals on this multitasking variable. Individuals who were less than one-half time employed were considered as unemployed, and individuals who were more than half-time employed were considered employed (Heaton et al., 1994). Only two participants had a work status that was ambiguous, and one of those participants was classified as employed and one unemployed after further review. Individuals who identified as “retired” were

not included in analyses due to classification ambiguity, leaving 56 HIV+ participants for analysis. Unemployed participants were more likely to be older ($p = .037$), have AIDS ($p = .029$), have a diagnosis of current depression ($p = .046$), and be classified as neuropsychologically impaired, although the latter finding only approached significance ($p = .083$). In addition, unemployed participants had lower overall scores on the multitasking test [$M = 26.2$, $SD = 7.2$ vs. $M = 31.8$, $SD = 9.4$; $t(53) = -2.37$, $p = .02$]. A nominal logistic regression was conducted that attempted to predict employment status from the overall score from the multitasking test while also accounting for the effects of depression (current diagnosis), AIDS status, and age. The model was significant [$R^2 = .28$; $\chi^2(4) = 18.42$, $p = .001$], with current depression diagnosis ($p = .006$), overall score on the multitasking test ($p = .019$), and AIDS status ($p = .015$) each providing significant, unique contributions to the prediction model.

DISCUSSION

This study aimed to assess the constructs of multitasking and script generation, their relationships with other neurocognitive constructs, and their relationships with ‘real world’ functional implications in HIV disease. It is the first to examine these constructs in HIV disease and one of only a handful that have examined the relationship of these constructs to neuropsychological impairment and everyday functioning outcomes in neurological or neuromedical disorders.

Psychometric Properties of the Experimental Tests

Preliminary analyses on a pilot sample of healthy, neurologically intact participants indicated that the variables within the script generation and multitasking measures possessed good to excellent inter-rater reliability. In exploratory analyses within the HIV- group, the measures of multitasking and script generation showed few correlations with demographic variables. However, our HIV- sample was quite small and could have been underpowered to detect small-to-medium effect sizes. Nonetheless, gender may be a significant factor to consider in future analyses of multitasking ability, as women tended to achieve more points on this measure of multitasking in the healthy comparison group. The possible reasons for this finding are unclear, as no previous studies have examined the specific effects of gender on multitasking, and few studies of sex differences in similar constructs (e.g., divided attention, executive functions) have yielded unequivocal results. Although highly speculative, functional imaging studies have shown that men tend to rely more on focused neural networks during many cognitive tasks while women rely on more

widely distributed networks, which some authors have interpreted as suggesting a higher use of wide-ranging executive control processes in women (e.g., Boghi et al., 2006; Gur et al., 2000). Such a cognitive processing style might prove beneficial for multitasking abilities, but this possibility awaits further study.

The fact that performance on the multitasking test was not associated with more demographic variables was somewhat surprising given the strong associations often found between demographic factors and traditional neuropsychological tests (e.g., age, education; Heaton et al., 2004). However, the relationship between demographic variables and functional performance measures is less clear from the literature, and it is possible that these relationships are somewhat weaker than those with NP tests. To this end, Heaton and colleagues (2004) found minimal demographic associations with their overall functional deficit score measuring performance on a battery of functional tests. Moreover, previous analyses have found that performance on similar tests of multitasking, such as the Six Elements Test and Multiple Errands Test, were not associated with age-related changes up to mid-life (Garden, Phillips, & McPherson, 2001), although they may be affected by age past this point (Alderman et al., 2003).

In the HIV+ group, however, years of education were associated with greater overall scores and more simultaneous task attempts on the multitasking measure. These relationships stress the need to balance groups on demographic characteristics in future studies of multitasking (as in the present study) and to develop demographically corrected normative standards for tests attempting to measure this construct.

In additional exploratory analyses, intercorrelations within the script generation measure indicated that error types were generally positively correlated, such that individuals who made one type of error were likely to make another, although sequencing errors were only weakly associated with other error types. On the multitasking measure, intercorrelations in both the HIV+ and HIV- samples showed that, with the exception of repetitions, all error types were negative correlated with overall score. These relationships suggest either that multitasking errors entailed a cost, subsequently causing individuals to achieve less in each task, or that participants who made more errors were simply more likely to achieve less in the tasks. Similarly, task switches and simultaneous task attempts were positively associated with multitasking overall score in both groups, suggesting that the capacity to effectively switch between tasks and simultaneously allocate attention between tasks was beneficial to one's overall score. Correlations between the script generation and multitasking measures were somewhat weak in the HIV- sample, as script generation repetitions were the only variable to be associated with any variable from the multitasking measure, being negatively correlated with overall score, task switches, and simultaneous task attempts. In the HIV+ sample, script generation intrusion, total errors, and boundary errors were all negatively correlated with the multitasking overall sample, suggesting that individuals who demonstrated script generation errors were likely to perform poorly on the multitasking measure. In addition, script boundary errors were positively associated with other errors and total errors on multitasking.

Impact of HIV Disease on Script Generation and Multitasking

Previous research has indicated that tests of multitasking and script generation may be particularly sensitive to prefrontal-striatal dysfunction in a range of clinical disorders. Extending these findings, the present study revealed medium-to-large effect sizes in script generation errors, multitasking errors, and overall multitasking performance between HIV-infected and healthy comparison samples, generally consistent with the proposed hypotheses. In other words, individuals with HIV infection had difficulties with the generation of script-based action schemas and demonstrated problems with the complex cognitive processes involved in organizing, structuring, and executing a series of goal-related behaviors.

Specifically, on a measure of script generation, HIV-infected individuals displayed adequate performance in generating the relevant actions required for a script but were deficient in inhibiting irrelevant action steps, as evidenced by an elevated number of total errors, in line with the proposed hypotheses. These findings are consistent with previous studies that have found increased script intrusions in patients with Parkinson's disease (Godbout & Doyon, 2000) and prefrontal lesions (Allain, Le Gall, Etcharry-Bouyx, Aubin, & Emile, 1999; Sirigu et al., 1996). In addition, the results follow from the findings of Woods and colleagues (2006), who found an elevated number of intrusions in an HIV+ sample on a measure of action fluency, a measure conceptually related to script generation.

Contrary to the study hypotheses, HIV+ individuals did not demonstrate an elevated number of script generation sequencing errors but did have difficulty staying within the prescribed boundaries of scripts (i.e., ending scripts before or after their

designated endpoint) in comparison to healthy comparison participants. Sirigu et al. (1995) previously found that individuals with prefrontal lesions displayed more sequencing and script boundary errors relative to a group of posterior lesion patients and a group of healthy comparison participants. However, the levels of neuropsychological impairment in our HIV+ sample were mild to mild-to-moderate in most cases (i.e., the mean GDS in the 30% of HIV+ participants who were impaired was 0.95), whereas many of the patients of Sirigu et al. (1995) displayed greater levels of cognitive impairment. Thus, there may not have been severe enough impairments in this sample to elicit increased sequencing errors. Supporting this contention, sequencing errors were more likely to occur in neuropsychologically impaired HIV+ participants in the present study. Interestingly, our script boundary errors predominantly involved extending the script beyond the prescribed goal, whereas in the study by Sirigu and colleagues (1995), these errors involved stopping the script short of the stated goal. In the present study, the script that most often resulted in script boundary errors was “going shopping for a meal,” in which the script end point is when one “puts the groceries away.” Individuals frequently went beyond this point to “cook the meal,” perhaps because the everyday conclusion of this action schema is to actually cook the food that one has just bought. Thus, although the sample from Sirigu et al. (1995) seemed to have failures in sustaining (or formulating) their initial plan for scripts, our sample, in contrast, seemed to have difficulty remembering or attending to the stated goal, even though the endpoint was on a constantly visible cue card.

Importantly, the script generation errors observed were not dependent on output potential or script fluency. That is, the amount of time taken to generate the scripts and the total number of script elements generated did not affect these group differences, as *post hoc* analyses indicated that the HIV+ and healthy comparison samples did not differ in terms of number of script elements generated or the amount of time taken to generate each script element (all p values $> .10$). In addition, the errors were not dependent on knowing the appropriate content of the scripts, as the groups showed equivalent performances in generating the most frequent script steps and recognizing appropriate script elements.

Individuals with HIV infection also had difficulties with the efficient management of multiple tasks and subgoals in the multitasking measure, evidencing a reduced overall score, a lower number of task switches, increased total errors, and fewer attempts at multitasking. These results are generally consistent with the multitasking performance that has been reported in prefrontal lobe lesion patients, who characteristically display an elevated number of task errors and a low overall score (e.g., Burgess, 2000). HIV+ individuals in this study, however, evidenced a low number of task switches in the context of an equivalent number of task attempts, which is somewhat distinct from the pattern of low task attempts *and* low switches reported in prefrontal lesion patients. This pattern is also quite disparate from the profile of multitasking performance commonly observed in schizophrenia, in which individuals switch constantly between tasks, presumably as a compensatory mechanism to help one remember to attend to all tasks (Krabbendam, De Vugt, Deriz, & Jolles, 1999; van Beilen, Withaar, van Zomeren, van den Bosch, & Bouma, 2006).

While switching tasks more frequently is not necessarily the optimal way to complete the most tasks because of the difficulty in attentional allocation, task switching as displayed in this study may indicate a level of confidence in one's abilities to allocate attention in the face of competing demands. On the other hand, HIV+ individuals still switched between tasks an average of 5 times; thus, the decreased number of task switches may have resulted from a slower approach to the tasks and a deficiency in progressing through the tasks. In other words, individuals who switched between tasks less frequently may not have achieved as much in each task, limiting the opportunity to task switch. Relatedly, HIV+ individuals also attempted fewer simultaneous task attempts (i.e., multitasks) overall, which may reflect either a lack of confidence in one's skills in simultaneous and divided attention or a decreased rate of achievement in each task, wherein opportunities for multitasking presented themselves less often.

An analysis of error types in the multitasking measure showed that most of the errors observed were "other errors," which consisted of a mix of rule violations (e.g., not trying part of all four tasks, calling the pharmacy before knowing which medication needed a refill), commission errors (e.g., putting the bread in the microwave instead of the toaster oven during cooking) and omission errors (e.g., forgetting to dispense medications on a day) in executing the four tasks. Such errors may have distinct origins or neuropsychological correlates, although the present study did not permit a sophisticated analysis of the various error types. For example, rule violations may reflect episodic memory failures (i.e., difficulty remembering the test rules) or executive dysfunction, although the fact that the rules and instructions were always available on a cue card for referral argues for the latter. Omission and

commission errors have traditionally been conceptualized as suggesting a breakdown in either the encoding of an intended action (e.g., inaccurate associations are initially formed) or in the process of retrieving the intended response.

On the other hand, it may be that such errors resulted from participants becoming overwhelmed with the management of a number of tasks, such that “action slips” were more likely to occur in carrying out a sequence of behavioral steps. As mentioned in the introduction, Norman and Shallice (1986) proposed a model of attention to action to explaining everyday behavior, in which various high-level schemas representing goals pass activation to low-level schemas, representing actions. Everyday routine tasks often operate automatically, primarily driven by a neural network that needs minimal interaction with the “supervisory attentional system” (SAS) in the prefrontal cortex. More novel or complex everyday behaviors, though, involve increasingly complex interactions with the SAS. With increased physiological arousal (i.e., stress) or damage to frontal-subcortical systems, the routine tasks often do not operate efficiently and require more modulation by prefrontal networks than would normally be expected. According to this model, when these networks are not fully efficient (either due to stress, disease, or allocation of resources to other areas of the brain), action slips are much more likely to occur. Supporting this explanation in the present study, the examiners often observed that errors appeared to reflect action slips, whereby participants recognized their errors subsequently but had difficulty preventing their behavior from being “captured” by similar (but inappropriate) behavioral sequences. However, given that these are somewhat speculative observations, future studies should more comprehensively examine the profiles of

errors that occur during multitasking, as delineation of the cognitive processes involved and the implications for everyday functioning may assist in remediation efforts or the development of compensatory strategies.

Effects of Neuropsychological Impairment

In addition to displaying group differences, the multitasking test demonstrated excellent concurrent validity with neuropsychological testing, as NP-impaired HIV+ individuals obtained a lower multitasking overall score, displayed an elevated number of intrusions and total errors, and multitasked between tasks less frequently in comparison to neuropsychologically normal HIV+ participants. As in the previous analyses, the most common error types were “other errors.” However, intrusive errors, although still relatively rare (only observed in 5 participants), were much more likely to occur in neuropsychologically impaired HIV+ individuals. These errors consisted of performing actions irrelevant to the task at hand, such as pulling out one’s wallet to check a receipt during the finances portion of the task.

In contrast to the multitasking measure, with the exception of sequencing errors, variables from the script generation measure were not significantly discrepant between NP-impaired and NP-normal HIV+ individuals, suggesting somewhat limited concurrent validity with neuropsychological data. It should be noted, though, that only 30% of the HIV+ participants in the current study were globally NP impaired on the comprehensive battery as defined by a GDS > 0.49 (Carey et al., 2004; Heaton et al., 1995), a rate which is below the established prevalence estimates of cognitive impairment in HIV-1 disease, which generally range between 30-50% (e.g., Heaton et

al., 1995). The low cognitive impairment rate in our sample may have limited the power of our analyses to detect between group differences, as most effect sizes in these analyses were within the small or small-to-medium range. Alternately, measures of script generation might not be sensitive to the neurocognitive impairments seen in HIV disease, and the group differences observed between the HIV+ and healthy comparison samples may reflect unmeasured differences between the groups. For example, given its open-ended nature, script generation had a tendency to evoke idiosyncratic response styles, which may have differed between groups and affected the overall generation and organization of script sequences. However, this possibility has not been previously investigated or considered as a confounding factor.

Associations with Traditional Neuropsychological Tests

The second aim of this study was to explore the construct validity of script generation and multitasking. Delis and colleagues (2003) have proposed that cognitive measures which appear to reflect unitary constructs in healthy control participants may actually dissociate and reveal distinct cognitive components in patient groups because of the disruption caused by clinical processes (e.g., neurodegeneration in specific brain structures). As such, this study investigated the potential convergent validity of multitasking and script generation separately in HIV- and HIV+ individuals.

In line with the contentions of Delis et al. (2003), analyses of the association between script generation and NP test domains revealed somewhat divergent correlations in the HIV- and HIV+ groups. In the HIV- group, script generation repetitions and boundary errors were moderately correlated with performance in the

memory and executive functions domains. Repetition errors on similar neuropsychological tests are thought to result from problems with output monitoring and episodic or working memory failures (e.g., Lezak, 1995), skills predominantly mediated by the prefrontal cortex (e.g., Baddeley, 1986). Script boundary errors likely operate in a similar fashion, involving a lack of attention to the initial script delineation or a tendency to get “stuck in set” (a common executive functioning failure), wherein individuals continue responding beyond the prescribed boundary. Thus, in neurologically healthy individuals, these script generation error types may operate via similar mechanisms, whereby memory and executive abilities are paramount in output and goal monitoring.

In HIV+ participants, however, script boundary errors were only significantly associated with processing speed, suggesting that these errors were more dependent on slowed processing than output monitoring and episodic memory. Thus, it may be that these errors reflect a breakdown in the efficient processing of script material or the prescribed boundaries of the script. Alternatively, given that boundary errors have been found in individuals with both Alzheimer’s disease (Grafman et al., 1991) and prefrontal lesions (Sirigu et al., 1995), such errors may not be specific to any cognitive domain and could result from deficits in a number of cognitive processes. Sequencing errors were also not indicative of a breakdown in any one cognitive process in the HIV-infected sample, as they were negatively associated with all three domains of cognitive functioning.

Consistent with the study hypotheses, performance on the multitasking measure was moderately associated with memory, executive functions, and speed of

information processing domains. However, similar to script generation, there were discrepancies between the HIV- and HIV+ samples in these relationships that did not appear to be solely a function of different sample sizes. In the HIV- sample, the strongest correlations were with measures of executive functions. Specifically, the multitasking overall score was significantly associated with executive functions, while task switches and simultaneous task attempts were strongly associated with executive functions and speed of information processing. In the HIV+ group, multitasking overall score and simultaneous task attempts were both moderately associated with memory and speed of information processing, while total errors and intrusions were both associated with memory and executive functions. All associations were in the expected direction, such that poorer neuropsychological performance corresponded with worse multitasking performance and increased errors.

Thus, the most frequent multitasking errors that were observed appear to reflect a combination of executive dysfunction and memory deficits in the HIV+ sample. Yet the correlations between executive functions and multitasking overall score and simultaneous task attempts were lower than expected in the HIV+ sample, especially given the hypothesized demands of the measure on planning, set-shifting, and flexibility. One possibility for the modest associations is that cognitive tests like the Trailmaking Test, Part B and Stroop Color-Word Interference Test often involve set-shifting and flexibility within seconds, whereas multitasking measures entail a deferral of task execution that predominantly occurs over longer periods of time (Burgess et al., 2000). Another possibility is that the skills used by HIV+ participants on the multitasking sub-tasks predominantly reflected more slowing and difficulties

with memory, a contention that may be supported by the decreased multitask attempts and task switches of the HIV+ group. Interestingly, a recent study posited that multitasking problems in individuals with selective vascular lesions of the basal ganglia may primarily reflect response slowing as opposed to response selection (Thoma et al., 2008).

An alternative hypothesis is that the multitasking measure, by virtue of being a test of everyday action organization (and a potential proxy for everyday functioning), may correspond to a number of cognitive skills, making neurocognitive classification difficult. In other words, participants could perform poorly on the measure secondary to a variety of cognitive deficits. As mentioned above, poor performance on the multitasking measure likely reflects deficits in a number of complex cognitive processes, including strategic planning, action initiation, organizing goals and sub-goals, monitoring the environment (including time), remembering one's plan, and allocating attention at each step. In addition, because of its use of relatively unstructured, open-ended situations with multiple goals and sub-goals, this specific measure of multitasking may access individual strategies that patients use in their everyday lives to compensate for their cognitive deficits. However, it is reasonable to assume that some individuals, aware of their cognitive weaknesses, structure their everyday behavior to limit the cognitive resources required in some areas, and they may have correspondingly done so during this test. For example, on this measure, a number of individuals wrote down a plan/strategy before the task and monitored the time with timers, which may have helped them compensate for cognitive problems.

Future studies should evaluate the effectiveness and utilization of such compensatory strategies in multitasking performance and everyday functional ability.

Implications for Everyday Functioning

Given the above considerations and the nature of everyday task demands, multitasking has clear conceptual relevance for everyday functioning and independent living. In an effort to examine the functional impact of multitasking in HIV infection, the current study compared the multitasking performance of HIV+ individuals who met criteria for dependence in IADL (i.e., reported declines in two or more areas of functioning that were attributed primarily to cognitive causes) to those who were deemed IADL independent. HIV+ individuals who reported significant difficulties in their everyday lives also demonstrated a significantly lower overall score on the multitasking test, as did individuals who reported that they were unemployed. Moreover, the overall score on multitasking uniquely contributed to the prediction of IADL dependence, even when a global measure of neuropsychological functioning was included in multivariate models. In other words, the multitasking measure demonstrated incremental validity in predicting IADL functioning above and beyond what was accounted for by neuropsychological test results. Similarly, in exploratory analyses, multitasking performance uniquely contributed to the prediction of employment status, even when depression, age, and AIDS status were included in models. Thus, the correspondence between the multitasking measure and IADL outcome measures not only provides preliminary evidence for the predictive validity of this construct in HIV infection, but also points to its potential ecological relevance

(i.e., validity) for important clinical outcomes in the daily lives of persons living with HIV infection.

With regard to medication adherence, few HIV+ participants endorsed difficulties managing their medication on a self-report measure of adherence, and those who did endorse difficulties did not have disease markers indicative of poorer HIV disease management (i.e., significantly lower CD4 counts or higher viral loads). Thus, the specific relationship between medication adherence and multitasking ability remains to be more thoroughly investigated in future studies. The low endorsement of nonadherence likely reflects the relatively low prevalence of global impairment in the HIV+ sample, as well as the reliability problems associated with self-report data (Liu et al., 2001). Nonetheless, it is important to note that participants who endorsed medication management problems also demonstrated relatively lower scores on the measure of multitasking.

A current diagnosis of major depressive disorder also emerged as a significant independent predictor of IADL and employment status. This study was not designed in a way that would allow determination of whether depression causes functional decline or whether functional decline leads to depression (or a combination of both).

However, these findings are consistent with a number of previous studies in HIV disease showing that depression has a significant impact on daily functioning. Studies have reported that depressive symptoms and impairment on both neuropsychological and laboratory-based functional tests are associated with IADL dependence (Heaton et al., 2004; Sadek, Vigil, Grant, & Heaton, 2007; Woods et al., 2006). Depression in HIV+ patients has also been identified as a significant risk factor for medication non-

adherence (e.g., Starace et al., 2002), increased use of medical services (e.g., Joyce, Chan, Orlando, & Burnam, 2005), and disease progression and survival (e.g., Farinopour et al., 2003). Outside of the context of HIV, depression has been shown to impose a significant burden on work performance and absenteeism (e.g., Kessler, Merikangas, & Wang, 2007) and the health care system in general (e.g., Donohue & Pincus, 2007), although those who receive and respond to treatment tend to show decreased functional decline and societal burdens (e.g., Mauskopf et al., 2009). Together with prior literature, the results of the present study reinforce the need to consider the influence of mood disorders in the prediction of HIV-associated neurocognitive disorders and everyday functioning.

Interestingly, while multitasking performance and current depression diagnosis were significant in the prediction model, neuropsychological performance was not a significant predictor of IADL status, even though there were significant differences in global neuropsychological impairment between groups. This finding is inconsistent with previous studies in HIV, which have found that cognitive deficits are associated with poorer functional outcomes, including impaired automobile driving (e.g., Marcotte et al., 2004), unemployment (e.g., van Gorp et al., 1999), medication nonadherence (e.g., Hinkin et al., 2004), and overall functional dependence (Heaton et al., 2004). The current results do not negate the importance of neuropsychological status in the prediction of everyday functioning. However, it may be that multitasking is an effective proxy for everyday functioning that restricts the amount of variance that can be accounted for in prediction models. To this end, previous studies in frontal lobe lesions patients (e.g., Shallice & Burgess, 1991), schizophrenia (e.g., Katz et al.,

2007), and traumatic brain injury (e.g., Levine et al., 1998) have shown that tests assessing multitasking ability were sensitive to everyday functioning difficulties that were not captured by some traditional cognitive assessment techniques. In combination with the current study, such results suggest that there may be a particular role for this construct in predicting everyday functioning. As such, assessment of multitasking ability may ultimately provide an important adjunct to neuropsychological testing when attempting to determine whether HIV+ individuals experience difficulties in everyday functioning.

In contrast, while participants with HIV infection demonstrated an increased rate of some script generation error types, the measure nonetheless provides unclear clinical utility in the assessment of HIV-associated cognitive or functional impairment. The majority of errors observed were in the form of intrusion errors and script boundary errors. It has been proposed that difficulty inhibiting irrelevant script elements may disrupt the everyday generation of action schemas and interfere with successful daily functioning (Godbout & Doyon, 2000). Such difficulties are proposed to occur when individuals cannot maintain an action schema “online” (i.e., in memory) while inhibiting other action schemas from interfering (Shallice, 1982). In the present study, however, script intrusion errors predominantly consisted of steps being added into the script that may have fit into a participant’s usual routine which nonetheless did not pertain to the goal of the script. For example, a number of individuals included errands irrelevant to the script in the portion of their list that involved transportation or extended their script to include “going out to lunch.” The potential disruption in everyday script generation or planning that may occur with these types of errors is

unclear, and there were not differences in the amount of intrusions generated by participants with differing functional statuses. Similarly, while increased script boundary errors in the HIV+ sample may reflect inattention to the endpoint of the script or a processing speed deficit (based on the correlational analyses), these error types were not elevated in neuropsychologically impaired individuals, limiting their interpretability.

In fact, only sequencing errors were greater in NP-impaired participants in comparison to NP-normal HIV+ individuals, and no script generation measures were significantly discrepant between IADL-dependent and IADL-independent individuals. This finding was surprising, especially given that action fluency, a test with putative associations with script generation, has demonstrated excellent sensitivity to HIV-associated neurocognitive deficits (Woods et al., 2005) and utility in identifying functional dependence in HIV infection (Woods et al., 2006). One possibility for this lack of findings is that in providing specific action scripts with distinct beginning and end points, script generation may provide a structural foundation that minimizes the search and retrieval processes that are likely implicated in the impaired fluency performance of HIV-infected individuals. Thus, the two measures may be assessing related but nonetheless distinct constructs. Supporting this contention, action fluency was not correlated with any script generation variable in the HIV- group and was only correlated with script boundary errors in the HIV+ group.

Confounding Factors

It is unlikely that the differences observed between the HIV+ and HIV- groups in this study were due to demographic factors that might influence task performance, as the two groups were equivalent in age, education, sex, ethnicity, and estimated premorbid verbal intelligence. Similarly, the NP-impaired and NP-normal HIV+ groups, as well as the IADL-dependent and IADL-independent samples, were comparable in demographic and disease variables, making it unlikely that the results observed can be attributed to these factors. Results were also likely not dependent on affective status, as self-reported depressive symptoms and depression diagnoses were not associated with performance on either experimental measure.

Results on the script generation measure also did not appear to be dependent on familiarity with or frequency of carrying out the tasks, as groups were generally equivalent on such measures. It is also unlikely that inexperience with these tasks among the HIV+ or NP-impaired participants can explain the multitasking results, as a large majority of participants reported significant current and/or past everyday experience with the tasks used in the multitasking test. *Post hoc* analyses revealed that of the 59 HIV+ participants who were given questionnaires assessing familiarity with the tasks used in the multitasking test, 51 (86%) reported currently using a checkbook, and of the 8 participants who did not currently use a checkbook, only one participant had not independently used a checkbook previously. Similarly, seven of the 26 HIV- participants reported not using a checkbook currently, and only one of those participants had not independently used a checkbook previously. A large majority of the 59 HIV+ participants (78%) reported that they currently cooked over twice per

week, while 92% of HIV- individuals reported cooking this frequently. Of the 13 HIV+ participants who reported that they did not cook this frequently, 12 reported that they had previously cooked this frequently. Of the 12 participants who currently did not cook frequently, seven were NP-impaired, a significant difference compared to those who cooked frequently ($p = .025$), but they did not differ in demographic characteristics. Eighty-five percent of HIV+ participants reported using the phone at least once per day, while 95% of HIV- individuals reported this level of phone use.

Limitations, Summary, and Future Directions

This study is not without its limitations. The tests of script generation and multitasking used have limited data regarding their basic psychometric properties, and clearly, further research on their reliability, construct validity, and demographic associations in healthy and clinical samples is needed. In addition, no demographically adjusted normative standards have been published for these measures. Moreover, one has to consider the amount of time and effort that the tasks require when considering their clinical utility. Generally, the script generation test required approximately 25 minutes to administer, while the multitasking measure took approximately 10 minutes to set up, 6-8 minutes to explain and answer questions to assure examinee understanding, and 12-15 minutes to administer (including the average planning time used by participants). In addition, a large testing room with a number of props is required to properly administer the test, which may not be feasible in many hospital, clinic, or even laboratory settings where space and time are at a premium. To enhance the everyday clinical applicability of these measures, briefer, more portable measures

should be developed. If a version of this measure could be set up in a virtual environment and run on a computer within the confines of a typical neuropsychological testing room, the everyday utility of the test might be vastly improved.

The use of a self-report measure of IADL functioning might have also introduced some bias because of mild anosognosia (Woods et al., 2006), which may be evaluated more directly by future studies that incorporate proxy-report questionnaires or observational report. In addition, the reliability of the findings may have been hampered by the absence of performance-based tests that individually assessed the specific functional skills used in the multitasking test (e.g., cooking, medication management; Heaton et al., 2004), which may have been helpful in determining whether individual deficits were due to multitasking skills, difficulties with the individual functional tests, or both. Moreover, this cross-sectional study did not evaluate the longitudinal predictive validity of impairment in everyday action organization in HIV but rather provided evidence of concurrent ecological validity. Finally, the generalizability of these data is restricted by the demographic characteristics (i.e., largely well-educated, Caucasian, and male) and the HIV disease characteristics (i.e., relatively immunocompetent) of the relatively small study sample.

Despite these limitations, findings from this study highlight the potential clinical benefits of assessing the organization of everyday actions as part of the broader neuropsychological evaluation of persons infected with HIV. One direction for future study might be to examine the usefulness of cognitive remediation and rehabilitation strategies that attempt to compensate for multitasking deficits in HIV-

associated neurocognitive disorders. For example, recent studies have shown that individuals with traumatic brain injuries who have problems in everyday planning and task execution can be trained to use autobiographical (i.e., personal) memories to facilitate the description of the steps required for a plan, which increases the effectiveness of such plans in performing everyday activities (Hewitt, Evans, & Dritschel, 2006). Incorporation of individualized environmental adaptations (e.g., cue cards, workspace changes) designed to minimize internal and external distractions may also be effective in enhancing the independent performance of IADLs in neurologic populations (e.g., Giovannetti, Bettcher, Libon, Brennan, Sestito, & Kessler, 2007; Gitlin, Corcoran, Winter, Boyce, & Hauk, 2001).

In sum, the present results indicate that HIV+ individuals have problems inhibiting irrelevant intrusions in generating scripts of everyday actions and have difficulty going beyond the prescribed boundaries of scripts, while more neuropsychologically impaired HIV+ individuals have difficulty with sequencing errors in generating complex scripts. However, these errors do not impose an associated cost for individual everyday functional ability. In contrast, the actual initiation, management, and execution of such an action plan, as was tested in the multitasking measure, presents particular problems for HIV+ individuals, especially those who are neuropsychologically impaired and those who also experience problems with everyday functioning. Although these results hint at a dissociation between communication of an everyday action plan and the execution of such a plan in HIV disease, the present study was not set up to test this distinction. Moreover, the script generation measure only required a script for one everyday activity, while the

multitasking measure required the execution of goal-related steps for multiple everyday activities. An interesting future direction that could potentially assess this potential dissociation might involve presenting a multitasking situation, having participants describe a plan of how they would proceed in the situation, followed by an attempt at carrying out their action plan.

Table 1

Hypothesized effects on Script Generation and Multitasking tests relative to controls

Deficit	HIV+ IADL Independent	HIV+ IADL Dependent
<u>Script Generation</u>		
Sequencing Errors	+	+++
Repetitions	-	-
Intrusions	+	++
Total Errors	++	+++
Omitted Actions	-	-
Mean Evocation Time	-	-
Boundary Errors	-	-
Recognition	-	-
<u>Multitasking</u>		
Overall Score	++	+++
Repetitions	?	?
Intrusions	-	-
Overall Errors (+ Rule Violations & Other Errors)	+	++
Task Switches	?	?
Multitasks	?	?

- No effect
+ Small effect
++ Medium effect
+++ Large effect
? Unknown effect

Table 2

HIV disease and medical characteristics of the HIV+ sample (n = 60)

	<i>M</i> or <i>P</i>	<i>SD</i> or <i>IQR</i>
Estimated HIV Duration (years)	15.3	6.6
ARV Regimen Duration (months)	32.6	27.7
Nadir CD4 ^a (cells/ μ l)	70.0	9.0, 202.0
Current CD4 ^a (cells/ μ l)	413.5	242.0, 748.3
Plasma HIV RNA ^a (\log_{10})	1.7	1.7, 1.8
CSF HIV RNA ^{a,b} (\log_{10})	1.7	1.7, 1.7
% Detectable Plasma HIV RNA	31.4%	--
% Detectable CSF HIV RNA	16.7%	--
Proportion with AIDS	73.3%	--
Proportion immunosuppressed ^c	16.7%	--
Antiretroviral Therapies (%)		
cART	86.7%	--
Non-cART ART	3.3%	--
No ART	10.0%	--
Disease Stage (%)		
CDC A	23.3%	--
CDC B	23.3%	--
CDC C	53.3%	--

Note: ART = antiretroviral therapy. cART = combination antiretroviral therapies. ^a Data represent medians with interquartile ranges. ^b *n* = 38. ^c Immunosuppression was defined as CD4 lymphocyte count < 200 cells μ L.

Table 3

Intraclass correlations for 10 HIV-seronegative pilot participants enrolled prior to the study

Variable	<i>ICC</i>
Multitasking	
Total Score	0.972
Total Errors	0.914
Planning Time	0.998
Task Switches	0.969
Simultaneous Task Attempts (Multitasks)	0.951
Repetitions	0.970
Intrusions ^a	1.000
Order Violations	0.842
Other Errors	0.854
Script Generation	
Total Generated Script Elements	0.990
Repetitions	0.856
Intrusions	0.836
Total Errors	0.888
Script Boundary Errors	0.957

Note: ICC = Intraclass correlation. ^a Range restricted by lack of errors.

Table 4

Demographic and psychiatric characteristics of the study sample

	HIV+ (n = 60)	HIV- (n = 26)	<i>t</i> / χ^2	<i>p</i>
Demographic Characteristics				
Age (years)	49.9 (9.4)	47.1 (12.6)	1.14	.259
Education (years)	14.3 (2.7)	14.3 (2.2)	-0.02	.983
WRAT Reading SS	108.3 (9.8)	105.1 (10.2)	-0.09	.130
Sex (% male)	83.6%	69.2%	2.18	.130
Ethnicity ^a			3.22	.489
% Caucasian ^b	75.0%	65.4%	0.92	.338
% Hispanic	8.3%	7.7%	--	--
% Black	15.0%	19.2%	--	--
% Other	1.7%	7.7%	--	--
Percent Employed	33.3%	69.2%	8.07	.005
Psychiatric Characteristics				
Lifetime Major Depression (%)	58.3%	34.6%	3.78	.052
Lifetime Substance Dependence (%)	34.3%	35.0%	0.00	.973
Current Major Depression (%)	10.0%	3.9%	0.88	.347
BDI-II ^c	9.6 (8.6)	3.9 (5.5)	3.10	.003
POMS Total ^d	53.2 (39.2)	32.5 (23.5)	2.41	.018

Note: WRAT = Wide Range Achievement Test; SS = Standard Score; BDI-II = Beck Depression Inventory-II; POMS = Profile of Mood States. ^a Chi-square analysis compares all ethnic groups. ^b Chi-square analysis compared Caucasian versus all other ethnic groups. ^c Fifteen HIV+ participants enrolled in CNTN received the Beck Depression Inventory. ^d N = 80.

Table 5

Participant performance characteristics of Script Generation and Multitasking measures for the combined sample (n = 86)

	Actual Range	Possible Range	<i>Mean</i>	<i>SD</i>	<i>Median</i>	<i>IQR</i>
Script Generation						
Script Elements Excluded	0-14	0-20	4.8	2.9	4.5	3.0 - 6.0
Sequencing Errors	0-4	--	0.2	0.6	0.0	0.0 - 0.0
Repetitions	0-4	--	0.4	0.8	0.0	0.0 - 0.0
Intrusions	0-13	--	1.4	2.2	1.0	0.0 - 2.0
Total Errors	0-20	--	2.0	2.9	1.0	0.0 - 2.0
Script Boundary Errors	0-6	0-6	1.6	1.4	1.0	0.0 - 3.0
Recognition Hits	27-30	0-30	29.8	0.5	30.0	30.0 - 30.0
Recognition False Positives	0-5	0-30	1.0	1.1	1.0	0.0 - 1.0
Multitasking ^a						
Overall Score	17-49	0-70	29.4	8.1	29.0	23.3 - 35.8
Repetitions	0-2	--	0.2	0.4	0.0	0.0 - 0.0
Intrusions	0-2	--	0.1	0.2	0.0	0.0 - 0.0
Other Errors	0-6	--	2.1	1.2	2.0	1.0 - 3.0
Total Errors	0-8	--	2.4	1.4	2.0	1.0 - 3.0
Task Switches	0-15	--	5.7	2.8	6.0	4.0 - 7.0
Tasks Attempted	1-4	0-4	3.3	0.5	3.0	3.0 - 4.0
Simultaneous Task Attempts	0-9	--	2.6	2.1	2.0	1.0 - 4.0

Note. -- indicates a zero to infinity range. ^a One HIV- participant was excluded as an outlier on the Multitasking measure, as he/she had an invalid administration, generated only 5 points, and evidenced an abnormally large number of errors.

Table 6

Intercorrelations between variables of the Script Generation and Multitasking tests in the HIV- healthy comparison group (n = 26)

Variable	1	2	3	4	5	6	7	8	9	10	11
1. SG Sequencing Errors	--										
2. SG Repetitions	.25	--									
3. SG Intrusions	.06	.08	--								
4. SG Total Errors	.39*	.49*	.86***	--							
5. SG Boundary Errors	.24	.18	.38*	.44*	--						
6. MT Overall Score	-.09	-.40*	.02	-.18	-.37	--					
7. MT Repetitions	-.15	.04	-.13	-.10	-.16	.11	--				
8. MT Other Errors	.27	.23	-.05	.16	-.06	-.51**	-.22	--			
9. MT Total Errors	.20	.23	-.13	.09	-.15	-.44*	.22	.90***	--		
10. MT Task Switches	-.18	-.58**	.01	-.27	-.11	.51**	.35	-.35	-.18	--	
11. MT Simultaneous Task Attempts	-.15	-.52*	.07	-.18	-.24	.54**	.36	-.34	-.17	.91***	--

Note. SG = Script Generation test; MT = Multitasking test.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 7

Intercorrelations between variables of the Script Generation and Multitasking tests in the HIV+ group (n = 60)

Variable	1	2	3	4	5	6	7	8	9	10	11
1. SG Sequencing Errors	--										
2. SG Repetitions	.13	--									
3. SG Intrusions	.01	.23	--								
4. SG Total Errors	.15	.44**	.90***	--							
5. SG Boundary Errors	-.15	.26*	.52***	.50***	--						
6. MT Overall Score	.06	-.10	-.42**	-.41***	-.29*	--					
7. MT Repetitions	-.06	.01	-.10	-.18	.13	-.01	--				
8. MT Other Errors	.04	-.18	.24	.15	.27*	-.28*	.25*	--			
9. MT Total Errors	.05	-.19	.25	.14	.30*	-.27*	.43**	.95***	--		
10. MT Task Switches	-.05	.11	-.16	-.09	-.09	.30*	.15	.04	.08	--	
11. MT Simultaneous Task Attempts	-.14	.12	-.27*	-.21	-.24	.40**	.11	.01	.01	.69***	--

Note. SG = Script Generation test; MT = Multitasking test.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 8

Script Generation performance in the HIV+ and HIV- healthy comparison samples

	HIV+ (n = 60)	HIV- (n = 26)	t/χ^2	p	d
Script Elements Excluded ^a	4.7 (2.5)	5.0 (3.5)	-0.47	.639	-0.10
Sequencing Errors	0.3 (0.7)	0.12 (0.4)	1.80	.179	0.29
Repetitions	0.5 (0.9)	0.2 (0.7)	1.90	.168	0.29
Intrusions	1.8 (2.5)	0.6 (1.0)	7.50	.006	0.65
Total Errors	2.5 (3.2)	0.9 (1.3)	8.47	.004	0.73
Script Boundary Errors	1.9 (1.4)	1.1 (1.3)	6.21	.013	0.55
Recognition Hits ^b	29.8 (0.4)	29.8 (0.7)	0.31	.581	0.19
Recognition False Positives ^b	0.87 (1.0)	1.2 (1.2)	1.66	.197	-0.32

Note: Chi-square values are from nonparametric Wilcoxon Ranked Sums tests. ^a Indicates a t test value. ^b Out of a total 30 possible.

Table 9

Multitasking performance in the HIV+ and HIV- healthy comparison samples

	HIV+ (n = 60)	HIV- (n = 25) ^a	t / χ^2	p	d
Overall Score ^b	28.1 (8.1)	32.4 (7.5)	-2.24	.028	-0.54
Repetitions	0.1 (0.4)	0.2 (0.4)	0.98	.322	-0.17
Intrusions	0.1 (0.3)	0.0 (0.0)	2.15	.143	0.42
Other Errors	2.4 (1.3)	1.4 (0.8)	15.38	<.0001	1.01
Total Errors	2.7 (1.5)	1.6 (0.8)	13.25	.0003	0.91
Task Switches	5.1 (2.1)	7.1 (3.5)	5.89	.015	-0.67
Tasks Attempted	3.2 (0.5)	3.4 (0.6)	1.11	.293	-0.23
Simultaneous Task Attempts	2.1 (1.5)	3.7 (2.9)	4.82	.028	-0.70

^a One HIV- participant was excluded as an outlier on the Multitasking measure, having an invalid administration, generating only 5 points, and evidencing an abnormally large number of errors. ^b Indicates a t test value.

Table 10

Comparisons of neuropsychologically (NP) normal and NP-impaired HIV+ groups on the Multitasking measure

	NP-Impaired (n = 18)	NP-Normal (n = 42)	t/χ^2	p	d
Overall Score ^a	24.1 (6.9)	30.2 (8.0)	2.84	.006	-0.83
Repetitions	0.2 (0.5)	0.1 (0.3)	1.28	.258	0.29
Intrusions	0.2 (0.4)	0.0 (0.2)	6.20	.013	0.62
Other Errors	3.0 (1.3)	2.1 (1.2)	5.98	.015	0.64
Total Errors	3.5 (1.7)	2.2 (1.2)	7.76	.005	0.78
Task Switches	4.7 (2.3)	5.3 (2.1)	1.05	.305	-0.25
Simultaneous Task Attempts	1.5 (1.3)	2.4 (1.5)	4.64	.031	-0.63

^a Indicates a t test value.

Table 11

Correlations between neuropsychological performance and Script Generation and Multitasking variables in the HIV- group (n = 26)

Variable	SIP Z Score	Memory Z Score	Executive Functions Z Score
Script Generation			
Sequencing Errors	.24	-.02	-.08
Repetitions	-.34	-.42*	-.49*
Total Errors	.04	-.24	-.02
Boundary Errors	-.17	-.47*	-.43*
Multitasking			
Overall Score	.31	.29	.50**
Repetitions	.08	.18	.08
Total Errors	-.31	-.02	-.24
Task Switches	.46*	.24	.53**
Simultaneous Task Attempts	.55**	.34	.53**

Note. SIP = Speed of Information Processing.

* $p < .05$. ** $p < .01$.

Table 12

Correlations between neuropsychological performance and Script Generation and Multitasking variables in the HIV+ group (n = 60)

Variable	SIP Z Score	Memory Z Score	Executive Functions Z Score
Script Generation			
Sequencing Errors	-.26*	-.29*	-.29*
Repetitions	-.03	.09	.15
Total Errors ^a	-.23	-.18	-.18
Boundary Errors	-.31*	-.16	-.24
Multitasking			
Overall Score	.36**	.39**	.20
Repetitions	.01	-.09	.13
Intrusions	-.24	-.28*	-.28*
Total Errors	-.22	-.44***	-.32**
Task Switches	.17	.19	.05
Simultaneous Task Attempts	.37**	.37**	.23

Note. SIP = Speed of Information Processing. ^a One HIV+ participant was excluded as an outlier on these measures, generating 13 intrusions, which contribute to total errors.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 13

Effect sizes for Script Generation Total Errors and Multitasking Overall Score with overall cognitive functioning and demographic, HIV disease, and psychiatric characteristics in the HIV+ sample (n = 60)

	Script Generation Total Errors	Multitasking Overall Score
Demographic Characteristics		
Age	.27*	-.12
Education (years)	-.08	.26*
Gender (male versus female) ^a	-0.19	0.15
Ethnicity (Caucasian versus non-Caucasian) ^a	-0.29	0.31
Cognitive Functioning		
WRAT Reading SS	.11	.23
GDS	.18	-.21
HIV Disease Characteristics		
Current CD4 Count	.23	-.12
Nadir CD4 Count	.02	-.01
AIDS versus Non-AIDS ^a	0.40	-0.20
cART versus Non-cART ^a	-0.41	0.22
Psychiatric Characteristics		
Lifetime Major Depression (versus not) ^a	-0.38	0.25
Lifetime Substance Dependence (versus not) ^a	-0.09	-0.13
Current Major Depression (versus not) ^a	-0.30	0.05
BDI-II	-.09	-.01
POMS Total	-.14	.05

Note. GDS = Global Deficit Score; NP = Neuropsychologically; cART = Combination Antiretroviral Therapy. Data are Spearman's *rho* correlations. ^a Indicates a Cohen's *d* effect size for the differences between the two groups indicated.

* $p < .05$.

Table 14

Demographic, HIV disease, and psychiatric characteristics of the HIV+ participants classified by IADL status (means and percentages)

	IADL Dependent (n = 14)	IADL Independent (n = 46)	<i>p</i>
Demographic Characteristics			
Age (years)	51.7 (8.4)	49.3 (9.6)	.401
Education (years)	14.1 (2.6)	14.3 (2.8)	.815
Proportion male (%)	71.4%	87.0%	.161
Proportion Caucasian (%) ^a	64.3%	78.3%	.271
Cognitive Functioning			
WRAT Reading SS	102.2 (15.2)	100.1 (10.4)	.557
Proportion NP Impaired (%)	50.0%	23.9%	.039
HIV Disease Characteristics			
Current CD4 Count ^b	426.5 (367.0)	407.0 (493.3)	.662
Nadir CD4 Count ^b	22 (286.5)	82.5 (182.5)	.464
Proportion with AIDS (%)	71.4%	73.9%	.947
Proportion on cART (%)	78.6%	91.3%	.207
Proportion Immunosuppressed (%)	14.3%	17.4%	.785
Psychiatric Characteristics			
Lifetime Major Depression (%)	78.6%	52.2%	.068
Lifetime Substance Dependence (%)	42.9%	32.6%	.449
Current Major Depression (%)	28.6%	4.4%	.007
BDI-II ^c	16.4 (7.5)	7.6 (7.8)	.0006
POMS Total ^d	87.5 (44.0)	44.8 (33.4)	.003
Modified Lawton & Brody IADL Scale			
“Best” Prior Level of Functioning ^e	0.1 (0.1)	0.2 (0.5)	.234
Overall Decline Severity	6.2 (4.4)	0.2 (0.5)	<.0001
Number of Areas Declined	4.1 (2.2)	0.2 (0.4)	<.0001

Note. IADL = Instrumental Activities of Daily Living; NP = Neuropsychologically; cART = Combination Antiretroviral Therapy. ^a Chi-square analysis compared Caucasian versus all other ethnic groups. ^b Median (interquartile range). ^c Fifteen HIV+ participants enrolled in CNTN received the Beck Depression Inventory. ^d N = 56. ^e Sum of self-reported “best” level of IADL functioning across domains, which range in score from 0 (*fully independent*) to 4 (*fully dependent*).

Table 15

Nominal logistic regression model predicting dependence in instrumental activities of daily living (IADL) by neuropsychological (NP) global deficit score (GDS), current major depression diagnosis, and Overall Score on the Multitasking test

Criterion Variable	Predictor Variable	χ^2	OR	<i>p</i>
IADL Dependence	NP GDS	1.18	2.28	.277
	Current Major Depression Diagnosis	7.50	19.45	.0006
	Multitasking Overall Score	5.77	0.88	.016

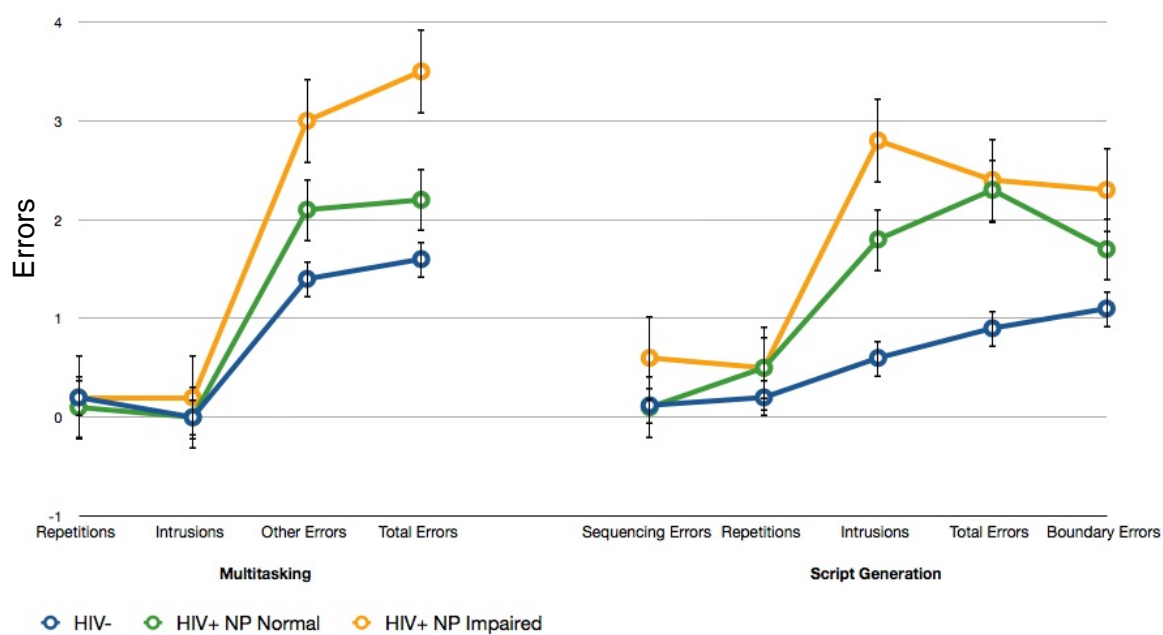


Figure 1

Comparisons of Multitasking and Script Generation error variables in the HIV-, HIV+ NP-Normal, and HIV+ NP-Impaired groups

Note. MT = Multitasking Test; SG = Script Generation Test; NP = Neuropsychologically.

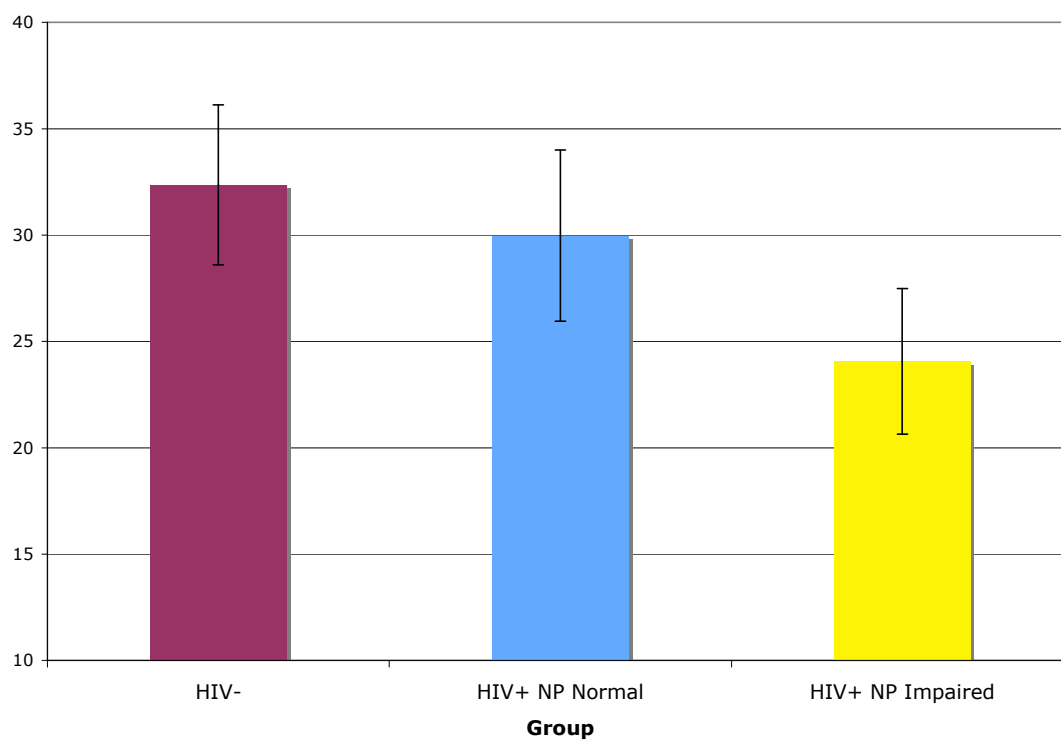


Figure 2

Multitasking Overall Score by group

Note. NP = Neuropsychologically.

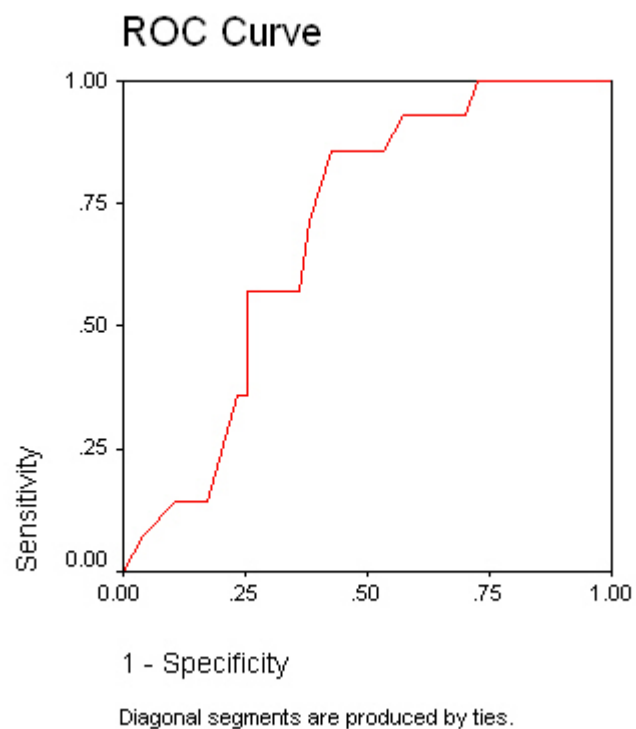


Figure 3

ROC Curve: Multitasking Overall Score predicting the presence of IADL dependence

Appendix A

General Instructions and Introduction for the Everyday Action Battery

“Today we are going to do two groups of tests which will measure your ability to do everyday tasks. For the first part, I will ask you to describe how you would carry out common daily tasks. In the second part, I will ask you to actually do some everyday tasks. Some parts of these tests are relatively simple while other parts will be more challenging. The tests are designed so that most people will do well on some parts and poorly on others.”

Appendix B

Administration Instructions for the Script Generation Task

“First, I am going to ask you about 6 activities that people do in their day-to-day lives. For each activity, I want you to tell me, in order, all of the things that you would need to do in order to successfully complete each activity. Please begin from the start of the activity and stop at its end. Be sure to tell me all of the important steps that are needed to complete each activity.”

“For example, if I asked you to tell me all of the things you would need to do if you decided to go out to dinner starting when you decide to go out to dinner and stopping when you leave the restaurant, you could say ‘Decide on a restaurant, get dressed, travel to the restaurant, give your name to the host, be seated, look at the menu, and so on...”

“You will have two minutes for each activity. Please tell me each time when you are finished.”

Prompts: **“I cannot tell you how much detail to go into. Just be sure to tell me all of the key activities that are needed to complete each task.”**

If delay or questions about starting over, etc.: **“Keep going. I’ll read back what you said when we are done and you can reorder things if needed.”**

(Randomized)

1) **“The next activity involves getting a new prescription filled.”**

“Your doctor has written you a new prescription for a medication and you need to get it filled at your neighborhood pharmacy. You have two minutes to tell me, in order, all of the things you need to do, starting when you are handed the prescription and stopping when you take the first dose.”

Confirm with subject the order of actions and renumber if needed. **“Now I’m going to read your list back to you, and I want you to tell me if you want to re-order or change anything.”**

Then ask:

“Please rate the importance of each action in this sequence to the objective (not to you personally) on a scale ranging from 1 (of limited relevance) to 5 (the action is absolutely essential).”

2) **“The next activity involves going shopping for a meal.”**

“You are planning a meal and need to go shopping. You have two minutes to tell me, in order, all of the things you need to do, starting when you look up the recipe and stopping when you put the groceries away.”

Confirm with subject the order of actions and renumber if needed. **“Now I’m going to read your list back to you, and I want you to tell me if you want to re-order or change anything.”**

Then ask:

“Please rate the importance of each action in this sequence to the objective (not to you personally) on a scale ranging from 1 (of limited relevance) to 5 (the action is absolutely essential).”

3) “The next activity involves getting in a car accident.”

“You have gotten into a car accident. You have two minutes to tell me, in order, all of the things you need to do, starting from the moment of impact and stopping when you leave the scene.”

Confirm with subject the order of actions and renumber if needed. **“Now I’m going to read your list back to you, and I want you to tell me if you want to re-order or change anything.”**

Then ask:

“Please rate the importance of each action in this sequence to the objective (not to you personally) on a scale ranging from 1 (of limited relevance) to 5 (the action is absolutely essential).”

4) “The next activity involves preparing to leave the house in the morning.”

“You need to get up in the morning to go to work or attend an appointment. You have two minutes to tell me, in order, all of the things you need to do, starting when you go to sleep the night before and stopping when you leave the house.”

Confirm with subject the order of actions and renumber if needed. **“Now I’m going to read your list back to you, and I want you to tell me if you want to re-order or change anything.”**

Then ask:

“Please rate the importance of each action in this sequence to the objective (not to you personally) on a scale ranging from 1 (of limited relevance) to 5 (the action is absolutely essential).”

5) “The next activity involves attending a dentist appointment.”

“You need to attend a dentist appointment. You have two minutes to tell me, in order, all of the things you need to do, starting when you leave for the appointment and stopping when you finish the appointment and leave the dentist’s office.”

Confirm with subject the order of actions and renumber if needed. **“Now I’m going to read your list back to you, and I want you to tell me if you want to re-order or change anything.”**

Then ask:

“Please rate the importance of each action in this sequence to the objective (not to you personally) on a scale ranging from 1 (of limited relevance) to 5 (the action is absolutely essential).”

6) “The next activity involves doing the laundry.”

“You need to do the laundry. You have two minutes to tell me, in order, all of the things you need to do, starting from the moment you decide to do the laundry and stopping when you put the clothes away.”

Confirm with subject the order of actions and renumber if needed. **“Now I’m going to read your list back to you, and I want you to tell me if you want to re-order or change anything.”**

Then ask:

“Please rate the importance of each action in this sequence to the objective (not to you personally) on a scale ranging from 1 (of limited relevance) to 5 (the action is absolutely essential).”

After all scripts are complete, ask the participant recognition and frequency portions of test (see scoring sheet).

Appendix C

Administration Instructions for the Multitasking Task

“Now we are going to do a test in which you will actually perform some daily tasks. Over the next 12 minutes, you will have 4 different tasks to try to complete. These tasks will involve different things that you might do in your everyday life. Look at the task sheet in front of you and we will go through each task together.”

“As you can see, these tasks will involve cooking, managing medications, making telephone calls, and managing finances. You will be able to refer back to these directions as often as you wish during the task, so don’t worry about remembering all of the rules right now. You can always refer back to these instructions and we will go through each of the tasks together slowly.”

“Please note that your ultimate goals are to cook a meal and manage your finances. Also, before doing the financial task, you need to call your credit card company.”

Cooking:

“For one of the tasks, you will be pretending to cook pasta and bread. You will not actually be cooking the items, but you will be following the instructions to prepare them.”

“Use the oven and the hot plates beside you and these cooking utensils to prepare the dishes. The appliances are not actually on so they will not heat. However, we would like you to turn the appliances on and off during the cooking task, just as you might in your own kitchen.”

“You can use these two timers if you need one or both of them.” Demonstrate how to set each timer for 2 minutes. Have participant set to 5 minutes, start, and reset to assure understanding.

“As I just noted, you will be making pasta and bread. Here are the recipes for each item.”

- Present 5x7 cards.

“You need to follow the instructions exactly. The two items must be completed at the same time; in other words, I would like you to pull the items out of the oven and off the hot plates at the same time.”

“Read through the recipes and plan how this will be done. After I finish reviewing the other three tasks, you can follow the directions to make the food. When your items are done, you will spoon the pasta on one of these plates (*point*) and place the two items on the desk.”

“Do you have any questions or want me to repeat these instructions?”

Medication management:

“For the next task, use this pill box to lay out the number of pills you will need each day of the week. These medications are NOT real and you DO NOT have to really take them, but you need to make sure you understand the directions for taking them, just as if you actually were going to take them.

“For medications taken twice a day, assume you need to take them once every 12 hours. The organizer has compartments marked for the time of day, including morning, noon, evening, and night (*point*). For example, if you were told to take a medication two times per day with meals, you might place one pill in the morning compartment, to be taken with breakfast, and one in the evening compartment to be taken with dinner (*examiner places pills in appropriate compartment*).

“You will not have enough of one medication to fill the week. For this medication, you need to call the pharmacy to request a refill with the medication name, dosage, and amount. I will tell you about the phone calls in just a moment. Here is the name and phone number of the pharmacy (*point to pill bottle*).”

“Do you have any questions or want me to repeat these instructions?”

Telephone Communication:

“In the telephone task, you need to make three telephone calls: one to your doctor, one to a credit card company, and one to your pharmacy. For each call, you will need to leave a message. The information you will need is on this sheet (*point*), but I will briefly explain each call to you.”

“When you call the Chase credit card company, you need to leave a message stating your name and account number, that you found an incorrect charge from Macy’s on July 8th, 2006 for \$56.88 on your account, and that you would like for the charge to be corrected.”

“When you call your doctor, Dr. Miller, you need to leave a message stating that you cannot make your appointment, would like to reschedule for Friday at 12:00PM, and leave your name and phone number.”

“When you call the pharmacy, you need to leave a message stating that you need a refill for one of the medications, leaving the name of the medication, dosage, and number of pills that you need, and leaving your name and phone number, which are provided here (*point*) on this sheet.”

“Here is an address book to look up the phone numbers.”

“Do you have any questions or want me to repeat these instructions?”

Advanced Finances:

“For one of the other tasks, you will be balancing a checkbook. You will have several bills that you need to pay using these checks (*show checks to participant*) as well as one check to deposit (*show check*). Remember to do this task as you normally would in everyday life.

“Imagine that you are ‘Dave Johnston’ (Diane Johnston) and this is a check written to you for \$15.00 that you need to put into your account.”

“This is your checkbook register. You see you have a balance of \$212.50 in your checking account. You have three bills to pay: a phone bill, a gas and electric bill, and a credit card bill. Remember, before doing this task you need to call your credit card company.”

“Use these checks and deposit slips to pay your bills and make your deposits.

“Here are the reminders of the things you will need to do. For both the checks and deposits, make sure you do everything you would as if you were actually paying the bill or making the deposit.”

“MAKE SURE to record your transactions in your checkbook register (*point*) and keep a running total of how much money you have after each check or deposit. You may use this calculator if you wish.”

“For the credit card bill (the Chase bank bill) if you do not have enough money for the entire bill, pay as much as you can, but be sure to leave exactly \$100 in your account at the end. Be sure to record your final balance when you are done.”

“Do you have any questions or want me to repeat these instructions?”

After all task instructions:

“Here are your overall reminders (*point*). You must attempt at least part of each of these four tasks. You can do the tasks in any order, and you can return to tasks as often as you like. Your job is to try to complete as much of the tasks as possible . You will receive points for each step you successfully take in each task. It is unlikely that you will be able to complete all 4 tasks in the 12 minute time limit.

“Your ultimate goals are to cook a meal and manage your finances. Before doing the financial task, however, you need to call your credit card company.”

“You can use this stopwatch or that clock (*point*) to help you organize your time if you like.”

“Take a moment to plan out the best course of action.” (*Begin recording Planning Time, and then begin the task after one minute*).

“You may begin.”

Appendix D

Example Examiner Scoring Sheets for Script Generation***Script Generation*****Getting a new prescription filled:****Importance**

1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	
11.	
12.	
13.	
14.	
15.	

	<u>Spontaneous</u>	<u>Checked</u>
--	--------------------	----------------

Total number of actions generated

Total time

Sequence errors (physically impossible or inconsistent)

Number of irrelevant intrusions

Number of repetitions

Early or late closure

1=NO 2=EARLY 3 = LATE

Appendix E

Script Generation Recognition Items and Frequency Ratings***Script Generation***

“Now I am going to give you the same six activities. For each activity, I will say a series of actions that are either are an important part of the activity or not part of the activity. Please say ‘yes’ if it is part of the activity and ‘no’ if it is not part of the activity.”

1. “For the activity getting a new prescription filled, is _____ a part of the activity?”

“Is _____ part of the activity?”

Go to the pharmacy	YES	NO
<i>Answer the phone</i>	YES	NO
<i>Pack a suitcase</i>	YES	NO
Hand the prescription to the pharmacist	YES	NO
<i>Ask for the check</i>	YES	NO
Get the prescription from the doctor	YES	NO
Pay for the medication	YES	NO
<i>Schedule a date and time</i>	YES	NO
Look at the dosage information	YES	NO
<i>Write a message</i>	YES	NO

2. “For the activity going shopping for a meal, is _____ a part of the activity?”

“Is _____ part of the activity?”

<i>Make an appointment</i>	YES	NO
<i>Pay the waitress</i>	YES	NO
Pick items off of the shelf	YES	NO
<i>Go to the office</i>	YES	NO
Get grocery cart	YES	NO
<i>Prepare the food</i>	YES	NO
Travel to the grocery store	YES	NO
Write a shopping list	YES	NO
<i>Decide on a restaurant</i>	YES	NO
Pay for the groceries	YES	NO

3. “For the activity getting in a car accident, is _____ a part of the activity?”

“Is _____ part of the activity?”

Exchange information with the other driver	YES	NO
<i>Decide on a location</i>	YES	NO
<i>Read the instructions</i>	YES	NO
Call the police	YES	NO
Get out of car, if not hurt	YES	NO
<i>Wash the car</i>	YES	NO
Assess the damage	YES	NO
<i>Sign in with the receptionist</i>	YES	NO
Call the insurance company	YES	NO
<i>Buy a ticket</i>	YES	NO

4. “For the activity preparing to go to work or attend an appointment in the morning, is _____ a part of the activity?”

“Is _____ part of the activity?”

<i>Wait in line</i>	YES	NO
Get dressed	YES	NO
<i>Greet guests</i>	YES	NO
Leave home	YES	NO
Eat breakfast	YES	NO
<i>Go to the cash register</i>	YES	NO
<i>Call the operator</i>	YES	NO
Get out of bed	YES	NO
<i>Mow the lawn</i>	YES	NO
Take a shower or bath	YES	NO

5. “For the activity attending a dentist appointment, is _____ a part of the activity?”

“Is _____ part of the activity?”

<i>Collect the money</i>	YES	NO
Sit in dentist chair	YES	NO
<i>Call a friend</i>	YES	NO
Check in with the receptionist	YES	NO
<i>Rent equipment</i>	YES	NO
Have teeth cleaned	YES	NO
<i>Read the menu</i>	YES	NO

Travel to the appointment	YES	NO
<i>Mail the letter</i>	YES	NO
Wait	YES	NO

6. “For the activity do the laundry, is _____ a part of the activity?”

“Is _____ part of the activity?”

Transfer clothes to the dryer	YES	NO
<i>Make a reservation</i>	YES	NO
<i>Decide which clothes to buy</i>	YES	NO
Add detergent	YES	NO
<i>Wash the dishes</i>	YES	NO
<i>Wake up</i>	YES	NO
Fold clothes	YES	NO
Take clothes to laundry room	YES	NO
<i>Mop the floor</i>	YES	NO
Load the washer	YES	NO

“Please rate the frequency that you perform each of these tasks on a scale from 1 (never) to 5 (very frequently)”

“How often do you:”

<i>1. “Get a new prescription filled?”</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>2. “Go shopping for food?”</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>3. “Get in a car accident?”</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>4. “Prepare to leave the house in the morning?”</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>5. “Attend a dentist appointment?”</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>
<i>6. “Do the laundry?”</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>

Appendix F

Examiner Scoring Sheets for Multitasking**ADVANCED FINANCES – CHECKING**

A. CHECKS	
1. All elements correct (Signature, Payee, Written Amount, Numeric Amount, Date)	1
2. All elements correct (Signature, Payee, Written Amount, Numeric Amount, Date)	1
3. All elements correct (Signature, Payee, Written Amount, Numeric Amount, Date)	1

A. TOTAL

SCORE (3 points possible): ____

B. DEPOSIT	
1. Date	1
2. Amount of Deposit	1
3. Endorse Check	1

B. TOTAL

SCORE (3 points possible): ____

C. TRANSACTIONS	
PHONE:	
1. Record amount of check (\$19.59)	1
2. Correct net balance	1
ELECTRIC:	
3. Record amount of check (\$43.56)	1
4. Correct net balance	1
CREDIT CARD:	
5. Record amount of check (\$64.35 if leaves exactly \$100)	1
6. Correct net balance	1
DEPOSIT:	
7. Record amount of deposit (\$15.00)	1
8. Correct net balance	1
9. Leaving \$100 in account	1

C. TOTAL

SCORE (9 points possible): ____

D. TOTAL PRE-BONUS**CHECKING SCORE (15 points possible):** ____**E. BONUS****COMPLETION OF FINANCES TASK:** +5**F. TOTAL****TOTAL SCORE WITH BONUS:** ____

PLEASE BE SURE TO DEDUCT ANY PER CHECK CHARGES OR SERVICE CHARGES THAT MAY APPLY TO YOUR ACCOUNT

NUMBER	DATE	CHECKS ISSUED TO OR DESCRIPTION OF DEPOSIT	(-) AMOUNT OF CHECK		T	(+) AMOUNT OF DEPOSIT		BALANCE	
								232	50
443		TO/FOR <i>Max's Grocery</i>	20	00				20	00
		-----						B A L 212	50
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	
		TO/FOR							
		-----						B A L	

REMEMBER TO RECORD AUTOMATIC PAYMENTS/DEPOSITS ON DATE AUTHORIZED.

COOKING SCORING SHEET

A. BREAD	
Preheating oven to 300 degrees	1
Wrapping bread in foil	1
Bread In : ____ Bread Out: ____ TOTAL BREAD TIME: __ MIN __ SEC	
3-4 minutes	1
Off by more than 45 seconds	0
Remove bread from oven	1

A. TOTAL

BREAD SCORE (4 points possible): ____

B. PASTA	
Correct measurement of water (2 cups)	1
On High	1
WATER COOK In: ____ Out: ____ TOTAL WATER TIME: __ MIN __ SEC	
1 minute	1
Off by more than 45 seconds	0
Correct measurement of pasta (1 cup)	1
Add dash of salt	1
On Medium	1
Stir pasta	1
PASTA COOK In: ____ Out: ____ TOTAL PASTA TIME: __ MIN __ SEC	
3-4 minutes	1
Off by more than 45 seconds	0
Turn off burner and spoon onto plate	1

B. TOTAL

PASTA SCORE (9 points possible): ____

C. All items done at same time (within 60 seconds of 1st item completed)	2
--------------------------------------------------------------------------------------------	---

D. TOTAL PRE-BONUS

COOKING SCORE (15 points possible): ____

E. BONUS

COMPLETION OF COOKING TASK: +5

F. TOTAL

TOTAL WITH BONUS: ____

TELEPHONE COMMUNICATION

A. CREDIT CARD COMPANY	
1. Correct phone number and leaves message	1
2. Account number	1
3. Incorrect charge	1
4. From Macy's on July 8 th , 2006	1
5. \$56.88	1
A. TOTAL	SCORE (5 points possible): _____

B. DOCTOR	
1. Correct phone number and leaves message	1
2. Cannot make appointment	1
3. Would like to reschedule	1
4. Friday at 12:00 PM	1
5. Name & phone number	1
B. TOTAL	SCORE (5 points possible): _____

C. PHARMACY	
1. Correct phone number and leaves message	1
2. Need a refill	1
3. Name of medication	1
4. Dosage of medication & number of pills	1
5. Name & phone number	1
C. TOTAL	SCORE (5 points possible): _____

D. TOTAL **TELEPHONE SCORE (15 points possible):** _____

MEDICATION MANAGEMENT

A. AFINAVIR	
1. 2 pills in each compartment	1
2. 3 separate compartments on each day	1

A. TOTAL SCORE (2 points possible): ____

B. CELETRA	
1. 1 pill in each compartment	1
2. 2 separate compartments on each day	1

B. TOTAL SCORE (2 points possible): ____

C. ZINOFUVINE	
1. 2 pills in each compartment	1
2. 3 separate compartments on each day	1
3. At mealtimes	1

C. TOTAL SCORE (3 points possible): ____

D. RITACEPT	
1. 1 pill in each compartment	1
2. 2 separate compartments on each day	1

D. TOTAL SCORE (2 points possible): ____

E. NIXAMIR	
1. 1 pill in each compartment	1
2. 3 separate compartments on each day	1
3. At bedtime (drowsiness)	1

E. TOTAL SCORE (3 points possible): ____

F. CELETRA (SHORT)	
1. Writes down name	1
2. Writes down dosage	1
3. Writes down amount	1

F. TOTAL SCORE (3 points possible): ____

G. TOTAL MEDICATION SCORE (15 points possible): ____

MULTITASKING OVERALL SCORING

1. Total time _____ seconds
2. Amount of planning time pre-task _____ seconds
3. Number of required task switches ☐ Phone/Finances ☐ Meds/Phone ____ / 2
4. Number of participant initiated task switches _____
5. Number of irrelevant intrusions _____
6. Number of repetitions _____
7. Number of order violations _____
8. Number of other errors _____
9. Number of tasks attempted _____ / 4
10. Number of simultaneous task attempts (multitasks) _____
11. Did participant attempt to ask examiner questions? 1=Y 2=N
12. Total points _____

Notes

Errors:

Appendix G

Everyday Functioning Surveys Given to Participants

INSTRUCTIONS TO PARTICIPANTS: Below are several questions about various everyday skills. For each question, please respond with your best answer.

Medication Questions

1. How many different medications (NOT including vitamins or supplements) do you take on a daily basis?

2. (*If Any Medications*) How many pills do you take on a daily basis?

3. Do you take vitamins or supplements on a daily basis?

Yes..... 1
No..... 2

4. (*If Any*) How many pills/doses of vitamins/supplements do you take daily?

5. Do you use a pill organizer or any other medication organizer?

Yes..... 1
No..... 2

6. Do you use a medication reminder (such as a timing device that alerts you to take your next pill)?

Yes..... 1
No..... 2

7. Does anyone help you to remember to take your pills?

Yes..... 1
No..... 2

8. Does anyone assist you with your medication regimen, such as counting pills or placing them in an organizer?

Yes..... 1
No..... 2

9. During the past two months, have you run out of any of your medications?

Yes..... 1
No..... 2

10. Are you having more problems now than you have had in the past with managing your medications?

Yes..... 1
No..... SKIP TO QUESTION 11..... 2

10a. (If yes) Please describe:

Telephone Questions

11. How often do you use the telephone? (Circle one number below)

Less than once per week..... 1
1 time per week..... 2
2-5 times per week..... 3
1 time per day..... 4
2-5 times per day..... 5
5-10 times per day..... 6
>10 times per day..... 7

12. Do you make mostly business related calls, mostly personal calls, or both?
(Circle one)

All business related calls..... 1
Mostly business related calls..... 2
About equal business related and personal calls..... 3
Mostly personal calls..... 4
All personal calls..... 5

13. How often do you use an address or phone book when making a telephone call? (Circle one)

Never.....	1
Rarely.....	2
Occasionally.....	3
Frequently.....	4
Very Frequently.....	5

14. Are you having more problems now than you have had in the past with making telephone calls?

Yes.....	1
No..... SKIP TO QUESTION 15.....	2

14a. (If yes) Please describe:

Finance Questions

15. Do you have a checking account?

Yes.....SKIP TO QUESTION 17.....	1
No.....	2

16. (If no) Have you ever had a checking account?

Yes.....	1
No.....	2

17. Do you/did you regularly balance your checkbook?

Yes.....SKIP TO QUESTION 19.....	1
No.....	2

18. (If no) Have you ever balanced a checkbook?

Yes.....	1
No.....	2

19. Do you know how to manage a checkbook?

Yes.....	1
No.....	2

20. Do/did you make errors in managing your checkbook?

Never.....	1
------------	---

Rarely.....	2
Sometimes.....	3
Often.....	4
I have never had a checking account.....	8

21. What type of errors do/did you usually make in managing your checkbook?

22. Do you have monthly utility bills (like phone, power, gas, internet)?

Yes.....SKIP TO QUESTION 24.....	1
No.....	2

23. Have you ever had monthly bills?

Yes.....	1
No.....	2

24. Do you pay your monthly bills in cash?

Yes.....SKIP TO QUESTION 26.....	1
No.....	2

25. (If no) Have you ever paid your bills in cash?

Yes.....	1
No.....	2

26. Does anyone assist you with managing your finances, such as organizing your money or paying your bills?

Yes.....	1
No.....	2

27. Are you having more problems now with managing your finances than you have had in the past?

Yes.....	1
No..... SKIP TO QUESTION 28.....	2

27a. (If yes) Please describe:

Cooking Questions

28. How often do you cook for yourself at home? *(Circle one number below)*

- 0-1 times per week..... 1
 2-5 times per week..... 2
 >5 times per week..... 3

29. What kinds of things do you usually make?

30. If 0-1 times per week: Have you ever cooked for yourself?

- Yes..... PLEASE ANSWER QUESTION 30A..... 1
 No..... PLEASE ANSWER QUESTION 30B..... 2

30a. If Yes: What kinds of things did you usually make?

30b. If No: Where did you get your meals?

31. Are you having more problems now with cooking than you have in the past?

- Yes..... 1
 No..... 2

32. What kinds of cooking problems are you having? *(Circle all that apply.)*

- Safety-related (leaving the gas on, leaving the stove on, getting distracted, etc.)..... 1
Timing-related (completing meal items at different times) 2
Physical problems (difficulty lifting pots and pans, trouble with coordination, fatigue). 3
Concentration problems (trouble staying on task, remembering what to do next)..... 4
Other (please describe: _____).... 5
Not having problems..... 8

Appendix H

Everyday Skills Survey

INSTRUCTIONS TO PARTICIPANTS: Below are several statements about activities that you might do in your everyday life. For each item, please circle the number that best describes how much you agree with the statement (e.g., 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree).

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I am an excellent cook.	1	2	3	4	5
2. If someone asked me to balance a checkbook, I would not feel competent to do so.	1	2	3	4	5
3. I am not very good at preparing meals.	1	2	3	4	5
4. I do not have trouble understanding medication instructions.	1	2	3	4	5
5. I am good at making telephone calls.	1	2	3	4	5
6. When I have to cook a meal, I get nervous.	1	2	3	4	5
7. I do a poor job at managing my financial paperwork.	1	2	3	4	5
8. I would feel on edge right now if I had to call a pharmacy to get a refill for a medication.	1	2	3	4	5
9. I would feel competent reading instructions for medications and then organizing them for the week.	1	2	3	4	5
10. I feel skilled at following a recipe to cook a meal.	1	2	3	4	5
11. I feel fine with making telephone calls to businesses.	1	2	3	4	5
12. I manage my finances without any problems.	1	2	3	4	5
13. If I was asked to put my medications into a medication organizer, I would not be very good at it.	1	2	3	4	5

14. I am good at balancing a checkbook.	1	2	3	4	5
15. I am not good about reading instructions on medications.	1	2	3	4	5
16. I do not feel comfortable making telephone calls.	1	2	3	4	5

References

- Albert, S. M., Marder, K., Dooneief, G., Bell, K., Sano, M., Todak, G. et al. (1995). Neuropsychologic impairment in early HIV infection: A risk factor for work disability. *Archives of Neurology*, 52, 525–530.
- Albert, S. M., Weber, C. M., Todak, G., Polanco, C., Clouse, R., McElhiney, M., et al. (1999). An observed performance test of medication management ability in HIV: Relation to neuropsychological status and medication adherence outcomes. *AIDS and Behavior*, 3, 121–128.
- Alderman, N., Burgess, P. W., Knight, C., & Henman, C. (2003). Ecological validity of a simplified version of the multiple errands shopping test. *Journal of the International Neuropsychological Society*, 9, 31-44.
- Alexander, G.E ., De Long, M. R., & Strick, P. L. (1986). Parallel organization of functionally segregated circuits linking basal ganglia and cortex. *Annual Review of Neuroscience*, 9, 357-381.
- Allain, P., Le Gall, D., Etcharry-Bouyx, F., Aubin, G., & Emile, J. (1999). Mental representation of knowledge following frontal lobe lesion: Dissociations on tasks using scripts. *Journal of Clinical and Experimental Neuropsychology*, 21, 643-665.
- American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., Text Revision). Washington, D.C.: American Psychiatric Association.
- Antinori, A., Arendt, G., Becker, J. T., Brew, B. J., Byrd, D. A., Cherner, M., et al. (2007). Updated research nosology for HIV-associated neurocognitive disorders. *Neurology*, 69, 1789-1799.
- Aylward, E. H., Henderer, J. D., McArthur, J. C., Brettschneider, P. D., Harris, G. J., Barta, P. E., et al. (1993). Reduced basal ganglia volume in HIV-1 associated dementia: Results from quantitative neuroimaging. *Neurology*, 43, 1892-1900.
- Baddeley, A. (1986). *Working memory*. Oxford: Clarendon Press.
- Bangsberg, D. R., Perry, S., Charlebois, E. D., Clark, R. A., Roberston, M., Zolopa, A. R., et al. (2001). Non-adherence to highly active antiretroviral therapy predicts progression to AIDS. *AIDS*, 15, 1181-1183.
- Beck, A. (1987). *Beck Depression Inventory*. San Antonio, TX: The Psychological Corporation.

- Beck, A. T., Steer, R. A., & Brown, G. K. (1996) *Manual for the Beck Depression Inventory-II*. San Antonio, TX: Psychological Corporation.
- Becker, J. T., Caldararo, R., Lopez, O. L., Dew, M. A., Dorst, S. K., Banks, G. (1995). Qualitative features of the memory deficit associated with HIV infection and AIDS: Cross-validation of a discriminant function classification scheme. *Journal of Clinical and Experimental Neuropsychology*, 17, 134-142.
- Becker, J. T., Sanchez, J., Dew, M. A., Lopez, O. L., Dorst, S. K., & Banks, G. (1997). Neuropsychological abnormalities among HIV-infected individuals in a community-based sample. *Neuropsychology*, 11, 592-601.
- Benedict, R. H. (1997). *Brief Visuospatial Memory Test - Revised*. Odessa, Florida: Psychological Assessment Resources, Inc.
- Benedict, R. H., Schretlen, D., Groninger, L., & Brandt, J. (1998). Hopkins Verbal Learning Test-Revised: Normative data and analysis of inter-form and test-retest reliability. *The Clinical Neuropsychologist*, 12, 43-55.
- Benton, L. A., Hamsher, K., & Sivan, A. B. (1994). Controlled Oral Word Association Test. *Multi-lingual Aphasia Examination* (3rd ed.). Iowa City, IA: AJA.
- Boghi, A., Rasetti, R., Avidano, F., Manzone, C., Orsi, L., D'Agata, F., et al. (2006). The effect of gender on planning: An fMRI study using the Tower of London task. *Neuroimage*, 33, 999-1010.
- Burgess, P. W. (2000). Strategy application disorder: The role of the frontal lobes in human multitasking. *Psychological Research*, 63, 279-288.
- Burgess, P. W., Alderman, N., Evans, J., Emslie, H., & Wilson, B. A. (1998). The ecological validity of tests of executive function. *Journal of the International Neuropsychological Society*, 4, 547-558.
- Burgess, P. W., Alderman, N., Forbes, C., Costello, A., Coates, L. M. A., Dawson, D. R., et al. (2006). The case for development and use of "ecologically valid" measures of executive function in experimental and clinical neuropsychology. *Journal of the International Neuropsychological Society*, 12, 194-209.
- Burgess, P. W., Veitch, E., de Lacy Costello, A., & Shallice, T. (2000). The cognitive and neuroanatomical correlates of multitasking. *Neuropsychologia*, 38, 848-863.
- Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research*. Boston: Houghton Mifflin Company.

- Carey, C. L., Woods, S. P., Gonzalez, R., Conover, E., Marcotte, T. D., Grant, I., et al. (2004). Predictive validity of global deficit scores for detecting neuropsychological impairment in HIV infection. *Journal of Clinical and Experimental Neuropsychology*, 26, 307-319.
- Carter, S., L., Rourke, S. B., Murji, S., Shore, D., & Rourke, B. P. (2003). Cognitive complaints, depression, medical symptoms, and their association with neuropsychological functioning in HIV infection: A structural equation model analysis. *Neuropsychology*, 17, 410-419.
- Channon, S. & Green, P. S. (1999). Executive function in depression: The role of performance strategies in aiding depressed and non-depressed participants. *Journal of Neurology, Neurosurgery, and Psychiatry*, 66, 162-171.
- Chaytor, N. and Schmitter-Edgecombe, M. (2003). The ecological validity of neuropsychological tests: a review of the literature on everyday cognitive skills. *Neuropsychology Review*, 13, 181-97.
- Cherner, M., Masliah, E., Ellis, R. J., Heaton, R. K., Marcotte, T. D., Moore, D. J., Grant, I., et al. (2002). Neurocognitive dysfunction during life predicts postmortem findings of HIV encephalitis. *Neurology*, 59, 1563-1567.
- Chesney, M. A., Ickovics, J. R., Chambers, D. B., Gifford, A. L., Neidig, J., Zwickl, B., et al. (2000). Self-reported adherence to antiretroviral medications in HIV clinical trials: The AACTG adherence instruments. Patient Care Committee & Adherence Working Group of the Outcomes Committee of the Adult AIDS Clinical Trials Group (AACTG). *AIDS Care*, 12, 255-266.
- Chevignard, M., Pillon, B., Pradat-Diehl, P., Taillefer, C., Rousseau, S., Le Bras, C., et al. (2000). An ecological approach to planning dysfunction: Script execution. *Cortex*, 36, 649-669.
- Cosentino, S., Chute, D., Libon, D., Moore, P., & Grossman, M. (2006). How does the brain support script comprehension? A study of executive processes and semantic knowledge in dementia. *Neuropsychology*, 20, 307-318.
- Crozier, S., Sirigu, A., Lehericy, S., van de Moortele, P. F., Pillon, B., Grafman, J., et al. (1999). Distinct prefrontal activations in processing sequence at the sentence and script level: An fMRI study. *Neuropsychologia*, 37, 1469-1476.
- Culbertson, W. C., & Zillmer, E. A. (1999). *The Tower of London, Drexel University, research version: Examiner's manual*. North Tonawanda, NY: Multi-Health Systems.

- Delis, D., Jacobson, M., Bondi, M., Hamilton, J. M., & Salmon, D. P. (2003). The myth of testing construct validity using factor analysis or correlations with normal or mixed populations: Lessons from memory assessment. *Journal of the International Neuropsychological Society*, 9, 936-946.
- Diehr, M. C., Cherner, M., Wolfson, T. J., Miller, S. W., Grant, I., Heaton, R. K., et al. (2003). The 50 and 100-item short forms of the Paced Auditory Serial Addition Task (PASAT): Demographically corrected norms and comparisons with the full PASAT in normal and clinical samples. *Journal of Clinical and Experimental Neuropsychology*, 25, 571-585.
- Donohue, J. M., & Pincus, H. A. (2007). Reducing the societal burden of depression: A review of economic costs, quality of care and effects of treatment. *Pharmacoeconomics*, 25, 7-24.
- Dreher, J. C., Koechlin, E., Tierney, M., & Grafman, J. (2008). Damage to the fronto-polar cortex is associated with impaired multitasking. *PLoS ONE*, 3, e3227.
- Durvasula, R. S., Miller, E. N., Myers, H. F., & Wyatt, G. E. (2001). Predictors of neuropsychological performance in HIV positive women. *Journal of Clinical and Experimental Neuropsychology*, 23, 149-163.
- Ellis, R. J., Hsia, K., Spector, S. A., Nelson, J. A., Heaton, R. K., Wallace, M. R., et al. (1997). Cerebrospinal fluid human immunodeficiency virus type 1 RNA levels are elevated in neurocognitively impaired individuals with acquired immunodeficiency syndrome. *Annals of Neurology*, 42, 679-688.
- Ellis, R. J., Moore, D. J., Childers, M. E., Letendre, S., McCutchan, J. A., Wolfson, T., et al. (2002). Progression to neuropsychological impairment in human immunodeficiency virus infection predicted by elevated cerebrospinal fluid levels of human immunodeficiency virus RNA. *Archives of Neurology*, 59, 923-928.
- Erdfelder, E., Faul, F., & Buchner, A. (1996). G*Power: A general power analysis program. *Behavior Research Methods, Instruments, & Computers*, 28, 1-11.
- Eslinger, P. J., & Damasio, A. (1985). Severe disturbances of higher cognition after bilateral frontal lobe ablation: Patient EVR. *Neurology*, 35, 1731-1741.
- Ettenhofer, M. L., Hinkin, C. H., Castellon, S. A., Durvasula, R., Ullman, J., Lam, M., et al. (2009). Aging, neurocognition, and medication adherence in HIV infection. *American Journal of Geriatric Psychiatry*, 17, 281-290.
- Evans, J. J., Chua, S., McKenna, P. J., & Wilson, B. A. (1997). Assessment of the dysexecutive syndrome in schizophrenia. *Psychological Medicine*, 27, 635-646.

- Farinpour, R., Miller, E. N., Satz, P., Selnes, O. A., Cohen, B. A., Becker, J. T., et al. (2003). Psychosocial risk factors of HIV morbidity and mortality: Findings from the Multicenter AIDS Cohort Study (MACS). *Journal of Clinical and Experimental Neuropsychology*, 25, 654-670.
- Garden, S. E., Phillips, L. H., & MacPherson, S. E. (2001). Midlife aging, open-ended planning, and laboratory measures of executive function. *Neuropsychology*, 15, 472-482.
- Giovannetti, T., Bettcher, B. M., Libon, D. J., Brennan, L., Sestito, N., & Kessler, R. K. (2007). Environmental adaptations improve everyday action performance in Alzheimer's disease: Empirical support from performance-based assessment. *Neuropsychology*, 21, 448-457.
- Gitlin, L., Corcoran, M., Winter, L., Boyce, A., & Hauk, W. (2001). A randomized, controlled trial of a home environmental intervention: Effect on efficacy and upset in caregivers and on daily function of persons with dementia. *The Gerontologist*, 41, 4-14.
- Gladysjo, J. A., Schuman, C. C., Evans, J. D., Peavy, G. M., Miller, S. W., & Heaton, R. K. (1999). Norms for letter and category fluency: Demographic corrections for age, education, and ethnicity. *Assessment*, 6, 147-178.
- Glass, J. D., Wesselingh, S. L., Selnes, O. A., & McArthur, J. C. (1993). Clinical neuropathologic correlation in HIV-associated dementia. *Neurology*, 43, 2230-2237.
- Godbout, L., & Doyon, J. (1995). Mental representations of knowledge following frontal lobe or postrolandic lesions. *Neuropsychologia*, 33, 1671-1696.
- Godbout, L., & Doyon, J. (2000). Defective representation of knowledge in Parkinson's Disease: Evidence from a script-production task. *Brain and Cognition*, 44, 490-510.
- Godbout, L., Cloutier, P., Bouchard C., Braun, C. M. J., & Gagnon S. (2004). Script generation following frontal and parietal lesions. *Journal of Clinical and Experimental Neuropsychology*, 26, 857-873.
- Golden, C. J. (1978). *Stroop Color and Word Test*. Chicago: Stoelting.
- Gonzalez, R., Heaton, R. K., Moore, D. J., Letendre, S., Ellis, R. J., Wolfson, T., et al. (2003). Computerized reaction time battery versus a traditional neuropsychological battery: Detecting HIV-related impairments. *Journal of the International Neuropsychological Society*, 9, 64-71.

- Gouveia, P. A., Brucki, S. M., Malheiros, S. M., & Bueno, O.F. (2007). Disorders in planning and strategy application in frontal lobe lesion patients. *Brain and Cognition*, 63, 240-246.
- Grafman, J. (2002). The structured event complex and the human prefrontal cortex. In D. Stuss & R. Knight (Eds.), *Principles of frontal lobe function* (pp. 196-230). New York: Guilford Press.
- Grafman, J. (1995). Similarities and distinctions among current models of prefrontal cortical functions. In J. Grafman, K. J. Holyoak, and F. Boller (Eds.), *Structure and functions of the human prefrontal cortex*. New York: New York Academy of Sciences.
- Grafman, J., Thompson, K., Weingartner, H. Martinez, R., Lawlor, B. A., & Sunderland, T. (1991). Script generation as an indicator of knowledge representation in participants with Alzheimer's disease. *Brain and Language*, 40, 344-358.
- Grant, I., Atkinson, J. H., Hesselink, J. R., Kennedy, C. J., Richman, D. D., Spector, S. A., et al. (1987). Evidence for early central nervous system involvement in the acquired deficiency syndrome (AIDS) and other human immunodeficiency virus (HIV) infections. Studies with neuropsychologic testing and magnetic resonance imaging. *Annals of Internal Medicine*, 107, 828-836.
- Gronwall, D. M. A. (1977). Paced auditory serial-addition task: A measure of recovery from concussion. *Perceptual and Motor Skills*, 44, 367-375.
- Gronwall, D., & Sampson, H. (1974). *The psychological effects of concussion*. Auckland, New Zealand: Auckland University Press.
- Gur, R. C., Alsop, D., Glahn, D., Petty, R., Swanson, C. L., Maldjian, J. A., et al. (2000). An fMRI study of sex differences in regional activation to a verbal and a spatial task. *Brain and Language*, 74, 157-170.
- Heaton, R. K., Grant I., Butters, N., White, D. A., Kirson, D., Atkinson, J. H., et. al. (1995). The HNRC 500- Neuropsychology of HIV infection at different disease stages. *Journal of the International Neuropsychological Society*, 1, 231-251.
- Heaton, R. K., Grant, I., & Matthews, C. G. (1991). *Comprehensive norms for an expanded Halstead-Reitan Battery: Demographic corrections, research findings, and clinical applications*. Odessa, FL: Psychological Assessment Resources.
- Heaton, R. K., Kirson, D., Velin, R. A., Grant, I., & the HNRC Group. (1994a). The utility of clinical ratings for detecting cognitive change in HIV infection. In I. Grant & A. Martin (Eds.), *Neuropsychology of HIV infection* (pp. 188-206). New York: Oxford University Press.

- Heaton, R. K., Marcotte, T. D., Mindt, M. R., Sadek, J., Moore, D. J., Bentley, H., et al. (2004). The impact of HIV-associated neuropsychological impairment on everyday functioning. *Journal of the International Neuropsychological Society*, *10*, 317-331.
- Heaton, R. K., Marcotte, T. D., White, D. A., Ross, D., Meredith, K., Taylor, M. J., et al. (1996). Natural and vocational significance of neuropsychological impairment associated with HIV infection. *The Clinical Neuropsychologist*, *10*, 1-14.
- Heaton, R. K., Taylor, M. J., & Manly, J. J. (2002). Demographic effects and use of demographically corrected norms with the WAIS-III and WMS-III. In D. Tulsky, D. Saklofske, R. K. Heaton, G. Chelune, R. Ivnik, R. A. Bornstein, A. Prifitera, & M. Ledbetter (Eds.) *Clinical Interpretation of the WAIS-III and WMS-III* (pp. 183-210). San Diego, CA: Academic Press.
- Heaton, R. K., Velin, R. A., McCutchan, J. A., Gulevich, S. J., Atkinson, J. H., Wallace, M. R., et al. (1994b). Neuropsychological impairment in human immunodeficiency virus-infection: Implications for employment. *Psychosomatic Medicine*, *56*, 8-17.
- Hewitt, J., Evans, J. J., & Dritschel, B. (2006). Theory driven rehabilitation of executive functioning: Improving planning skills in people with traumatic brain injury through the use of an autobiographical episodic memory cueing procedure. *Neuropsychologia*, *44*, 1468-1474.
- Hinkin, C. H., Castellon, S. A., Durvasula, R. S., Hardy, D. J., Lam, M. N., Mason, K. I., et al. (2002). Medication adherence among HIV+ adults: Effects of cognitive dysfunction and regimen complexity. *Neurology*, *59*, 1944-1950.
- Hinkin, C. H., Hardy, D. J., Mason, K. I., Castellon, S. A., Durvasula, R. S., Lam, M. N., et al. (2004). Medication adherence in HIV-infected adults: Effect of patient age, cognitive status, and substance abuse. *AIDS*, *18*(Suppl. 1), S19-S25.
- Jernigan, T. L., Archibald, S., Hesselink, J. R., Atkinson, J. H., Velin, R. A., McCutchan, J. A., et al. (1993). Magnetic resonance imaging morphometric analysis of cerebral volume loss in human immunodeficiency virus infection. *Archives of Neurology*, *50*, 250-255.
- Joyce, G. F., Chan, K. S., Orlando, M., & Burnam, M. A. (2005). Mental health status and use of general medical services for persons with human immunodeficiency virus. *Medical Care*, *43*, 834-839.

- Katz, N., Tadmor, I., Felzen, B., & Hartman-Maeir, A. (2007). The Behavioural Assessment of the Dysexecutive Syndrome (BADS) in schizophrenia and its relation to functional outcomes. *Neuropsychological Rehabilitation, 17*, 192-205.
- Kessler, R. C., Merikangas, K. R., & Wang, P. S. (2007). Prevalence, comorbidity, and service utilization for mood disorders in the United States at the beginning of the twenty-first century. *Annual Review of Clinical Psychology, 3*, 137-158.
- Kløve, H. (1963). *Grooved Pegboard*. Lafayette, IN: Lafayette Instruments.
- Knutson, K. M., Wood, J. N., & Grafman, J. (2004). Brain activation in processing temporal sequence: An fMRI study. *NeuroImage, 23*, 1299-1307.
- Kongs, S. K., Thompson, L. L., Iverson, G. L., & Heaton, R. K. (2000). *Wisconsin Card Sorting Test - 64 Card Computerized Version*. Odessa, FL: Psychological Assessment Resources.
- Krabbendam, L., De Vugt, M. E., Deriz, M. M. A., & Jolles, J. (1999). The Behavioral Assessment of the Dysexecutive Syndrome as a tool to assess executive function in schizophrenia. *The Clinical Neuropsychologist, 13*, 370-375.
- Langford, T. D., Everall, I. P., & Masliah, E. (2005). Current concepts in HIV neuropathogenesis: Neuronal injury, white matter disease, and neurotrophic factors. In H.E. Gendelman, I. Grant, I.P. Everall, S.A. Lipton, & S. Swindells (Eds.), *The neurology of AIDS* (2nd ed.), pp. 405-414. New York: Oxford University Press.
- Lawton, M. P., & Brody, E. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *Gerontologist, 9*, 179-186.
- Levine, B., Stuss, D. T., Milberg, W. P., Alexander, M. P., Schwartz, M., & McDonald, R. (1998). The effect of focal and diffuse brain damage on strategy application: Evidence from focal lesions, traumatic brain injury, and normal aging. *Journal of the International Neuropsychological Society, 4*, 247-264.
- Lezak, M. D. (1995). *Neuropsychological assessment*. New York: Oxford University Press.
- Liu, H., Colin, A. E., Miller, L. G., Hays, R. D., Beck, K., Sanandaji, A., et al. (2001). A comparison study of multiple measures of adherence to HIV protease inhibitors. *Annals of Internal Medicine, 134*, 968-977.
- Lovejoy, T. I., & Suhr, J. A. (in press). The relationship between neuropsychological functioning and HAART adherence in HIV-positive adults: A systematic review. *Journal of Behavioral Medicine*.

- Lowenstein, D. A., & Bates, B. C. (1992). *Manual for administration and scoring the Direct Assessment of Functional Status scale for older adults (DAFS)*. Miami Beach, FL: Mount Sinai Medical Center.
- Marcotte, T. D., Deutsch, R., McCutchan, J. A., Moore, D. J., Letendre, S., Ellis, R. J., et al. (2003). Prediction of incident neurocognitive impairment by plasma HIV RNA and CD4 levels early after HIV seroconversion. *Archives of Neurology*, 60, 1406-1412.
- Marcotte, T. D., Heaton, R. K., and Albert, S. (2005). Everyday impact of HIV-associated neurocognitive disorders. In H. E. Gendelman, I. Grant, S. Swindells, I. Everall and S. A. Lipton (Eds.), *The neurology of AIDS* (2nd ed., pp. 743-752). New York: Oxford University Press.
- Marcotte, T. D., Heaton, R. K., Reicks, C., Gonzalez, R., Grant, I., & the HNRC Group (2000). HIV-related neuropsychological impairment and automobile driving [Abstract]. *Journal of the International Neuropsychological Society*, 6, 233.
- Marcotte T. D., Heaton, R. K., Wolfson, T., Taylor, M. J., Alhassoon, O., Arfaa, K., et al. (1999). The impact of HIV-related neuropsychological dysfunction on driving behavior. *Journal of the International Neuropsychological Society*, 5, 579-592.
- Marcotte, T. D., Wolfson, T., Rosenthal, T. J., Heaton, R. K., Gonzalez, R., Ellis, R. J., et al. (2004). A multimodal assessment of driving performance in HIV infection. *Neurology*, 63, 1417-1422.
- Martin, E. M., Sullivan, T. S., Reed, R. A., Fletcher, T. A., Pitrak, D. L., Weddington, W., et al. (2001). Auditory working memory in HIV-1 infection. *Journal of the International Neuropsychological Society*, 7, 20-26.
- Masliah, E., Heaton, R. K., Marcotte, T. D., Ellis, R. J., Wiley, C. A., Mallory, M., et al. (1997). Dendritic injury is a pathological substrate for human immunodeficiency virus-related cognitive disorders. *Annals of Neurology*, 42, 963-972.
- Mauskopf, J. A., Simon, G. E., Kalsekar, A., Nimsch, C., Dunayevich, E., & Cameron, A. (2009). Nonresponse, partial response, and failure to achieve remission: Humanistic and cost burden in major depressive disorder. *Depression and Anxiety*, 26, 83-97.
- McKibbin, C. L., Brekke, J. S., Sires, D., Jeste, D. V., & Patterson, T. L. (2004). Direct assessment of functional abilities: Relevance to persons with schizophrenia. *Schizophrenia Research*, 72, 53-67.

- McNair, D. M., Loo, M., & Droppleman, L. F. (1981). *Profile of Mood States*. San Diego, CA: Educational and Industrial Testing Service.
- Moore, D. J., Masliah, E., Rippeth, J. D., Gonzalez, R., Carey, C. L., Cherner, M., et al. (2006). Cortical and subcortical neurodegeneration is associated with HIV neurocognitive impairment. *AIDS*, 20, 879-887.
- Murji, S., Rourke, S. B., Donders, J., Carter, S. L., Shore, D., & Rourke, B. P. (2003). Theoretically derived CVLT subtypes in HIV-1 infection: Internal and external validation. *Journal of the International Neuropsychological Society*, 9, 1-16.
- Norman, D. A., & Shallice, T. (1986). Attention to action: Willed and automatic control of behavior. In G.E. Schwartz and D. Shapiro (Eds.), *Consciousness and self-regulation*. New York: Plenum Press.
- Partiot, A., Grafman, J., Sadato, N., Wachs, J., & Hallett, M. (1995). Brain activation during the generation of non-emotional and emotional plans. *Neuroreport*, 6, 1397-1400.
- Partiot, A., Grafman, J., Sadato, N., Flitman, S., & Wild, K. (1996). Brain activation during script event processing. *Neuroreport*, 7, 761-766.
- Patterson, T. L., Goldman, S., McKibbin, C. L., Hughs, T., & Jeste, D. V. (2001). UCSD performance based skills assessment: Development of a new measure of everyday functioning for severely mentally ill adults. *Schizophrenia Bulletin*, 27, 235-245.
- Piatt, A. L., Fields, J. A., Paolo, A. M., & Tröster A. I. (1999). Action (verb naming) fluency as an executive function measure: Convergent and divergent evidence of validity. *Neuropsychologia*, 37, 1499-1503.
- Psychological Corporation. (1997). *Wechsler Adult Intelligence Scale – Third Edition*. San Antonio, TX: Author.
- Reger, M., Welsh, R., Razani, J., Martin, D. J., & Boone, K. B. (2002). A meta-analysis of the neuropsychological sequelae of HIV infection. *Journal of the International Neuropsychological Society*, 8, 410-424.
- Reitan, R. M. (1979). *Manual for administration of neuropsychological test batteries for adults and children*. Tucson, AZ: Reitan Neuropsychological Laboratory.
- Reitan, R. M., & Wolfson, D. (1993). *The Halstead-Reitan Neuropsychological Test Battery: Theory and clinical interpretation*. Tucson, AZ: Neuropsychology Press.

- Rosen, V. M., Caplan, L., Sheesley, L., Rodriguez, R., & Grafman, J. (2003). An examination of daily activities and their scripts across the adult lifespan. *Behavior Research Methods, Instrument, & Computers*, 35, 32-48.
- Sadek, J. R., Vigil, O., Grant, I., & Heaton, R. K. (2007). The impact of neuropsychological functioning and depressed mood on functional complaints in HIV-1 infection and methamphetamine dependence. *Journal of Clinical and Experimental Neuropsychology*, 29, 266-276.
- Sbordone, R. J., & Long, C. J. (Eds.). (1996). *Ecological Validity of Neuropsychological Testing*. Florida, USA: Gr. Press/St Lucie Press, Inc.
- Scott, J. C., Woods, S. P., Patterson, K. A., Morgan, E. E., Heaton, R. K., Grant, I., et al. (2006). Recency effects in HIV-associated dementia are characterized by deficient encoding. *Neuropsychologia*, 44, 1336-1343.
- Shallice, T. (1982). Specific impairments of planning. *Philosophical Transactions of the Royal Society of London*, 298, 199-209.
- Shallice, T. (1988). *From Neuropsychology to mental structure*. Cambridge: Cambridge University Press.
- Shallice, T., & Burgess, P. W. (1991). Deficits in strategy application following frontal lobe damage in man. *Brain*, 114, 727-741.
- Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin*, 86, 420-428.
- Sirigu, A., Zalla, T., Pillon, B., Grafman, J., Agid, Y., & Dubois, B. (1995). Selective impairments in managerial knowledge following pre-frontal cortex damage. *Cortex*, 31, 301-316.
- Starace, F., Ammassari, A., Trotta, M. P., Murri, R., De Longis, P., Izzo, C., et al. (2002). Depression is a risk factor for suboptimal adherence to highly active antiretroviral therapy. *Journal of Acquired Immune Deficiency Syndromes*, 31, S136-139.
- Stout, J. C., Ellis, R. J., Jernigan, T. L., Archibald, S. L., Abramson, I., Wolfson, T., et al. (1998). Progressive cerebral volume loss in human immunodeficiency virus infection: A longitudinal volumetric magnetic resonance imaging study. *Archives of Neurology*, 55, 161-168.
- Thoma, P., Koch, B., Heyder, K., Schwarz, M., & Daum, I. (2008). Subcortical contributions to multitasking and response inhibition. *Behavioural Brain Research*, 194, 214-222.

- Van Beilen, M., Withaar, F. K., van Zomeren, E. H., van den Bosch, R. J., & Bouma, A. (2006). Deviant strategy on the Six Elements Test in patients with schizophrenia. *The Clinical Neuropsychologist*, 20, 469-479.
- Van Gorp, W. Z. G., Baerwald, J. P., Ferrando, S. J., McElhiney, M. C., & Rabkin, J. G. (1999). The relationship between employment and neuropsychological impairment in HIV infection. *Journal of the International Neuropsychological Society*, 5, 534-39.
- Wensing, A. M., van de Vijver, D. A., Angarano, G., Asjo, B., Balotta, C., Boeri, E., et al. (2005). Prevalence of drug-resistant HIV-1 variants in untreated individuals in Europe: Implications for clinical management. *Journal of Infectious Disease*, 192, 958-966.
- Wilkinson, G. S. (1993). *Wide Range Achievement Test administration manual* (3rd ed.). Wilmington, DE: Wide Range, Inc.
- Wilkinson, G. S., & Robertson, G. J. (2006). *Wide Range Achievement Test professional manual* (4th ed.). Lutz, FL: Psychological Assessment Resources.
- Woods, S. P., Carey, C. L., Tröster, A. I., Grant, I., & The HNRC Group. (2005). Action (verb) generation in HIV-1 infection. *Neuropsychologia*, 43, 1144-1151.
- Woods, S. P., Dawson, M. S., Weber, E., Gibson, S., Grant, I., & Atkinson, J. H. (2009). Timing is everything: Antiretroviral nonadherence is associated with impairment in time-based prospective memory. *Journal of the International Neuropsychological Society*, 15, 42-52.
- Woods, S. P., & Grant, I. (2005). Neuropsychology of HIV. In H.E. Gendelman, I. Grant, I.P. Everall, S.A. Lipton, & S. Swindells (Eds.), *The neurology of AIDS* (2nd ed., pp. 607-616). New York: Oxford University Press.
- Woods, S. P., Iudicello, J. E., Moran, L. M., Carey, C. L., Dawson, M. S., & Grant, I. (2008). HIV-associated prospective memory increases risk of dependence in everyday functioning. *Neuropsychology*, 22, 110-117.
- Woods, S. P., Morgan, E. E., Dawson, M., Scott, J. C., Grant, I., & The HNRC Group. (2006). Action (verb) fluency predicts dependence in instrumental activities of daily living in persons infected with HIV-1. *Journal of Clinical and Experimental Neuropsychology*, 28 (Suppl. 1), 1030-1042.
- Woods, S. P., Rippeth, J. D., Frol, A. B., Hinkin, C. H., Levy, J. K., Ryan, E., et al. (2004). Interrater reliability of clinical ratings and neurocognitive diagnoses in HIV. *Journal of Clinical and Experimental Neuropsychology*, 26, 759-778.

- Zalla, T., Plaissiat, C., Pillon, B., Grafman, J., & Sirigu, A. (2001). Action planning in a virtual context after prefrontal cortex damage. *Neuropsychologia*, 39, 759-770.
- Zalla, T., Sirigu, A., Pillon, B., Dubois, B., Agid, Y., & Grafman, J. (2000). How patients with Parkinson's disease retrieve and manage cognitive event knowledge. *Cortex*, 36, 163-179.
- Zalla, T., Sirigu, A., Pillon, B., Dubois, B., Grafman, J., & Agid, Y. (1998). Deficit in evaluating pre-determined sequences of script events in patients with Parkinson's disease. *Cortex*, 34, 621-627.
- Zweig, M. H., & Campbell, G. (1993). Receiver-operating characteristic (ROC) plots: A fundamental evaluation tool in clinical medicine. *Clinical Chemistry*, 39, 561-577.