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Elements of attention in HIV-infected adults: Evaluation of an existing model

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Abstract

Because of the multifactorial nature of neuropsychological tests, attention remains poorly defined from a neuropsychological perspective, and conclusions made regarding attention across studies may be limited due to the different nature of the measures used. Thus, a more definitive schema for this neurocognitive domain is needed. We assessed the applicability of Mirsky and Duncan's (2001) neuropsychological model of attention to a cohort of 104 HIV+ adults. Our analysis resulted in a five-factor structure similar to that of previous studies, which explained 74.5% of the variance. However, based on the psychometric characteristics of the measures comprising each factor, we offer an alternative interpretation of the factors. Findings also indicate that one factor, which is generally not assessed in clinical neuropsychology settings, may be more predictive of real-world behaviors (such as medication adherence) than those composed of traditional measures. Suggestions for further research in this important area are discussed.

Deficits in attention are a common consequence of HIV infection (Hardy & Hinkin, 2002; Heaton et al., 1995). The central importance of attentional deficits in the assessment of HIV-related cognitive changes was recognized early on by the NIMH Workshop on Neuropsychological Assessment Approaches, whose members recommended special emphasis on assessing divided and sustained attention as deficits in these abilities may be among the earliest signs of cognitive decline among those with HIV (Butters et al., 1990). Because such deficits may be early indicators of progressing neuropathology, neuropsychological assessment can alert clinicians to begin or alter treatment plans for their patients. Further, deficits in attention have functional significance for the individual, as they can affect capacity to maintain adequate adherence to antiretroviral medication (Hinkin et al., 2002; Levine et al., 2005), to drive (Marcotte et al., 2004), and to perform other activities of daily living (Heaton et al., 2004). Thus, a thorough assessment of attention is an essential component of the neuropsychological evaluation of those with HIV.

Relative to other neuropsychological constructs, such as memory and language, the nature and neuroanatomical substrates of attention are poorly understood. As a consequence, the definition, behavioral markers, and methods used to assess attention have not been well defined. Within the “neuroAIDS” field, two general approaches have been used to investigate

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attentional functioning. The first draws from cognitive psychology and utilizes information-processing measures to assess specific aspects of attention. In this conceptualization, attention, like memory, is not a single entity but a concept that includes a variety of distinct but categorically related processes (Parasuraman & Davies, 1984). Through this approach, deficits in HIV-infected adults have been shown in several attentional processes, such as divided attention (Hinkin, Castellon, & Hardy, 2000), visuospatial orienting (Martin, Sorensen, Robertson, Edelstein, & Chirurgi, 1992; Maruff et al., 1995), inhibiting a prepotent response (Martin et al., 1992), and preparatory processing (Law et al., 1995) (see Hardy & Hinkin, 2002, for review). The second, with its roots in clinical neuropsychology, considers attention as one of a number of distinguishable cognitive "domains." In this approach, various neuropsychological measures are grouped based upon a priori theoretical considerations. In the context of the current study, the greatest limitation of this approach has been the lack of consistency in the definition of attention and the measures used to assess it. This is largely due to an inherent limitation of most clinical neuropsychological tests—that is, their multifaceted nature. Unlike most measures used in the cognitive psychology approach, neuropsychological measures usually require multiple cognitive abilities for successful performance. This was demonstrated in the often-cited study by Heaton et al. (1995), in which the investigators used a number of such multifaceted, traditional neuropsychological measures in creating their "Attention Domain," including Digit Span, Arithmetic, Seashore Rhythm, Speech Sounds, Digit Vigilance Test (time and errors), and Paced Auditory Serial Addition Test (PASAT). In that study, the authors conducted a principal components analysis (PCA) on the dataset in order to determine the underlying factors common among their various measures. Their analysis revealed two factors believed to be related to attention: "Attention/Speed of Processing" (with highest factor loadings from Digit Symbol, Digit Vigilance time, Trails Making Test Parts A & B) and "Attention/Working Memory" (with highest factor loadings from Digit Span). That study revealed an important limitation with the domain approach—namely, that attentional factors do not necessarily overlap well with predefined domains. Despite this, researchers using traditional neuropsychological measures continue to use the domain approach. The variety of tests comprising attention domains across a sampling of neuropsychological studies is summarized in Table 1. As shown in that table, there is a wide range of measures used to assess attention in the neuroAIDS field. The obvious drawback of this is that conclusions made regarding attention may be limited to the measures used or confounded by various other cognitive processes required by each of the measures. The ultimate consequence is that the effects of HIV upon attention remain unclear.

In an effort to identify discrete attentional elements, Mirsky, Anthony, Duncan, Ahearn, and Kellam (1991) used exploratory factor analysis to uncover underlying similarities among a variety of commonly used neuropsychological measures, resulting in a multicomponent model of attention. In the original study, four factors were found that explained approximately 80% of the variance across tests. The factors and their functions were described as follows: (a) *focus/execute*, which is the capacity to selectively attend to a stimuli and execute responses required by the task; (b) *encode*, the ability to briefly maintain information in memory; (c) *shift*, or the capacity to shift focus from one stimulus to another; and (d) *sustain*, the capacity to maintain focus for appreciable length of time. Since that initial study, other researchers have found similar factor structures based on a comparable battery of tests. This has been the case across healthy individuals as well as patients with a variety of neurologic and psychiatric illnesses (Kelly, 2000; Kremen, Seidman, Faraone, Pepple, & Tsuang, 1992; Mirsky & Duncan, 2001; Pogge, Stokes, & Harvey, 1994), although some have found somewhat disparate results when alternative analytic methods were used (Strauss, Thompson, Adams, Redline, & Burant, 2000). More recently, Mirsky and Duncan (2001) reported a five-factor model of attention, with the addition of a *stabilize* factor consisting of variables from a continuous performance task (CPT) that are related to consistency of responding over time. Recently, our group reported findings of CPT performance among a cohort of HIV+ adults, many of whom were stimulant

abusers (Levine et al., 2006). It was found that only certain variables from the CPT, similar to those that comprised Mirsky's *stabilize* element, were able to discriminate drug users from nonusers. Specifically, the stimulant users had higher rates of omissions and reaction time variability, but these rates did not diverge from those of the nonusers until two or more minutes into the task. Therefore, shorter tasks, such as many traditional clinical neuropsychological measures used to assess attention, would have missed these differences. Further, the groups did not differ on other measures of attention, suggesting that the CPT captures a component of attention (i.e., sustained attention) often not assessed by traditional measures used in current batteries. Finally, data from our laboratory indicate that an attentional factor with high loading from CPT variables is more strongly associated with outcome measures such as medication adherence than are factors of attention composed of other neuropsychological measures. Thus, it behoves clinicians and researchers who work with HIV+ individuals to understand what attentional measures are assessing and to what degree they relate to real-world outcomes.

In the current study, we assessed the validity of Mirsky's model of attention among a cohort of HIV+ adults, many of whom were stimulant (cocaine and methamphetamine) users. The growing prevalence of HIV among stimulant users calls for examining the attentional deficits in this population as such deficits are apparently exacerbated by concomitant drug abuse (Levine et al., 2006; Rippeth et al., 2004). Mirsky's methodology has not been applied to a similar population to the best of our knowledge. Thus, we examined (a) whether similar factors to those in previous studies would emerge in our HIV-infected cohort and (b) the association of such factors with demographic characteristics, virologic factors, and functional measures (e.g., adherence and verbal IQ).

METHOD

Participants

The sample consisted of 104 HIV-infected adults recruited from the Los Angeles area. Participants were enrolled in a longitudinal study examining factors associated with medication adherence among HIV-infected adults. All participants were taking antiretroviral medication, with adherence monitored via the Medication Event Monitoring System, or MEMS cap (Aprex, Union City, CA). Overall adherence rate was expressed as a percentage of prescribed doses taken, according to MEMS cap data. A total of 66 participants (64%) met the Centers for Disease Control (CDC) diagnostic criteria for AIDS (CDC, 1994). Average age in years at study onset was 40.9 (*SD*=7.4), and average education was 13.1 (*SD*=1.9) years. A total of 17 (16.3%) participants were female. The sample was ethnically diverse, with 56% African American, 22% Caucasians, 15% Hispanics, 4% Asian or Native American, and 3% multiracial. Viral load was obtained via blood samples. Of the 104 participants, 23 were diagnosed with current stimulant use disorders (cocaine or amphetamine), and 50 with past only, according to DSM-IV diagnoses (Spitzer, Williams, Gibbon, & First, 1992). A total of 31 participants had neither past nor current stimulant use disorders. In addition, self-reported CD4 was obtained from participants. Demographic, behavioral, and virologic characteristics of the sample are shown in Table 2. History of the following medical conditions precluded participation in the study: significant head trauma with loss of consciousness greater than 1 hour, brain-related opportunistic infection (e.g., cryptococcal meningitis, progressive multifocal leukoencephalopathy, and toxoplasmosis), and psychosis. Participants were not excluded if they were current drug users; however, participants were asked to return another time if they were intoxicated at the time of testing as determined via self-report and clinical observation.

Measures

As part of the study protocol, all participants underwent a psychodiagnostic interview and neuropsychological testing. The former consisted of the Structured Clinical Interview based on the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders, or SCID (Spitzer et al., 1992). Mood, psychotic disorders, and drug use modules were administered. Mood was also assessed with the Beck Depression Inventory, Second Edition (BDI-II; Beck, Steer, & Brown, 1996). Neuropsychological testing consisted of a comprehensive battery of standardized instruments described elsewhere (Hinkin et al., 2002). For the purposes of the current study, we list in Table 3 those measures from our battery that were used in the statistical factor analysis. In addition, in order to characterize our sample's cognitive ability relative to the general population, a Global Neuropsychological Score for each participant was obtained by averaging *T*-scores across all tests. Demographically corrected *T*-scores for all measures were obtained through published normative data. In addition, all participants were administered the Conners' Continuous Performance Test, Second Edition (CPT-II; Conners, 2000), a computerized vigilance test in which the examinee must press a button whenever they see a letter appear on a computer screen, with the exception of the target letter (X). Specific procedures for this measure were described in a previous paper (Levine et al., 2006). For the purposes of this study, we were interested in the following variables: reaction time, variations in performance over time, rates of omission errors (i.e., false negatives), and rates of commission errors (i.e., false positives). *T*-scores for these variables were generated by the CPT software based on a normative sample. Finally, a verbal IQ estimate was obtained with the American New Adult Reading Test, or AMNART (Grober & Sliwinski, 1991).

Statistical analysis

A principal components analysis with promax rotation was used to explore the factor structure of our attention measures. These measures are listed in Table 3 and overlap considerably with those of Mirsky and Duncan (2001). An eigenvalue cutoff of 1 was the criterion for inclusion as a factor in the final model. The resulting factors were then saved as variables for additional analyses. Pearson's bivariate correlations were determined between the factors and a number of demographic, behavioral, and cognitive variables in order to determine the contribution of the obtained attention elements.

RESULTS

Five factors with eigenvalues greater than 1 were found to explain a cumulative total of 74.5% of variance. The factors structure is presented in Table 4. The factor structure derived from our sample is very similar to that of Mirsky and Duncan (2001). That is, similar measures loaded on similar factors when compared to their model. Factor 1, interpreted by Mirsky as the *focus/ execute* element, included high loadings from both forms of the Trail Making Test, Symbol Search, Digit Symbol, and Stroop Interference and explained a total of 28.4% of the variance. Factor 2, Mirsky's *encode* element, included Digit Span, Letter–Number Sequencing, and the PASAT, explaining a total of 13.7% of the variance. Factor 3, considered the *switch* element by Mirsky, included the Wisconsin Card Sorting Test (WCST) variables and explained 10.8% of the variance. Factor 4, Mirsky's *stabilize* element, included the CPT variables of total omissions and overall variability, explaining 11.8% of the variance. Finally, Factor 5, or *sustain* in Mirsky's schema, included CPT variables of total commissions and hit reaction time, explaining 9.8% of the variance. Total number of commission errors was negatively correlated with Factor 5, indicating that faster reaction time was associated with greater rate of false positive responses.

Pearson's bivariate correlations revealed a number of modest, positive correlations (Table 5). Factor 4 (sustain) was significantly associated with medication adherence (R=.26, p=.01).

Factors 1 and 2 (focus/execute and encode) were associated with education (R=.21, p=.04, R=.27, p=.01, respectively), while age was negatively associated with Factor 3 (switching; R=.20, p=.04). Estimated verbal IQ had its strongest relationship with Factor 2 (R=.58, $p < .001$) and was also correlated with Factors 1 (R=.26, p=.01) and 4 (R=.26, p=.01). Finally, the BDI was correlated with Factor 5 (R=.21, p=.04).

DISCUSSION

In the current study, we examined the factor structure of a battery of neuropsychological tests commonly conceptualized as attention measures. Our aims were to assess the applicability of an existing multielement model of attention in a sample of HIV-infected adults, many of whom were drug users, and to determine whether the individual derived factors were associated with a variety of cognitive, behavioral, and virologic variables. This was the first time the model described by Mirsky and colleagues (1991) has been applied to an HIV+ population.

The factor structure based on our data is very similar to that described by Mirsky and Duncan (2001) and others (Kelly, 2000; Kremen et al., 1992; Mirsky & Duncan, 2001; Pogge et al., 1994), in that there were similar loadings of the measures across factors. Five factors resulted from our PCA. The first, similar to the *focus/execute* element described by Mirsky, consisted primarily of measures requiring speeded visual processing and some type of cognitive operation, such as form discrimination (Symbol Search), visuomotor integration (Digit Symbol), and response inhibition (Stroop Interference). Whether or not *focus* and *execute* are accurate descriptors for the underlying similarity among these measures is open to debate. In this case, the interpretation difficulty of such a factor is not due to the multifactorial nature of attention, as tasks with specific processing demands can assess specific aspects of attention. Rather, as mentioned before, the difficulty lies in the multifactorial nature of these tests. Without good (or any) control conditions, it can be tricky to ascertain what links a group of test measures. Perhaps *visual processing speed* would be a more accurate characterization for this factor, as it was only timed visual measures that comprised this factor. Thus, all measures on this factor shared in common a visual stimulus and administration under the pressure of time. However, CPT reaction time, which also presumably reflects visual processing speed, did not load on this factor. This could be due to the difference in cognitive demands between the CPT and the other measures.

Factor 2, called *encode* by Mirsky and others, consisted exclusively of verbal tests. These tests required working-memory ability, as well as maintenance of information in a temporary buffer. Such buffers have been called a phonological loop in the past (Baddeley, 2001). Therefore, it is conceivable that this factor could be considered one of *working memory* and/or *basic auditory attention*. Indeed, as shown in Table 1, there is a trend among researchers in recent years to include some of the tests that comprised this measure in an “attention/working memory” domain. Thus, according to our results, this domain label may be accurate.

It is important to point out that the inherent characteristics of the tests that comprised Factors 1 and 2 (i.e., visual vs. auditory) may be the primary reason that they appear as different factors. In other words, it may be that the sensory modalities through which these tests are successfully completed are the underlying “factors.” It will be necessary to include cross-modality tests in order to investigate this problem. For example, including a spatial span test, considered to be one of basic attention and working memory, will help determine the nature of these factors.

Factor 3, Mirsky's *switch* element, was composed solely of the WCST variables, consistent with the previous studies cited above. Switching is synonymous with alternating attention and requires the ability to disengage from one stimulus or mental set and to reengage in another. However, this is an ability that is arguably necessary for successful performance on measures

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such as Part B of the Trail Making Test. This measure did not load at all on Factor 3. Therefore, it is possible that this factor is reflecting some other ability inherent to the WCST. The WCST itself is a highly complex test with a number of underlying factors according to a recent study (Greve, Stickle, Love, Bianchini, & Stanford, 2005). Thus, it will be necessary to include additional, yet more simple, measures of set shifting in future analyses to confirm the validity of this as the *switch* factor.

Factor 4, equivalent to Mirsky's *stabilize*, was comprised of variability and omission variables of the CPT. Based upon the definition provided by Parasuraman and Davies (1984), this appears consistent with sustained attention, or vigilance. This element is of special interest, because it is not commonly assessed psychometrically in neuropsychological evaluations per their definition. Furthermore, common everyday tasks (e.g., driving) require vigilance in addition to other aspects of attention. We have recently shown the importance of the CPT in providing additional information regarding attentional functioning in those with HIV (Levine et al., 2006). Looking specifically at sustained attention among HIV+ individuals, stimulant users were found to have a greater numbers of omission errors and variability in reaction time than had non-drug-users, indicative of impaired sustained attention. No difference was found on a general global neuropsychological ability rating or, importantly, on other tests comprising the attention domain between the groups. That finding underscores the importance of a multifaceted assessment of attention.

Finally, Factor 5 was composed of reaction time and commission errors from the CPT. Not surprisingly, the faster the reaction time in our sample, the greater number of commission errors. This factor was termed *sustain* by Mirsky and Duncan (2001), and was described as the capacity to maintain a “vigilant attitude” over time. This is differentiated from CPT variables that comprise the *stabilize* factor, which indicates “consistency or stability with which a person can respond to a designated target stimulus.” Arguably, these are actually two aspects of sustained attention, or vigilance, as defined by Parasuraman and Davies (1984). According to their definition, sustained attention is the ability to maintain a certain level of performance, especially in the ability to detect the occurrence of infrequent or unpredictable events over extended periods of time. Further, demonstration of a vigilance problem requires an interaction among task conditions, such as an incremental decline in response speed or accuracy over time. Therefore, both the *stabilize* and *sustain* elements from Mirsky's model (Factors 4 and 5 in our analysis, respectively) may be considered aspects of sustained attention, as both are important for determining a vigilance problem. Alternatively, Factor 5 may also be a reflection of impulsivity, response style (d'), or simply reaction time.

The factors had modest correlations with demographic and behavioral measures. Verbal IQ, as estimated via a reading task, had the strongest correlation with Factor 2. That verbal IQ would be related to Factor 2 is not unexpected considering that it was composed exclusively of verbal tests (Digit Span, PASAT, and Letter–Number Sequencing). Estimated verbal IQ was also mildly associated with Factors 1 and 4. One functional outcome variable, medication adherence, was associated with Factor 4, considered by the authors to reflect sustained attention. Individuals with greater adherence, expressed as a high percentage of prescribed doses that were taken over the course of a 6-month study according to the MEMS cap data, performed with less variability and fewer omission errors on the CPT. Thus there appears to be a parallel between this laboratory measure of inconsistency and omissions and a real-world measure. Finally, depression was correlated with our Factor 5. Our interpretation of this factor as one of impulsivity may be accurate if one considers a common underlying substrate for impulsivity and some aspects of depression. This has in fact been reported by others from our laboratory. Specifically, it was shown that specific items on the BDI cluster together and covary with frontal/executive cognitive abilities (Castellon et al., 2006). In addition, Castellon, Hinkin, and Myers (2000) showed that apathy, a common symptom of depression, is associated with

performance on a response inhibition task. Thus, it is conceivable that as depression increased in our sample so did a risky response style, or impulsivity in responding, on the CPT.

There are several limitations to our study that need to be mentioned. First, as in previous studies, two or more variables from a single measure were all that represented a particular factor in some instances. For example, number of errors, number of categories, and number correct from the WCST were the sole variables constituting Factor 3, our equivalent of Mirsky's *shift* element. Because variables derived from the same measure tend to be highly correlated, this results in multicollinearity of variables and therefore an artificially inflated correlation between them. In future studies, it would be useful to have at least one additional measure to assess the switch, sustain, and stabilize categories. Second, as with the majority of the replication studies described earlier, we employed PCA, which is generally theoretically sound when used as an exploratory method for elucidating patterns of correlations among a set of variables (Tabachnik & Fidell, 1996). However, the degree to which the derived factors represent latent underlying variables or true constructs is uncertain with PCA alone. Further, because we sought to assess the validity of an existing model, it can be argued that a confirmatory approach would have been warranted. PCA is not recommended for use as a confirmatory tool, as there are strict requirements for the data, including very large sample size, use of “marker” variables, and adequate spread in scores on the variables of interest (Tabachnik & Fidell, 1996). Taking a different tact, Strauss et al. (2000) used structural equation modeling in order to as a confirmatory factor analytic approach in their attempt to validate Mirsky's model. Using structural equation modeling and a Mirsky's original four-factor solution, they failed to replicate the earlier findings. However, structural equation modeling also has significant theoretical limitations, and our decision to employ PCA was based on our goal of replicating previous investigations of Mirsky's model. Clearly, continued analysis using a variety of methods and neuropsychological measures are necessary to assess the validity of our interpretation of Mirsky's factors. While data reduction strategies such as PCA are useful as an initial step in uncovering behavioral constructs from performance across a myriad of tests, additional strategies are required to determine whether those factors represent actual endophenotypes with specific anatomical or neural systems. Both Mirsky et al. (1991) and Posner and Dehaene (1994) have suggested that different neural substrates underlie the various elements of their theoretical models. Some support has been established for Posner's model, included functional imaging and genetic association studies (Fan & Posner, 2004; Fan, Wu, Fossella, & Posner, 2001; Fossella et al., 2002). However, no such data are available for models such as Mirsky's. This may be due to the psychometric (multifactorial) nature of Mirsky's model. The research that has grown from Posner's model has generally relied upon a simple visual attention paradigm called the Attention Network Test (Fan et al., 2001), perhaps making physiological and genetic associations more feasible. Therefore, additional effort is required to empirically verify the elements found in this and previous studies of attentional elements derived from traditional neuropsychological tests.

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TABLE 1

Variations in measures used to assess attention

Study	Domain name	Measures
Butters et al., 1990	Attention	Digit Span (WMS-R)
		Visual Span (WMS-R)
Levin, Berger, Didona, & Duncan, 1992	Attention	Digit Span (WAIS-R)
		Corsi Cube Test (visual span)
		Rey–Osterrieth Complex Figure, Immediate Recall
Marsh & McCall, 1994	Attention	Paced Auditory Serial Addition Test
		Trail Making Test (Parts A & B)
Heaton et al., 1995	Attention	Digit Span (WAIS–R)
		Arithmetic (WAIS–R)
		Seashore Rhythm Test
		Speech Sounds Perception Test
		Digit Vigilance (Errors & Time)
		Paced Auditory Serial Addition Test
Brouwers et al., 1997	Attention	Digit Span (WAIS–R)
		Digit Symbol (WAIS–R)
		Trail Making Test (Parts A & B)
Manly et al., 1997	Attention/speed of information processing	Digit Span (WAIS–R)
		Arithmetic (WAIS–R)
		Digit Vigilance (time and no. errors)
		Seashore Rhythm Test
		Speech Sounds Perception Test
		Paced Auditory Serial Addition Test
Nielsen-Bohlman, Boyle, Biggins, Ezekiel, & Fein, 1997	Attention	Microcog[a] (MC)
		Numbers forward
		Numbers reversed
		Alphabet
		Word List
Stern et al., 1998	Attention	Adaptive Rate Continuous Performance Test[b]
		Performance Assessment Battery[c]
		Letter-matching
		Stroop
		Time-wall
Honn & Bornstein, 2002	Attention	Spatial Span (WMS-III)
		Paced Auditory Serial Addition Test
Richardson, Morgan, Vielhauer, Buondonno, & Keane, 2003	Working memory	Digit Span (WAIS-III)
		Spatial Span (WMS-III)
Baldewicz et al., 2004	Attention	2 and 7 Test[d]
Heaton et al., 2004	Attention/Working memory	Digit Span (WAIS-R)

Study	Domain name	Measures
		Arithmetic (WAIS-R)
		Paced Auditory Serial Addition Test
Hinkin et al., 2004	Attention/Working memory	Letter/Number Sequencing (WAIS-III)
		Paced Auditory Serial Addition Test
		Digit Span (WAIS-III)
Marcotte et al., 2004	Attention/Working memory	Letter/Number Sequencing (WAIS-III)
		Paced Auditory Serial Addition Test

Note. WMS-R=Wechsler Memory Scale–Revised. WAIS-R=Wechsler Adult Intelligence Scale–Revised. WMS-III=Wechsler Memory Scale–Third Edition. WAIS-III=Wechsler Adult Intelligence Scale–Third Edition.

[a]Powell et al. (1993).

[b]Cohen and Fisher (1989).

[c]Thorne, Genser, Sing, and Hegge (1985).

[d]Ruff, Evans, and Light (1986).

TABLE 2

Characteristics of the study sample

Variable	Mean	SD	% of participants
Age[a]	40.9	7.4	
Education[a]	13.1	1.8	
Viral Load[b]	7,848	47,713	
CD4 (self-report)[c]	459	282	
Global Neurocognitive Functioning T-score	44.3	5.7	
Verbal IQ[d]	105.4	9.3	
BDI-II[e]	12.7	8.9	
AIDS Diagnosis			63.5
Current Stimulant Use Disorder[f]			22.0
Female			16.3
Ethnicity			
Caucasian			22.0
African American			56.0
Hispanic			15.0
Asian/Native American			04.0
Mixed			03.0

[a] In years.

[b] Median=undetectable.

[c] Median=377.

[d] Estimated Verbal IQ based on the American New Adult Reading Test (AMNART; Grober & Sliwinski, 1991).

[e] Beck Depression Inventory, Second Edition (Beck, Steer, & Brown, 1996).

[f] American Psychiatric Association (1994).

TABLE 3

Comparison of the Mirsky and Duncan (2001) battery with that of the current study

Proposed factor	Mirsky and Duncan (2001) measure	Levine et al. measure
Encode	Digit Span[a]	Digit Span[a]
	Arithmetic[a]	PASAT[b] (Trial 1) Letter/Number Sequencing[a]
Focus/Execute	Digit Symbol[a]	Digit Symbol[a]
	Stroop[c] (all trials)	Stroop Interference[c]
	Trail Making Test A & B[d]	Trail Making Test A & B[d]
	Letter Cancellation[g]	Symbol Search[a]
Shift	WCST[e] *or* Reciprocal Motor Programs Test	WCST[e] (total errors, total conceptual level responses)
Sustain	Visual CPT[h] (Accuracy, RT)	Conners' CPT[f] (Hit RT, Commissions)
	Auditory CPT[h] (Accuracy, RT)	
Stabilize	Visual CPT (Variability of RT)	Conners' CPT (Variability, Omissions)
	Auditory CPT (Variability of RT)	

Note. PASAT=Paced Auditory Serial Addition Test. WCST=Wisconsin Card Sorting Test. CPT=continuous performance task.

[a]Wechsler (1997).

[b]Gronwall (1974).

[c]Stroop (1935).

[d]Army Individual Test Battery (1944).

[e]Heaton (1981).

[f]Conners (2000).

[g]Talland (1965).

[h]Rosvold, Mirsky, Sarason, Bransome, and Beck (1956).

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TABLE 4

Correlations of individual measures with PCA factors

	Factor				
Measure	**1 Focus/execute**	**2 Encode**	**3 Switch**	**4 Stabilize**	**5 Sustain**
Symbol Search	***.793***	.372	.277	.380	.049
Digit Symbol	***.768***	.328	.242	.394	.049
Stroop Interference	***.641***	.177	.099	.404	.238
Trails A	***.676***	–.062	.112	–.106	.109
Trails B	***.777***	.394	.179	.085	.077
Letter/Number Seq	.360	***.873***	.167	.211	.055
Digit Span	.177	***.903***	.138	.059	–.034
PASAT	.586	***.635***	.333	–.052	.056
WCST Errors	.228	.169	***.954***	–.005	.002
WCST Concept Resp	.228	.190	***.950***	.045	.098
CPT Variability	.238	.170	.104	***.841***	.194
CPT Omissions	.157	.031	–.064	***.848***	–.173
CPT Commissions	.047	.027	–.004	.304	***–.863***
CPT Hit Reaction Time	.293	.049	.096	.405	***.854***

Note. PASAT=Paced Auditory Serial Addition Test. WCST=Wisconsin Card Sorting Test. CPT=continuous performance task. Large factor loadings are in bold italic typeface.

TABLE 5

Correlations among attention factors and other variables

	Factor				
	1 Focus/execute	2 Encode	3 Switch	4 Stabilize	5 Sustain
% adherence	.037	–.016	.006	***.210****	.048
Education	***.212****	***.274*****	–.132	.191	.010
Age	.135	.067	***–.203****	–.118	–.142
Verbal IQ	***.255****	***.577*****	.118	***.263*****	–.136
CD4	.007	–.135	–.174	.005	.053
BDI–II	–.016	–.089	–.028	.002	***.207****

BDI-II = Beck Depression Inventory, Second Edition.

Large factor loadings are in bold italic typeface.

* significant at .05.

** significant at .001.