Age Differences and Neurocognitive Performance in HIV-Infected Adults

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A clinical sample of 257 men were examined in a study of age-group differences on neurocognitive performance in adults with the Human Immunodeficiency Virus Type-1 (HIV-1). Older HIV-infected (HIV+) adults (M = 44.5 years) performed worse than younger HIV+ adults (M = 31.5 years) on a variety of neurocognitive tests. Similarly, HIV+ adults with the Acquired Immunodeficiency Syndrome (AIDS) performed worse than HIV+ adults without AIDS. Of greatest interest, age-group differences were larger in the AIDS group versus the No AIDS group. Brinley plot analyses show that the HIV+ adults presented minimal (or no) generalized cognitive slowing but that individual differences were systematically larger as a function of age and AIDS diagnosis. These results support both a brain reserve capacity model and a common-cause model of aging and HIV infection. Implications of aging and individual differences in HIV infection are discussed.

Acquired Immunodeficiency Syndrome (AIDS) is a clinical syndrome resulting from the collapse of cell-mediated immunity secondary to infection with the Human Immunodeficiency Virus-Type 1 (HIV-1). The most common gross anatomical changes associated with AIDS include brain atrophy with sulcul widening and ventricular enlargement. Histopathological analyses reveal white matter abnormalities, multinucleated giant cells of macrophage origin, microglial nodules, and diffuse reactive astrocytosis to be present in 70 to 90% of the brains of patients with AIDS who come to autopsy.

HIV often invades the central nervous system early in the course of infection producing a variety of neurocognitive symptoms. These include deficits in attention and concentration, abstraction, learning, memory, psychomotor and cognitive processing speed (Bornstein et al., 1993; Heaton et al., 1995; Hinkin, van Gorp, & Satz, 1995; McArthur & Selnes, 1997). Symptom severity ranges from subtle psychomotor deficits to pronounced AIDS-related dementia (see Grant & Martin, 1994).

It has become increasingly clear that the nature of the HIV epidemic is evolving, changing from a disease primarily affecting younger, gay White men to one affecting people of color, women, and the older adult. Indeed, the number of AIDS cases in adults over 50 years old has more than tripled in the last several years. Current estimates suggest that 10% of adults with AIDS are over 50 years old and about 3% are over 60 years old (CDC 1994, 1996; Chen et al., 1998; Shipp, Wolf, & Selik, 1991). This demographic shift is important because clinical outcomes are often worse in older adults with AIDS. The time between HIV infection and AIDS diagnosis (Phillips et al., 1991) and AIDS and death (Chen et al., 1998; Ferro & Salit, 1992; Gordon & Thomas, 1995; Shipp et al., 1991) is shorter in older adults compared to younger adults. Less clear is the neurocognitive prognosis of older adults with AIDS.

Only a few studies have examined neurocognitive functioning in relation to HIV infection and aging. In a relatively large community sample (N = 199) of asymptomatic and symptomatic HIV-infected adults, Becker and colleagues (1997) found that test performance declined with age. This is noteworthy considering the mean age of the sample was 38 years with a standard deviation of 8.2 years. Performance also declined with age in HIV seronegative and seropositive adults in a large scale study by van Gorp and colleagues (1994). However, they did not find the effect of aging on standard test and reaction time performance to be different in HIV-positive adults compared to seronegative adults. In contrast, in an experimental study (Arendt, Hefter, Hilperath, & Strohmeyer, 1993) auditory event-related brain potentials (ERPs) were examined in 100 HIV-positive adults (mean age = 35 years) and 43 seronegative controls (mean age = 36 years). Amplitude of P300, an ERP component that has been linked to cognition

(see Rugg & Coles, 1995), declined twice as fast with age in the HIV-infected adults relative to controls.

Based on the results of these few studies and the paucity in general of research that has examined aging and HIV infection, the effects of aging on neurocognitive functioning in HIV-infected adults remain unclear. With ERP measures the effect of aging appears to interact with or exacerbate the effect of HIV infection on neurocognitive processing even in relatively young adults (Arendt et al., 1993). Studies based on clinical neuropsychological measures have yielded mixed results. Clearly there is a need for more studies of aging in the HIV-seropositive population. Elucidation of the mechanisms of HIV-related neurocognitive impairment, and the possible exacerbating effects of aging, also needs to be addressed.

Several theoretical models can be advanced that provide a rationale for expecting that age and HIV infection would interact. First, from the perspective of a brain or cognitive reserve capacity model (for review see Satz, 1993), aging and HIV infection are considered as co-risk factors that reduce cognitive reserve capacity. The greater the reduction in reserve, the more likely that an impairment threshold will be crossed producing an observable neurocognitive deficit. Second, at a more specific conceptual level, perhaps aging and HIV infection have a common or significantly overlapping neuropathological locus therefore impairing the same neurocognitive processes. For instance, Hinkin et al. (1990) reported that the level and pattern of performance on neuropsychological testing was similar in a sample of young adults diagnosed with AIDS (mean age = 38 years) and a group of older neurologically normal HIV-seronegative adults (mean age = 70 years). The similar performance, despite an age difference greater than 30 years, was attributed to a common mechanism, disruption of subcortical-frontal white matter connections. Similarly, behavioral slowing, a fundamental symptom of both aging and HIV infection, has been ascribed to basal ganglia dysfunction in both older (Bashore, 1993) and HIV-infected (Martin, 1994) adults. A third possible mechanism is that of a *general* slowing of cognitive operations. In other words, the uniform slowing of all cognitive operations produce the performance deficits observed in specific tasks. There is evidence for general slowing with age (Cerella, 1985; Salthouse, 1985). One source of evidence is the Brinley plot[1], where the performance means in a variety of timed tasks (or conditions) for older adults are regressed on those of younger adults. The slope of the regression represents the degree of slowing in the older adults. These are described in more detail in the method section of this study. Because of the aforementioned similarities between HIV and aging (e.g., basal ganglia dysfunction), one can hypothesize that HIV infection results in generalized cognitive slowing. If so, then older HIV-infected adults should experience even more slowing or an aggregated slowing, producing larger neurocognitive deficits on a variety of tasks compared to younger adults with HIV. All of the above models predict an interaction between the effects of aging and HIV infection.

The present study has two specific aims. One is to examine the effect of aging on the neurocognitive functioning in adults infected with HIV. As mentioned above, the independent and interactive effects of aging on cognition in HIV-infection remains unclear. In addition, it has not been shown how the relationship between aging and HIV infection changes with the specific development of an AIDS diagnosis. It is predicted that older HIV-infected adults, even within the relatively restricted age range in the present study, will perform worse than younger HIV-infected adults. Furthermore, the age-group difference in neurocognitive performance will be larger in the adults with AIDS relative to HIV-infected adults without AIDS. The second aim of this study is the examination of generalized cognitive slowing in older HIV-infected adults. Brinley plot analyses are conducted on younger and older groups of HIV-infected adults with and without AIDS performing a variety of psychometric tests. This type of analysis has not yet been used in studies of HIV. It is predicted that older HIV-infected adults will show a general slowing factor (slope greater than one) relative to younger HIV-infected adults. In addition, because Brinley plot slopes have been shown to reflect disease severity (such as in Alzheimer's disease, Nebes & Brady, 1992), it is predicted that generalized slowing will be greater (i.e., the slope will be steeper) in the older HIV-infected adults with AIDS versus the older HIV-infected adults without a diagnosis of AIDS.

Method

Participants

Participants were 257 HIV-positive male adults who were neuropsychologically assessed between the years 1989 and 1995 at a clinic affiliated with a major community hospital and medical center in the Los Angeles area. Approximately 27% (n = 69) of the sample were diagnosed with AIDS. Participants showed no evidence of learning disorders or opportunistic infection of the central nervous system. Substance abuse was self-reported in 3% of HIV-infected adults without AIDS and in 8% of adults with AIDS. Anti-retroviral medications (most of these did not include protease inhibitors) were being used by approximately 53% of HIV-infected adults without AIDS and 36% of adult with AIDS. Participants, who ranged in age from 22 to 66 years were divided at the median age into younger (36 years or younger) and older (37 years or older) age groups. A subset of the participants in the present study were examined in a previously published study (van Gorp et al., 1994).

Participant characteristics are shown in Table 1. There was no significant difference between HIV groups (No AIDS and AIDS) in age (p = .28), years of education (p = .70), or reported depression on the Beck Depression Inventory (BDI) (p = .79). Mean CD4 cell count was lower in the AIDS

1. Brinley (1965) first reported group means (comparing younger and older adults) in this format. Theoretical interpretations were subsequently developed by Salthouse (1985, 1991), Cerella (1985), and other cognitive aging theorists (e.g., Myerson, Hale, Wagstaff, Poon, & Smith, 1990).

group (M = 128, SD = 218) versus the No AIDS group (M = 295, SD = 210) ($p < .001$). There were no significant interactions between HIV group (No AIDS and AIDS) and age group (Younger and Older) for age ($p = .33$), education ($p = .84$), BDI score ($p = .28$), or CD4 cell count ($p = .99$). The older age group was significantly more educated than the younger age group ($p = .01$). There was no clear age group difference in BDI score ($p = .11$).

Table 1. Participant Characteristics

	HIV + No AIDS		AIDS	
Variable	Younger n = 99	Older n = 89	Younger n = 41	Older n = 28
Age	31.5 (3.5)	44.1 (6.4)	31.6 (3.3)	45.7 (8.2)
Education (years)	14.4 (1.7)	15.3 (2.4)	14.6 (1.8)	15.3 (2.5)
BDI Score	13.7 (9.8)	10.4 (8.1)	12.7 (6.7)	12.1 (7.2)
CD4 Cells[a]	309 (196)	280 (226)	139 (255)	111 (157)

Notes. Means are presented with standard deviations inside parentheses.
BDI = Beck Depression Inventory.
[a] Data were available on 66, 59, 28, and 20 participants respectively.

Neuropsychological Tests and Measures

Participants completed the following neuropsychological tests, all of which are described in Lezak (1995) or Spreen and Strauss (1998). These tests were part of a larger test battery that all participants completed. The *Trail Making Test* is a brief test of visual-motor function, attention, and psychomotor speed. Completion times (sec) for Parts A and B were obtained. The *Stroop Color Word Test* assesses performance in word reading, color naming, and, in the interference condition, selective attention and inhibition. Thus, three measures are obtained from this test. The dependent variable is number of items correctly completed in 45 seconds. The *Grooved Pegboard Test* is a measure of speed and dexterity of upper extremity fine motor movements. Time (sec) to place all pegs with the dominant hand was obtained. The *Symbol Digit Modalities Test* is a test of concentration, mental proficiency, and speed. The obtained score for this test is the number of items completed in 90 seconds. The *Controlled Oral Word Association Test* assesses phonemic and semantic fluency. The score is the sum of all acceptable words beginning with the letter F, A, or S produced in three one-minute trials respectively. An additional score is the number of animal names produced in a one-minute trial.

Selected for the present study were timed tests that included either a completion time score or a number of items completed score. All test scores were transformed into a measure of time (sec) per test item. These tests were selected and the transformation conducted because the subsequent Brinley plot analyses require a common test performance measure. If the test score was completion time (e.g., Trail Making Test), then completion time was divided by the number of test items. If the test score was number of completed items (e.g., the Symbol Digit Modalities Test), then the time limit for the test (e.g., 90 sec) was divided by the number of completed test items. For the Brinley plot analyses, although response requirements across tests were not identical, the major difference in difficulty among the nine tests (with the possible exception of the Grooved Pegboard Test) was due to cognitive rather than response demands. Therefore, it is reasonable to interpret slopes as predominantly reflecting cognitive slowing.

Statistical Analyses

To examine group differences in neurocognitive performance, a 2 x 2 analysis of covariance (ANCOVA) was conducted on each set of transformed test scores. Between-subjects variables were HIV group (No AIDS and AIDS) and age group (Younger and Older). Years of education and BDI score were treated as covariates.

To examine group differences in generalized cognitive slowing, Brinley plot analyses were conducted on the No AIDS and AIDS groups. A Brinley plot analysis regresses mean response times of one group (typically older adults) against mean response times of another group (typically younger adults) in conditions C_1, C_2, . . . C_i. When a variety of task conditions or tasks with similar response requirements are assessed in a Brinley plot analysis, the slope of the regression function is considered a measure of generalized cognitive slowing in the criterion or Y axis group. For instance, a slope of 1.5 means that the Y axis group is 50% slower than the X axis group across the various tasks. A slope of 1.0 shows there is no generalized slowing. The nature of the slowing is general because the slope represents a variety of disparate condition and processing requirements. The fit of the regression function is represented by r^2. Brinley plots have been used most extensively in studies of aging (Bashore, Osman, & Heffley, 1989; Cerella, 1985; Hardy & Parasuraman, 1987; Hartley, 1992; Salthouse, 1985). In studies of normal aging Brinley plot slopes range from about 1.4 to 2. Although not without interpretive difficulties (see Schulz, 1994; Cerella, 1994; Fisk & Fisher, 1994; Myerson, Wagstaff, & Hale, 1994; Perfect, 1994), such slope results are considered as evidence for age-related generalized cognitive slowing.

For the present Brinley plot analyses, mean time per item for each of nine test measures was the dependent variable. Older participant times were regressed on younger participant times separately for the No AIDS and AIDS groups. The slope of each regression function represents the degree of generalized cognitive slowing. To determine the presence of generalized slowing, t tests were conducted to determine if each slope was different than a slope of one. The difference between the No AIDS and AIDS slopes was also tested.

Results

ANCOVA results are presented in Table 2. Importantly, the older adult group performed worse (i.e., average time per individual item per test was greater) than the younger adults on every test measure. Similar to HIV group differences, age group differences ranged from .56 seconds (Trail Making Test Part B) to .02 seconds (Stroop word reading). Although these differences appear small, remember that the dependent measure for all tests is the transformed score of mean time *per stimulus item* for each test. If these scores are considered like computerized reaction times (the transformed neuropsychological test scores roughly approximate a reaction time type of score—the time to process a single item), while 20 ms (.02 sec) is a small effect a group difference of 560 ms (.56 sec) is quite large.

The adults with AIDS performed worse than the No AIDS group on most of the neuropsychological test measures. Significant HIV group differences ranged from .57 seconds (Trail Making Test Part B) to .03 seconds (Stroop word reading). The only difference between the No AIDS and AIDS group that failed to reach significance was on the COWAT (.33 sec).

Of greatest interest are the interactions. Significant interaction effects were seen on Trail Making Test Part B and the Grooved Pegboard Test with the older adults with AIDS showing the poorest performance (versus the other groups). A trend toward a significant interaction between age and HIV was also evident for Trail Making Test Part A, the Symbol Digit Modalities Test, and semantic word fluency. Post hoc analyses included a 2 x 2 x 2 ANCOVA on Trail Making Test performance with HIV group (No AIDS and AIDS) and age group (Younger and Older) as between-subjects variables and Trail Making Test (Part A and Part B) as a within-subjects variable. Taking precedence is the three-way interaction, $F(1, 231) = 5.16$, $p = .02$, illustrated in Figure 1, which clearly depicts the deleterious effects of aging on cognition when HIV infection has progressed to AIDS.

Brinley plot analyses are illustrated in Figure 2. For the No AIDS group, the regression function was: Older test item time = [(1.04) x younger test item time + .04], with $r^2 = .99$. The 95% confidence interval for the slope was .99 and 1.09. The slope of 1.04, which is interpreted as 4% slowing in the older No AIDS group, was not different from a value of one (i.e., 0% slowing) at a .05 level of significance ($t = 2.10$, $p < .10$). For the AIDS group, the regression function was: Older test item time = [(1.18) x younger test item time + .06], with $r^2 = .96$. The 95% confidence interval for the slope was .96 and 1.40. This slope did not differ from one at the .05 level ($t = 1.94$, $p < .10$). A Welch-Aspin test (where sample variances are not assumed to be equal, Marascuilo & Serlin, 1988) determined that there was no significant difference between the slopes of the No AIDS and AIDS groups ($t = 1.51$).

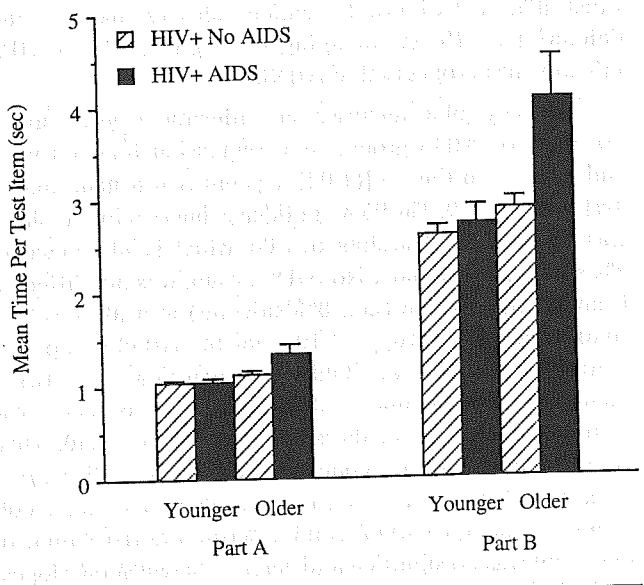
Standard deviations in Table 2 suggests that individual differences in test performance increased as a function of HIV group and age group. Standard deviations were noticeably larger in the older AIDS group and, not surprisingly, particularly on the test measures where they performed the worst. Exploratory Brinley plot analyses were conducted to examine the relationship between standard deviation and participant groups. For these analyses, the scores are standard deviation values (sec) instead of mean time per test item. These are shown in Figure 3. For the No

Table 2. ANCOVA of Neuropsychological Test Performance Across HIV and Age Groups

	No AIDS		AIDS		*p*		
Variable	Younger	Older	Younger	Older	H	A	H x A
Trail Making A	1.03 (0.32)	1.13 (0.32)	1.04 (0.30)	1.34 (0.55)	.034	.001	.086
Trail Making B	2.59 (1.19)	2.89 (1.12)	2.72 (1.13)	4.05 (2.49)	.001	.001	.013
Stroop Word	0.42 (0.07)	0.44 (0.07)	0.45 (0.09)	0.47 (0.09)	.002	.010	.926
Stroop Color	0.60 (0.12)	0.65 (0.12)	0.64 (0.14)	0.71 (0.16)	.006	.001	.628
Stroop Inter	1.11 (0.30)	1.20 (0.33)	1.13 (0.36)	1.36 (0.38)	.057	.001	.191
Pegboard DH	2.51 (0.44)	2.63 (0.37)	2.63 (0.34)	3.14 (1.18)	.001	.001	.019
Symbol Digit	1.75 (0.30)	1.84 (0.33)	1.84 (0.33)	2.15 (0.61)	.001	.001	.066
FAS	4.20 (1.21)	4.35 (1.81)	4.37 (1.25)	4.88 (1.93)	.120	.026	.517
Animals	2.53 (0.64)	2.64 (0.62)	2.56 (0.53)	3.03 (0.98)	.037	.001	.096

Notes. Means (sec per test item) are presented with standard deviations inside parentheses.
Covariates were years of education and BDI score. Stroop Inter = Stroop interference test.
Pegboard DH = Grooved Pegboard with dominant hand.
FAS and Animals are from the Controlled Oral Word Association Test.
H = HIV group (No AIDS vs AIDS). A = age group (younger vs older). H x A = interaction.

Figure 1. Trail Making Test performance (seconds per test item) in younger and older HIV groups.



AIDS group, the regression function was: Older standard deviation = [(1.25) x younger standard deviation - .07], with $r^2 = .90$. The 95% confidence interval for the slope was .87 and 1.62. The slope was not significantly different from a value of one ($t = 1.56$, $p < .20$). For the AIDS group, the regression function was: Older standard deviation = [(1.84) x younger standard deviation + .02], with $r^2 = .86$. The 95% confidence interval for the slope was: 1.19 and 2.49. The slope was significantly different from a slope of one ($t = 3.04$, $p < .02$). This finding indicates that across the nine tasks, the older AIDS adults experienced an 84% increase in standard deviation over the younger AIDS adults. Compatible with this finding, the difference between the slopes of the No AIDS and AIDS groups was statistically significant, $F(1, 7) = 6.54$, $p < .05$.

Discussion

These data suggest that aging exacerbates neurocognitive decline in HIV-infected adults. In the present study older HIV-infected adults (both AIDS and No AIDS) performed worse than younger HIV-infected adults on every measure. Age group differences were largest in tests of psychomotor skills and attention/concentration (Trail Making Test, Grooved Pegboard, and Symbol Digit Modalities Test). However, even tasks of simple verbal skills such as word reading showed significant age group differences. By itself the aging effect on cognition would be expected to be small. There was a low age criterion for the older group, 37 years or older, and because the age groups were split with a median age many "younger" and "older" members' age differed by a mere one to a few years. In addition, although the age range for each older group (No AIDS and AIDS) was between 37 and 66 years, the relatively young mean ages (44 and 46 years respectively) indicate that a majority of the older individuals were under 50 years of age. Nonetheless, among HIV-infected adults even these small age differences between age groups was enough to produce

Figure 2. Brinley plot of test performance means (seconds per test item) in younger and older HIV groups. For the No AIDS group, the regression function was: Older test item time = [(1.04) x younger test item time + .04]. For the AIDS group, the regression function was: Older test item time = [(1.18) x younger test item time + .06]. Neither slope differed from a value of one at the .05 level of significance. There was also no significant difference between the slopes.

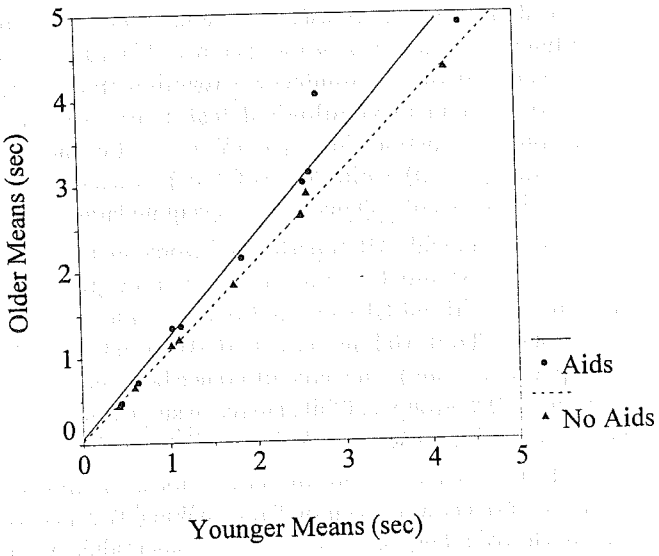
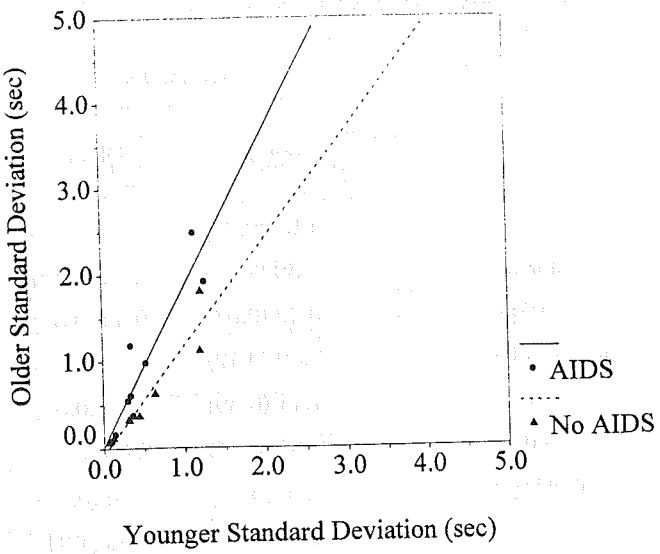


Figure 3. Brinley plot of test performance standard deviations (seconds) in younger and older HIV groups. For the No AIDS group, the regression function was: Older standard deviation = [(1.25) x younger standard deviation - .07]. For the AIDS group, the regression function was: Older standard deviation = [(1.84) x younger standard deviation + .02]. Only the AIDS group slope was significantly greater than a slope of one. In addition, there was a significant difference between the slopes.



a difference in cognitive performance.

There was also a broad HIV group effect. Adults with AIDS performed significantly worse than HIV-infected adults without AIDS on all tests but one. Mirroring the age group differences, the largest difference was found in Trail Making Test Part B and the smallest difference was in the

relatively easy word reading condition of the Stroop test. In general, these group differences in performance replicate previous research that demonstrated that progression of HIV infection is related to declining neurocognitive skills.

Central to the present study is the finding that aging effects on neurocognition were more detrimental in adults with AIDS compared to the HIV-infected adults without AIDS. This interaction was most evident in tests of psychomotor skills and concentration. Older AIDS adults also tended to perform differentially worse in verbal fluency. That there was an age group difference and an HIV group difference on Stroop task performance is compatible with previous Stroop research on older adults (Cohn, Dustman, & Bradford, 1984; Comalli, Wapner, & Werner, 1962; Houx, Jolles, & Vreeling, 1993;) and HIV-infected adults (Hinkin, Castellon, Hardy, Granholm, & Siegle, 1999; Martin, Robertson, Edelstein, Jagust, & Sorensen, 1992; Saykin et al., 1988). However, age group did not interact with HIV group on the Stroop interference score. Therefore, aging does not appear to enlarge the greater deficit in inhibitory processes observed in the AIDS group. The age difference between groups is relatively small in the present study and so this finding will require replication and extension. Nonetheless, for the other neurocognitive functions assessed such as psychomotor skills, attention/ concentration, and semantic fluency, this admittedly weak age manipulation was sufficient to produce differential aging decrements in adults with AIDS. An important implication is that the observed age-related exacerbation of neurocognitive deficits in adults with AIDS may be expected to be even more dramatic in adults older than those examined in the present study.

The effect of aging and HIV infection on neurocognition is clear. Older HIV-infected adults, especially those with an AIDS diagnosis, perform a variety of cognitive tasks worse compared to younger HIV-infected adults. Less clear is the mechanism for this interaction between aging and HIV infection. The results from the present study support both the previously mentioned common cause hypothesis (of aging and HIV infection) and a cognitive reserve capacity model. Although there were task measures that did not show an interaction between HIV infection and aging (such as all the Stroop measures), it is impossible without seronegative controls to disconfirm the hypothesis that aging and HIV infection share common neuropathological/processing dysfunction (Hinkin et al., 1990). Also, the restricted age range of the present study with relatively young older adults makes a weak test of this common cause hypothesis. The cognitive reserve capacity model is supported if older age and HIV infection are considered as risk factors to neurocognitive impairment. This is a reasonable consideration. However, the definition of impairment needs to be clearly defined and the inclusive nature of a cognitive reserve capacity model needs to be treated cautiously and better defined.

A potential mechanism for the interaction between aging and HIV infection that was directly tested was that of generalized cognitive slowing. If both aging and HIV infection independently produce a generalized slowing of cognitive processing, that could explain the poorer performance in the older adults with AIDS. This assumes that generalized slowing increases with the onset of AIDS. However, the evidence for generalized slowing in the present study is weak. The slope for each the No AIDS and AIDS group was greater than one at $p < .10$. Even if these results were more convincing, which would suggest generalized slowing among the older HIV-infected adults, the magnitude of slowing would be fairly small. The regression slopes of 1.04 and 1.18 across the nine task measures indicate that the older No AIDS and AIDS groups were 4% and 18% slower respectively relative to the younger No AIDS and AIDS groups. However, there was no statistical difference between slopes, and the AIDS group had one outlier mean, suggesting that both slopes were probably not much larger than a value of one (see the Brinley plots in Figure 2). This implies that there was little or no generalized cognitive slowing in the present groups.

Even if a small generalized slowing effect contributed to the main effect of age, where older HIV-infected adults performed worse than younger HIV-infected adults on every task measure, it is unlikely that it mediated the interactions between age and HIV group, where the older AIDS group performed the worst. This is because the generalized slowing slopes were no different between the No AIDS and AIDS groups. Note that both regression functions accounted for an impressive amount of the variance between age groups across the nine task measures ($r^2 = .99$ for the No AIDS group and $r^2 = .96$ for the AIDS group). Therefore, the small slope values (whether or not they are really greater than a slope value of one) are representative of the HIV-infected groups examined in the present study.

Perhaps the most provocative aspect of this study was the examination of individual differences. Individual differences are fundamental to the aging process and to HIV infection (and, consequently, to a brain reserve capacity model, see Satz, 1993). In the present investigation performance standard deviations were largest in the older adults with AIDS. Although this was not evident on every measure, systematic examination of standard deviation with Brinley plot analyses showed that the standard deviations of the older adults with AIDS increased by 84% (i.e., slope = 1.84) relative to the younger adults with AIDS across the nine test measures. This finding indicates that irrespective of specific task demands or requirements, individual differences in the older AIDS adults increased at a constant proportional rate (84%) relative to the younger adults with AIDS. This magnitude of increase in standard deviations is surprising considering (again) the presumably weak manipulation of age in the present study. That this systematic increase in standard deviation was not found in the No AIDS group implies that the difference in age and the development of AIDS both contributed to the increase in individual differences.

There are limitations in the present study in terms of validity and generalizability. First, a cross-sectional design was used. Although cross-sectional designs are convenient and often used in studies of aging, aging effects or results from this research design should always be treated with

caution. It is well known that an age-group difference does not necessarily translate into an age-related change (possibly due to cohort effects, etc.). Second, because seroconversion dates were not known, the possibility exists that age and disease duration is confounded. This problem is often unavoidable when examining clinical samples of HIV-infected adults because date of infection is typically unknown. Third, because only men were examined, it is unclear whether these results would generalize to women, who comprise one of the fastest growing segments of HIV-infected adults. Fourth, more elderly HIV-infected adults need to be examined. It is clear that the "older" adults in the present study are not particularly old. It is likely that the effects of aging and the possible interactions with HIV infection are underestimated in the present study (group and individual differences). If so, it will be important to determine the magnitude and pattern of cognitive deficits in HIV-infected adults as they survive beyond say 50 years of age.

In conclusion, it is axiomatic that individual differences should be considered in the neurocognitive examination of HIV-infected adults. Despite the limitations of the present study, we argue that the standard deviation results suggest that individual differences may be especially important in studies of older adults (even those older than just 36 years) who have progressed to AIDS. They might also explain the negative results in a previous examination of aging and HIV infection (van Gorp et al., 1994). In this study, neurocognitive performance was separately regressed on age for HIV-seropositive adults and seronegative adults. Dramatic individual differences in the older adults with AIDS (or perhaps who were symptomatic) may have undermined their regression functions. Individual differences of course may also sabotage analyses of group differences (such as an ANCOVA), though this does not appear to be the case in the present study. Nonetheless, analysis of outliers or cases of neurocognitive impairment (e.g., dementia) in the examination of age and HIV infection may be fruitful. Based on the present results, it appears that even minimally older age puts some, but not all, adults with AIDS at risk for greater neurocognitive decline.

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Acknowledgements

This study was supported in part by grants from the National Institute of Mental Health (Nos. T32 MH-19535 and MH-19200). We gratefully acknowledge Herbert Weiner, Daniel J. Slick, and Steven A. Castellon for helpful comments and thank Marta Stefaniak for assistance in manuscript preparation.

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