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Risky Decision Making Assessed With the Gambling Task in Adults with HIV

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Abstract

Decision making was assessed using a laboratory gambling task in 67 adults with the Human Immunodeficiency Virus (HIV+) and in 19 HIV-seronegative (HIV−) control participants. Neurocognitive test performance across several domains was also analyzed to examine potential cognitive mechanisms of gambling task performance. As predicted, the HIV+ group performed worse on the gambling task, indicating greater risky decision making. Specifically, the HIV+ group selected more cards from the “risky” or disadvantageous deck that included relatively large payoffs but infrequent large penalties. The control group also selected such risky cards but quickly learned to avoid them. Exploratory analyses also indicated that in the HIV+ group, but not in the control group, gambling task performance was correlated with Stroop Interference performance and long delay free recall on the California Verbal Learning Test, suggesting the role of inhibitory processes and verbal memory in the poorer gambling task performance in HIV. These findings indicate the usefulness of the gambling task as a laboratory tool to examine risky decision making and cognition in the HIV population.

Keywords

HIV; decision making; gambling task; cognition

Risky Decision Making Assessed with the Gambling Task in Adults with HIV

For over two decades, the world has witnessed a devastating epidemic brought on by the HIV. In combating this epidemic, many researchers have grappled with the psychological and social facets of disease proliferation. Particularly over the past decade, infection with HIV has been

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found to be associated with risky behaviors, such as unprotected sex, promiscuity, and intravenous drug use (Holmberg, 1996). Furthermore, it has been suggested that risk may be a function of decision-making style. Thus, deci sion-making style is an important area of study both in individuals at risk for HIV infection and in those who are already HIV positive (HIV +). Such knowledge could allow for the development of countermeasures, such as prevention and education programs that target at-risk individuals. For those who are already infected, decisions made take on the greatest salience in areas such as medication adherence, abstinence from substances that might compromise their immune systems, and further unprotected sexual contact.

Assessing the degree and type of risky behaviors in persons at risk for or infected with HIV is important. Also relevant is the investigation of the cognitive mechanisms underlying these decisions. Neurocognitive instruments are commonly employed to investigate the cognitive operations underlying observed behavior. One such instrument, referred to as the gambling task (Bechara, Damasio, Damasio, & Anderson, 1994), was developed in order to investigate the decision-making strategies in individuals with frontal lobe lesions. The task includes four decks of cards from which to choose, with each selected card resulting in either winning or losing a sum of replica money. The arrangement of the decks is such that selection from two of them will result in a net profit by the end of the task, while card selection from the other two will result in a loss. The decks that result in the net loss, however, offer larger payoffs than the others early on. Through its design, this task assesses participants' capacity for prudent decision making and risk taking by tracking which decks they draw from, thereby measuring their responses to reward/punishment and concern for future outcomes. A number of studies have found that bilateral lesions of the ventromedial prefrontal lobe (VM) are associated with poor (i.e., risky) performance (Bechara, Damasio, Damasio, & Lee, 1999; Bechara, Damasio, Tranel, & Anderson, 1998; Bechara, Tranel, & Damasio, 2000), while left-sided lesions do not affect performance (Manes et al., 2002). From these studies, it appears that such lesions result in a decision-making that is based on immediate gratification with little concern for future outcome.

Research into the decision-making characteristics of substance abusers (Grant, Contoreggi, & London, 2000), including HIV-infected substance abusers (Martin et al., 2004), has also employed the gambling task. Substance abusers and VM individuals often overlap in real-life behaviors in which they opt for choices that result in immediate reward despite the potential for negative consequences, and this observation has been replicated with the gambling task (Bechara et al., 2001; Bechara, Dolan, & Hindes, 2002; Bechara & Damasio, 2002). The gambling task has also been used in studies of individuals with neurodegenerative disease. Stout, Rodawalt, and Siemers (2001) examined decision making in individuals with Huntington's disease (HD) or Parkinson's disease (PD) as compared to that of healthy controls. HD primarily affects the basal ganglia. Thus, the authors hypothesized that because of the high connectivity between the basal ganglia and prefrontal cortex, behaviors such as poor decision making seen in those with frontal lobe lesion would also be seen in the HD group. As expected, they found that the HD group demonstrated increased risky decision-making compared to the controls and PD group, such that the HD group drew more from disadvantageous decks even when they appeared to know such decks were "bad."

HIV infection can also lead to neurocognitive degeneration, leading to a range of symptoms from subtle subclinical cognitive decline to outright dementia (Hinkin, Castellon, van Gorp, & Satz, 1998). Frontostriatal circuits and subcortical nuclei to which they connect are most commonly affected by HIV neuropathological change, and there is appreciable overlap in those areas affected by HD and HIV. Therefore, it is reasonable to expect similar neurocognitive and behavioral changes to occur in HIV.

In the current study, we describe the performance of HIV+ individuals on the gambling task compared to that of HIV− controls. It is expected that the HIV+ group will exhibit greater decision-making deficits, based on both the psychosocial and neurocognitive factors described above. A novel component to our study, relative to previous gambling task studies, is that we examine performance separately for each card deck to further characterize HIV-related decision making. The rationale for this further analysis is that contingencies differ across decks. For instance, although the disadvantageous decks produce the same immediate reward and average losses, one deck includes frequent but smaller penalties while the other includes infrequent but larger penalties. The cognitive mechanisms involved with such decision making may be susceptible to such differences in reward/punishment contingencies. Related to this point, we have also considered the potential role of neurocognitive processes on gambling task performance, and provide measures of attention and executive abilities as well as other test measures (psychomotor and processing speed, concept development, and verbal memory) in assessing neurocognitive differences between HIV+ and HIV− participants and the potential mediating role of such processes in gambling task performance. Many previous studies failed to find appreciable correlations between neurocognitive measures sensitive to frontal lobe dysfunction and the gambling task (e.g., Bechara et al., 1998; Grant et al., 2000). This may be the case in HIV-infected adults as well, although we have no strong predictions about this.

Method

Participants

Participants for the present study included 67 HIV+ adults and 19 HIV− controls recruited from an infectious disease clinic and from community agencies specializing in services for HIV-infected patients. Sero-negative controls were recruited using posted fliers and referrals from these sites. Background information and medical history of participants was provided through self-report data based on questionnaires and interviews. Exclusionary criteria included history of head injury with loss of consciousness in excess of 60 minutes and adverse neurological history (e.g., stroke or seizure disorder) including secondary HIV-related central nervous system infection or lymphoma. See Table 1 for demographic comparisons. There was no significant difference between HIV+ and HIV− groups in average age or in general cognitive status as measured by the HIV Dementia Scale (HDS). The HIV− group was slightly more educated (1.2 years) than the HIV+ group and the HIV+ group did score significantly higher on self-reported symptoms on the Beck Depression Inventory II. Because the optimal cut-off score on the HDS is less than or equal to 10 for identifying HIV-associated dementia (Power, Selnes, Grim, & McArthur, 1995), and the 95% confidence interval for the HIV+ group is between 12.7 and 13.3, it is likely that most if not all HIV+ participants in the present study do not meet diagnostic criteria for dementia. Five individuals in the HIV+ group and none in the HIV− group met *Diagnostic and Statistical Manual of Mental Disorders (4th ed.) (DSM–IV)* (American Psychiatric Association, 1994) criteria for current drug (alcohol or substance) dependence. Forty-three adults in the HIV+ group and four HIV− participants were diagnosed with past drug dependence. A large proportion of participants were African-American (50%) and female (34%). Fifty-eight percent of HIV+ participants met Centers for Disease Control (CDC, 1992) diagnostic criteria for Acquired Immunodeficiency Syndrome (AIDS) and all HIV+ participants were currently on highly active antiret-roviral therapy (HAART). Participants provided written informed consent and were paid $50 for their participation.

Tasks and Procedure

Participants completed the gambling task (and other parts of the protocol such as the background questionnaires and interviews, etc.) and other neurocognitive tests as part of a larger neuropsychological study of HIV-infected adults. All participants completed the entire protocol according to a uniform procedure, which was always completed within a single day.

Gambling task—The gambling task used in the present study is a replica of the gambling task by Bechara and colleagues (e.g., Bechara et al., 1994). Participants are given a $2,000 loan in realistic play money and presented with four decks, 40 cards in each deck. Cards are presented face down, each deck being identical in appearance. They are told that the game requires a long series of selections, one card at a time, from any of the four decks until they are told to stop. After each selected card, the participant receives some money ($100 for decks A and B, $50 for decks C and D). For some cards intermittently placed within each deck, the participant is also asked to pay a penalty, which varies but on average is larger for decks A and B relative to decks C and D. In addition, among the high penalty decks, deck A is comprised of 20 more frequent relatively smaller penalties (four cards each of a penalty of $150, $200, $250, $300, and $350) while deck B is comprised of four infrequent large penalties of $1,250 each. Similarly, among the low penalty decks, deck C includes 20 relatively smaller penalties (five cards with a penalty of $25, 10 cards with a penalty of $50, and five cards with a penalty of $75), with deck D includes four relatively larger penalties of $250. As per Bechara's original instructions, participants are told that (a) the goal of the task is to maximize profit on the loan of play money, and (b) they are free to switch decks whenever and as often as they desire. They are not told how many cards they are allowed to select (the game is over after 100 cards are selected). The order of rewards and penalties for each deck is prearranged. For instance, if a subject ends up selecting card 3 from deck A, they receive $100 but also pay a penalty of $150, with a net of −$50. The ultimate yield is smaller for the higher-paying decks A and B because of larger penalties. The ultimate yield is larger for the lower-paying decks C and D because of the smaller penalties. Thus participants must discriminate between short-term and long-term consequences.

Attention and executive neurocognitive tests—Several tests of attention and/or executive abilities were given. *Digit Span Backward* from the Wechsler Adult Intelligence Scale (Wechsler, 2004), where the dependent variable was the digit span backward score. For *Simple Reaction Time* (SRT), the participant must press a button with the dominant forefinger as quickly as possible when an *X* is presented on a monitor. Each *X* was presented at the center of the monitor (black *X* on white background) and remained until a response. According to a random sequence, a subsequent *X* appeared 1000 ms, 1500 ms, or 2000 ms later, therefore, this task requires a certain degree of vigilance or attention. A total of 30 *X*s were presented. The dependent measure was mean response time in milliseconds. The *Stroop Interference* test (Kaplan version) requires the naming of colors printed with incongruent words, thus involving inhibitory processing. The measure assessed was completion time (in seconds). The *Trail Making Test-Part B* (TMT-B) (Reitan, 1969) requires scanning and set-switching, where the participant must connect in an alternating sequence a series of numbers and letters. Completion time (in seconds) was analyzed. The *Paced Auditory Serial Addition Test* (PASAT) (Gronwall, 1977) involves the auditory presentation of a list of digits; the participant is required to add the current digit to the previously presented digit. Lists were presented at four rates (one digit per 1.2, 1.6, 2.0, and 2.4 seconds) and the analyzed score was the total number of mistakes.

Other neurocognitive tests—Several neurocognitive tests representing other cognitive domains were also administered. The *Grooved Pegboard* (Psychological Assessment Resources, Inc., 2004) requires the proper orienting and insertion of pegs into grooved holes and is a measure of fine psychomotor speed and dexterity. Completion time was analyzed for the nondominant hand. The *Symbol Digit Modalities Test* (SDMT) (Smith, 1991) involves the pairing of novel symbols with numbers and is a test of processing speed and mental proficiency. The dependent measure was test completion time (in seconds). The *Booklet Category Test* (Wetzel & Boll, 1987) was used to assess concept formation. Total errors were examined. The *California Verbal Learning Test* (CVLT) (Delis, Kramer, Kaplan, & Ober, 1987) assesses

learning and memory with a 16-item list. Dependent measure analyzed was free recall after the long (20-minute) delay.

Statistical analyses—Two-tailed tests with a .05 level of significance were chosen for all analyses. Group differences were analyzed on the gambling task and all other neurocognitive tests using analysis of covariance (ANCOVA). All ANCOVAs included the covariates of BDI score, current drug dependence, and past drug dependence. Partial eta squares are presented as a measure of effect size. Gambling task performance was initially analyzed with a one-way ANCOVA with subject group (HIV− and HIV+) as a between-subjects variable. The dependent variable was an overall index of performance, the number of cards chosen from a "safe" deck (i.e., from decks C and D) minus the number of cards chosen from a "risky" deck (decks A and B). Thus, lower scores indicate more risky gambling task performance, higher scores indicate more optimal performance (i.e., winnings will be greater). It was predicted that the HIV+ group would have a significantly lower overall gambling task score compared to the HIV− group.

To specify where group differences were evident in the gambling task, a 2 × 4 mixed-model ANCOVA was conducted with subject group (HIV− and HIV+) as a between-subjects variable and gambling task deck (A, B, C, and D) as a within-subjects variable. A Greenhouse-Geisser correction was applied to within-subjects effects (i.e., gambling task deck). If the interaction between subject group and gambling task deck was significant, then post hoc comparisons were conducted to clarify the nature of the interaction. A one-way ANCOVA was conducted at each deck, comparing the number of cards selected from that deck between the HIV+ group and the HIV− group. Although it was predicted that the HIV+ group would select more cards from the "risky" decks (decks A or B) relative to the HIV− group, there was no prediction about a specific risky deck. If there was a significant group difference with a risky deck, then a follow-up analysis was conducted to examine the pattern of card selection at that deck(s) across five 20-trial blocks.

Neurocognitive performance on each test was analyzed with a one-way ANCOVA with subject group (HIV− and HIV+) as a between-subjects variable. In general, the HIV+ group was expected to perform worse than the HIV− group on these tests. To explore the possible relationship between cognition and risk-related decision making, exploratory Pearson Product Moment correlations were analyzed between neurocognitive test measures and gambling task performance measures (the overall measure as well as the separate deck measures) within the HIV+ group and seronegative control group. Due to the exploratory nature of these correlations, the significance level was set at .05, acknowledging the relatively high probability of committing a Type I error due to the many correlation coefficients calculated.

Results

Gambling Task

For the ANCOVA on the overall performance measure (decks C + D minus decks A + B), there was a significant difference between groups, $F(1, 81) = 5.34$, $p = .02$, $\eta^2 = .06$, with the HIV+ group ($M = 6.6$, $SE = 3.0$) showing more risky performance compared to the HIV− group ($M = 22.3$, $SE = 5.9$). Covariates were not significant ($p > .17$).

For the 2 × 4 mixed-model ANCOVA examining performance across decks, there was no main effect of subject group (this would be expected because both groups select the same overall number of cards). More interestingly, there was a significant interaction between subject group and gambling task deck, $F(3, 243) = 5.50$, $p = .003$, $\eta^2 = .06$, which is illustrated in Figure 1. None of the covariates interacted with gambling task deck ($p > .34$).

For the separate ANCOVAs at each deck, there was no significant group difference at decks A ($p = .60$) or D ($p = .24$). There was a significant group difference at deck B, $F(1, 81) = 14.12$, $p < .01$, $\eta^2 = .15$, with the HIV+ group selecting more cards ($M = 28.3$, $SE = 1.0$) than did the seronegative group ($M = 19.2$, $SE = 2.1$). There was also a significant difference at deck C, $F(1, 81) = 5.59$, $p = .02$, η^2 .07, with the HIV- group selecting more cards ($M = 30.7$, $SE = 1.8$) than did the HIV+ group ($M = 25.9$, $SE = 0.9$). Covariates were not significant (p values were $\geq .10$).

Because there was a group difference on the risky deck B, a 2 × 5 ANCOVA was conducted to examine card selection at this deck across five 20-trial blocks in the HIV− and HIV+ groups. The central finding was a significant interaction between subject group and block, $F(4, 324) = 3.16$, $p = .02$, $\eta^2 = .04$, which illustrated in Figure 2. None of the covariates interacted with block ($p > .29$).

Neurocognitive Tests

Results are presented in Table 2. As is evident, the HIV+ group performed worse than the HIV − group on SRT and PASAT Although not statistically significant at the .05 level, differences on most of the other tests were in the expected direction, with poorer performance in the HIV + group.

Correlations

Pearson correlations were calculated between the overall index of gambling task performance (cards chosen from decks C and D minus those chosen from decks A and B) and neurocognitive test scores in the HIV+ group and in the HIV− group. No correlations were significant. Pearson correlations were then calculated be tween number of cards drawn from each deck on the gambling task and neurocognitive test scores for each the HIV+ and HIV− groups. No correlations were significant within the HIV− group. In the HIV+ group, there were significant correlations between deck B and Stroop performance ($r = .26$, $p = .03$), and between deck B and the CVLT ($r = -.25$, $p = .04$).

Discussion

Supporting our main hypothesis, the HIV+ group performed worse on the gambling task compared to the seronegative control group. As previously mentioned, worse performance on the gambling task is typically interpreted as indicating more risky decision making. This finding of greater risky decision making in HIV+ adults on a laboratory task is clearly compatible with the risky decisions and behavior that has been associated with large segments of the HIV-infected population. This finding is also compatible with reports showing deficient gambling task performance in other populations that show risky decision-making characteristics in real life, such as drug abusers, as well as in individuals with lesions in prefrontal cortical regions or with neurodegenerative disorders that could disrupt prefrontal functioning such as in Huntington's Disease. Martin and colleagues (2004) have previously reported a group difference in gambling task performance between HIV+ adults and HIV− negatives. However, in their study all participants had a diagnosis of current or past substance dependence. In the present study, few individuals met criteria for current drug dependence and although half of the HIV+ group were classified with past drug dependence, all gambling task analyses examining group differences between HIV+ and HIV− groups included the variables of current and past drug dependence as covariates. Thus, our results more likely represent a performance difference on the gambling task mainly due to serostatus. In addition, the reported group difference may be an underestimate of the effect of HIV on the gambling task. All HIV+ participants in the present study were currently receiving HAART. Martin and colleagues

(2004) reported a preliminary analysis showing that HIV+ individuals on HAART performed better than untreated HIV+ adults or those only on reverse transcriptase inhibitors.

A unique aspect of our study relative to previous gambling task studies is that we examined not only overall performance, but performance on each of the four separate card decks. The results are quite straightforward. HIV+ adults did not overly select from both risky decks but only from deck B. Deck B is characterized by infrequent large penalties, in contrast to the frequent relatively small penalties in deck A (the other risky deck). Although drawing cards from either deck A or B will result on average in losing the same amount of money, the HIV-infected group seemed to understand the detrimental nature of the penalties only in deck A. As Figure 2 clearly illustrates, although the HIV− group learned over time to avoid deck B, the HIV+ group maintained selecting cards from this deck throughout the entire task. The HIV+ group never stopped "going for broke," as one infected subject put it while selecting a deck B card. Although preliminary in nature, one explanation or at least a partial explanation for the HIV+ group selecting more cards from the risky deck B is provided by the exploratory correlational analyses. In the HIV+ group, both Stroop Interference performance and delayed memory recall on the CVLT was significantly correlated (in expected directions) with the number of cards selected from deck B. Thus, although the stimulus characteristics between the two tasks are considerably different, perhaps those HIV+ individuals with weaker inhibitory processing as evidenced on the Stroop task had more difficulty resisting or inhibiting their selection of cards from deck B. Likewise, those HIV+ individuals with poorer delayed recall scores on the CVLT presumably had more difficulty remembering the severity of the infrequent penalties on deck B. These correlations with Stroop Interference and CVLT can also be placed within the framework of a recent formal model of gambling task performance by Busemeyer and Stout (2002). In their expectancy-valence model, there are three parameters. An updating rate parameter determines the memory for past consequences produced by each deck. They found this parameter to be central in the worse gambling task performance in individuals with Huntington's Disease. Our current finding with the CVLT in HIV+ adults is consistent with their finding with this parameter. Two other parameters include a weight parameter, which determines the amount of attention allocated to gains versus losses, and a threshold parameter, which determines the sensitivity of response mechanisms (the degree of impulsiveness or recklessness in responses). Our finding with Stroop Interference seems compatible with either of these parameters. Of interest, Busemeyer and Stout (2002) found their Huntington group to be more sensitive on the threshold parameter (suggesting greater impulsivity), indicating a similar finding we report here with the HIV+ group and Stroop Intereference.

Our finding with the CVLT is also compatible with a gambling task study by Stout et al. (2001) who employed the Mattis Dementia Rating Scale (MDRS) in examining individuals with Huntington's disease, Parkinson's disease and normal controls. They found that the Huntington's group made fewer advantageous selections than the other groups, and that the memory and conceptualization sections of the MDRS correlated with the number of advantageous selections made during early card selections. Although not displayed in paper, Stout et al. (2001) also mentioned unpublished correlations between a list-learning task and gambling task performance in their Huntington's group. No correlations were found in the other groups, leaving the authors to conclude that it was deficits in memory and conceptual thinking that were responsible for the Huntington's group's poor performance (see also Sevigny et al., 2005).

In sum, the present results indicate that the gambling task is a useful laboratory instrument in the assessment of decision making in HIV+ adults. Results of former studies, along with our preliminary findings, indicate that specific neurocognitive processes might be involved in poor gambling task performance. In our study, exploratory correlations between Stroop Interference and delayed recall trials of the CVLT in HIV+ individuals provide a preliminary suggestion

that impulsivity and deficient encoding or recall are key factors in poor gambling task performance. The gambling task may prove useful in helping clarify the decision making process of HIV+ adults, both at a cognitive and behavioral level of analysis.

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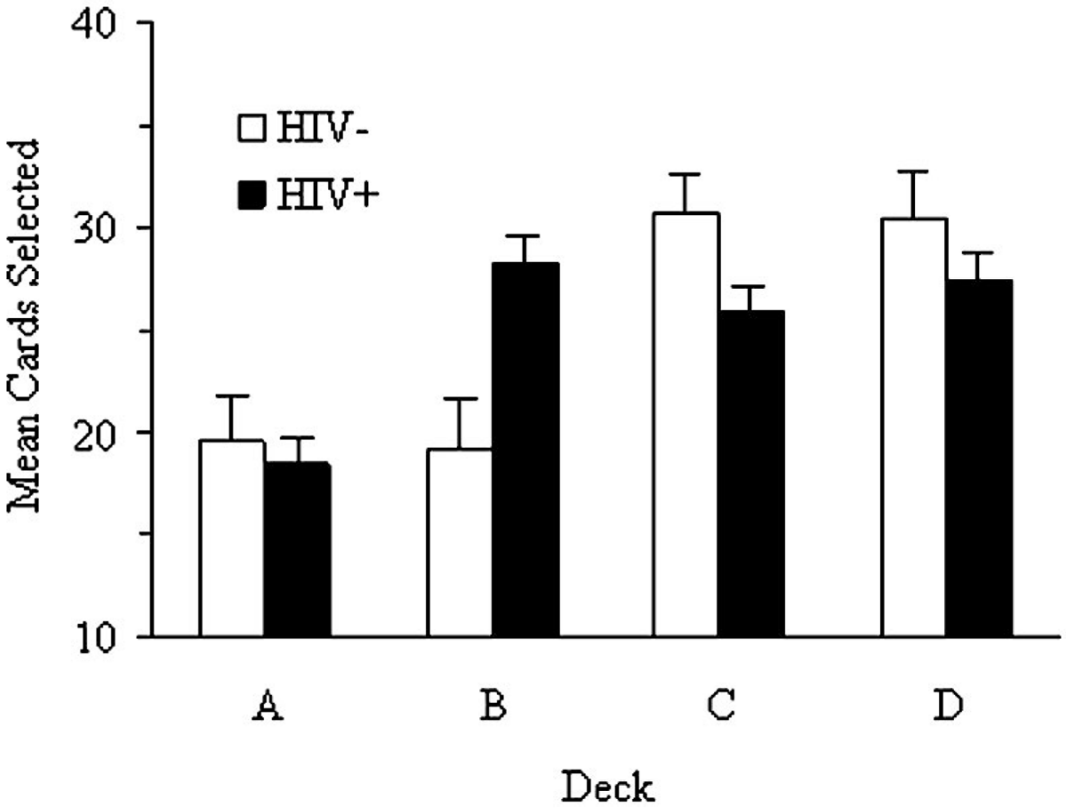

Figure 1.
Average number of cards selected from each deck on the gambling task for the HIV+ and HIV − group. Means are presented with *SE* bars.

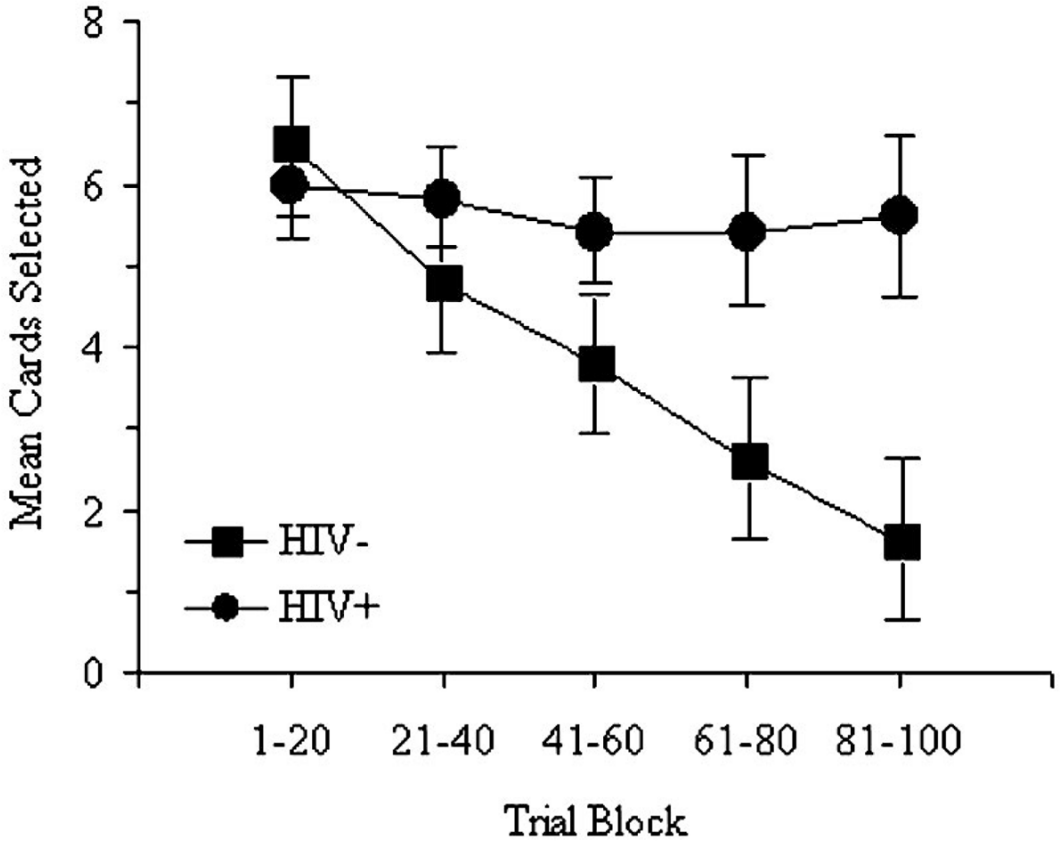

Figure 2.
Average number of cards selected from deck B across five blocks of trials on the gambling task for the HIV+ and HIV− group Means are presented with *SE* bars.

Table 1

Demographics for HIV− and HIV+ Groups

Variable	HIV−	HIV+	*p*
n	19	67	
Age	47.6 (15.5)	43.8 (08.1)	NS
Education (years)	13.9 (02.1)	12.7 (02.3)	.04
Beck Depression Inventory II	05.7 (06.2)	14.4 (12.0)	.01
HIV dementia scale	14.2 (01.8)	13.0 (02.5)	NS
CD4 count	—	399 (221)	—

Note. In upper portion of table, means are presented with standard deviations inside parentheses. NS = not statistically significant at the .05 level.

Table 2

Neurocognitive Test Performance in HIV− and HIV+ Groups

Cognitive domain/test	HIV−	HIV+	*p*
Attention and executive ability			
Digit Span Backward	05.0 (00.4)	04.4 (00.2)	NS
Simple Reaction Time	247.6 (18.0)	299.0 (10.9)	.02
Stroop Interference	121.1 (09.4)	138.0 (04.7)	NS
Trail Making Test-Part B	93.0 (16.0)	104.4 (08.0)	NS
PASAT errors	75.9 (09.3)	100.7 (04.8)	.03
Other domain tests			
Grooved Pegboard NH	83.5 (08.9)	93.5 (04.5)	NS
Symbol Digit Modalities Test	46.8 (02.7)	41.6 (01.4)	NS
Booklet Category Test	42.4 (03.3)	41.8 (01.7)	NS
CVLT long delay free recall	10.5 (00.7)	09.6 (00.4)	NS

Note. Means are presented with standard error inside parentheses. PASAT = Paced Auditory Serial Addition Test. NS = not statistically significant at the .05 level.