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A deconstruction of gambling task performance among HIV+ individuals: The differential contributions of problem solving and risk taking

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Abstract

This study sought to deconstruct gambling task (GT) performance among HIV+ individuals ($N=143$) and intended to capture other cognitive features of task performance (i.e., problem-solving and strategy preference). Consistent with our hypotheses, cluster analysis identified three GT groups: a safe/advantageous (AS) strategy group, a risky/disadvantageous (RS) strategy group, as well as a novel third group who failed to develop a strategy (NS). The NS group performed worst on global neuropsychological performance, processing speed, and executive function. Our results support a novel measure of GT task performance, and suggest that failure to develop/implement a strategy reflects cognitive dysfunction.

Identifying individuals who are most likely to engage in risky behaviors—or behaviors with the potential for loss or negative consequences—and factors that contribute to such behavior is clinically important. High-risk behavior (e.g., unprotected sex, needle sharing) has been associated with the spread of HIV (Holmberg, 1996). Among individuals living with HIV, rates of risk behavior often fluctuate during the course of the disease, but remain continuously high among a significant subset of individuals (Eaton & Kalichman, 2009). Although the processes preceding risky behavior are complex, one important process is decision-making, or the evaluation of several possible responses and the subsequent selection of a preferred response. Historically, there have been numerous theories and models of decision-making; broadly, most describe the process as beginning with an understanding or appreciation of the problem (e.g., a problem-solving phase) and conclude with the identification and implementation of a solution (Bransford & Stein, 1984; Newell & Simon, 1972; Oliveira, 2007). Therefore, problem-solving, or the reasoning involved in attempting to reach a goal state, is thought to play an important role in decision-making.

Among HIV+ individuals, decision-making can influence whether one engages in beneficial or detrimental health behaviors—not only behaviors with public health consequences, like risky sexual and drug-use behaviors, but also choices that can impact an individual's disease trajectory, like antiretroviral medication adherence. Both neuropsychological and psychiatric/personality factors can affect decision-making. In the HIV literature, several studies have shown that HIV-associated cognitive impairments can adversely affect decision-making (Hardy, Hinkin, Levine, Castellon, & Lam, 2006). HIV preferentially targets frontostriatal circuits that are involved in the maintenance and regulation of higher-level cognitive processes, including decision-making (Everall, 1999; Hinkin, Castellon, van Gorp, & Satz, 1998; Pfefferbaum et al., 2009). Personality factors such as sensation seeking, or preference for situations that provide greater stimulation/arousal (Zuckerman, 1994), can also influence decision-making (Gonzalez et al., 2005). Sensation seeking is influenced by

reward sensitivity, and has been linked to risk-taking behaviors among HIV+ men and intravenous drug users (Kalichman, Heckman, & Kelly, 2005).

The Gambling Task is a neuropsychological measure that involves decision-making under conditions of uncertainty. It is a measure that taps into both cognition and personality, particularly reward sensitivity (GT; Bechara, 2007; Bechara, Damasio, Damasio, & Anderson, 1994). Previous research has shown that HIV+ individuals are more likely to select more cards from high risk decks compared to controls (Hardy et al., 2006; Martin et al., 2004; Thames et al., 2012) and that ARV-naïve HIV+ individuals perform worse on the GT compared to HIV+ individuals on combined antiretroviral therapy (CART; Martin et al., 2004). However, results on the GT are not always consistent across studies. The GT was designed to be sensitive to ventromedial prefrontal cortex (vmPFC) damage, which can cause individuals to fixate on immediate rewards. Individuals with vmPFC damage perform worse on the GT compared to controls, selecting more cards from risky decks (Bechara et al., 1994). However, neuroimaging studies have shown task-related activation not only in the ventromedial and orbitofrontal cortex (Ernst et al. 2002; Lawrence, Jollant, O'Daly, Zelaya, & Phillips, 2009; Li, Lu, D'Argembeau, Ng, & Bechara, 2010; Tanabe et al. 2007; Tucker et al. 2004), but also in other brain regions including the dorsolateral prefrontal cortex (Ernst et al. 2002; Lawrence et al., 2009; Li et al., 2010; Tanabe et al. 2007; Tucker et al. 2004), insula (Ernst et al. 2002; Li et al., 2010), ventral striatum (Li et al., 2010), supplementary motor area (Li et al., 2010) and inferior parietal cortex (Ernst et al. 2002). Additionally, results on the relationship between GT scores and performance on other frontally-mediated tasks have been conflicting (Toplak, Sorge, Benoit, West, & Stanovich, 2010). Finally, a variety of personality and psychological factors—such as trait anxiety (Miu, Heilman, & Hauser, 2008) depressive symptoms (Smoski et al., 2008; Thames et al., 2012), impulsivity (Franken, van Strien, Nijis, & Muris, 2008), and addictive personality traits (Davis, Patte, Tweed, & Curtis, 2007)—have been linked to GT performance. However, results are often inconsistent across studies, particularly in relation to sensation seeking. For example, some studies have shown that poor (i.e., more risky) GT performance is associated with higher sensation-seeking scores, including “fun seeking” (Suhr & Tsanadis, 2007) and disinhibition (Crone, Vendel, & Van der Molen, 2003). Conversely, other studies have shown that better GT performance (i.e., more advantageous) is associated with higher sensation seeking scores (Gonzalez et al., 2005; Reavis & Overman, 2001), or have not found any significant relationship between GT scores and sensation seeking measures (Harmsen, Bischof, Brooks, Hohagen, & Rumpf, 2006). These discrepancies in the literature may be related to nature of the GT outcome measure used. Given the complexity of the GT, there are several possible definitions of “poor” task performance that have been used across studies such as the GT net score (which is obtained by subtracting the number of cards selected from advantageous decks (C & D) from the number of cards selected from disadvantageous decks (decks A & B; Bechara, Damasio, Tranel, & Anderson, 1998). It provides a continuous measure of task performance with higher scores typically interpreted as reflecting better performance and lower scores typically indicating worse/more risky performance. However, the GT net score may not capture some important aspects of task performance. Specifically, the net score is not sensitive to changes in task strategy over time and may not adequately differentiate between the contributions of problem solving and risk taking.

However, as a decision-making test, the GT involves multiple cognitive processes. We posit that the GT tests the ability to discern differences between decks in immediate and long-term rewards/penalties and also tests the ability to use this information effectively, which involves developing and implementing a problem-solving strategy. This process can be viewed as involving 1) understanding or learning the task (i.e., reflecting problem-solving ability, involving dorsolateral prefrontal and striatal functioning), and subsequently, 2)

adopting a safe or a risky strategy (reflecting reward/penalty sensitivity and more ventromedial-orbitofrontal functioning). Traditionally, studies have only examined the latter: the preference for advantageous decks versus risky decks (e.g., strategy use) using the GT net score. One potential limitation of this measure is that individuals who fail to discern differential cost/benefit contingencies associated with each deck and continue to select indiscriminately across decks will score intermediate between those who prefer safe or risky decks. Consequently, the net score may obscure important differences in performance patterns and thus fail to capture useful data about GT task performance. Therefore, examining both problem-solving and strategy development on the GT may provide another useful index of cognitive functioning.

This study sought to characterize GT performance in a sample of HIV+ individuals using a novel method of examining GT outcome. Although some studies have classified individuals as learners vs. non-learners (i.e., those whose net scores do increase over trial blocks vs. those whose net scores do not; Davis et al., 2007) or quantified performance based on shifts between advantageous and disadvantageous decks (Sinz, Zamarian, Benke, Wenning, & Delazer, 2008), no study to date has categorized participants by GT strategy use, specifically separating individuals who develop specific strategies from those who do not appear to develop any clear strategy. While implicit memory systems may contribute to GT performance, the ability to determine that certain decks contain advantageous outcomes and others contain disadvantageous outcomes may be more important. Once the respondent is aware of these contingencies, they can decide whether to select from high-risk decks or to select from low risk/low yield decks. We hypothesized that three different performance patterns would emerge on the gambling task: 1) those who selected more cards from “advantageous” or “safe” decks, 2) those who selected more cards from “disadvantageous” or “risky” decks, and 3) individuals who failed to preferentially select cards from either good or bad decks. We also sought to characterize these groups based on neuropsychological (NP) performance, sensation seeking, and risk-taking behavior.

Method

Participants

The present study included 143 HIV+ participants recruited through various infectious disease clinics and hospitals within the Los Angeles area between 2000-2006. A subset of 24 HIV- controls who completed the gambling task were also examined in exploratory analyses. Exclusion criteria included history of neurological disorder (e.g., head injury with loss of consciousness in excess of 30 minutes, stroke, seizure disorder, or CNS opportunistic infection). All participants were required to demonstrate at least a 6th-grade reading level and provide written informed consent. Study procedures received approval from UCLA and West Los Angeles VA institutional review boards.

Procedure

Neuropsychological Performance

Participants completed a comprehensive neuropsychological test battery that assessed verbal fluency, attention/working memory, executive function, learning/memory, processing speed, and motor functioning using an approach previously validated by our group (see Ettenhofer et al., 2009 for a detailed description). Raw scores were converted to demographically-corrected T-scores based on published normative data and averaged within domain to obtain domain T-scores (see Table 1). All T-scores were averaged to obtain the global NP T-score. The BDI-II was administered to assess current depressive symptomatology (Beck, Steer, & Brown, 1996).

Additionally, we administered Bechara's gambling task (GT). The GT is a decision-making test that employs a pseudo-gambling paradigm. Following Bechara's original task instructions (Bechara et al., 1994), and using the original, non-computerized version of the task, participants were given fake money (i.e. "loaned" \$2,000) at the beginning the task and were presented with four different decks of cards, each containing 40 cards. Each card drawn provided a monetary gain; some also incurred a loss. Participants were instructed to attempt to win as much money as possible and were told that they could select cards from any of the four decks. Unbeknownst to the participants, two of these decks, C and D, were "good" or "advantageous" decks; they provided smaller monetary rewards (\$50) and smaller penalties (ranging from \$25-\$250, depending on the deck), but ultimately resulted in a net gain. Two were "risky" or "disadvantageous" decks which provided larger monetary rewards (\$100) but also larger penalties (ranging from \$150-\$1250, depending on the deck) and ultimately resulted in a net loss. The GT task includes 100 trials and each of the 4 decks contain only 40 cards, therefore, it is possible for participants to run out of cards in two decks near the end of the task (for example, both advantageous decks or both risky decks), at which point card selection would be forced. As such, we only analyzed task performance up to trial 80. Of note, newer versions of the gambling task have eliminated this issue by including unlimited cards in each deck (Bechara, 2007).

Sensation Seeking Scale-V (SSS-V)—Participants completed the Sensation Seeking Scale-V (SSS-V), a 40-item scale designed to assess personality and risk preference across the following areas: Thrill and Adventure Seeking (TAS), Disinhibition (Dis), Experience Seeking (ES), and Boredom Susceptibility (BS; Zuckerman, Eysenck, & Eysenck, 1978).

Substance Use—Participants received a semi-structured interview in order to assess for current and past history of substance abuse and dependence based on Diagnostic and Statistical Manual of Mental Disorders-IV Text Revision (DSM-IV-TR) criteria.

Risk-Taking Behavior—Participants were also asked about their history of risk-taking behavior. Groups were compared on the percentage of the sample that reported lifetime (i.e., did they ever engage in the behavior) and recent (i.e., both in the past month and in the past year) risk-taking behaviors that have the potential for spreading HIV infection: needle sharing and unprotected sex.

Statistical Analyses

Statistical analyses were performed using IBM SPSS Statistics Version 21. In order to identify typologies of GT strategies, a two-step cluster (TSC) analysis was computed to automatically determine the optimal number of clusters, allowing for a maximum of 15 clusters (TSCA, developed by Chiu, Fang, Chen, Wang, & Jeris, 2001). GT net scores by 10 trials were entered into the model for cluster creation. Variables were standardized by the clustering procedure. Log-likelihood criteria was used as the distance measure, and Akaike's Information Criteria (AIC) was selected as the clustering criteria. Noise-handling was not applied, initial distance change threshold was 0 with a maximum of 8 branches per leaf node and a maximum of 3 tree depth levels. One-way ANOVAs and independent samples *T*-tests were used to analyze group differences on continuous variables. All dependent variables met homogeneity of variance assumptions and were normally distributed except plasma HIV viral load, which was logarithmically transformed. Posthoc comparisons were conducted using least significant difference (LSD). Categorical variables were examined using chi-square.

Results

Overall, our sample had a mean GT net score of 0.10 ($SD = 21.63$). Using traditional methods, this would suggest that, as a group, participants engaged in neither a risky nor advantageous strategy. However, in order to further identify and classify subtypes of GT performance, a two-step cluster analysis was computed which generated a 3-group solution. Performance patterns for each group are shown in Figure 1.

Consistent with study hypotheses, two of the three groups adopted a clear strategy. One group selected more cards from the safe/advantageous decks, Decks C and D (which will be referred to as the “advantageous strategy” (AS) group). The AS group had a mean GT net score of 20.68 ($SD = 17.91$). The second group increasingly selected cards from the risky/disadvantageous decks, Decks A and B, adopting a disadvantageous or “risky” strategy (i.e., the risky strategy (RS) group) and had a mean net score of -24.18 ($SD = 17.93$). Finally, a third group did not appear to develop or implement a clear strategy or possibly had no specific preference (i.e., the “no strategy” (NS) group). Their mean GT net score was -0.93 ($SD = 9.70$). GT groups did not significantly differ on demographic, virological, or medical characteristics (see Table 2).

Next, we sought to determine whether or not these groups differed on key study variables. First, we combined the two strategy groups (i.e., risky and safe strategy) and compared them to the NS group. This overall strategy group performed significantly better on global NP, processing speed, attention/working memory, and executive functioning compared to the NS group (all p 's $< .04$). Second, we examined whether or not the three groups (i.e., safe strategy, risky strategy, and no strategy), differed significantly on neuropsychological function. Significant differences were observed for global NP, processing speed, and executive functioning (see Table 3). A trend was observed for attention/working memory. Posthoc analyses showed that the AS group performed significantly better than the NS group on all four measures. The RS group performed significantly better than the NS group on executive functioning, and a trend was observed for processing speed. The risky and safe strategy groups did not differ on any NP domains or global NP using independent samples t -tests (all p 's $> .15$).

No significant differences were observed on depressive symptoms (BDI-II scores). On the Sensation Seeking Scale-V (SSS-V), none of the omnibus models were significant, although there was a trend for Boredom Sensitivity (see Table 4). Posthoc analyses showed that the RS group had significantly higher scores compared to the NS group on boredom sensitivity. The AS and RS groups also had significantly higher rates of current substance use disorder diagnoses compared to the NS group.

We also examined history of risk-taking behavior (see Table 5). Contrary to expectations, GT groups did not significantly differ on lifetime or recent history of needle sharing or unprotected sex. Qualitatively, inspection showed that the risky group reported more recent risk-taking behavior compared to the other two groups.

Finally, we conducted an exploratory analysis. We sought to compare the distribution of GT net scores from our HIV+ sample to a small subset of HIV- controls ($n = 24$) who also received the gambling task. HIV+ and HIV- individuals differed significantly on GT net score, with the HIV- individuals performing similarly to the HIV+ individuals in the AS group (HIV+ mean = 0.10 ± 21.63 , HIV- mean = 18.42 ± 18.66 , $p < .01$).

Discussion

Prior studies, including those conducted by our group, tended to examine GT net score as their outcome variable and have conceptualized the GT as a measure of decision-making/risk-taking. Increasingly, however, we have come to believe that problem-solving and strategy development/implementation may be more salient cognitive processes involved in GT task performance. We suggest that participants engage problem-solving; they must gather information regarding reward/risk contingencies associated with each deck through successive card selection. As more data is obtained, hypotheses regarding deck contingencies can be formed and tested and then discarded if so desired. If a participant is never able to discern how the decks differ, then they can never make an informed decision as to which decks are risky or advantageous. Therefore, we suggest that successful problem-solving is necessary for the respondent to make an informed decision to select from the low risk or the high risk decks (i.e., strategy selection/implementation). One could argue that conscious awareness of the risk/reward contingencies is not necessary, or that an implicit learning pathway could be operable. However, one would not expect implicit memory to be the default approach since the GT can be solved using a top-down deductive approach. Additionally, previous research has shown that individuals who selectively draw from advantageous decks were aware of deck contingencies (Maia & McClelland, 2004).

This study sought to test a novel method of examining GT outcome by attempting to identify groups of individuals based on strategy use in an HIV+ sample. Consistent with our hypotheses, three specific GT groups emerged: one group of individuals who failed to develop/implement a strategy (i.e., no strategy group, NS), and two groups of individuals who were able to identify/implement a strategy (i.e., individuals who preferred “advantageous” decks (AS), or individuals who preferred “risky” decks (RS). The “no strategy” group performed significantly worse on global NP, processing speed, and executive function compared to the “advantageous strategy” group, and worse on executive function compared to the “risky strategy” group. Typically, risky performance on the GT (i.e., lower GT net score) has been thought of as “worse” performance. However, our results suggest that failure to develop a strategy on the GT, or failure to appreciate task demands and learn from rewards/penalties, actually represents worse cognition. Consistent with our hypotheses, and in contrast to much of the extant literature, we did not find any cognitive differences between individuals who developed a strategy, regardless of whether that strategy was advantageous or “risky.” This suggests that risky strategy selection reflects preference not poor cognition. Moreover, while GT net scores are not always associated with performance on other frontally-mediated tasks in the literature (see Toplak et al., 2010 for a review), our GT groups significantly differed on attention/working memory and executive function, suggesting convergent validity. However, we cannot rule out the possibility that the RS group did have neuropsychological deficits that were not captured by these traditional neuropsychological tasks, but are captured by the GT. Therefore, our results will need to be replicated in other samples and explored further with additional neuropsychological or experimental cognitive measures.

Interestingly, just under half of our HIV+ sample fell into the “no strategy” group. The advantageous strategy group was comparatively smaller (29%), and the least were in the risky strategy group (23%). Although previous research suggests that HIV+ individuals prefer risky decks (Hardy et al., 2006; Martin et al., 2004), perhaps some of these individuals labeled as “risky” in actuality did not employ a clear strategy. The GT net score could have obscured this difference since those who fail to develop a strategy would still have lower overall GT net scores than those who adopted an advantageous strategy.

Many participants may have failed to appreciate the differential rewards/penalties associated with each deck and hence fell into the NS category due to the frontostriatal nature of HIV-associated neuropsychological impairments, which can interfere with problem-solving abilities. Therefore, HIV+ individuals may have more difficulty identifying and/or effectively implementing a strategy. This appears to be consistent with previous research showing that even when given a variant of the gambling task that reduces the demand for reversal learning, individuals with DLPFC lesions continued to perform poorly on the task while individuals with vmPFC lesions were able to improve. Additionally, those individuals with DLPFC lesions selected about 50 cards from the advantageous cards, reflecting a net score of 0, which suggests failure to develop a strategy (Fellows & Farrah, 2005). Overall, our results suggest that failure to employ a strategy on the GT may be a relatively sensitive measure of the subtle deficits associated with HIV, including problem-solving deficits. Our exploratory analyses conducted with a HIV- control group suggested that controls had higher mean net GT scores compared to HIV+ individuals, suggesting that controls were more likely to use a “safe” strategy. Mean GT net scores and the GT net score distribution observed in controls differed from those observed in HIV+ individuals, with the exception of HIV+ individuals who adopted an advantageous strategy. However, our HIV- comparison group was small. Therefore, this will need to be investigated further. Future research will be also needed to determine whether or not this pattern generalizes to other neurological populations, as it is possible that GT strategy development may differ across disease groups.

There were no significant between-group differences on the Sensation Seeking Scale. However, there was a statistical trend for differences on Boredom Sensitivity, and posthoc analyses showed that the RS group endorsed significantly higher levels of boredom sensitivity compared to the NS group. The RS group and AS groups did not significantly differ on any sensation-seeking scores, which may explain why previous studies using GT net score as an outcome measure have reported inconsistent relationships between sensation seeking characteristics and GT task performance (Gonzalez et al., 2005; Reavis & Overman, 2001; Suhr & Tsanadis, 2007). When considered along with the neurocognitive findings, our results indicate that, at least with respect to HIV infection, individuals who adopt a risky strategy may actually be cognitively intact and able to understand the nature of the GT task. However, they prefer to adopt a “risky” strategy by selecting from decks that have the potential for larger wins but ultimately result in greater loss. However, we were not able to identify the factors that underlie this preference. Most prior studies of GT performance in HIV infected adults, including those conducted by our group, have interpreted “poor” GT performance as indicative of cognitive dysfunction. Based on a re-analysis and reconsideration of our data and the GT task in general, this classic interpretation may obscure potentially useful information about GT task performance. This is consistent with the idea that individuals who score high on sensation seeking prefer more arousing stimuli (Zuckerman, 1994). High sensation seekers may be particularly drawn to larger, immediate reinforcement; they are either willing to tolerate a higher level of risk for this possibility or they may simply prefer the high-stakes environment.

The lack of relationship between GT strategy group and risk behavior may be due to the fact that our participants are not recently HIV-infected, but have been HIV+ for about 9 years on average. Our sample reported a relatively high rate of past risk-taking behavior—particularly unprotected sex, which was endorsed by over 96% of our sample—yet reported very low rates of recent risk-taking behavior. Therefore, the lack of adequate statistical variance precludes meaningful statistical comparisons. Qualitatively, however, it appeared that our risky group did report more recent risk-taking behavior compared to the advantageous and no strategy groups. Additionally, both cognition and behavior are influenced by a host of factors, therefore, GT performance may only be part of the picture.

Results may also have been limited by the nature of our risk-taking assessment. Risk taking is a sensitive topic, particularly when the behaviors assessed have the potential for spreading HIV infection (such as needle sharing and unprotected sex). Some have suggested by that individuals may be more willing to report risk-taking behavior on self-report measures rather than face-to-face interviews (Gonzalez et al., 2005). Our risk-taking assessment was conducted as a brief interview, which may have impacted individuals' willingness to report these behaviors. This may explain why relatively low rates of recent risk-taking were reported among individuals with such high rates of past risk behavior. Alternatively, it is also possible that our sample is no longer engaging in as many risky behaviors as they did in the past. Research has shown that risk behavior can fluctuate over the course of HIV disease, and often precipitously declines after one becomes aware of their HIV status (Eaton & Kalichman, 2009).

Another potential limitation is that the GT may not adequately capture the propensity for "real world" risk taking. Some of our participants may have chosen risky decks because they knew that their decisions would not have real-world consequences. Adding an ecological component to the task (e.g., having participants win or lose real money) may increase the GT's overall ecological validity. Finally, decision-making is a multifactorial process; therefore, the complexity of the GT task is another potential limitation. Although the GT does present the option for immediate or delayed reward, the decks actually differ on at least 4 constructs: 1) size of immediate pay, 2) size of penalty, 3) consistency of penalty size (i.e., penalties for Deck A & C range from \$25-\$350, while Decks B & D always have a consistent penalty of \$1250 or \$250, respectively), and 4) *frequency of penalty* (i.e., Decks A & C have penalties on 50% of trials, while Decks B & D have penalties on 10% of trials). Several of these factors are internally confounded and cannot be assessed separately based on the GT task design. For instance, decks either have infrequent and inconsistent penalties or frequent and consistent penalties. No deck has both frequent and inconsistent penalties, or infrequent and consistent penalties. Participants may be differentially responding to specific factors, yet the influence of these factors cannot be disentangled. For example, perhaps some participants will tolerate a higher level of penalty in exchange for consistency (i.e., predictability) of penalty size, while others will prefer an unpredictable penalty that has the possibility of being smaller. Additionally, the reward scheme is not structured similarly (e.g., all decks produce the same size reward after each trial), and there is no variability across decks in terms of frequency or consistency of rewards.

Limitations aside, our results show that a novel approach toward understanding and evaluating gambling task performance (i.e., problem-solving and strategy use) is a promising measure of decision-making that may be sensitive to HIV-associated cognitive impairments. This measure may provide useful GT performance data that is not otherwise captured in other GT outcome measures. Additionally, there are a number of ways that this concept could be investigated further in future research. For example, rationally-defined rather than empirically-driven GT groups could be investigated. Additionally, more fine-grained analysis at the item level may help to further parse task learning, strategy execution, and strategy persistence.

Finally, future research should examine multivariate models including GT strategy group as well as other characteristics, particularly in more varied samples. Our sample reported high rates of past of risk-taking behavior; 100% of our sample reported engaging in either unprotected sex or needle sharing in the past. Therefore, an important limitation in our sample is that we cannot compare individuals with and without a history of risky behavior; we can only compare those who no longer engage in risky behavior to those who still do. We do not have any individuals who represent a purely "low-risk" group. Therefore, multivariate models may provide more interesting results in samples with a broader range of

risk-taking characteristics, including individuals with no history of past risk-taking behavior. However, identifying a subset of “high-risk” individuals within a high-risk population (i.e., HIV) is critical for prevention of HIV spread and treatment. Intervention and prevention strategies should differ depending upon the individuals cognitive versus personality characteristics. In the context of treatment failures, the practitioner should question whether or not the individual is able to comprehend and follow treatment instructions (a question of cognitive ability), or if they simply choose to engage in practices that place them at risk for treatment failures despite full understanding the consequences (a question of personality style). Our results suggest that the GT may be a useful measure for parsing cognitive versus personality contributions to decision-making.

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Figure 1.
Mean GT net scores for each trial block by strategy group. Note: AS = Advantageous Strategy, NS = No Strategy, RS = Risky Strategy.

Figure 2.
Mean total GT net score for each strategy group.

Table 1
Neuropsychological tests and normative data sources

Domain/Test	Normative Source
Speed of Information Processing	
Trail Making Test (Part A)	Heaton, Grant, & Matthews, 1991
Symbol Digit Modalities Test	Smith, 1982
WAIS-III Digit Symbol Coding	Wechsler, 1997
Learning and Memory	
California Verbal Learning Test	Delis, Kramer, Kaplan, & Ober, 1987
California Verbal Learning Test-II	Delis, Kramer, Kaplan, & Ober, 2000
Attention and Working Memory	
Paced Auditory Serial Addition Test (PASAT)	Stuss, Stetham, & Pelchat, 1988
Executive Functioning	
Trail Making Test (Part B)	Heaton, Grant, & Matthews, 1991
Stroop Color-Word Test	Selnes et al., 1991
Short Category Test	Wetzel & Boll, 1987
Wisconsin Card Sorting Test—64 card version	Kongs, Thompson, Iverson, & Heaton 2000
Verbal Fluency	
COWAT Letter Fluency	Selnes et al., 1991
COWAT Category Fluency	Selnes et al., 1991
Motor Functioning	
Grooved Pegboard (dominant hand; non-dominant hand)	Heaton, Grant, & Matthews, 1991

Table 2
Demographic, virological, and medical characteristics by GT strategy group

	AS (<i>n</i> = 41)	NS (<i>n</i> = 69)	RS (<i>n</i> = 33)		
<i>Characteristic</i>	<i>M ± SD or %</i>	<i>M ± SD or %</i>	<i>M ± SD or %</i>	<i>Statistic</i>	<i>P</i>
Age	41.98 ± 7.00	42.70 ± 7.08	42.29 ± 9.41	<i>F</i> =0.07	.94
Education	13.10 ± 1.87	12.62 ± 2.28	12.85 ± 1.95	<i>F</i> =0.67	.52
Gender (% male)	88	81	87	χ^2 =1.08	.58
Race/ethnicity (%)					
African American	56	62	52	χ^2 =10.06	.44
American Indian	0	2	0		
Asian	2	4	3		
Hispanic/Latino	22	13	7		
Bi-/Multiracial	0	3	3		
Non-Hispanic white	20	16	35		
Hepatitis C	17%	24%	18%	χ^2 =0.80	.67
Substance Abuse/Dependence					
Current	44	19	40	χ^2 =9.12	.01
Past	78	77	87	χ^2 =1.26	.53
Length of HIV infection (years)	8.84 ± 5.82	9.81 ± 5.55	9.41 ± 5.43	<i>F</i> =0.36	.70
cART regimen (%)	90	84	85	χ^2 =0.91	.63
Adherence (%)	72.82 ± 24.31	74.71 ± 22.44	76.70 ± 18.53	<i>F</i> =0.25	.78
Optimal adherence (% with 95% or greater)	28	15	15	χ^2 =2.92	.23
	<i>Mdn (IQR)</i>	<i>Mdn (IQR)</i>	<i>Mdn (IQR)</i>		
CD4 count	352 (298)	373 (392)	401 (371)	χ^2 =0.54	.76
Viral Load ^a	3.01 (4.33)	2.18 (3.65)	2.18 (2.70)	χ^2 =1.42	.49

Note: AS = Advantageous Strategy, NS = No Strategy, RS = Risky Strategy.

^a log₁₀ transformed

Table 3
ANOVAs comparing NP T-scores by GT strategy group

<i>Scores</i>	AS (<i>n</i> = 41)	NS (<i>n</i> = 69)	RS (<i>n</i> = 33)	<i>F</i>	<i>LSD</i>
	<i>M</i> ± <i>SD</i>	<i>M</i> ± <i>SD</i>	<i>M</i> ± <i>SD</i>		
Global NP	44.63 ± 6.39	41.20 ± 5.90	42.88 ± 5.83	4.23 *	AS>NS **
Processing Speed				4.22 *	AS>NS **
	46.04 ± 7.94	41.65 ± 8.18	44.81 ± 8.09		RS>NS †
Learning/ Memory	43.12 ± 9.97	39.98 ± 10.60	40.18 ± 11.52	1.23	
Attention/ Working				2.34 †	AS>NS *
Memory	45.71 ± 8.02	42.71 ± 8.06	45.24 ± 6.48		
Executive Function				3.76 *	AS>NS *
	44.37 ± 8.23	40.65 ± 7.42	43.96 ± 7.51		RS>NS *
Verbal Fluency	46.52 ± 11.94	44.49 ± 11.22	47.36 ± 14.51	0.72	
Motor	41.31 ± 9.61	37.54 ± 10.85	38.03 ± 9.03	1.88	

Note: AS = Advantageous Strategy, NS = No Strategy, RS = Risky Strategy.

† *p* < .10

* *p* < .05

** *p* < .01

Table 4
Sensation seeking, depressive symptoms, and substance use diagnoses by GT strategy group

	AS (n = 41)	NS (n = 69)	RS (n = 33)		
<i>Score</i>	<i>M ± SD or %</i>	<i>M ± SD or %</i>	<i>M ± SD or %</i>	<i>F or χ^2</i>	<i>LSD</i>
SSS-V					
Thrill & Adventure Seeking	5.15 ± 2.65	4.65 ± 2.90	5.15 ± 3.11	0.52	
Boredom Sensitivity	2.38 ± 1.68	2.28 ± 1.42	3.03 ± 2.02	2.36 [†]	RS>NS [*] RS>AS [†]
Experience Seeking	5.20 ± 1.62	5.14 ± 1.97	5.52 ± 2.39	0.41	
Disinhibition	3.71 ± 2.15	3.64 ± 2.17	4.45 ± 1.80	1.82	RS>NS ^t
Total score	16.44 ± 5.02	15.72 ± 5.61	18.18 ± 6.67	2.06	RS>NS [*]
BDI-II					
Total score	13.95 ± 7.85	12.94 ± 10.95	14.48 ± 12.78	0.26	
Substance Abuse/ Dependence Diagnoses					
Current (%)	44	19	40	9.12 [*]	
Past (%)	78	77	87	1.26	

Note: SSS-V = Sensation Seeking Scale-V, BDI-II = Beck Depression Inventory-II, AS = Advantageous Strategy, NS = No Strategy, RS = Risky Strategy.

[†] $p < .10$

^{*} $p < .05$

^{**} $p < .01$

Table 5
Chi-square analyses comparing risk behavior by GT strategy group

	AS (<i>n</i> = 41)	NS (<i>n</i> = 69)	RS (<i>n</i> = 33)		
<i>Risk variable</i>	%	%	%	<i>x</i> ²	<i>p</i>
Needle Sharing					
Lifetime	31	26	32	0.29	.87
In the past year	4	5	9	0.70	.71
In the past month	0	0	0	-	
Unprotected Sex					
Lifetime	100	100	96	3.24	.20
In the past year	55	54	67	1.11	.58
In the past month	23	22	36	2.16	.34

% = percent of sample who reported engaging in the behavior.