ALIGNING MEASURES OF IMPULSIVITY WITH UNDERLYING CONSTRUCTS

ON CHU CHEUNG

M.Phil

The Hong Kong Polytechnic University

2012

The Hong Kong Polytechnic University

Department of the Applied Social Sciences

Aligning Measures of Impulsivity with Underlying Constructs

On Chu Cheung

A thesis submitted in partial fulfillment of the requirements for the Degree of Master of Philosophy

August 2011

Certificate of Originality

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of other degree or diploma, except where due acknowledgement has been made in the text.

____

Cheung On Chu

Acknowledgements

I would like to express my greatest gratitude to Prof. Michael Bond and Dr. Alma Au for their supervision in this study. I would also like to thank Dr. Wai Chung Lam, Mr. Ka Wai Kong and Mr. Chung Hing Leung from the United Christian Hospital, Mr. Kiu Ho Ho from the New Life Hong Kong and Miss May Lai from Caritas Wong Yiu Nam Centre in the data collection process.

Table of Contents

Abstract

This study attempts to clarify the dimensionality of impulsivity. Although research has employed the construct of impulsivity to explain normal and pathological behaviors, there have been divergent interpretations. This study is the first in Hong Kong to investigate the construct and dimensionality of impulsivity based on self-report measures and neurocognitive tests. The subjects in this study were people with a history of substance abuse and people living with HIV/AIDS. The Barratt Impulsiveness Scale (BIS) was used for self-reporting and the Stop Signal Task and Matching Familiar Figures Test (MFFT) were the neurocognitive tests used to assess motor impulsivity and cognitive impulsivity, respectively. Two subscores (stop signal delay and stop signal reaction time) from the Stop Signal Task and three subscores (the first response time, total response time, and number of errors) from the MFFT were obtained for analysis. The Iowa Gambling Task was also examined, revealing the uniqueness of its underlying structure. Additionally, the Beck Depression Inventory-II (BDI-II) and Symbol Digit Modalities Test were administered to investigate their relationships to the measures of impulsivity. Exploratory factor analysis identified three fundamental dimensions of the data sample: inhibitory control, reflection impulsivity, and emotion-induced impulsivity. Further analysis suggested that rather than demonstrating linkages with the fundamental dimensions of impulsivity, the first response and total response times of the MFFT were associated with psychomotor speed. Furthermore, the motor and attentional subscales of the BIS related to the BDI-II.

Aligning Measures of Impulsivity with Underlying Constructs

Chapter 1: Introduction

Impulsivity is a common feature of human behavior. We more or less engage in some kind of impulsive behavior every day, e.g., spending extra money while shopping or drinking one more cup of coffee. Impulsivity is so prevalent in daily life that some researchers have even suggested that it may not be as maladaptive in evolutionary history as most believe. Dickman (1990) illustrated that not all impulsive behavior is dysfunctional. A growing volume of literature uses the concept of impulsivity to explain normal and pathological behaviors.

Although it is relatively easy to list different examples of impulsive behavior, clearly defining the concept is slightly more complicated. As disagreement over the concept poses problems for scientific research, clarifying the dimensionality of impulsivity is important. As impulsivity plays a significant role in human living, like problem behavior such as substance abuse and unprotected sex, this study attempts to examine the dimensionality of impulsivity through the use of two clinical groups: a substance abuse group and an HIV+ group. Before moving on to review the literature on impulsivity, the background of substance abuse and HIV/AIDS is discussed in the next section.

Substance Abuse

Substance abuse is a serious problem in Hong Kong that affects many lives. More distressingly, the number of young people who abuse drugs has been soaring in the past three years. Rather than traditional drugs like heroin, these young people abuse psychotropic substances like ketamine, methylamphetamine, and ecstasy, with the false belief that these substances are less harmful and not addictive. On the contrary, the harmful effects of these drugs are immense, and the damage is permanent and irreversible. Apart from health problems, substance abuse also adversely influences an individual’s interpersonal relationships and daily activities. At the societal level, it also imposes heavy burdens on the criminal justice, social welfare, and health care systems. Despite different efforts to eliminate recreational drug use, substance abuse is still a major problem in our society. Later in this chapter, the most recent figures on substance abuse will be presented to illustrate the trends, but before demonstrating these statistics, some important terms should be clarified to facilitate further discussion.

What are Drugs?

Among drug users themselves, there are many different street names for specific drugs, methods of taking them, and effects produced by them. However, those terms are mostly local, frequently changing, and not universally accepted. Therefore, to avoid ambiguity and misunderstanding of the meaning, the terminology proposed by the World Health Organization will be employed.

According to the World Health Organization (WHO, 1969), a drug is any substance that alters the functioning of the body or mind. This generic definition includes alcohol, tobacco, and caffeine. However, because these substances each have a different legal status in Hong Kong, they will be excluded from further consideration in this research.

What is Abuse?

The term “abuse” is usually used interchangeably with “addiction,” “dependence,” “misuse,” or “problem use,” but in some cases, they refer to different concepts. For example, in the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV), substance abuse and substance dependence belong to two distinct categories.

What is substance abuse? In DSM-IV, substance abuse focuses on the maladaptive pattern of substance use, leading to clinically significant impairment or distress as manifested by recurrent substance use or recurrent substance related legal problems in spite of health problems or failing to perform major role obligations.

What is substance dependence? In DSM-IV, substance dependence stresses the maladaptive pattern of substance use leading to clinically significant impairment or distress as manifested by symptoms such as tolerance or withdrawal.

Current Trends in Hong Kong

According to the Central Registry of Drug Abuse administered by the Narcotics Division, Security Bureau of the Hong Kong Special Administrative Region (2009), the total number of drug abusers reported was 13,591 in 2007, and the number further increased to 14,175 in 2008. The annual increases were 2.6% and 4.3% for 2007 and 2008, respectively.

The number of people under 21 years of age who are abusing drugs has been increasing recently, with 3,430 in 2008. Thus, the number has increased by 51% in 3 years. Meanwhile, the total number of people with a substance abuse problem rose only by 0.4% during this same period. The population of young abusers is larger than that of older abusers, with the proportion of those aged under 21 against the total rising from 14.0% in 2003 to 24.2% in 2008. In particular, both the number and proportion of those aged 12–17 have increased steadily in recent years. From 2006 to 2009, abusers under the age of 30 constituted above 80% of the total number of newly reported abusers. Furthermore, individuals who have previously been convicted of criminal offenses consistently constitute more than 73% of all reported cases of substance abuse.

Opiates (mainly heroin) have long been the dominant, traditional illicit drugs in Hong Kong, but their popularity is steadily decreasing. Between 1999 and 2008, the number of reported abusers taking opiates decreased from 13,060 to 7,260, or a drop of 44%. On the contrary, there was a steady increase in the number of reported abusers taking psychotropic substances over the same period, from 3,549 to 8,306, or an increase of 134%. In 2008, the reported number of abusers taking psychotropic substances was 1,046 (or 7.4%) more than those taking opiates. There was a general rising trend in the number of reported psychotropic substance abusers as a whole between 1999 and 2008, except for 2002 and 2003. The number of reported psychotropic substance abusers rose to a record high of 8,306 in 2008.

Among the psychotropic substances, ketamine, triazolam/midazolam/zopiclone, methylamphetamine (commonly known as ice), ecstasy, and cannabis have been more commonly abused in recent years. Before 2000, cannabis topped the list of commonly abused psychotropic substances. However, in 2000, ecstasy overtook cannabis to become the most commonly abused psychotropic substance, followed by ketamine. Starting from 2001, ketamine overtook ecstasy to top the list. Triazolam/midazolam/zopiclone became increasingly popular starting from 2002 and has ranked second since 2003. In 2008, methylamphetamine overtook triazolam/midazolam/zopiclone to rank second for the first time in history. Triazolam/midazolam/zopiclone and ecstasy ranked third and fourth, respectively, on the list in 2008.

Abusing more than one type of drug at once has also become a common phenomenon among drug abusers. A multiple drug abuser is defined as a person who is reported to have taken more than one type of drug in a given year, irrespective of whether the drugs were taken concurrently on one occasion. The proportion of reported multiple drug abusers has been increasing over the years, reaching 31.9% in 2006, but falling to 22.8% in 2008. The majority abused two types of drugs at the same time.

About half of the reported drug abusers were unemployed. The proportion increased from 47.8% in 2001 to 58.1% in 2004, then declined to 45.9% in 2008. Among the reported drug abusers, the proportion of reported student drug abusers has picked up again in recent years. The proportion rose from 2.1% in 1999 to 5.1% in 2001, and then dropped to 3.5% in 2004, followed by a steady increase to 6.6% in 2008.

What are Ketamine and Ecstasy?

As shown in Figure 2, there is an increasing trend of abusing psychotropic substances, such as ketamine and ecstasy. These psychotropic substances are generally associated with the rave culture in Hong Kong. Youngsters take these club drugs to enhance the enjoyment of music and dancing. Ketamine is an arylcyclohexylamine by its chemical nature. It is a dissociative anesthetic that produces unresponsiveness to external stimuli by dissociating various components of the mind. The pharmacological action of ketamine is mainly performed by its non-competitive blockade of the N-methyl-Daspartate (NMDA) receptor in the brain. Users experience amnesia, marked analgesia, and a trance-like state dissociated from the environment, resulting in an out-of-body or near-death experience. It is because of this induced feeling of dissociation that this drug is popular in the party and club scene.

Ecstasy (3,4-methylenedioxymethamphetamine; MDMA) is another popular illicit drug that possesses both stimulant and mild hallucinogenic properties. Users experience a sudden, amphetamine-like rush with a feeling of euphoria and relatedness to the rest of the world. The psychomotor agitation induced can be pleasurably relieved by dancing, making it the ideal party drug.

What is Human Immunodeficiency Virus (HIV)?

Human immunodeficiency virus (HIV) is a lentivirus (a member of the retrovirus family) that causes acquired immunodeficiency syndrome (AIDS) (Weiss, 1993)—a condition in humans in which the immune system begins to fail, leading to life-threatening opportunistic infections. HIV is transmitted by the transfer of blood, semen, vaginal fluid, pre-ejaculate or breast milk. Within these bodily fluids, HIV is present as both free virus particles and a virus within infected immune cells. The four major routes of transmission are unsafe sex, contaminated needles, breast milk, and transmission from an infected mother to her baby at birth (perinatal transmission). The screening of blood products for HIV has largely eliminated transmission through blood transfusions or infected blood products in the developed world.

The World Health Organization (WHO) considers HIV infection in humans a pandemic. From its discovery in 1981 to 2006, AIDS killed more than 25 million people, and HIV infected about 0.6% of the world's population (Joint United Nations Programme on HIV/AIDS, 2006).

HIV primarily infects vital cells in the human immune system, such as helper T cells (specifically $CD4^+$ T cells), macrophages, and dendritic cells (Cunningham, Donaghy, Harman, Kim, & Turville). Moreover, HIV infection leads to low levels of $CD4^+$ T cells through three main mechanisms: first, the direct viral killing of infected cells; second, increased rates of apoptosis in infected cells; and third, the killing of infected $CD4^+$ T cells by CD8 cytotoxic lymphocytes that recognize infected cells. When $CD4^+$ T cell numbers decline below a critical level, cell-mediated immunity is lost, and the body becomes progressively more susceptible to opportunistic infections.

Prevalence of HIV in Hong Kong

The first case of HIV infection in Hong Kong was reported in 1984 (Lee, Lee ,& Wong, 2006). Under the voluntary HIV/AIDS reporting system, Department of Health had received a total of 4,730 reports of HIV infection at the end of 2010. All except perinatally transmitted or transfusion related cases were adults. It is estimated that in 2005, there were 3,240 people living with HIV infection in Hong Kong, giving an overall prevalence in the adult population of less than 0.1%. The number of AIDS reports has been maintained at a stable level of about 60 cases annually since the availability of HAART in the mid-1990s. At present, PCP and tuberculosis are the most common primary AIDS-defining illnesses in Hong Kong. The HIV epidemic in Hong Kong can be roughly divided into three phases, according to the rate of growth in the number of reports and predominant risk for transmission.

Implications

An increasing number of studies have found an association between impulsivity and addictive behaviors, such as binge eating and gambling. Regardless of the directionality of the relationship (whether impulsivity causes or is caused by drug abuse), impulsivity plays an important role in different phases of drug abuse, namely, acquisition, escalation/dysregulation, abstinence, treatment, and relapse. An impulsive person may find it harder to resist peer influences (De Wit & Richards, 2004), or prefer the immediate euphoric effects despite the harmful consequences (De Wit & Richards, 2004; Madden, Petry, Badger, & Bickel, 1997). Studies also provide consistent evidence that impulsivity relates to escalation/dysregulation. Past research demonstrated that impulsivity predicts elevated alcohol intake (Poulos, Le, & Parker, 1995) and a greater escalation of cocaine intake (Perry, Nelson, & Carroll, 2008).

More importantly, impulsivity, just like other cognitive impairments, may adversely influence the effectiveness of treatment/rehabilitation programs. Past literature demonstrated that cognitive impairment results in higher drop-out rates in interventions, less efficacious therapy, and a greater propensity to relapse as well as risks of unemployment (Turner, LaRowe, Horner, Herron, & Malcolm, 2009). Treatment/rehabilitation programs involve learning new coping and situation avoidance skills to prevent relapse. Individuals must attend to, comprehend, and recall the information presented in therapy sessions. Furthermore, they must learn how to adapt and apply general techniques to situations in their own lives. Another critical component is learning to challenge automatic thoughts and suppress behaviors associated with triggers and biopsychosocial cues to use. Since the context of every patient’s use pattern is unique, creative problem-solving strategies must be developed, often through trial and error, to create a new lifestyle that is incompatible with continued use. Thus, cognitive declines could hamper drug abusers' ability to benefit from treatment and place them at greater risk of a poor outcome.

As treatment/rehabilitation programs also require individuals to attend all sessions to learn the skills and to adopt what they learn in their lives, people with higher levels of impulsivity may benefit less from those programs. In addition to consistent evidence that impulsivity scores relate to drug abuse, studies have demonstrated that treatment dropout rates significantly correlate with impulsivity (Moeller et al., 2001; Patkar et al., 2004), further suggesting that impulsive behavior might also be a factor involved in relapse (De Wit & Richards, 2004). The increases in impulsivity caused by the chronic administration of drugs of abuse may continue despite drug cessation, resulting not only in shorter abstinence, but also in the reduced likelihood of treatment success. Withdrawal from some drugs of abuse, like MDMA, increases impulsivity in some inhibition tasks (Dalley et al., 2006), which may increase the likelihood of treatment dropout and subsequent relapse. Therefore, it is expected that the likelihood of acquisition/escalation/relapse can be reduced due to a better understanding of the relation between impulsivity and drug abuse.

Chapter 2: Cognitive Profile and Role of Impulsivity in the Two Clinical Populations

Common Cognitive Impairments Found in Drug Abusers

Deficits in multiple domains of cognitive function have been widely reported in substance abusing individuals. Studies have revealed that substance abuse is associated with deficits in memory, the processing speed of executive functioning, abstract reasoning, visuospatial processing, and the speed of using fine motor skills (Bates, Labouvie, & Voelbel, 2002; Bolla, Brown, Eldreth, Tate, & Cadet, 2002; Bolla, Funderburk, & Cadet, 2000; Fals-Stewart & Bates, 2003; Rosenberg, Grigsby, Dreisbach, Busenbark, & Grigsby, 2001; Solowij et al., 2002). The expressions of deficits can be influenced by many factors such as the type of substance used as well as the duration, quantity, and recency of use. For instance, duration has been noted to be a significant predictor of memory and attention deficits for cannabis users (Solowij et al., 2002). Cocaine abuse and dependence have been noted to produce a wide range of neuropsychological and cognitive deficits (Bolla et al., 2002; O'Malley, Adamse, Heaton, & Gawin, 1992; Smelson, Roy, Santana, & Engelhart, 1999). Likewise, broad patterns of neurocognitive impairment have been reported in methamphetamine dependence and abuse (Kalechstein, Newton, & Green, 2003; Simon et al., 2000), solvent inhalant abuse (Rosenberg et al., 2001), and ecstasy (MDMA) abuse (Gouzoulis-Mayfrank et al., 2000; Morgan, McFie, Fleetwood, & Robinson, 2002).

The Role of Impulsivity in Substance Abuse

One area of growing interest in psychology is studies on impulsivity. In psychology, impulsivity refers to the behavior that is exhibited with little or inadequate forethought (Evenden, 1999). It relates to actions that may be criminal and/or harmful to others as well as to the self. In neuropsychology and cognitive neuroscience, impulsivity can be classified as behavioral impulsivity, which refers to the idea that top-down control mechanisms ordinarily suppress automatic or reward-driven responses that are not appropriate to the current demands (Aron, 2007).

The relevance of impulsivity is not difficult to discern in different key transition phases of substance abuse, such as the acquisition of drug self-administration, escalation/dysregulation, abstinence, relapse, and treatment. In the acquisition phase, an increased level of impulsivity could lead to substance abuse. Whether an individual tries and experiments with different recreational drugs and takes them regularly is related to impulsivity. Impulsive individuals may make the impulsive choice to initiate drug use because they value the immediate euphoric effects of a drug over larger future benefits (De Wit & Richards, 2004; Madden et al., 1997). Furthermore, an impulsive individual may find it harder to resist environmental cues, and this inability to resist temptation makes them more vulnerable to substance abuse (De Wit & Richards, 2004). Once they become dependent, impulsive individuals may persist in drug-taking, despite the harmful effects on their health. All these behaviors can be explained by deficient inhibitory control over a response that is inappropriate or unable to provide immediate reinforcement.

The Complexity of Impulsivity

Impulsivity leads to substance abuse. Studies have demonstrated that impulsive choice predicts elevated alcohol intake (Poulos, Le, & Parker, 1995), faster acquisition of cocaine self-administration (Perry, Larson, German, Madden, & Carroll, 2005), and greater drug- (Perry, Nelson, & Carroll, 2008) and cue-induced (Diergaarde et al., 2008) reinstatement of drug-seeking behavior. Impaired inhibition also predicts elevated cocaine self-administration (Dalley et al., 2007), higher levels of response during the acquisition of nicotine self-administration (Diergaarde et al., 2008) and reinstatement of cocaine-seeking behavior (Deroche-Gamonet, Belin, & Piazza, 2004). In addition, impulsive choice in humans predicts a greater likelihood of relapse (Krishnan-Sarin et al., 2007; Yoon et al., 2007).

Substance abuse increases the level of impulsivity. Some studies have demonstrated how substance abuse leads to impulsivity. For instance, they have shown that chronic dosing of nicotine (Dallery & Locey, 2005), cocaine (Logue et al., 1992; Paine, Dringenberg, & Olmstead, 2003), and methamphetamine (Richards, Sabol, & de Wit, 1999) produce increases in impulsive choice that may contribute to escalated intake. The increases in impulsivity caused by the chronic administration of drugs of abuse may continue despite drug cessation, resulting in shorter abstinence, faster relapse, and reduced likelihood of treatment success. For example, both in humans and rodents, nicotine (Bickel, Odum, & Madden, 1999; Dallery & Locey, 2005) and cocaine (Heil, Johnson, Higgins, & Bickel, 2006; Kirby & Petry, 2004; Simon, Mendez, & Setlow, 2007) exposure produced reversible increases in impulsive choice that persisted even after drug use was discontinued. Less is known about the relationship between inhibitory failure and withdrawal, but withdrawal from some drugs of abuse (i.e., MDMA) increased impulsivity on the 5CSRT task (Dallery & Raiff, 2007).

The Role of Impulsivity in HIV

To clarify the construct of impulsivity, another clinical group will be examined in this study. Data from those with HIV will be used to investigate the dimensionality of impulsivity. There are many similarities between HIV+ individuals and substance abusers in terms of how they value immediate rewards over long-term gains. The following sections will discuss the generic cognitive profile and the role of impulsivity in HIV.

Common Cognitive Profile Found in HIV+ Individuals

HIV and the central nervous system. HIV crosses the blood-brain barrier and often leads to neuropathological and neurochemical changes that affect the brain (Avison et al., 2004; Gonzalez-Scarano & Martin-Garcia, 2005). Frontostriatal pathology is especially prominent in HIV, resulting in neurobehavioral symptoms marked by mild to moderate bradyphrenia, bradykinesia, executive dysfunction, and deficits in episodic memory (Chang et al., 2004; Grant et al., 1987). Research has reported that approximately 55% of all AIDS patients and 44% of all symptomatic patients show some degree of cognitive impairment (Heaton et al., 2009). Although the administration of HAART has been shown to improve neuropsychological function, it has been reported that nearly one third of patients still exhibited neuropsychological impairment (Tozzi et al., 2004).

HIV-associated neurocognitive impairment in Hong Kong. While rather extensive investigations of the neurobehavioral effects of HIV have already been carried out in the West, very few systematic studies have been reported in China. However, there has been some initial effort to explore the prevalence of HIV-associated neurocognitive impairment in the Asia Pacific region, including Hong Kong. The Asia Pacific NeuroAIDS Consortium (APNAC) investigated the prevalence of neurocognitive impairment and depression in ten countries, including Hong Kong and Mainland China (Wright et al., 2008). The results of the study found an alarming prevalence of both depression and neurocognitive impairment in HIV+ patients in Hong Kong. It was found that the vast majority (92%) of Hong Kong Chinese patients suffered from significant depression, while the mean for the whole sample was only 36%. In addition, 23% of Hong Kong Chinese patients were defined as neurocognitively impaired, while the mean prevalence of the whole sample was only 12%. The findings of the present research suggested a high prevalence of HIV-associated neurocognitive impairment and depression among our HIV+ patients.

HIV-associated neurocognitive deficits and daily functioning. Both AIDS-related neurocognitive impairment and depression have been found to be associated with increased risk of limitations in everyday functioning, medical morbidity, and reduced quality of life (Heaton et al., 2004; Trepanier et al., 2005). Heaton and colleagues found that many HIV+ persons with neurocognitive deficits encounter difficulties in managing activities of daily living independently (Heaton et al., 2004). It is also well-documented that HIV-related cognitive impairment can lead to decrements in medication management (Albert et al., 1999), vocational functioning (van Gorp, Baerwald, Ferrando, McElhiney, & Rabkin, 1999), and automobile driving (Marcotte et al., 1999). More recent literature has started to explore specific neuropsychological processes that affect daily living. For instance, episodic memory (or the memory of events) is among the strongest neuropsychological predictors of activities of daily living (Benedict, Mezhir, Walsh, & Hewitt, 2000). On the other hand, prospective memory is concerned with the individual's ability to execute a future intention (i.e., remembering to remember) (Woods et al., 2008). Impairment in this respect would lead to difficulty in medication adherence in HIV+ patients. Research has highlighted that deficits in executive functioning led to impairment in judgment as well. Such executive dysfunction would result in a person's poor assessment of the relationship between his or her current behavior and future consequences (Bechara, 2003). Such deficits can contribute to an engagement in high-risk behaviors such as unprotected sex, multiple sexual partners, and other behaviors that increase the likelihood of contracting and transmitting HIV or other infectious diseases (Gonzalez et al., 2005).

HIV+ Status and Impulsivity

HIV+ individuals and substance abusers overlap in real-life behaviors in which they opt for choices that result in immediate reward despite the potential negative consequences. Over the past decade, infection with HIV has been found to be associated with risky behaviors such as unprotected sex and promiscuity (Holmberg, 1996). It has been suggested that these risky behaviors may be a function of certain decision-making styles such as sensation seeking and impulsive choice. Therefore, decision-making style is an important area of study in those with HIV.

Past studies have demonstrated the associations between an HIV+ status and impulsivity. In a six-month follow-up assessment with a South African sample at high-risk for HIV transmission, the results revealed that sensation seeking significantly predicts HIV risk behavior, as indexed by rates of unprotected intercourse weighted by numbers of sex partners (Kalichman, Weinhardt, DiFonzo, Austin, & Luke, 2002).

The relevance of impulsivity in HIV+ patients was also investigated by using laboratory measures. A study has demonstrated the impulsive decision-making pattern of people with HIV and control participants. The HIV+ group performed worse on the gambling task, indicating greater risky decision-making. Specifically, the HIV+ group selected more cards from the bad decks that included relatively large payoffs but infrequent large penalties (Hardy, Hinkin, Castellon, Levine, & Lam, 2006). These findings are consistent with the hypothesis that impulsivity relates to an HIV+ status.

In another study, Martin et al. (Martin et al., 2004) administered the Iowa Gambling Task to HIV+ and well-matched HIV– groups. The correlations between the subjects' scores on the Iowa Gambling Task and Delayed Nonmatch to Sample (DNMS) Task were examined to test if working memory deficits accounted for cognitive impulsivity among the HIV+ subjects. The results showed that the HIV+ subjects performed significantly more poorly on the Iowa Gambling Task compared to the HIV– subjects, but the effect could not be explained by working memory deficits. The findings suggested that those who are HIV+ are more vulnerable to cognitive impulsivity than those who are HIV–.

The Neurochemistry of Impulsivity

Psychopathological studies have shown the involvement of serotonin and dopamine in impulsivity (Winstanley, Theobald, Dalley, & Robbins, 2005). Low concentrations of cerebrospinal fluid 5-hydroxyindoleacetic acid (CSF 5-HIAA; the major metabolite of serotonin) have been found in impulsive offenders (Linnoila et al.,

1983) as well as in depressive and suicidal individuals (Asberg, 1976; Asberg, Traskman, & Thoren, 1976). Moreover, patients with cluster B personality disorders, in which impulsivity is a core feature, presented lower CSF 5-HIAA concentrations than those with personality disorders that do not suffer from impulsive behavior (Brown et al., 1982). Patients with borderline personality disorder showed traits of impulsivity similar to those presented by ventromedial prefrontal patients when performing a decision-making task (Rahman, Sahakian, Cardinal, Rogers, & Robbins, 2001), suggesting a link between brain lesion and characterologic features. Using positron emission tomography (PET), Siever, Buchsbaum, New, Spiegel-Cohen, Wei, Hazlett, Sevin, Nunn, and Mitropoulou (1999) found that impulsive-aggressive patients showed significantly blunted metabolic responses to a serotonergic enhancing agent (d,l-fenfluramine) in the ventromedial area of the prefrontal cortices. Thus, subjects with different diagnoses that displayed impulsivity were commonly characterized by poor levels of serotonin metabolization.

Impulsivity as a Multidimensional Construct

An expanding volume of research suggests that impulsivity is a multi-faceted rather than a unitary construct (Arce & Santisteban, 2006; Winstanley, Eagle, & Robbins, 2006). It encompasses a range of actions that are poorly conceived, prematurely expressed, unduly risky, or inappropriate to the situation and that often result in undesirable consequences (Daruna & Barnes, 1993). Studies have attempted to fractionate the construct in order to investigate the underpinnings of different aspects of impulsive behavior. A variety of measurement methods that have been used for this purpose can be classified into two broad categories: self-reported measures, which assess a respondent's perception of his or her own behaviors across different situations, and laboratory behavioral measures, which provide relatively objective measures of specific behavioral processes.

There has been a considerable volume of literature identifying factors of impulsivity with the use of self-reported measures. The common themes identified include decreased inhibitory control, intolerance of delay for rewards, quick decision-making due to a lack of consideration, as well as broader deficits such as poor attentional ability (Winstanley et al., 2006). On the other hand, there has been less research on fractionating impulsivity with behavioral measures (Reynolds, Penfold, & Patak, 2008). Basically, there are two predominant paradigms in the field: motor impulsivity and cognitive impulsivity. Motor impulsivity refers to the inability to inhibit a response, whereas cognitive impulsivity highlights the distorted judgment of alternative outcomes. Studies using behavioral measures, to date, have mainly been based on these two paradigms (Reynolds, Ortengren, Richards, & de Wit, 2006; Moeller et al., 2001).

The interrelations among the different components of impulsivity have remained poorly understood. The few available studies include the one by Pietras, Cherek, Lane, Tcheremissine, and Steinberg (2003) on healthy adult subjects and that of Sonuga-Barke (2002) on children with ADHD, both of which suggest that impairments in motor impulsivity are not related to impairments in cognitive impulsivity.

Taken together, it seems appropriate to delineate the dimensions of impulsivity to understand how different types of impulsivity influence behavior.

Motor Impulsivity

Motor impulsivity has been operationalized in terms of the ability to inhibit a planned or prepotent course of action (Logan, Schachar, & Tannock, 1997). Specifically, within the framework of cognitive psychology and behavioral neuroscience, it is suggested that an active inhibitory mechanism is involved in modulating an internally or externally driven, pre-potent desire for primary reinforcers. This inhibitory mechanism provides the substrate by which rapid conditioned responses and reflexes are transiently suppressed so that slower cognitive mechanisms can guide behavior (Winstanley et al., 2006).

This view shares the central aspect of Barkley's (1997) hybrid model of executive functions, which suggests that behavioral inhibition is critical to the performance of executive functions. According to Barkley, the inhibitory control process provides a delay in the decision to respond, allowing time for further directed or executive actions that help guide, regulate, or control motor responses. In a recent review paper, Verbruggen and Logan (2008) gave supporting evidence that two control mechanisms are at work in response inhibition, as measured by the Stop Signal Task (Logan, Cowan, & Davis, 1984). The researchers found an interaction between a fast control mechanism that prevents the execution of the motor response and a slower control mechanism that monitors and adjusts performance in order to resolve the conflict between the opposing task demands in the paradigm.

The Stop Signal Task is a dual-task paradigm. It requires subjects to respond as quickly as possible to a stimulus and to withhold the response when a stop signal is presented after a variable delay. In other words, the paradigm indexes the inhibition of an already-started response. As there is no overt response when stopping is successful, the efficiency of inhibitory control cannot be directly observed, but it can be examined by using the horse-race model proposed by Logan and colleagues (Logan et al., 1984). According to the model, the success or failure of response inhibition depends on the relative finishing time of two independent processes (i.e., the “go” process and the “stop” process) that race against each other. If the “stop” process finishes before the “go” process does, the response is inhibited, and if the “go” process finishes before the “stop” process does, inhibition fails. The Stop Signal Reaction Time (SSRT), which refers to the latency between the presentation of the stop signal and the initiation of the stop process, provides a measure of behavioral inhibition. A longer SSRT suggests poorer response inhibition. Based on previous studies, SSRTs have been estimated to be close to 200 milliseconds for human adult subjects (Logan et al., 1984), but may exceed 400 milliseconds in adults classified as impulsive (Logan et al., 1997).

Most studies using the Stop Signal Task have been conducted with patients with neurological or psychiatric disorders. SSRT was found to be elevated in children (Sergeant, Geurts, & Oosterlaan, 2002) and adults with ADHD (Ossmann & Mulligan, 2003). Some studies have also suggested that children with ADHD are impaired in other aspects of the Stop Signal Task. For example, they make more commission errors, i.e., respond wrongly in the go trials, and omission errors, i.e., do not respond at all (Bedard et al., 2003; Kuntsi, Stevenson, Oosterlaan, & Sonuga-Barke, 2001; Tannock, Schachar, Carr, Chajczyk, & Logan, 1989). A significant relationship has also been found between behavioral impulsivity and aggressive and health-risk behaviors such as suicide, pathological gambling, and substance use.

Cognitive Impulsivity

Cognitive impulsivity predominantly refers to reflection-impulsivity, but can also refer to abnormal decision making on tasks where the subject may select between conservation option and a more risky option (Verdejo-Garcia, Lawrence, & Clark, 2008).

The reflection-impulsivity construct is conceptualized as a person's consistent tendency to display slow or fast response times in problem situations with high response uncertainty (Kagan, 1965). It describes the degree to which a subject reflects on the differential validity of alternative solution hypotheses (Kagan, 1966). Conceptually different from behavioral impulsivity, cognitive impulsivity does not involve a pre-potent response that is primed and then forcibly inhibited, but implicates, to a greater degree, decision-making processes (Winstanley et al., 2006).

The Matching Familiar-Figures Test (MMFT; Kagan, 1964) is a commonly used instrument to examine reflectivity-impulsivity that is operationally defined with reference to the response latency and accuracy of the response. The subjects are required to find among six very similar alternative figures the one that matches the standard figure. Impulsives show a tendency to jump to a conclusion in problem situations without adequate consideration of the available alternatives and, as such, make a fair number of errors. Reflectives, on the other hand, tend to invest their time in making a correct initial choice and, therefore, make fewer errors, although they take more time in decision-making.

Given the above, it seems logical to postulate that the use of a reflective strategy is related to success on many daily tasks, most of which require planning, deliberation, and organization. However, research on the association between reflection-impulsivity, as measured by the MFFT, and academic performance has yielded mixed findings. Some studies have found a negative relationship between impulsiveness in the MFFT and academic measures, such as scholastic achievements tests (Weithorn, Kagen, & Marcus, 1984) and reading achievement (Cullinan, Epstein, & Silver, 1977). Such relationships remain after intelligence is controlled for (Miyakawa, 2001). In specific tasks, impulsives are found to consistently perform more poorly than reflectives in problem-solving (Kagan, 1965, 1966). Impulsives use more redundant actions and make more errors in solving fault-diagnosis problems (Rouse & Rouse, 1982). Impulsives also use fewer strategies and less metamemory during transfer situations for new learning (Borkowski, Peck, Reid, & Kurtz, 1983). On the other hand, some other studies have found no relationship between cognitive impulsivity and academic performance (Harrison & Romanczyk, 1991).

Cognitive impulsivity may also refer to the distorted judgment of alternative outcomes, which results in loss in the long term. This is commonly measured by the Iowa Gambling Task (Bechara et al., 1994), which simulates real-life decision-making problems. A study by Zermatten et al. (Zermatten, Van der Linden, d'Acremont, Jermann, & Bechara, 2005) demonstrated that there is a negative relation between the Iowa Gambling Task and the impulsivity-related trait of lacking premeditation, one of the four facets proposed by Whiteside and Lynam (Whiteside & Lynam, 2001). The association between impulsivity and Iowa Gambling Task performance was in line with another study by Franken (Franken, van Strien, Nijs, & Muris, 2008) in which the author demonstrated that high-impulsives have lower Iowa Gambling Task net scores as compared to low-impulsives. In addition, the results of the regression analyses showed that the Iowa Gambling Task net score was the most powerful predictor of self-reported impulsivity. Poor Iowa Gambling Task performance is observed in patients with damage to the mesial obitofrontal/ventromedial prefrontal cortex, and to the bilateral amygdala (Bechara, 2003). HIV+ substance-dependent males also exhibited poor decision-making in this task (Martin et al., 2004).

However, the outcome varies from that of Franken and Muris' (2005) previous studies conducted among healthy populations, in which they found no correlation between decision-making, as measured by the Iowa Gambling Task, and impulsivity. Franken and Muris pointed out that the reason for the divergence was the progressive schedule of increased delayed punishments used in the Iowa Gambling Task (the punishments increased progressively as the subjects selected more cards from the disadvantageous decks (Bechara, Damasio, & Damasio, 2000)), resulting in a somewhat different task that may not be related to impulsivity. Further, in these studies, different questionnaires were employed to measure impulsivity (i.e., the Dickman Impulsivity Inventory vs. the Eysenck Impulsiveness Scale). It is conceivable that different impulsivity questionnaires tap into different behavioral aspects of impulsivity.

Types of Measures to Assess Impulsivity

Self-report measures. There are different types of measures to assess impulsivity. The self-report questionnaires assess the general dispositional characteristics of the individual, that is, how the individual would typically behave in a given situation, or the extent to which the subject agrees or disagrees with particular statements. There are many well-validated, self-report measures in the field that assess impulsivity, such as the Barratt Impulsivity Scale (Patton, 1995), the Impulsivity-Venturesomeness-Empathy Scale (Eysenck, Pearson, Easting, & Allsopp, 1985), or the Sensation Seeking Scale

(SSS) of the Zuckerman-Kuhlman Personality Questionnaire (Zuckerman, Kuhlman, Joireman, Teta, & Kraft, 1993).

Neurocognitive measures. Apart from self-report measures, impulsivity can also be quantified with neurocognitive measures. Generally, there are two types of neurocognitive tests used to measure impulsivity: (a) measures of response inhibition based on the suppression of an automatic response, such as in the stop task or the go and not go task, and (b) measures of cognitive impulsivity, which refers to the tendency to gather and evaluate information before making complex decisions, thereby enhancing the accuracy of the final decision (Evenden, 1999); this is commonly assessed using the MFFT. Cognitive impulsivity may also contribute to abnormal decision-making in tasks where the subject may select between a conservative option and a riskier option that offers a “superficially seductive” gain. The measures used to assess this aspect of cognitive impulsivity include the Iowa Gambling Task (Bechara, Damasio, Damasio, & Anderson, 1994) and the Cambridge Gambling Task (Rogers et al., 1999).

Self-Report Measures vs. Neurocognitive Measures

The self-report measures of impulsivity may have substantial value in assessment, as they offer a quick and easily administered snapshot of cognitive concerns, shedding light on how participants perceive their own cognitive functioning in daily life. However, the validities of these measures are controversial. Little evidence has demonstrated that a strong relationship exists between self-report measures and actual cognitive performance (Rourke, Halman, & Bassel, 1999a, 1999b). In fact, some studies have found that self-report measures relate to other non-cognitive variables such as depression (Au et al., 2008; Rourke et al., 1999a, 1999b). In a recent study of substance abusing patients, Richardson-Vejlgaard et al. (Richardson-Vejlgaard, Dawes, Heaton, & Bell, 2009) found that self-report cognitive complaints, as measured by the Patient's Assessment of Own Functioning Inventory (PAOFI), were related more to depression than actual cognitive performance. Given the known effects of depression on the self-report of cognition and the many findings on the linkages among depression, substance abuse, and HIV (Ostacher, 2007; Rao, 2006; Starace et al., 2002), the validity of using only self-report assessments to investigate the levels of impulsivity of participants is disputable.

Neurocognitive Measures and Psychomotor Speed

The performance in many neurocognitive tasks can be affected by relatively general processing constraints, such as psychomotor speed (Salthouse, 1996, 2000). For example, learning and memory performance were related to psychomotor speed (Bryan & Luszcz, 1996). Controlling for the variance accounted for by measures of the information processing speed reduced the observed differences in memory measures between young and older subjects (Kail & Salthouse, 1994). Reduced processing speed has frequently been described in depressive patients, and may mediate memory deficits in depression (Flint, Black, Campbell-Taylor, Gailey, & Levinton, 1993). This study will examine if psychomotor speed will influence the performance in any neurocognitive measures.

Existing Substance Abuse Research in Hong Kong

In this section, some current studies conducted in Hong Kong will be reviewed. Basically, the results consistently demonstrate the associations between cognitive deficits and substance abuse, which more or less support the Western findings. Besides, there is a study that examined the impulsivity of Hong Kong club drug users from the perspective of personality psychology.

In 2005, a study conducted by Narcotics Division, Security Bureau, found that ketamine abusers had more soft neurological signs of motor coordination than control subjects did. There was impaired executive function with difficulty organizing the performance of tasks primarily in Ketamine abusers. Moreover, a trend of verbal-memory impairment was observed in drug abusers. Ketamine polydrug abusers less commonly used semantic clustering and abstract thinking in their memory strategy. However, further studies with larger sample sizes and detailed memory assessments are required before unequivocal conclusions can be drawn (Narcotic Division, HKSAR, 2005).

In 2009, the Hong Kong Polytechnic University and the University of Hong Kong jointly conducted research titled, “Brain Health and Emotional Profile for Youth Drug Users” (Siu, 2009). The study found that 64.9% of the subjects had at least one neuropsychological deficit and 62.2% had depression symptoms. Many of them had impairment in concentration (31%), visual memory (22.8%), and figural fluency (35%), which could have a great impact on daily functioning and work ability. Many (62.25) participants showed symptoms of depression. The test results were presented to each participant (n = 75), and counselors explored the clients’ perceptions of the test results and tried to promote their motivation for change.

In another self-report study (Loxton et al., 2008), the relationship among personality, club drug use, and high-risk drug-related behavior was investigated. Three hundred and sixty club-drug users and 303 non-drug users in Hong Kong were assessed on measures of two impulsivity dimensions—reward drive and rash impulsivity—as well as a related trait of punishment sensitivity. The results showed that club drug users were more rash-impulsive and reward-driven and less punishment-sensitive than non-drug users. Rash impulsivity, but not reward-driven or punishment sensitivity, was significantly associated with risky drug-related behavior. The findings suggest that while those who use club drugs are generally more impulsive and less punishment-sensitive, some discrete facets of impulsivity are associated with differing patterns of drug use behavior.

Past studies in Hong Kong have illustrated that substance abuse relates to cognitive impairment. However, no systematic research has been conducted to understand the construct of impulsivity. Although Loxton et al. (2008) examined the association between club drug use and the two dimensions of impulsivity, no cognitive variables were used in the study. The present study attempts to explore the multi-dimensions of impulsivity with cognitive correlates.

Heterogeneity of samples

This study attempt to understand the dimensionality of impulsivity. In order to improve the generalizability, data were obtained from two clinical populations. A finding emerging from the study of heterogeneous populations would be more robust and thus more likely to be useful in understanding various other populations than one emerging from the study of several very similar populations. If similar factor structures across two different clinical populations—people with substance abuse history and patients with HIV—can be found, it would add to the robustness of the findings.

Moreover, statistically, including another clinical population can increase the sample size and thus the generalizability of the study. Larger samples are better than smaller samples (all other things being equal) because larger samples tend to minimize the probability of errors, maximize the accuracy of population estimates, and increase the generalizability of the results. As some statistics research suggested, the optimal sample size and item numbers for exploratory factor analysis should be a ratio of 20:1 (Hair, Anderson, Tatham, & Black, 1995). Therefore, another clinical population was included in this study to increase the sample size of the study.

Aims of the Present Study

The current study aims to investigate the dimensionality of impulsivity in two clinical populations. This research stands to broaden the existing literature in several significant ways. First, three laboratory behavioral measures purportedly reflecting two dimensions of impulsivity—motor impulsivity and cognitive impulsivity—are used in the study. The selected measures, namely, the Stop Signal Task and the MFFT, and the Iowa Gambling Task have been studied in separate research contexts. However, little research to date has put them together to understand the construct of impulsivity. Second, although some past studies have demonstrated the factor structure of impulsivity (Stanford et al., 2009; Yao et al., 2007; Zuckerman, 1971), those outcomes were mainly based on self-report measures. This study attempts to determine the dimensionality of impulsivity based on cognitive variables. Third, in addition to investigating the relationship between self-report measures and actual cognitive performance, this study attempts to determine whether the self-report measures relate to a non-cognitive variable, i.e., depression.

Fourth, this study also seeks to understand the role of psychomotor speed, as measured by the Symbol Digit Modalities Test, in the dimensionality of impulsivity.

Hypotheses

This is one of the few studies in Hong Kong that has aimed to clarify the dimensionality of impulsivity in two clinical populations. In the field of neurocognitive psychology, the two paradigms of motor impulsivity and cognitive impulsivity have been predominantly used to understand the concept of impulsivity. Therefore, this study hypothesizes that at least two dimensions of impulsivity can be found. Further, as past studies demonstrated that self-report measures relate to other non-cognitive variables such as depression, this study hypothesizes that depression, as measured by the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996), will be loaded on the same factor as the self-report measures of impulsivity (i.e., the Barratt Impulsiveness Scale; Patton, 1995).

Chapter 3: Study Methodology

Participants

It is very important to consider how many participants are needed in a study, as too few participants will not produce a precise, reliable, and definitive finding, while too many participants is a needless waste of research resources. Factor analysis is employed to explore the dimensionality of impulsivity. To determine the sample size in this study, the subjects-to-variables ratio of 20:1 proposed by Hair, Anderson, Tatham, and Black (Hair, Anderson, Tatham, & Black, 1995) was applied. In this study, there are 8 outcome variables, and therefore, about 160 participants were required. In the first part of the study, 185 participants were recruited. Eighty five participants with a history of drug abuse were recruited, and the remaining 100 cases were drawn from the HIV+ population. The participants with a history of drug abuse were recruited from substance abuse clinics and the United Christian Hospital in Hong Kong. In the attempt to recruit a representative sample, the present study recruited substance abusers using the most common types of drugs found in existing cases in Hong Kong (Narcotic Division, HKSAR, 2009). These include ketamine, triazolam, and MDMA (ecstasy). The data from the HIV+ population was secondary data obtained from another study conducted by the Department of Applied Social Sciences, the Hong Kong Polytechnic University (Au, 2008).

To be eligible for the intervention trial, the participants had to satisfy the following inclusion criteria: (a) They had to be between 18 and 40 years of age and (b) they must be currently receiving treatment or social services.

Participants were excluded from the study on the basis of the following criteria: the presence of psychotic disorder, a major depressive episode, suicidal ideations, or active drug or alcohol use. Participants' demographics were demonstrated in Table 1 to 5.

Measures

Neurocognitive Assessment

Stop Signal Task. The Stop Signal Task (Logan et al., 1984) assesses the speed of the process of inhibition in an action that has already been initiated. A square or circle will appear on the screen, and the participant will be asked to push the corresponding key as quickly as he or she can. The critical measure on this task is the time taken to stop a response, from the point at which the stop signal is presented. In this test, the participant must stop pressing the key when he or she hears a "beep" sound (stop signal).

The Stop Signal Task is the most commonly used measure to assess behavioral impulsivity. The performance in the Stop Signal Task can be conceptualized in terms of a race in which the stop process and the go process compete to see which one finishes first. If the stop process finishes before the go process does, the response is inhibited. By contrast, if the go process finishes before the stop process does, the response is executed. The Stop Signal Task measures both the efficiency of response execution (by means of reaction times) and the efficiency of inhibitory control (by means of SSRT, where a longer SSRT reflects the general slowing of inhibitory processes and indicates a lower level of inhibitory efficiency). The Stop Signal Task has also been adopted for use in ADHD samples in Hong Kong (McAlonan et al., 2009).

A study has demonstrated that although cocaine users and non-users are comparable in terms of response execution, users need significantly more time to inhibit responses to stop signals than non-users, and the magnitude of the inhibitory deficit is positively correlated with the individual's lifetime cocaine exposure.

Matching Familiar Figures Test. In the MFFT (Kagan, 1964), the participants are asked to select the one drawing, from six variants, that is identical to a standard drawing (of a familiar object).

This test is the most common instrument for measuring cognitive impulsivity, which refers to the inadequate reflection at the pre-decisional stage. Normal subjects consistently take longer to respond and make fewer errors. Impulsivity is indicated by rapid, inaccurate decisions.

Typically, the MFFT has been used in children to measure the construct of reflection impulsivity (Kagan, 1966). Moreover, it has been shown that MDMA users display an elevated behavioral impulsivity in the test (Morgan et al., 2002). The test has also been adopted for use in Hong Kong's ADHD population (Leung et al., 1996; Luk, Leung, & Yuen, 1991).

Iowa Gambling Task. In the Iowa Gambling Task (Bechara et al., 1994), the participants are presented with four virtual decks of cards on a computer screen. They are told that each time they choose a card, they will win some game money. Every so often, however, choosing a card causes them to lose some money. The goal of the game is to win as much money as possible. Every card drawn will earn the participant a reward. Occasionally, a card will also have a penalty. Thus, some decks are "bad decks," and other decks are "good decks," because some will lead to losses in the long run and others will lead to gains. The decks differ from each other in the number of trials over which the losses are distributed.

This test is widely used to assess the cognitive impulsivity of individuals. Individuals with a high level of impulsivity may choose the “superficially seductive” gain instead of other more conservative options. A study found that long-term, heavy marijuana users made more decisions that led to larger immediate gains, in spite of more costly losses than controls, exhibiting specific deficits in the ability to balance rewards and punishments that may contribute to continued drug-taking behavior (Whitlow et al., 2004). In another study, the polysubstance abusers performed much more poorly on the task and were more likely to make maladaptive decisions in the task that resulted in the long-term losses exceeding the short-term gains (Grant, 1999).

Symbol Digit Modalities Test. Symbol Digit Modalities Test (Smith, 2000) was used as measure of psychomotor speed. Participants were required to identify nine different symbols corresponding to the number 1 through 9, and to practice writing the correct number under the corresponding symbol. Then they manually fill the blank space under each symbol with the corresponding number. Participants were given 90 seconds to complete the test.

Self-Report Measure

The Barratt Impulsiveness Scale. The Barratt Impulsiveness Scale (Patton, 1995), is one of the most common self-report measures. It uses a three-factor model that includes both motor impulsivity and cognitive impulsivity. This scale has 30 items grouped into 3 subscales of factors: attentional (inattention and cognitive instability), motor (motor impulsiveness and lack of perseverance), and non-planning (lack of self-control and intolerance of cognitive complexity). Due to its simplicity and rapid administration, this instrument has been widely used in studies of bipolar disorder (Henry et al., 2001a; Swann, Anderson, Dougherty, & Moeller, 2001; Swann, Dougherty, Pazzaglia, Pham, & Moeller, 2004; Swann, Pazzaglia, Nicholls, Dougherty, & Moeller, 2003), alcohol and substance use (Moeller et al., 2004; Moeller et al., 2001; Preuss et al., 2003), and personality disorders (Henry et al., 2001b; Soloff, Kelly, Strotmeyer, Malone, & Mann, 2003), among others. Additionally, this scale has been translated into many different languages and adapted to younger samples. The version used in this study was translated to Chinese and back-translated to English.

The Beck Depression Inventory-II. The BDI-II (Beck, Steer, & Brown, 1996) is a revision of the original BDI (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), which conforms more closely to the symptom descriptions listed in the DSM-IV (APA, 1994). The BDI-II is a 21-item self-report scale that measures the attitudes and symptoms of depression. The items on the scale ask about how the subject has been feeling in the last week, with a set of at least four possible answer choices of varying intensity from 0: I do not feel sad, to 3: I am so sad or unhappy that I can’t stand it. Each of the 21 items corresponds to a symptom of depression and is summed to give a single total score. A total score of 0–13 represents minimal symptoms; 14–19 indicates mild depression; 20–28 is moderate; and 29–63 represents severe depression (Beck & Steer, 1993). Past studies have provided strong support for the valid use of the BDI-II to measure depressive symptoms in Hong Kong samples (Byrne, Stewart, & Lee, 2004).

Procedures

Eligible subjects were invited to participate in the study by informed consent after going through a full written explanation of the program by the research assistants. Then, the cognitive function of each subject was examined by a research assistant using a battery of neuropsychological tests. All neuropsychological tests were run by a laptop computer with a 15" screen display. The neuropsychological tests were administered in the following orders: Stop Signal Task, Matching Familiar Figures Test, Iowa Gambling Task. No order effect and practice effect were discerned. This part of the study lasted for 45 minutes.

Among the 85 participants with a history of substance abuse, 61 were recruited in the second part of the study after finishing the neuropsychological tests. They were asked to complete the self-reported measures of impulsivity, the Beck Depression Inventory-II, and the Symbol Digit Modalities Test. The second part of the study lasted for 20 minutes.

Results

Descriptive statistics. Table 6 presents the descriptive statistics for the results of the different measures. These include the results of the MFFT, Symbol Digit Modality Test, Iowa Gambling Task, the Stop Task, the Barratt Impulsiveness Scale, and the Beck Depression Inventory-II.

Dimensionality of Impulsivity

Part I: Three Fundamental Factors of Impulsivity

To further understand the construct of impulsivity, the dimensionality of impulsivity was examined. The technique of factor analysis was applied to explore the underlying structure of the construct. The technique originated a century ago with Charles Spearman's attempts to show that a wide variety of mental tests could be explained by a single underlying intelligence factor. This is a method used to uncover the latent structure of a set of variables. It reduces attribute space from a larger number of variables to a smaller number of factors.

A principal component analysis with a varimax (orthogonal) rotation of 6 outcome variables of the cognitive measures of impulsivity, namely, the Stop Signal Delay (SSD), the Stop Signal Reaction Time (SSRT), First Response Time, Total Response Time and Total Error of MFFT, and the Number of Bad Decks in the Iowa Gambling Task, was conducted on the data. An examination of the Kaiser-Meyer Olkin measure of sampling adequacy suggested that the sample was factorable (KMO = .54).

The results of the extraction of components were demonstrated in Table 12. Those factors of which the eigenvalues were larger than 1 were retained for further analysis. Since the first three components had eigenvalues larger than one, three components were extracted. This 3-factor solution represented 81.4% of the variance in the data.

The results of the orthogonal rotation of the solution were shown in Table 13. When loadings less than 0.40 were excluded, the analysis yielded a 3-factor solution with a simple structure (factor loadings => .40).

The three fundamental factors. Three scores loaded on factor one. It is clear from Table 12 that the three items all related to the scores of the MFFT, namely, the number of errors, the first response time, and the total response time. As this factor related to the level of inadequacy in the reflection at the pre-decisional stage, it is labeled "reflection impulsivity."

Two scores loading on the second factor related to the participants' performance in the Stop Task. As this factor related to inhibition of responses, it was labeled "inhibitory control."

The other score that loaded on factor 3 related to the Iowa Gambling Task. The Iowa Gambling Task simulates a complex and uncertain real-life situation, and the decision made in this task is guided by a more automatic, implicit system. Therefore, this factor was labeled "emotion-induced impulsivity."

The one-factor and two-factor solutions. Although the analysis demonstrated that a three-factor solution was yielded by referring to the eigenvalues of the components, other possible solutions were also examined. The study further sought to understand if the variables could be explained in terms of fewer factors. The one-factor and two-factor solutions with the six outcome measures were tested. Tables 4 and 5 below present the results of the analysis.

When one factor was extracted, only the first three scores, namely, the number of errors, the first response time, and the total response time of the MFFT, clearly loaded on the factor. With regard to the two-factor solution, the number of errors, the first response time, and the total response time for the MFFT loaded on the first factor, while the SSD and the SSRT of the Stop Signal Task loaded on the second factor. The "good decks minus the bad decks" variable in the Iowa Gambling Task could not load on any of the two components.

Part II: Exploring the Factor Structure of Impulsivity with Both Neurocognitive Measures and Self-report Measures of Impulsivity

Having examined the underlying structures of the common neurocognitive measures of impulsivity, this study also attempted to understand whether the factor structure would remain unchanged if the self-report measures were included in the analysis. The neurocognitive variables used in the previous analysis and the subscales scores of the Barratt Impulsiveness Scale were examined.

The four-factor solution. If the factors of which the eigenvalues were smaller than one were dropped, a four-factor solution was yielded. Table 12 demonstrates that the first response time and total response time of the MFFT loaded on the first component. The attentional and motor subscales of the BIS loaded on the second component. The number of errors in the MFFT and the non-planning subscales of the BIS loaded on the third component. The SSD and the SSRT of the Stop Task loaded on the fourth component.

The five-factor solution. Since the “Good Decks Minus Bad Decks” in the Iowa Gambling Task could not load on any components in the four-factor solution, the variables were analyzed again with the five-factor solution. Table 13 demonstrates that the five-factor solution yielded identical patterns, except that the “good decks minus bad decks” variable loaded on the fifth component.

Tested with the controlled variables. As the previous findings could have been influenced by other factors such as activity level and mood, the study further examined how these factors affect the underlying structure of impulsivity. The scores of the Symbol Digit Modality Test and the Beck Depression Inventory-II were also included in the analysis.

Using the criteria of "the eigenvalues larger than one," the analysis yielded a four-factor solution, with the first response time and the total response time, as well as the Symbol Digit Modalities loading on the first factor; the attentional and motor subscales of the BIS, as well as the total score of BDI-II loading on the second component; the number of errors of the MFFT and the non-planning subscale of the BIS loading on the third component; and the SSD and SSRT of the Stop Task loading on the fourth component.

The five-factor solution. Again, as the "good minus bad" variable in the Iowa Gambling Task could not fit well in the four-factor solution, the five-factor solution was also examined.

Three scores loaded on factor one. The first response time and total response time of the MFFT, as well as the Symbol Digit Modalities load on this factor. As this factor relates to the amount of time it takes to process and respond to a stimulus, it is labeled "psychomotor speed."

Three items loaded on the second factor. The three items were the attentional and motor subscales of the BIS and the total score of the BDI-II. All of the three items were affective related measures.

Two scores loading on the third factor related to the level of inadequacy in reflection at the pre-decisional stage. The two scores were the number of errors in the MFFT and the non-planning subscale score of the BIS. This factor is labeled "reflection impulsivity."

The SSD and SSRT of the Stop Task loaded on the fourth factor. This factor is labeled "inhibitory control," as both scores related to inhibitory control.

The score that loaded on the last factor was “good decks minus bad decks” in the Iowa Gambling Task. This factor is labeled “emotion-induced impulsivity.”

Chapter 4: Discussion

This is the first study in Hong Kong that aimed to clarify the dimensionality of impulsivity in two clinical populations. In the field of neurocognitive psychology, two paradigms—motor impulsivity and cognitive impulsivity—have been predominantly used in understanding the concept of impulsivity (Verdejo-Garcia, Lawrence, & Clark, 2008). However, the present study revealed that there are three dimensions of impulsivity. In the first part of the study, three commonly used neurocognitive tests—the Stop Signal Task, the MFFT, and the Iowa Gambling Task—were administered. Employing the technique of factor analysis, three fundamental factors for the construct of impulsivity were identified. In contrast to conventional concepts of impulsivity, this study revealed that there are three underlying dimensions of impulsivity, namely, inhibitory control, reflection impulsivity, and emotion-induced impulsivity, as measured by the Iowa Gambling Task. In the second part of the study, the change of the underlying structure of impulsivity was examined by incorporating a self-report measure, the BIS, and two confounding variables, the BDI-II and Symbol Digit Modalities.

One of the predominant paradigms of impulsivity is inhibitory control. The ability to inhibit an ongoing response is the core component of this concept. It is a crucial executive function that comes into play when one tries to withhold or interrupt an ongoing or planned response. In this study, the Stop Signal Task was used as the measure of inhibitory control. Two scores, namely, the SSD and SSRT, which is the time required to stop a response, were obtained. These two scores have been used extensively to study inhibitory control in numerous experimental manipulations, and the results yielded in this study were similar, demonstrating the generality of the task as an empirical model of inhibitory control. Consistent with the conceptual framework laid by past literature, both the SSD and SSRT were loaded on the same factor in the present study.

Another predominant paradigm of impulsivity is reflection impulsivity, first introduced by Kagan. The main concern of this concept is the tendency to gather and evaluate sufficient information before making a decision in a situation characterized by uncertainties. In the present study, the MFFT was administered, and the first response time, the total response time, and the number of errors in the test were measured. The three variables loading on the same factor indicates that reflection impulsivity indexed by the MFFT is distinct from other dimensions of impulsivity. Moreover, the two response times and the number of errors being clustered in the same factor also signify one important principal demand of reflection impulsivity: slowing down the decision-making process would increase the accuracy in the task, and inadequate reflection would reduce the accuracy of the eventual decision.

The behavioral analysis of impulsivity has predominantly used two paradigms: inhibitory control and cognitive impulsivity. However, as the outcome score of the Iowa Gambling Task loaded on a distinct factor, it is suggested that there is another dimension of impulsivity. The task is an experimental paradigm designed to mimic real-life decision-making situations in the way that it factors in uncertainty, reward, and punishment. Similar to the Matching Familiar Figures Test, the task requires the participants to make a choice among different options. However, unlike the measure of reflection impulsivity, the key feature of the task is that its reward/punishment schedule is unclear; therefore, learning occurs on a non-declarative, largely implicit level.

The three dimensions of impulsivity as different modulating mechanisms. Our data provides support for the hypothesis that impulsivity is a multidimensional construct. There are at least three dimensions of the construct of impulsivity, from the most simple action-inhibition task to elaborate paradigms where the evaluation of future consequences depends on the immediate choice. Inhibitory control highlights the inhibition of a prepotent response. Reflection impulsivity emphasizes the tendency to gather and evaluate information before making a choice. Emotion-induced impulsivity focuses on the decision made at the non-declarative and implicit level. Although the three dimensions of impulsivity may result in similar impulsivity behaviors or undesirable/dysfunctional consequences, the underlying mechanisms involved are different.

The key feature of inhibitory control is the suppression of a prepotent response. All animals are subject to behavioral control by internal motivational states that are either innate or conditioned. These states can be related to the desire to seek food, water, sex, and other primary reinforcers such as drug use. However, there appears to be an active inhibitory control mechanism in the brain that modulates this type of prepotent response, particularly in higher mammals (Damasio, Everitt, & Bishop, 1996; Dias, Robbins, & Roberts, 1997). Some have suggested that this inhibitory control mechanism may provide the substrate by which rapid, conditioned responses and reflexes are transiently suppressed so that slower cognitive mechanisms can guide behavior (Bechara, 2003).

However, inhibitory control is not the only mechanism that exerts influence over internal motivational states. A human will estimate the consequences of different options before engaging in a particular behavior. A choice is made after reflecting on the consequences of that choice. The choice between another drug use episode and the potential of losing a job, or engaging in unprotected sex and the risk of becoming infected with HIV, presents a dilemma to an individual, and a decision has to be made. Humans possess the ability to select the most adaptive course of action for them from a set of possible alternative behaviors. People can normally make a decision that is consistent with social norms. However, those with a higher level of reflection impulsivity make inappropriate choices because they do not spend enough time gather and evaluating the information at hand; instead, they decide quickly and make more errors. This association between the extent of information sampling and the accuracy of the subsequent decision represents the core feature of this dimension of impulsivity (Evenden, 1999). Inadequate reflection also represents a potential mechanism for risk-taking behavior, because decision-making might be biased toward salient or immediately rewarding options. Risky decision-making has been observed in various substance user populations (Dom, Sabbe, Hulstijn, & Van Den Brink, 2005; Garavan & Stout, 2005) and was also reported in a group of detoxified alcoholics who had been sober for an average of 6.6 years (Fein, Klein, & Finn, 2004). Reduced information sampling might plausibly reflect an inability or anxiety to delay responding to gather more information, or an increased conviction in the decision at a point of relative uncertainty. A point to be highlighted is that as the construct of non-planning impulsivity outlined by the BIS (Patton, Stanford, & Barratt, 1995) bears some resemblance to our operational definition of reflection impulsivity. The errors of the MFFT and the non-planning subscale of the BIS loaded on the same factor when the BIS scale was incorporated in the analysis.

The third dimension identified in this study is emotion-induced impulsivity. Similar to the dimension of reflection impulsivity, this is also involved in the process of making a choice. However, rather than making a decision before gathering and evaluating sufficient information, this dimension focuses on a non-declarative or implicit level. In this task, the decisions were based on highly uncertain and complex situations. The normal, controlled strategies could not lead people to make a rational decision in this context. Rather, a more automatic, implicit, "intuitive" system guided the decision-making. Damasio (1994) referred to this as the "somatic marker," which is an emotional signal that helps people to make fast and adaptive responses in a complex and uncertain situation. Emotions, as defined by Damasio, are changes in both the body and brain states in response to different stimuli. Physiological changes (e.g., muscle tone, heart rate, endocrine release, posture, and facial expression) in the body are relayed to the brain. The signals in the brain are then transformed into an emotion that tells the individual something about the stimulus that he or she has encountered. Over time, emotions and their corresponding bodily changes become associated with particular situations and their past outcomes. When making decisions in the future, these "somatic markers" and the evoked emotions are consciously or unconsciously associated with their past outcomes and bias decision-making toward certain behaviors while avoiding others. When a somatic marker associated with a positive outcome is perceived, the person may feel happy and motivated to pursue that behavior. When a somatic marker associated with a negative outcome is perceived, the person may feel sad, acting as an internal alarm to warn him or her to avoid a course of action. These situation-specific somatic states based on and reinforced by past experiences help to guide behavior in favor of more advantageous choices and are, therefore, adaptive.

The somatic marker hypothesis was supported by a study of patients with lesions of the medial prefrontal cortex, who tended to exhibit normal cognitive functioning in some respects, but who were highly impaired in their decision-making in social and emotional contexts (Anderson, Bechara, Damasio, Tranel, & Damasio, 2002). Whereas normal adults learn over time which decks are advantageous and shift toward playing preferentially from those decks, patients with lesions in the ventromedial region persist in drawing from disadvantageous decks—a pattern that is generally interpreted as favoring immediate gratification at the expense of longer term adverse consequences (Anderson, Bechara, Damasio, Tranel, & Damasio, 2002). Importantly, the deck payoff schedules in the Iowa Gambling Task are intended to be too complicated for participants to readily discern them. Consequently, participants must rely, at least in part, on emotion-based signals (the "somatic marker") to guide their decision-making (Bechara, Damasio, Tranel, & Damasio, 1997). The failure of individuals with ventromedial brain damage to shift toward decks that yield long-term gains suggests that this prefrontal region plays a critical role in utilizing emotional information to guide decision making.

The hypothesis requires the integrity of memory, especially working memory, and the neural system of emotional responses. Using the fMRI during the performance of the Iowa Gambling Task, a study Using the fMRI during the performance of the Iowa Gambling Task, a study demonstrated that a neural circuitry of the dorsolateral prefrontal cortex, the insula and posterior cingulate cortex, the mesial orbitofrontal and ventromedial prefrontal cortex, and the ventral striatum and anterior cingulate was activated (Li, Lu, D'Argembeau, Ng, & Bechara, 2010). Those areas are responsible for working memory, representations of emotional states, incorporating the two previous processes and implementing behavioral decisions correspondingly. The activated regions were consistent with the neural circuitry hypothesized by the somatic marker hypothesis.

Some studies have questioned the role of somatic markers, such as Maia & McClelland (2004), who revealed that the participants in their study may have had conscious knowledge in the task; therefore, it is not necessary to appeal to nonconscious somatic markers. They suggested that the participants simply had trouble shifting their strategy when the rewards changed. However, using the post-decision wagering method, a recent study found that these findings had been influenced by the authors' quantitative questions, which forced the participants to introspect about their awareness. However, when using open-ended questions instead, the participants performed well before they were aware of the advantageous strategy.

Examining the dimensionality with confounding variables. In the second part of the study, the change of the underlying structure of impulsivity was examined by incorporating a self-report measure, the BIS, and two confounding variables—the BDI-II and the Symbol Digit Modalities.

Affective related measures and depression. Consistent with the prediction, the motor subscale and the attentional subscale related more to depression than the neurocognitive measures. In the second part of the study, together with the total scores of the BDI-II, both the attentional and motor subscales of the BIS loaded on the same factor. Although the administration of self-report measures on cognitive profiles is quick and easy, a growing volume of research demonstrates that the outcomes of self-report measures may be heavily influenced by affective factors (Au et al., 2008; Rourke et al., 1999a, 1999b). The findings of the current study support this assertion. Instead of clustering together to form another factor or loading on other dimensions of impulsivity, the two subscales of the BIS and the total BDI-II scores loaded on the same factor. Further study of impulsivity employing self-report measures should address the relationship between the test outcomes and the level of depression.

Response times and psychomotor speed. Although the MFFT has been used extensively to measure the reflection impulsivity in children, some of its variables may yield inconsistent findings in the adult population (Morgan, 1998). In the second part of this study, instead of loading on the factor of reflection impulsivity, the first response time and total response time of the MFFT were grouped with the Symbol Digit Modalities. It is possible that both tests demand the ability of visual search, visual memory, as well as psychomotor speed. Indeed, there are two experiments on ecstasy users by Morgan (1998) that reported reduced MFFT errors without significant effects on MFFT response times. The MFFT places high demands on visual search, visual working memory, and strategy use, and these domains may be independently disrupted in recreational ecstasy users (Fox et al., 2002), perhaps leading to inflated error rates (Block, Block, & Harrington, 1974; Clark, Robbins, Ersche, & Sahakian, 2006).

Implications for treatment. The findings in this study further support the hypothesis that the clinical construct of impulsivity is multi-dimensional. This study reveals that there are three underlying dimensions of impulsivity, namely, inhibitory control, reflection impulsivity, and emotion-induced impulsivity. Different measures should be used in order to delineate the multifaceted aspects of impulsivity. Individual measures in isolation cannot capture all dimensions of impulsivity. Therefore, it is not appropriate to use a single measure to conclude that an individual is impulsive. On the contrary, a profile of impulsivity should be used. The underlying mechanisms of different persons with manifestations of impulsivity can be different: some may have problems in inhibitory controls; some make a decision before gathering enough information, whereas some make a decision guided by the intuitive somatic marker. These differences may have implications for treatment. It is not appropriate to apply a single type of treatment to all people with manifestations of impulsivity. It is imperative to analyze the profile of impulsivity and understand which underlying dimension of impulsivity constitutes the impulsive behavior, and instead of applying a single treatment against all forms of impulsivity, a more focused treatment method can be used to address the particular type of impulsivity. For example, treatment with psychostimulant drugs has been shown to improve performance in the Stop Signal Task in rats and humans, and a study demonstrated that it is particularly effective in alleviating impulsive action in the Stop Signal Task in individuals with relatively poor baseline performance. Therefore, if an individual demonstrates impulsive behavior, we should first examine which types of impulsivity influence his or her behavior, and if he or she performs poorly in the Stop Signal Task, focused treatment (i.e., psychostimulant drugs) can be used to alleviate his impulsive behavior.

Future directions and limitations. Although the heterogeneity of the two clinical samples provides a good foundation for the possible transferability of findings to other populations, the generalizability of this study is still limited. Future studies should obtain data from wider range of populations to enhance the generalizability. Participants from different clinical groups, or even normal population, should be included. Also, to draw a conclusion with greater confidence, apart from larger sample size, longitudinal design study is needed in future research.

This study helps clarifying the dimensionality of impulsivity. However, the interrelationships among substance abuse, HIV+ and manifestation of impulsivity are still not clear. Future studies can explore if the substance abuse and HIV+ contribute to the manifestation of impulsivity, based on the factors found in this study.

Another limitation of this study is since the histories of drug consumptions were assessed using only subjective reports, the precise chemical composition of the substance used is uncertain. However, as this study is not attempting to examine the level of impulsivity manifested by people with substance abuse problems, the influence should be minimal in this study.

References

Albert, S. M., Weber, C. M., Todak, G., Polanco, C., Clouse, R., McElhiney, M., et al. (1999). An observed performance test of medication management ability in HIV: Relation to neuropsychological status and medication adherence outcomes. *AIDS and Behavior, 3*(2), 121-128.

American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 4th ed. DSM-IV. Washington, DC: American Psychiatric Association, 1994.

Anderson, S. W., Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (2002). Impairment of social and moral behavior related to early damage in human prefrontal cortex. *Foundations of Social Neuroscience*, 333-343.

Arce, E., & Santisteban, C. (2006). Impulsivity: A review. *Psciothema, 18*(2), 213.

Aron, A. R. (2007). The neural basis of inhibition in cognitive control. *The Neuroscientist, 13*(3), 214.

Asberg, M. (1976). " Serotonin depression": A biochemical subgroup within the affective disorders? *Science, 191*(4226), 478-480.

Asberg, M., Traskman, L., & Thoren, P. (1976). 5-HIAA in the cerebrospinal fluid: A biochemical suicide predictor? *Archives of General Psychiatry, 33*(10), 1193-1197.

Au, A., Cheng, C., Chan, I., Leung, P., Li, P., & Heaton, R. K. (2008). Subjective memory complaints, mood, and memory deficits among HIV/AIDS patients in

Hong Kong. *Journal of Clinical and Experimental Neuropsychology, 30*(3), 338-348.

Avison, M. J., Nath, A., Greene-Avison, R., Schmitt, F. A., Bales, R. A., Greenberg, R. N., et al. (2004). Inflammatory changes and breakdown of microvascular integrity in early human immunodeficiency virus dementia. *Journal of neurovirology, 10*(4), 223-232.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological bulletin, 121*(1), 65-94.

Bates, M. E., Labouvie, E. W., & Voelbel, G. T. (2002). Individual differences in latent neuropsychological abilities at addictions treatment entry. *Psychology of Addictive Behaviors, 16*(1), 35-46.

Bechara, A. (2003). Risky business: emotion, decision-making, and addiction. *Journal of Gambling Studies, 19*(1), 23-51.

Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex* 1. *Cognition, 50*(1-3), 7-15.

Bechara, A., Damasio, H., & Damasio, A. R. (2000). Emotion, decision making and the orbitofrontal cortex. *Cerebral cortex, 10*(3), 295.

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (1997). Deciding advantageously before knowing the advantageous strategy. *Science, 275*(5304), 1293.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). Beck Depression Inventory-II (BDI-II). *San Antonio, TX: Psychological Corporation*.

Beck, A. T., Ward, C. H., Mendelson, M., Mock, J., & Erbaugh, J. (1961). An inventory for measuring depression. *Archives of general psychiatry, 4*(6), 561.

Bedard, A. C., Ickowicz, A., Logan, G. D., Hogg-Johnson, S., Schachar, R., & Tannock, R. (2003). Selective inhibition in children with attention-deficit hyperactivity disorder off and on stimulant medication. *Journal of Abnormal Child Psychology, 31*(3), 315-327.

Benedict, R. H. B., Mezhir, J. J., Walsh, K., & Hewitt, R. G. (2000). Impact of human immunodeficiency virus type-1-associated cognitive dysfunction on activities of daily living and quality of life. *Archives of clinical neuropsychology, 15*(6), 535-544.

Bickel, W. K., Odum, A. L., & Madden, G. J. (1999). Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers. *Psychopharmacology, 146*(4), 447-454.

Block, J., Block, J. H., & Harrington, D. M. (1974). Some misgivings about the Matching Familiar Figures Test as a measure of reflection-impulsivity. *Developmental Psychology, 10*(5), 611.

Bolla, K. I., Brown, K., Eldreth, D., Tate, K., & Cadet, J. L. (2002). Dose-related neurocognitive effects of marijuana use. *Neurology, 59*(9), 1337-1343.

Bolla, K. I., Funderburk, F. R., & Cadet, J. L. (2000). Differential effects of cocaine and cocaine alcohol on neurocognitive performance. *Neurology, 54*(12), 2285.

Borkowski, J. G., Peck, V. A., Reid, M. K., & Kurtz, B. E. (1983). Impulsivity and strategy transfer: Metamemory as mediator. *Child Development, 54*(2), 459-473.

Brown, G. L., Ebert, M. H., Goyer, P. F., Jimerson, D. C., Klein, W. J., Bunney, W. E., et al. (1982). Aggression, suicide, and serotonin: relationships to CSF amine metabolites. *American Journal of Psychiatry, 139*(6), 741.

Bryan, J., & Luszcz, M. A. (1996). Speed of information processing as a mediator between age and free-recall performance. *Psychology and Aging, 11*(1), 3.

Byrne, B. M., Stewart, S. M., & Lee, P. W. H. (2004). Validating the Beck depression inventory-II for Hong Kong community adolescents. *International Journal of Testing, 4*(3), 199-216.

Chang, L., Lee, P. L., Yiannoutsos, C. T., Ernst, T., Marra, C. M., Richards, T., et al. (2004). A multicenter in vivo proton-MRS study of HIV-associated dementia and its relationship to age. *Neuroimage, 23*(4), 1336-1347.

Clark, L., Robbins, T. W., Ersche, K. D., & Sahakian, B. J. (2006). Reflection impulsivity in current and former substance users. *Biological Psychiatry, 60*(5), 515-522.

Cullinan, D., Epstein, M. H., & Silver, L. (1977). Modification of impulsive tempo in learning-disabled pupils. *Journal of Abnormal Child Psychology, 5*(4), 437-444.

Cunningham, A. L., Donaghy, H., Harman, A. N., Kim, M., & Turville, S. G. Manipulation of dendritic cell function by viruses. *Current opinion in microbiology, 13*(4), 524-529.

Dallery, J., & Locey, M. L. (2005). Effects of acute and chronic nicotine on impulsive choice in rats. *Behavioural Pharmacology, 16*(1), 15.

Dallery, J., & Raiff, B. R. (2007). Delay discounting predicts cigarette smoking in a laboratory model of abstinence reinforcement. *Psychopharmacology, 190*(4), 485-496.

Dalley, J. W., Fryer, T. D., Brichard, L., Robinson, E. S. J., Theobald, D. E. H., Laane, K., et al. (2007). Nucleus accumbens D2/3 receptors predict trait impulsivity and cocaine reinforcement. *Science, 315*(5816), 1267.

Dalley, J. W., Laane, K., Theobald, D. E. H., Pena, Y., Bruce, C. C., Huszar, A. C., et al. (2006). Enduring deficits in sustained visual attention during withdrawal of intravenous methylenedioxymethamphetamine self-administration in rats: Results from a comparative study with d-amphetamine and methamphetamine. *Neuropsychopharmacology, 32*(5), 1195-1206.

Damasio, A. R. (1994). Descartes' error: Emotion, rationality and the human brain. *New York: Putnam*, 352.

Damasio, A. R., Everitt, B., & Bishop, D. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex [and discussion]. *Philosophical transactions: Biological sciences*, 1413-1420.

Daruna, J. H., & Barnes, P. A. (1993). A neurodevelopmental view of impulsivity. *The impulsive client: Theory, research and treatment*, American Psychological Association; Washington, D.C.: 1993. p. 23.

De Wit, H., & Richards, J. B. (2004). *Dual determinants of drug use in humans: Reward and impulsivity*. *Nebraska symposium on motivation, 50***,** 19-55.

Deroche-Gamonet, V., Belin, D., & Piazza, P. V. (2004). Evidence for addiction-like behavior in the rat. *Science, 305*(5686), 1014.

Dias, R., Robbins, T., & Roberts, A. C. (1997). Dissociable forms of inhibitory control within prefrontal cortex with an analog of the Wisconsin Card Sort Test: restriction to novel situations and independence from “on-line” processing. *The Journal of Neuroscience, 17*(23), 9285.

Dickman, S. J. (1990). Functional and dysfunctional impulsivity: Personality and cognitive correlates. *Journal of Personality and Social Psychology, 58*(1), 95.

Diergaarde, L., Pattij, T., Poortvliet, I., Hogenboom, F., de Vries, W., Schoffelmeer, A. N. M., et al. (2008). Impulsive choice and impulsive action predict vulnerability to distinct stages of nicotine seeking in rats. *Biological psychiatry, 63*(3), 301-308.

Dom, G., Sabbe, B., Hulstijn, W., & Van Den Brink, W. (2005). Substance use disorders and the orbitofrontal cortex: systematic review of behavioural decision-making and neuroimaging studies. *The British Journal of Psychiatry, 187*(3), 209.

Evenden, J. L. (1999). Varieties of impulsivity. *Psychopharmacology, 146*(4), 348-361.

Eysenck, S. B. G., Pearson, P. R., Easting, G., & Allsopp, J. F. (1985). Age norms for impulsiveness, venturesomeness and empathy in adults. *Personality and Individual Differences, 6*(5), 613-619.

Fals-Stewart, W., & Bates, M. E. (2003). The neuropsychological test performance of drug-abusing patients: An examination of latent cognitive abilities and associated risk factors. *Experimental and Clinical Psychopharmacology, 11*(1), 34-45.

Fein, G., Klein, L., & Finn, P. (2004). Impairment on a simulated gambling task in long-term abstinent alcoholics. *Alcoholism, clinical and experimental research, 28*(10), 1487.

Flint, A. J., Black, S. E., Campbell-Taylor, I., Gailey, G. F., & Levinton, C. (1993). Abnormal speech articulation, psychomotor retardation, and subcortical dysfunction in major depression. *Journal of Psychiatric Research*, *27*(3), 309-319.

Fox, H., McLean, A., Turner, J., Parrott, A., Rogers, R., & Sahakian, B. (2002). Neuropsychological evidence of a relatively selective profile of temporal dysfunction in drug-free MDMA (" ecstasy") polydrug users. *Psychopharmacology, 162*(2), 203-214.

Franken, I. H. A., & Muris, P. (2005). Individual differences in decision-making. *Personality and Individual Differences, 39*(5), 991-998.

Franken, I. H. A., van Strien, J. W., Nijs, I., & Muris, P. (2008). Impulsivity is associated with behavioral decision-making deficits. *Psychiatry research, 158*(2), 155-163.

Garavan, H., & Stout, J. C. (2005). Neurocognitive insights into substance abuse. *Trends in Cognitive Sciences, 9*(4), 195-201.

Gonzalez, R., Vassileva, J., Bechara, A., Grbesic, S., Sworowski, L., Novak, R. M., et al. (2005). The influence of executive functions, sensation seeking, and HIV serostatus on the risky sexual practices of substance-dependent individuals. *Journal of the International Neuropsychological Society, 11*(02), 121-131.

Gonzalez-Scarano, F., & Martin-Garcia, J. (2005). The neuropathogenesis of AIDS. *Nature Reviews Immunology, 5*(1), 69-81.

Gouzoulis-Mayfrank, E., Daumann, J., Tuchtenhagen, F., Pelz, S., Becker, S., Kunert, H. J., et al. (2000). Impaired cognitive performance in drug free users of recreational ecstasy (MDMA). *Journal of Neurology, Neurosurgery & Psychiatry, 68*(6), 719.

Grant, I., Atkinson, J. H., Hesselink, J. R., Kennedy, C. J., Richman, D. D., Spector, S. A., et al. (1987). Evidence for early central nervous system involvement in the acquired immunodeficiency syndrome (AIDS) and other human immunodeficiency virus (HIV) infections. *Annals of Internal Medicine, 107*(6), 828-836.

Grant, S. J., Bonson, K. R., Contoreggi, C. C., & London, E. D. (1999). Activation of the ventromedial prefrontal cortex correlates with gambling task performance: a FDG-PET study. *Society for Neuroscience Abstracts, 25*(2), 1551

Hair, J., Anderson, R., Tatham, R., & Black, W. (1995). Multivariate Data Analysis with Readings. Prentice-Hall, Englewood, NJ.

Hardy, D. J., Hinkin, C. H., Castellon, S. A., Levine, A. J., & Lam, M. N. (2006). Risky decision making assessed with the gambling task in adults with HIV. *Neuropsychology, 20*(3), 355.

Harrison, K. A., & Romanczyk, R. G. (1991). Response patterns of children with learning disabilities: is impulsivity a stable response style? *Journal of Learning Disabilities, 24*(4), 252.

Heaton, R. K., Grant, I., Butters, N., White, D. A., Kirson, D., Atkinson, J. H., et al. (2009). The HNRC 500-Neuropsychology of HIV infection at different disease stages. *Journal of the International Neuropsychological Society, 1*(03), 231-251.

Heaton, R. K., Marcotte, T. D., Mindt, M. R., Sadek, J., Moore, D. J., Bentley, H., et al. (2004). The impact of HIV-associated neuropsychological impairment on everyday functioning. *Journal of the International Neuropsychological Society, 10*(03), 317-331.

Heil, S. H., Johnson, M. W., Higgins, S. T., & Bickel, W. K. (2006). Delay discounting in currently using and currently abstinent cocaine-dependent outpatients and non-drug-using matched controls. *Addictive Behaviors, 31*(7), 1290-1294.

Henry, C., Mitropoulou, V., New, A. S., Koenigsberg, H. W., Silverman, J., & Siever, L. J. (2001b). Affective instability and impulsivity in borderline personality and bipolar II disorders: similarities and differences. *Journal of Psychiatric Research, 35*(6), 307-312.

Henry, C., Mitropoulou, V., New, A., Koenigsberg, H., Silverman, J., & Siever, L. (2001a). Affective instability and impulsivity in borderline personality and bipolar disorders: Similarities and differences. *Journal of Pyschiatric Research*, 35,307-312.

Holmberg, S. D. (1996). The estimated prevalence and incidence of HIV in 96 large US metropolitan areas. *American Journal of Public Health, 86*(5), 642.

Joint United Nations Programme on HIV/AIDS (2010). "Overview of the global AIDS epidemic". *UN report on the global AIDS epidemic 2010*.

Kagan, J. (1964). *The matching familiar figures test*: Cambridge MA: Harvard University.

Kagan, J. (1965). Reflection-impulsivity and reading ability in primary grade children. *Child Development, 36*(3), 609-628.

Kagan, J. (1966). Reflection-impulsivity: The generality and dynamics of conceptual tempo. *Journal of Abnormal Psychology, 71*(1), 17-24.

Kail, R., & Salthouse, T. A. (1994). Processing speed as a mental capacity. *Acta Psychologica, 86*(2-3), 199-225.

Kalechstein, A. D., Newton, T. F., & Green, M. (2003). Methamphetamine dependence is associated with neurocognitive impairment in the initial phases of abstinence. *Journal of Neuropsychiatry and Clinical Neurosciences, 15*(2), 215.

Kalichman, S. C., Weinhardt, L., DiFonzo, K., Austin, J., & Luke, W. (2002). Sensation seeking and alcohol use as markers of sexual transmission risk behavior in HIV-positive men. *Annals of Behavioral Medicine, 24*(3), 229-235.

Kirby, K. N., & Petry, N. M. (2004). Heroin and cocaine abusers have higher discount rates for delayed rewards than alcoholics or non-drug-using controls. *Addiction, 99*(4), 461-471.

Krishnan-Sarin, S., Reynolds, B., Duhig, A. M., Smith, A., Liss, T., McFetridge, A., et al. (2007). Behavioral impulsivity predicts treatment outcome in a smoking cessation program for adolescent smokers. *Drug and Alcohol Dependence, 88*(1), 79-82.

Kuntsi, J., Stevenson, J., Oosterlaan, J., & Sonuga-Barke, E. J. S. (2001). Test-retest reliability of a new delay aversion task and executive function measures. *British Journal of Developmental Psychology, 19*(3), 339-348.

Lee, S., Lee, K., & Wong, K (2006). The contribution of methadone maintenance treatment to HIV prevention-the case of Hong Kong. The Chinese University of Hong Kong.

Leung, P. W., Luk, S. L., Ho, T. P., Taylor, E., Mak, F. L., & Bacon-Shone, J. (1996). The diagnosis and prevalence of hyperactivity in Chinese schoolboys. *The British Journal of Psychiatry, 168*(4), 486.

Li, X., Lu, Z. L., D'Argembeau, A., Ng, M., & Bechara, A. (2010). The Iowa Gambling Task in fMRI images. *Human brain mapping, 31*(3), 410-423.

Linnoila, M., Virkkunen, M., Scheinin, M., Nuutila, A., Rimon, R., & Goodwin, F. K. (1983). Low cerebrospinal fluid 5-hydroxyindoleacetic acid concentration differentiates impulsive from nonimpulsive violent behavior. *Life Sciences, 33*(26), 2609-2614.

Logan, G. D., Cowan, W. B., & Davis, K. A. (1984). On the ability to inhibit simple and choice reaction time responses: a model and a method. *Journal of Experimental Psychology, 10*(2), 276-291.

Logan, G. D., Schachar, R. J., & Tannock, R. (1997). Impulsivity and inhibitory control. *Psychological Science, 8*(1), 60.

Logue, A. W., Tobin, H., Chelonis, J. J., Wang, R. Y., Geary, N., & Schachter, S. (1992). Cocaine decreases self-control in rats: a preliminary report. *Psychopharmacology, 109*(1), 245-247.

Loxton, N. J., Wan, V. L. N., Ho, A. M. C., Cheung, B. K. L., Tam, N., Leung, F. Y. K., et al. (2008). Impulsivity in Hong Kong-Chinese club-drug users. *Drug and Alcohol Dependence, 95*(1-2), 81-89.

Luk, S. L., Leung, P. W. L., & Yuen, J. (1991). Clinic observations in the assessment of pervasiveness of childhood hyperactivity. *Journal of Child Psychology and Psychiatry, 32*(5), 833-850.

Madden, G. J., Petry, N. M., Badger, G. J., & Bickel, W. K. (1997). Impulsive and self-control choices in opioid-dependent patients and non-drug-using control patients: Drug and monetary rewards. *Experimental and Clinical Psychopharmacology, 5*(3), 256-262.

Maia, T. V., & McClelland, J. L. (2004). A reexamination of the evidence for the somatic marker hypothesis: What participants really know in the Iowa Gambling Task. *Proceedings of the National Academy of Sciences of the United States of America, 101*(45), 16075.

Marcotte, T. D., Heaton, R. K., Wolfson, T., Mj, T., Alhassoon, O., Arfaa, K., et al. (1999). The impact of HIV-related neuropsychological dysfunction on driving behavior. *Journal of the International Neuropsychological Society, 5*, 579-592.

Martin, E. M., Pitrak, D. L., Weddington, W., Rains, N. A., Nunnally, G., Nixon, H., et al. (2004). Cognitive impulsivity and HIV serostatus in substance dependent males. *Journal of the International Neuropsychological Society, 10*(07), 931-938.

McAlonan, G. M., Cheung, V., Chua, S. E., Oosterlaan, J., Hung, S., Tang, C., et al. (2009). Age-related grey matter volume correlates of response inhibition and shifting in attention-deficit hyperactivity disorder. *The British Journal of Psychiatry, 194*(2), 123.

Miyakawa, J. (2001). Performance on Matching Familiar Figures Test, classroom behaviors, and school achievements of elementary school children in Japan. *Japanese Journal of Psychology, 72*(5), 435-442.

Moeller, F. G., Barratt, E. S., Fischer, C. J., Dougherty, D. M., Reilly, E. L., Mathias, C. W., et al. (2004). P300 event-related potential amplitude and impulsivity in cocaine-dependent subjects. *Neuropsychobiology, 50*(2), 167-173.

Moeller, F. G., Dougherty, D. M., Barratt, E. S., Schmitz, J. M., Swann, A. C., & Grabowski, J. (2001). The impact of impulsivity on cocaine use and retention in treatment. *Journal of Substance Abuse Treatment, 21*(4), 193-198.

Morgan, M. J. (1998). Recreational use of “ecstasy" (MDMA) is associated with elevated impulsivity. *Neuropsychopharmacology, 19*(4), 252-264.

Morgan, M. J., McFie, L., Fleetwood, L. H., & Robinson, J. A. (2002). Ecstasy (MDMA): are the psychological problems associated with its use reversed by prolonged abstinence? *Psychopharmacology, 159*(3), 294-303.

Narcotics Division, Security Bureau, Hong Kong Special Administrative Region Government (2005). *Report on A Study on the Cognitive Impairment and Other Harmful Effects Caused by Ketamine Abuse.* Narcotics Division, Security Bureau, Hong Kong Special Administrative Region Government.

Narcotics Division, Security Bureau, Hong Kong Special Administrative Region Government (2009). *Central Registry of Drug Abuse Fifty-ninth Report.* Narcotics Division, Security Bureau, Hong Kong Special Administrative Region Government.

O'Malley, S., Adamse, M., Heaton, R. K., & Gawin, F. H. (1992). Neuropsychological impairment in chronic cocaine abusers. *The American journal of drug and alcohol abuse, 18*(2), 131-144.

Ossmann, J. M., & Mulligan, N. W. (2003). Inhibition and attention deficit hyperactivity disorder in adults. *The American journal of psychology, 116*(1), 35-50.

Ostacher, M. J. (2007). Comorbid alcohol and substance abuse dependence in depression: impact on the outcome of antidepressant treatment. *Psychiatric Clinics of North America, 30*(1), 69-76.

Paine, T. A., Dringenberg, H. C., & Olmstead, M. C. (2003). Effects of chronic cocaine on impulsivity: relation to cortical serotonin mechanisms. *Behavioural Brain Research, 147*(1-2), 135-147.

Patkar, A. A., Murray, H. W., Mannelli, P., Gottheil, E., Weinstein, S. P., & Vergare, M. J. (2004). Pre-treatment Measures of Impulsivity, Aggression and Sensation

Seeking Are Associated with Treatment Outcome for African American Cocaine Dependent Patients. *Journal of addictive diseases, 23*(2), 109-122.

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the Barratt impulsiveness scale. *Journal of clinical psychology*, *51*(6), 768-774.

Patton, S. (1995). Factor structure of the Barratt Impulsiveness Scale. *Journal of Clinical Psychology, 51*, 768-774.

Perry, J. L., Larson, E. B., German, J. P., Madden, G. J., & Carroll, M. E. (2005). Impulsivity (delay discounting) as a predictor of acquisition of IV cocaine self-administration in female rats. *Psychopharmacology, 178*(2), 193-201.

Perry, J. L., Nelson, S. E., & Carroll, M. E. (2008). Impulsive choice as a predictor of acquisition of IV cocaine self-administration and reinstatement of cocaine-seeking behavior in male and female rats. *Experimental and Clinical Psychopharmacology*, *16*(2), 165-177.

Pietras, C. J., Cherek, D. R., Lane, S. D., Tcheremissine, O. V., & Steinberg, J. L. (2003). Effects of methylphenidate on impulsive choice in adult humans. *Psychopharmacology*, *170*(4), 390-398.

Poulos, C. X., Le, A. D., & Parker, J. L. (1995). Impulsivity predicts individual susceptibility to high levels of alcohol self-administration. *Behavioural Pharmacology, 6*(8), 810-814.

Preuss, U. W., Rujescu, D., Giegling, I., Koller, G., Bottlender, M., Engel, R. R., et al. (2003). Factor structure and validity of a German version of the Barratt Impulsiveness scale. *Fortschritte der Neurologie-Psychiatrie, 71*(10), 527.

Rahman, S., Sahakian, B. J., Cardinal, R. N., Rogers, R. D., & Robbins, T. W. (2001). Decision making and neuropsychiatry. *Trends in Cognitive Sciences, 5*(6), 271-277.

Rao, U. (2006). Links Between Depression and Substance Abuse in Adolescents:: Neurobiological Mechanisms. *American journal of preventive medicine, 31*(6), 161-174.

Reynolds, B., Ortengren, A., Richards, J. B., & de Wit, H. (2006). Dimensions of impulsive behavior: Personality and behavioral measures. *Personality and individual differences, 40*(2), 305-315.

Reynolds, B., Penfold, R. B., & Patak, M. (2008). Dimensions of impulsive behavior in adolescents: Laboratory behavioral assessments. *Experimental and Clinical Psychopharmacology, 16*(2), 124-131.

Richards, J. B., Sabol, K. E., & de Wit, H. (1999). Effects of methamphetamine on the adjusting amount procedure, a model of impulsive behavior in rats. *Psychopharmacology, 146*(4), 432-439.

Richardson-Vejlgaard, R., Dawes, S., Heaton, R. K., & Bell, M. D. (2009). Validity of cognitive complaints in substance-abusing patients and non-clinical controls: The Patient's Assessment of Own Functioning Inventory (PAOFI). *Psychiatry research, 169*(1), 70-74.

Rogers, R. D., Everitt, B. J., Baldacchino, A., Blackshaw, A. J., Swainson, R., Wynne, K., et al. (1999). Dissociable Deficits in the Decision-Making Cognition of Chronic Amphetamine Abusers, Opiate Abusers, Patients with Focal Damage to

Prefrontal Cortex, and Tryptophan-Depleted Normal Volunteers:: Evidence for Monoaminergic Mechanisms. *Neuropsychopharmacology, 20*(4), 322-339.

Rosenberg, N. L., Grigsby, J., Dreisbach, J., Busenbark, D., & Grigsby, P. (2001). Neuropsychologic impairment and MRI abnormalities associated with chronic solvent abuse. *Clinical Toxicology, 40*(1), 21-34.

Rourke, S. B., Halman, M. H., & Bassel, C. (1999a). Neurocognitive complaints in HIV-infection and their relationship to depressive symptoms and neuropsychological functioning. *Journal of Clinical and Experimental Neuropsychology, 21*(6), 737-756.

Rourke, S. B., Halman, M. H., & Bassel, C. (1999b). Neuropsychiatric correlates of memory-metamemory dissociations in HIV-infection. *Journal of Clinical and Experimental Neuropsychology, 21*(6), 757-768.

Rouse, S. H., & Rouse, W. B. (1982). Cognitive style as a correlate of human problem solving performance in fault diagnosis tasks. *IEEE Transactions on Systems, Man, and Cybernetics, 12*(5), 649-652.

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological review, 103*(3), 403.

Salthouse, T. A. (2000). Aging and measures of processing speed. *Biological psychology, 54*(1-3), 35-54.

Sergeant, J. A., Geurts, H., & Oosterlaan, J. (2002). How specific is a deficit of executive functioning for attention-deficit/hyperactivity disorder? *Behavioural Brain Research, 130*(1-2), 3-28.

Siever, L. J., Buchsbaum, M. S., New, A. S., Spiegel-Cohen, J., Wei, T., Hazlett, E. A., et al. (1999). d, l-fenfluramine response in impulsive personality disorder assessed with [18F] fluorodeoxyglucose positron emission tomography. *Neuropsychopharmacology: official publication of the American College of Neuropsychopharmacology, 20*(5), 413.

Simon, N. W., Mendez, I. A., & Setlow, B. (2007). Cocaine exposure causes long-term increases in impulsive choice. *Behavioral Neuroscience, 121*(3), 543-549.

Simon, S. L., Domier, C., Carnell, J., Brethen, P., Richard, B., Walter, R., et al. (2000). Cognitive impairment in individuals currently using methamphetamine. *American Journal on Addictions, 9*(3), 222-231.

Siu, A. (2009). Brain Health and Emotional Profile for Youth Drug Users. The Hong Kong Polytechnic University and the University of Hong Kong.

Smelson, D. A., Roy, A., Santana, S., & Engelhart, C. (1999). Neuropsychological deficits in withdrawn cocaine-dependent males. *The American Journal of Drug and Alcohol Abuse, 25*(2), 377-381.

Smith, A. (2000). *Symbol digit modalities test: Manual*: Western Psychological Services Los Angeles, CA.

Soloff, P. H., Kelly, T. M., Strotmeyer, S. J., Malone, K. M., & Mann, J. J. (2003). Impulsivity, gender, and response to fenfluramine challenge in borderline personality disorder. *Psychiatry Research, 119*(1-2), 11-24.

Solowij, N., Stephens, R. S., Roffman, R. A., Babor, T., Kadden, R., Miller, M., et al. (2002). Cognitive functioning of long-term heavy cannabis users seeking treatment. *Jama, 287*(9), 1123.

Sonuga-Barke, E. J. S. (2002). Psychological heterogeneity in AD/HD--a dual pathway model of behaviour and cognition. *Behavioural Brain Research, 130*(1-2), 29-36.

Stanford, M. S., Mathias, C. W., Dougherty, D. M., Lake, S. L., Anderson, N. E., & Patton, J. H. (2009). Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personality and Individual Differences, 47*(5), 385-395.

Starace, F., Bartoli, L., Aloisi, M. S., Antinori, A., Narciso, P., Ippolito, G., et al. (2002). Cognitive and affective disorders associated to HIV infection in the HAART era: findings from the NeuroICONA study Cognitive impairment and depression in HIV/AIDS. The NeuroICONA study. *Acta Psychiatrica Scandinavica, 106*(1), 20-26.

Swann, A. C., Anderson, J. C., Dougherty, D. M., & Moeller, F. G. (2001). Measurement of inter-episode impulsivity in bipolar disorder. *Psychiatry Research, 101*(2), 195-197.

Swann, A. C., Dougherty, D. M., Pazzaglia, P. J., Pham, M., & Moeller, F. G. (2004). Impulsivity: a link between bipolar disorder and substance abuse. *Bipolar disorders, 6*(3), 204-212.

Swann, A. C., Pazzaglia, P., Nicholls, A., Dougherty, D. M., & Moeller, F. G. (2003). Impulsivity and phase of illness in bipolar disorder. *Journal of Affective Disorders, 73*(1-2), 105-111.

Tannock, R., Schachar, R. J., Carr, R. P., Chajczyk, D., & Logan, G. D. (1989). Effects of methylphenidate on inhibitory control in hyperactive children. *Journal of Abnormal Child Psychology, 17*(5), 473-491.

Tozzi, V., Balestra, P., Murri, R., Galgani, S., Bellagamba, R., Narciso, P., et al. (2004). Neurocognitive impairment influences quality of life in HIV-infected patients receiving HAART. *International Journal of STD & AIDS, 15*(4), 254.

Trepanier, L. L., Rourke, S. B., Bayoumi, A. M., Halman, M. H., Krzyzanowski, S., & Power, C. (2005). The impact of neuropsychological impairment and depression on health-related quality of life in HIV-infection. *Journal of Clinical and Experimental Neuropsychology, 27*(1), 1-15.

Turner, T. H., LaRowe, S., Horner, M. D., Herron, J., & Malcolm, R. (2009). Measures of cognitive functioning as predictors of treatment outcome for cocaine dependence. *Journal of Substance Abuse Treatment, 37*(4), 328-334.

van Gorp, W. G., Baerwald, J. P., Ferrando, S. J., McElhiney, M. C., & Rabkin, J. G. (1999). The relationship between employment and neuropsychological impairment in HIV infection. *Journal of the International Neuropsychological Society, 5*(06), 534-539.

Verbruggen, F., & Logan, G. D. (2008). Long-term aftereffects of response inhibition: Memory retrieval, task goals, and cognitive control. *Journal of Experimental Psychology: Human Perception and Performance, 34*(5), 1229-1235.

Verdejo-Garcia, A., Lawrence, A. J., & Clark, L. (2008). Impulsivity as a vulnerability marker for substance-use disorders: review of findings from high-risk research, problem gamblers and genetic association studies. *Neuroscience & Biobehavioral Reviews, 32*(4), 777-810.

Weiss, R. A. (1993). How does HIV cause AIDS? *Science, 260*(5112), 1273.

Weithorn, C. J., Kagen, E., & Marcus, M. (1984). The relationship of activity level ratings and cognitive impulsivity to task performance and academic achievement. *Journal of Child Psychology and Psychiatry, 25*(4), 587-606.

Whiteside, S. P., & Lynam, D. R. (2001). The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences, 30*(4), 669-689.

Whitlow, C. T., Liguori, A., Brooke Livengood, L., Hart, S. L., Mussat-Whitlow, B. J., Lamborn, C. M., et al. (2004). Long-term heavy marijuana users make costly decisions on a gambling task. *Drug and Alcohol Dependence, 76*(1), 107-111.

Winstanley, C. A., Eagle, D. M., & Robbins, T. W. (2006). Behavioral models of impulsivity in relation to ADHD: translation between clinical and preclinical studies. *Clinical Psychology Review, 26*(4), 379-395.

Winstanley, C. A., Theobald, D. E. H., Dalley, J. W., & Robbins, T. W. (2005). Interactions between serotonin and dopamine in the control of impulsive choice in rats: therapeutic implications for impulse control disorders. *Neuropsychopharmacology, 30*(4), 669-682.

Woods, S. P., Moran, L. M., Carey, C. L., Dawson, M. S., Iudicello, J. E., Gibson, S., et al. (2008). Prospective memory in HIV infection: Is. *Archives of Clinical Neuropsychology, 23*(3), 257-270.

World Health Organization (1969). WHO expert committee on drug dependence. *Technical Report Series/WHO*.

Wright, E., Brew, B., Arayawichanont, A., Robertson, K., Samintharapanya, K., Kongsaengdao, S., et al. (2008). Neurologic disorders are prevalent in HIV-positive outpatients in the Asia-Pacific region. *Neurology, 71*(1), 50.

Yao, S., Yang, H., Zhu, X., Auerbach, R. P., Abela, J. R. Z., Pulleyblank, R. W., et al. (2007). An Examination of the Psychometric Properties of the Chinese Version of the Barratt Impulsiveness Scale, 11th Version in a Sample of Chinese Adolescents. *Perceptual and Motor Skills, 104*(3), 1169.

Yoon, J. H., Higgins, S. T., Heil, S. H., Sugarbaker, R. J., Thomas, C. S., & Badger, G. J. (2007). Delay discounting predicts postpartum relapse to cigarette smoking among pregnant women. *Experimental and Clinical Psychopharmacology, 15*(2), 176-186.

Zermatten, A., Van der Linden, M., d'Acremont, M., Jermann, F., & Bechara, A. (2005). Impulsivity and decision making. *The Journal of Nervous and Mental Disease, 193*(10), 647.

Zuckerman, M. (1971). Dimensions of sensation seeking. *Journal of Consulting and Clinical Psychology, 36*(1), 45-52.

Zuckerman, M., Kuhlman, D. M., Joireman, J., Teta, P., & Kraft, M. (1993). A comparison of three structural models for personality: The Big Three, the Big Five, and the Alternative Five. *Journal of Personality and Social Psychology, 65*(4), 757-768.

Figures

Figure 1. Reported drug abusers by age group

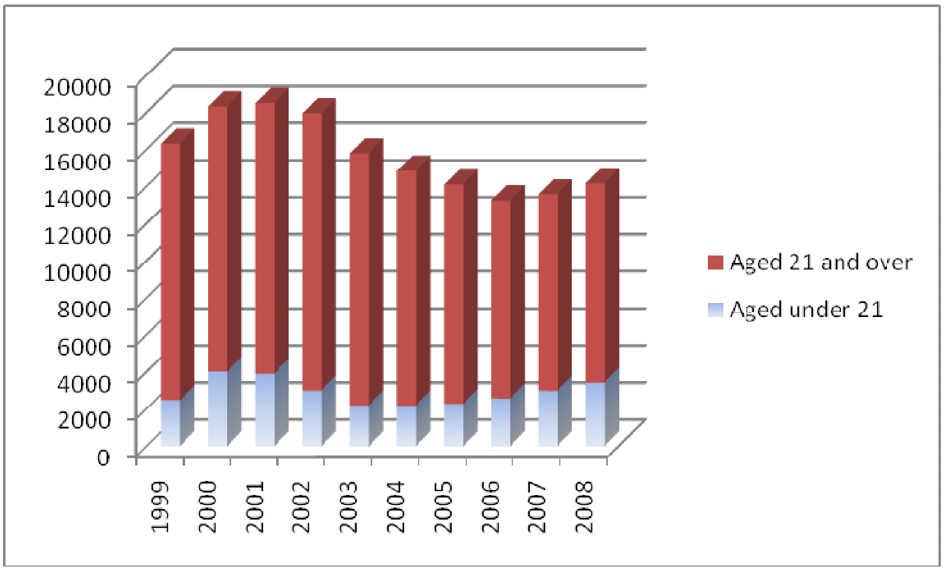
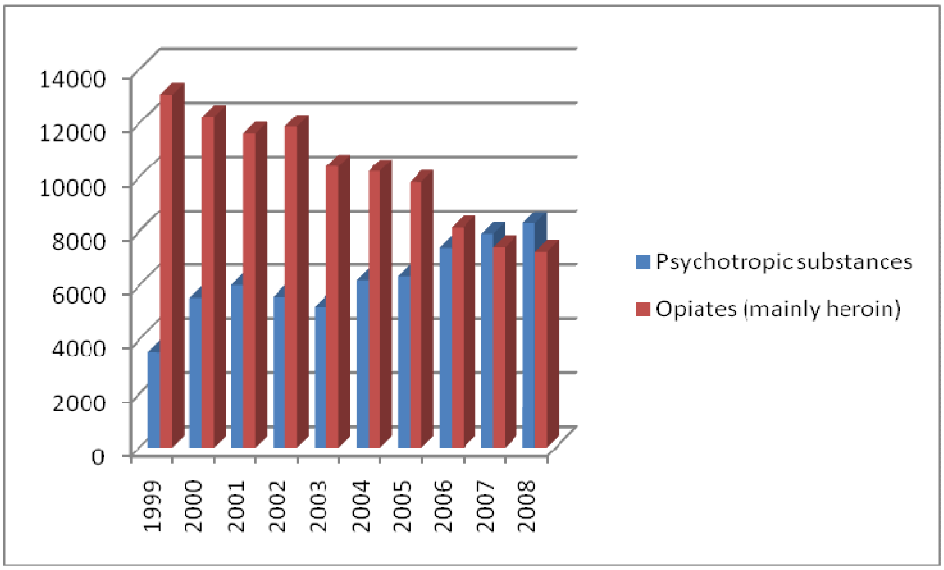


Figure 2. Reported abusers of psychotropic substances and opiates



Tables

Table 1. Gender of Participants

		Frequency	Percent
HIV+	Male	77	77.0
	Female	23	23.0
	Total	100	100.0
Substance Abuse	Male	74	87.1
	Female	11	12.9
	Total	85	100.0

Table 2. Age and Education Levels of Participants

Substance abuse case		Mean	Std. Deviation
HIV+	Age	33.75	6.897
	Education (years)	12.33	3.493
Substance Abuse	Age	26.02	5.800
	Education (years)	9.26	2.005

Table 3. t-test on Age and Education

		t	df	Sig. (2-tailed)
Age	Equal variances assumed	8.118	180	.000
	Equal variances not assumed	8.211	179.711	.000
Edu	Equal variances assumed	7.027	179	.000
	Equal variances not assumed	7.412	162.610	.000

Table 4. Types of Drugs Abused

Types of Drugs Abused	Frequency	Percent
Depressants	11	12.94
Stimulants	12	14.12
Hallucinogens	48	56.47
Others	14	16.47

Table 5. Duration of Substance Abuse

Minimum (years)	Maximum (years)	Mean (years)	Std. Deviation (years)
.50	20.00	5.5833	4.32393

Table 6. Descriptive Statistics for the Results of Different Measures

	Minimum	Maximum	Mean	Std. Deviation
MFFT Total 1st Response Time	14.23	710.77	224.84	120.85
MFFT Total Response Time	37.29	817.30	284.25	132.15
MFFT Total No. of Errors	1.00	77.00	16.40	11.32
Symbol Digit Modalities	34	77	57.09	9.71
Iowa Gambling Task Good Minus Bad Scores	–88	86	–16.15	29.59
BIS Attentional	2.00	19.00	10.82	3.42
BIS Motor	5.00	27.00	14.31	4.36
BIS Non-planning	11.00	27.00	17.45	3.62
BDI-II Total	.00	52.00	15.15	12.32
SSD	50.00	1056.40	394.50	201.01
SSRT	–96.00	522.10	278.03	72.54

*Abbreviations

MFFT = The Matching Familiar Figure Test

SSD = Stop Signal Delay

SSRT = Stop Signal Reaction Time

BIS = The Barratt Impulsiveness Scale

Table 7. Extraction of Components of Variables of Impulsivity

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	2.42	40.45	40.45
2	1.43	23.94	64.39
3	1.02	17.05	81.44
4	.66	10.99	92.43
5	.41	6.91	99.34
6	.04	.66	100.00

Table 8. Orthogonal Rotated Component Loadings for the Outcome Measures of Impulsivity

	Component		
	1	2	3
SSD	.13	.86	.01
SSRT	.04	.89	.03
MFFT Total No. of Errors	.61	.22	.32
MFFT 1st Response Time	.98	.06	–.02
MFFT Total Response Time	.95	.02	–.08
Iowa Gambling Task Good Decks Minus Bad Decks	.02	.01	.97

*Abbreviations

MFFT = The Matching Familiar Figure Test

SSD = Stop Signal Delay

SSRT = Stop Signal Reaction Time

Table 9. Component Loadings for the One-Factor Solution

	Component 1
MFFT Total No. of Errors	.68
MFFT 1st Response Time	.91
MFFT Total Response Time	.87
SSD	.47
SSRT	.40
Iowa Gambling Task Good Decks Minus Bad Decks	–.13

*Abbreviations

MFFT = The Matching Familiar Figure Test

SSD = Stop Signal Delay

SSRT = Stop Signal Reaction Time

Table 10. Orthogonal Rotated Component Loadings for the Two-Factor Solution

	Component	
	1	2
MFFT Total No. of Errors	.62	.29
MFFT 1st Response Time	.97	.08
MFFT Total Response Time	.95	.03
SSD	.10	.86
SSRT	.02	.88
Good Decks Minus Bad Decks	–.06	–.17

*Abbreviations

MFFT = The Matching Familiar Figure Test

SSD = Stop Signal Delay

SSRT = Stop Signal Reaction Time

Table 11. Extraction of Components of Variables of Both Neurocognitive Measures and BIS Subscales

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	2.35	26.08	26.08
2	1.65	18.31	44.39
3	1.53	17.03	61.42
4	1.14	12.68	74.10
5	.98	10.92	85.02
6	.63	6.97	91.99
7	.44	4.90	96.89
8	.25	2.77	99.66
9	.03	.34	100.00

Table 12. Orthogonal Rotated Component Loadings for the Four-Factor Solution

	Component			
	1	2	3	4
MFFT 1st Response Time	.97	.05	.18	.01
MFFT Total Response Time	.97	.01	.06	.07
MFFT Total No. of Errors	.32	–.02	.75	–.28
Good Decks Minus Bad Decks	–.10	–.25	.39	.33
SSD	.25	.01	–.22	.77
SSRT	–.10	.11	.09	.81
BIS Attentional	–.04	.90	.07	–.05
BIS Motor	.08	.84	.04	.14
BIS Non-planning	.08	.20	.82	.05

*Abbreviations

MFFT = The Matching Familiar Figure Test

SSD = Stop Signal Delay

SSRT = Stop Signal Reaction Time

BIS = The Barratt Impulsiveness Scale

Table 13. Orthogonal Rotated Component Loadings for the Five-Factor Solution

	Component				
	1	2	3	4	5
MFFT 1st Response Time	.96	.05	.21	.016	–.00
MFFT Total Response Time	.97	.02	.07	.062	.02
MFFT Total No. of Errors	.28	–.07	.81	–.22	–.02
Good Decks Minus Bad Decks	.01	–.04	.03	.02	.99
SSD	.23	–.02	–.20	.80	–.02
SSRT	–.13	.07	.11	.85	.05
BIS Attentional	–.05	.87	.13	–.01	–.19
BIS Motor	.11	.90	–.03	.07	.14
BIS Non-planning	.03	.15	.87	.11	.05

*Abbreviations

MFFT = The Matching Familiar Figure Test

SSD = Stop Signal Delay

SSRT = Stop Signal Reaction Time

BIS = The Barratt Impulsiveness Scale

Table 14. Extraction of Components of Variables of Both Measures of Impulsivity and Controlled Variables

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	2.51	22.85	22.85
2	1.99	18.08	40.93
3	1.72	15.61	56.54
4	1.32	11.98	68.52
5	.94	8.55	77.07
6	.85	7.71	84.78
7	.72	6.58	91.35
8	.48	4.39	95.74
9	.30	2.74	98.48
10	.14	1.30	99.78
11	.02	.22	100.00

Table 15. Orthogonal Rotated Component Loadings for the Four-Factor Solution

	Component			
	1	2	3	4
MFFT 1st Response Time	.90	.07	.34	.03
MFFT Total Response Time	.95	.03	.17	.06
MFFT Total No. of Errors	.17	–.03	.89	–.16
Good Decks Minus Bad Decks	.01	–.22	.03	.55
SSD	.21	.04	–.16	.76
SSRT	–.14	.23	.04	.74
BIS Attentional	–.01	.91	.03	–.07
BIS Motor	.07	.79	.02	.17
BIS Non-planning	.04	.15	.79	.07
Symbol Digit Modalities	.66	–.00	–.43	–.02
BDI-II Total	.03	.68	.08	–.08

*Abbreviations

MFFT = The Matching Familiar Figure Test

SSD = Stop Signal Delay

SSRT = Stop Signal Reaction Time

BIS = The Barratt Impulsiveness Scale

BDI-II = The Beck Depression Inventory-II

Table 16. demonstrates the result of the five-factor solution.

	Component				
	1	2	3	4	5
MFFT 1st Response Time	.90	.05	.32	.07	–.07
MFFT Total Response Time	.96	.02	.15	.08	–.03
MFFT Total No. of Errors	.19	–.05	.88	–.10	–.16
Good Decks Minus Bad Decks	.00	–.11	.03	.13	.88
SSD	.22	–.02	–.16	.78	.16
SSRT	–.13	.14	.05	.85	.00
BIS Attentional	–.01	.90	.04	.03	–.14
BIS Motor	.06	.84	.02	.05	.29
BIS Non-planning	.06	.18	.78	–.03	.22
Symbol Digit Modalities	.65	.03	–.44	–.12	.18
BDI-II Total	.03	.65	.08	.07	–.26

*Abbreviations

MFFT = The Matching Familiar Figure Test

SSD = Stop Signal Delay

SSRT = Stop Signal Reaction Time

BIS = The Barratt Impulsiveness Scale

BDI-II = The Beck Depression Inventory-II