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The Impact of Methamphetamine Dependence, HIV, and Frontal Systems Dysfunctions on the Relationship Between Sexual Risk Intentions and Behaviors

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The Impact of Methamphetamine Dependence, HIV, and Frontal Systems Dysfunctions on the Relationship Between Sexual Risk Intentions and Behaviors

A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor in Philosophy

in

Clinical Psychology

by

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The Dissertation of Lisa Christine Obermeit is approved, and it is acceptable in quality and form for publication on microfilm and electronically:

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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ABSTRACT OF THE DISSERTATION

The Impact of Methamphetamine Dependence, HIV, and Frontal Systems Dysfunctions on the Relationship Between Sexual Risk Intentions and Behaviors

by

Lisa Christine Obermeit

Doctor of Philosophy in Clinical Psychology

University of California, San Diego, 2018
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Rationale: Sexual risk-taking often occurs in the context of methamphetamine use and promotes HIV transmission. Methamphetamine and HIV preferentially impact the frontostriatal circuits, resulting in frontal systems dysregulation and risky behaviors. Interventions for risky sex often target motivation/intentions to change. However, safe intentions do not always translate to safe behaviors. In order to develop more effective interventions for resolving this intention-behavior discrepancy, it is important to better understand what factors affect this relationship. **Design:** The sample included 234 adults recruited from the community. It was hypothesized that disinhibition, executive dysfunction, HIV, and methamphetamine dependence would moderate the relationship between intentions and behavior (evaluated through multiple linear regressions), and intentions would mediate the relationship between apathy and behavior (evaluated through bootstrapping). **Results:** As hypothesized disinhibition and methamphetamine dependence each were significant moderators (ps $< .05$), such that for those without methamphetamine dependence or disinhibition, safer intentions predicted safer behaviors ($ps < .001$), however, for those with either methamphetamine dependence or disinhibition difficulties, intentions no longer predicted behaviors ($ps > .05$). There was a significant three-way interaction between intentions, executive dysfunction, and HIV, such that for those without HIV, executive functioning did not alter the relationship between intentions and behavior ($p = .130$); however, for those with HIV, better executive functioning resulted in a positive relationship between intentions and behaviors ($p = .005$) while those with worse executive functioning no longer implemented their intentions ($p = .845$). Finally, intentions mediated the relationship between apathy and behaviors (CI = [.006, .130]). **Conclusions:** Disinhibition, executive functioning, methamphetamine dependence, and HIV are important factors that interfere with one's ability to implement safe intentions. Additionally, apathy dampens an individual's desire to behave safely thereby resulting in problematic risk. These findings identify possible areas of intervention when trying to reduce sexual risk-taking behaviors. Implementing substance use treatment and cognitive rehabilitation (targeting impulsivity and executive dysfunction) as well as finding external motivators when

apathy is present may be helpful interventions for improving a patient's ability to implement their intended behaviors and increase safety during sex.

INTRODUCTION

Sexual Risk-Taking Behaviors

There are approximately 20 million new cases of sexually transmitted infections (STIs; Centers for Disease Control [CDC], 2013) and 6 million unplanned pregnancies (Finer & Zolna, 2016) each year. It is estimated that the direct STI treatment and unintended pregnancy cost on the American healthcare system is more than $20 billion annually (NIMH, 2013; Trussell, 2007). Risky sexual behaviors (e.g., sex without a condom, sex with multiple casual partners, sex in exchange for money or drugs, sex with someone known to carry an STI) continue to be the largest contributor to these sex-related consequences (e.g., Wellings et al., 2013; Millstein & Moscicki, 1995), which result in many of the leading causes of mortality in the United States (Rimm, Chan, Stampfer,, Colditz, & Willett, 1995; Mozaffarian et al., 2016; Siegel, Miller, & Jemal, 2015; Vestbo et al., 2013; Nobel, Mayo, Hanley, Nadeau, & Daskalopoulou, 2014; Liu et al., 2013). Conversely, engaging in safe sexual practice leads to a 47-fold reduction in STI contraction compared to risky sex (Varghese, Maher, Peterman, Branson, & Steketee, 2002). Despite the prevalence of interventions and knowledge about the benefits of safe sex, approximately one third of those with a known STI continue to participate in risky sexual behaviors and more than 25% of HIV+ men who have sex with men (many of whom are virally detectable; Mattson et al., 2014) engage in sex without a condom with serodiscordant partners (Crepaz et al., 2009). It is important to better understand the predictors of risky sexual behaviors in order to reduce its prevalence and subsequent consequences.

Current Attempts at Reducing Sexual Risk-Taking Behaviors

Historically, most sexual risk interventions focused primarily or solely on providing education about safe sexual behaviors and the consequences of not adhering to safety. However, the construct of health information is consistently separable from motivation to act (Fisher, Fisher, Williams, & Malloy, 1994) and information-only interventions have not lead to significant risky behavior change (e.g., Helweg-Larsen & Collins, 1997). Interventions that have expanded to focus both on enhancing an individual's behavioral skills (e.g., communication skills, assertiveness training) and increasing an individual's motivation/intention to behave more safely (e.g., education, motivational enhancement) show promise (e.g., Meader et al., 2013; Herbst et al., 2005). The focus on both intentions and behaviors is deeply rooted in empirically supported health behavior models (e.g., Ajzen, 1991) that specify the most robust predictor of behavior is an individual's intention to complete the behavior (Triandis, 1980; Rogers, 1983). For example, the intention to use a condom prior to a sexual encounter directly predicts the use of a condom in the subsequent sexual intercourse (Boldero, Moore, & Rosenthal, 1992).

Intentions

Intentions are defined as an individual's perceived likelihood of actually carrying out the target behavior (Glanz, Rimer, & Viswanath, 2008) and they index an individual's motivation to perform such an act (Sheeran, 2002). Based on common health behavior models, intentions are a function of an individual's attitudes about the behavior, perceptions about how normal the behavior is, expectations about the behavior, and perceived susceptibility to the consequences of the behavior (DeHart & Birkimer, 1997). Interventions that directly target both intentions (e.g., goal setting) and behaviors (e.g., practicing safe-sex implementation skills, role playing and problem solving) simultaneously, show significant continued change toward safe behaviors at follow-up (Kekana, Banyini, Jooste, Simbayi, & Peltzer, 2011) and are more effective than comparison treatments that focus on only behaviors (Anderson et al., 2006). Despite our increasing knowledge of the predictors of intentions and behaviors, less is known about the factors that contribute to the relationship between intentions and behaviors. Intentions account for 16-67% of the variance in behavior (Sheeran, 2002), which means intentions is both the most robust predictor of behaviors and other predictors likely exist that would help to better account for the remaining variance. In order to improve clinicians' ability to change risky sexual behaviors it is important to understand what may be perpetuating discrepancies between intentions and behaviors.

Possible Moderators of the Intention-Behavior Relationship

Methamphetamine.

One variable that is likely to moderate the relationship between intentions and behaviors is substance use. Substance use is one of the most robust predictors of sexual risk-taking (e.g., Leigh & Stall, 1993). Substance use is a particularly problematic risky behavior because it is both inherently risky and can promote other risky behaviors (e.g., Ersche, Turton, Pradhan, Bullmore, & Robbins, 2010; Duarte et al., 2012). For example, methamphetamine use promotes direct HIV transmission through needle use and can enhance pleasure-seeking behaviors (e.g., Ersche et al., 2010) and risky decision-making (Duarte et al., 2012), which often increases risky sexual behaviors (Ritchwood, Ford, DeCoster, Sutton, & Lochman, 2015) including condomless sex (Halkitis, Parsons, & Wilton, 2003). As a result, 99% of HIV transmissions are caused by unsafe sexual practice and/or substance use (Centers for Disease Control, 2013), making these simultaneous behaviors a significant public health concern.

Methamphetamine and sexual risk behaviors.

While many substances are associated with sexual risk (e.g., Springer, Peters, Shegog, White, & Kelder, 2007; Colfax et al., 2005; Tavitian-Exley, Vickerman, Bastos, Boily, 2015; Li, Baker, Korostyshevskiy, Slack, & Plankey, 2012; Mansergh et al., 2008; Stueve, O'Donnell, Duran, San Doval, & Geier, 2002), methamphetamine is of particular importance. Methamphetamine use increases the number of sexual partners (Strathdee & Sherman, 2003), reduces the prevalence of condom use (Strathdee & Sherman, 2003; Molitor, Truax, Ruiz, & Sun, 1998), and increases the contraction of STIs (Molitor, Truax, Ruiz, & Sun, 1998). When compared to alcohol, another substance often associated with sexual risk, methamphetamine resulted in more of these risky sexual behaviors (i.e., sex while under the influence and more sexual experimentation; Rawson, Washton, Domier, & Reiber, 2002). In fact, sexual risk behaviors and consequences are worse for methamphetamine users when compared to both non-drug users (e.g., Molitor, Truax, Ruiz, & Sun, 1998) and those who use other substances including cocaine, marijuana, and alcohol (e.g., Chesney, Barrett, & Stall, 1998; Molitor, Truax, Ruiz, & Sun, 1998; Tavitian-Exley et al., 2015).

The heightened association between methamphetamine and sexual risk compared to other substances may, in part, be due to the pharmacokinetics of the substance. Methamphetamine has a longer half-life than many other substances (e.g., Cook et al., 1993; Kater, Roggin, Tobon, Zieve, & Iber, 1969; Papac & Foltz, 1990) increasing the opportunities of sex, including more prolonged and vigorous sex that may lead to mucosal tears, while under the influence. Also, the stimulating effects that enhance socializing behaviors may increase the time spent in social situations that lead to sexual encounters. Therefore, an individual who takes methamphetamine will experience effects that allow them to stay at the party longer and encourage them to interact with more people, thereby increasing the probability of a sexually risky opportunity.

Methamphetamine and sexual risk intentions.

No studies have been completed looking directly at the impact of methamphetamine on intentions specifically. However, findings from some studies imply that substance use may impact many factors that lead to risky sexual intentions. First, other substances, such as alcohol, are associated with sexual risk intentions. For example, when intoxicated by alcohol unprotected sex was viewed more favorably (MacDonald, MacDonald, Zanna, & Fong, 2000), perceived likelihood of condom use declined (Abbey, Saenz, & Buck, 2005), and more risky sexual intentions were reported (Davis, Hendershot, George, Norris, & Heiman, 2007). Methamphetamine, specifically, has long been cited as increasing hypersexuality (Volkow et al., 2007), or drive, which is likely to influence sexual intentions. However, only one study evaluated the long-term effects of methamphetamine on likely predictors of intentions. Rawson, Washton, Domier, and Reiber (2002) found that abstinent individuals who were diagnosed with methamphetamine dependence showed increased sexual desire, sexual drive, obsessions with sex, sexual pleasure, beliefs about improved performance, and subsequent sexual risk-taking when compared to other substances (e.g., alcohol, cocaine, or opiates).

Methamphetamine moderation.

There is also limited research on whether substance use moderates the relationship between intentions and behaviors. One study found that the frequency of methamphetamine use over the past 30 days moderated the relationship between attitudes (a predictor of intentions) about sexual risk-taking and condom use during anal sex (Nakamura, Mausbach, Ulibarri, Semple, & Patterson, 2011). This study found that for those who had more negative attitudes about condom use, frequency of methamphetamine use was significantly correlated with unprotected anal sex. However, for those with more positive attitudes about condom use, no significant association existed between frequency of methamphetamine use and unprotected anal intercourse. Another study evaluated the moderating effects of duration of drug use and sex work on the relationship between predictors of intentions (i.e., attitudes, social norms, behavioral control) and stated intentions, on actual condom use behaviors (Gu et al., 2009). This study found that the relationship between attitudes about condom use (a predictor of intentions) and risky sexual behavior was moderated by duration of substance use (Gu et al., 2009), with those who had a longer use patterns showing weaker relationships between attitudes about condom use and their actual use of condoms. In this study, substance use duration did not moderate the relationship between the other predictors of intentions or stated intentions and condom use behaviors (Gu et al., 2009). However, several limitations exist that may be attributed to the lack of significant findings. First, this study only evaluated duration of use (rather than substance dependence), which they operationalized as $\geq$ 9 years of injection drug use versus < 9 years of injection drug use. Not only was the selection of 9 years for dichotomization not explained, no information about the type of drug used was reported, further limiting the implications for methamphetamine as a moderator. Additionally, condom use was dichotomized as 100% versus less than 100%, reducing the variability available to be accounted for by the predictors. Another study found that only self-efficacy (another predictor of intentions) moderated the intention-behavior relationship (e.g., Schutz, Godin, Kok, Vezina-Im, Naccache, & Otis, 2011), with higher levels of self-efficacy regarding safe sex behaviors predicting a greater concordance between safe sex intentions and safe sexual behaviors. This study found that past behavior, intentions, self-efficacy, and drug use significantly predicted 100% use of a condom in a population of HIV+ men who have sex with men (MSM). While many predictors of intentions were tested (i.e., attitudes about condom use, perceived control over condom use, self-efficacy about condom use, beliefs about moral norms about condom use) as moderators of the intention-behavior relationship, only self-efficacy emerged as a significant moderator. Further, this study did not find that substance use significantly moderated the relationship between intentions and behaviors; however, it is possible that dichotomizing condom use at such a high level of adherence (100% versus < 100%) as in the aforementioned study reduced the variability necessary to detect a significant interaction. Additionally, substance use was operationalized as "sex drug" use, which included prescription medications for erectile dysfunction (i.e., Viagra), therefore limiting our understanding of the impact of illicit substance use, and more specifically methamphetamine use, on the intentions-behavior relationship. While these studies begin to evaluate substance use as a possible moderator in the relationship between sexual risk intentions and behaviors, more research is needed to understand if methamphetamine specifically influences the relationship between sexual risk intentions and behaviors.

HIV.

Because those who practice risky sex are at higher risk of contracting HIV it is possible that HIV is associated with riskier intentions and riskier behaviors. However, it is also possible that contracting HIV may lead to the realization one's sexual risk-taking behaviors should be changed and therefore may result in safer intentions and behaviors.

HIV and sexual risk-taking behaviors.

Some studies show that a larger percentage of HIV+ individuals engage in risky sex than HIV- individuals (Hays, Paul, Ekstrand, Kegeles, Stall, & Coates, 1997) but that the predictors of sexual behaviors remain similar across these groups. Other evidence indicates that as antiretroviral medications (ARVs) have improved, the consequences of HIV have decreased, resulting in riskier sexual behaviors among those with HIV (e.g., Dukers, Goudsmit, de Wit, Prins, Weverling, & Coutinho, 2001). As these consequences increase, safer behaviors emerge (Dolezal et al., 1999). However, those with HIV have evidenced safer health behaviors than those without HIV (e.g., adhering to vaccination recommendations; Montaner et al., 1996) and many studies indicate that sexual risk behaviors actually decrease after they discover they are HIV+ (Marks, Crepaz, Senterfitt, & Janssen, 2005).

HIV and sexual risk intentions.

It is possible that HIV may reduce the concern of future negative outcomes because they already have HIV or it may increase the concern because they have learned from their past behaviors. Predictors of sexual risk in the HIV+ population are similar to those in HIV- populations including attitudes about unsafe sex, perceived consequences perceived control, perceptions about norms of risky sex (each being predictors of intentions) as well as intentions themselves (Crepaz & Marks, 2002).

HIV moderation.

Behavioral theory indicates that individuals change their behavior based on feedback from past behaviors (e.g., Berridge & Robinson, 1998; Panksepp, 1998). Therefore, getting a consequence from a risky behavior (e.g., HIV) should reduce an individual's future risk-taking. However, this requires cognitive processing of the behavior-consequence relationship and the ability to change previous behavior (e.g., mental flexibility). The dorsolateral circuit/executive functioning system is important for stimulus response learning, integrating information about behaviors and consequences, problem solving, executing a goal, and reversing learned behaviors (Takahashi, Roesch, Stalnaker, & Schoenbaum, 2007). Therefore, it is possible that frontal systems likely affect the relationship between HIV, intentions and behaviors.

Frontal systems dysfunctions.

Several other variables may impact the effect that methamphetamine has on the relationship between intentions and behaviors. For example, methamphetamine preferentially affects the dopaminergic systems and frontostriatal circuitry (Ersche, et al., 2012; Kim et al., 2006; Schwartz et al., 2010; Thompson et al., 2004), which are responsible for regulating risky/rewarding behaviors. Frontal changes from methamphetamine occur in both gray and white matter, result in both structural and functional changes, and lead to neurological and metabolic dysfunction (Chang, Alicata, Ernst, & Volkow, 2007; Ersche, et al., 2012; Alicata, Chang, Cloak, Abe, & Ernst, 2009; Chung et al., 2007; Salo, Ursu, Buonocore, Leamon, & Carter, 2009; Tobias et al., 2010). These striatal structures are important for modifying, inhibiting, and reasoning through risky behaviors.

Cummings (1993) provided a conceptualization of the three distinct frontostriatal circuits (the orbitofrontal, anterior cingulate, and dorsolateral circuits) that are distinct yet associated with each other and each important for behavioral regulation. The orbitofrontal circuit is primarily responsible for inhibitory control, therefore, when this system is dysregulated the orbitofrontal syndrome is characterized by significant impulsivity and sensation seeking behaviors (e.g., Cummings, 1993; Verdejo- García et al., 2013). Those with orbitofrontal circuit lesions evidence poor decision-making on risk-reward contingent assessments, such as the Iowa Gambling Task (IGT; Bechara, 2007). The dorsolateral prefrontal circuit is responsible for more cognitive aspects of frontal systems such as hypothesis generation, problem solving, and mental flexibility (Cummings, 1993). Those with executive dysfunction evidence difficulties with these skills on tests such as the Wisconsin Card Sorting Test (WCST) and the Trail Making Test, Part B (TMT-B; Milner, 1963; Reitan, 1992; Cummings, 1993). Finally, the anterior cingulate circuitry is responsible for goal-directed desires and behaviors (Cummings, 1993). Therefore, those with lesions in this circuit show a reduction in concern about their circumstances, drive for action, and behavioral self-initiation (Cummings, 1993). These later deficits constitute the cluster of symptoms known as apathy (Cummings, 1993). While these circuits are distinct, each circuit runs through similar neurological locations (e.g., thalamus; Lichter & Cummings, 2001) and dysfunction in one of these pathways is often associated with dysregulation in another (e.g., Faerden et al., 2010; Monterosso et al., 2007; Kim, Sohn, & Jeong, 2011). The neural circuitry associated with these three frontal dysfunctions are each preferentially activated by acute methamphetamine exposure (e.g., Völlm et al., 2004) and dysregulated by chronic methamphetamine use (Ersche, et al., 2012; Kim et al., 2006; Schwartz et al., 2010; Thompson et al., 2004), and each frontal syndrome may be implicated in affecting the relationship between intentions and behaviors.

Disinhibition.

Krueger and colleagues (2002) indicated that disinhibition is based on undercontrolled behavior, impulsivity (a propensity for rapid and unplanned responses to a stimulus without concern for negative consequences; Zucker, Heitzeg, & Nigg, 2011; Chamberlain & Sahakian, 2007), inattention, and neural dysregulation, and that it often leads to risk-taking (e.g., substance use). In animal models, significant changes in inhibitory mRNA expression occur in the prefrontal cortex after long-term methamphetamine exposure (Wearne, Parker, Franklin, Goodchild, & Cornish, 2016). Sensation seeking is the propensity to pursue highly arousing/stimulating situations (Kalichman, Simbayi, Jooste, Cain, & Cherry, 2006) and is often enhanced in the context of impulsivity and disinhibition (e.g., Verdejo- García et al., 2013). Methamphetamine predicts worse disinhibition/impulsivity (Marquine et al., 2014; Lee et al., 2009; Semple, Zians, Grant, & Patterson, 2005; Winhusen et al., 2013), sensation seeking (Brecht, O'Brien, Von Mayrhouser, Anglin, 2004), novelty seeking (Churchwell, Carey, Ferrett, Stein, & Yurgelun-Todd, 2012) and delayed gratification (Ballard et al., 2015; Lyoo et al., 2015). Methamphetamine preferentially affects areas responsible for these behaviors (Völlm et al., 2004) and leads to dysfunction in its circuitry through regular use (Volkow et al., 2001). The orbitofrontal cortex is important for behavioral inhibition and impulsivity and its circuitry extends through the caudate (which, when lesioned also results in disinhibition), globus pallidus, subthalamic nucleus and substantia nigra (e.g., Horn, Dolan, Elliott, Deakin, & Woodruff, 2003). The expressions of dysfunction are especially highlighted when an outcome has the potential to be either extremely rewarding or punishing (Breiter, Aharon, Kahneman, Dale, & Shizgal, 2001). Therefore, the ability to make the appropriate decisions in risk/reward contingent situations (like sexual intercourse) is strongly linked to orbitofrontal circuitry and disinhibited/impulsive/sensation seeking behaviors.

Disinhibition and sexual risk-taking behaviors

Impulsivity, disinhibition, and sensation seeking are strongly associated with sexual risk-taking behaviors. Compared to individuals with low impulsive decision-making, those with high impulsivity were twice as likely to have used substances, engaged in unwanted sex when pressured, had unwanted sex while intoxicated, and had a greater likelihood of intentions to have sex in the future (Donohew et al., 2000). Sensation seeking was also associated with a greater likelihood of having had sex, intending to have sex, engaging in acts other than sex, having unwanted intercourse while intoxicated, using substances (Donohew et al., 2000), and engaging in risky behavior as a means of coping (Brady & Donenberg, 2006). Additionally, the ability to inhibit sexual arousal when risk is imminent is linked to a greater proportion of unprotected sex (Bancroft et al., 2004). Performance on tests of inhibition (e.g., Stroop) significantly predicts risky/impulsive behaviors (Hall, Elias, & Crossley, 2006; Mullan, Wong, Allom, & Pack, 2011), more sexual partners overall, and more casual sexual partners (sexual partners for only one night; Bancroft et al., 2004).

Disinhibition and sexual risk intentions.

Few studies have evaluated the relationship between disinhibition and intentions. One study found that when intoxicated and more aroused, individuals were more likely to reason through the benefits of sexual risk-taking behaviors, were less likely to consider the risks, were more likely to justify their risky behaviors (e.g., "getting a disease from having unprotected sex is really rare"), and were more likely to have favorable attitudes toward unprotected sex (MacDonald, MacDonald, Zanna, & Fong, 2000). Another study found that many of the factors associated with behavioral intentions were influenced by a high propensity for impulsivity (Dévieux et al., 2002). Sensation seeking directly influenced sexual arousal in a hypothetical sexual situation and negatively impacted individuals' intention to engage in protected sex (Norris et al., 2009).

Disinhibition moderation.

While disinhibition influences both intentions and behaviors individually, its moderating role on the relationship between sexual risk intentions and behaviors is unknown. Despite a dearth of research in sexual risk-taking, disinhibition has emerged as a moderator of the relationship between other health intentions and behaviors. For example, response inhibition as measured by a go/no-go task predicted health-related behaviors over and above the effect of intentions (Kor & Mullan 2011). Inhibitory abilities predicted healthy dietary behavior/physical activity and moderated the relationship between intentions and behavior (Hall, Fong, Epp, & Elias, 2008). Wong and Mullan (2009) found that disinhibition combined with planning ability accounted for significant variance above and beyond past behaviors and intentions on healthy eating behaviors and when frontal systems variables were included as a moderator, even greater variance was accounted for in these healthy behaviors (Wong & Mullan, 2009). These moderation effects have also been noted with intentions of other impulsive behaviors (e.g., substance use). Performance on the Stroop inhibition trial significantly moderated the relationship between binge drinking intentions and behaviors (Mullan, Wong, Allom, & Pack, 2011), impulsivity moderated the relationship between methamphetamine use and sexual risk-taking (Semple, Zians, Grant, & Patterson, 2006), and in another study those high in sensation seeking did not evidence a significant relationship between intentions to quit substances and substance use behaviors while those low in sensation seeking showed a significant relationship between quitting intentions and behaviors (Moshier, Ewen, Otto, 2013).

Executive functions.

Another predictor of risky behaviors is executive functioning. Executive functions involve the ability to engage in independent, purposeful, self-serving behavior (Lezak, Howieson, & Loring,1995), therefore, representing the ability to implement the skills necessary to initiate and complete intended/goal-directed behaviors (Lezak 1982; Lezak, Howieson, & Loring,1995). According to Cummings (1993) and Grace and Malloy (2000), the dysexecutive syndrome includes problems with perseverative thinking, novel or complex problem solving (e.g., WCST), mental flexibility (e.g., set shifting; Trails Part B), planning, and organization of cognitive information (e.g., learning and recall; Cummings 1993). Executive functioning is thought to play a role in the formation, maintenance and shifting of cognitive processes to develop goals (or intentions), maintain motivation and reduce distraction from and complete the intended goals, as well as utilize the mental flexibility necessary to alter behaviors/plans based on changing needs in the current situation (Suchy, 2009).

The dorsolateral prefrontal cortex is especially programmed for this type of cognitive reasoning (Smith & Jonides, 1999). For example, performance on a test of novel problem solving (WCST) was associated with both lesions in the dorsolateral prefrontal cortex (Milner, 1963) and greater blood flow in the dorsolateral prefrontal cortex (Berman, Zec, & Weinberger, 1986; Rezai et al., 1993; Weinberger, Berman, Suddath, & Torry, 1992). While tests like the TMT-B are not used for brain localization, the test is sensitive to neurological changes caused by stimulant use (Warner et al., 2006) and functional imaging studies show increased activation in frontal areas, including the dorsolateral prefrontal cortex during part B of the TMT (Moll, Oliveira-Souza, Moll, Bramati, Andreiuolo, 2002). Performance on the TMT-B was worse in patients with lesions in the dorsolateral frontal cortex when compared to non-frontal lesioned patients (Stuss et al., 2001).

Executive functioning and sexual risk-taking behavior.

Multiple components of executive functioning, as operationalized by Cummings (1993) are associated with risky behaviors. For example, planning explains a unique proportion of variance in general health behaviors (healthy eating behaviors; Wong & Mullan, 2009). With regard to sexual risk-taking specifically, planning for goal-congruent behaviors significantly predicted intention congruent safe sexual behaviors (e.g., Abraham et al., 1999; Bryan, Fisher, & Fisher, 2002). When evaluating the relationship between intentions and behaviors, advanced planning was associated with condom use in those who intended to use contraceptives both with casual partners and relationship partners and planning correctly classified condom use more than 70% of the time in those who intended to participate in safe sex (Turchik & Gidycz, 2012). Additionally, the ability to reason through and solve problems is related to reasonable use of condoms (condom use $\geq$ 75%; Johnson & Green, 1993). Those who were less apt to use problem-solving skills were twice as likely to engage in unprotected anal sex with their primary partner than those who were better problem solvers (Paul, Stall, Crosby, Barrett, & Midanik, 1994). When problem-solving skills are included in interventions, the interventions are significantly more effective in reducing risky behaviors (Herbst et la., 2007) and sexual offenses (Travers, Man, & Holin, 2014) than those that do not incorporate problem-solving skills.

Executive functioning and sexual risk intentions.

Studies that show executive functioning moderates the relationship between intentions or behaviors tend to conceptualize executive functioning using Cummings' (1993) characterization of disinhibition. Many of these findings classify tests such as the Iowa Gambling Test (a measure of impulsive decision-making) as measures of executive functions. However, few studies have evaluated the association between executive functions and intentions or behaviors based on Cummings (1993) model of frontal dysfunction, which primarily conceptualizes executive functioning as skills in problem solving and mental flexibility. One study found that confidence in problem solving abilities influenced motivation for engaging in safe sexual behaviors (Abel & Miller, 1997). While minimal research exists on this relationship, there is evidence that executive functioning ability may moderate the relationship between intentions and behavior.

Executive functioning moderation.

In a study on the effect of both disinhibition and planning abilities on intentions and behaviors, neither disinhibition nor planning had an impact on intentions or behaviors directly, however, the interaction of intentions and executive functions (e.g., planning ability; tower of Hanoi) significantly predicted health-related behaviors (healthy eating; Wong & Mullan, 2009). Further, specifically in those who are in environments that do not support healthy decisions, planning and problem solving aid in translating intentions into intention congruent healthy behaviors (Booker & Mullan, 2013). Both planning and inhibitory control moderated the relationship between binge drinking intentions and behaviors (Mullan, Wong, Allom, & Pack, 2011). Executive function was also found to moderate the relationship between breakfast eating intentions and behaviors (Wong & Mullan, 2009). In this study, planning ability did not significantly predict healthy eating behavior. However, higher healthy eating behavior was seen for those with strong intentions and/or good planning ability, but not for those with low intentions who also had poor planning ability (Wong & Mullan, 2009). Among those who have intact executive functioning abilities, intentions appear to significantly predict health-related behaviors (e.g., diet and exercise; Hall, Fong, Epp, & Elias, 2008).

When an individual perseverates on one goal/strategy or has difficulty with mental flexibility, they may be unable to change to a more effective strategy that would aid in fulfilling their intention. Tests such as WCST, help measure an individuals ability to reason abstractly and cognitively shift from one mental strategy to another based on changing contextual rules in order to achieve a goal (Kongs, Thompson, Iverson, & Heaton, 2000; Heaton, Chelune, Curtiss, Kay, & Talley, 1993). Therefore, many executive functions necessary for goal-directed behavior (the relationship between intentions and behaviors) are represented by the WCST and likely influence the relationship between intentions and implementing problem solving strategies necessary for the intention-congruent behaviors. In a study of frontal lesioned non-human primates, a variant of the Wisconsin Card Sorting Test performance was worse in frontal lobe primates because of an inability to disengage the executive control system from the current action and switch to novel strategies (even ones that provided the goal easier; Mansouri, Buckley, & Tanaka, 2015). Though research on perseveration is non-existent in the intention-behavior literature, the biggest predictor of future behavior is past behavior. Therefore, it is likely that if one is unable to disconnect from habitual perseverative behaviors they are not going to do well at problem solving in risky situations, reasoning through a conversation on condom use with a new partner, or changing previously habitual behavior.

Apathy.

Apathy is often the result of neurological deficits caused by stroke (Robinson, Kubos, Starr, Rao, & Price, 1984), psychological disorders (e.g., schizophrenia; Crow 1980), and frontal lobe dysfunction (e.g., Stuss & Benson, 1984) and is expressed as a reduction in both goal-directed desires (interest, plans, care about personal health or wellbeing; e.g., Marin, Biedrzycki, & Firinciogullari, 1991; Mulin et al., 2011; Starkstein, Petracca, Chemerinski, & Kremer, 2001) and behaviors (e.g., Levy & Dubois, 2006). Marin (1990) emphasized the important role that apathy plays in reducing intentions to perform behaviors while others emphasize the behavioral component of apathy as reducing goal-directed behavior and inertia to begin a behavior (e.g., Levy & Dubois, 2006). Chronic methamphetamine use is associated with significant dopaminergic dysregulation and is linked to a significant chronic deficit in an ability to experience pleasure (e.g., apathy; Mimiaga et al., 2008). Several studies have confirmed a direct link between methamphetamine and the behavioral disturbance of apathy (Marquine et al., 2014; Looby & Earleywine, 2007), further noting that this increased apathy is associated with everyday functioning outcomes (e.g., Kamat, Woods, Marcotte, Ellis, & Grant, 2012; Barclay et al., 2007; Rabkin et al., 2000).

Apathy, intentions, and behavior.

In neurological samples with frontal subcortical dysfunction (e.g., Huntington’s disease), apathy has a direct association with completing everyday tasks (Zawacki et al., 2002) because of a reduction in goal-directed intentions (e.g., Mulin, Biedrzycki, & Firinciogullari, 2011). While the relationship between intentions and behaviors depends on levels of disinhibition and executive functions (moderation), apathy is defined by a reduction in both intentions (e.g., Mulin et al., 2011; Selten, Wiersma, & van den Bosch, 2000) and behaviors (Marin, Biedrzycki, & Firinciogullari, 1991; Starkstein, Petracca, Chemerinski, & Kremer, 2001; Stuss, Van Reekum, & Murphy, 2000) and is inseparable from both. Because apathy directly reduces intentions and behaviors and intentions are the most proximal causal predictor of behaviors, it appears that apathy would reduce behaviors through a mechanism of reduced motivation/concern, which would mean that intentions mediates the relationship between apathy and behavior. For example, apathy may lead to a decreased desire to have sex, which would influence intentions to have sex, and would reduce sexual acts (thereby reducing risk), or an individual may not care about the risks associated with unprotected sex due to apathy, thereby reducing intentions to use a condom, and reducing subsequent condom use. This will be the first study to evaluate the association of apathy with intentions or behaviors. Therefore this hypothesized mechanistic relationship is based solely on the theoretical definition of apathy and conceptualization of the intention behavior model.

Higher-order interactions.

In one study, impulsivity and intensity of methamphetamine use interacted to predict unprotected sex behaviors (Semple, Zians, Grant, & Patterson, 2006) with higher levels of impulsivity resulting with those who were dually affected (MA+ and high impulsivity) being more likely to participate in riskier sex. This may be because a greater cognitive burden is introduced when dually affected and that this burden interferes with the decision making necessary for the implementation of intention-congruent behaviors. Methamphetamine use also often co-occurs with other variables that may impact the relationship between intentions and behaviors (e.g., sexual dysfunction; Cocores, Miller, Pottash, & Gold, 1988) possibly leading to an interaction. For example, those who use methamphetamine regularly are more likely to acquire sexual dysfunction and those with sexual dysfunction are more likely to participate in riskier sex (such as reduced condom use; Musacchio, Hartrich, & Garofalo, 2006) to enhance sensitivity and ameliorate sexual dysfunction symptoms. Despite good intentions to use a condom, a condom may be avoided in a moment where sexual dysfunction is interfering with intercourse. However, if the individual is low on impulsivity, they may be better able to weigh the possible long-term consequences with the short-term satisfaction to make more intention-congruent safe sex behaviors. Therefore, those with methamphetamine dependence may be at greater risk for impulsivity leading to intention incongruent risky behaviors (enhanced concern about immediate gratification despite possible long-term consequences) than those without methamphetamine dependence. It is also possible that the habituation of riskier sex occurs in those with chronic methamphetamine use and the ability to overcome these habits is more difficult in individuals with worse frontal systems dysfunction. As mentioned before, acute methamphetamine exposure leads to sexual risk-taking. The regular engagement in methamphetamine use (as seen in methamphetamine dependence) means more regular engagement in subsequent risky behaviors, forming a greater habit of riskier sex. The bias toward continuing a habitual response over goal-directed behavior is seen in MA+ individuals even after abstinence (Voon et al., 2015) and is harder to overcome when frontal systems dysfunction is present (Yin & Knowlton, 2006; Torregrossa, Quinn, & Taylor, 2008). Which means that those with frontal systems behaviors may have greater difficulty overcoming habitual sexual risk behaviors that formed due to the regular use of methamphetamine. For these reasons it is hypothesized that methamphetamine, frontal systems behaviors, and intentions will interact to predict sexual risk behaviors. Those who are dually infected are hypothesized to have the weakest relationship between intentions and behaviors and those dually not affected will have the strongest relationship between intentions and behaviors.

Novelty

Despite the breadth of research detailing the association between intentions and behaviors, little is known about what variables might lead to a discrepancy between intentions and behaviors. Additionally, little is known about how frontal systems dysfunctions might affect this discrepancy. Further, no study to date has evaluated these moderating/mediating relationship in the context of MA dependence and HIV.

Specific Aims and Hypotheses (See Figure 1)

Specific Aim 1: Evaluate the role of frontal systems dysfunctions in modifying the relationship between sexual risk intentions and sexual risk behaviors.

Hypothesis 1: Sexual risk intentions will account for a significant proportion of variance in sexual risk-taking behaviors.

Hypothesis 2: Disinhibition will moderate the relationship between intentions and behavior such that those with worse disinhibition will have a weaker sexual risk intention-behavior relationship.

Hypothesis 3: Executive dysfunction will moderate the relationship between intentions and behaviors such that those with worse executive dysfunction will have a weaker sexual risk-taking intention-behavior relationship.

Hypothesis 4: Unlike disinhibition and executive dysfunction, the relationship of apathy on behavior will be mediated by intentions, resulting in apathy having a direct (greater apathy leads to decreased safe sexual behaviors) and indirect (greater apathy leads to decreased concern about safe sexual intentions which decreases safe sexual behaviors) effect on sexual behaviors.

Specific Aim 2: Evaluate whether methamphetamine dependence and HIV serostatus moderate the role that frontal systems dysfunction plays in modifying the relationship between sexual risk-taking intentions and behaviors.

- *Hypothesis 1:* Methamphetamine and HIV will moderate the relationship between intentions and behaviors, such that those with methamphetamine dependence and HIV will have a weaker relationship between intentions and behaviors than those without methamphetamine dependence. Additionally, those in the HIV+/MA+ group will show weaker intention-behavior relationships than any other HIV/MA group.
- *Hypothesis 2:* The role of disinhibition in moderating the relationship between sexual-risks intentions and behaviors will be stronger in methamphetamine non-dependent individuals and HIV- individuals than MA+ individuals and HIV- individuals. Additionally, those in the HIV+/MA+ group will show the weakest effect of disinhibition on the intention-behavior relationships than any other HIV/MA group.
- *Hypothesis 3:* The role of executive dysfunction in moderating the relationship between sexual risk intentions and behaviors will be stronger in methamphetamine non-dependent and HIV- individuals than MA+ individuals. Additionally, those in the HIV+/MA+ group will show the weakest effect of executive functioning on the intention-behavior relationships than any other HIV/MA group.
- *Hypothesis 4:* The moderating effect of methamphetamine and HIV will remain significant when accounting for the effects of apathy and intentions on behavior.

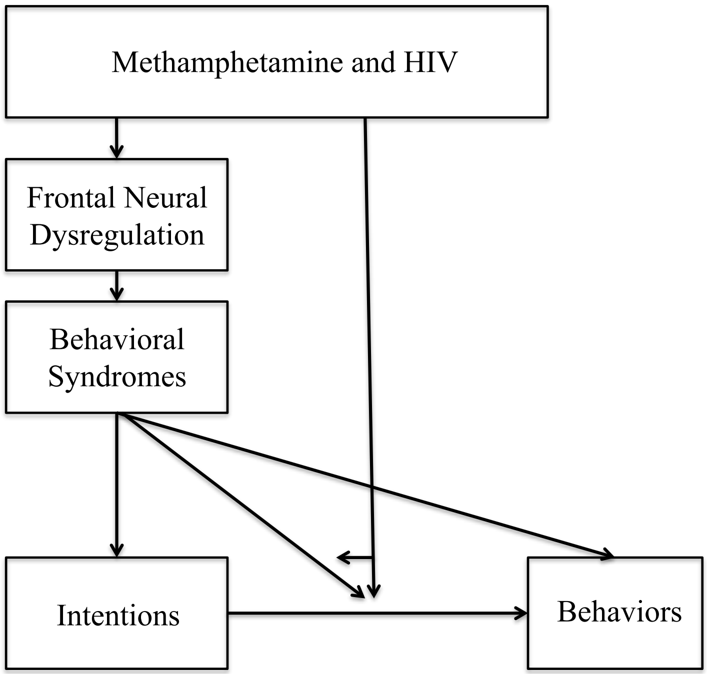

Figure 1. Conceptual effect of methamphetamine, HIV, and behavioral syndromes on the relationship between sexual risk intentions and behaviors.

Section Acknowledgements

Parts of this section will be prepared for publication. The publication will be co-authored by doctors Igor Grant, Steven P. Woods, Erin E. Morgan, Scott Roesch, and Paul Gilbert. The author of this dissertation was/will be the primary author of this material.

METHOD

This original sample included 305 adult participants and the final sample for this study included 234 adult participants who were HIV- (n = 125) and HIV+ (n = 109) and MA- (n = 133) and MA+ (n = 101; HIV-/MA- n = 72; HIV-/MA+ n = 53; HIV+/MA- n = 61; HIV+/MA+ n = 48) from the Translational Methamphetamine AIDS Research Center (TMARC) study funded by National Institute on Drug Abuse and conducted at the University of California San Diego (UCSD) HIV Neurobehavioral Research Program (HNRP). The UCSD Human Research Protections Program approved the study procedures and all participants provided written informed consent prior to data collection.

Materials and Procedures

Participants.

All participants received comprehensive neuromedical, psychiatric and neuropsychological evaluations at their study visit (see below for detailed descriptions). Participants were asked to abstain from substance use prior to testing to reduce neuropsychological confounds associated with acute intoxication or withdrawal. Recent substance use was evaluated through self-report and confirmed through a urine toxicology screening using a detection limit of 72 hours. Participants were excluded if they tested positive for alcohol or illicit substances (other than marijuana) on the day of testing, if they met DSM-IV criteria for a non-methamphetamine substance use disorder within 30 days of testing, if they met for alcohol dependence within one year of their visit, met criteria for another substance use disorder within five years of their visit (other than marijuana), or had a history of severe psychiatric disorders (e.g., schizophrenia) or neuromedical conditions that commonly impact cognition (e.g., closed head injury with greater than 15 minutes of lost consciousness, seizure disorder).

Measurement of primary variables.

The measures used for each variable are presented in Table 1 and described in detail below.

Table 1. Measures Used/Proposed for Each Variable.

Sexual Risk Behaviors
-Risk Assessment Battery
Sexual Risk Intentions
-Sexual Risks Scale – Intentions to Try Subscale
Disinhibition Composite
-Frontal Systems Behavior Scale – Disinhibition Subscale -Stroop Color and Word Test – Interference Trial -UPPS Impulsive Behavior Scale (Premeditation, Urgency, and Sensation Seeking Subscales) -Barratt Impulsiveness Scale (Non-Planning Subscale) -Kalichman Sensation Seeking Scale – Nonsexual Experience Seeking Subscale -Iowa Gambling Task
Executive Dysfunction Composite
-Frontal Systems Behavior Scale – Executive Dysfunctions Subscale -Wisconsin Card Sorting Test – 64 Cards (Perseverative Responses and Number of Categories Complete) -Trail Making Test – Part B -UPPS Impulsive Behavior Scale (Perseveration Subscale)
Apathy Composite
-Frontal Systems Behavior Scale – Apathy Subscale -Profile of Mood States (Depression-Dejection, Vigor-Activation, and Fatigue-Inertia Subscales) -Beck Depression Inventory-II
Methamphetamine Dependence
-Composite International Diagnostic Interview

Sexual risk behaviors.

The Risk Assessment Battery (RAB; Metzger et al., 1993) is a 24-item self-report questionnaire created for administration in substance using populations. The purpose of the measure is to assess risk behaviors associated with HIV transmission. The 24 questions are separated into two subscales that represent transmission risk through risky sexual behaviors (8 items; e.g., sex without a condom) and through risky substance use behaviors (15 items; e.g., needle sharing). An additional item exists that asks about sexual orientation (i.e., straight, gay/homosexual, or bisexual). The instructions of this measure include a brief introduction about what will be asked in the questionnaire, an assurance of confidentiality, and a simple set of instructions asking the participant to answer honestly. Each question requires respondents to answer based on their behaviors over the past six months. All responses range from 0 (never) to 3 (once or more each week) with higher numbers indicating the greatest risk. One item ("In the past six months, how often did you use condoms when you had sex") ranges from 0 (I have not had sex in the past six months) to 4 (none of the time). This measure produces three scores, a substance use risk behaviors subscale score, a sexual risk behaviors subscale score, and a total score (calculated by summing across the items in the subscales and the entire measure respectively). The authors justified not assigning weights to more or less risky behaviors in order to account for the likelihood of underreporting that often occurs for stigmatized behaviors such as sexual risk-taking. Because this study is associated with risky sexual behaviors only, the sexual risk subscale was used. The total subscale score was converted to a sample-based z-score to provide a more standardized interpretation of results.

The RAB has a high concordance with interview methods for obtaining similar information (Kappa = 97.5% Concordance) and an adequate test-retest reliability (r = .68-.90; Pechansky, Hirakata, & Metzger, 2002; Metzger et al., 1993). Internal consistency of the sexual-risk subscale is rather low (Cronbach alpha = .42), however, this may be due to the pattern of risk-taking behaviors being rather heterogeneous between individuals. For example, simply having a high number of sexual partners does not necessarily mean that a condom was not used during each sexual encounter or that this individual ever traded sex for money or drugs (other indications of sexual risk). Therefore, endorsement of one risky sexual behavior is not necessarily associated with other specific sexual risk behaviors, limiting the internal consistency of the measure.

Sexual risk intentions.

The Sexual Risks Scale (SRS; DeHart & Birkimer, 1997) is a 40-item questionnaire designed to measure intentions to try to practice safer sex. All responses range from 1 (strongly disagree) to 5 (strongly agree). The SRS was created using the concepts of risky behavioral intentions from the most prominent health-behavior models (i.e., Theory of Reasoned Action, Theory of Trying, Information-Motivation-Behavioral Skills, Health Behaviors Model). The measure consists of 6 subscales, each with adequate internal consistency. These subscales include attitudes about sexual risk behaviors (13 items; Cronbach's alpha = .90), beliefs about how normative sexual risk behaviors are (7 items; Cronbach's alpha = .84), intention to try to practice safe sex (7 items; Cronbach's alpha = .76), expectation items (7 items; Cronbach's alpha = .82), beliefs about susceptibility to sexual risk consequences (4 items; Cronbach's alpha = .80), and substance use items (2 items; Cronbach's alpha = .78). The SRS has good construct validity and the intentions subscale specifically showed good predictive validity for condom use behaviors (DeHart & Birkimer, 1997). For the purposes of this study, a sample-based z-score of the intentions to try subscale total was used to represent sexual-risk intentions.

Methamphetamine dependence.

Lifetime methamphetamine dependence (yes versus no) was determined using The Composite International Diagnostic Interview (CIDI version 2.1 World Health Organization [WHO], 1997). The CIDI (WHO, 1997) is a structured clinical interview used to categorize participants based on the Diagnostic and Statistical Manual of Mental Disorders (4th ed.; American Psychiatric Association, 1994) criteria.

HIV.

HIV status was confirmed using point of care testing and a Western Blot confirmatory test. HCV was determined by immunoglobulin G (IgG) antibody detection in plasma using ELISA.

Disinhibition.

Disinhibition was measured using several performance-based measures (Stroop Color and Word Test; Iowa Gambling Task) and self-report questionnaires (Frontal Systems Behavior Scale - Disinhibition subscale; Barratt Impulsiveness Scale; UPPS Impulsive Behavior Scale; Kalichman Sensation Seeking Scale). A composite score was derived by first converting raw scores to sample based z-scores then confirming the fit of the tests in the model using factor analysis and modification indices (e.g., LaGrange Multiplier test, Wald test) to revise the inclusion/exclusion of measures where necessary. Composite scores became the mean z-score of the measures included in the disinhibition composite variable.

Stroop Color and Word Test.

The Stroop Color and Word Test (Golden, 1978) is based on the idea that identifying and naming simple written words is an automatic process from practice reading simple words throughout life, while identifying and naming colors is the result of conscious effort (Cattell, 1886). This measure includes three trials. In the first trial, participants are given 45 seconds to read out loud the words “red”, “green” and “blue” listed in random order on a page. These words are printed in black ink. Participants are instructed to read down the columns, starting with the first column and to continue down the remaining columns (5 columns total) until instructed to stop. Participants are also instructed that if they finish reading all 100 words before being told to stop, they are to begin the task again starting with the first column. The total number of words read in 45 seconds is recorded as the score. The second trial shows the same number of items (100 across 5 columns), however the stimulus is no longer black printed words, but instead is rows of colored X's (red, green, or blue). This second trial is administered using the same procedures, however, instead of reading words on a page, participants are instructed to name out loud the colors of these rows of X's that are printed on the page. The third trial presents words (red, green, or blue) that are printed with colors of ink (red, green, or blue) that do not match the written word (e.g., the written word blue is printed in green ink). The procedures for trials 1 and 2 are repeated for trial 3, however, the participant is asked to name out loud the color of ink the word is printed in while ignoring the word that is printed. This third trial measures a participant's ability to inhibit the automatic word-reading response in favor of the more cognitively taxing color naming response. Participants with pre-frontal pathology and subsequent inhibition difficulties tend to perform poorly on the third trial of this task (Golden, 1978). Uncorrected sample-based z-scores were used for the inhibition trial of this measure.

Iowa Gambling Task.

The Iowa Gambling Task (IGT; Bechara, 2007) was designed to mimic real-world decision-making by providing alternative choices, each with different probabilities of immediate reward and delayed risk (requiring temporal discounting skills and an ability to overcome immediate pleasure in favor of delayed benefits in order to perform well). In this task, participants begin at a computer screen with a hypothetical loan of $2000 (which is identified at the top of the screen with a red bar filled to the $2000 mark) and participants are instructed to choose cards from 4 possible decks (Decks A, B, C, or D) in order to win unspecified amounts of money (Bechara, 2007). Participants are informed that different cards result in winning or losing different amounts of money, that cards in each deck are provided at random, and that some decks are better than others (result in more money earned than lost; Bechara, 2007). Participants are then requested to choose cards (100 total) from any deck and are allowed to switch from one deck to another as frequently as they would like (Bechara, 2007). As they choose each card, they are provided with either a red (winning) or black (losing) card, a sound similar to a slot machine, a notification of the dollar amount they won or lost, and a display of their net winnings and losses at the top of the screen with changes in green (amount won) and red (amount owed) bars (Bechara, 2007).

Two of the decks (decks A and B) result in greater reward but greater losses (Bechara, 2007). These two "bad" decks result in a net loss of $250 after 10 draws (Bechara, 2007). The two "good" decks (decks C and D) result in smaller payoffs but smaller losses, but after 10 draws result in a net gain of $250 (Bechara, 2007). Therefore, the decks with more risk/reward potential result in long-term loss and the decks with less risk/reward potential result in long-term gain (Bechara, 2007). The net total score accounts for all decisions made across the trials while considering both advantageous decisions and disadvantageous choices and allows for inclusion of decisions made in both ambiguous (e.g., being unsure if a sexual partner has an STI or being unsure if the female recipient will become pregnant) and unambiguous (e.g., knowledge of the individuals HIV/AIDS status) situations. The number of cards chosen from the disadvantageous decks (A and B) is subtracted from the number chosen from the advantageous decks (C and D), to derive the net total score, with a negative score indicating disadvantageous/risky decision-making.

Reliability on the IGT has been noted to be poor for test-retest due to practice effects (Dahne, Richards, Ernst, MacPherson, & Lejuez, 2013). As expected, IGT scores were associated with delayed discounting (e.g., Monterosso, Ehrman, Napier, O'Brien, & Childress, 2001), and substance use (Bechara, 2001; Grant, Contoreggi, & London, 2000; Petry, 2001).

Frontal Systems Behavior Scale – disinhibition subscale.

The Frontal Systems Behavior Scale (FrSBE; Grace, Stout, & Malloy, 1999) is a 46-item self-report measure designed for assessment of frontal dysfunctions in numerous populations (e.g., patients with focal lesions, dementia, neurologic disorders, traumatic brain injury, psychiatric disorders, and adult Attention-Deficit/Hyperactivity Disorder). The measure assesses patient responses in three frontal area abilities that map onto Cummings (1993) model (disinhibition, executive dysfunction, and apathy). The measure differentiates the extent to which the behaviors are experienced currently and previously (before an illness or injury). Item responses are on a 5-point Likert Scale from 1 (almost never) to 5 (almost always). This allows for a total score, three subscale scores, comparison of scores before/after an illness/injury and assessment of current functioning in these areas. Because this research is focused on current intentions and behaviors, only the scores for current FrSBE behaviors were used.

Cronbach's alpha was high in both normal (total scale = .88; FrSBE Apathy subscale = .72; Disinhibition subscale = .75; Executive Dysfunction subscale = .79) and neurological (total scale = .94; Apathy subscale = .78; Disinhibition subscale = .84; Executive Dysfunction subscale = .84). The three factor structure of the FrSBE was retained through factor analysis (41% of the common variance was accounted for by the three factors) and medium to large correlations were observed between Executive Dysfunction and Disinhibition (r = .43) and between Executive Dysfunction and Apathy (r = .43) while small to medium correlations were seen between disinhibition and apathy ($r = .22$) subscales. Good convergent (comparing the FrSBE with a similar measure, the Neuropsychiatric Inventory; $r = .64$, $p < .001$; Cummings et al., 1994), discriminant (across multiple frontal and non-frontal groups; e.g., fronto temporal dementia, Alzheimer's disease, and nonfrontal stroke; healthy control and frontal dysfunction groups; e.g., Paulsen et al., 2006; Boyle et al., 2003), and construct (changes across time, differences between normal and frontal patients, frontal lesions versus other lesions; e.g., Grace, Stout, & Malloy, 1999) validity have also been shown.

UPPS Impulsive Behavior Scale.

Whiteside and Lynam (2001) developed the UPPS Impulsive Behavior Scale, a 45-item self-report questionnaire, by combining items from 10 measures of impulsivity to develop a measure that encompassed the multifaceted components of impulsiveness. There are 4 subscales of items represented in this measure. The premeditation subscale (11 items) represents difficulty with planning in advance. The urgency subscale evaluates difficulty inhibiting immediate urges/impulses (12 items). The sensation seeking subscale evaluates a desire to move toward more exciting situations (e.g., "I sometimes like doing things that are a bit frightening"). Finally, the Perseverance subscale measures general distractibility and see tasks through until they are finished. Each subscale showed good internal consistency (Cronbach alpha ranging from .82-.91) and the measure overall had good convergent validity with gold standard personality measures that map onto impulsivity (Whiteside & Lynam, 2001). The overall total score is designed to generally measure impulsiveness. However, the Urgency, Premeditation, and Sensation Seeking subscales map onto Cummings (1993) concept of disinhibition, while the Perseveration subscale maps more closely onto the concept of executive functioning. Therefore, when evaluating the factors for composite scores, the total will be used first and if the factor structure does not fit well, the subscales will instead be used for further specificity and differentiation of the separable frontal systems.

Barratt Impulsiveness Scale.

The Barratt Impulsiveness Scale (BIS; Barratt, 1959) is a 30-item self-report questionnaire designed to measure the frequency with which participants think or behave impulsively (e.g., "I buy things on impulse"). Responses are rated on a scale from 1 (rarely/never) to 4 (almost always/always). Internal consistency of the BIS was adequate across numerous populations including undergraduates (Cronbach's alpha = .82), substance using populations (Cronbach's alpha = .79), psychiatric populations (Cronbach's alpha = .83), and prison inmates (Cronbach's alpha = .80). The items either represent impulsive ("I say things without thinking") or non-impulsive ("I am a careful thinker") behaviors. Thus, the non-impulsive items are reverse scored to ensure that higher scores indicate greater impulsivity. There are 3 second-order factors of the BIS (Non-Planning, Attention, and Motor). While the measure overall was designed to evaluate general impulsivity, the Non-Planning subscale more specifically represents the construct of disinhibition (Cummings, 1993). Therefore if using the total scores in the factor analysis does not result in the predicted factor structure, the Non-Planning subscale will be used instead to enhance specificity.

Kalichman Sensation Seeking Scale – nonsexual experience seeking subscale.

The Kalichman Sensation Seeking Scale (SSS) is a 30-item self-report questionnaire that asks individuals to provide responses based on questions in three domains of sensation seeking: Sexual Sensation Seeking (e.g., "I like wild 'uninhibited' sexual encounters"), Nonsexual Experience Seeking (e.g., "I would like parachute jumping"), and Sexual Compulsivity Scale (e.g., "I sometimes get so horny I could lose control"). Responses range from 1 (not at all likely) to 4 (very likely). The two sexual sensation seeking subscales of this measure have some overlap with the Risk Assessment Battery questions (e.g., SSS item #3: “I enjoy the sensations of intercourse without a condom.”). Therefore, to reduce biasing the analyses only the Nonsexual Experience Seeking subscale was used in the disinhibition composite score. The SSS Nonsexual Sensation Seeking subscale provided adequate internal consistency (Cronbach’s alpha = .79) and test-retest reliability (r = .86) and construct validity (Kalichman & Rompa, 1995).

Executive functioning.

Executive functioning was measured using several performance-based measures (Wisconsin Card Sorting Test-64; Trails Trial B) and a self-report questionnaire (FrSBE - Executive Functions subscale). A composite score was derived by first confirming the fit of the tests in the model using factor analysis and LaGrange Multiplier test and/or Wald test to revise the inclusion/exclusion of measures where necessary. The composite score created by deriving sample-based z-scores from total raw scores of each measure and determining the average z-score across all included measures.

Frontal Systems Behavior Scale – executive dysfunction subscale.

The FrSBE Executive Dysfunction subscale was used for self-reported experience of executive dysfunction (see description of questionnaire above).

Wisconsin Card Sorting Test-64.

The Wisconsin Card Sorting Test-64 (WCST-64; Heaton, Chelune, Curtiss, Kay, & Talley, 1993) was developed as a shorter version of the original 128-item WCST (Heaton, 1981). The test measures an individual’s ability to reason abstractly, switch mental sets, and solve problems based on changing contextual rules to obtain a desired outcome. The computerized version of this test was used for this research (Heaton et al., 1993). In the administration of the measure, participants are initially informed that not much information can be described about the test, but that the participant should match the card that appears on the bottom of the screen to one of four key cards at the top of the screen that they believe their card best represents. Participants do this by pressing the key on the keyboard that shows the key card symbol to which they would like to match to their card. Each card (including key cards) has a combination of number of stimuli (1-4), color of stimuli (red, blue, yellow, or green), and shape of stimuli (triangle, cross, circle, or star). The test is designed so that the cards can be matched on 1 (e.g., shape only), 2 (e.g., both shape and color), or 3 (i.e., shape, color, and number) dimensions with any of the four key cards. Therefore, participants are required to reason through which rule (color, number, or shape) they believe is the best matching strategy for the current rule. Participants are told after each match selection whether they were correct or incorrect in their choice by the visual and auditory presentation of the words "right" or "wrong". Therefore, participants are given the opportunity to reflect on and change their strategy depending on current feedback. After a participant makes 10 correct matches, the rule switches without the participant being notified. This gives the participant an opportunity to change their strategy based on new contextual feedback (a strategy that previously worked is no longer effective). Participants with good problem solving skills (ability to reason through the multiple options available for matching) and mental flexibility/cognitive set shifting (changing their strategy based on changing contextual feedback about accuracy) should perform well on this test.

Scores are divided into Perseverative Responses (which represent the number of times in which a participant continues to use the same strategy despite being told this strategy produces inaccurate results), Number of Categories Completed (which represents the total number of successfully completed sets of responses prior to the rule changing), Trials to Complete the First Category (which represents the number of matches the participant makes before correctly identifying the strategy that produces an accurate response; it also shows the initial understanding of matching strategies before shifting set is required), Failure to Maintain Set (which represents the inability to continue a strategy after using it for five trials), Conceptual Level Responses (which represents the individuals understanding of the sorting principles based on responding with correct responses on three consecutive trials), and Learning to Learn (which represents the individual's increased ability to apply accurate sorting strategies as the test continues). Each of the scores was associated with some sort of brain damage (Heaton, Chelune, Curtiss, Kay, & Talley, 1993). However, only the Total Number of Errors, Perseverative Responses, and Perseverative Errors, Conceptual Level Responses, and Number of Categories Completed showed main effects due to brain lesion location (though no lesion location differences were seen for Nonperseverative Errors, Trials to Complete First Category, or Failure to Maintain Set), and only Perseverative Reponses and Number of Categories Completed showed significantly worse performance in frontal lesioned patients than non-frontal lesioned patients (Kongs, Thompson, Iverson, & Heaton, 2000). These two scores have been shown to load onto the same factor (e.g., Kongs et al., 2000; Greve, Ingram, & Bianchini, 1998), but represent slightly different abilities (mental flexibility and problem solving respectively). Therefore, these two scores were used in this study.

Test-retest reliability of the WCST is fair to moderate (Kongs, Thompson, Iverson, & Heaton, 2000), however, when retested at a longer intervals (2.5 years), the test-retest reliability is better (with generalizability coefficients greater than .90; Ozonoff, 1995). The construct validity of the WCST has been shown across multiple studies (e.g., Shute & Huertas, 1990;

Perrine, 1993). Perseverative Errors has been associated with another measure that represents abstract thinking abilities (Piagetian formal operational reasoning factor; Shute & Huertas, 1990). Perseverative Responses, Total Number of Errors, and Number of Categories Completed were related to the ability to identify attributional patterns across trials (Perrine, 1993). The Perseverative Errors, Perseverative Responses, and Total Number of Errors have consistently been associated with other tests of mental flexibility and set shifting, while Conceptual Level Responses, Number of Categories Completed and Total Correct Responses map onto problem solving abilities (e.g., Greve, Ingram, & Bianchini, 1998). Additionally, performance on the WCST has been associated with dorsolateral prefrontal lesions (Milner, 1963).

Trail Making Test.

The Trail Making Test (TMT; Strauss, Sherman, Spreen, 1998) is a performance-based test that is split into two trials (Part A and Part B). Both trials require participants to sequentially connect 25 circled items (numbers or numbers and letters). In Part A (TMT-A) participants are asked to connect only numbers. TMT-A measures general visual search, processing speed, and psychomotor speed (Bowie & Harvey, 2006). Part B (TMT-B) requires participants to sequentially connect both numbers and letters by switching back and forth (1-A-2-B-3-C…; Bowie & Harvey, 2006). TMT-B measures cognitive flexibility/set shifting (Bowie & Harvey, 2006). The total time the participant required for TMT-B was used for this study.

TMT-B has shown adequate test-retest reliability across numerous samples (e.g., Bornstein, Baker, & Douglas, 1987, Dikmen, Heaton, Grant, Temkin, 1999; Levine, Miller, Becker, Selnes, & Cohen, 2004; Mitrushina & Satz, 1991) including various neurological populations (Goldstein & Watson, 1989) and good interrater reliability (.90; Schafer & Fals-Stewart, 1991). While the TMT-B has poor discriminative validity (e.g., Iverson, Lange, &

Franzen, 2005), performance on this test is associated with other measures of executive functioning (e.g., WCST; Kortte, Horner, & Windham, 2002) and set shifting tasks (Arbuthnott & Frank, 2000). The measure is sensitive to impairments due to substance use (McCaffrey, Krahula, Heimberg, Keller, & Purcell, 1988), neurological damage (Reitan & Wolfson, 1995; Reitan & Wolfson, 2004), head injury (DesRosiers, & Kavanagh, 1987), and HIV infection (Di Sclafani et al., 1997).

Apathy.

Apathy was measured using several self-report questionnaires (FrSBE - Apathy subscale; Profile of Mood States Vigor/Activation and Fatigue/Inertia subscales; Beck Depression Inventory-II apathy items). A composite score was derived by first converting raw scores to sample-based z-scores, then confirming the fit of the tests in the model using factor analysis and LaGrange Multiplier test and/or Wald test to revise the inclusion/exclusion of measures where necessary. Composite scores became the mean z-score of the measures included in the disinhibition composite variable.

Frontal Systems Behavior Scale – apathy subscale.

The FrSBE Apathy subscale was used for self-reported experiences of apathy (see detailed description of measure above).

Profile of Mood States subscales.

The Profile of Mood States (POMS; McNair, Lorr, & Droppleman, 1981) is a 65-item self-report questionnaire that asks participants to rate their feelings over the past week. Participants rate numerous feelings associated with six subscales (Tension-anxiety, Depression-Dejection, Anger-Hostility, Fatigue-Inertia, Vigor/Activity, and Confusion/Bewilderment). Items are scores from 0 (not at all) to 4 (extremely), with higher scores representing greater endorsement of that scale. The Vigor/Activation subscale was reverse scored to indicate greater apathy. Test-retest reliability ranges from .65-.74. Internal consistency was strong (.90) for items within each factor; McNair, Lorr, & Droppleman, 1981) and it shows good criterion validity (e.g., Terry, Lane, & Fogarty, 2003). Uncorrected sample-based z-scores were derived from the Depression-Dejection, Vigor-Activity and the Fatigue-Inertia subscale totals.

Beck Depression Inventory-II.

The Beck Depression Inventory-II (BDI-II) is a 21-item self-report questionnaire designed to measure symptoms of depression. Participants rate their responses on a 0-3 scale with higher scores indicating worse feelings (e.g., 0 = “I do not feel sad”, 1 = “I feel sad much of the time”, 2 = “I am sad all of the time”, 3 = “I am so sad or unhappy that I can’t stand it”). Several items in the BDI-II map onto the construct of apathy. These items include loss of pleasure, loss of interest, and loss of energy. These items cluster together to represent a more motivationally mediated factor of mood disturbance that is associated with neurocognitive abilities (Castellon et al., 2006) and have previously been used in conjunction with other measures to represent apathy (e.g., Marquine et al. 2014). Therefore, these items were extracted from the BDI-II and used as a subscale for the Apathy composite.

Statistical analysis.

To construct the composite variables, confirmatory factor analysis (with statistically indicated modifications when necessary and theoretically supported) was completed. To evaluate each moderation hypothesis a multivariable linear regressions was completed. When no higher-order (e.g., four-way) interaction was detected, the regression was rerun without the higher-order interaction (e.g., evaluating all three-way interactions in the model). This process was repeated until either significant effects were detected or only main effects remained in the model. An alpha level of $p < .05$ was used for all analyses. When significant interactions were detected, follow-up analysis were completed to understand the simple slopes using Bonferroni corrections. To evaluate the mediated model, first, a series of simple and multivariable linear regressions were completed to determine the direct and indirect effects of apathy on sexual risk behavior. Next, bootstrapping methods (e.g., Efron & Tibshirani, 1994) were completed to determine the confidence intervals for testing whether the indirect effect is statistically different from zero. Bootstrapping for mediation confidence interval testing is a more powerful method than more traditional methods such as the Sobel test (Shrout & Bolger, 2002; Sobel, 1982; Sobel, 1986).

Selection of covariates.

Due to the robust differences in sexual risk intentions and behaviors in men versus women and those who do/do not have antisocial personality disorder (ASPD; e.g., Byrnes, Miller, & Schafer, 1999; DeHart & Birkimer, 1997; Nydegger, Ames, & Stacy, 2015), as well as those of different ages (e.g., Steinberg, 2004), education levels (Strathdee et al., 1998), and ethnicities (Laumann & Youm, 1999), these variables were included as covariates in all analyses.

The neurological effects of HIV share some of the same frontostriatal pathology (e.g., Melrose, Tinaz, Castelo, Courtney, & Stern, 2008) and cognitive dysfunction (e.g., Woods, Moore, Weber, & Grant, 2009) with the effects of methamphetamine. Additionally, individuals with HIV may represent a higher propensity for risk-taking (e.g., more risk-taking puts them at higher odds of contracting HIV; e.g., Page-Shafer et al., 1997). On the contrary, it is also possible that the contraction of HIV may reduce subsequent risk-taking (Gorbach, Drumright, Daar, & Little, 2006; Marks, Crepaz, Senterfitt, & Janssen, 2005) compared to HIV-counterparts. Therefore, the effects of HIV will be evaluated in a stratified sample to determine whether HIV+ individuals should be excluded from the sample. First, the association between HIV status and sexual risk intentions, sexual risk behaviors, frontal systems behaviors, and methamphetamine dependence will be evaluated in the HIV- group, followed by evaluation in the HIV+ group to allow for a consideration of the impact of HIV on the results. The determination of the inclusion of HIV+ individuals in the sample and whether or not to include HIV status as a covariate in the analyses will be determined after a comprehensive holistic review of these findings has been completed. If HIV is to be included in the sample, it is important to evaluate whether HIV also moderates these relationships and will be included in the hypotheses.

Power analysis.

A sensitivity power analysis was completed to determine the f^2 necessary for detecting significance in the proposed regressions. Using an alpha cutoff of .05 with up to 19 predictors (the largest model in this study), power (1-β) at .80, and sample size of 234, the projected f^2 of .08 (small-medium effect) would be the minimal detectable effect (MDE). Therefore, if frontal systems behaviors, methamphetamine dependence, and/or HIV have even a small to medium effect on the relationship between intentions and behaviors, significant results should be detected. An identical power analysis was completed for detecting significance in the HIV- sample (*n* = 125) if the exclusion of HIV+ individuals is deemed appropriate. In this smaller sample, an f^2 of .16 (medium-large effect) would be the minimal detectable effect (MDE).

Data preparation.

Prior to statistical analysis, all study variables were evaluated to determine whether they met or violated assumptions of factor analysis, regression, and mediation analyses. When missing data existed, consistent with recommendations by Tabachnick and Fidell (2001), these data points were removed to ensure the results would not be impacted. The resulting sample included 234 participants, which is considered a fair to good sample size for factor analysis (Comrey & Lee, 1992). Continuous variables were evaluated for outliers and assumptions of normality. When outliers were detected, the following evaluation methods were completed: 1. Data entry was double checked to ensure the outliers were not due to entry errors, 2. Value codes were evaluated to ensure unintended codes were not used (e.g., 999 for missing data), 3. The outlier was evaluated to ensure it was indeed part of the intended sample (e.g., did not meet exclusion criteria), and 4. Data were evaluated to determine whether the instances were simply more of an extreme response. The first three common causes for missing data were not discovered in this dataset. When the fourth description above was the cause, transformations ($\log_{10}$) were first completed to decrease the impact of the outlier on the analyses. Transformations did not resolve the assumptions (i.e., distributions were not normalized, and in many cases log transforming resulted in additional outliers) therefore the original distributions using z-scores were retained. Table 2 displays raw data descriptive statistics for all variables in the dataset prior to transforming into z-scores (M = 0; SD = 1).

Table 2. Raw Score Descriptive Statistics.

Variable	Mean (SD) or % Raw Scores $N = 234$
Primary Study Variables	
Gender (% Male)	81%
ASPD	14%
Age	41.6(13.0)
Education	13.7(2.4)
Ethnicity (% Caucasian)	56%
MA+	43%
Age at First Use	26.0(10.2)
Days Since Last Use	128.6(143.6)
Duration of MA Use (Years)	6.7(7.1)
Total Quantity of Use (Grams)	2666(5532)
Current MA Abuse/Dependence (of MA+)	18%
Ever Injected (of MA+)	37%
HIV+	47%
Current CD4	553.7(264.2)
Nadir CD4	288.2(223.2)
Duration of HIV (Years)	9.2(8.3)
AIDS (of those with HIV)	44%
On Antiretroviral Medication	74%
Sexual Risk Intentions	25.3(6.7)
Sexual Risk Behavior	-5.6(3.6)
Psychiatric and Other Substance Use Variables	
Major Depressive Disorder (% Lifetime)	35%
Major Depressive Disorder (% Current)	8%
Attention-Deficit/Hyperactivity Disorder (% Lifetime)	9%
Cannabis (% Lifetime Dependence)	32%
Cannabis (% Current Dependence)	2%
Other Substance (% Lifetime Dependence)	47%
Opioid (% Lifetime Dependence in sample)	6%
Cocaine (% Lifetime Dependence in sample)	13%
Alcohol (% Lifetime Dependence in sample)	46%
Individual Measures and Subscales	
FrSBe Total	-92.9(28.0)
FrSBe Disinhibition	-28.1(9.2)
FrSBe Executive Functioning	-35.2(11.0)
FrSBe Apathy	-29.4(10.1)
UPPS Total	-96.1(18.5)
UPPS Premeditation	-20.2(6.1)
UPPS Urgency	-26.0(7.7)
UPPS Sensation Seeking	-30.8(8.3)

Table 2. Raw Score Descriptive Statistics. Continued	
UPPS Perseveration	19.1(5.3)
BIS Total	-64.1(13.6)
BIS Non-Planning	-26.5(6.1)
BIS Attention	-17.3(4.2)
BIS Motor	-20.4(5.1)
POMS Total	-57.3(43.3)
POMS Depression-Dejection	-11.5(14.6)
POMS Vigor-Activation	16.3(7.0)
POMS Fatigue-Inertia	-6.9(6.5)
BDI-Apathy Items	-1.7(1.8)
Stroop Interference	41.3(9.8)
Kalichman Non-Sexual Sensation Seeking	-2.1(.7)
Iowa Gambling Task	7.7(27.5)
WCST Perseverative Responses	-9.7(5.6)
WCST Number of Categories	3.0(1.5)
TMT-B	-66.8(24.5)

Note. Negative values indicates variables that were "flipped" to ensure higher values represent better performance across all variables. FrSBe = Frontals Systems Behavior Scale; UPPS = Urgency, Perseverance, Premeditation, Sensation Seeking. WCST = Wisconsin Card Sorting Test – 64; POMS. Profile of Mood States. BDI = Beck Depression Inventory – II. TMT-B = Trail Making Test – Trial B.

Evaluation of assumptions.

Because transformations did not improve the assumptions, the preferred method for removing the effect of outliers on the analyses was winsorizing (Tabachnick & Fidell, 2001). Winsorizing was conducted by removing the outlier and replacing the value with the maximum + 1 or the minimum minus 1. When removing outliers resulted in new outliers, the procedures above were repeated until all outliers were removed.

No outliers were identified for sexual risk intentions, risky sexual behaviors, or the z-scores for UPPS Total, BIS Non-Planning subscale, POMS Vigor-Activation, and WCST Number of Categories. Outliers were found for FrSBe Disinhibition subscale (1 outlier: z = 3.7), Stroop Interference (5 outliers: z = 3.0, 2.6, -2.6, -2.9, -3.2), BIS Total (2 outliers; z = -2.9, -2.8), Kalichman Non-Sexual Sensation Seeking (3 outliers; z = -2.8, -2.8, -2.7), IGT (1 outlier; z = -2.9), FrSBe Executive subscale (2 outliers; z = -4.0, -3.1), WCST Perseverative Responses (14 outliers; z = -4.5, -4.2, -3.1, -3.1, -2.8, -2.8, -2.8, -2.7, -2.7, -2.5, -2.5, -2.5, -2.4, -2.2), TMT-B (16 outliers; z = -6.7, -4.5, -3.2, -3.2, -2.8, -2.8, -2.8, -2.5, -2.2, -2.2, -2.0, -2.0, -1.9, -1.8, -1.6, -1.6), FrSBe Apathy subscale (1 outlier; z = -3.5), POMS Total (4 outliers; z = -3.4, -2.9, -2.9, -2.7), POMS Fatigue-Inertia (8 outliers; z = -3.1, -2.9, -2.8, -2.5, -2.5, -2.5, -2.4, -2.4) and BDI apathy items (1 outlier; z = 4.0). Due to the skewed distribution of the POMS Depression-Dejection variable, 45 outliers (19% of the sample for this variable) were identified (or they became outliers after removing previously). Because changing this number of outliers would significantly change the distribution, the outliers were retained for this variable.

All variables that originally represented worse performance when scores were higher were multiplied by -1 to “flip” the scores so that higher scores on all continuous variables would indicate better performance. The reference level for all dichotomous yes/no variables (e.g., has HIV, MA dependence, ASPD) were identified as the absence of the categorical variable (e.g., reference group = No ASPD; comparison group = has ASPD). In instances of gender and ethnicity, the reference level was male and non-white respectively.

Inclusion of HIV.

Surprisingly, HIV was not significantly associated with disinhibition (p = .896) or executive functioning (p = .135). HIV was also not associated with ASPD (p = .184) or being dependent on methamphetamine (p = .842). Having HIV was associated with riskier intentions (p = .001), riskier behaviors (p < .001), more apathy (p = .005), and being male (p < .001). Because of the importance of HIV in predicting intentions, behaviors, and apathy, and because of the power necessary to detect higher-order interactions, participants with HIV were retained in the study and evaluations were completed to determine if the primary analyses differed depending on HIV serostatus.

Section Acknowledgements

Parts of this section will be prepared for publication. The publication will be co-authored by doctors Igor Grant, Steven P. Woods, Erin E. Morgan, Scott Roesch, and Paul Gilbert. The author of this dissertation was/will be the primary author of this material.

RESULTS

Confirmation of Composite Variables

Tables 6 displays the model fit of the hypothesized and final factor structure. Table 4 and 8 display the covariance matrix and standardized parameter estimates of the final factor structure. Model fit was determined based on Bentler (2007) guidelines. Two of three of the following fit indices must be met in order to accept the model fit, including 1. the Comparative Fit Index (CFI; Bentler, 1990) with values greater than .90 (> .90 is plausible fit; > .95 is reasonable fit) indicating adequate model fit, 2. the root mean square error of approximation (RMSEA; Steiger, 1990) with values less than .08 (< .08 is acceptable; < .05 is good) indicating adequate model fit, and 3. The Standardized Root Mean Residual (SRMR; Hu & Bentler, 1999) with values less than .08 (< .08 is acceptable; < .05 is good) indicating adequate model fit. The likelihood ratio χ^2 is also reported for completeness.

A three-factor frontal systems model was evaluated using confirmatory factor analysis with Maximum Likelihood (MLR) estimation in Mplus Version 7.2 statistical software. The three latent variables (disinhibition, executive, and apathy) were initially evaluated with total scores of each measure (see Table 1), but due to poor fit [χ^2 (62, N = 233) = 1725.98, p < .001; CFI = < .001; RMSEA .339, p < .001; SRMR = .190], the subscales were used for the following analyses. The hypothesized factors included 8 (FrSBe Disinhibition subscale, Stroop Color and Word Test – Interference Trial, UPPS Urgency subscale, UPPS Premeditation subscale, UPPS Sensation Seeking subscale, Barratt Impulsiveness Scale Non-Planning subscale, Kalichman Non-Sexual Sensation Seeking subscale, Iowa Gambling Task), 5 (FrSBe Executive Dysfunctions subscale, WCST Perseverative Responses, WCST Number of Categories, TMT-B, UPPS Perseverative Responses), and 5 (FrSBe Apathy subscale, POMS Depression-Dejection, POMS Vigor-Activation subscale, POMS Fatigue-Inertia subscale, BDI-Apathy) observed variables respectively. The original three-factor model using subscales did not fit well statistically [χ^2 (132, N = 233) = 954.251, p < .001) or descriptively (CFI = .629; RMSEA .164, p < .001; SRMR = .135). However, after evaluating potential modifications using modification indices and theory, the FrSBe Apathy subscale, FrSBe Disinhibition subscale, and UPPS Sensation Seeking subscale were removed, improving the model statistically [χ^2 (132, N = 233) = 954.251, p < .001) and descriptively (CFI = .681, RMSEA = .151, SRMR = .128). Additional modifications were then completed (TMT-B, Stroop, and IGT loading on the executive factor and FrSBe Executive and UPPS Perseveration removed) resulting in an adequate factor structure that fit descriptively (CFI = .913, RMSEA = .081, SRMR = .063; [χ^2 (62, N = 233) = 157.181, p < .001). Tables 7-9 display the fit of the hypothesized and final models, the covariance matrix, and the standardized parameter estimates respectively. Figure 2 depicts the factor structure.

The resulting three-factor structure included the disinhibition factor (Kalichman Non-Sexual Sensation Seeking subscale, UPPS Urgency subscale, UPPS Premeditation subscale, and BIS Non-Planning subscale), executive factor (WCST Perseverative Responses, WCST Number of Categories, TMT-B, Stroop Interference, and IGT), and the apathy factor (POMS Fatigue-Inertia, POMS Vigor-Activation, POMS Depression-Dejection, BDI apathy items).

Table 3. Hypothesized Factor Structure**.**

Disinhibition Composite
-Frontal Systems Behavior Scale – Disinhibition Subscale -Stroop Color and Word Test – Interference Trial -UPPS Impulsive Behavior Scale (Premeditation and Urgency Subscales) -Barratt Impulsiveness Scale (Non-Planning) -Kalichman Sensation Seeking Scale – Nonsexual Experience Seeking Subscale -Iowa Gambling Task
Executive Dysfunction Composite
-Frontal Systems Behavior Scale – Executive Dysfunctions Subscale -Wisconsin Card Sorting Test – 64 Cards -Trail Making Test – Part B
Apathy Composite
-Frontal Systems Behavior Scale – Apathy Subscale -Profile of Mood States (Depression-Dejection, Vigor Activation, and Fatigue-Inertia Subscales) -Beck Depression Inventory-II

Table 4. Confirmatory Factor Analysis Fit Indices.

Model	χ^2	df	CFI	RMSEA	SRMR
Desired Model Fit	*Not Significant*	-	> .90	< .08	< .08
Hypothesized	*954.251**	62	.629	.164*	.135
Final	*157.18**	62	.913	.081*	.063

Note. χ^2 = chi square goodness of fit statistic. df = degrees of freedom. RMSEA = Root-Mean-Square Error of Approximation. CFI = Comparative Fit Index. SRMR = Standardized Square Root Mean Residual. *$p < .05$.

Table 5. Covariance Matrix of the Final Model.

	TMT	Cat	PR	IGT	SS	Str	Apa	F-I	V-A	D-D	NP	Urg	Pre
TMT	.983	.507	.441	.231	.092	.532	.168	.098	.091	.200	.081	-.004	.038
Cat		1.00	.724	.336	-.012	.424	.053	-.078	-.085	.052	.035	.034	.021
PR			1.00	.273	-.056	.385	.065	.005	-.049	.073	.035	.000	.724
IGT				1.00	-.106	.158	.059	-.033	.056	.060	.077	.079	-.002
SS					.996	-.136	.011	.118	-.171	.135	.254	.221	.213
Str						.993	.200	.043	.056	.092	.116	.079	.071
Apa							1.00	.643	.459	.651	.405	.420	.301
F-I								1.00	.496	.743	.357	.460	.275
V-A									.993	.415	.309	.352	.296
D-D										1.00	.460	.539	.330
NP											.995	.672	.632
Urg												.995	.603
Pre													1.00

Note. Pre = UPPS Premeditation. Urg = UPPS Urgency. NP = BIS Non-Planning. D-D = POMS Depression-Dejection. V-A = POMS Vigor-Activation. F-I = POMS Fatigue-Inertia. Apa = Beck Depression Inventory-II Apathy Items. Str = Stroop Interference. SS = Kalichman Non-Sexual Sensation Seeking. Iowa Gambling Task. PR = Wisconsin Card Sorting Test – Perseverative Responses. Cat = Wisconsin Card Sorting Test – Number of Categories. TMT = Trail Making Test – Trial B.

Table 6. Confirmatory Factor Analysis Standardized Parameter Estimates.

Latent Factor	Observed Variable	Standardized Estimate	Standard Error	C.R.	*p*
Apathy	BDI Apathy	.762	.043	17.809	<.001
Apathy	POMS Depression-Dejection	.864	.029	30.176	<.001
Apathy	POMS Vigor-Activation	.550	.056	-.985	<.001
Apathy	POMS Fatigue-Inertia	.849	.031	27.011	<.001
Executive	WCST Number of Categories	.880	.031	28.153	<.001
Executive	WCST Perseverative Responses	.802	.033	24.102	<.001
Executive	TMT-B	.604	.057	10.576	<.001
Executive	Stroop Interference	.521	.065	8.052	<.001
Executive	Iowa Gambling Task	.364	.063	5.759	<.001
Disinhibition	BIS Non-Planning	.825	.035	23.455	<.001
Disinhibition	Kalichman Non-Sexual Sensation Seeking	.276	.074	3.747	<.001
Disinhibition	UPPS Urgency	.837	.039	21.506	<.001
Disinhibition	UPPS Premeditation	.730	.043	17.169	<.001
Latent Factor	**Latent Factor**	**Standardized Estimate**	**Standard Error**	**C.R.**	***p***
Executive	Apathy	.057	.079	.722	.470
Disinhibition	Apathy	.619	.058	10.642	<.001
Disinhibition	Executive	.052	.076	.683	.495

Note. WCST = Wisconsin Card Sorting Test – 64. POMS: Profile of Mood States. BDI = Beck Depression Inventory – II. TMT-B = Trail Making Test – Trial B. UPPS = Urgency, Premeditation, Perseverance, and Sensation Seeking. C.R. = Critical Ratio.

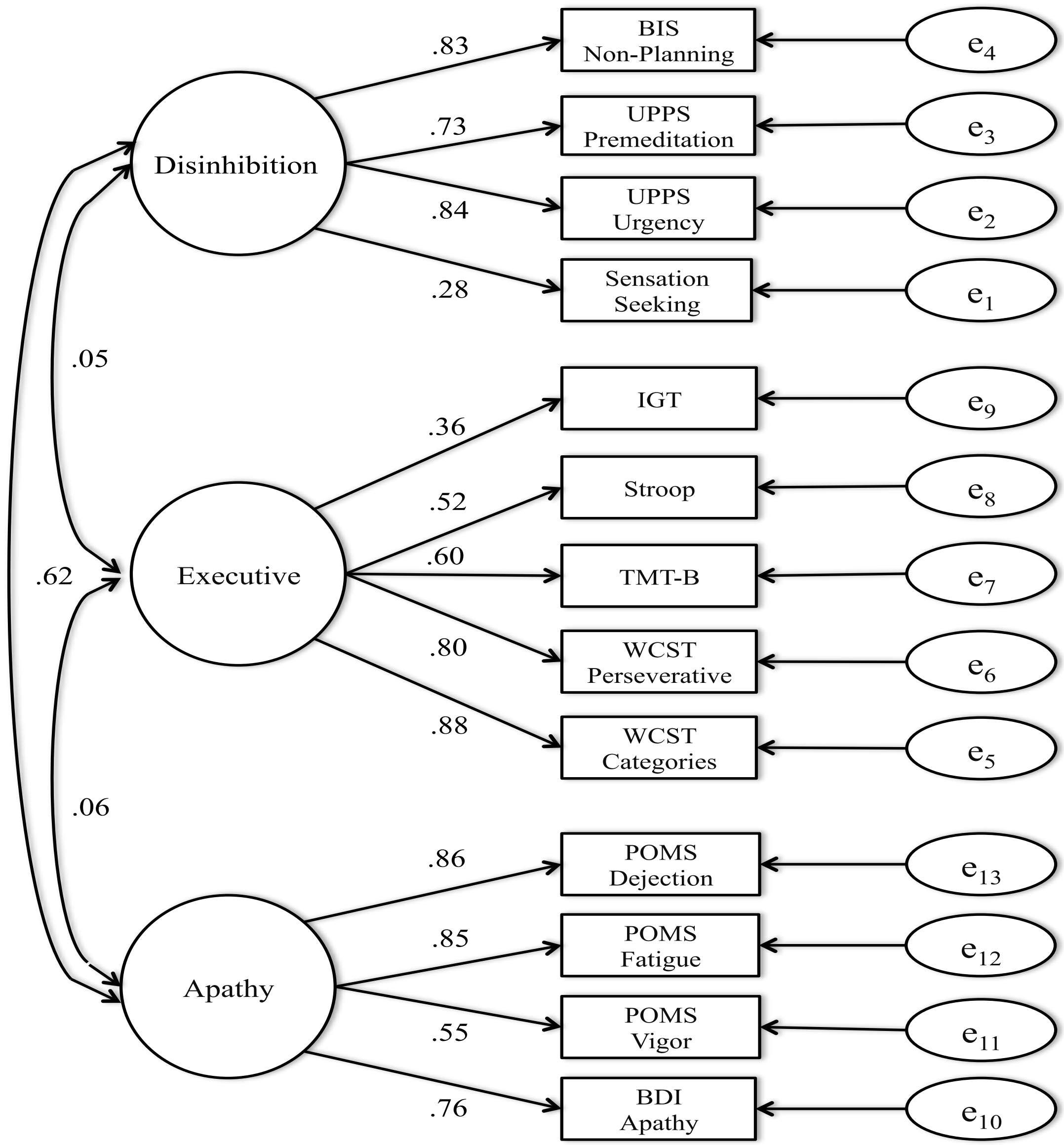

Figure 2. Confirmatory factor analysis with standardized estimates.

Note. UPPS = Urgency, Premeditation, Perseverance, and Sensation Seeking. BIS = Barratt Impulsiveness Scale. POMS = Profile of Mood States. Sensation Seeking = Kalichman Non-Sexual Sensation Seeking Scale. POMS Dejection = POMS Depression-Dejection Subscale. POMS Fatigue = POMS Fatigue-Inertia Subscale. POMS Vigor = POMS Vigor-Activation Subscale. BDI Apathy = Beck Depression Inventory-II Apathy Items. IGT = Iowa Gambling Task. Stroop = Stroop Interference. TMT-B = Trail Making Test Trial B. WCST Perseverative = Wisconsin Card Sorting Test Perseverative Responses. WCST Categories = Wisconsin Card Sorting Test Number of Categories Complete.

Primary Aims

Specific aim 1.

Table 7 shows the bivariate associations for all of the continuous study variables. Table 8 shows the bivariate associations for all dichotomous study variables. At the bivariate level, safer sexual intentions were associated with safer behaviors ($r = .34$), better inhibition ($r = .37$), less apathy ($r = .18$), being female not having ASPD, HIV, or methamphetamine dependence, and not being Caucasian ($ps < .01$). Safer behaviors were associated with less education ($r = -.14$), safer intentions ($r = .34$), being female, and not having HIV or MA dependence ($ps < .05$). Better inhibition was associated with higher education ($r = .28$), intentions ($r = .37$), apathy ($r = .43$), being female, not having ASPD, and not having MA dependence. Better executive functioning was associated with being younger ($r = -.27$), higher education ($r = .26$), not having MA dependence, and being white ($ps < .05$). Less apathy was associated with being younger ($r = -.09$), having safer intentions ($r = .18$), better inhibition ($r = .43$), and not having ASPD, HIV, MA dependence.

Table 7. Bivariate Associations Between All Continuous Study Variables.

	Apathy	Executive	Disinhibition	Behaviors	Intentions	Education	Age
Apathy	1.0	*.12	****.43	*.12	***.18	.06	***-.09
Executive	-	1.0	.03	*-.12	-.10	****.26	****-.27
Disinhibition	-	-	1.0	*.12	****.37	****.28	.18
Behaviors	-	-	-	1.0	****.34	**-.14	.05
Intentions	-	-	-	-	1.0	-.02	-.07
Education	-	-	-	-	-	1.0	***.19
Age	-	-	-	-	-	-	1.0

*$p < .10$. **$p < .05$. ***$p < .01$. ****$p < .001$.

Table 8. Bivariate Associations Between All Dichotomous Study Variables.

	Gender			ASPD		
	Male	Female	*p*	-	+	*p*
Gender (Male)	-	-	-	80%	91%	.095
Has ASPD	16%	7%	.095	-	-	-
Age	41(12)	43(16)	.393	42(13)	40(12)	.369
Education	14(2)	14(2)	.670	14(2)	12(2)	<.001
Ethnicity(%White)	57%	50%	.376	56%	60%	.583
HIV+	54%	16%	<.001	49%	36%	.184
MA+	46%	32%	.088	38%	73%	<.001
Intentions	-.12(1.0)	.51(.80)	<.001	.06(1.0)	-.35(.94)	.032
Behaviors	-.20(.95)	.86(.74)	<.001	-.01(1.0)	.10(1.0)	.550
Disinhibition	-.06(.76)	.26(.72)	.012	.08(.73)	-.49(.74)	<.001
Executive	.01(.71)	-.04(.76)	.680	.01(.73)	-.09(.66)	.473
Apathy	-.01(.58)	.05(.57)	.510	.03(.56)	-.22(.65)	.021
	HIV			MA		
	-	+	*p*	-	+	*p*
Gender (Male)	70%	94%	<.001	77%	86%	.088
Has ASPD	17%	11%	.184	93%	76%	<.001
Age	41(14)	42(12)	.444	41(15)	42(11)	.867
Education	14(2)	14(2)	.184	14(2)	13(3)	<.001
Ethnicity(%White)	56%	56%	.940	55%	57%	.698
HIV+	-	-	-	46%	48%	.842
MA+	43%	44%	.842	-	-	-
Intentions	.20(.95)	-.23(1.0)	.001	.22(.96)	-.29(.98)	<.001
Behaviors	.37(.91)	-.42(.93)	<.001	.11(.88)	-.15(1.1)	.048
Disinhibition	-.01(.82)	.00(.68)	.896	.32(.62)	-.42(.73)	<.001
Executive	.07(.67)	-.07(.77)	.135	.14(.74)	-.18(.66)	<.001
Apathy	.10(.51)	-.11(.63)	.005	.16(.46)	-.21(.64)	<.001

	Ethnicity		
	Non-Caucasian	Caucasian	*p*
Gender (Male)	79%	83%	.376
Has ASPD	13%	15%	.583
Age	38(13)	44(13)	<.001
Education	13(2)	14(2)	.136
Ethnicity(%White)	-	-	-
HIV+	47%	47%	.940
MA+	42%	44%	.698
Intentions	.32(.87)	-.25(1.0)	<.001
Behaviors	.08(.91)	-.06(1.1)	.309
Disinhibition	.08(.70)	-.07(.80)	.133
Executive	-.12(.65)	.09(.76)	.024
Apathy	.04(.59)	-.03(.56)	.313

Note. ASPD = Antisocial Personality Disorder. MA = methamphetamine.

Aim 1, hypothesis 1

Table 9 displays the results for Aim1, Hypothesis 1. At the bivariate level, intentions were significantly associated with behaviors (r = .34, p < .001). The overall regression ($F_{6,223}$ = 14.27, Adjusted R^2 = .26, p < .001) evaluating the relationship between sexual risk intentions and behaviors was significant (B = .25, t = 4.11, p < .001) when accounting for covariates (gender and education, ps <.001; ASPD, age, education, ps > .10).

Table 9. Regression Results for Aim 1, Hypothesis 1.

Variable (Reference Group)	B	Standard Error	t Ratio	F Ratio	Adjusted R^2	p
Omnibus				$F_{(6,223)}$ = 14.27	.26	<.001
Gender(Male)	.963	.150	-6.41	-	-	<.001
ASPD(No)	.246	.169	1.46	-	-	.147
Age	.005	.005	1.09	-	-	.279
Education	-.052	.025	-2.14	-	-	.033
Ethnicity(Non-white)	-.009	.121	-.07	-	-	.942
Intentions	.251	.061	4.11	-	-	<.001

Note. ASPD = Antisocial Personality Disorder. B = Unstandardized parameter. estimates.

Aim 1, hypothesis 2.

Table 10 displays the results for Aim 1, Hypothesis 2. The overall regression model accounting for disinhibition was significant ($F_{8,221}$ = 11.51, Adjusted R^2 = .27, p < .001). Disinhibition significantly moderated the relationship between intentions and behaviors (B = .17, t = 2.27, p = .024). Figure 3 displays the follow-up analysis of simple slopes in better versus worse (based on a median split) disinhibition groups. Those with better inhibitory abilities had a significant positive relationship between intentions and behaviors (p < .001) with safer intentions leading to safer behaviors, while those with worse disinhibition showed no relationship between intentions and behaviors (p = .588).

Table 10. Regression Results for Aim 1, Hypothesis 2

	B	Standard Error	t Ratio	F Ratio	Adjusted R^2	p
Variable (Reference Group)	-	-	-	$F_{8,221}$ = 11.51	.27	<.001
Gender(Male)	.936	.150	-6.23	-	-	<.001
ASPD(No)	.239	.170	1.41	-	-	.161
Age	.005	.005	1.08	-	-	.283
Education	-.053	.025	-2.12	-	-	.035
Ethnicity (Non-White)	-.013	.121	-.11	-	-	.911
Intentions	.268	.065	4.16	-	-	<.001
Disinhibition	.013	.088	.15	-	-	.878
IntentionsX Disinhibition	.166	.073	2.27	-	-	.024

Note. ASPD = Antisocial Personality Disorder. X = interaction.

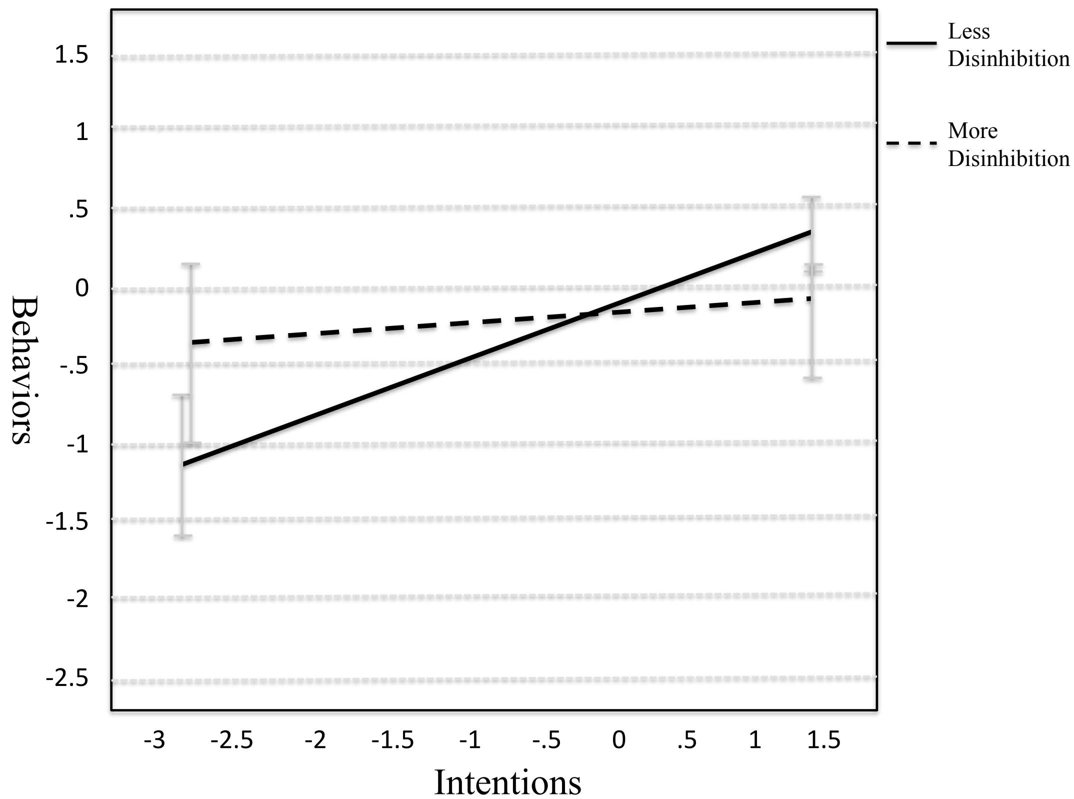

Figure 3. Aim 1, Hypothesis 2 Follow-up analysis of simple slopes.

Note. Disinhibition was dichotomized using a median split. Intentions were significantly associated with behaviors in the Less Disinhibition group ($p < .001$) but not the More Disinhibition group ($p = .588$).

Aim 1, hypothesis 3.

Table 11 displays the results for Aim1, Hypothesis 3. The overall regression model accounting for executive dysfunction was significant ($F_{8,221}$ = 10.73, Adjusted R^2 = .25, p < .001). However, executive dysfunction did not moderate the relationship between intentions and behaviors (without covariates: B = .07, t = .82, p = .411).

Table 11. Regression Results for Aim 1, Hypothesis 3.

	B	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{(8,221)}$ = 10.73	.25	<.001
Gender(Male)	.951	.152	-6.28	-	-	<.001
ASPD(No)	.240	.170	1.42	-	-	.157
Age	.005	.005	1.06	-	-	.290
Education	-.053	.026	-2.05	-	-	.042
Ethnicity(Non-White)	-.001	.124	-.01	-	-	.945
Intentions	.243	.062	3.93	-	-	<.001
Executive	-.006	.090	-.07	-	-	.945
Intentions X Executive	.069	.084	.82	-	-	.411

Note. ASPD = Antisocial Personality Disorder. X = intentions.

Aim 1, hypothesis 4.

Table 12 and Figure 4 displays the results for Aim 1, Hypothesis 4. Regression analysis with bootstrapping (samples = 5,000) was used to evaluate the hypothesis that apathy mediates the relationship between sexual intentions and behaviors (Hayes & Rockwood, in press). Using a 95% confidence interval, the null hypothesis that the indirect effect is zero was rejected (B = .054, SE = .031, CI = [.006, .130]), indicating a significant mediation effect. For descriptive purposes, the individual steps for determining paths are described herein. The first step of the mediation model indicated that, when accounting for other covariates, the total effect of apathy on behaviors (path c) trended toward significance (*B* = .199, *t* = 1.93, *p* = .055). The second step of the mediation model indicated that, when accounting for covariates, the effect of intentions on apathy (path a) was significant (*B* = .227, t = 2.08, p = .039). The third step (path b) indicated that intentions remained a significant predictor of behaviors (*B* = .238, *t* = 3.88, *p* < .001) when accounting for apathy and other covariates. The fourth step of the mediation model indicated that the direct effect (path c') of apathy on behaviors (when accounting for intentions) was still not significant (*B* = .145, *t* = 1.44, *p* = .152) when accounting for other covariates.

Table 12. Mediation Results for Aim 1, Hypothesis 4.

MODEL 1 Outcome: Intentions						
Full Model Summary						
R	***R^2***	**MSE**	***F***	**df1**	**df2**	***p***
.399	.159	.865	7.029	6	223	<.001
Variable	***B***	**Standard Error**	***t***	***p***	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
(Constant)	.436	.397	1.099	.273	-.346	1.218
Apathy (path a)	.227	.109	2.078	.039	.012	.442
Gender	.561	.159	3.529	.001	.248	.875
ASPD	-.258	.184	-1.399	.163	-.621	.105
Age	-.002	.005	-.460	.646	-.012	.008
Education	-.010	.027	-.358	.720	-.062	.043
Ethnicity	-.494	.128	-3.872	.000	-.745	-.243

MODEL 2 Outcome: Behaviors						
Full Model Summary						
R	***R^2***	**MSE**	***F***	**df1**	**df2**	***p***
.533	.284	.728	12.589	7	222	<.001
Variable	**B**	**Standard Error**	**t**	**p**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**

Table 12. Mediation Results for Aim 1, Hypothesis 4. Continued						
(Constant)	.302	.365	.827	.409	-.418	1.021
Intention (path b)	.238	.061	3.880	.000	.117	.359
Apathy (path c’)	.145	.101	1.438	.152	-.054	.345
Gender	.960	.150	6.398	.000	.664	1.255
ASPD	.277	.170	1.629	.105	-.058	.611
Age	.006	.005	1.218	.225	-.003	.015
Education	-.054	.025	-2.204	.029	-.102	-.006
Ethnicity	-.008	.121	-.066	.948	-.246	.230
MODEL 3 Outcome: Behaviors						
Full Model Summary						
R	***R^2***	**MSE**	***F***	**df1**	**df2**	***p***
.485	.236	.774	11.457	6	223	<.001
Variable	***B***	**Standard Error**	***t***	***p***	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
(Constant)	.406	.375	1.081	.281	-.334	1.145
Apathy (path c)	.199	.103	1.932	.055	-.004	.403
Gender	1.093	.151	7.266	.000	.797	1.390
ASPD	.215	.174	1.234	.219	-.128	.559
Age	.005	.005	1.066	.288	-.004	.014
Education	-.056	.025	-2.229	.027	-.106	-.007
Ethnicity	-.126	.121	-1.041	.299	-.363	.112
Indirect Effect						
Variable (reference group)	***B***	**Standard Error**	***t***	***p***	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Intentions	.054	.031	-	-	.006	.130

Note. ASDP = Antisocial Personality Disorder. c' = c prime.

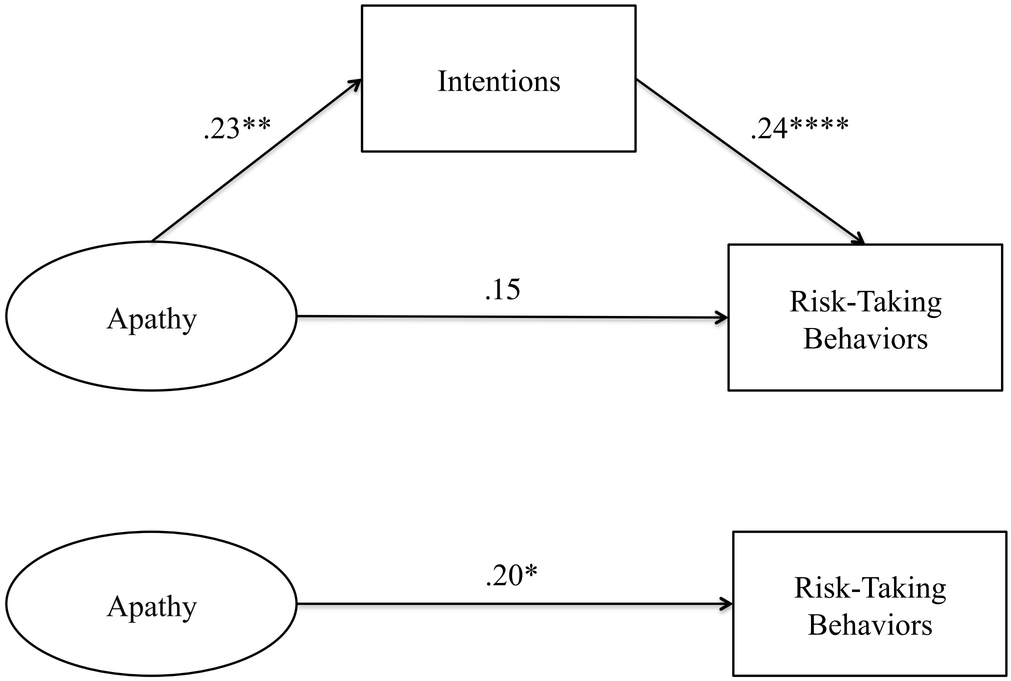

Figure 4. Aim 1, Hypothesis 4 Mediation analysis model.

Note. The top figure represents the mediated model (path a, b, and c'). The bottom figure represents the total effect of apathy (path c). *p < .10. **p < .05. ****p < .001.

Specific aim 2.

At the bivariate level, methamphetamine dependence was associated with riskier intentions and behaviors, worse disinhibition, executive dysfunction, and apathy, and higher rates of ASPD (*ps* < .05) and at the trend level, being male (p = .088). At the bivariate level, being HIV+ was associated with being male, having riskier intentions and behaviors, and having more apathy (*ps* < .01).

Aim 2, hypothesis 1.

Table 13 displays the regression analyses for Aim 2, Hypothesis 1, including the original regression and the regression repeated without non-significant higher-order (three-way) interactions. The overall regression model evaluating the moderating effect of MA and HIV on intentions was significant ($F_{8,221} = 10.86$, Adjusted $R^2 = .34$, $p < .001$). HIV did not moderate this relationship (three- and two-way interactions were not significant; $p = .123$ and $p = .915$ respectively). However, MA dependence significantly moderated the relationship between intentions and behaviors both with non-significant higher-order interactions were included in the model ($B = -.11$, $t = -2.42$, $p = .017$) and after they were removed ($B = -.28$, $t = -2.33$, $p = .021$). Figure 5 displays the follow-up analysis of simple slopes in the significant interaction. Those without MA dependence had a positive relationship between intentions and behaviors ($B = .15$, $t = 4.30$, $p < .001$) while with those with MA dependence had no relationship between intentions and behaviors ($B = -.10$, $t = -.31$, $p = .758$).

Table 13. Regression Results for Aim 2, Hypothesis 1.

Original Regression with all Higher-Order (Three-Way) Interactions						
Full Model	*B*	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{12,216}$ = 10.86	.34	<.001
Gender(Male)	.761	.148	-5.14	-	-	<.001
ASPD(No)	.171	.164	1.04	-	-	.297
Age	.008	.004	1.82	-	-	.070
Education	-.068	.025	-2.73	-	-	.007
Ethnicity (Non-White)	-.043	.115	-.37	-	-	.711
Intentions	.189	.123	2.30	-	-	.022
HIV(HIV-)	-.553	.153	-5.00	-	-	<.001
MA(MA-)	-.172	.167	-1.81	-	-	.072
HIV X MA	-.106	.234	-.45	-	-	.651
Intentions X HIV	.194	.156	.11	-	-	.915
Intentions X MA	-.107	.163	-2.42	-	-	.017
Intentions X MA X HIV	-.363	.235	-1.55	-	-	.123
Non-Significant Higher-Order Interactions Removed						
	B	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{11,217}$ = 11.55	.34	<.001
Gender(Male)	.770	.148	-5.18	-	-	<.001
ASPD(No)	.168	.164	1.02	-	-	.308
Age	.008	.004	1.78	-	-	.077
Education	-.064	.025	-2.59	-	-	.010
Ethnicity (Non-White)	-.048	.115	-.41	-	-	.679
Intentions	.283	.108	2.68	-	-	.008
HIV(HIV-)	-.513	.152	-4.74	-	-	<.001
MA(MA-)	-.131	.166	-1.42	-	-	.157
HIV X MA	-.078	.234	-.33	-	-	.740
Intentions X HIV	.038	.119	.32	-	-	.750
Intentions X MA	-.278	.120	-2.33	-	-	.021

Note. ASPD = Antisocial Personality Disorder. MA = methamphetamine X = interaction.

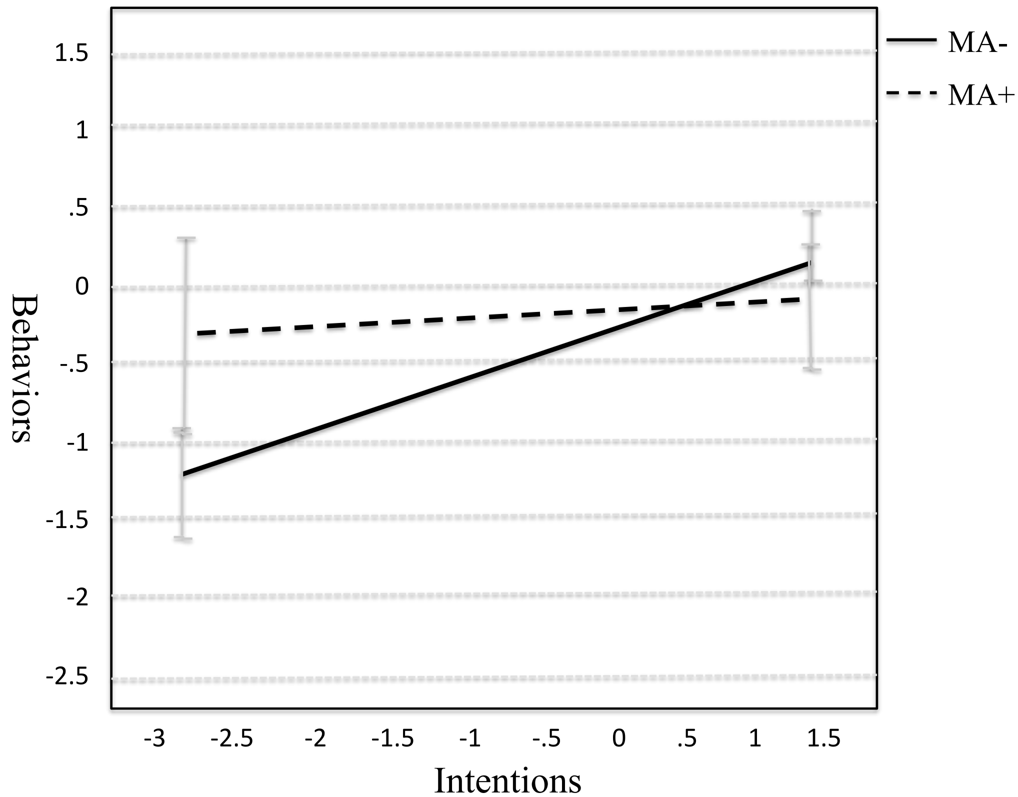

Figure 5. Aim 2, Hypothesis 1 Follow-up analysis of the interaction between methamphetamine and intentions.

Note. Intentions were significantly ($p < .001$) associated with behaviors in the MA- group but not the MA+ group ($p = .758$).

Aim 2, hypothesis 2.

Table 14 displays the regression analyses for Aim 2, Hypothesis 2, including the original regression (including all higher-order interactions two-way, three-way, and four-way), regression repeated without insignificant higher-order interactions (without four-way then without three-way interactions). The overall regression model evaluating the moderating effect of MA, HIV, and disinhibition on intentions were significant ($F_{20,208} = 6.60$, Adjusted $R^2 = .33$, $p < .001$). There were no significant four-way, three-way, or two-way interactions (*ps* > .10).

Table 14. Regression Results for Aim 2, Hypothesis 2.

Original Regression with all Higher-Order Interactions						
Full Model	*B*	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{20,208}$ = 6.60	.33	<.001
Gender(Male)	.765	.152	-5.05	-	-	<.001
ASPD(No)	.195	.169	1.15	-	-	.250
Age	.008	.005	1.68	-	-	.094
Education	-.062	.026	-2.39	-	-	.018
Ethnicity(Non-White)	-.046	.118	-.39	-	-	.697
Intentions	.092	.167	1.99	-	-	.048
HIV(HIV-)	-.563	.171	-4.60	-	-	<.001
MA(MA-)	-.179	196	-1.76	-	-	.080
Disinhibition	-.071	194	-.41	-	-	.683
HIV X MA	-.133	.267	-.50	-	-	.619
Intentions X HIV	.281	.194	.35	-	-	.730
Intentions X MA	-.067	.225	-1.09	-	-	.276
Intentions X Disinhibition	.459	.294	1.26	-	-	.208
Disinhibition X HIV	.121	.254	-.30	-	-	.765
Disinhibition X MA	.119	.253	-.31	-	-	.760
Intentions X MA X HIV	-.459	.294	-1.56	-	-	.119
Disinhibition X MA X Intentions	-.105	.281	.08	-	-	.936
Disinhibition X HIV X Intentions	-.231	.272	-.55	-	-	.581
Disinhibition X HIV X MA	-.359	.391	-.92	-	-	.361
Disinhibition X Intentions X MA X HIV	.243	.397	.61	-	-	.542
Non-Significant Four-Way Interaction Removed						
	B	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{19,209}$ = 6.95	.33	<.001
Gender(Male)	.757	.151	-5.02	-	-	<.001
ASPD(No)	.190	.169	1.13	-	-	.261
Age	.008	.005	1.68	-	-	.095
Education	-.062	.026	-2.44	-	-	.016
Ethnicity(Non-White)	-.048	.117	-.41	-	-	.681
Intentions	.130	.155	2.13	-	-	.035

Table 14. Regression Results for Aim 2, Hypothesis 2. Continued						
HIV(HIV-)	-.574	.170	-4.68	-	-	<.001
MA(MA-)	-.190	.195	-1.83	-	-	.069
Disinhibition	-.051	.191	-.48	-	-	.630
HIV X MA	-.127	.266	-.48	-	-	.634
Intentions X HIV	.243	.183	.05	-	-	.957
Intentions X MA	.053	.223	-1.27	-	-	.207
Intentions X Disinhibition	.146	.190	1.11	-	-	.269
Disinhibition X HIV	.104	.252	-.53	-	-	.596
Disinhibition X MA	.103	.251	-.53	-	-	.600
Intentions X MA X HIV	-.471	.293	-1.61	-	-	.109
Disinhibition X MA X Intentions	.016	.198	.08	-	-	.935
Disinhibition X HIV X Intentions	-.118	.198	-.59	-	-	.553
Disinhibition X HIV X MA	-.403	.384	-1.05	-	-	.295
Non-Significant Three-Way Interactions Removed						
	B	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{15,213}$ = 8.44	.33	<.001
Gender(Male)	.764	.151	-5.07	-	-	<.001
ASPD(No)	.167	.166	1.00	-	-	.317
Age	.007	.005	1.55	-	-	.122
Education	-.061	.025	-2.40	-	-	.017
Ethnicity(Non-White)	-.051	.117	-.44	-	-	.663
Intentions	.259	.115	2.70	-	-	.007
HIV(HIV-)	-.493	.160	-4.51	-	-	<.001
MA(MA-)	-.126	.191	-1.30	-	-	.196
Disinhibition	.055	.163	-.27	-	-	.787
HIV X MA	-.090	.265	-.34	-	-	.734
Intentions X HIV	.056	.125	.45	-	-	.657
Intentions X MA	-.223	.139	-1.60	-	-	.111
Intentions X Disinhibition	.052	.082	.63	-	-	.527
Disinhibition X HIV	-.082	.180	-.46	-	-	.650
Disinhibition X MA	-.079	.182	-.43	-	-	.666

Note. ASPD = Antisocial Personality Disorder. MA = methamphetamine X = interaction.

Aim 2, hypothesis 3.

Table 15 displays the regression analyses for Aim 2, Hypothesis 3, including the original regression (with all higher-order interactions two-way, three-way, and four-way), and the regression repeated without the non-significant four-way interaction. The overall regression model evaluating the moderating effect of MA, HIV, and executive functioning on intentions was significant both when the non-significant four-way interaction was ($F_{20,208}$ = 7.36, Adjusted R^2 = .36, p < .001) and was not ($F_{19,209}$ = 7.66, Adjusted R^2 = .36, p < .001) included. In both the original (B = .26, t = 2.58, p = .011) and simpler regression (B = .44, t = 2.38, p = .018), HIV moderated the effect of executive functioning on intentions. Figure 6 displays the follow-up analysis evaluating two-way interactions between intentions and executive dysfunction (better versus worse using median split) in the HIV- and HIV+ groups. For those without HIV, executive functioning did not moderate the relationship between intentions and behaviors (B = -.14, t = -1.53, p = .130). However, for those

with HIV, there was a trend level (after making Bonferroni corrections) interaction of executive functioning (B = .272, t = 2.15, p = .034). Figure 7 displays the follow-up analysis evaluating the simple slopes for the effect of intentions on behavior for those who are HIV+ and have better versus worse executive functioning (dichotomized by a median split). Among those with better executive functioning, intentions significantly predicted behaviors (B = .26, t = 2.94, p = .005) after Bonferroni corrections. Among those with worse executive functioning, intentions was not significantly associated with behaviors (B = .03, t = 20, p = .845).

Table 15. Regression Results for Aim 2, Hypothesis 3.

Original Regression with all Higher-Order Interactions						
	B	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{20,208}$ = 7.36	.36	<.001
Gender(Male)	.810	.149	-5.43	-	-	<.001
ASPD(No)	.119	.164	.73	-	-	.468
Age	.005	.005	1.02	-	-	.308
Education	-.069	.026	-2.65	-	-	.009
Ethnicity (Non-White)	-.042	.116	-.36	-	-	.716
Intentions	.202	.125	2.13	-	-	.034
HIV(HIV-)	-.541	.160	-4.68	-	-	<.001
MA(MA-)	-.148	.178	-1.62	-	-	.107
Executive	-.057	.187	.57	-	-	.567
HIV X MA	-.124	.252	-.49	-	-	.623
Intentions X HIV	.108	.166	-.17	-	-	.862
Intentions X MA	-.111	.168	-1.92	-	-	.056
Intentions X Executive	-.157	.193	.17	-	-	.861
Executive X HIV	-.058	.225	-.99	-	-	.324
Executive X MA	.408	.266	1.53	-	-	.128
Intentions X MA X HIV	-.260	.247	-1.05	-	-	.294
Executive X MA X Intentions	-.143	.263	.43	-	-	.666
Executive X HIV X Intentions	.264	.239	2.58	-	-	.011
Executive X HIV X MA	-.245	.367	-.67	-	-	.506
Executive X Intentions X MA X HIV	.451	.381	1.18	-	-	.239
Non-Significant Four-Way Interaction Removed						
	B	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{19,209}$ = 7.66	.36	<.001
Gender(Male)	.806	.149	-5.40	-	-	<.001
ASPD(No)	.111	.164	.67	-	-	.501
Age	.005	.005	1.11	-	-	.268
Education	-.071	.026	-2.76	-	-	.006
Ethnicity (Non-White)	-.036	.116	-.31	-	-	.759

Table 15. Regression Results for Aim 2, Hypothesis 3. Continued						
Intentions	.222	.124	2.10	-	-	.037
HIV(HIV-)	-.517	.159	-4.79	-	-	<.001
MA(MA-)	-.121	.177	-1.70	-	-	.091
Executive	.001	.181	.53	-	-	.594
HIV X MA	-.197	.245	-.81	-	-	.422
Intentions X HIV	.069	.163	-.50	-	-	.620
Intentions X MA	-.115	.168	-1.95	-	-	.052
Intentions X Executive	-.272	.167	-.16	-	-	.874
Executive X HIV	-.105	.221	-1.52	-	-	.131
Executive X MA	.361	.263	1.19	-	-	.237
Intentions X MA X HIV	-.259	.247	-1.05	-	-	.296
Executive X MA X Intentions	.072	.190	.38	-	-	.705
Executive X HIV X Intentions	.443	.186	2.38	-	-	.018
Executive X HIV X MA	-.307	.364	-.84	-	-	.399

Note. ASPD = Antisocial Personality Disorder. MA = methamphetamine. X = interaction.

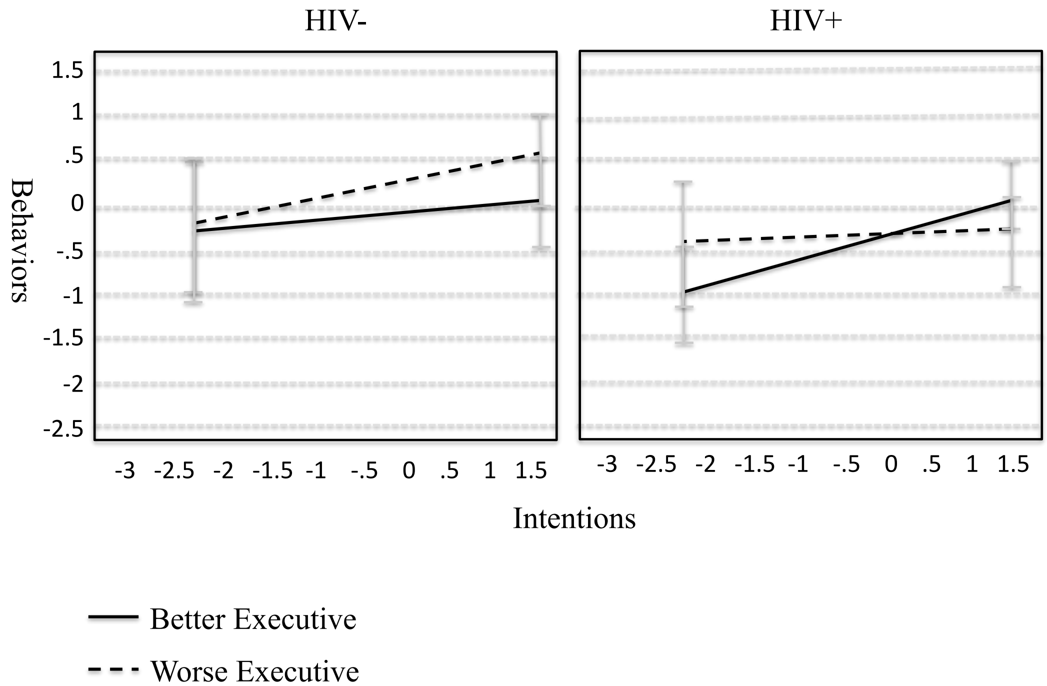

Figure 6. Aim 2, Hypothesis 3 Follow-up analysis of HIV, executive functioning, and intentions.

Note. After applying Bonferroni corrections, the interaction between executive functioning was significant at the trend-level (*p* = .034) in HIV+. This interaction was not significant in the HIV- group (*p* = .130).

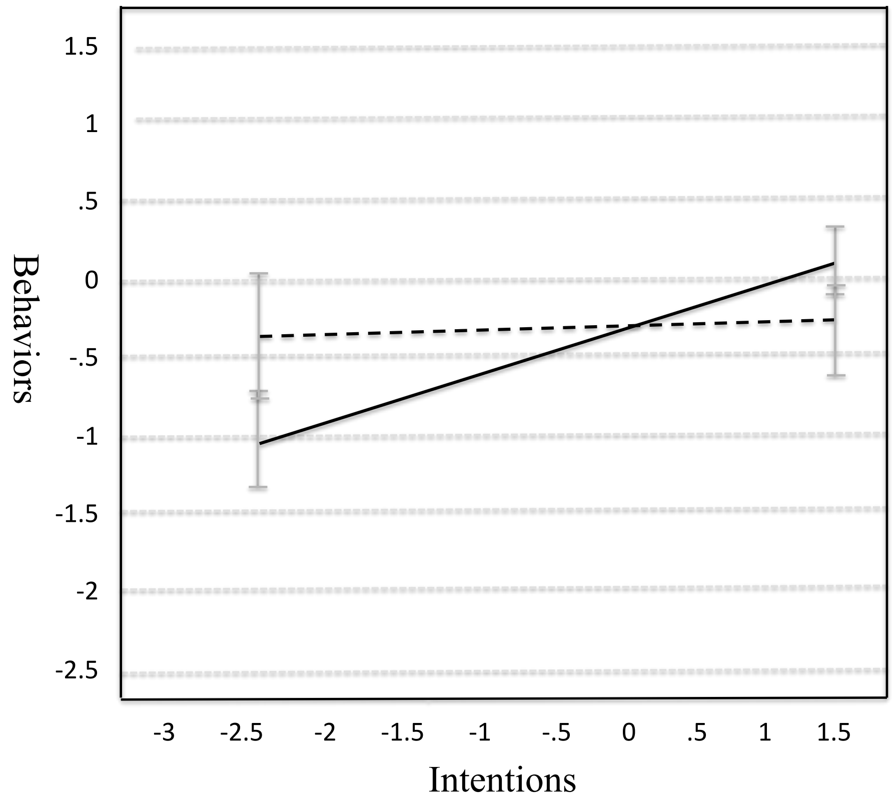

Figure 7. Aim 2, Hypothesis 3 Follow-up analysis evaluating the simple slopes for intentions in HIV+ individuals with better or worse executive functioning.

Note. The association between intentions and behaviors was not significant (p = .845) for those with worse executive dysfunction, but was significant for those with better executive functioning (p = .005), even after making Bonferroni corrections.

Aim 2, hypothesis 4.

Table 16 displays the results for Aim 2, Hypothesis 4. The linear regression evaluating the moderation of intentions and methamphetamine when accounting for apathy was significant at the trend level ($F_{12,228}$ = 9.99, Adjusted R^2 = .34, p < .001). The interaction between methamphetamine and intentions remained significant (p = .023) even after accounting for Bonferroni corrections, but the relationship between apathy and risky behaviors was not significant in this model (p = .798).

Table 16. Regression Results for Aim 2, Hypothesis 4.

Original Regression with all Higher-Order Interactions						
	B	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{13,228} =$ 9.99	.34	<.001
Gender(Male)	.754	.150	5.03	-	-	<.001
ASPD(No)	.163	.166	.98	-	-	.326
Age	.008	.004	1.80	-	-	.073
Education	-.07	.025	-2.75	-	-	.007
Ethnicity (Non-White)	-.045	.116	-.39	-	-	.697
Intentions	.190	.123	1.54	-	-	.125
HIV	-.570	.161	-3.54	-	-	<.001
MA	-.189	.176	-1.08	-	-	.283
Apathy	-.027	.074	-.37	-	-	.715
HIV X Intentions	.194	.156	1.24	-	-	.215
HIV X MA	.194	.156	1.24	-	-	.706
Intentions X MA	-.105	.163	-.65	-	-	.519
Intentions X HIV X MA	-.362	.235	-1.54	-	-	.126
Non-Significant Three-Way Interaction Removed						
	B	Standard Error	*t* Ratio	*F* Ratio	Adjusted R^2	*p*
Variable (Reference Group)	-	-	-	$F_{12,228} =$ 10.56	.33	<.001
Gender(Male)	.762	.150	5.08	-	-	<.001
ASPD(No)	.159	.166	.96	-	-	.340
Age	.008	.004	1.76	-	-	.080
Education	-.065	.025	-2.61	-	-	.010
Ethnicity (Non-White)	-.050	.116	-.43	-	-	.664
Intentions	.283	.108	2.62	-	-	.009
HIV(HIV-)	-.530	.159	-3.33	-	-	.001
MA(MA-)	-.150	.174	-.86	-	-	.391
HIV X Intentions	.038	.119	.32	-	-	.748
MA X Intentions	-.276	.120	-2.30	-	-	.023
HIV X MA	-.061	.239	-.26	-	-	.798

Note. ASPD = Antisocial Personality Disorder. MA = methamphetamine. X = interaction.

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Parts of this section will be prepared for publication. The publication will be co-authored

by doctors Igor Grant, Steven P. Woods, Erin E. Morgan, Scott Roesch, and Paul Gilbert. The author of this dissertation was/will be the primary author of this material.

DISCUSSION

Summary of Findings

The purpose of this study was to understand the role of frontal systems dysfunctions in modifying the relationship between sexual risk intentions and sexual risk behaviors and determine how these relationships differ based on methamphetamine dependence and HIV serostatus. Disinhibition, executive dysfunction, and apathy were confirmed as separable constructs represented by generally predicted measures. Multiple hypotheses within the two primary aims were confirmed and each is discussed in detail below. In short, intentions predicted behaviors, and both methamphetamine and disinhibition were each significant moderators of the relationship between intentions and behaviors when modeled separately, but these moderated effects were not significant when included in the model together (implying their effects on the intention-behavior relationship may have similar mechanisms). These moderating effects were such that if an individual was either MA+ or had difficulties with disinhibition, they were no longer able to implement their intentions (no relationship between intentions and behaviors). However, if an individual was not dependent on methamphetamine and did not have inhibitory difficulties, safer intentions resulted in safer behaviors. When evaluating higher-order moderations (three-way and four-way), the effect of executive functioning on the relationship between intentions and behavior differed based on HIV serostatus (three-way interaction). This relationship showed that for those without HIV, executive functioning was not a factor in these relationships; however, when HIV was present, better executive functioning was important for intention implementation. No four-way interactions were identified. When evaluating the mediated relationship, intentions significantly mediated the relationship between apathy and behaviors, indicating that apathy exerts its effects on risky behaviors through reducing the desire to act safely.

Composite Variables

The predicted factor structure was generally confirmed, with the three latent variables including disinhibition, executive dysfunction, and apathy. There were some minor changes to the hypothesized variable groupings. First, the FrSBe subscales did not improve the factor structure, even though the theory of the hypothesized factor structure was modeled on the underlying theory for the FrSBe subscale development. These subscales were strongly related to one another (subscale correlations ranged from *r* = .65-.80), resulting in too much correlation to aid in the discriminability of separate factors. The developers of the FrSBe acknowledge the intercorrelation of the subscale concepts due to the interconnections of the neural circuits (Grace & Malloy, 2000). However, in studies evaluating the associations of these subscales much smaller correlations were found (*r* = .22-.43; Stout, Ready, Grace, Malloy, & Paulsen, 2003). The lower subscale correlations seen by Stout and colleagues (2003) may be a factor of the sample used. Stout and colleagues evaluated the factor structure in informant reporters (e.g., family members) rather than the patient's own report. Therefore, the higher correlations seen in the present sample may be due to metacognitive deficits, or an inability to accurately evaluate and discriminate one's own deficits, an issue that tends to be problematic in individuals with MA dependence and HIV (Obermeit et al., 2016; Casaletto et al., 2015). Goverover, Chiaravalloti, and Deluca (2005) evaluated the differences of self-report versus informant report on the FrSBe and noted that participants with neurological insults typically reported more frontal systems symptoms than the informants on all three of the subscales. Additionally, it may be true that the population of this sample has experienced more diffuse neurological insults than the general population or other populations evaluated in these aforementioned studies. The sample used for the current study is typically less well educated, lower socioeconomic status, and more homelessness than the general population and therefore may have had worse health and neurological insults than others who have better access to health care, education, and nutrition. With greater insults come worse cognitive performance, which would result in more reports of symptoms across all subscales of the measure, potentially resulting in less differentiation and higher correlations between the subscales. Compared to the normative sample, our sample tended to report worse symptoms on all subscales of the FrSBe, even among those who were MA- and HIV-.

The other difference was that the IGT and Stroop Interference test were predicted to correlate more with other measures of impulsivity and sensation seeking (impulsivity composite) rather than those that measure the cognitive ability to reason, generate hypotheses, solve problems, and switch tasks/goals based on feedback (executive composite). The data evidenced that the reverse was true.

This may in part be due both to how and when these separable frontal circuits work together. The “hot” versus “cool” theory of frontal functioning describes “hot” processes as those that are mediated by affective stimuli (e.g., orbito-frontal and medial prefrontal cortex; e.g., Zelazo & Mueller, 2002; Haber, 2003) and “cool” processes, which are purely cognitive (e.g., dorsolateral circuitry; Ahn & Picard, 2005). Even though they both play a role in decision-making and impulse control, the latter are typically measured by ability in a laboratory setting where distractions, rewards, and affective stimuli are removed (e.g., Stroop, Go/No-Go, Wisconsin Card Sorting Test). Therefore, tests like the IGT may be activating the more cognitively mediated decision-making systems represented by the executive/dorsolateral circuits.

Specific Aim 1

The first aim was to evaluate the role of frontal systems dysfunctions in modifying the relationship between sexual risk intentions and sexual risk behaviors.

Aim 1, hypothesis 1.

The first hypothesis was substantiated. It was hypothesized that sexual risk intentions would account for a significant proportion of variance in sexual risk-taking behaviors. Indeed, these results were significant. At the bivariate level, intentions had a medium-large association with behaviors and accounted for 11% of the variance of sexual risk-taking. When evaluating this effect in the context of covariates, intentions remained a significant predictor (retaining a small-medium effect). This is consistent with the literature though it was a smaller effect than expected (Sheeran, 2002). The smaller effect was likely a factor of the sample. For example, being MA+ was associated with worse intentions, worse behaviors, and a weaker association between the two (r = .17 versus r = .47). Therefore, the inclusion of MA+ individuals (approximately 43% of the sample) reduced the strength of the association between intentions and behaviors. Despite this reduction, the strength of the association remained significant.

Aim 1, hypothesis 2.

The second hypothesis was substantiated. It was hypothesized that disinhibition would moderate the relationship between intentions and behavior such that those with worse disinhibition would have a weaker intention-behavior relationship. At the bivariate level, when individuals performed in the top half of inhibitory control performance, there was a large positive association (r = .51) between intentions and behaviors, but when individuals had worse disinhibition their association decreased to small (r = .16). When accounting for other covariates, a similar reduction was seen (B = .43 versus B = .05), indicating that when individuals are able to inhibit immediate impulses, their longer-term intentions are more likely to be fulfilled.

This moderating effect has been reported in other health behavior studies involving dietary behaviors (e.g., Wong & Mullan, 2009). As the literature indicates, impulsivity is indirect conflict with safe decision-making (e.g., Zucker, Heitzeg, & Nigg, 2011). DeHart and Birkimer (1997) found that one's own perceptions about the likelihood of experiencing behavioral consequences influences intentions to act and subsequent behaviors (e.g., if an individual perceives they are more likely to get diabetes, they will plan on eating less sugar and are more likely to reduce their sugar intake). Therefore, it makes sense that impulsivity, or the disregard for negative consequences, will interfere with the effect of intentions on behaviors and the ability to implement consequence-free intentions. Sensation seeking (a component of the disinhibition composite variable) also likely plays a role in modifying the intention-behavior relationship. Sensation seeking is associated with greater sexual arousal (Norris et al., 2009) and increased arousal lead to more justifications of risky behaviors (e.g., "The probability of getting a sexually transmitted disease is really low so I will probably be okay if I have sex without a condom tonight."; MacDonald, MacDonald, Zanna, & Fong, 2000). In a situation like this, despite an individual's best intentions, sensation seeking/disinhibition are likely to interfere with an individual's ability to implement safe sexual behaviors.

Aim 1, hypothesis 3.

The third hypothesis was not substantiated. It was hypothesized that executive dysfunction would moderate the relationship between intentions and behaviors such that those with worse executive dysfunction would have a weaker sexual risk-taking intention-behavior relationship. This interaction was not significant, however, this relationship was dependent on HIV and is discussed in greater detail in the context of Aim 2, Hypothesis 3.

Aim 1, hypothesis 4.

The fourth hypothesis was substantiated. It was hypothesized that the effect of apathy on behavior would be mediated by intentions, resulting in apathy having a direct effect (greater apathy leads to decreased safe sexual behaviors) and indirect effect (greater apathy leads to decreased concern about safe sexual intentions which decreases safe sexual behaviors) on sexual behaviors. Both the direct and indirect effects of apathy on behavior were significant, with the direct effect being reduced when the indirect effect was accounted for, indicating intentions mediated the relationship between apathy and behaviors. Having higher levels of apathy resulted in both reduced safe intentions and a reduction in safer behaviors. This is the first known study to directly evaluate the effect of apathy on sexual risk-taking intentions and behaviors. However, the hypothesis and findings are consistent with our general understanding of apathy. For example, we know that greater levels of apathy lead to a reduction of goal directed behaviors (e.g., everyday tasks; Zawacki et al., 2002) and it is believed that apathy leads to a decrease in both desires to act (e.g., intentions; e.g., Mulin et al., 2011; Selten, Wiersma, & van den Bosch, 2000) and completing actions (e.g., Starkstein, Petracca, Chemerinski, & Kremer, 2001; Stuss, Van Reekum, & Murphy, 2000). Therefore it makes sense that increased apathy would result in both decreased behaviors directly and to decreased safe behaviors through a reduction in intentions to behave safely.

Specific Aim 2

The purpose of the second specific aim was to evaluate whether methamphetamine dependence and HIV moderates the role that frontal systems dysfunction plays in modifying the relationship between sexual risk-taking intentions and behaviors.

Aim 2, hypothesis 1.

The first hypothesis was partially substantiated. It was hypothesized that methamphetamine dependence and HIV would moderate the relationship between intentions and behaviors, such that those with methamphetamine dependence and HIV would have the weakest relationship between intentions and behaviors than those without methamphetamine dependence or HIV. When accounting for covariates, methamphetamine dependence moderated the relationship between intentions and behaviors such that for those who were MA-, safer intentions resulted in safer behaviors, however for those with methamphetamine dependence, no relationship between intentions and behaviors was found.

This is likely due to the changes in impulsive behavior associated with both acute and chronic methamphetamine use (e.g., Cocores, Miller, Pottash, & Gold, 1988; Voon et al., 2015). For example, methamphetamine use is associated with more risky behavior during use (Halkitis, Parsons, & Stirratt, 2001), with up to 85% of MA+ participants reporting methamphetamine use and sex “often” or “always” co-occur and often include “compulsive” and disinhibited behaviors (Reback, Larkins, & Shoptaw, 2004). In one study by Reback, Larkins, and Shoptaw (2004), participants explained their anecdotal experience with methamphetamine and how it affected their sexual desire. One participant described their experience qualitatively as “I don’t dance. I don’t clean my apartment. I don’t get chatty. I’m just required to have sex.” while another described it as being “programmed” to have sex, without thought (Reback et al., 2004). It is these anecdotal experiences of impulsive, and even compulsive reactions to methamphetamine that may be driving the moderated relationship between intentions and behaviors. If an individual initially thoughtfully planned intentions to use a condom, but then used methamphetamine, the sexually compulsory experience that methamphetamine provides likely overrides their pre-planned intentions, and results in risky behaviors regardless of their long-term desires/goals. However, when methamphetamine use is not a factor, these intentions are likely easier to implement through thoughtful, inhibited, uninterrupted planning and follow-through.

HIV did not moderate the relationship between intentions and behaviors. However, HIV had a main effect on behaviors such that those with HIV consistently participated in riskier behaviors and exhibited riskier intentions, with both HIV+ and HIV- participants generally showing a positive relationship between intentions and behaviors. This main effect may be because those with HIV may have had riskier intentions and behaviors prior to contracting HIV, which put them at greater risk for HIV in the first place. This also may, at least in part, be due to the relationship between HIV and apathy. Those with HIV tend to be more apathetic, which may result in the consistent reduction of both intentions and behaviors seen in Hypothesis 4 above.

Aim 2, hypothesis 2.

The second hypothesis was not substantiated. It was hypothesized that the role of disinhibition in moderating the relationship between sexual-risk intentions and behaviors would be stronger in MA- and HIV- individuals than for those with MA+ and/or HIV+. There were no significant four-way, three-way, or two-way interactions. However, as noted in previous hypotheses, disinhibition moderated the effect of intentions on behaviors (Aim 1, Hypothesis 2) and methamphetamine moderated the relationship between intentions and behaviors (Aim 2, Hypothesis 1) when these interactions were evaluated in a model without the effect of the other. However, when these moderation effects were included in the model together (Aim 2, Hypothesis 2; Table 14), the shared variance and/or reduction in power made it impossible to detect their moderating effects.

There is of course some variability in impulsivity among those who use methamphetamine (Semple, Zians, Grant, & Patterson, 2006; Semple, Zians, Grant, & Patterson, 2005) indicating there is not a direct 1:1 relationship between disinhibition and methamphetamine use. However, it is clear that MA dependence and disinhibition are robustly related (Table 8) and share some similar effects on behaviors (Marquine et al., 2014; Lee et al., 2009; Semple et al., 2005; Winhusen et al., 2013; Brecht, O'Brien, Von Mayrhauser, & Anglin, 2004; Churchwell, Carey, Ferrett, Stein, & Yurgelun-Todd, 2012; Ballard et al., 2015; Lyoo et al., 2015). Methamphetamine is often described as leading to impulsivity (e.g., Lee et al., 2009) and it is understood that those who are more disinhibited and seek sensation tend to use substances more. Lee and colleagues (2009) identified that MA+ individuals had fewer D_2 and D_3 striatal dopamine receptors, which likely results in an impulsive response pattern. Ersche and colleagues (2012) identified that for those who are dependent on substances, higher impulsivity were found in close relatives who had not used substances. Additionally, impulsive behaviors seen in children were associated with adult substance use at 20-year follow-up (Ayduk, Mendoza-Denton, Mischel, Downey, Peake, & Rodriguez, 2000). Methamphetamine use and impulsivity appear to be intertwined and may even have a cyclical relationship with one perpetuating the other. Because of the similar effects of both methamphetamine (leading to impulsive and sensation seeking behaviors) and impulsivity (leading to drug use and sensation seeking behaviors), it is likely that they similarly impact the relationship between intentions and behaviors, share mechanisms, and account for each others' variance when included simultaneously in the same model.

Because of the stronger effect of MA on the relationship between intentions and behaviors and because this moderation remained at the trend level when accounting for the moderating effect of disinhibition only, it is likely that there is an additional effect of MA that is not entirely captured by the effect of disinhibition. This may be because MA affects multiple frontal systems rather than just the orbitofrontal circuit.

Aim 2, hypothesis 3.

This hypothesis was partially substantiated. It was hypothesized that MA and HIV would moderate the effect of executive functions on the relationship between sexual risk intentions and behaviors (four-way interaction). There was no four-way interaction, but there was a significant three-way interaction between intentions, executive functioning, and HIV, such that for those without HIV executive functioning did not affect the relationship between intentions and behaviors. However for those with HIV, better executive functioning resulted in a positive relationship between intentions and behaviors whereas worse executive functioning resulted in intentions not predicting behaviors. As noted in Aim 1, Hypothesis 3, executive functioning did not have a main effect on behaviors or simple interaction effect on the sample overall. At the bivariate level, there was only a trend level association between executive functioning and behaviors but none between executive functioning and intentions. Therefore, the cognitive reasoning that is undertaken by the higher-level executive control system is important for the implementation of intentions and behaviors, but only in specific populations/contexts.

The importance of HIV in the effect of executive functioning on intentions and behaviors is likely the result of HIV being the direct result of sexual risk-taking. Operant theory (Skinner, 1953) indicates that we tend to seek out behaviors that maximize rewards and minimize punishment (e.g., Berridge & Robinson, 1998; Panksepp, 1998). Individuals then adapt their future behaviors based on the consequence of their past behavior (reward or punishment; Wrase et al., 2007). Obtaining a reward because of a behavior changes an individual's perception of how rewarding the behavior is (e.g., Lepper, Sagotsky, Dafoe, & Greene, 1982). Therefore, getting a consequence will also likely change the attitude toward the behavior and one's likelihood of future implementation.

In order to change future behaviors based on these consequences, an individual must 1. Identify that the consequence is the direct result of (paired with) the behavior, 2. Be able to integrate this consequence feedback information in order to update the prediction of future consequences (Vitaro, Arsenault, & Tremblay, 1999), and 3. Be able to switch goals/tasks based on these past experiences (Vitaro et al., 1999; Liddle et al., 1992; Lanser, Berger, Ellenbroek, Cools, & Zitman, 2002; Leierson & Pihl, 2007). The dorsolateral circuit/executive functioning system is important for stimulus response learning and habituation learning and reversal (Takahashi, Roesch, Stalnaker, & Schoenbaum, 2007). This circuit helps to integrate information about behaviors and consequences and problem solving in order to plan and executive a goal (e.g., Leierson & Pihl, 2007). Therefore, if the executive system is intact, an individual should be able to identify that contracting HIV (consequence) was the direct result of risky behaviors (paired with the behavior), predict that future risk taking will then likely enhance additional negative outcomes (integrate consequence feedback information), and change their behaviors in the future (e.g., switch goals/tasks based on this feedback). However, when an individual has not experienced a negative consequence (i.e., is HIV-) or does not have the cognitive ability to integrate this information about consequences, intentions and behaviors are likely not affected.

Aim 2, hypothesis 4.

The fourth hypothesis was partially substantiated. The significant moderating effect of methamphetamine remained significant when accounting for the effect of apathy and intentions on behavior. Therefore, despite the association between disinhibition and apathy, disinhibition has a unique effect on the relationship on intentions and behavior above and beyond apathy.

Limitations and Future Directions

While these findings are helpful in understanding the relationship between intentions and behaviors, there are several limitations of this study. The first limitation is inherent in the question being asked. Currently executive functioning is broadly defined with no general consensus of differentiating processes or measures between different frontal circuits. Researchers often describe executive functioning in many ways including the ability to plan, set shift, inhibit responses, abstract information, and so on. The idea of separate frontal circuits is accepted, however, identifying measures specific enough to differentiate these circuits continues to be a challenge.

Though distinct, these frontal systems circuits are interconnected and stimulation in one circuit often leads to stimulation in another. Additionally, the measures we use in the laboratory typically require multiple cognitive processes (e.g., the IGT requires estimation of risk, temporal discounting, integration of feedback from current/previous card selections, maintenance of useful strategies, and switching when strategies are not helpful) and therefore draw upon multiple circuits in the brain making it difficult to pinpoint exactly which pathway is responsible for which component of decision-making. The field would benefit from a more widely accepted, well-defined definition of these differentiated pathway functions (behavioral and cognitive differentiators) and a better understanding of how they work together.

Relatedly, performance-based and self-report measures were not evenly distributed across all three factors. This may be due to the “hot” versus “cold” executive functioning theory as described above, but because two of the factors included only self-report measures, if metacognitive deficits exist, they are likely to disproportionately affect 2/3 of the composite variables. It would be helpful in future studies to identify measures, both self-report and performance-based, which hold together in these three separate representative factors (e.g., Meda et al., 2009).

Another limitation in this study is that the HIV-/MA- subsample was recruited with the intention of serving as a comparison group. Determining these interaction effects across groups that include a control group more representative of the general population may be beneficial for generalizability.

Additionally, the Risk Assessment Battery has not been validated in HIV+ versus HIV- populations. It may be true that behaviors that represent risk taking in HIV- individuals are different than in HIV+ individuals (e.g., having sex with someone who is HIV+ likely more risky for someone without HIV than for someone with HIV); therefore the scoring process of the risk assessment battery may benefit from a higher level of scrutiny. Future work would benefit from confirming the psychometric properties of the RAB and expanding the psychometric evaluation to different populations.

Finally, models with interactions require much larger sample size to detect an effect, especially when higher-order interactions are included such as three-way and four-way interactions (Heo & Leon, 2010). It is possible that there was not enough power in this sample to detect all possible effects and that if the sample were larger more hypotheses would have been substantiated. For example, the interaction between HIV, MA, and intentions were not significant (p = .109). But when looking at MA- and MA+ groups separately, the interaction between HIV and intentions were significant in MA- and was not significant in MA+ population. Despite these limitations, multiple interactions, including a three-way interaction, *were* significant. Despite these limitations, the results from this study are important in beginning to understand the relationship between intentions and behaviors and the frontal systems that may interfere with successful intention implementation.

This study was a cross-sectional, quantitative study evaluating the effect of frontal systems, MA and HIV on the relationship between intentions and behaviors. This study presents complex findings that include significant three-way interactions. While conclusions were drawn from substantiated theories in the literature, it would be helpful to better understand the causality of these factors (e.g., Does obtaining HIV change the relationship between intentions and behaviors longitudinally?) and to better understand the mechanism of change. In addition to longitudinal analysis, qualitative analysis to understand the meaning of sexual risk and the reasons for practicing safe sex before and after HIV would help to better understand why executive functioning plays a different moderating role in HIV+ and HIV- individuals.

Implications

These findings emphasize the importance of factors outside of motivation alone and indicate that simply enhancing motivation is not enough for intervening on a patient's behavior. First, despite an individual's best intentions, or their stated goals in treatment, if they are using methamphetamine, they may be unable to follow-through on intended plans. In this situation it may be better to initially intervene on substance use before implementing safe sexual behavior interventions for maximum effectiveness. Disinhibition also emerged as a significant predictor of intention-behavior discrepancy. Another target for intervention is disentangling the need for action in the moment for those who have disinhibition deficits. For example, daily pre-exposure prophylaxis (PrEP) medication can be used to reduce some of the risk associated with unprotected sex. By taking a medication daily, it allows for an individual to maintain their safe intentions while not having to rely on their inhibitory ability to make safe choices in the moment. For those who have already contracted HIV, it may be important to emphasize the pairing of risky behaviors and consequences for those who have poor executive functioning and are unable to integrate this information on their own in order to make behavioral change. Those with HIV are a particularly desirable population to target because risky sex is especially dangerous for transmission. Taken together, substance use, HIV, and frontal systems appear to be important targets for interventions to enhance one's ability to turn safe sexual intentions into intention-congruent behaviors.

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