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Risky Sexual Behavior and the Role of Decision-making

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FLORIDA INTERNATIONAL UNIVERSITY

Miami, Florida

RISKY SEXUAL BEHAVIOR AND THE ROLE OF DECISION-MAKING

A dissertation submitted in partial fulfillment of the

requirements for the degree of

DOCTOR OF PHILOSOPHY

in

PSYCHOLOGY

by

Jessica Megan Ross

2017

To: Dean Michael R. Heithaus
College of Arts, Sciences and Education

This dissertation, written by Jessica Megan Ross, and entitled Risky Sexual Behavior and the Role of Decision-making, having been approved in respect to style and intellectual content, is referred to you for judgment.

We have read this dissertation and recommend that it be approved.

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Florida International University, 2017

DEDICATION

I dedicate this dissertation thesis to my family and fiancé. My parents have supported me throughout my education and have always encouraged me to pursue a career that makes me happy. They always reminded me of a famous quote attributed to Confucius, choose a job you love, and you will never work a day in your life.

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I would also like to thank all of the Substance Use and HIV Neuropsychology Lab members for their help and especially Karen Granja for her help in data collection and scoring.

ABSTRACT OF THE DISSERTATION
RISKY SEXUAL BEHAVIOR AND THE ROLE OF DECISION-MAKING

by

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Florida International University, 2016

Miami, Florida

Professor Raul Gonzalez, Major Professor

Risky sexual behavior (RSB) is the number one transmission method of HIV among adolescents. Reducing the rates of HIV among adolescents is of dire importance considering the rises in rates during the last several years. Minority adolescents are disproportionately affected by HIV, and a majority of the individuals living in Miami-Dade County (location of the proposed project) are minorities. RSB, externalizing disorders and cannabis use commonly occur together, such that both greater externalizing disorder symptoms and greater amounts of cannabis use have predicted engagement in more RSB. In addition, decision-making (a neurocognitive function) has found to be associated with cannabis use, externalizing disorders, and RSB. Little research has been conducted on these factors among adolescents. No study has evaluated externalizing disorders, cannabis use and decision-making together to determine the unique contribution of each factor to RSB among a sample of adolescents.

The current study used the infrastructure and participants of an existing project examining how decision-making abilities and memory performance are impacted by cannabis use during adolescence. Structural equation modeling and multiple linear regression were used to analyze how externalizing disorders, cannabis use, and decision-

making predict RSB. Results suggest that externalizing symptoms, cannabis use and some decision-making tasks predict RSB. Several interactions effects emerged between externalizing symptoms and decision-making tasks, cannabis use and decision-making tasks as well as externalizing symptoms and cannabis use to predict RSB. The results of the study will help future prevention and intervention efforts such that interventions can be tailored to address the areas that contribute the most to RSB among adolescents. Furthermore, cognitive skill building is one possible intervention that may be beneficial to adolescents with poorer decision-making performance.

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LIST OF ACROYNMS AND ABRREVIATIONS

Acquired Immunodeficiency Syndrome	AIDS
Attention deficit/hyperactivity disorder	ADHD
Balloon Analog Risk-Taking Task	BART
Blood oxygen level dependent	BOLD
Child Behavior Checklist	CBCL
Conduct disorder	CD
Cups Task	CT
Game of Dice Task	GDT
Human immunodeficiency virus	HIV
Inferior parietal lobe	IPL
Iowa Gambling Task	IGT
Oppositional defiant disorder	ODD
Marijuana Problems Scale	MPS
Middle frontal gyrus	MFG
Right inferior frontal gyrus	rIFG
Risky sexual behavior	RSB
Risky Sexual Behavior Questionnaire	RSBQ
Sexually transmitted infections	STI
Youth Self-Report	YSR

CHAPTER I.

INTRODUCTION TO THE RESEARCH

The program of research developed for this dissertation focuses on how neurocognitive factors and relevant psychosocial factors are associated with risky sexual behavior (RSB) among adolescents. Adolescence is an important period in development when rapid neurodevelopment is occurring, therefore, neurocognitive functioning is a crucial area of research for this age-group. Several theories, highlighting the importance of neurocognitive factors, have been developed to explain the increases in risk-taking behavior often observed during adolescence. A majority of the theories about increases in risk-taking behavior (including RSB) among adolescences suggest that the uneven development between the prefrontal cortical structures (i.e., executive functioning) and the limbic system (i.e., reward systems) results in increases in risk-taking behavior. The current study has two sections that focus on the psychosocial and neurocognitive factors that predict RBS. First, a review paper is presented, published in the Journal of International Neuropsychological Society, that focuses on the neurocognitive factors associated with RSB among adolescents, young adults and adults. Second, an original manuscript that examines how the main and interaction effects of externalizing disorders, cannabis use and decision-making are associated with RSB among a sample of adolescents.

CHAPTER II.

THE NEUROPSYCHOLOGY OF RISKY SEXUAL BEHAVIOR

J. Megan Ross, Jacqueline Duperrouzel, Melanie Vega, & Raul Gonzalez,

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Abstract

Objective: Engagement in risky sexual behavior (RSB) is a significant public health concern. A growing body of literature is elucidating the role of brain systems and neuropsychological constructs implicated in RSB, which may pave the way for novel insights and prevention efforts. **Methods:** In this article, we review studies incorporating neuropsychology into the study of RSB across the lifespan. The review of the literature on the neuropsychology of RSB is separated into three different sections by age of participants. Background is presented on research associating RSB with neurocognitive processes and the brain systems involved. Given the overlap between RSBs and substance use, studies addressing these problems in tandem are also discussed. **Results:** Neurocognitive constructs are implicated in RSB, including impulsivity, decision-making, and working memory. **Discussion:** Thus far, evidence suggest that neuropsychological factors are associated with engagement in RSB. More research on the influence of neuropsychological factors on engagement in RSB is necessary and may help inform future prevention efforts.

Keywords: risky sexual behavior, risk-taking, neuropsychology, substance use, adolescents, neurodevelopment

Introduction

Engagement in risky sexual behavior (RSB) is a significant public health concern. Negative consequences as a result of RSB include sexually transmitted infections (STIs) and unplanned pregnancies. Adolescents and young adults often fail to consistently use any type of protection against pregnancy or STIs (Kann et al., 2014; Leichliter, Chandra, Liddon, Fenton, & Aral, 2007; Satterwhite et al., 2013). Although recent national trends suggest an increase in condom use over the last several decades (Kann et al., 2014), this population accounts for over half of the STIs in the United States (Satterwhite et al., 2013). Several research studies have established that there is an association between substance use and RSB (Bellis et al., 2008; Copper, 2002), specifically substance use is associated with a greater number of sexual partners, less consistent condom use, and more STIs (Santelli, Brener, Lowry & Zabin, 1998; Tapert, Aarons, Sedlar, & Brown, 2001). RSB is also a vector for transmission of HIV, which causes a negative impact on the physical health of infected individuals.

Studies focusing on how neurocognitive functioning influences risky behaviors (including RSB) present a promising new area of inquiry and growth. Indeed, we think there is a role for neuropsychology to expand our knowledge on the determinants of RSB, which may help increase our understanding of contributing factors and provide additional clues for more effective prevention and intervention efforts. Although the role of brain structure, function, and neurocognitive abilities in RSB remains poorly understood, significant progress has been made in recent years. As such, we think it timely to present a review of this work. The goal of this review are twofold. First, we briefly describe literature examining brain systems and neurocognitive functions relevant to RSB

focusing on executive function, as well as structural and functional neuroimaging studies. Secondly, and more importantly, we review and summarize the current literature on neuropsychological functioning and RSB.

Brain Systems and Functions Relevant to Risky Sexual Behavior

An exhaustive review of all the brain regions relevant to a behavior as complex as “sexual behavior” is beyond the scope of this paper. However, here we briefly review some important brain systems and neurocognitive functions relevant to RSB, which include executive functioning, functional and structural neuroimaging studies and neurodevelopment.

Executive Functions

The prefrontal-subcortical circuits innervating dorsolateral prefrontal, orbitofrontal, and anterior cingulate cortex are important for sexual behavior (Spinella, 2007) as well as executive functioning (Alvarez & Emory, 2006; Masterman & Cummings, 1997; Stuss & Levine, 2002; Tekin & Cummings, 2002). Executive functions are the complex cognitive processes involved in goal-oriented, autonomous behavior (Elliott, 2003) as well as inhibiting responses. As presented by Spinella (2007), human lesion and animal studies have shown that the orbitofrontal cortex, medial prefrontal cortex (including the anterior cingulate), striatum, nucleus accumbens, and the thalamus are likely implicated in RSB. Lesions to the orbitofrontal cortex (specifically ventromedial orbitofrontal cortex) and the thalamus can result in sexual disinhibition (Malloy, Bihle, Duffy, & Cimino, 1993; Starkstein & Robinson, 1997). As discussed in Spinella (2007), reward, punishment, initiation, and motivation – all processes relevant to sexual behavior – are influenced by functioning of orbitofrontal cortex, medial prefrontal

cortex, striatum, nucleus accumbens and thalamus. As such, disruptions of these regions have been found to be associated with either decreases or increases in sexual behavior.

Functional Neuroimaging Studies and RSB among Youth

Functional neuroimaging (fMRI; PET) techniques have been utilized with impulse control paradigms to specifically assess the association between neural response and RSB among adolescents. Response inhibition among sexually active youth was assessed with a Go/No-Go task by Feldstein Ewing, Houck, and Bryan (2015) and heightened blood oxygenation level dependent (BOLD) response was found within the middle frontal gyrus (MFG), inferior parietal lobules (IPL), and insula to correlate with risk-taking behaviors (substance use; risky sex). Independently, hyperactivation observed in the right inferior frontal gyrus (rIFG) was positively correlated with recent RSB. In contrast, a previously conducted study assessed neural responses in sexually active youth reporting varying levels of risky contraceptive use within an inhibition Go/No-Go paradigm (Goldenberg, Telzer, Lieberman, Fuligni, & Galván, 2013). Within this sample, RSB (minimal contraceptive use) was associated with hypoactivation in the insula and right inferior frontal gyrus (rIFG) suggesting that frontal regions implicated in impulse control and emotion regulation were under employed in individuals who engage in more RSB. These mixed results indicate that despite relevance of IFG recruitment in risky sex decision-making, determining directionality and conclusions based on various levels of activation continues to be a challenge.

Feldstein Ewing and colleagues (2016) recently proposed a unique neural network for adolescent sexual decision-making in a systematic review of extant functional neuroimaging studies on adolescent sexual riskiness (N=7). The authors suggest that

adolescent sexual decision-making includes activation in the ventral tegmental area, striatum, prefrontal cortex, limbic system, and insula and anterior cingulate cortex. Compared with other types of adolescent risk-taking, signaling between the mesocorticolimbic, emotion- regulation (VTA, striatum, insula), prefrontal cortex, and gonadal and stress hormone centers may facilitate increased RSB in adolescents. Studies employing functional neuroimaging techniques suggest that brain regions associated with impulse control, emotion regulation, and reward are implicated in RSB. However, the mixed findings (i.e., hypoactivation and hyperactivation within the right inferior frontal gyrus correlating with RSB) also demonstrate the need for more research on the neural substrates of RSB and the importance of reviewing the literature on the neuropsychology of RSB.

Search Strategy for Review of Literature on Neuropsychological Functioning and RSB

In this paper, we set out to review literature examining relationships between neuropsychological functioning and RSB. We conducted a literature review that focused solely on studies examining the association between neuropsychological functioning and RSB. RSB is defined, for the purposes of this study, as any sexual behavior that increases an individual's risk for STIs or unwanted pregnancies. Broad definitions of RSB were included in this review because we wanted to be as inclusive as possible. Studies included in the review had varying definitions of RSB including not using a condom or other form of protection, younger age of sex initiation, and greater numbers of regular and casual sexual partners. Our literature review was limited to studies conducted prior to August 2015 via Google Scholar and PubMed. Search terms were "risky sexual

behavior” and “neurocognition” or “neuropsychology” and abstracts were reviewed to identify papers relating neuropsychological function and RSB. Lastly, we reviewed the reference sections of articles that met our inclusion criteria (located during the first literature review) to determine if any articles cited met our inclusion criteria. Inclusion criteria were: 1) English language, 2) peer-reviewed, 3) published before August 2015, 4) examined relationships between neuropsychological tests and RSB (i.e., number of partners, condom use, age of initiation), and 6) human participants. This manuscript did not require Institutional Review Board approval and this research was conducted in accordance with the Helsinki Declaration.

Review of Literature on Neuropsychological Functioning and RSB

The sections below summarize the studies identified by our search, which are grouped by the age of the participant sample (i.e., adolescents, young adults, and adults). For the purposes of this review, we define adolescence as ages 12 to 18 and young adulthood as ages 18 to 25. Adolescence has been defined as beginning at puberty and ending when the individual takes on adult responsibilities, however there are varying definitions of what constitutes the age of adolescence (Dahl, 2004; Spear, 2000). Most definitions suggest that it spans in age from 10 to 25 (Dahl, 2004). The final section reviews studies that contain adult participant samples (ages 26 and older). However, it is important to note that there are no studies that evaluate the association of neuropsychological functioning and RSB in a normative sample of adults. Table 1 summarizes these studies.

Adolescents

The Balloon Analogue Risk Task (BART) is a commonly used measure of risk-taking that has been employed across numerous studies (Lejuez et al., 2007; Lejuez, Read, Kahler, Richards, Ramsey, Stuart, Strong, & Brown, 2002). The BART is a computerized measure that evaluates propensity for risk-taking by presenting the participant with a situation where they can take increased risk for potential rewards, which is offset by increased risk to lose accumulated rewards on a given trial. Among a sample of high school students, poorer BART performance (i.e., more risk-taking) was associated with a greater frequency of sex without a condom (Lejuez et al., 2007). Another study employing the BART, reported that among 96 male and female black high school students, childhood physical, emotional and sexual abuse was related to sexual intercourse without a condom and the relationship was mediated by BART performance and sensation-seeking (Bornoalova, Gwadz, Kahler, Aklin & Lejuez, 2008). However, one study found that condom use was not related to performance on the BART among a sample of 51 male and female black high school students. Of note, other measures of risk behavior have also been related to performance on the BART, including substance use, stealing, and gambling (Aklin, Lejuez, Zvolensky, Kahler, & Gwadz, 2005), suggesting that poor performance on this task is may not specific to RSBs.

A notable study conducted by Khurana and colleagues (2012) examined whether several aspects of executive function, including working memory, and impulsivity, were related to age of sexual debut among 350 adolescents. Khurana and colleagues (2012) found that poorer working memory predicted younger age of sex initiation, but the relationship was entirely mediated by greater impulsivity (i.e. temporal discounting and “acting without thinking”). However, sensation seeking did not predict a younger age of

sex initiation. Importantly, the complex nature of RSB and the importance of socio-cultural factors, which are not covered in this review, are highlighted by the finding that low socioeconomic background also predicted age of sex initiation and the effect of low SES on age of sexual debut was partially mediated by temporal discounting and working memory, with each accounting for 53% and 47% of variance in the model, respectively. Khurana and colleagues (2015) conducted a follow-up study with the same participant sample and found that poorer working memory predicted a younger age of sexual initiation and more unprotected sex, even after controlling for parental influences in the analysis. These findings suggest that some neurocognitive abilities may continue to account for RSB even when controlling for relevant psychosocial factors.

Young Adults

Similar to studies among adolescents, the BART has also been commonly used in studies with young adults. Results of studies employing the BART among young adults have reported that BART performance is associated with sex without a condom (Derefinko et al., 2014; Lejuez et al., 2007, Schuster, Crane, Mermelstein, & Gonzalez, 2012). More specifically, one study evaluated the association between BART performance and different indices of RSB (other than sex without a condom), which were total number of sexual partners and total number of sexual partners who the individual had known for less than 24 hours among 135 male undergraduate students. BART performance was a better predictor of number of sexual partners and causal sexual partners compared to the other behavior traits and characteristics evaluated, including skin conductance reactivity and self-report personality measures. However, in the same

study, Go/No-go task performance (i.e., measure of response inhibition) was not associated with RSB (Derefinko et al., 2014).

In addition to using the BART, Schuster and colleagues (2012) also included the Iowa Gambling Task (IGT), and reported that more risk-taking and poorer decision-making was associated with more RSB among late adolescent and young adult participants who used cannabis. The IGT is a measure of decision-making under conditions of ambiguous risk and individuals with lesions to the ventromedial prefrontal cortex as well as individuals with drug addiction often perform poorly on this task. Furthermore, the interaction between greater amounts of recent cannabis use and poorer IGT performance was associated with more overall RSB, while the interaction between greater amounts of recent cannabis use and poorer BART performance was associated with more negative consequences from RSB (e.g., STIs and unplanned pregnancies). Among the same sample of young adult cannabis users, Ross, Cox, Schuster, Rojas and Gonzalez (2015) found that conduct disorder symptoms were related to number of oral sex partners and age of vaginal sex initiation. Furthermore, this relationship was moderated by decision-making performance (on the IGT) and amount of lifetime cannabis use. At high levels of cannabis use, more conduct disorder symptoms were associated with more oral sex partners when decision-making was poor and less oral sex partners when decision-making was better.

Adults

Unlike most studies conducted with adolescents and young adults, studies evaluating RSB in adult samples have typically focused on substance users. It has been well established that alcohol and drug use are associated with engagement in RSB (Bellis

et al., 2008; Brodbeck, Matter, & Moggi, 2006; Cooper, 2002; Santelli, Brener, Lowry, Bhatt, & Zabin, 1998; Tapert, Aarons, Sedlar, & Brown, 2001). However, the role of neurocognition in the relationship between substance use and RSB is not well understood. There are several ways by which neurocognition may interact with substance use and RSB. First, individuals may be more likely to engage in RSB when intoxicated as the effects of many substances of abuse can impair judgment, thus increasing the likelihood of engaging in risk behaviors. Secondly, as substance use, per se, is often viewed as a risky behavior, it is likely that common underlying factors may contribute to both substance abuse and RSB (e.g., conduct disorder and impulsivity; Giancola & Tarter, 1999; Tarter, 2002; Tarter, Kirisci, Habeych, Reynolds, & Vanyukov, 2004). Finally, to the extent that neurocognitive functions influence RSB, it is also possible that adverse effects of substances of abuse on executive functions may make some individuals more likely to engage in RSB. Of these, it is the latter which has received the least attention in the scientific literature.

To date, several studies have employed laboratory tasks to examine how neurocognition might influence the relationship between alcohol and/or drug use and RSB. Golub, Starks, Kowalczyk, Thompson and Parsons (2012) found that performance on tasks of executive functions (IGT, Wisconsin Card Sorting Task, Counting Span and Go/No-go Task) predicted engagement in RSB in a sample of 104 homosexual and substance-using adult men. Participants were divided into three groups based on executive function performance: high performing on all measures of executive function ($n = 26$), low performing on all measures of executive function ($n = 52$), and a group with low IGT performance but high performance on all other measures of executive function

($n = 22$). The low performing group had a significantly higher number of total sex acts compared to the other groups. Compared to the low IGT performance group, the low performing group had higher numbers of high-risk sex acts and high-risk sex acts under the influence of drugs. In addition, the low performing group had an association between the number of drug use days and increased high risk sex acts. Lastly, differences between the groups also emerged for sober sex acts; the high performing group had the least percentage of sober high-risk sex acts.

Others have also examined the influence of executive functions on RSB among substance users, and have revealed additional psychosocial and neurocognitive variables relevant to RSB. In a sample of 76 adults who resided in a substance abuse treatment center, impulsivity, self-esteem, and risk-taking were independently related to RSB, with risk-taking evaluated by the BART (Lejuez, Simmons, Aklin, Daughters, & Dvir, 2004). Among a sample of adult drug offenders, response inhibition, measured by the Go/No-go task, moderated the relationship between problems related to drug use and RSB, such that the relationship between problematic drug use and less condom use as strongest for individuals with poorer inhibitory control (Nydegger, Ames, Stacy, & Grenard, 2014; Nydegger, Keeler, Hood, Siegel, & Stacy, 2013).

Two additional studies on neurocognition and RSB in the context of substance use disorders have also included subsets of participants who are HIV seropositive (HIV+). Gonzalez and colleagues (2005) found that positive HIV serostatus, sensation seeking, and decision-making performance (assessed via the IGT) were associated with RSB. However the relationship was not straightforward. Rather, decision-making performance and HIV serostatus moderated the relationship between sensation seeking and risky sex.

Specifically, individuals who were HIV+ and had better decision-making abilities had a significant relationship between sensation seeking and RSB; however this relationship was not present among those who performed more poorly on the decision-making task or among HIV- individuals. Wardle, Gonzalez, Bechara and Martin-Thormeyer (2010) also examined the influence of emotional distress (i.e., symptoms of depression and anxiety) in conjunction with decision-making among a sample of HIV+ and substance dependent individuals. Greater emotional distress was associated with greater sexual risk-taking, but only among those who performed better on decision-making tasks (also measured via the IGT). In these studies, the emergence of significant relationships between sensation-seeking or emotional distress and RSB only among those with more intact decision-making was speculated to be at least partially explained by the somatic marker hypothesis (Damasio, Everitt, & Bishop, 1996), which posits that the orbitofrontal cortex is essential for incorporating information from somatic states into cognitive processes. Thus, for emotional distress or sensation seeking to influence RSB an individual would need to have intact brain systems relevant for decision-making.

Summary

In summary, across most studies assessing the association of neuropsychological performance with RSB, poorer executive functioning was found to be associated with RSB, either directly or indirectly. More specifically, studies with adolescent participant samples suggest that working memory (Khvarana et al., 2012, 2015) and risk-taking propensity (Bornovola et al., 2008; Lejuez et al., 2007) may contribute to RSB. Studies with young adult participant samples report that greater risk-taking propensity (Derefinko et al., 2014; Lejuez et al., 2002; Schuster et al., 2012) and poorer decision-making

performance (Ross et al., 2014; Schuster et al., 2012) is associated with RSB. Similar to findings among adolescents and young adults, various indices of executive functioning are associated with more RSB among adults. Specifically, response inhibition (Golub et al., 2012; Nydegger et al., 2014), working memory (Golub et al., 2012), decision-making (Golub et al., 2012) and risk-taking propensity (Lejuez et al., 2004) are associated with more RSB among adults. Although similar factors seem to influence RSB across studies, it is important to note that to our knowledge, there are no studies that evaluate the association of neurocognition and RSB among a sample of non-substance using adults. Many questions remain to be answered, including whether individuals who use substances are more likely to engage in RSB because of an underlying propensity to make risky decisions, or whether the acute effects of alcohol and drugs reduces inhibitions or the long term effects of continued use reduce neurocognitive abilities. Future studies that address such questions may shed further light on the relationship between substance use and RSB.

Conclusions and Future Directions

In this review, we argue that the study of neurocognition is relevant to our understanding of RSB. The recent, but growing body of literature we presented highlights neurocognitive constructs and underlying neural systems implicated in RSB. Executive functions, including constructs such as decision-making and risk-taking, appear to play an important role in RSB.

Given the focus of the reviewed studies on measures of executive functioning and their association with RSB, it is worth considering these findings in the context of the dual systems theory of risk-taking, which highlights the importance of the development

of the cognitive control system (i.e., executive functioning) in influencing risk-taking behavior among adolescents (Steinberg, 2007, 2010). This theory focuses on the interplay between the cognitive control system with the drive and motivation system. Uneven development between the ‘cognitive control system’ (which develops later) and the ‘socioemotional system’ (which develops earlier) are theorized as the reason that increases in risk-taking behavior is often observed during adolescence (Steinberg, 2007, 2010). Taken together, the current literature supports that poorer executive functioning may lead to more RSB, which only partially supports the dual systems model. Drive and motivation, or the socioemotional system, has received far less attention in neuropsychological research on RSB.

However, there have been several criticisms to the dual systems theory of adolescent risk-taking which are relevant to this review. Specifically, these include evidence that suggests risk-taking actually peaks in young adulthood and may continue well beyond (Willoughby, Good, Adachi, Hamza, & Tavernier, 2013), findings inconsistent with poor executive functions being invariably associated with greater risk taking (Pfeifer & Allen, 2012), and the absence of considering the role of important psychosocial factors like early persistent life stressors (Romer, 2010). Willoughby and colleagues (2013) emphasize the importance of a lifespan perspective on risky behaviors due to epidemiological studies suggesting that risk-taking behaviors begin during adolescence and peak in young adulthood (e.g., binge drinking) and, at times, may continue into adulthood (e.g., RSB). Several studies have been found to be inconsistent with the dual systems theory. For example, in a sample of adolescents, greater white matter integrity in the frontal subcortical regions is associated with more risk taking

behavior (i.e., substance use, delinquency) compared to those with lower white matter integrity. Adolescents with greater white matter integrity in frontal subcortical structures more closely resemble adult frontal subcortical structures (Berns, Moore, & Capra, 2009; Squeglia, Jacobus, Brumback, Meloy, & Tapert, 2014). It is not surprising that any single and circumscribed theory for a complex and heterogeneous set of behaviors such as risk-taking or RSB may be overly simplistic.

We note that although this paper focuses on the neuropsychology of RSB, this is not meant to deemphasize the importance of established environmental and individual characteristics reported to be associated with engagement in RSB. RSB is incredibly complex such that it is likely that environmental, psychosocial and neurocognitive factors influence each other and RSB. These include parenting style (Biglan et al., 1990), cultural factors (Kann et al., 2014), and religiosity (Rostosky, Wilcox, Wright, & Randall, 2004), which have been discussed in several excellent reviews (Buhi & Goodson, 2007; Kotchick, Shaffer, Miller, & Forehand, 2001; Miller & Moore, 1990).

Another complexity in the study of the neuropsychology of RSB, is a fundamental limitation in the research of brain-behavior relationships. When neuropsychological measures are associated with behaviors, the behavior is, many times, not measured at the same time as the neuropsychological task. Unfortunately, it is difficult, particularly with a behavior like RSB, to measure neuropsychological functioning concurrently with the behavior.

Examining the role of neurocognitive factors and the brain systems involved in RSB not only elucidates why adolescents and young adults engage in greater amounts of RSB compared to other ages, but may also reveal avenues for successful intervention and

prevention programs aimed at reducing RSB. The findings from this review suggest that improving executive functioning in adolescence as well as adults is one possible new route of intervention. For example, a pilot study implementing Goal Management Training and Mindfulness in combination has successfully improved executive functions (e.g., decision-making assessed by the IGT) in a sample of abstinent drug abusers (Alfonso, Caracul, Delgado-Pastor, & Verdejo-García, 2011). Tang, Yang, Leve, and Harold, (2012) reviewed studies that assessed the impact of mindfulness-based techniques on different dimensions of executive functioning. Results suggest that mindfulness-based techniques improve sustained attention and emotion regulation. Additionally, these techniques have also been shown to improve academic performance and social behavior. As such, focusing on interventions known to improve executive functioning among individuals who engage in RSB may have a greater impact on reducing RSB. Attempts to improve executive functions in specific populations (e.g., individuals with attention deficit hyperactivity disorder who have executive control dysfunctions) may prove to be more difficult.

Moving forward, research in this area could benefit from several approaches. For example, longitudinal studies (particularly from adolescence into adulthood) on neuropsychological functioning and engagement in RSB are sorely needed. Such studies allow tracking how changes in neurocognitive functioning (through normal development, neurological trauma or heavy substance use) prospectively influences RSB. They may also be better poised to capture the complex interactions between the cognitive control and socioemotional systems from early adolescence to young adulthood. Advances in neuroscience research over the last decade have greatly increased our understanding of

mechanisms that underlie various complex behaviors. Incorporating neuropsychological approaches into studies of RSB may help to further move this research forward and determine more effective approaches for preventing risky health behaviors and subsequent negative consequences. As this research continues to grow with stronger research designs, larger sample sizes, and more robust measures of brain functioning and sexual risk, we anticipate that this new knowledge will be applied to develop better intervention and prevention programs that will help reduce the spread of STIs and reduce negative consequences of RSBs particularly.

CHAPTER III.

RISKY SEXUAL BEHAVIOR AND THE ROLE OF DECISION-MAKING

Abstract

Externalizing symptoms, cannabis use, and decision-making abilities are interrelated and associated with risky sexual behavior (RSB). Briefly, previous research has demonstrated that more externalizing symptoms, more cannabis use and poorer decision-making abilities are related to more RSB. However, few studies have examined the association of neurocognitive factors (e.g., decision-making abilities) and RSB. Therefore, the current study was developed to determine how relevant psychosocial factors (i.e., externalizing disorders and cannabis use) and neurocognitive factors (i.e., decision-making abilities) interact to predict RSB among a sample of adolescents. Participants in this study are part of a larger longitudinal study designed to assess how cannabis use and neurocognitive factors are associated.

The current study has three primary aims that will be addressed. The first aim is to examine how externalizing symptoms, cannabis use, decision-making abilities and the interaction of these variables are associated with RSB. The second aim is to determine how baseline levels of externalizing symptoms, amount of cannabis used over the past year/changes in problems from cannabis use and changes in decision-making performance are associated with changes in RSB. The third aim is an exploratory analysis to determine if decision-making performance moderates the relationship between externalizing symptoms and problems from cannabis use. Participants in the current study are 204 adolescents at-risk for escalation in cannabis use. Structural equation modeling and multiple linear regression were used for all analyses and simple slope difference tests were used for all post-hoc analysis.

Results for the first aim, were that more externalizing symptoms, more cannabis use, more problems from cannabis use and greater risk-taking on the Cups Task (CT) predicted more RSB. Several interactions emerged between lifetime amount of cannabis use/problems from cannabis use with risk-taking, externalizing symptoms and risk-taking, and externalizing symptoms and problems from cannabis use in predicting RSB. Results for the second aim were that more cannabis use and increases in risk-taking on the GDT predicted increases in RSB over the past year. Results from the third aim were that more externalizing symptoms and more risk-taking on the CT predicted more problems from cannabis use. Future research directions are discussed, including analyzing the main and interaction effects of externalizing symptoms, cannabis use and decision-making abilities in predicting RSB in a larger longitudinal design. Clinical implications of the results of the current study are discussed including how different decision-making abilities may warrant different treatment approaches.

Introduction

Increases in risky sexual behavior (RSB), as well as other risk-taking behaviors, are often observed during adolescence. Teens are at a greater risk of engaging in RSB compared to other ages, with young persons accounting for nearly half of the new sexually transmitted infections (STIs) diagnosed throughout the United States (Satterwhite et al., 2013). Externalizing disorder symptoms (i.e., attention-deficit/hyperactivity disorder (ADHD), oppositional defiant disorder (ODD) and conduct disorder (CD)), cannabis use and decision-making abilities have all shown to be associated with RSB (Flory, Molina, Pelham, Gnagy, & Smith, 2006; Ross, Coxe, Schuster, Rojas, & Gonzalez, 2015; Sarver, McCart, Sheidow, & Letourneau, 2014; Schuster, Crane, Mermelstien & Gonzalez, 2012). The unique contribution of externalizing disorder symptomology, cannabis use and decision-making abilities and how these variables interact to predict RSB among adolescents is unknown. More research in this area will help in our understanding of what factors are most relevant in predicting RSB.

Consequences of RSB

RSB remains an important public health risk for adolescents. In 2014, individuals ages 13 to 24 were ranked as the second highest in the number of new human immunodeficiency virus (HIV)/acquired immunodeficiency syndrome (AIDS) infections compared to other ages. Young people account for 22% of the total number of new HIV/AIDS infections. Although vectors of transmission for HIV among adolescents include injection drug use and tattooing without proper sterilization, RSBs are by far the most relevant and common reason for new infections (CDC, 2015). Minorities are

disproportionately affected by HIV/AIDS. From 2005 to 2014 among black and Hispanic/Latino men who have sex with men, human immunodeficiency virus new diagnosis increased by 87% (CDC, 2015). Currently, Miami Dade County (location of the study) has the second highest new HIV/AIDS diagnosis rates in the United States (CDC, 2015). The economic and public health cost associated with RSB is large for adolescents: estimated to be around \$48 billion dollars per year (Biglan et al., 2004). Clearly, research aimed at understanding factors underlying RSB among adolescents is of dire importance to improve the health and quality of life among our youth and to slow the spread of HIV.

HIV infection is not the only negative consequence associated with RSB, as unplanned pregnancies and STIs also adversely affect adolescents. Each year, around 750,000 females between the ages of 15-19 become pregnant in the United States (Kost & Henshaw, 2012). Among Western societies the United States has the highest rate of teen pregnancies (Darroch, Singh, & Frost, 2001). Teen mothers' are more likely to be socioeconomically disadvantaged than those who wait until later in life to have a child and are less likely than peers to earn a high school diploma or to attend college (Frisco, 2008; Spriggs, 2008). STIs, other than HIV, are also negative consequence of engagement in RSB that can negatively affect an individual's health and quality of life. Chlamydia and gonorrhea rates are higher among adolescents compared to adults. Adolescents account for more than half of the new STI cases, even though adolescents account for only one quarter of the sexually active population. Among sexually active females, 15% are infected with human papillomavirus which has been linked to cervical cancer (Weinstock, Berman, & Cates, 2004). STIs and teen pregnancies are clearly

problematic for teen's physical and emotional health and can result in academic underachievement among numerous other problems. Although the proposed plan focuses on HIV-risk behaviors among adolescents, other negative consequences occur as a result of RSB and will be assessed as well. For the proposed study, we define RSB as sexual behaviors that can directly lead to sexually transmitted infections or unplanned pregnancy. RSB includes having sex intercourse without protection (e.g., condom), more sexual partners, sex with someone known less than 24 hours, having a younger age of initiation, and having sex under the influence of alcohol and/or drugs (Kann et al., 2014).

Externalizing Disorder Symptomology and RSB

Externalizing disorder symptomology is one likely contributor to RSB. Adolescents and adults with externalizing symptoms have been shown to engage in greater amounts of RSB compared to those without externalizing symptoms. Individuals diagnosed with externalizing disorders in childhood (i.e., ADHD, ODD, and CD), are more likely to have earlier sexual initiation and during adolescence to have more frequent casual sex, greater numbers of sexual partners, more sex under the influence of alcohol and drugs and these individuals continue to engage in greater amounts of RSB in adulthood (Flory et al., 2006). In a sample of runaway adolescents, CD diagnosis was the most robust predictor of exchanging sex for money, number of drugs used and number of sexual partners which are all known contributors to human immunodeficiency virus-risk (Booth & Zhang, 1997). Additionally, high levels of antisocial behaviors during childhood (ages 5-11) are associated with an earlier sex initiation (before age 16) and engagement in more RSB throughout adolescence and young adulthood (Ramrakha et al., 2007). In a large sample of adolescents receiving treatment for psychiatric disorders

(inpatient and outpatient), adolescents with an externalizing disorder, mania or comorbid externalizing and internalizing disorders were more likely to engage in RSB compared to those with depressive or anxiety disorders (Brown et al., 2010). The fact that individuals with externalizing disorders are more likely to engage in RSB is not surprising given the symptoms of each disorder. For example, ADHD symptoms include inattention to details, impulsivity, and forgetfulness and conduct disorder symptoms include often running away overnight and being truant from school.

Neurocognition (Decision-Making) and RSB

There is little research on the neurocognitive risk factors of adults and adolescents engagement in RSB. Determining the neurocognitive factors associated with engagement in RSB may help with development of prevention programs that are tailored to adolescents neurocognitive functioning. With few exceptions, most research on contributors to RSB have been with psychosocial risk factors, for example poor parenting practices and deviant peer groups (Biglan et al., 1990), and have largely ignored neurocognitive performance. Adolescence is a time in development when risk-taking is seen in greater amounts compared to other ages (Steinberg, 2004), which parallels protracted development of prefrontal cortex throughout adolescence into early adulthood. Neurocognitive abilities subserved by prefrontal cortex and particularly orbitofrontal cortex, which is implicated in inhibitory control, may be a factor accounting for individual differences in propensity for engagement in risky behavior among youth. There has been extensive study in the role of sensation-seeking and risk-taking behavior in adolescents. To date, across all studies, among adolescents, young adults and adults, that have assessed the association of neurocognitive functioning and risky sexual

behavior, most studies have found that poorer executive functioning is associated with more RSB (Ross, Duperrouzel, Vega, & Gonzalez, 2016). Specifically among adolescents, poorer working memory performance is associated with a younger age of sex initiation (Khurana et al., 2012; Khurana et al., 2015) and risk-taking propensity it associated with more RSB (Bornovalova et al., 2008; Lejuez et al., 2007).

Decision-making is one facet of impulsivity that has been neglected in the risky sexual behavior literature as most research has been conducted with the propensity towards risk-taking. Although individuals who have poor decision-making are more likely to engage in risk-taking, these constructs are different. Decision-making is how an individual makes a choice with ambiguous consequences that requires a tradeoff between reward and risk (Bechara, 2005). Despite a strong literature linking “decision-making” abilities with orbitofrontal functioning (Bechara, Damasio, Damasio, & Anderson, 1994), only two studies has specifically assessed the relationship of decision-making to risky sexual behavior, and it was studied among a sample of young adult cannabis users. Among young adult (ages 17-24) cannabis users, the amount of recent cannabis use predicted negative consequences from engagement in risky sexual behavior, but only among the individuals who performed poorly on a decision-making task, the IGT (Schuster et al., 2012). Decision-making may be a valuable neurocognitive construct to examine in the context of RSB, yet to our knowledge, no study has examined its influence on RSB during adolescence, a time when a majority of individuals have their first sex initiation. Among the same sample of participants, interactions between CD symptoms, cannabis use and decision-making abilities (on the Iowa Gambling Task (IGT)) interacted to predict age of vaginal sex initiation and number of oral sex partners.

More CD symptoms were associated with more oral sex partners, only at higher levels of cannabis use and poorer decision-making performance. However, more CD symptoms were associated with fewer oral sex partners at better levels of decision-making performance and again at high levels of cannabis use. Additionally, more CD symptoms predicted a younger age of vaginal sex initiation, with age decreasing as amount of cannabis use increased only when decision-making performance was poor (Ross et al., 2015). Most research has been conducted with young adults, typically when individuals are already engaging in RSB, thus yielding less valuable information for prevention efforts.

Cannabis Use and RSB

Numerous studies have documented the association of illicit drug use with RSB (Biglan et al., 2004) as well as problems from substance use with greater amounts of RSB (Tapert et al., 2001). Fewer studies have evaluated specifically the association of cannabis use with RSB. Motives to use cannabis reported by active cannabis users (e.g., to have a fun, to relax, to heighten senses, to help socialize and for sexual reasons; Hecimovic, Barrett, Darredeau, & Stewart, 2014) could lead to increases in sexual behavior. Several studies have found that earlier initiation of cannabis use and greater amounts of cannabis use are associated with more RSB. Specifically, among a large sample of female twins, initiation of cannabis use during adolescence was associated with a greater number of repeated voluntary unprotected vaginal sex throughout adolescences and young adulthood compared to those who never initiated cannabis or initiated after adolescence (Agrawal et al., 2016). Among a sample of adolescents, cannabis use is associated with RSB and increases in use of sexual health services (Harper, Dittus, &

Ethier, 2016). Given the recent changes in cannabis legislation, the importance of determining the negative consequences from cannabis use is imperative for the health and safety of youth.

Importance of Cannabis Use Research among Adolescents. Cannabis use among adolescents has increased in the last several years coupled with a decrease in perceived risk. With increases in the legalization of cannabis in the United States, cannabis addiction and other problems from cannabis use continue to rise. Cannabis is the most commonly used illicit drug among adolescents, with approximately 40% of 12th graders reporting use at least once in the last year and 7% reporting daily use (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2014). Nine percent of individuals that try cannabis will develop a cannabis addiction (Lopez-Quintero et al., 2011), and reports suggest that approximately 4.2 million people met criteria for cannabis abuse or dependence in the past year (SAMHSA, 2014). Most studies conducted about addiction exclusively include participants who are poly-drug users, indicating a need for studies that specifically include participants who primarily use cannabis.

Indeed, cannabis accounts for more drug addiction treatment among teens (and adults) than any other illicit drug (SAMHSA, 2014), thus making it a leading mental health issue among adolescents. By definition, those meeting criteria for a cannabis use disorder continue use despite experiencing adverse consequences, which include poor academic outcomes (Bray, Zarkin, Ringwalt, & Qi, 2000; Lynskey & Hall, 2000) and psychotic symptoms (Caspi et al., 2005; Di Forti et al., 2009). In addition, cannabis use is associated with cognitive decline (Meier et al., 2012), changes in brain development (Zalesky et al., 2012) and a greater likelihood of an internalizing or externalizing

diagnosis (Chan, Dennis, & Funk, 2008). Clearly there is a need for more focused research studies on consequences of cannabis use and addiction.

Cannabis Use and Externalizing Disorder Symptomology

Cannabis use and externalizing symptoms are commonly comorbid (Bidwell, Henry, Willcutt, Kinnear, & Ito, 2014; Molina & Pelham, 2003; Molina, Bukstein, & Lynch, 2002; Sibley et al., 2014). For example, adolescents with ADHD are more likely to use cannabis frequently and escalate to heavy cannabis use after the first initiation compared to adolescents without attention deficit hyperactivity disorder (Sibley et al., 2014). Individuals with externalizing disorders are more likely to engage in illicit drug use at younger ages and continue engagement into adulthood, with more persons with a externalizing disorders meeting criteria for a substance use disorder compared to individuals without an externalizing diagnosis (Molina & Pelham, 2003). Previous research has demonstrated that a relationship exists between externalizing symptoms, cannabis use and RSB but the relationships between these factors are complex. Currently little is known about how the above factors, externalizing symptoms and cannabis use, interact with neurocognitive factors to predict RSB.

Cannabis Use and Decision-Making

Cannabis use during adolescence is related to poor neurocognitive functioning. Longitudinal studies have found that cannabis use during adolescence is associated with poor performance on tasks of attention (Tapert, Granholm, Leedy, & Brown, 2002), verbal memory (Tait, Mackinnon, & Christensen, 2011) and reductions in IQ (Meier et al., 2012). Dose related effects of cannabis use have also been documented among adults, even after 28 days of abstinence those who are heavy cannabis users have poorer

neurocognitive functioning compared to adults who do not use cannabis (Bolla, Brown, Eldreth, Tate, & Cadet, 2002). Several studies conducted with adults have suggested that poor decision-making is associated with cannabis addiction (Clark, Roiser, Robbins, & Sahakian, 2009; Crane, Schuster, Mermelstein, & Gonzalez, 2015; Lamers, Bechara, Rizzo, & Ramaekers, 2006; Whitlow et al., 2004). However, some evidence suggests that problems with decision-making may precede cannabis use and be a risk factor for cannabis addiction (Gonzalez et al., 2012). Fewer studies have evaluated the association between cannabis use and decision-making among adolescents.

Externalizing Disorder Symptomology and Decision-Making

The symptoms of externalizing disorders are characterized by executive dysfunction. Specifically, a review of the literature suggests that individuals with ADHD experience deficits in behavioral inhibition, working memory, motivation regulation and motor control (Barkley, 1997). Executive functioning deficits have shown to be directly related to symptoms of ADHD among children who are 4-6 years old (Thorell & Wåhlstedt, 2006). Furthermore, a meta-analytic review was conducted to compare the executive functioning abilities among those with attention deficit hyperactivity disorder (total $N = 3734$) compared with those without ADHD ($N = 2969$). Across 83 studies, individuals with ADHD exhibited impairment across all measures of executive functioning and the greatest impairments were present in response inhibition, vigilance, working memory and planning (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005). As previously discussed, individuals with externalizing disorders are more likely to engage in risk-taking behavior. However, few studies have documented how symptoms of externalizing disorders interact with measures of executive functioning in predicting risk-

taking behavior (e.g., RSB and substance use). One possible measure of executive functioning that may be related to risk-taking behavior in individuals with externalizing disorders is decision-making. Across 37 studies, individuals with ADHD ($n = 1175$) and without ADHD ($n = 1222$) were compared on decision-making performance. Individuals with ADHD made more risky choices on decision-making tasks compared to individuals without ADHD. Additionally, co-morbid externalizing disorders (e.g., ODD and CD) moderated the association between ADHD diagnosis and risk-taking, in that those with comorbid externalizing disorders engaged in more risk-taking than those without a comorbid externalizing disorder (Dekkers, Popma, van Rentergem, Bexkens, & Huizenga, 2016). Similarly to ADHD, there is a positive association between high levels of aggression and more risk-taking during decision-making tasks across different populations (Kuin, Masthoff, Kramer, & Scherder, 2015).

Externalizing Disorders and Decision-Making Association with Problems from Cannabis Use

Another common risk-taking behavior in adolescence is substance use and cannabis is the most commonly used illicit drug among adolescents (Johnston et al., 2014; SAMHSA, 2014). Cannabis abuse and dependence constitute a significant public health concern for adolescents, particularly among adolescents with externalizing symptoms who are at a greater risk for cannabis addiction compared to individuals with fewer symptoms (Molina, & Pelham, 2003). Research to date has not thoroughly explored the neurocognitive factors that affect the relationship between externalizing symptoms and cannabis addiction. Aspects of neurocognitive performance, specifically decision-making abilities (the ability to make choices with ambiguous consequences), are

one potential moderator of the relationship between externalizing symptoms and cannabis use (Bechara, 2005). Most studies conducted to determine how neurocognitive performance moderates the relationship between externalizing symptoms and cannabis use have primarily used adult samples and the results have been conflicting. Considering the many adverse consequences of cannabis addiction (Hall & Degenhardt, 2009), more targeted prevention and intervention programs may benefit from being developed with specific neurocognitive considerations in mind.

Why do some teens experience significant problems from their cannabis use, whereas others do not? One potential mechanism to explain why cannabis experimentation develops into cannabis addiction in some individuals while not others are mental health issues (specifically externalizing disorder symptomology) and neurocognitive deficits (specifically deficits in decision-making). Two inter-related and promising factors that may contribute to problems from cannabis use and symptoms of addiction will be examined. The impairments exhibited by cannabis users and those with more externalizing symptoms overlap specifically in the area of decision-making (Gonzalez et al., 2012; Toplak, Jain, & Tannock, 2005; Tamm et al., 2013).

Summary and Proposed Studies

Adolescents with externalizing disorders are more likely to engage in illicit drug use including cannabis use (Bidwell, et al., 2014; Molina & Pelham, 2003; Molina, et al., 2002; Sibley et al., 2014). Externalizing disorders and cannabis use have been associated with poorer executive functioning, including decision-making (Clark, et al., 2009; Crane, et al., 2015; Dekkers, et al., 2016; Kuin, et al., 2015; Lamers, et al., 2006; Whitlow et al., 2004). Although externalizing disorders, cannabis use and decision-making abilities have

been shown to be associated with RSB (Flory, et al., 2006; Ross, et al., 2015; Sarver, et al., 2014; Schuster, et al., 2012), it is currently unknown how externalizing symptoms, cannabis use and decision-making abilities interact to predict RSB in a sample of adolescents. The present study will evaluate the unique contribution and interaction effects of each variable in predicting RSB among adolescents in a cross-sectional analysis (aim 1) as well as a longitudinal analysis (aim 2). An exploratory analysis will be conducted to assess how externalizing symptoms, decision-making abilities and the interaction of externalizing symptoms and decision-making abilities are associated with problems from cannabis use (aim 3). Participants for the project will be 204 adolescents (ages 14 to 17) recruited from an existing research study about the development of cannabis addiction in adolescents. Below are the specific aims for the current study.

Aim 1. To determine the unique variance in RSB accounted for by cannabis use/problems from cannabis use, externalizing symptoms and decision-making as well as examine the potential moderation effects of decision-making on the associations between externalizing symptoms and RSB as well as cannabis use/problems from cannabis use and RSB.

Hypothesis 1a. Decision-making abilities, externalizing symptoms and cannabis use will all account for unique variance in predicting RSB. Externalizing symptoms will account for the most variance and decision-making abilities will account for the least variance. Greater amounts of externalizing symptoms, more cannabis use and more risk-taking on decision-making tasks will be associated with more RSB.

Hypothesis 1b. Decision-making abilities will moderate the relationship between cannabis use and RSB as well as externalizing symptoms and RSB. Greater amounts of

cannabis use/problems from cannabis use and more externalizing symptoms will be associated with more RSB, however only at levels of more risk-taking on the decision-making tasks. There will be no association between cannabis use/problems from cannabis use and externalizing symptoms at levels of less risk-taking on the decision-making tasks.

Aim 2. To examine if changes in decision-making abilities and amount of cannabis use/problems from cannabis use, and the number of externalizing symptoms at baseline predict change in RSB over one year.

Hypothesis 2a. Increases in risk-taking on decision-making tasks, increases in cannabis use/problems from cannabis use, and more externalizing symptoms at baseline will be associated with increases in RSB.

Aim 3. To examine if decision-making abilities moderates the relationship between externalizing symptoms and problems from cannabis use among a sample of adolescents.

Hypothesis 3a. Both externalizing symptoms and decision-making abilities will predict problems from cannabis use, specifically that more externalizing symptoms and more risk-taking on the decision-making tasks will predict more problems from cannabis use.

Hypothesis 3b. The interaction between externalizing symptoms and decision-making will predict problems from cannabis use. Specifically, more externalizing symptoms will be associated with more problems from cannabis use, at levels of more risk-taking on the decision-making tasks.

Methods

Participants

Participants were recruited from South Florida middle and high schools, flyers distributed throughout the city and word-of-mouth. Eligibility for inclusion in the study was obtained via a phone screening. Most participants in the study were recruited to obtain a sample of adolescents who are at risk for escalation of cannabis use. Inclusion criteria included being between 14 to 17 years old at baseline, ability to read and write in English and some use of alcohol, cigarettes or other drugs. Participants were excluded from participation in the study for self-reported developmental disorders, birth complications, neurological disorders, or history of mood, thought or attention deficit/hyperactivity disorder. Towards the end of the study, participants with attention/deficit hyperactivity disorder were not excluded from the study. Participants were also excluded at screening for behavior suggestive of an alcohol or cannabis use disorder as well as frequent or recent use of drugs other than alcohol, nicotine or cannabis. At baseline and follow-up assessments, participants were assessed on their mental health, substance use, and medical history. The baseline and 1-year follow-up assessments were in-person assessments conducted at the clinic while the 6-month follow-up assessment was conducted via the phone. Oral fluid toxicology screening tests were administered to participants during the baseline and 1-year follow-up assessments using an Intercept oral fluid drug test (OraSure Technologies, Inc.: Bethlehem, PA).

Participants were 204 adolescents ages 14 to 17. Oral fluid tests for recent drug use revealed that five participants had recently used cannabis, one participant had recently used cocaine and one participant had recently used amphetamines. Only 5

participants used drugs (other than alcohol, nicotine, or cannabis) more than 20 times in their lifetime. All participants were included for aim 1 and aim 3. A majority of the participants were Hispanic/Latino. Few participants met diagnostic criteria for a psychiatric disorder. No participant met criteria for a substance use disorder with the exception of alcohol and cannabis. The most commonly used drug reported among participants was cannabis. Participant characteristics for the sample are presented in Table 2.

Only a subset of participants completed the parent/caregiver report measure, the Child Behavior Checklist (CBCL; $n = 97$), this subset of participants were included in the analysis that required parent/caregiver report. Participant characteristics for individuals that completed a CBCL are located in Table 3. Parent/caregiver report of externalizing symptoms was significantly correlated with self-report of externalizing symptoms ($r = 0.28, p < .01$). The correlation between parent/caregiver report and self-report of externalizing symptoms is lower compared to other studies. Other studies have reported correlations between parent/caregiver and self-report of total externalizing symptoms on the same measure between 0.34 and 0.51 (Berg-Nielsen, Vika, & Dahl, 2003; Sourander, Helstelä, & Helenius, 1991). Group comparisons were conducted with a one-way ANOVA to compare participants who had a completed CBCL ($n = 97$) with participants who did not have a completed CBCL ($n = 107$) on relevant demographic information, decision-making tasks and cannabis use. Findings revealed no group differences for participant's age, race, ethnicity, estimated IQ, mother's education level, amount of lifetime cannabis use, and performance across all three decision-making tasks (i.e., IGT, GDT and CT).

For aim 2, only participants who had a completed baseline and 1-year follow-up assessment ($n = 61$) were included in the analyses. Participant characteristics for this sample are in Table 4 (baseline participant characteristics) and Table 5 (1-year follow-up participant characteristics).

Procedures

The Institutional Review Board of Florida International University approved all study procedures and protocols. Participant assent and parental consent were obtained for all participants. Additional consent was obtained from the parent to administer questionnaires about HIV risk behavior to the participants. Parents who did not want their child to answer questions about HIV risk behavior (e.g., sexual behavior) had the opportunity to refuse participation via the consent. Participants in this study were part of a larger longitudinal study designed to assess how decision-making performance may influence cannabis use trajectories and how cannabis use during adolescence may influence both decision-making and memory performance. The parent project (PI: Raul Gonzalez, Decision-Making and Episodic Memory in Trajectories to Cannabis Addiction, DA031176) has five measurement waves conducted every six months over two years. All measures collected for aim 1 and aim 3 were administered at the participant's baseline assessment. All measures collected for aim 2 were collected at the participant's baseline, 6-month follow-up and 1-year follow-up assessments.

Measures

Demographic Information. Demographic information was collected on age, race, gender, years of education, mother's years of education as well as other pertinent information.

Externalizing Symptoms Measures. Externalizing symptoms were assessed via two measures that included a self-report and a parent/caregiver report. These measures were chosen based on strong psychometric properties, normed scoring and extensive testing with a variety of adolescent populations. In addition, the measures have been translated into Spanish, which was important for parents in Miami-Dade County, as many parents do not speak English.

Youth Self-Report (YSR) and Child Behavior Checklist (CBCL). The YSR (self-report) and CBCL (parent-report) are measures that assess empirically based syndrome scales and DSM-oriented scales. Subscales include, for example, internalizing symptoms, externalizing symptoms, aggressive behavior and social skills. Questions range from open-ended to Likert-scaled (0 = not at all true, 1 = somewhat true, 2 = very true). The measures for both parent/caregiver and adolescent are exactly the same except that the parent is asked about the behavior in their child and the children are asked about themselves. Externalizing symptoms total score were used as the measure for externalizing symptoms. Additionally, the empirically derived syndrome scales for externalizing disorders (i.e., attention problems, rule-breaking behavior, and aggressive behavior) were used to evaluate how the different syndromes were associated with RSB. The YSR and CBCL have strong psychometric properties (reliability and validity) and have been co-normed. The measures have been empirically tested and validated with many different ethnicities and translated, tested and validated in other languages (e.g., Latino/Hispanic populations and translated into Spanish; Achenbach, & Rescorla, 2007; Achenbach & Rescorla, 2001).

Cannabis Use. Cannabis use was quantified by two variables. The variables were lifetime amount of cannabis use (in grams) and the total score from the Marijuana Problems Scale (MPS), which quantified problems related to cannabis use that are suggestive of a cannabis use disorder.

Drug Use History Questionnaire (DUHQ). The DUHQ is modeled after drug use history questionnaires used successfully in various studies of substance use (Gonzalez et al., 2008; Gonzalez et al., 2004; Rippeth et al., 2004). This measure was used to obtain detailed topography of lifetime, 12 month, 6 month, and 1 month cannabis use. In addition to collecting detailed information on cannabis use, data was also obtained on alcohol, cigarettes, cocaine, amphetamines, methamphetamine, ecstasy, heroin and other opiates, benzodiazepines, and other drugs. Total lifetime amount of cannabis used (in grams) was used during analysis to quantify cannabis use.

Marijuana Problems Scale (MPS). The MPS is a 19-item scale developed to assess negative consequences as a result of cannabis use (Stephens, Roffman, & Curtin, 2000). For the baseline assessment, the MPS queried participants about lifetime negative consequences while the 6-month follow-up as well as the 1-year follow-up queried participants about negative consequences experienced from cannabis use over the previous six months. The negative consequences assessed include a variety of domains like social relationships, occupational/educational achievement, finances, and legal problems. Participants choose from three options which are 0 = no problem, 1 = minor problem, and 2 = serious problem. The measure has been used in studies among both adults (Buckner, Ecker, & Cohen, 2010; Day, Metrik, Spillane, & Kahler, 2013; Gonzalez, Schuster, Mermelstein, & Diviak, 2015) and adolescents (Foster, Li, McClure,

Sonne, & Gray, 2016). The MPS has demonstrated adequate internal consistency (Buckner et al., 2010; Buckner & Zvolensky, 2014; Stephens et al., 2000). The total score (ranging from 0-38), calculated by summing the choices from the participant, was used as the measure of cannabis use problems.

Decision-Making. Decision-making was assessed via three measures, all of which assess facets of impulsive decision-making via computerized tasks. Structural equation modeling was used to create a latent variable with the three decision-making tasks. In order to ensure motivated responding and add realism to the gains and losses experienced during the decision-making tasks, participants won different prizes based on their overall level of performance across all decision-making tasks.

Cups Tasks (CT). The CT was created specifically to measure decision-making in children, and under conditions of specified risk (Levin & Hart, 2003; Levin, Hart, Weller, & Harshman, 2007). The CT consists of 54 trials that are considered either a “gain” or “loss” trial. Participants are given a visual display of 2, 3 or 5 cups on both the left and right side of the computer screen (see Figure 1). Participants are instructed to pick a cup from either the right or left side. Choices from one side always yield a definite reward/smaller loss, whereas choices from the opposite side provide a chance for a greater reward or loss. Gain trials have two options: 1) definite gain of one quarter or 2) the chance to win multiple quarters or no quarters. Loss trials also have two options: 1) definite loss of one quarter or 2) a chance to lose multiple quarters or no quarters. Performance on the task is associated with functioning of dorsal and ventromedial prefrontal cortex, amygdala, and insula (Levin, Hart, et al., 2007; Weller, Levin, Shiv, & Bechara, 2009; Xue, Lu, Levin, & Bechara, 2010; Xue et al., 2009). The total number of

risk disadvantageous choices (i.e., choosing the side with chances to lose multiple quarters or chance to win multiple quarters during the trials with 3 or 5 cups on either side) will be used as one of the factors to create the latent variable of decision-making during analysis. A risky choice was considered advantageous when the participant chooses the side with chances to lose no quarters/win multiple quarters when there were 2 cups on either side. The participant had a 50% chance of choosing the cup that will win multiple quarters (“gain” trials) or lose no quarters (“loss” trial). Risk disadvantageous choices were when the participant chooses the side with chances to lose no quarters or win multiple quarters when the participant had a 33% or 20% chance of choosing the cup that would win multiple quarters (“gain” trials) or lose no quarters (“loss” trial). The CT has been successfully used with children and adolescents (Levin & Hart, 2003; Levin, Hart, et al., 2007; Levin, Weller, Pederson, & Harshman, 2007).

Game of Dice Task (GDT). The GDT assesses decision-making when the participant is given certain rules and probabilities for monetary gains and losses throughout the task (Brand et al., 2005). The task evaluates decision-making under conditions of specific risk. Participants predict the outcome of a dice roll by choosing from four different options (e.g., one number vs. multiple numbers). Options with more numbers (i.e., higher probability of winning) are associated with a lesser reward compared to those with one or two possible numbers (i.e., lower probability of winning; see Figure 2). ‘Risky choices’ are the two options with the lowest probability of winning. Participants underwent 18 trials of this task and the total number of risky choices was used as one of the factors to create the latent variable of decision-making. Performance on the GDT is associated with damage to prefrontal circuits (Brand et al., 2005),

hypometabolism in prefrontal cortex and anterior cingulate (Brand et al., 2004), and amygdala damage (Brand, Grabenhorst, Starcke, Vandekerckhove, & Markowitsch, 2007). It has been administered successfully to adolescents (Drechsler, Rizzo, & Steinhausen, 2008) and found to be sensitive to substance use disorders (Brand, Roth-Bauer, Driessen, & Markowitsch, 2008).

Iowa Gambling Task (IGT). The IGT is different from the aforementioned tasks in that it assesses decision-making under conditions of ambiguous risk. The task was developed to measure poor judgment and impulsive decision-making typically seen in patients with lesions of the orbitofrontal cortex (Bechara et al., 1994). Performance on the task has also been shown to involve dorsolateral, orbitofrontal and ventromedial prefrontal cortex, insula, ventral striatum and anterior cingulate (Li, Lu, D'Argembeau, Ng, & Bechara, 2010). Participants are given a visual display of four decks of cards (see Figure 3). Also, participants are given directions that some decks are better than others and that more choices from “good decks” will yield a positive net total while more choices from “bad decks” will yield a negative total. Iowa Gambling Task net score (choices from good decks – bad decks) was used as one of the factors to create the latent variable of decision-making. The IGT has been successfully used with children and adolescents (Crone & Van Der Molen, 2004; Ernst et al., 2003; Ernst et al., 2010).

HIV-Risk Behavior Measure. One measure was used to assess RSB and was chosen for several reasons: 1) previous research has shown that there is a relationship between RSB with neurocognitive performance and cannabis use with this measure and 2) the measure includes various indices of RSB (e.g., age of initiation, number of partners, and frequency of condom use).

Risky Sexual Behavior Questionnaire (RSBQ). The RSBQ is a detailed measure used to assess RSB (Schuster, 2012) which was adapted by the AIDS Risk Behavior Assessment (Donenberg, Emerson, Bryant, Wilson, & Weber-Shiffrin, 2001). The RSBQ is an interview about the individuals past sexual history that creates five subscale variables that are as follows: 1) total number of sexual encounters (i.e. number of oral, anal and vaginal sexual partners); 2) frequency that cannabis use interferes with sexual experiences; 3) frequency of protection use (e.g. condom use, birth control); 4) lifetime number of negative consequences as a result of RSB (e.g. unplanned pregnancies, STIs); and 5) a total score of RSB that incorporates all of the above-mentioned subscales. The total score of the RSBQ was used as the measure for RSB.

Statistical Analysis

All analysis were conducted in either AMOS 20 using structural equation modeling or SPSS 22 using multiple linear regression. Each analysis evaluated how a measure of externalizing symptoms, cannabis use, decision-making tasks and the interaction of these variables were associated with RSBQ-total score. All independent variables were mean-centered prior to analyses with the exception of differences scores. DFBETAS were examined to determine if any outliers were present for all analyses. Outliers were flagged if DFBETAS values were greater than the absolute value of one. If outliers were present, analyses were conducted again without outliers and the results from analyses with and without outliers were compared. Due to the number of outliers present in analyses, all analyses were also conducted using bootstrapping with 2000 replicates. Age, grade, mother's education, estimated IQ and race were included in a separate multiple linear regression to determine if the variables significantly predicted RSBQ-total

score. None of the variables significantly predicted RSBQ-total score ($p > 0.13$).

Therefore, none of these variables were included as controls in the analysis. A correlation matrix of the variables from the analyses is located in Table 6.

Aim 1. Structural equation modeling was used to evaluate if lifetime amount of cannabis use, decision-making performance, and number of self-reported externalizing symptoms predict RSBQ-total score. Decision-making performance was made into a latent variable using scores from the CT, GDT and IGT.

Despite structural equation modeling being an optimal method of analysis compared to multiple linear regression for our analyses, because it takes into account measurement error and also provides information of how well the model fits the data, such analyses were not possible because the decision-making tasks did not load onto a single latent variable. Thus, all analyses were conducted with each decision-making task separately using multiple linear regression. These analyses nonetheless determine how the decision-making tasks interact with cannabis use and externalizing disorders.

Analyses were also conducted with poisson regression due to the low mean score of the RSBQ-total score (Mean = 4.1, standard deviation = 5.6) and positive skewness, resembling “count data.” Among the poisson regression analyses, square root transformation was utilized with the amount of lifetime cannabis use variable because of the skewness of this variable. The results reported in detail below are for the multiple linear regression analyses. Differences between the results conducted with multiple linear regression and poisson regression are reviewed in the Discussion section. Each analysis included a measure of externalizing symptoms (i.e., externalizing symptoms total score, attention problems, rule-breaking behavior and aggressive behavior), a measure of

cannabis use (i.e., lifetime amount of cannabis use and MPS-total score), and a measure of decision-making abilities (i.e., CT, GDT and IGT). Each linear regression analysis contained one decision-making task, one measure of cannabis use and one measure of externalizing symptoms. All possible combinations between these variables, totaling 30 analyses, were run separately. One disadvantage of conducting this many analyses is that it increases the risk of error in the results (i.e., multiple comparisons).

Numerous outliers were present; therefore all analyses were conducted with and without outliers. Because each of the 30 analyses will be run with and without outliers, there were a total of 60 analyses conducted for aim 1. When self-report of externalizing symptoms and lifetime amount of cannabis use were run together in the same analysis three separate times with the CT, GDT and IGT, a total of thirteen outliers were present across the three linear regressions with DFBETAS ranging from 1.20 to 3.00. When attention symptoms and lifetime amount of cannabis use were run together in the same analysis three separate times with the CT, GDT and IGT, a total of twelve outliers were present across the three linear regressions with DFBETAS ranging from 1.00 to 3.79. When rule-breaking behavior and lifetime amount of cannabis use were run together in the same analysis three separate times with the CT, GDT and IGT, a total of twelve outliers were present across the three linear regressions with DFBETAS ranging from 1.01 to 2.74. When aggressive behavior and lifetime amount of cannabis use were run together in the same analysis three separate times with the CT, GDT and IGT, a total of ten outliers were present across the three linear regressions with DFBETAS ranging from 1.04 to 3.23. When the MPS total score was included as the measure of cannabis use, across all possible analyses combinations only one outlier was identified with DFBETAS

ranging from 1.02 to 3.24. One other outlier was identified for the analysis that included rule-breaking behavior, MPS and CT with a DFBETA of 1.01.

For analyses that included only participants with a completed CBCL (parent/caregiver report; $n = 97$), ten outliers, with DFBETAS ranging from 1.19 to 5.27, were identified when externalizing symptoms (parent/caregiver report) and lifetime amount of cannabis use were run together in the same analysis three separate times with the CT, GDT and IGT. Nine outliers were identified when externalizing symptoms (parent/caregiver report) and MPS were run together in the same analysis three separate times with the CT, GDT and IGT with DFBETAS ranging from 1.04 to 3.30.

Simple slope difference test were used to follow-up all two-way interactions. CT performance was set at one standard deviation below the mean (labeled as “less risk-taking,” corresponding to 5.90 risk disadvantageous choices made during the task), at the mean (labeled as “average risk-taking” corresponding to 9.90 risky choices made during the task) and one standard deviation above the mean (labeled as “more risk-taking,” corresponding to 13.90 risk disadvantageous choices made during the task). GDT performance was set at one standard deviation below the mean (labeled as “less risk-taking” GDT performance, corresponding to 2.52 risky choices made during the task), at the mean (“average risk-taking” corresponding to 7.72 risky choices made during the task) and one standard deviation above the mean (labeled as “more risk-taking” GDT performance, corresponding to 12.92 risky choices made during the task). Attention problems was set at one standard deviation below the mean (labeled as “less attention problems,” corresponding to 1.83 total score of attention problems), at the mean (labeled as “average attention problems” corresponding to 4.62 total score of attention problems)

and one standard deviation above the mean (labeled as “more attention problems,” corresponding to 7.41 total score of attention problems).

Aim 2. A total of nine analyses were run to determine how past year amount of cannabis use/changes in problems from cannabis use, changes in decision-making task performance and baseline reports of externalizing symptoms are associated with changes in RSB total score. Difference scores were created (from baseline assessment to 1-year follow-up accounting for baseline scores) for all decision-making tasks, MPS-total score and RSBQ-total score. Difference scores were calculated by obtaining the regression coefficient in the association between baseline and 1-year follow-up. Next, the baseline score was multiplied by the regression coefficient (between baseline score and 1-year follow-up), then that score was subtracted from the 1-year follow-up score. Amount of cannabis used over the past year was the measure of amount of cannabis use. Externalizing symptoms remain relatively stable (Biederman et al., 2007; Price et al., 2005); as such externalizing symptoms data were only collected at the baseline assessment and difference scores were not created. Two outliers were present across all six analyses with DFBETAS ranging from 1.02 – 1.07.

Aim 3. A total of twelve analyses were conducted to determine how externalizing symptoms, decision-making performance and the interaction of externalizing symptoms and decision-making performance were associated with the MPS-total score. Each analysis included a measure of self-report of externalizing symptoms (i.e., externalizing symptoms, attention problems, rule-breaking behavior and aggressive behavior) and a measure of decision-making abilities (i.e., CT, GDT and IGT). Across the twelve

analyses, each combination of externalizing symptoms and decision-making task were run. No outliers were present.

Results

Results for Aim 1

The model was statistically just-identified. Examination of univariate indices of skewness and kurtosis revealed absolute values of less than 1.96 (Mardia's Index) for all variables with the exception of lifetime amount of cannabis use. For the lifetime amount of cannabis use skewness was 7.11 and kurtosis was 63.93. These values of skewness and kurtosis suggested that amount of lifetime cannabis use data was non-normal. Due to non-normal data being present, all analyses were conducted using bootstrapping with 2000 replicates. One advantage to bootstrapping is that it does not require changes to the variables that would become difficult to interpret. Since the model was just-identified, fit statistics were not available.

The model accounted for 9% of the variance in RSBQ-total score. None of the factor loadings for decision-making were statistically significant ($p > 0.12$). However, both amount of lifetime cannabis use ($\beta = 0.003$ (0.20), $SE = 0.001$, $p > 0.01$) and externalizing symptoms ($\beta = 0.11$ (0.16), $SE = 0.05$, $p = 0.03$) significantly predicted RSBQ-total score. Specifically, a one unit increase in amount of lifetime cannabis use predicted an increase in RSBQ-total score by 0.003 and an one unit increase in externalizing symptoms predicted an increase of 0.11 in RSBQ-total score. The factor loadings for the decision-making latent variable were not statistically significant suggesting that each decision-making task may assess different aspects of decision-making. The CT and GDT were significantly correlated ($r = 0.25$, $p < 0.01$) while the IGT

was not significantly correlated with the CT ($r = -0.14, p > 0.05$) or the GDT ($r = 0.08, p > 0.05$). All of the following analyses were conducted separately for each decision-making task. Self-report of externalizing symptoms significantly predicted RSBQ-total score, therefore externalizing symptoms were evaluated separately for each self-reported externalizing subscale (i.e., attention problems, rule-breaking behavior and aggressive behavior) to determine which types of externalizing symptoms are associated with RSBQ-total score. Lifetime amount of cannabis use significantly predicted RSBQ-total score, therefore MPS-total score were run in all analyses to determine if there is a difference between amount of cannabis use and problems from cannabis use in predicting RSBQ-total score. Additionally, none of the results reported below changed significantly when gender was included in the analysis.

Externalizing Symptoms. Overall, self-reported externalizing symptoms significantly predicted RSBQ-total score ($\beta = 0.09 - 0.13$ (0.15-0.20), $SE = 0.05, p = 0.01-0.07$) in all twelve analyses that included self-reported externalizing symptoms, with one exception. The analysis that included the MPS-total score and GDT performance, self-reported externalizing symptoms was approaching significance in predicting RSBQ-total score ($p = 0.07$). However, when parent/caregiver report of externalizing symptoms was included in the analyses, parent/caregiver report of externalizing symptoms did not significantly predict RSBQ-total score ($p > 0.07$) in all twelve of the analyses that included parent/caregiver report of externalizing symptoms. Results for aim 1 conducted with multiple linear regression are located in Table 7 and post hoc analyses are located in Table 9. Results for aim 1 conducted with poisson regression and square root transformation are located in Table 8 and post hoc analyses are located in Table 10.

Attention Problems. Self-reported attention problems did not significantly predict RSBQ-total score ($p > 0.29$) in any of the twelve analyses that included self-reported attention problems.

Rule-Breaking Behavior. Self-reported rule-breaking behavior significantly predicted RSBQ-total score ($\beta = 0.19 - 0.34$ ($0.15 - 0.25$), $SE = 0.09$, $p = 0.01 - 0.04$) in all twelve analyses that included self-reported rule-breaking behavior.

Aggressive Behavior. Self-reported aggressive behavior did not significantly predict RSBQ-total score ($p > 0.10$) in any of the analyses that included self-reported aggressive behavior.

Cannabis Use.

Lifetime Amount of Cannabis Use. Lifetime amount of cannabis use significantly predicted RSBQ-total score ($\beta = 0.003 - 0.02$ ($0.26 - 0.84$), $SE = 0.001 - 0.004$, $p = 0.01 - 0.05$) in all thirty analyses that included lifetime amount of cannabis use with one exception. The one exception included self-reported aggressive behaviors and performance on the CT with outliers removed ($p = 0.13$).

Marijuana Problems Scale. MPS-total score significantly predicted RSBQ-total score ($\beta = 0.30 - 0.66$ ($0.19 - 0.45$), $SE = 0.09 - 0.016$, $p = 0.01 - 0.05$) across all thirty analyses that included the MPS-total score with the exception of six analyses.

Additionally, three out of six analyses that were not significant had p -values approaching significance. The analyses, which were approaching significance, were self-reported aggressive behaviors and CT performance ($p = 0.06$), self-reported aggressive behaviors and IGT performance ($p = 0.17$), and parent/caregiver report of externalizing symptoms and the GDT ($p = 0.08$). There were three analyses in which the p -value was not

approaching significance, which included self-reported externalizing symptoms and CT performance ($p = 0.24$), self-reported rule-breaking behaviors and CT performance ($p = 0.43$), and parent/caregiver report of externalizing symptoms and CT performance ($p = 0.28$).

Decision-Making.

Cups Task. Performance on the CT significantly predicted RSBQ-total score ($\beta = 0.30 - 0.66$ ($0.19 - 0.45$), $SE = 0.09 - 0.016$, $p = 0.01 - 0.05$) across all twenty analyses that included CT performance with the exception of six analyses. Additionally, four out of the six exceptions had p -values approaching significance. The analyses, which were approaching significance, were self-reported externalizing symptoms and lifetime amount of cannabis use with outliers removed ($p = 0.07$), self-reported attention problems and lifetime amount of cannabis use with outliers removed ($p = 0.13$), self-reported attention problems and MPS-total score with outliers included ($p = 0.07$), and parent/caregiver report of externalizing symptoms and MPS-total score with outliers included ($p = 0.18$). There were two analyses when the p -value were not close to significance, which included the parent/caregiver report of externalizing symptoms and lifetime amount of cannabis use with outliers included ($p = 0.92$) and with outliers removed ($p = 0.93$).

Game of Dice. Performance on the GDT did not significantly predict RSBQ-total score ($p > 0.14$) across all twenty analyses that included GDT performance.

Iowa Gambling Task. Performance on the IGT did not significantly predict RSBQ-total ($p > 0.17$) across all twenty analyses that included IGT performance, with one exception. IGT performance significantly predicted RSBQ-total score ($\beta = -0.02$ (-

0.07), $SE = 0.01$, $p < 0.01$), when self-reported externalizing symptoms and MPS-total score were included in the analysis and outliers were included.

Interactions.

Externalizing Symptoms and Lifetime Amount of Cannabis Use. The interaction between self-report as well as parent/caregiver report of externalizing symptoms and lifetime amount of cannabis use did not significantly predict RSBQ-total score ($p > 0.16$) across all twelve analyses that included the interaction.

Externalizing Symptoms and Marijuana Problems Scale. The interaction between self-reported externalizing symptoms and MPS-total score was significantly associated with RSBQ-total score in three out of the twelve analyses that included the interaction. The interaction between self-reported externalizing symptoms and MPS-total score significantly predicted RSBQ-total score, only when outliers were included ($\beta = -0.03 - -0.04$ ($-0.17 - -0.21$), $SE = 0.01$, $p < 0.01$). When outliers were removed, the interaction between self-reported externalizing symptoms and MPS-total score did not significantly predict RSBQ-total score ($p > 0.17$). When parent/caregiver report of externalizing symptoms was included in the analysis, the interaction between parent/caregiver report of externalizing symptoms and MPS-total score did not significantly predict RSBQ-total score ($p > 0.53$).

Externalizing Symptoms and Cups Task. The interaction between externalizing symptoms (both self and parent/caregiver report) and CT performance did not significantly predict RSBQ-total score ($p > 0.43$) in all eight analyses that included the interaction.

Externalizing Symptoms and Game of Dice Task. The interaction between externalizing symptoms (both self and parent/caregiver report) and GDT performance did not significantly predict RSBQ-total score ($p > 0.47$) in all eight analyses that included the interaction.

Externalizing Symptoms and Iowa Gambling Task. The interaction between externalizing symptoms (both self and parent/caregiver report) and IGT performance did not significantly predict RSBQ-total score ($p > 0.08$) in all eight analyses that included the interaction.

Attention Problems and Lifetime Amount of Cannabis Use. The interaction between self-reported attention problems and lifetime amount of cannabis use did not significantly predict RSBQ-total score for a majority of the six analyses that included the interaction between these variables ($p > 0.45$). There was one exception, when GDT performance was included in the analysis; there was a significant interaction between self-reported attention problems and lifetime amount of cannabis use ($\beta = -0.001$ (-0.28), $SE = 0.001$, $p = 0.01$) when outliers were included.

Attention Problems and Marijuana Problems Scale. The interaction between self-reported attention problems and MPS-total score significantly predicted RSBQ-total score across all six analyses that included the interaction ($\beta = -0.07$ – -0.10 (-0.14 – -0.19), $SE = 0.03$ – 0.04 , $p = 0.01$ – 0.04). Simple slope difference test revealed that MPS-total score predicted RSBQ-total score and the relationship varied depending on the level of self-reported attention problems. When CT performance was included in the analysis, at low ($\beta = 0.80$ (0.55), $SE = 0.15$, $p < 0.01$) and average ($\beta = 0.53$ (0.36), $SE = 0.11$, $p < 0.01$) levels of attention problems there was a significant association between MPS-total

score and RSBQ-total score. At high levels of attention problems, there was no association between the MPS-total score and RSBQ-total score ($p = 0.07$; see Figure 4). However, when GDT and IGT performance were included, there was a significant association across all levels of attention problems between the MPS-total score and RSBQ-total score. The magnitude of the relationship between MPS-total score and RSBQ-total score was weakest at higher levels of attention problems and increased in magnitude from average to low levels of attention problems.

Attention Problems and Cups Task. The interaction between self-reported attention problems and CT performance did not significantly predict RSBQ-total score ($p > 0.10$) among the four analyses that included the interaction with one exception. The interaction between self-reported attention problems and CT performance significantly predicted RSBQ-total score ($\beta = -0.06$ (-0.14), $SE = 0.03$, $p = 0.04$), when MPS-total score was included as well as outliers removed.

Attention Problems and Game of Dice Task. The interaction between self-reported attention problems and GDT performance significantly predicted RSBQ-total score, ($\beta = 0.05$ (0.13 – 0.14), $SE = 0.02 – 0.03$, $p = 0.01 – 0.05$), across all four analyses with one exception. Self-reported attention problems were associated with RSBQ-total score and the association varied depending on GDT performance, when the MPS-total score was included in the analysis. Specifically, at levels of less risk-taking there was a negative association between self-reported attention problems and RSBQ-total score ($\beta = -0.39$ (-0.19), $SE = 0.17$, $p = 0.03$). The association between self-reported attention problems and RSBQ-total score was not significant at levels of average ($p = 0.41$) and more risk-taking ($p = 0.34$; see Figure 5). The interaction between self-reported attention

problems and GDT performance was approaching significance in predicting RSBQ-total score when lifetime amount of cannabis use was included as well as outliers removed ($p = 0.09$).

Attention Problems and Iowa Gambling Task. The interaction between self-reported attention problems and IGT performance did not significantly predict RSBQ-total score ($p > 0.09$) across all four analyses that included the interaction.

Rule-Breaking Behavior and Lifetime Amount of Cannabis Use. The interaction between self-reported rule-breaking behavior and lifetime amount of cannabis use did not significantly predict RSBQ-total score ($p > 0.11$) across all six analyses, with one exception. The interaction between self-reported rule-breaking behavior and lifetime amount of cannabis use significantly predicted RSBQ-total score ($\beta = -0.001$ (-0.43), $SE = 0.004$, $p < 0.01$) when CT performance was included and outliers were removed.

Rule-Breaking Behavior and Marijuana Problems Scale. The interaction between self-reported rule-breaking behavior and MPS-total score significantly predicted RSBQ-total score ($\beta = -0.05 - -0.06$ (-0.15 - -0.18), $SE = 0.02$, $p = 0.01 - 0.02$) across the three analyses that included outliers. However, when outliers were removed from the analyses, the interaction did not significantly predict RSBQ-total score ($p > 0.26$) across the three analyses.

Rule-Breaking Behavior and Cups Task. The interaction between self-reported rule-breaking behavior and CT performance did not significantly predict RSBQ-total score ($p > 0.32$) across all four analyses that included the interaction.

Rule-Breaking Behavior and Game of Dice Task. The interaction between self-reported rule-breaking behavior and GDT performance did not significantly predict RSBQ-total score ($p > 0.52$) across all four analyses that included the interaction.

Rule-Breaking Behavior and Iowa Gambling Task. The interaction between self-reported rule-breaking behavior and IGT performance did not significantly predict RSBQ-total score ($p > 0.14$) across all four analyses that included the interaction.

Aggressive Behavior and Lifetime Amount of Cannabis Use. The interaction between self-reported aggressive behavior and lifetime amount of cannabis use significantly predicted RSBQ-total score ($\beta = 0.0005 - 0.001$ ($0.13 - 0.18$), $SE = 0.0003$, $p = 0.01 - 0.08$) in the two analyses with outliers removed. The interaction between self-reported aggressive behavior and lifetime amount of cannabis use did not significantly predict RSBQ-total score ($p > 0.44$) in the two analyses with outliers included.

Aggressive Behavior and Marijuana Problems Scale. The interaction between self-reported aggressive behavior and MPS-total score significantly predicted RSBQ-total score ($\beta = -0.05 - -0.06$ ($-0.17 - -0.19$), $SE = 0.02$, $p = 0.01$) only in the two analyses with outliers included. The interaction between self-reported aggressive behavior and MPS-total score did not significantly predict RSBQ-total score in the two analyses with outliers removed ($p > 0.27$).

Aggressive Behavior and Cups Task. The interaction between self-reported aggressive behavior and CT performance did not significantly predict RSBQ-total score ($p > 0.57$) across all four analyses that included the interaction.

Aggressive Behavior and Game of Dice Task. The interaction between self-reported aggressive behavior and GDT performance did not significantly predict RSBQ-total score ($p > 0.78$) across all four analyses that included the interaction.

Aggressive Behavior and Iowa Gambling Task. The interaction between self-reported aggressive behavior and IGT performance did not significantly predict RSBQ-total score ($p > 0.32$) across all four analyses that included the interaction.

Lifetime Amount of Cannabis Use and Cups Task. The interaction between lifetime amount of cannabis use and CT performance significantly predicted RSBQ-total score ($\beta = -0.002 - 0.001$ ($-0.47 - 0.29$), $SE = 0.0002 - 0.001$, $p = 0.01 - 0.03$) in seven out of the ten analyses conducted with the interaction. Across all analyses with outliers included, the interaction between lifetime amount of cannabis use and CT performance significantly predicted RSBQ-total score. Only two out of the five analyses, with outliers removed, did the interaction between lifetime amount of cannabis use and CT performance predict RSBQ-total score, these analyses included rule-breaking behavior and parent/caregiver report of externalizing symptoms. When rule-breaking behavior was included in the analysis, lifetime amount of cannabis use was associated with RSBQ-total score and the association varied depending on CT performance. Specifically, the strongest association between amount of lifetime cannabis use and RSBQ-total score was at levels of more risk-taking on the CT ($\beta = 0.006$ (0.50), $SE = 0.002$, $p < 0.01$). The magnitude of the association between lifetime amount of cannabis use and RSBQ-total score decreased with average levels of risk-taking on the CT ($\beta = 0.004$ (0.33), $SE = 0.001$, $p < 0.01$). There was no relationship between amount of lifetime cannabis use and RSBQ-total score at levels of less risk-taking on the CT ($p = 0.14$; see Figure 6).

However, when parent/caregiver report of externalizing symptoms was included in the analyses, the results did not follow a similar pattern. The strongest association between amount of lifetime cannabis use and RSBQ-total total score was at levels of less risk-taking on the CT ($\beta = 0.02$ (1.12), $SE = 0.01$, $p < 0.01$) and the magnitude of the association between amount of lifetime cannabis use and RSBQ-total score decreased from average ($\beta = 0.02$ (0.80), $SE = 0.16$, $p < 0.01$) to more risk-taking ($\beta = 0.01$ (0.35), $SE = 0.002$, $p < 0.01$; see Figure 7). The difference between the post hoc analysis may be due to the substantially smaller sample size for the parent/caregiver report of externalizing symptoms ($n = 97$) compared to the entire sample size included in the self-reported rule-breaking behavior analysis ($n = 204$).

Lifetime Amount of Cannabis Use and Game of Dice Task. The interaction between lifetime amount of cannabis use and GDT performance did not significantly predict RSBQ-total score ($p > 0.29$) across all ten analyses that included the interaction.

Lifetime Amount of Cannabis Use and Iowa Gambling Task. The interaction between lifetime amount of cannabis use and IGT performance significantly predicted RSBQ-total score ($\beta = 0.0001$ (0.26 – 0.34), $SE = 0.00003 - 0.00004$, $p = 0.01$) in three (all with outliers included) out of the ten analyses that included the interaction. The interaction between lifetime amount of cannabis use and IGT performance did not significantly predict RSBQ-total score in seven of the analyses ($p > 0.11$).

Marijuana Problems Scale and Cups Task. The interaction between the MPS-total score and CT performance significantly predicted RSBQ-total score ($\beta = -0.002$ (-0.47 – -0.43), $SE = 0.001$, $p = 0.01 - 0.02$) in five out of the ten analyses that included the interaction. The interaction between MPS-total score and CT did not significantly predict

RSBQ-total score in the five other analyses ($p > 0.07$). However, when self-reported attention problems were included in the analysis the interaction between the MPS and CT performance significantly predicted RSBQ-total score with outliers included and removed. Simple slope difference tests revealed that the MPS-total score significantly predicted RSBQ-total score, however, the association varied depending on the CT performance. MPS-total score significantly predicted RSBQ-total score at levels of more ($\beta = 0.80$ (0.55), $SE = 0.13$, $p < 0.01$) and average risk-taking ($\beta = 0.52$ (0.36), $SE = 0.10$, $p < 0.01$) on the CT. However, the association between MPS-total score and RSBQ-total score was not significant at levels of less risk-taking on the CT ($p = 0.21$; see Figure 8).

Marijuana Problems Scale and Game of Dice Task. The interaction between MPS-total score and GDT performance significantly predicted RSBQ-total score ($\beta = -0.04 - -0.07$ (-0.13 - -0.17), $SE = 0.02 - 0.03$, $p = 0.01 - 0.05$) in eight out of the ten analyses conducted with the interaction. When self-reported externalizing symptoms, self-reported attention problems and self-reported aggressive behavior were included in the analyses, the interaction between the MPS-total score and GDT performance was significant with outliers included and removed. Simple slope difference tests were conducted to determine the point of significance for the analysis that included self-reported externalizing symptoms total score, self-reported attention problems and self-reported aggressive behavior. Specifically, among the analyses that included self-reported externalizing symptoms, the association between the MPS-total score and RSBQ-total score was strongest at the level of less risk-taking on the GDT ($\beta = 0.85$ (0.59), $SE = 0.15$, $p < 0.01$). The magnitude of the association between MPS and RSB decreased at

levels of average ($\beta = 0.58$ (0.40), $SE = 0.10$, $p < 0.01$) and more risk-taking ($\beta = 0.30$ (0.21), $SE = 0.14$, $p = 0.04$) on the GDT (see Figure 9). Similar patterns emerged when both self-reported attention problems and self-reported aggressive behavior were included in the analyses as the measure of externalizing disorders. The two analyses that the interaction between MPS-total score and GDT performance did not significantly predict RSBQ-total had results approaching significance (i.e., rule-breaking behavior ($p = 0.09$) and parent/caregiver report of externalizing symptoms ($p = 0.13$)).

Marijuana Problems Scale and Iowa Gambling Task. The interaction between the MPS-total score and IGT performance did not significantly predict RSBQ-total score ($p > 0.32$) across all ten analyses that included the interaction.

Results for Aim 2

Externalizing Symptoms. Baseline self-reported externalizing symptoms did not significantly predict changes in the RSBQ-total score ($p > 0.67$) across all nine analyses that included self-reported externalizing symptoms. All results for aim 2 are located in Table 11. Aim 2 results could not be conducted with a poisson regression because the difference scores produce negative values regarding the outcome.

Cannabis Use.

Amount of Cannabis Use over Past Year. Amount of cannabis used over the past year significantly predicted changes in the RSBQ-total score across three out of five analyses that included the variable ($\beta = 0.01$ (0.30 – 0.33), $SE = 0.003$, $p = 0.01$). However, when outliers were removed for two of the analyses, amount of cannabis used over the past year did not significantly predict changes in the RSBQ-total score ($p > 0.81$).

Marijuana Problems Scale. Changes in the MPS-total score did not significantly predict changes in the RSB-total score ($p > 0.67$) in the four analyses that changes in MPS-total score was included.

Decision-Making Tasks.

Cups Task. Change in CT performance did not significantly predict changes in the RSBQ-total score ($p > 0.76$) in the three analyses that included CT performance.

Game of Dice Task. Change in GDT performance significantly predicted changes in the RSBQ-total score ($\beta = 0.23 - 0.24$ ($0.24 - 0.25$), $SE = 0.11 - 0.12$, $p = 0.04 - 0.05$) in the two analyses that included the GDT.

Iowa Gambling Task. Changes in IGT performance did not significantly predict changes in the RSBQ-total score ($p > 0.69$) across the four analyses that included IGT performance.

Results for Aim 3

Externalizing Symptoms. Self-reported externalizing symptoms did not significantly predict MPS-total score ($\beta = 0.15$ ($0.31-0.34$), $SE = 0.03$, $p = 0.01$) across all three analyses. Results for aim 3 conducted with multiple linear regression are located Table 12. Results for aim 3 conducted with poisson regression and square root transformation of non-normal data are located in Table 13. Post hoc analyses for the poisson regression and square root transformations are located in Table 14.

Attention Problems. Self-reported attention problems significantly predicted MPS-total score ($\beta = 0.22 - 0.23$ ($0.16 - 0.17$), $SE = 0.10$, $p = 0.02$) in two out of the three analyses that included attention problems. In the analysis that included CT

performance, self-reported attention problems were approaching significance in predicting MPS-total score ($p = 0.10$).

Rule-Breaking Behavior. Self-reported rule-breaking behavior significantly predicted MPS-total score ($\beta = 0.31 - 0.33$ ($0.32 - 0.35$), $SE = 0.06$, $p = 0.01$) in all three analyses that self-reported rule-breaking behavior was included.

Aggressive Behavior. Self-reported aggressive behavior significantly predicted MPS-total score ($\beta = 0.20 - 0.23$ ($0.25 - 0.28$), $SE = 0.06$, $p = 0.01$) across all three analyses that included self-reported aggressive behavior.

Decision-Making Task.

Cups Task. Performance on the CT significantly predicted the MPS-total score ($\beta = 0.14$ (0.15), $SE = 0.07$, $p = 0.03$) in one out of the four analyses that included CT performance. However, CT was approaching significance ($p = 0.06 - 0.07$) in the other three analyses.

Game of Dice Task. Performance on the GDT did not significantly predict the MPS-total score ($p > 0.49$) across all four analyses that included GDT performance.

Iowa Gambling Task. Performance on the IGT did not significantly the MPS-total score ($p > 0.42$) across all four analyses that included IGT performance.

Discussion

The current study analyzed two theoretical models focused on risk-taking behavior, specifically problems from cannabis use and RSB, among a sample of adolescents at-risk for escalation of cannabis use. The study examined how externalizing symptoms, cannabis use, decision-making performance and the interactions of these variables were associated with RSB. In addition, an exploratory analysis was conducted

to determine how externalizing symptoms, decision-making tasks and the interaction of these variables were associated with problems from cannabis use. For each of the aims, several different patterns emerged. Generally, externalizing symptoms predicted RSB and problems from cannabis use. Amount of lifetime cannabis use and problems from cannabis use predicted RSB. Lastly, CTs performance predicted both RSB and problems from cannabis use. However, changes in GDT performance and amount of cannabis use over the past year predicted changes in RSB. Interaction effects emerged between externalizing symptoms and cannabis use, externalizing symptoms and decision-making performance, as well as between cannabis use and decision-making tasks. Several of the hypotheses were supported by the results of the study, however results that were inconsistent with the hypotheses also emerged.

Aim 1

Among the main effects for aim 1, which examined the effects of externalizing symptoms, cannabis use and decision-making abilities predicting RSB, self-report of externalizing symptoms, self-report of rule-breaking behavior, amount of lifetime cannabis use, problems from cannabis use, and the CT significantly predicted RSB. Some of hypothesis 1a was supported by the results; with the exception that only one decision-making task predicted RSB (as opposed to all decision-making tasks as hypothesized). Attention problems, aggressive behaviors, GDT performance and IGT performance did not significantly predict RSB. In regards to interaction effects for aim 1, interaction effects were revealed for predicting RSB between attention problems and problems from cannabis use, attention problems and GDT, amount of lifetime cannabis use and CT, problems from cannabis use and CT, as well as problems from cannabis use and GDT.

All other interactions did not significantly predict RSB. Hypothesis 1b was partially supported by the results, more specifically, not all interactions between lifetime amount of cannabis use/problems from cannabis use and externalizing symptoms with decision-making tasks predicted RSB. Furthermore, many of the interactions were not in the hypothesized direction. For example, among individuals who engaged in less risk-taking on the GDT, had the strongest positive relationship between problems from cannabis use and RSB.

When aim 1 analyses were conducted using poisson regression, the main effects remained relatively the same as when the analyses were conducted with multiple linear regression. Externalizing symptoms, rule-breaking behavior, amount of lifetime cannabis use, problems from cannabis use and cups task performance predicted RSB. However, many of the interaction effects (e.g., the interaction between problems from cannabis use and cups task performance) did not significantly predict RSB when poisson regression analyses were used. However, other interaction effects emerged which included interactions between externalizing symptoms and problems from cannabis use and rule-breaking behavior and amount of lifetime cannabis use. Specifically, more problems from cannabis use predicted more RSB, at all levels of externalizing symptoms. The strongest association between problems from cannabis use and RSB was at low levels of externalizing symptoms followed by average levels of externalizing symptoms. Additionally, amount of lifetime cannabis use significantly predicted RSB, at all levels of rule-breaking behavior. The strongest association between amount of lifetime cannabis use and RSB was at low levels of rule-breaking behavior followed by average levels of rule-breaking behavior.

Results are consistent with previous research studies that suggest more externalizing symptoms are associated with more RSB. Furthermore, among externalizing symptoms, more rule-breaking behavior was associated with more RSB. The results are not surprising, given several studies that suggest adults with childhood diagnosis of ADHD engage in earlier sex initiation, greater number of sexual partners and causal partners and more unplanned pregnancies compared to adults without a childhood diagnosis of ADHD and that the association is partial accounted for by comorbid externalizing disorders (like rule-breaking behavior; Flory et al., 2006). Another study found that a childhood diagnosis of ADHD was associated with more RSB during young adulthood (Barkley, Fischer, Smallish, & Fletcher, 2006). Our findings among adolescents who are at-risk for escalation of cannabis use are consistent with previous research results that suggest individuals with more externalizing symptoms are at-risk for engaging in more RSB compared to those with fewer symptoms of externalizing disorders.

Greater lifetime amount of cannabis use and more problems from cannabis use were associated with more RSB. Findings are consistent with the few studies that have documented the associations of cannabis use and RSB among adolescents. For example, several studies have found that sexual intercourse, having four or more lifetime partners, and not using a condom during the last sexual intercourse was associated with cannabis use (Lowry et al., 1994). Other studies have found that earlier initiation of cannabis use and a greater frequency of cannabis use is associated with a greater number of lifetime partners among high school students (Shrier, Emans, Woods, & DuRant, 1997). Importantly, individuals who begin cannabis use during adolescence compared to those

who begin in adulthood or never use cannabis have a greater risk of engaging in unprotected sex during adulthood (Agrawal et al., 2016). Generally, our findings are consistent with studies that have documented the associations between cannabis use and RSB among adults and adolescent.

More risk-taking (i.e., risk disadvantageous) during the CT was associated with more RSB. No studies, to our knowledge, have examined the relationship between CT performance and RSB. As previously mentioned, the CT was specifically designed to measure decision-making abilities in children and adolescents. Decision-making is one aspect of executive functioning. Thus, our findings are consistent with previous research findings that suggest poorer executive functioning is associated more RSB (Ross et al., 2016). Additionally, no studies, to our knowledge, have assessed the association between decision-making and RSB among a sample of adolescents. However, among a sample of young adults, performance on the IGT moderated the association between cannabis use and conduct disorder symptoms in predicting RSB (Ross et al., 2015; Schuster et al., 2012).

The interaction between problems from cannabis use and attention problems significantly predicted RSB. Specifically, at levels of less attention problems, there was a stronger association between problems from cannabis use and RSB compared to levels of average and high attention problems. At levels of high attention problems, the relationship between problems from cannabis use and RSB is non-significant or weaker compared to those with average or less attention problems. In other words, among individuals with no or minimal attention problems, more cannabis use problems more RSB. The association between problems from cannabis use and RSB was positive but

weaker at average levels of attention problems. These findings are consistent with previous research. For example, one study recently evaluated the association of ADHD and RSB among a sample of adolescents in the juvenile justice system. Problematic alcohol and cannabis use as well as conduct problems were examined as mediators in the association between ADHD and RSB. Results suggested that there was an association between ADHD and RSB; however the association was fully accounted for by problematic alcohol or cannabis use. Conduct problems did not mediate the relationship (Sarver et al., 2014). The sample of adolescents in the current study were recruited from the community and selected because they were at-risk for escalation in cannabis use compared to adolescents in the juvenile justice system from the Sarver and colleagues (2014) study. The Sarver and colleagues (2014) study also had a sample of adolescent with over 40% meeting diagnostic criteria for an externalizing disorder. Our sample of adolescents only contained a small number of adolescents with ADHD (<5%). Therefore, the findings from the current study extend the findings documented by Sarver and colleagues (2014) to include adolescents recruited from the community, who are primarily cannabis users and few meeting diagnostic criteria for an externalizing disorder.

One explanation for the interaction effects between attention problems and number of problems from cannabis use, is the well-documented social impairments often observed among individuals with ADHD (Bagwell, Molina, Pelham, & Hoza, 2001; Sibley, Evans, & Serpell, 2010). Several studies have determined that these social impairments transcends to romantic relationships during young adulthood (Canu & Carlson, 2007; Canu & Carlson, 2003; Canu, Tabor, Michael, Bazzini, & Elmore, 2014). Young adults with ADHD are viewed as less desirable by confederates (Canu & Carlson,

2003). These social impairments are one potential explanation for the results; it could be that it is more difficult for an individual with attention problems to find a sexual partner because they are viewed as less desirable.

Attention problems were negatively associated with RSB, however, only at low levels of risk-taking on the GDT. At high and average levels of risk-taking on the GDT, the association between attention problems and RSB was non-significant. These findings suggest that low levels of risk-taking may be protective for individuals with greater attention problems. This is consistent with previous research that suggests better decision-making (i.e., less risk-taking) performance may be protective against RSB among individuals with more conduct problems and who engage in greater amounts of cannabis use (Ross et al., 2015). As previously discussed, individuals with ADHD, characterized by impulsive behavior, exhibit more deficits in decision-making (Dekkers et al., 2016), perhaps better decision-making is associated with less impulsive behavior. Thus, another explanation for the negative relationship between attention problems and RSB, among individuals who engaged in less risk-taking on the GDT is that studies have shown that young adults with ADHD-inattentive subtype are viewed as less desirable by confederates and may experience romantic relationship impairment (Canu & Carlson, 2003). Attention problems measured by the Youth Self Report, although experienced by ADHD-inattentive type and ADHD-combined type, are rated higher by adolescents with ADHD-inattentive type compared to those with ADHD-combined type (Graetz, Sawyer, Hazell, Arney, & Baghurst, 2001). Furthermore, individuals with ADHD-combined subtype experience higher levels of impulsive behavior and engage in earlier and a greater number of sexual experiences (Canu & Carlson, 2007; Canu & Carlson, 2003).

Amount of lifetime cannabis use was positively associated with RSB, however, amount of lifetime cannabis use was only associated with RSB at levels of average and more risk-taking on the CT. At levels of low risk-taking on the CT, there was not a significant association between amount of lifetime cannabis use and RSB. This is further evidence that less risk-taking on decision-making tasks may be protective against engagement in RSB. As previously discussed, these results are similar to several studies that have documented cannabis use is associated with RSB, only at levels of poorer decision-making performance (Ross et al., 2015; Schuster et al., 2012). Specifically, one study found that greater amounts of recent cannabis use was associated with more overall RSB and negative consequences associated with RSB, however, only among individuals who performed worse on a decision-making task (IGT) among a sample of young adult cannabis users. The current study did not find any moderating effects with the IGT, but CT performance moderated the relationship between amount of lifetime cannabis use and RSB with a similar pattern to the previously mentioned study.

The results, when parent/caregiver report of externalizing behaviors was included in the analyses, were different compared to self-reported externalizing behaviors. Specifically, individuals who use more cannabis over their lifetime engaged in more RSB across all levels of risk-taking on the CT. However, the association between amount of cannabis use and RSB was strongest among individuals who were at levels of less risk-taking and weakest among individuals who were at levels of more risk-taking. The contradictory results may be due to the smaller sample size of the study that included parent/caregiver report of externalizing symptoms, perhaps led to decreased power in detecting effects.

The interaction between problems from cannabis use and CT significantly predicted RSB, similar to the pattern that emerged when amount of lifetime cannabis use was included as the measure of cannabis use. Specifically, at more and average levels of risk-taking on the CT, more problems from cannabis use were associated with more RSB. However, at low levels of risk-taking, there was no association between the problems from cannabis use and RSB. These findings suggest that less risk-taking may be protective against engaging in more RSB despite experiencing more problems from cannabis use.

Problems from cannabis use were associated with RSB, but varied depending on the GDT performance. Specifically, the relationship between problems from cannabis use and RSB was strongest for those with less risk-taking on the GDT and weakest for those who engaged in more risk-taking on the GDT. The interaction effects between GDT and problems from cannabis use in predicting RSB differed compared to the interaction effects of the CT and problems from cannabis use in predicting RSB. The CT and GDT are similar in that both tasks provide information about specific risks. However, there are several differences that may have led to divergent results between the two tasks. First, the CT has situations in which risk-taking is advantageous, which is not the case in the GDT. Second, the CT gains/losses are smaller amounts (in quarters) while the GDT gains/losses are in (\$100-\$1000). It may be the case that these contrasts between the tasks are related to the differences in the outcomes. Additionally, more risk-taking on the GDT may be protective or normative among adolescent cannabis users. However, further investigation is necessary to better understand why the results differ between the CT and GDT.

Aim 2

In regard to aim 2, more cannabis used over the past year and increases in risk-taking on the GDT predicted increases in RSB. However, changes in problems from cannabis use, changes in CT performance, changes in IGT performance and baseline levels of self-reported externalizing symptoms did not significantly predict changes in RSB. Part of hypothesis 2a was supported by the results, however changes in problems from cannabis use, CT, IGT performance and baseline levels of externalizing symptoms did not predict RSB.

These findings are different from the cross-sectional results in that changes in problems from cannabis use, changes in CT performance and baseline levels of externalizing symptoms did not predict changes in RSB. The sample size for aim 2 was substantially smaller than the previous results, which is one possible reason for the divergent results between aim 1 and aim 2. However, the results for aim 2 are preliminary evidence to warrant further investigation about the longitudinal associations between externalizing symptoms, cannabis use and decision-making performance predicting RSB.

Aim 3

Regarding aim 3, self-reported externalizing symptoms, attention problems, rule-breaking behavior, aggressive behavior and CT predicted problems from cannabis use. GDT and IGT performance did not predict problems from cannabis use. Interestingly, no interactions between externalizing symptoms and decision-making performance emerged in predicting problems from cannabis use. Part of hypothesis 3a was supported by the results, but not all decision-making tasks predicted RSB. Hypothesis 3b was not supported by the results.

Main effects for aim 3 were similar when these analyses were conducted with poisson regression compared to multiple linear regression. Externalizing symptoms, attention problems, rule-breaking behavior, and CT predicted problems from cannabis use. There were no significant interaction effects predicting problems from cannabis use when the analyses were conducted with multiple linear regression. However, when the analyses were conducted with poisson regression there were significant interactions between attention problems and CT performance as well as rule-breaking behavior and GDT performance predicting problems from cannabis use.

The findings from the current analyses are consistent with previous research that individuals with externalizing disorders are more likely to have a younger age of cannabis use initiation, more likely to meet diagnostic criteria for a cannabis use disorder at a younger age, and experience problems from cannabis use (Molina & Pelham, 2003; Sibley et al., 2014; Tarter et al., 2003). In the current study, externalizing symptoms, attention problems, rule-breaking behavior and aggressive behavior were all associated with problems from cannabis use. Additionally, risk-taking on the CT was associated with problems from cannabis use. Specifically, more risk disadvantageous choices on the CT was associated with more problems from cannabis use. This is also consistent with previous research studies that suggest poorer decision-making is associated with more problems from cannabis use (Gonzalez et al., 2012; Gonzalez et al., 2015). However, the IGT was not associated with problems from cannabis use, which has been shown in previous studies (Gonzalez et al., 2012; Gonzalez et al., 2015). The IGT was designed to assess decision-making among adults. Perhaps differences were not observed among adolescents in IGT performance for the current study because the IGT is not sensitive

enough to differentiate better versus poor decision-making among a sample of adolescents.

Limitations

There are several limitations to consider about the current study. First, participants in the current study were recruited to obtain a sample of adolescents who were at-risk for escalation of cannabis use. However, participants were excluded at baseline if there was a history of ADHD. Therefore, few participants met diagnostic criteria for an externalizing disorder (i.e., ADHD = 3.4%, ODD = 1.9% or CD = 8.3%). Furthermore, these findings may not be generalizable to adolescents with a diagnosed externalizing disorder. Children (Hoza et al., 2004), adolescents (Smith, Pelham Jr, Gnagy, Molina, & Evans, 2000) and young adults (Sibley et al., 2012) with externalizing disorders are poor reporters of their own competencies and symptoms. The current study utilized a self-report measure of externalizing symptoms and therefore may be less accurate compared to an informant report. The number of completed parent/caregiver report of externalizing symptoms (i.e., parent/caregiver report) was substantially smaller compared to the original sample size ($n = 97$). In addition, the longitudinal analyses had a relatively small sample size ($n = 61$). Future studies should examine main and interaction effects of baseline levels of externalizing symptoms, changes in decision-making performance and changes in cannabis use in predicting changes in RSB among a larger sample size.

Future Directions

Results from the current study warrant further examination, specifically evaluation of how changes in amount of cannabis use, changes in problems from

cannabis use, changes in decision-making performance, and externalizing symptoms are associated with changes in RSB among a larger sample of participants. A longitudinal analysis will help in our understanding of how these variables may influence RSB over time. Executive functioning includes many cognitive functions that were not included in the current study. Different executive functioning aspects, other than decision-making, may be relevant to RSB. For example, delay discounting, which is how much the value of a reward declines with different time delays before receiving the reward. Although, it may be that improvements in executive functioning or decreases in risk-taking through cognitive training among a sample of adolescent cannabis users may decrease RSB among a sample of at-risk adolescents. Further investigation into the reason for differences in risk-taking measured by the GDT and CT were observed. Future research studies should consider evaluating how gender may influence engagement in substance use and RSB given the well-documented pubertal brain development differences between male and female adolescents (Goddings, Mills, Clasen, Giedd, Viner & Blakemore, 2014).

Clinical Implications

Determining what neurocognitive factors predict or moderate predictors of RSB in a high-risk population of adolescents will inform future prevention and intervention efforts. For example, in the current study decision-making performance moderated the association between amount of lifetime cannabis use/problems from cannabis use and RSB. Overall, problems from cannabis use and more cannabis use was associated with RSB but only among those who had more and average risk disadvantageous choices on the CT. There was no association between cannabis use and RSB among those with less

risk disadvantageous choices on the CT. Future prevention and treatment programs may benefit from tailoring specifically to an adolescent's decision-making abilities. In other words, interventions for adolescents who engage in less risk-taking on the CT would focus on reducing cannabis use to reduce RSB. However, adolescents who engage in average and greater risk-taking on the CT may benefit from cognitive training strategies to improve decision-making abilities, which may in turn reduce engagement in RSB.

Generally, research on the effectiveness of intervention for adolescents have produced modest effect sizes (Jensen et al., 2011) and may benefit from incorporation of novel techniques in the development of interventions. As previously discussed, there are dramatic changes in brain development occurring during adolescence. Research that incorporates neurocognitive factors may improve the current intervention strategies for this age-group. Research in neuroscience has begun to focus on how to apply findings from neurocognitive and neuroimaging studies to clinical practice. Many frontline clinicians do not believe that neuroscience applies to their clinical practice. Recently, Feldstien-Ewing, Tapert, and Molina (2016) suggested a five-step process for the application of neuroscience research to enhancing clinical practice with the first step being to identify the area of treatment response that is desired to change. Improvement in executive functioning, including decision-making abilities, is one possible area to target treatment.

Unfortunately, there are few studies that have directly examined the impact different intervention strategies have on executive function. Goal Management Training in combination with mindfulness meditation is one effective approach at improving executive functioning among individuals who have experienced traumatic brain injuries

(Levine et al., 2011). Additionally, goal management training and mindfulness meditation have shown to improve decision-making and executive functioning among poly-substance users (Alfonso, Caracuel, Delgado-Pastor, & Verdejo-Garcia, 2011). No studies have evaluated the effectiveness of goal management training and mindfulness meditation among adolescents or to address risk-taking behavior. Thus, incorporation of these strategies in the prevention and treatment of risk-taking behavior among adolescents may result in more successful outcomes for youth.

REFERENCES

- Achenbach, T. M., & Rescorla, L. A. . (2007). *Multicultural Supplement to the Manual for the ASEBA School-Age Forms & Profiles*. Burlington, VT: University of Vermont Research Center for Children, Youth, and Families.
- Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for the ASEBA School-Age Forms & Profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families.
- Agrawal, A., Few, L., Nelson, E. C., Deutsch, A., Grant, J. D., Bucholz, K. K., . . . Lynskey, M. T. (2016). Adolescent cannabis use and repeated voluntary unprotected sex in women. *Addiction*, published online: July 2016. doi:10.1111/add.13490.
- Aklin, W. M., Lejuez, C., Zvolensky, M. J., Kahler, C. W., & Gwadz, M. (2005). Evaluation of behavioral measures of risk taking propensity with inner city adolescents. *Behaviour Research and Therapy*, 43(2), 215-228.
- Alfonso, J. P., Caracuel, A., Delgado-Pastor, L. C., & Verdejo-García, A. (2011). Combined goal management training and mindfulness meditation improve executive functions and decision-making performance in abstinent polysubstance abusers. *Drug and Alcohol Dependence*, 117(1), 78-81.
- Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review*, 16(1), 17-42.
- Bagwell, C. L., Molina, B. S., Pelham, W. E., & Hoza, B. (2001). Attention-deficit hyperactivity disorder and problems in peer relations: Predictions from childhood to adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry*, 40(11), 1285-1292.
- Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: constructing a unifying theory of ADHD. *Psychological Bulletin*, 121(1), 65.
- Barkley, R. A., Fischer, M., Smallish, L., & Fletcher, K. (2006). Young adult outcome of hyperactive children: Adaptive functioning in major life activities. *Journal of the American Academy of Child & Adolescent Psychiatry*, 45(2), 192-202.
- Bechara, A. (2005). Decision making, impulse control and loss of willpower to resist drugs: a neurocognitive perspective. *Nature Neuroscience*, 8(11), 1458-1463.
- Bechara, A., Damasio, A. R., Damasio, H., & Anderson, S. W. (1994). Insensitivity to future consequences following damage to human prefrontal cortex. *Cognition*, 50(1), 7-15.

- Bellis, M. A., Hughes, K., Calafat, A., Juan, M., Ramon, A., Rodriguez, J. A., . . . Phillips-Howard, P. (2008). Sexual uses of alcohol and drugs and the associated health risks: A cross sectional study of young people in nine European cities. *BMC Public Health*, 8(1), 1-11.
- Berg-Nielsen, T.S., Vika, A., & Dahl, A. A. (2003). When adolescents disagree with their mothers: CBCL-YSR discrepancies related to maternal depression and adolescent self-esteem. *Child: Care, Health and Development*, 29(3), 207-213.
- Berns, G. S., Moore, S., & Capra, C. M. (2009). Adolescent engagement in dangerous behaviors is associated with increased white matter maturity of frontal cortex. *PloS One*, 4(8), 1-12.
- Bidwell, L., Henry, E., Willcutt, E., Kinnear, M., & Ito, T. (2014). Childhood and current ADHD symptom dimensions are associated with more severe cannabis outcomes in college students. *Drug and Alcohol Dependence*, 135, 88-94.
- Biederman, J., Petty, C. R., Fried, R., Doyle, A. E., Spencer, T., Seidman, L. J., ... & Faraone, S. V. (2007). Stability of executive function deficits into young adult years: a prospective longitudinal follow-up study of grown up males with ADHD. *Acta Psychiatrica Scandinavica*, 116 (2), 129-136.
- Biglan, A., Brennan, P., Foster, S., Holder, H., Miller, T., & Cunningham, P. (2004). *Helping Adolescents at Risk: Prevention of Problem Behaviors*. New York, NY: Guilford Press.
- Biglan, A., Metzler, C. W., Wirt, R., Ary, D., Noell, J., Ochs, L., . . . Hood, D. (1990). Social and behavioral factors associated with high-risk sexual behavior among adolescents. *Journal of Behavioral Medicine*, 13(3), 245-261.
- Bolla, K. I., Brown, K., Eldreth, D., Tate, K., & Cadet, J. (2002). Dose-related neurocognitive effects of marijuana use. *Neurology*, 59(9), 1337-1343.
- Booth, R. E., & Zhang, Y. (1997). Conduct disorder and HIV risk behaviors among runaway and homeless adolescents. *Drug and Alcohol Dependence*, 48(2), 69-76.
- Bornovalova, M. A., Gwadz, M., Kahler, C. W., Aklin, W. M., & Lejuez, C. W. (2008). Sensation seeking and risk-taking propensity as mediators in the relationship between childhood abuse and HIV-related risk behavior. *Child Abuse and Neglect*, 32(1), 99-109.
- Brand, M., Fujiwara, E., Borsutzky, S., Kalbe, E., Kessler, J., & Markowitsch, H. J. (2005). Decision-making deficits of korsakoff patients in a new gambling task

- with explicit rules: Associations with executive functions. *Neuropsychology*, 19(3), 267-277.
- Brand, M., Grabenhorst, F., Starcke, K., Vandekerckhove, M. M., & Markowitsch, H. J. (2007). Role of the amygdala in decisions under ambiguity and decisions under risk: Evidence from patients with Urbach-Wiethe disease. *Neuropsychologia*, 45(6), 1305-1317.
- Brand, M., Kalbe, E., Kracht, L. W., Riebel, U., Münch, J., Kessler, J., & Markowitsch, H. J. (2004). Organic and psychogenic factors leading to executive dysfunctions in a patient suffering from surgery of a colloid cyst of the Foramen of Monro. *Neurocase*, 10(6), 420-425.
- Brand, M., Roth-Bauer, M., Driessen, M., & Markowitsch, H. J. (2008). Executive functions and risky decision-making in patients with opiate dependence. *Drug and Alcohol Dependence*, 97(1), 64-72.
- Bray, J. W., Zarkin, G. A., Ringwalt, C., & Qi, J. (2000). The relationship between marijuana initiation and dropping out of high school. *Health Economics*, 9(1), 9-18.
- Brodbeck, J., Matter, M., & Moggi, F. (2006). Association between cannabis use and sexual risk behavior among young heterosexual adults. *AIDS and Behavior*, 10(5), 599-605.
- Brown, L. K., Hadley, W., Stewart, A., Lescano, C., Whiteley, L., Donenberg, G., & DiClemente, R. (2010). Psychiatric disorders and sexual risk among adolescents in mental health treatment. *Journal of Consulting and Clinical Psychology*, 78(4), 590-597.
- Buckner, J. D., Ecker, A. H., & Cohen, A. S. (2010). Mental health problems and interest in marijuana treatment among marijuana-using college students. *Addictive Behaviors*, 35(9), 826-833.
- Buckner, J. D., & Zvolensky, M. J. (2014). Cannabis and related impairment: The unique roles of cannabis use to cope with social anxiety and social avoidance. *The American Journal on Addictions*, 23(6), 598-603.
- Buhi, E. R., & Goodson, P. (2007). Predictors of adolescent sexual behavior and intention: A theory-guided systematic review. *Journal of Adolescent Health*, 40(1), 4-21.
- Canu, W. H., & Carlson, C. L. (2007). Rejection sensitivity and social outcomes of young adult men with ADHD. *Journal of Attention Disorders*, 10(3), 261-275.

- Canu, W. H., & Carlson, G. L. (2003). Differences in heterosocial behavior and outcomes of ADHD-symptomatic subtypes in a college sample. *Journal of Attention Disorders*, 6(3), 123-133.
- Canu, W. H., Tabor, L. S., Michael, K. D., Bazzini, D. G., & Elmore, A. L. (2014). Young adult romantic couples' conflict resolution and satisfaction varies with partner's attention-deficit/hyperactivity disorder type. *Journal of Marital and Family Therapy*, 40(4), 509-524.
- Caspi, A., Moffitt, T. E., Cannon, M., McClay, J., Murray, R., Harrington, H., . . . Braithwaite, A. (2005). Moderation of the effect of adolescent-onset cannabis use on adult psychosis by a functional polymorphism in the catechol-O-methyltransferase gene: Longitudinal evidence of a gene X environment interaction. *Biological Psychiatry*, 57(10), 1117-1127.
- Chan, Y.-F., Dennis, M. L., & Funk, R. R. (2008). Prevalence and comorbidity of major internalizing and externalizing problems among adolescents and adults presenting to substance abuse treatment. *Journal of Substance Abuse Treatment*, 34(1), 14-24.
- Clark, L., Roiser, J., Robbins, T., & Sahakian, B. (2009). Disrupted 'reflection' impulsivity in cannabis users but not current or former ecstasy users. *Journal of Psychopharmacology*, 23(1), 14-22.
- Center for Disease Control and Prevention (2015). HIV surveillance report, 2014, 26.
- Cooper, M. L. (2002). Alcohol use and risky sexual behavior among college students and youth: Evaluating the evidence. *Journal of Studies on Alcohol and Drugs*(14), 101.
- Crane, N. A., Schuster, R. M., Mermelstein, R. J., & Gonzalez, R. (2015). Neuropsychological sex differences associated with age of initiated use among young adult cannabis users. *Journal of Clinical and Experimental Neuropsychology*, 37(4), 389-401.
- Crone, E. A., & Van Der Molen, M. W. (2004). Developmental changes in real life decision making: Performance on a gambling task previously shown to depend on the ventromedial prefrontal cortex. *Developmental Neuropsychology*, 25(3), 251-279.
- Dahl, R. E. (2004). Adolescent brain development: A period of vulnerabilities and opportunities. Keynote address. *Annals of New York Academy of Sciences*, 1021(1), 1-22.

- Damasio, A. R., Everitt, B., & Bishop, D. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex [and discussion]. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, 351(1346), 1413-1420.
- Darroch, J. E., Singh, S., & Frost, J. J. (2001). Differences in teenage pregnancy rates among five developed countries: the roles of sexual activity and contraceptive use. *Family Planning Perspectives*, 244-281.
- Day, A. M., Metrik, J., Spillane, N. S., & Kahler, C. W. (2013). Working memory and impulsivity predict marijuana-related problems among frequent users. *Drug and Alcohol Dependence*, 131(1), 171-174.
- Dekkers, T. J., Popma, A., van Rentergem, J. A. A., Bexkens, A., & Huizenga, H. M. (2016). Risky decision making in attention-deficit/hyperactivity disorder: A meta-regression analysis. *Clinical Psychology Review*, 45, 1-16.
- Derefinko, K. J., Peters, J. R., Eisenlohr-Moul, T. A., Walsh, E. C., Adams, Z. W., & Lynam, D. R. (2014). Relations between trait impulsivity, behavioral impulsivity, physiological arousal, and risky sexual behavior among young men. *Archives of Sexual Behavior*, 43(6), 1149-1158.
- Di Forti, M., Morgan, C., Dazzan, P., Pariante, C., Mondelli, V., Marques, T. R., . . . Paparelli, A. (2009). High-potency cannabis and the risk of psychosis. *The British Journal of Psychiatry*, 195(6), 488-491.
- Donenberg, G. R., Emerson, E., Bryant, F. B., Wilson, H., & Weber-Shiffrin, E. (2001). Understanding AIDS-risk behavior among adolescents in psychiatric care: Links to psychopathology and peer relationships. *Journal of the American Academy of Child & Adolescent Psychiatry*, 40(6), 642-653.
- Drechsler, R., Rizzo, P., & Steinhausen, H.-C. (2008). Decision-making on an explicit risk-taking task in preadolescents with attention-deficit/hyperactivity disorder. *Journal of Neural Transmission*, 115(2), 201-209.
- Elliott, R. (2003). Executive functions and their disorders: Imaging in clinical neuroscience. *British Medical Bulletin*, 65(1), 49-59.
- Ernst, M., Grant, S. J., London, E. D., Contoreggi, C. S., Kimes, A. S., & Spurgeon, L. (2003). Decision making in adolescents with behavior disorders and adults with substance abuse. *American Journal of Psychiatry*, 160(1), 33-40.
- Ernst, M., Luckenbaugh, D. A., Moolchan, E. T., Temple, V. A., Jenness, J., Korelitz, K. E., . . . Kimes, A. S. (2010). Decision-making and facial emotion recognition as

- predictors of substance-use initiation among adolescents. *Addictive Behaviors*, 35(3), 286-289.
- Feldstein Ewing, S. W., Houck, J. M., & Bryan, A. D. (2015). Neural activation during response inhibition is associated with adolescents' frequency of risky sex and substance use. *Addictive Behaviors*, 44, 80-87.
- Feldstein Ewing, S. W., Ryman, S. G., Gillman, A. S., Weiland, B. J., Thayer, R. E., & Bryan, A. D. (2015). Developmental cognitive neuroscience of adolescent sexual risk and alcohol use. *AIDS and Behavior*, 20(1), 97-108.
- Feldstein Ewing, S. W., Tapert, S. F., & Molina, B. S. (2016). Uniting adolescent neuroimaging and treatment research: Recommendations in pursuit of improved integration. *Neuroscience & Biobehavioral Reviews*, 62, 109-114.
- Flory, K., Molina, B.S.G., Pelham, W.E., Gnagy, E. & Smith, B. (2006). Childhood ADHD predicts risky sexual behavior in young adulthood. *Journal of Clinical Child and Adolescent Psychology*, 35(4), 571-577.
- Foster, K. T., Li, N., McClure, E. A., Sonne, S. C., & Gray, K. M. (2016). Gender differences in internalizing symptoms and suicide risk among men and women seeking treatment for cannabis use disorder from late adolescence to middle adulthood. *Journal of Substance Abuse Treatment*, 66, 16-22.
- Frisco, M. L. (2008). Adolescents' sexual behavior and academic attainment. *Sociology of Education*, 81(3), 284-311.
- Giancola, P. R., & Tarter, R. E. (1999). Executive cognitive functioning and risk for substance abuse. *Psychological Science*, 10(3), 203-205.
- Goddings, A.-L., Mills, K. L., Clasen, L. S., Giedd, J. N., Viner, R. M., & Blakemore, S. J. (2014). The influence of puberty on subcortical brain development. *Neuroimage*, 88, 242-251.
- Goldenberg, D., Telzer, E. H., Lieberman, M. D., Fuligni, A., & Galván, A. (2013). Neural mechanisms of impulse control in sexually risky adolescents. *Developmental Cognitive Neuroscience*, 6, 23-29.
- Golub, S. A., Starks, T. J., Kowalczyk, W. J., Thompson, L. I., & Parsons, J. T. (2012). Profiles of executive functioning: Associations with substance dependence and risky sexual behavior. *Psychology of Addictive Behaviors*, 26(4), 895.
- Gonzalez, R., Jacobus, J., Amatya, A. K., Quartana, P. J., Vassileva, J., & Martin, E. M. (2008). Deficits in complex motor functions, despite no evidence of procedural

- learning deficits, among HIV+ individuals with history of substance dependence. *Neuropsychology*, 22(6), 776.
- Gonzalez, R., Rippeth, J. D., Carey, C. L., Heaton, R. K., Moore, D. J., Schweinsburg, B. C., . . . Grant, I. (2004). Neurocognitive performance of methamphetamine users discordant for history of marijuana exposure. *Drug and Alcohol Dependence*, 76(2), 181-190.
- Gonzalez, R., Schuster, R. M., Mermelstein, R. J., Vassileva, J., Martin, E. M., & Diviak, K. R. (2012). Performance of young adult cannabis users on neurocognitive measures of impulsive behavior and their relationship to symptoms of cannabis use disorders. *Journal of Clinical and Experimental Neuropsychology*, 34(9), 962-976.
- Gonzalez, R., Schuster, R. M., Mermelstein, R. M., & Diviak, K. R. (2015). The role of decision-making in cannabis-related problems among young adults. *Drug and Alcohol Dependence*, 154, 214-221.
- Gonzalez, R., Vassileva, J., Bechara, A., Grbesic, S., Sworowski, L., Novak, R. M., . . . Martin, E. M. (2005). The influence of executive functions, sensation seeking, and HIV serostatus on the risky sexual practices of substance-dependent individuals. *Journal of the International Neuropsychological Society*, 11(2), 121-131.
- Graetz, B.W., Sawyer, M.G., Hazell, P.L., Arney, F., & Baghurst, P. (2001). Validity of DSM-IV subtypes in a nationally representative sample of Australian children and adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry*, 40, 1410-1417.
- Hall, W., & Degenhardt, L. (2009). Adverse health effects of non-medical cannabis use. *The Lancet*, 374(9698), 1383-1391.
- Harper, C., Dittus, P., & Ethier, K. (2016). Associations between marijuana use and 15 indicators of sexual risk and sexual health service use. *Journal of Adolescent Health*, 58(2), S109-S110.
- Hecimovic, K., Barrett, S. P., Darredeau, C., & Stewart, S. H. (2014). Cannabis use motives and personality risk factors. *Addictive Behaviors*, 39(3), 729-732.
- Hoza, B., Gerdes, A. C., Hinshaw, S. P., Arnold, L. E., Pelham Jr, W. E., Molina, B. S., . . . Hechtman, L. (2004). Self-perceptions of competence in children with ADHD and comparison children. *Journal of Consulting and Clinical Psychology*, 72(3), 382.

- Jensen, C. D., Cushing, C. C., Aylward, B. S., Craig, J. T., Sorell, D. M., & Steele, R. G. (2011). Effectiveness of motivational interviewing interventions for adolescent substance use behavior change: A meta-analytic review. *Journal of Consulting and Clinical Psychology, 79*(4), 433.
- Johnston, L. D., O'Malley, P. M., Miech, R. A., Bachman, J. G., & Schulenberg, J. E. (2014). Monitoring the future national results on drug use 1975-2013: Overview key findings on adolescent drug use. Ann Arbor, MI: Institute for Social Research, The University of Michigan.
- Kann, L., Kinchen, S., Shanklin, S. L., Flint, K. H., Kawkins, J., Harris, W. A., . . . Chyen, D. (2014). Youth risk behavior surveillance-United States, 2013. *MMWR: Surveillance Summaries, 63*(4), 1-168.
- Khurana, A., Romer, D., Betancourt, L. M., Brodsky, N. L., Giannetta, J. M., & Hurt, H. (2012). Early adolescent sexual debut: The mediating role of working memory ability, sensation seeking, and impulsivity. *Developmental Psychology, 48*(5), 1416-1428.
- Khurana, A., Romer, D., Betancourt, L. M., Brodsky, N. L., Giannetta, J. M., & Hurt, H. (2015). Stronger working memory reduces sexual risk taking in adolescents, even after controlling for parental influences. *Child Development, 86*(4), 1125-1141.
- Kost, K., & Henshaw, S. (2012). US teenage pregnancies, births and abortion, 2008: National trends by age, race and ethnicity. New York, NY: Guttmacher Institute.[Online]. <http://www.guttmacher.org/pubs/USTPtrends08.pdf>, accessed June, 6, 2016.
- Kotchick, B. A., Shaffer, A., Miller, K. S., & Forehand, R. (2001). Adolescent sexual risk behavior: A multi-system perspective. *Clinical Psychology Review, 21*(4), 493-519.
- Kuin, N., Masthoff, E., Kramer, M., & Scherder, E. (2015). The role of risky decision-making in aggression: A systematic review. *Aggression and Violent Behavior, 25*, 159-172.
- Lamers, C., Bechara, A., Rizzo, M., & Ramaekers, J. (2006). Cognitive function and mood in MDMA/THC users, THC users and non-drug using controls. *Journal of Psychopharmacology, 20*(2), 302-311.
- Leichliter, J. S., Chandra, A., Liddon, N., Fenton, K. A., & Aral, S. O. (2007). Prevalence and correlates of heterosexual anal and oral sex in adolescents and adults in the United States. *Journal of Infectious Diseases, 196*(12), 1852-1859.

- Lejuez, C., Aklin, W., Daughters, S., Zvolensky, M., Kahler, C., & Gwadz, M. (2007). Reliability and validity of the youth version of the Balloon Analogue Risk Task (BART-Y) in the assessment of risk-taking behavior among inner-city adolescents. *Journal of Clinical Child and Adolescent Psychology*, 36(1), 106-111.
- Lejuez, C. W., Read, J. P., Kahler, C. W., Richards, J. B., Ramsey, S. E., Stuart, G. L., Strong, D. R., & Brown, R. A. . (2002). Evaluation of a behavioral measure of risk taking: The Balloon Analogue Risk Task (BART). *Journal of Experimental Psychology: Applied*, 8(2), 75-84.
- Lejuez, C. W., Simmons, B.L., Aklin, W.M., Daughters, S.B., & Dvir, S. . (2004). Risk-taking propensity and risky sexual behavior of individuals in residential substance use treatment. *Addictive Behaviors*, 29, 1643-1647.
- Levin, I. P., & Hart, S. S. (2003). Risk preferences in young children: Early evidence of individual differences in reaction to potential gains and losses. *Journal of Behavioral Decision Making*, 16(5), 397-413.
- Levin, I. P., Hart, S. S., Weller, J. A., & Harshman, L. A. (2007). Stability of choices in a risky decision-making task: A 3-year longitudinal study with children and adults. *Journal of Behavioral Decision Making*, 20(3), 241-252.
- Levin, I. P., Weller, J. A., Pederson, A., & Harshman, L. A. (2007). Age-related differences in adaptive decision making: Sensitivity to expected value in risky choice. *Judgment and Decision Making*, 2(4), 225-233.
- Levine, B., Schweizer, T. A., O'Connor, C., Turner, G., Gillingham, S., Stuss, D. T., ... & Robertson, I. H. (2011). Rehabilitation of executive functioning in patients with frontal lobe brain damage with goal management training. *Frontiers in Human Neuroscience*, 5 (9), 1-9.
- Li, X., Lu, Z. L., D'Argembeau, A., Ng, M., & Bechara, A. (2010). The Iowa gambling task in fMRI images. *Human Brain Mapping*, 31(3), 410-423.
- Lopez-Quintero, C., Cobos, J. P. d. l., Hasin, D. S., Okuda, M., Wang, S., Grant, B. F., & Blanco, C. (2011). Probability and predictors of transition from first use to dependence on nicotine, alcohol, cannabis, and cocaine: Results of the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). *Drug and Alcohol Dependence*, 115(1), 120-130.
- Lowry, R., Holtzman, D., Truman, B. I., Kann, L., Collins, J. L., & Kolbe, L. J. (1994). Substance use and HIV-related sexual behaviors among US high school students: Are they related? *American Journal of Public Health*, 84(7), 1116-1120.

- Lynskey, M., & Hall, W. (2000). The effects of adolescent cannabis use on educational attainment: A review. *Addiction*, 95(11), 1621-1630.
- Malloy, P., Bihrlle, A., Duffy, J., & Cimino, C. (1993). The orbitomedial frontal syndrome. *Archives of Clinical Neuropsychology*, 8(3), 185-201.
- Masterman, D. L., & Cummings, J. L. (1997). Frontal-subcortical circuits: the anatomic basis of executive, social and motivated behaviors. *Journal of Psychopharmacology*, 11(2), 107-114.
- Meier, M. H., Caspi, A., Ambler, A., Harrington, H., Houts, R., Keefe, R. S., . . . Moffitt, T. E. (2012). Persistent cannabis users show neuropsychological decline from childhood to midlife. *Proceedings of the National Academy of Sciences*, 109(40), 2657-2664.
- Miller, B. C., & Moore, K. A. (1990). Adolescent sexual behavior, pregnancy, and parenting: Research through the 1980s. *Journal of Marriage and the Family*, 52(4), 1025-1044.
- Molina, B. S., & Pelham Jr, W. E. (2003). Childhood predictors of adolescent substance use in a longitudinal study of children with ADHD. *Journal of Abnormal Psychology*, 112(3), 497.
- Molina, B. S. G., & Pelham, W. E., Jr. (2003). Childhood predictors of adolescent substance use in a longitudinal study of children with ADHD. *Journal of Abnormal Psychology*, 112(3), 497-507. doi:10.1037/0021-843X.112.3.497
- Molina, B. S. G., Bukstein, O. G., & Lynch, K. G. . (2002). Attention-deficit/hyperactivity disorder and conduct disorder symptomatology in adolescents with alcohol use disorder. *Psychology of Addictive Behaviors*, 16(2), 161-164.
- Nydegger, L. A., Ames, S. L., Stacy, A. W., & Grenard, J. L. (2014). Response inhibition moderates the association between drug use and risky sexual behavior. *Substance Use & Misuse*, 49(11), 1457-1464.
- Nydegger, L. A., Keeler, A. R., Hood, C., Siegel, J. T., & Stacy, A. W. (2013). Effects of a one-hour intervention on condom implementation intentions among drug users in Southern California. *AIDS Care*, 25(12), 1586-1591.
- Pfeifer, J. H., & Allen, N. B. (2012). Arrested development? Reconsidering dual-systems models of brain function in adolescence and disorders. *Trends in Cognitive Sciences*, 16(6), 322-329.

- Price, T.S., Simonoff, E., Asherson, P., Curran, S., Kuntsi, J., Waldman, I., & Plomin, R. (2005). Continuity and change in preschool ADHD symptoms: Longitudinal genetic analysis with contrast effects, *Behavior Genetics*, 35 (2), 121-132. doi:10.1007/s10519-004-1013-x
- Ramrakha, S., Bell, M. L., Paul, C., Dickson, N., Moffitt, T. E., & Caspi, A. (2007). Childhood behavior problems linked to sexual risk taking in young adulthood: A birth cohort study. *Journal of the American Academy of Child & Adolescent Psychiatry*, 46(10), 1272-1279.
- Rippeth, J. D., Heaton, R. K., Carey, C. L., Marcotte, T. D., Moore, D. J., Gonzalez, R., . . . Grant, I. (2004). Methamphetamine dependence increases risk of neuropsychological impairment in HIV infected persons. *Journal of the International Neuropsychological Society*, 10(01), 1-14.
- Romer, D. (2010). Adolescent risk taking, impulsivity, and brain development: Implications for prevention. *Developmental Psychobiology*, 52(3), 263-276.
- Ross, J. M., Coxe, S., Schuster, R. M., Rojas, A., & Gonzalez, R. (2015). The moderating effects of cannabis use and decision making on the relationship between conduct disorder and risky sexual behavior. *Journal of Clinical and Experimental Neuropsychology*, 37(3), 303-315.
- Ross, J. M., Duperrouzel, J., Vega, M., & Gonzalez, R. (2016). The Neuropsychology of Risky Sexual Behavior. *Journal of the International Neuropsychological Society*, 22(6), 586-594.
- Rostosky, S. S., Wilcox, B. L., Wright, M. L. C., & Randall, B. A. (2004). The impact of religiosity on adolescent sexual behavior: A review of the evidence. *Journal of Adolescent Research*, 19(6), 677-697.
- Substance Abuse and Mental Health Services Administration (2014). Results from the 2013 national survey on drug use and health: Summary of national findings, NSDUH Series H-48, HHS Publication No. 14-4863. Rockville, MD: Substance Abuse and Mental Health Services Administration.
- Santelli, J. S., Brener, N. D., Lowry, R., Bhatt, A., & Zabin, L. S. (1998). Multiple sexual partners among US adolescents and young adults. *Family Planning Perspectives*, 271-275.
- Sarver, D. E., McCart, M. R., Sheidow, A. J., & Letourneau, E. J. (2014). ADHD and risky sexual behavior in adolescents: Conduct problems and substance use as mediators of risk. *Journal of Child Psychology and Psychiatry*, 55(12), 1345-1353.

- Satterwhite, C. L., Torrone, E., Meites, E., Dunne, E. F., Mahajan, R., Ocfemia, M. C. B., . . . Weinstock, H. (2013). Sexually transmitted infections among US women and men: prevalence and incidence estimates, 2008. *Sexually Transmitted Diseases*, 40(3), 187-193.
- Schuster, R. M., Crane, N.A., Mermelstein, R., & Gonzalez, R. (2012). The influence of inhibitory control and episodic memory on the risky sexual behavior of young adult cannabis users. *Journal of International Neuropsychology*, 18(5), 827-833.
- Shrier, L. A., Emans, S. J., Woods, E. R., & DuRant, R. H. (1997). The association of sexual risk behaviors and problem drug behaviors in high school students. *Journal of Adolescent Health*, 20(5), 377-383.
- Sibley, M. H., Evans, S. W., & Serpell, Z. N. (2010). Social cognition and interpersonal impairment in young adolescents with ADHD. *Journal of Psychopathology and Behavioral Assessment*, 32(2), 193-202.
- Sibley, M. H., Pelham Jr, W. E., Molina, B. S., Coxe, S., Kipp, H., Gnagy, E. M., . . . Lahey, B. B. (2014). The role of early childhood ADHD and subsequent CD in the initiation and escalation of adolescent cigarette, alcohol, and marijuana use. *Journal of Abnormal Psychology*, 123(2), 362.
- Sibley, M. H., Pelham Jr, W. E., Molina, B. S., Gnagy, E. M., Waxmonsky, J. G., Waschbusch, D. A., . . . Babinski, D. E. (2012). When diagnosing ADHD in young adults emphasize informant reports, DSM items, and impairment. *Journal of Consulting and Clinical Psychology*, 80(6), 1052.
- Smith, B. H., Pelham Jr, W. E., Gnagy, E., Molina, B., & Evans, S. (2000). The reliability, validity, and unique contributions of self-report by adolescents receiving treatment for attention-deficit/hyperactivity disorder. *Journal of Consulting and Clinical Psychology*, 68(3), 489.
- Sourander, A., Helstelä, L., & Helenius, H. (1999). Parent-adolescent agreement on emotional and behavioral problems. *Social Psychiatry and Psychiatric Epidemiology*, 34(12), 657-663.
- Spear, L. P. (2000). The adolescent brain and age-related behavioral manifestations. *Neuroscience & Biobehavioral Reviews*, 24(4), 417-463.
- Spinella, M. (2007). The role of prefrontal systems in sexual behavior. *International Journal of Neuroscience*, 117(3), 369-385.
- Spriggs, A. L. H., C.T. (2008). Timing of sexual debut and initiation of postsecondary education by early adulthood. *Perspectives on Sexual and Reproductive Health*, 40(3), 152-161. doi:10.1363/4015208

- Squeglia, L. M., Jacobus, J., Brumback, T., Meloy, M., & Tapert, S. F. (2014). White matter integrity in alcohol-naïve youth with a family history of alcohol use disorders. *Psychological Medicine*, 44(13), 2775-2786.
- Starkstein, S. E., & Robinson, R. G. (1997). Mechanism of disinhibition after brain lesions. *The Journal of Nervous and Mental Disease*, 185(2), 108-114.
- Steinberg, L. (2004). Risk taking in adolescence: What changes, and why? *Annals of New York Academy of Sciences*, 1021, 51-58. doi:10.1196/annals.1308.005
- Steinberg, L. (2007). Risk taking in adolescence new perspectives from brain and behavioral science. *Current Directions in Psychological Science*, 16(2), 55-59.
- Steinberg, L. (2010). Commentary: A behavioral scientist looks at the science of adolescent brain development. *Brain and Cognition*, 72(1), 160.
- Stephens, R. S., Roffman, R. A., & Curtin, L. (2000). Comparison of extended versus brief treatments for marijuana use. *Journal of Consulting and Clinical Psychology*, 68(5), 898.
- Stuss, D. T., & Levine, B. (2002). Adult clinical neuropsychology: Lessons from studies of the frontal lobes. *Annual Review of Psychology*, 53(1), 401-433.
- Tait, R. J., Mackinnon, A., & Christensen, H. (2011). Cannabis use and cognitive function: 8-year trajectory in a young adult cohort. *Addiction*, 106(12), 2195-2203.
- Tamm, L., Epstein, J. N., Lisdahl, K. M., Molina, B., Tapert, S., Hinshaw, S. P., . . . Swanson, J. M. (2013). Impact of ADHD and cannabis use on executive functioning in young adults. *Drug and Alcohol Dependence*, 133(2), 607-614.
- Tang, Y. Y., Yang, L., Leve, L. D., & Harold, G. T. (2012). Improving executive function and its neurobiological mechanisms through a mindfulness-based intervention: advances within the field of developmental neuroscience. *Child Development Perspectives*, 6(4), 361-366.
- Tapert, S. F., Aarons, G. A., Sedlar, G. R., & Brown, S. A. (2001). Adolescent substance use and sexual risk-taking behavior. *Journal of Adolescent Health*, 28(3), 181-189.
- Tapert, S. F., Granholm, E., Leedy, N. G., & Brown, S. A. (2002). Substance use and withdrawal: Neuropsychological functioning over 8 years in youth. *Journal of the International Neuropsychological Society*, 8(07), 873-883.

- Tarter, R. E. (2002). Etiology of adolescent substance abuse: A developmental perspective. *The American Journal on Addictions, 11*(3), 171-191.
- Tarter, R. E., Kirisci, L., Habeych, M., Reynolds, M., & Vanyukov, M. (2004). Neurobehavior disinhibition in childhood predisposes boys to substance use disorder by young adulthood: Direct and mediated etiologic pathways. *Drug and Alcohol Dependence, 73*(2), 121-132.
- Tarter, R. E., Kirisci, L., Mezzich, A., Cornelius, J. R., Pajer, K., Vanyukov, M., . . . Clark, D. (2003). Neurobehavioral disinhibition in childhood predicts early age at onset of substance use disorder. *American Journal of Psychiatry, 160*(6), 1078-1085.
- Tekin, S., & Cummings, J. L. (2002). Frontal-subcortical neuronal circuits and clinical neuropsychiatry: An update. *Journal of Psychosomatic Research, 53*(2), 647-654.
- Thorell, L. B., & Wåhlstedt, C. (2006). Executive functioning deficits in relation to symptoms of ADHD and/or ODD in preschool children. *Infant and Child Development, 15*(5), 503-518.
- Toplak, M. E., Jain, U., & Tannock, R. (2005). Executive and motivational processes in adolescents with attention-deficit-hyperactivity disorder (ADHD). *Behavioral and Brain Functions, 1*(1), 8.
- Wardle, M. C., Gonzalez, R., Bechara, A., & Martin-Thormeyer, E. M. (2010). Iowa Gambling Task performance and emotional distress interact to predict risky sexual behavior in individuals with dual substance and HIV diagnoses. *Journal of Clinical and Experimental Neuropsychology, 32*(10), 1110-1121.
- Weinstock, H., Berman, S., & Cates, W. (2004). Sexually transmitted diseases among American youth: Incidence and prevalence estimates, 2000. *Perspectives on Sexual and Reproductive Health, 36*(1), 6-10.
- Weller, J. A., Levin, I. P., Shiv, B., & Bechara, A. (2009). The effects of insula damage on decision-making for risky gains and losses. *Social Neuroscience, 4*(4), 347-358.
- Whitlow, C. T., Liguori, A., Brooke Livengood, L., Hart, S. L., Mussat-Whitlow, B. J., Lamborn, C. M., . . . Porrino, L. J. (2004). Long-term heavy marijuana users make costly decisions on a gambling task. *Drug and Alcohol Dependence, 76*(1), 107-111.
- Willcutt, E. G., Doyle, A. E., Nigg, J. T., Faraone, S. V., & Pennington, B. F. (2005). Validity of the executive function theory of attention-deficit/hyperactivity disorder: A meta-analytic review. *Biological Psychiatry, 57*(11), 1336-1346.

- Willoughby, T., Good, M., Adachi, P. J., Hamza, C., & Tavernier, R. (2013). Examining the link between adolescent brain development and risk taking from a social–developmental perspective. *Brain and Cognition*, 83(3), 315-323.
- Xue, G., Lu, Z., Levin, I. P., & Bechara, A. (2010). The impact of prior risk experiences on subsequent risky decision-making: the role of the insula. *Neuroimage*, 50(2), 709-716.
- Xue, G., Lu, Z., Levin, I. P., Weller, J. A., Li, X., & Bechara, A. (2009). Functional dissociations of risk and reward processing in the medial prefrontal cortex. *Cerebral Cortex*, 19(5), 1019-1027.
- Zalesky, A., Solowij, N., Yücel, M., Lubman, D. I., Takagi, M., Harding, I. H., . . . Pantelis, C. (2012). Effect of long-term cannabis use on axonal fibre connectivity. *Brain*, 135(7), 2245-2255.

APPENDICES

Table 1: Summary of studies assessing relationships between neuropsychological functioning and RSB

Study	Sample Size	Age	Sample Characteristics	Neurocognitive Measures	Neurocognitive Functions Assessed	Measure of Risky Sexual Behavior	Outcomes
Aklin, Lejuez, Zvolensky, Kahler, & Gwadz, 2005	N = 51	M = 14.8 (9 th – 12 th grade)	Male = 51% African American/black = 98%	BART-Y	Risk-taking	Sex without a condom	Risk-taking not related to condom use
Bornovalova, Gwadz, Kahler, Aklin & Lejuez, 2008	N = 96	13 – 18	Male = 52% African American/black = 100%	BART-Y	Risk-taking	Sex without a condom	Risk-taking mediated relationship between physical, emotional and sexual abuse with HIV risk behavior which included sex without a condom
Derefinko et al., 2014	N = 135	17-26	Male = 100% Race/ethnicity not reported	BART, Go/No-Go Task	Risk-taking and inhibitory control	Total number of partners, number of times had sex with a stranger, sex without a condom use	Risk-taking associated with number of partners and ever having sex with a stranger
Golub, Starks, Kowalczyk, Thompson, & Parsons, 2012	N = 130	M = 30	Male = 100% Non-Hispanic white = 38% Gay or bisexual = 100% Substance users = 100%	Counting Span, Wisconsin Card Sorting Task, Go/No-Go Task, IGT and IGT-variant	Executive Function Profiles (i.e., low on all measures, high on all measures and low only on IGT)	Number of anal sex acts, number of times had unprotected anal sex or had sex with HIV serdiscordant main partner	Low performing group had higher numbers of high risk sex acts and high risk sex acts under the influence compared to low IGT group

Gonzalez et al., 2005	N = 263	M = 44.1	Male = 87% African American/black = 91% Met criteria for substance dependence or abuse = 97% HIV + = 41%	IGT, delayed non-matching to sample, stroop task—reaction time version	Decision-making, working memory, inhibitory control	Total score calculated with variables like frequency of condom use, number of partners, number of times paid for sex, etc.	HIV+ status, sensation seeking and better decision-making associated with RSB
Khurana, Romer, Betancourt, Brodsky, Ginnetta & Hurt, 2012	N = 347	10-12 years old at baseline, follow-up assessment 3 and 4 fours years later	Male = 48% Non-Hispanic white = 55%	Digit Span, Corsi Block, Tapping, Letter two-back, Object two-back, Spatial working memory	Working Memory, Impulsivity-acting without thinking and temporal discounting, sensation seeking	Age of sex initiation	Working memory and impulsivity were associated with age of sexual debut
Khurana, Romer, Betancourt, Brodsky, Ginnetta & Hurt, 2015	N = 387	9-12 years old at baseline, follow-up assessment 3 and 4 fours years later	Male = 48% Non-Hispanic white = 56%	Corsi block tapping, Digit span backwards, Object two-back, Spatial working memory	Working memory, acting without thinking and inability to delay gratification, sensation seeking	Ever had vaginal sex and vaginal sex without a condom	Weak working memory predicts more RSB, even when parental influence is controlled
Lejuez et al., 2007	N = 98	M = 14.8 (9 th – 12 th grade)	Male = 52% African American/black = 100%	BART-Y	Risk-taking	Sex without a condom	Risk-taking was associated with risk composite score that included having sex without a condom

Lejuez et al., 2002	N = 86	18-25	Male = 50% Non-Hispanic white = 75%	BART	Risk-taking	Sex without a condom	Risk-taking associated with having sex without a condom
Lejuez et al., 2004	N = 76	21-58	Male = 76% African American/black = 91% In-patient at substance use residential treatment center = 100%	BART	Risk-taking	Sex without a condom	Risk-taking related to RSB
Nydegger, Ames, Stacy & Grenard, 2014	N = 196	M = 31.26	Male = 67% Hispanic = 55% Drug diversion clients = 100%	Go/No-Go Task	Inhibitory control	Sex without a condom	Greater drug use problems predicted more RSB, however, only among those with poorer inhibitory control
Ross, Coxe, Schuster, Rojas & Gonzalez, 2015	N = 79	17-24	Male = 64% Non-Hispanic white = 48%	IGT	Decision-making	Age of vaginal sex initiation and number of oral sex partners	Poorer decision- making and more cannabis use moderated the relationship between more conduct disorder symptoms and more RSB .

Schuster, Crane, Mermelstein & Gonzalez, 2012	N = 66	M = 20.77	Male = 62% Non-Hispanic white = 38% Cannabis users = 100%	Hopkins Verbal Learning Test, IGT, BART, GoStop Task, Monetary Choice Questionnaire	Memory, decision-making, risk-taking, inhibitory control, delayed discounting	Number of STIs and unplanned pregnancies	Greater cannabis use and poorer performance on the IGT and BART associated with more RSB
Wardle, Gonzalez, Bechara, & Martin-Thormeyer, 2010	N = 190	M = 43.53	Male = 79% African American/black = 93% Met criteria for substance dependence or abuse = 100% HIV + = 100%	IGT, delayed non-matching to sample, stroop task—reaction time version	Decision-making, working memory, inhibitory control	Total score calculated with variables like frequency of condom use, number of partners, number of times paid for sex, etc.	Greater emotional distress and more sensation seeking was associated with more RSB but only among those with better decision-making

Note: IGT = Iowa Gambling Task, BART = Balloon Analog Risk-Taking Task, BART-Y= Balloon Analog Risk-Taking Task-Youth Version, RSB = risky sexual behavior.

Table 2: Participant characteristics for aim 1

	<i>n = 204</i>
Age	15.49 (0.68)
Years of Education	9.26 (0.86)
Years of Education (Mother)	14.14 (2.41)
WRAT-4 Reading Standard Score	107.94 (14.46)
Ethnicity/race (%)	
Hispanic/Latino	72.8
Caucasian	2.9
African-American	4.4
More than one race	18.6
Other	0.5
Male (%)	54.9
Amount of Lifetime Nicotine (cigarettes; MD, IQR)	0 (0, 3)
Amount of Lifetime Alcohol (1 serving; MD, IQR)	10 (1, 65.5)
Amount of Lifetime Cannabis (g; MD, IQR)	8.05 (0.51, 81.8)
Ever Used Cannabis (%)	79.9
Used Cannabis in Past Month (%)	55.4
Used Cannabis in Past Six Months (%)	74.0
Used Cannabis in Past Year (%)	77.5
Ever Used Alcohol (%)	84.3
Ever Used Nicotine (%)	44.6
Ever Used Other Drugs (%)	33.5
Marijuana Problems Scale Total Score	3.05 (3.84)
Iowa Gambling Task (total net)	-1.37 (23.71)
Cups Task (number of risk disadvantageous choices)	9.90 (4.00)
Cups Task Total Risky Choices	33.93 (10.84)
Game of Dice Task (risky choices)	7.72 (5.20)
Risky Sexual Behavior Questionnaire Total Score	4.06 (5.59)
Ever had oral sex (%)	60.3
Ever had vaginal sex (%)	44.8
Ever had anal sex (%)	7.4
Externalizing Problems Total Score	14.03 (8.05)
Attention Problems Total Score	4.62 (2.79)
Rule-Breaking Behavior Total Score	7.53 (4.06)
Aggressive Behavior Total Score	6.49 (4.69)
Current Panic Disorder Diagnosis (%)	1.0
Current Generalized Anxiety Disorder Diagnosis (%)	1.0
Current Obsessive Compulsive Disorder Diagnosis (%)	4.4
Current Major Depression Diagnosis (%)	0.5
Current ADHD Diagnosis (%)	3.4
Current ODD Diagnosis (%)	1.9
Current Conduct Disorder Diagnosis (%)	8.3
Current Cannabis Abuse Diagnosis (%)	11.7
Current Cannabis Dependence Diagnosis (%)	2.9
Current Alcohol Abuse Diagnosis (%)	1.0
Current Alcohol Dependence Diagnosis (%)	1.0
Current Other Drug Abuse Diagnosis (%)	0
Current Other Drug Dependence Diagnosis (%)	0

Note: All values are means and standard deviations unless otherwise specified. WRAT = Word Reading Achievement Test, MD = median, IQR = interquartile range, ADHD = attention deficit hyperactivity disorder, ODD = oppositional defiant disorder.

Table 3: Participant characteristics for individuals who had a completed CBCL (aim 1)

	<i>n = 97</i>
Age	15.42 (0.70)
Years of Education	9.15 (0.83)
Years of Education (Mother)	14.46 (2.38)
WRAT-4 Reading Standard Score	109.43 (16.13)
Ethnicity/race (%)	
Hispanic/Latino	67
Caucasian	5.2
African-American	4.1
More than one race	22.7
Other	1.0
Male (%)	58.8
Amount of Lifetime Nicotine (cigarettes; MD, IQR)	0 (0, 1)
Amount of Lifetime Alcohol (1 serving; MD, IQR)	10 (1, 49.5)
Amount of Lifetime Cannabis (g; MD, IQR)	7.6 (0.25, 81.8)
Ever Used Cannabis (%)	78.4
Used Cannabis in Past Month (%)	55.7
Used Cannabis in Past Six Months (%)	75.3
Used Cannabis in Past Year (%)	77.3
Ever Used Alcohol (%)	83.5
Ever Used Nicotine (%)	33.0
Ever Used Other Drugs (%)	28.9
Marijuana Problems Scale Total Score	3.37 (4.57)
Iowa Gambling Task (total net)	-3.40 (22.36)
Cups Task (number of risk disadvantageous choices)	10.40 (3.69)
Cups Task Total Risky Choices	35.05 (9.47)
Game of Dice Task (risky choices)	7.43 (5.12)
Risky Sexual Behavior Questionnaire Total Score	3.63 (5.77)
Ever had oral sex (%)	50.5
Ever had vaginal sex (%)	36.1
Ever had anal sex (%)	7.2
Externalizing Problems Total Score (Parent report)	5.65 (6.56)
Attention Problems Total Score (Parent report)	2.93 (3.26)
Rule-Breaking Behavior Total Score (Parent report)	2.06 (2.87)
Aggressive Behavior Total Score (Parent report)	3.59 (4.05)
Externalizing Problems Total Score	14.46 (8.27)
Attention Problems Total Score	4.82 (2.82)
Rule-Breaking Behavior Total Score	7.72 (4.18)
Aggressive Behavior Total Score	6.71 (4.70)
Current Panic Disorder Diagnosis (%)	0.00
Current Generalized Anxiety Disorder Diagnosis (%)	0.00
Current Obsessive Compulsive Disorder Diagnosis (%)	6.20
Current Major Depression Diagnosis (%)	0.00
Current ADHD Diagnosis (%)	2.10
Current ODD Diagnosis (%)	3.10
Current Conduct Disorder Diagnosis (%)	9.30
Current Cannabis Abuse Diagnosis (%)	9.30
Current Cannabis Dependence Diagnosis (%)	2.10
Current Alcohol Abuse Diagnosis (%)	2.10
Current Alcohol Dependence Diagnosis (%)	0.00
Current Other Drug Abuse Diagnosis (%)	0.00
Current Other Drug Dependence Diagnosis (%)	0.00

Note: All values are means and standard deviations unless otherwise specified. WRAT = Word Reading Achievement Test, MD = median, IQR = interquartile range, ADHD = attention deficit hyperactivity disorder, ODD = oppositional defiant disorder.

Table 4: Participant characteristics at baseline for aim 2

	<i>n = 61</i>
Age	15.54 (0.65)
Years of Education	9.25 (0.91)
Years of Education (Mother)	14.02 (2.54)
WRAT-4 Reading Standard Score	109.10 (16.32)
Ethnicity/race (%)	
Hispanic/Latino	72.1
Caucasian	1.6
African-American	1.6
More than one race	23.0
Other	1.6
Male (%)	59.0
Amount of Lifetime Nicotine (cigarettes; MD, IQR)	0 (0, 6.00)
Amount of Lifetime Alcohol (1 serving; MD, IQR)	14.0 (0, 61.5)
Amount of Lifetime Cannabis (g; MD, IQR)	19.0 (2.74, 121.75)
Ever Used Cannabis (%)	95.1
Used Cannabis in Past Month (%)	60.7
Used Cannabis in Past Six Months (%)	85.2
Used Cannabis in Past Year (%)	93.4
Ever Used Alcohol (%)	91.8
Ever Used Nicotine (%)	42.6
Ever Used Other Drugs (%)	36.1
Marijuana Problems Scale Total Score	4.02 (3.92)
Iowa Gambling Task (total net)	-2.32 (26.52)
Cups Task (number of risk disadvantageous choices)	10.02 (3.71)
Cups Task Total Risky Choices	33.79 (11.00)
Game of Dice Task (risky choices)	8.70 (4.96)
Risky Sexual Behavior Questionnaire Total Score	4.77 (5.29)
Ever had oral sex (%)	72.1
Ever had vaginal sex (%)	52.5
Ever had anal sex (%)	11.5
Externalizing Problems Total Score	16.26 (8.10)
Attention Problems Total Score	4.70 (3.06)
Rule-Breaking Behavior Total Score	8.66 (3.99)
Aggressive Behavior Total Score	7.61 (4.83)
Current Panic Disorder Diagnosis (%)	3.3
Current Generalized Anxiety Disorder Diagnosis (%)	1.6
Current Obsessive Compulsive Disorder Diagnosis (%)	6.6
Current Major Depression Diagnosis (%)	0
Current ADHD Diagnosis (%)	3.3
Current ODD Diagnosis (%)	3.3
Current Conduct Disorder Diagnosis (%)	6.6
Current Cannabis Abuse Diagnosis (%)	11.5
Current Cannabis Dependence Diagnosis (%)	4.9
Current Alcohol Abuse Diagnosis (%)	3.3
Current Alcohol Dependence Diagnosis (%)	0.0
Current Other Drug Abuse Diagnosis (%)	0.0
Current Other Drug Dependence Diagnosis (%)	0.0

Note: All values are means and standard deviations unless otherwise specified. WRAT = Word Reading Achievement Test, MD = median, IQR = interquartile range, ADHD = attention deficit hyperactivity disorder, ODD = oppositional defiant disorder.

Table 5: Participant characteristics at the 1-year follow-up assessment for aim 2

	<i>n = 61</i>
Age	16.56 (0.74)
Years of Education	10.21 (0.86)
Amount of Nicotine Use Past Year (cigarettes; MD, IQR)	0 (0, 14.2)
Amount of Alcohol Use Past Year (1 serving; MD, IQR)	24 (5, 84.6)
Amount of Cannabis Use Past Year (g; MD, IQR)	16.50 (1.33, 85.62)
Ever Used Cannabis (%)	96.7
Used Cannabis in Past Six Months (%)	77.0
Used Cannabis in Past Year (%)	83.6
Ever Used Alcohol (%)	95.1
Used Alcohol in Past Year (%)	90.2
Ever Used Nicotine (%)	60.7
Used Nicotine in Past Year (%)	41.0
Used Other Drugs in Past Year (%)	36.1
Ever Used Other Drugs (%)	52.5
Marijuana Problems Scale Total Score	3.26 (4.78)
Iowa Gambling Task (total net)	5.08 (30.87)
Cups Task (number of risk disadvantageous choices)	9.51 (3.74)
Cups Task Total Risky Choices	33.77 (9.25)
Game of Dice Task (risky choices)	6.69 (4.71)
Risky Sexual Behavior Questionnaire Total Score	7.13 (6.79)
Ever had oral sex (%)	18.0
Ever had vaginal sex (%)	26.2
Ever had anal sex (%)	8.2
Current Panic Disorder Diagnosis (%)	0.00
Current Generalized Anxiety Disorder Diagnosis (%)	0.00
Current Obsessive Compulsive Disorder Diagnosis (%)	0.00
Current Major Depression Diagnosis (%)	0.00
Current ADHD Diagnosis (%)	1.6
Current ODD Diagnosis (%)	3.3
Current Conduct Disorder Diagnosis (%)	8.2
Current Cannabis Abuse Diagnosis (%)	13.1
Current Cannabis Dependence Diagnosis (%)	3.3
Current Alcohol Abuse Diagnosis (%)	1.6
Current Alcohol Dependence Diagnosis (%)	0.00
Current Other Drug Abuse Diagnosis (%)	1.6
Current Other Drug Dependence Diagnosis (%)	0.00

Note: All values are means and standard deviations unless otherwise specified. WRAT = Word Reading Achievement Test, MD = median, IQR = interquartile range, ADHD = attention deficit hyperactivity disorder, ODD = oppositional defiant disorder.

Table 6. Correlation matrix

	RSBQ-Total Score	Amount of Lifetime Cannabis Use	Marijuana Problems Scale	Externalizing Symptoms	Attention Problems	Rule- Breaking Behavior	Aggressive Behavior	Cups Task	Game of Dice Task	Iowa Gambling Task
RSBQ-Total Score	1									
Amount of Lifetime Cannabis Use	0.24**	1								
Marijuana Problems Scale	0.41**	0.18*	1							
Externalizing Symptoms Total Score	0.22**	0.19**	0.34**	1						
Attention Problems	-0.01	0.06	0.16*	0.56**	1					
Rule-Breaking Behavior	0.28**	0.22**	0.35**	0.90**	0.46**	1				
Aggressive Behavior	0.14*	0.13	0.27**	0.93**	0.56**	0.67**	1			
Cups Task	0.18*	0.08	0.18*	0.17*	0.30**	0.19**	0.13	1		
Game of Dice Task	-0.03	-0.06	0.05	0.04	0.04	0.07	0.01	0.25**	1	
Iowa Gambling Task	-0.08	-0.11	0.02	-0.05	-0.18**	0.001	-0.08	-0.14	0.08	1

Table 7. Aim 1 results for multiple linear regression analyses

	Unstandardized Regression Coefficient	Standardized Regression Coefficient	SE	p- value	Unstandardized Regression Coefficient	Standardized Regression Coefficient	SE	p- value
Outliers Included in Analyses					Outliers Removed in Analyses			
Externalizing Symptoms, Amount of Cannabis Use and Cups Task								
Externalizing Symptoms	0.11	0.15	0.05	0.03	0.09	0.14	0.05	0.05
Amount of Cannabis Use	0.004	0.27	0.001	0.03	0.01	0.27	0.002	0.01
Cups Task	0.21	0.15	0.10	0.03	0.19	0.14	0.10	0.07
Externalizing Symptoms x Cannabis Use	-0.0001	-0.04	0.0001	0.65	-0.0002	-0.10	0.0002	0.35
Externalizing Symptoms x Cups Task	0.01	0.04	0.01	0.63	0.01	0.03	0.01	0.71
Cannabis Use x Cups Task	0.001	0.19	0.0002	0.01	0.001	0.11	0.001	0.37
Externalizing Symptoms, Amount of Cannabis Use and Game of Dice Task								
Externalizing Symptoms	0.13	0.19	0.05	<0.01	0.10	0.15	0.05	0.03
Amount of Cannabis Use	0.004	0.32	0.001	<0.01	0.01	0.35	0.002	<0.01
Game of Dice Task	-0.03	-0.03	0.07	0.71	-0.04	-0.04	0.07	0.56
Externalizing Symptoms x Cannabis Use	-0.0001	-0.11	0.0001	0.30	-0.0002	-0.08	0.0002	0.44
Externalizing Symptoms x Game of Dice Task	-0.004	-0.03	0.009	0.68	-0.0003	-0.002	0.01	0.98
Cannabis Use x Game of Dice Task	0.0002	0.07	0.0002	0.45	-0.0002	-0.04	0.0004	0.61
Externalizing Symptoms, Amount of Cannabis Use and Iowa Gambling Task								
Externalizing Symptoms	0.11	0.16	0.05	0.02	0.12	0.18	0.05	<0.01
Amount of Cannabis Use	0.01	0.27	0.002	<0.01	0.01	0.27	0.002	<0.01
Iowa Gambling Task	-0.01	-0.05	0.02	0.45	-0.01	-0.05	0.02	0.54
Externalizing Symptoms x Cannabis Use	-0.0001	-0.04	0.0001	0.69	0.0002	0.10	0.0001	0.16
Externalizing Symptoms x Iowa Gambling Task	0.0002	0.006	0.002	0.93	0.0002	0.01	0.002	0.90
Cannabis Use x Iowa Gambling Task	0.0001	0.27	0.00003	0.01	0.0001	0.07	0.0001	0.47
Externalizing Symptoms, Marijuana Problems Scale and Cups Task								
Externalizing Symptoms	0.10	0.14	0.05	0.05	0.13	0.20	0.05	<0.01
Marijuana Problems Scale	0.45	0.31	0.11	<0.01	0.17	0.11	0.14	0.24
Cups Task	0.19	0.13	0.09	0.05	0.22	0.16	0.09	0.02
Externalizing Symptoms x Marijuana Problems Scale	-0.04	-0.21	0.01	<0.01	-0.01	-0.07	0.01	0.31
Externalizing Symptoms x Cups Task	0.0001	0.001	0.01	0.99	-0.01	-0.04	0.01	0.60
Marijuana Problems Scale x Cups Task	0.07	0.15	0.04	0.07	0.10	0.23	0.04	<0.01
Externalizing Symptoms, Marijuana Problems Scale and Game of Dice Task								
Externalizing Symptoms	0.09	0.12	0.05	0.07	0.10	0.15	0.05	0.04

Marijuana Problems Scale	0.58	0.40	0.10	<0.01	0.46	0.30	0.13	<0.01
Game of Dice Task	-0.08	-0.08	0.07	0.22	-0.07	-0.07	0.07	0.31
Externalizing Symptoms x Marijuana Problems Scale	-0.03	-0.17	0.01	<0.01	-0.02	-0.10	0.01	0.17
Externalizing Symptoms x Game of Dice Task	0.004	0.03	0.01	0.65	0.002	0.02	0.01	0.80
Marijuana Problems Scale x Game of Dice Task	-0.05	-0.16	0.02	0.01	-0.04	-0.14	0.02	0.04
Externalizing Symptoms, Marijuana Problems Scale and Iowa Gambling Task								
Externalizing Symptoms	0.09	0.13	0.05	0.05	0.11	0.18	0.05	0.02
Marijuana Problems Scale	0.57	0.39	0.10	<0.01	0.39	0.25	0.12	<0.01
Iowa Gambling Task	-0.02	-0.07	0.01	<0.01	-0.02	-0.09	0.01	0.18
Externalizing Symptoms x Marijuana Problems Scale	-0.03	-0.18	0.01	<0.01	-0.01	-0.07	0.01	0.36
Externalizing Symptoms x Iowa Gambling Task	-0.00002	-0.001	0.002	0.99	0.001	0.04	0.002	0.65
Marijuana Problems Scale x Iowa Gambling Task	-0.001	-0.01	0.01	0.84	-0.004	-0.05	0.01	0.54
Attention Problems, Amount of Cannabis Use, and Cups Task								
Attention Problems	-0.08	-0.04	0.14	0.55	-0.02	-0.01	0.15	0.87
Amount of Cannabis Use	0.003	0.26	0.001	<0.01	0.01	0.28	0.002	<0.01
Cups Task	0.23	0.16	0.10	0.03	0.16	0.12	0.10	0.13
Attention Problems x Cannabis Use	-0.00003	-0.01	0.001	0.96	0.001	0.06	0.001	0.45
Attention Problems x Cups Task	-0.05	-0.11	0.03	0.10	-0.05	-0.10	0.03	0.13
Cannabis Use x Cups Task	0.001	0.20	0.0003	0.03	-0.000004	-0.001	0.001	0.99
Attention Problems, Amount of Cannabis Use, and Game of Dice Task								
Attention Problems	-0.10	-0.05	0.14	0.48	-0.03	-0.02	0.15	0.83
Amount of Cannabis Use	0.01	0.36	0.001	<0.01	0.01	0.35	0.001	<0.01
Game of Dice Task	-0.03	-0.03	0.07	0.71	-0.02	-0.02	0.07	0.78
Attention Problems x Cannabis Use	-0.001	-0.28	0.001	0.01	-0.0003	-0.02	0.001	0.77
Attention Problems x Game of Dice Task	0.05	0.13	0.03	0.05	0.04	0.11	0.03	0.09
Cannabis Use x Game of Dice Task	-0.0002	-0.09	0.0003	0.46	-0.0002	-0.03	0.0004	0.68
Attention Problems, Amount of Cannabis Use and Iowa Gambling Task								
Attention Problems	-0.08	-0.04	0.14	0.56	-0.04	-0.02	0.14	0.78
Amount of Cannabis Use	0.01	0.45	0.001	<0.01	0.01	0.34	0.002	<0.01
Iowa Gambling Task	-0.01	-0.05	0.02	0.46	-0.02	-0.07	0.02	0.32
Attention Problems x Cannabis Use	-0.0003	-0.07	0.001	0.52	0.0001	0.005	0.001	0.95
Attention Problems x Iowa Gambling Task	0.01	0.11	0.01	0.12	0.01	0.11	0.01	0.09

Cannabis Use x Iowa Gambling Task	0.0001	0.22	0.00004	0.11	-0.00002	-0.01	0.0001	0.88
Attention Problems, Marijuana Problems Scale, and Cups Task								
Attention Problems	-0.13	-0.06	0.13	0.33	-0.09	-0.05	0.13	0.51
Marijuana Problems Scale	0.52	0.36	0.10	<0.01	0.30	0.19	0.12	0.02
Cups Task	0.17	0.12	0.09	0.07	0.22	0.16	0.22	0.02
Attention Problems x Marijuana Problems Scale	-0.10	-0.18	0.04	<0.01	-0.07	-0.14	0.04	0.04
Attention Problems x Cups Task	-0.05	-0.10	0.03	0.13	-0.06	-0.14	0.03	0.04
Marijuana Problems Scale x Cups Task	0.07	0.15	0.03	0.04	0.10	0.23	0.03	<0.01
Attention Problems, Marijuana Problems Scale, and Game of Dice								
Attention Problems	-0.10	-0.05	0.12	0.40	-0.09	-0.05	0.12	0.50
Marijuana Problems Scale	0.66	0.45	0.09	<0.01	0.56	0.36	0.11	<0.01
Game of Dice Task	-0.06	-0.05	0.07	0.38	-0.05	-0.05	0.07	0.44
Attention Problems x Marijuana Problems Scale	-0.09	-0.17	0.04	0.01	-0.08	-0.16	0.04	0.02
Attention Problems x Game of Dice Task	0.05	0.14	0.02	0.03	0.05	0.14	0.02	0.03
Marijuana Problems Scale x Game of Dice Task	-0.05	-0.15	0.02	0.02	-0.04	-0.13	0.02	0.05
Attention Problems, Marijuana Problems Scale, and Iowa Gambling Task								
Attention Problems	-0.14	-0.07	0.13	0.29	-0.11	-0.06	0.13	0.40
Marijuana Problems Scale	0.65	0.45	0.09	<0.01	0.53	0.34	0.11	<0.01
Iowa Gambling Task	-0.02	-0.08	0.01	0.19	-0.02	-0.09	0.01	0.19
Attention Problems x Marijuana Problems Scale	-0.10	-0.19	0.03	<0.01	-0.08	-0.16	0.04	0.02
Attention Problems x Iowa Gambling Task	0.01	0.09	0.01	0.19	0.01	0.11	0.01	0.12
Marijuana Problems Scale x Iowa Gambling Task	-0.004	-0.05	0.01	0.48	-0.01	-0.07	0.01	0.32
Rule-Breaking Behavior, Amount of Cannabis Use, and Cups Task								
Rule-Breaking Behavior	0.27	0.20	0.09	<0.01	0.19	0.15	0.09	0.04
Amount of Cannabis Use	0.04	0.33	0.001	<0.01	0.01	0.66	0.002	<0.01
Cups Task	0.20	0.14	0.09	0.04	0.22	0.16	0.09	0.01
Rule-Breaking Behavior x Cannabis Use	-0.0004	-0.15	0.0002	0.11	-0.001	-0.43	0.0004	<0.01
Rule-Breaking Behavior x Cups Task	0.02	0.07	0.03	0.32	0.02	0.05	0.02	0.45
Cannabis Use x Cups Task	0.001	0.17	0.0002	0.02	0.001	0.29	0.0003	<0.01
Rule-Breaking Behavior, Amount of Cannabis Use, and Game of Dice Task								
Rule-Breaking Behavior	0.32	0.24	0.09	<0.01	0.30	0.23	0.09	<0.01
Amount of Cannabis Use	0.04	0.34	0.001	<0.01	0.01	0.29	0.002	<0.01

Game of Dice Task	-0.04	-0.04	0.07	0.58	-0.02	-0.02	0.07	0.77
Rule-Breaking Behavior x Cannabis Use	-0.0004	-0.16	0.0003	0.11	-0.0002	-0.05	0.0003	0.54
Rule-Breaking Behavior x Game of Dice Task	-0.01	-0.04	0.02	0.52	-0.01	-0.04	0.02	0.52
Cannabis Use x Game of Dice Task	0.0002	0.07	0.0002	0.48	0.0002	0.04	0.0003	0.59
Rule-Breaking Behavior, Amount of Cannabis Use and Iowa Gambling Task								
Rule-Breaking Behavior	0.29	0.21	0.09	<0.01	0.34	0.25	0.09	<0.01
Amount of Cannabis Use	0.01	0.47	0.001	<0.01	0.01	0.32	0.002	<0.01
Iowa Gambling Task	-0.013	-0.05	0.02	0.41	-0.01	-0.05	0.02	0.51
Rule-Breaking Behavior x Cannabis Use	-0.0003	-0.13	0.0002	0.18	0.00001	0.001	0.0004	0.98
Rule-Breaking Behavior x Iowa Gambling Task	-0.003	-0.05	0.004	0.49	-0.01	-0.10	0.004	0.14
Cannabis Use x Iowa Gambling Task	0.0001	0.26	0.00003	0.01	0.0001	0.12	0.0001	0.19
Rule-Breaking Behavior, Marijuana Problems Scale, and Cups Task								
Rule-Breaking Behavior	0.23	0.16	0.09	0.02	0.33	0.25	0.09	<0.01
Marijuana Problems Scale	0.44	0.30	0.11	<0.01	0.11	0.07	0.14	0.43
Cups Task	0.18	0.13	0.09	0.05	0.22	0.17	0.09	0.02
Rule-Breaking Behavior x Marijuana Problems Scale	-0.06	-0.18	0.02	<0.01	-0.01	-0.04	0.02	0.56
Rule-Breaking Behavior x Cups Task	0.02	0.05	0.03	0.52	-0.001	-0.002	0.03	0.98
Marijuana Problems Scale x Cups Task	0.05	0.12	0.04	0.14	0.09	0.22	0.04	0.01
Rule-Breaking Behavior, Marijuana Problems Scale, and Game of Dice								
Rule-Breaking Behavior	0.21	0.15	0.09	0.03	0.26	0.20	0.10	<0.01
Marijuana Problems Scale	0.56	0.39	0.10	<0.01	0.41	0.26	0.13	<0.01
Game of Dice Task	-0.10	-0.09	0.07	0.14	-0.08	-0.08	0.07	0.26
Rule-Breaking Behavior x Marijuana Problems Scale	-0.06	-0.16	0.02	<0.01	-0.03	-0.08	0.03	0.26
Rule-Breaking Behavior x Game of Dice Task	0.01	0.03	0.02	0.62	0.004	0.01	0.02	0.83
Marijuana Problems Scale x Game of Dice Task	-0.05	-0.17	0.02	<0.01	-0.04	-0.12	0.02	0.09
Rule-Breaking Behavior, Marijuana Problems Scale, and Iowa Gambling Task								
Rule-Breaking Behavior	0.23	0.17	0.09	0.01	0.31	0.24	0.09	<0.01
Marijuana Problems Scale	0.55	0.37	0.10	<0.01	0.33	0.21	0.12	<0.01
Iowa Gambling Task	-0.02	-0.07	0.01	0.30	-0.02	-0.09	0.01	0.17
Rule-Breaking Behavior x Marijuana Problems Scale	-0.05	-0.15	0.02	0.02	-0.01	-0.03	0.03	0.64
Rule-Breaking Behavior x Iowa Gambling Task	-0.004	-0.08	0.004	0.26	-0.001	-0.03	0.004	0.73
Marijuana Problems Scale x Iowa Gambling Task	0.003	0.04	0.01	0.60	-0.002	-0.02	0.01	0.78

Aggressive Behavior, Amount of Cannabis Use, and Cups Task								
Aggressive Behavior	0.10	0.08	0.08	0.23	0.11	0.09	0.08	0.18
Amount of Cannabis Use	0.003	0.23	0.001	<0.01	0.003	0.15	0.002	0.13
Cups Task	0.24	0.17	0.10	0.01	0.23	0.18	0.11	0.03
Aggressive Behavior x Cannabis Use	0.0002	0.07	0.0002	0.44	0.001	0.18	0.0003	<0.01
Aggressive Behavior x Cups Task	0.01	0.02	0.02	0.79	0.01	0.04	0.02	0.57
Cannabis Use x Cups Task	0.001	0.23	0.0002	<0.01	0.001	0.09	0.01	0.38
Aggressive Behavior, Amount of Cannabis Use, and Game of Dice Task								
Aggressive Behavior	0.13	0.11	0.08	0.10	0.12	0.10	0.08	0.13
Amount of Cannabis Use	0.004	0.31	0.001	<0.01	0.01	0.28	0.002	<0.01
Game of Dice Task	-0.01	-0.01	0.07	0.86	0.01	0.01	0.07	0.92
Aggressive Behavior x Cannabis Use	-0.0001	-0.02	0.0003	0.83	0.0005	0.13	0.0003	0.08
Aggressive Behavior x Game of Dice Task	-0.002	-0.01	0.02	0.90	0.001	0.003	0.02	0.96
Cannabis Use x Game of Dice Task	0.0003	0.11	0.0003	0.29	0.0002	0.05	0.0003	0.50
Aggressive Behavior, Amount of Cannabis Use and Iowa Gambling Task								
Aggressive Behavior	0.10	0.09	0.08	0.20	0.10	0.09	0.08	0.17
Amount of Cannabis Use	0.01	0.43	0.001	<0.01	0.01	0.28	0.002	<0.01
Iowa Gambling Task	-0.01	-0.05	0.02	0.49	-0.01	-0.05	0.02	0.52
Aggressive Behavior x Cannabis Use	0.0002	0.07	0.0003	0.44	0.001	0.14	0.0003	0.05
Aggressive Behavior x Iowa Gambling Task	0.002	0.03	0.003	0.62	0.001	0.03	0.003	0.68
Cannabis Use x Iowa Gambling Task	0.0001	0.34	0.00004	<0.01	0.0001	0.07	0.0001	0.72
Aggressive Behavior, Marijuana Problems Scale, and Cups Task								
Aggressive Behavior	0.09	0.08	0.08	0.28	0.13	0.11	0.08	0.13
Marijuana Problems Scale	0.49	0.34	0.11	<0.01	0.25	0.16	0.14	0.06
Cups Task	0.19	0.14	0.09	0.04	0.22	0.17	0.09	0.02
Aggressive Behavior x Marijuana Problems Scale	-0.06	-0.19	0.02	<0.01	-0.02	-0.08	0.02	0.30
Aggressive Behavior x Cups Task	-0.002	-0.01	0.02	0.94	-0.01	-0.04	0.02	0.64
Marijuana Problems Scale x Cups Task	0.06	0.14	0.04	0.08	0.09	0.21	0.04	0.01
Aggressive Behavior, Marijuana Problems Scale, and Game of Dice								
Aggressive Behavior	0.08	0.07	0.08	0.30	0.10	0.09	0.08	0.23
Marijuana Problems Scale	0.60	0.41	0.09	<0.01	0.50	0.32	0.12	<0.01
Game of Dice Task	-0.06	-0.06	0.07	0.33	-0.06	-0.06	0.07	0.40
Aggressive Behavior x Marijuana Problems Scale	-0.05	-0.17	0.02	<0.01	-0.03	-0.08	0.02	0.27
Aggressive Behavior x Game of Dice Task	0.004	0.02	0.01	0.78	0.002	0.01	0.01	0.91

Marijuana Problems Scale x Game of Dice Task	-0.05	-0.16	0.02	0.01	-0.05	-0.15	0.02	0.03
Aggressive Behavior, Marijuana Problems Scale, and Iowa Gambling Task								
Aggressive Behavior	0.08	0.07	0.08	0.32	0.10	0.09	0.08	0.22
Marijuana Problems Scale	0.61	0.42	0.10	<0.01	0.46	0.30	0.01	0.17
Iowa Gambling Task	-0.02	-0.08	0.01	0.19	-0.02	-0.09	0.01	0.22
Aggressive Behavior x Marijuana Problems Scale	-0.05	-0.17	0.02	<0.01	-0.03	-0.08	0.02	0.27
Aggressive Behavior x Iowa Gambling Task	0.003	0.06	0.003	0.41	0.003	0.07	0.003	0.32
Marijuana Problems Scale x Iowa Gambling Task	-0.004	-0.04	0.01	0.53	-0.004	-0.06	0.01	0.43
Externalizing Symptoms (Parent Report), Amount of Cannabis Use and Cups Task								
Externalizing Symptoms	0.05	0.06	0.10	0.59	-0.05	-0.07	0.06	0.41
Amount of Cannabis Use	0.02	0.79	0.004	<0.01	0.02	0.84	0.004	<0.01
Cups Task	-0.02	-0.01	0.16	0.92	-0.01	-0.01	0.16	0.93
Externalizing Symptoms x Cannabis Use	-0.0002	-0.11	0.0002	0.34	-0.0001	-0.08	0.0002	0.42
Externalizing Symptoms x Cups Task	0.01	0.05	0.02	0.58	0.02	0.07	0.02	0.43
Cannabis Use x Cups Task	-0.002	-0.43	0.001	0.02	-0.002	-0.47	0.001	0.01
Externalizing Symptoms (Parent Report), Amount of Cannabis Use and Game of Dice Task								
Externalizing Symptoms	0.10	0.11	0.002	0.30	-0.03	-0.05	0.06	0.61
Amount of Cannabis Use	0.01	0.44	0.002	<0.01	0.02	0.46	0.004	<0.01
Game of Dice Task	0.08	0.07	0.10	0.44	0.07	0.07	0.10	0.50
Externalizing Symptoms x Cannabis Use	-0.0001	-0.03	0.0002	0.81	0.0001	0.01	0.001	0.91
Externalizing Symptoms x Game of Dice Task	-0.02	-0.07	0.02	0.47	0.01	0.05	0.02	0.65
Cannabis Use x Game of Dice Task	0.0001	0.02	0.001	0.86	-0.001	-0.10	0.001	0.33
Externalizing Symptoms (Parent Report), Amount of Cannabis Use and Iowa Gambling Task								
Externalizing Symptoms	0.13	0.15	0.10	0.17	-0.01	-0.02	0.06	0.82
Amount of Cannabis Use	0.01	0.47	0.002	<0.01	0.02	0.45	0.003	<0.01
Iowa Gambling Task	-0.0004	-0.002	0.03	0.99	-0.01	-0.03	0.02	0.77
Externalizing Symptoms x Cannabis Use	0.0001	0.04	0.0002	0.77	0.0001	0.01	0.0005	0.90
Externalizing Symptoms x Iowa Gambling Task	0.01	0.20	0.01	0.08	0.005	0.005	0.09	0.34
Cannabis Use x Iowa Gambling Task	-0.00004	-0.04	0.0001	0.75	-0.00002	-0.01	0.0002	0.91
Externalizing Symptoms (Parent Report), Marijuana Problems Scale and Cups Task								
Externalizing Symptoms	0.04	0.04	0.09	0.68	0.10	0.13	0.09	0.26
Marijuana Problems Scale	0.55	0.43	0.14	<0.01	0.18	0.13	0.17	0.28
Cups Task	0.20	0.13	0.15	0.18	0.28	0.21	0.14	0.05

Externalizing Symptoms x Marijuana Problems Scale	-0.02	-0.003	0.02	0.88	0.004	0.02	0.02	0.86
Externalizing Symptoms x Cups Task	0.02	0.08	0.03	0.44	0.01	0.02	0.02	0.83
Marijuana Problems Scale x Cups Task	-0.06	-0.15	0.05	0.18	-0.01	-0.03	0.05	0.81
Externalizing Symptoms (Parent Report), Marijuana Problems Scale and Game of Dice Task								
Externalizing Symptoms	0.07	0.08	0.09	0.45	0.11	0.15	0.08	0.18
Marijuana Problems Scale	0.52	0.41	0.12	<0.01	0.26	0.19	0.15	0.08
Game of Dice Task	-0.001	-0.001	0.10	0.99	0.03	0.03	0.10	0.78
Externalizing Symptoms x Marijuana Problems Scale	-0.01	-0.07	0.02	0.53	0.002	0.01	0.02	0.92
Externalizing Symptoms x Game of Dice Task	0.001	0.01	0.02	0.95	-0.01	0.04	0.02	0.66
Marijuana Problems Scale x Game of Dice Task	-0.07	-0.24	0.03	0.01	-0.04	-0.16	0.03	0.13
Externalizing Symptoms (Parent Report), Marijuana Problems Scale and Iowa Gambling Task								
Externalizing Symptoms	0.12	0.13	0.10	0.24	0.17	0.22	0.09	0.07
Marijuana Problems Scale	0.49	0.39	0.13	<0.01	0.31	0.21	0.16	0.05
Iowa Gambling Task	-0.01	-0.03	0.03	0.73	-0.003	-0.01	0.02	0.89
Externalizing Symptoms x Marijuana Problems Scale	-0.01	-0.05	0.02	0.62	-0.004	-0.02	0.02	0.88
Externalizing Symptoms x Iowa Gambling Task	0.003	0.06	0.01	0.59	0.01	0.15	0.005	0.22
Marijuana Problems Scale x Iowa Gambling Task	0.003	0.04	0.01	0.67	-0.01	-0.08	0.01	0.47

Note: Bolded results indicate significant variables.

Table 8. Aim 1 results conducted with poisson regression

	Unstandardized Regression Coefficient	SE	p- value	Unstandardized Regression Coefficient	SE	p-value
	Outliers Included in Analyses			Outliers Removed in Analyses		
Externalizing Symptoms, Amount of Cannabis Use and Cups Task						
Externalizing Symptoms	0.02	0.01	0.03	0.03	0.01	0.03
Amount of Cannabis Use	0.03	0.01	<0.01	0.03	0.01	0.01
Cups Task	0.04	0.02	0.09	0.04	0.02	0.09
Externalizing Symptoms x Cannabis Use	-0.001	0.001	0.18	-0.001	0.001	0.46
Externalizing Symptoms x Cups Task	0.001	0.003	0.86	0.001	0.003	0.79
Cannabis Use x Cups Task	0.002	0.003	0.24	0.002	0.003	0.31
Externalizing Symptoms, Amount of Cannabis Use and Game of Dice Task						
Externalizing Symptoms	0.03	0.01	<0.01	0.03	0.01	0.01
Amount of Cannabis Use	0.04	0.01	<0.01	0.03	0.01	<0.01
Game of Dice Task	-0.01	0.02	0.48	-0.01	0.02	0.59
Externalizing Symptoms x Cannabis Use	-0.001	0.0001	0.16	-0.001	0.001	0.42
Externalizing Symptoms x Game of Dice Task	-0.0004	0.002	0.80	-0.0005	0.002	0.75
Cannabis Use x Game of Dice Task	0.001	0.002	0.65	0.001	0.002	0.42
Externalizing Symptoms, Amount of Cannabis Use and Iowa Gambling Task						
Externalizing Symptoms	0.03	0.01	0.02	0.03	0.01	0.01
Amount of Cannabis Use	0.04	0.01	<0.01	0.03	0.01	<0.01
Iowa Gambling Task	-0.01	0.004	0.14	-0.01	0.004	0.12
Externalizing Symptoms x Cannabis Use	-0.001	0.001	0.21	0.0003	0.001	0.68

Externalizing Symptoms x Iowa Gambling Task	0.0002	0.0005	0.53	0.0004	0.0004	0.29
Cannabis Use x Iowa Gambling Task	0.0003	0.0004	0.21	-0.0002	0.0004	0.52
Externalizing Symptoms, Marijuana Problems Scale and Cups Task						
Externalizing Symptoms	0.04	0.01	<0.01	0.04	0.01	<0.01
Marijuana Problems Scale	0.05	0.03	<0.01	0.04	0.04	0.23
Cups Task	0.04	0.02	0.07	0.04	0.03	0.08
Externalizing Symptoms x Marijuana Problems Scale	-0.01	0.003	0.01	-0.01	0.003	0.11
Externalizing Symptoms x Cups Task	-0.002	0.003	0.50	-0.002	0.003	0.48
Marijuana Problems Scale x Cups Task	0.01	0.01	0.06	0.02	0.01	0.07
Externalizing Symptoms, Marijuana Problems Scale and Game of Dice Task						
Externalizing Symptoms	0.03	0.004	<0.01	0.03	0.01	<0.01
Marijuana Problems Scale	0.07	0.01	<0.01	0.11	0.03	<0.01
Game of Dice Task	-0.01	0.01	0.332	-0.01	0.02	0.58
Externalizing Symptoms x Marijuana Problems Scale	-0.003	0.001	<0.01	-0.01	0.003	0.03
Externalizing Symptoms x Game of Dice Task	0.00005	0.002	0.97	0.0004	0.002	0.79
Marijuana Problems Scale x Game of Dice Task	-0.01	0.01	0.14	-0.01	0.01	0.03
Externalizing Symptoms, Marijuana Problems Scale and Iowa Gambling Task						
Externalizing Symptoms	0.03	0.01	<0.01	0.03	0.01	<0.01
Marijuana Problems Scale	0.08	0.03	<0.01	0.10	0.03	<0.01
Iowa Gambling Task	-0.01	0.004	0.14	-0.01	0.004	0.16
Externalizing Symptoms x Marijuana Problems Scale	-0.003	0.003	0.08	-0.01	0.004	0.09
Externalizing Symptoms x Iowa Gambling Task	0.0004	0.0005	0.30	0.0003	0.0004	0.45
Marijuana Problems Scale x Iowa Gambling Task	-0.001	0.002	0.71	-0.0001	0.002	0.91
Attention Problems, Amount of Cannabis Use, and Cups Task						
Attention Problems	-0.01	0.03	0.67	-0.01	0.03	0.70
Amount of Cannabis Use	0.03	0.01	<0.01	0.03	0.01	<0.01
Cups Task	0.04	0.02	0.03	0.04	0.02	0.06
Attention Problems x Cannabis Use	-0.0004	0.004	0.92	-0.001	0.004	0.78
Attention Problems x Cups Task	-0.01	0.01	0.08	-0.01	0.01	0.12
Cannabis Use x Cups Task	0.002	0.003	0.19	0.002	0.003	0.27
Attention Problems, Amount of Cannabis Use, and Game of Dice Task						
Attention Problems	-0.01	0.03	0.80	-0.01	0.03	0.81
Amount of Cannabis Use	0.04	0.01	<0.01	0.05	0.01	<0.01
Game of Dice Task	-0.01	0.02	0.65	-0.01	0.02	0.74
Attention Problems x Cannabis Use	-0.004	0.004	0.21	0.0003	0.004	0.93
Attention Problems x Game of Dice Task	0.02	0.01	<0.01	0.01	0.01	0.03
Cannabis Use x Game of Dice Task	0.00005	0.002	0.97	0.001	0.002	0.59

Attention Problems, Amount of Cannabis Use and Iowa Gambling Task						
Attention Problems	-0.01	0.03	0.66	-0.01	0.03	0.79
Amount of Cannabis Use	0.04	0.01	<0.01	0.04	0.01	<0.01
Iowa Gambling Task	-0.01	0.004	0.19	-0.01	0.004	0.18
Attention Problems x Cannabis Use	-0.001	0.004	0.80	0.001	0.004	0.87
Attention Problems x Iowa Gambling Task	0.003	0.001	0.06	0.003	0.001	0.02
Cannabis Use x Iowa Gambling Task	0.0003	0.0004	0.34	-0.0004	0.0004	0.22
Attention Problems, Marijuana Problems Scale, and Cups Task						
Attention Problems	-0.004	0.04	0.92	-0.002	0.04	0.95
Marijuana Problems Scale	0.07	0.02	<0.01	0.05	0.03	0.06
Cups Task	0.04	0.02	0.06	0.05	0.02	0.04
Attention Problems x Marijuana Problems Scale	-0.01	0.01	0.14	-0.01	0.01	0.19
Attention Problems x Cups Task	-0.02	0.01	0.07	-0.02	0.01	0.05
Marijuana Problems Scale x Cups Task	0.01	0.01	0.17	0.01	0.01	0.13
Attention Problems, Marijuana Problems Scale, and Game of Dice						
Attention Problems	-0.002	0.03	0.93	-0.003	0.03	0.93
Marijuana Problems Scale	0.08	0.02	<0.01	0.10	0.03	<0.01
Game of Dice Task	-0.01	0.02	0.76	-0.004	0.02	0.81
Attention Problems x Marijuana Problems Scale	-0.01	0.01	0.20	-0.01	0.01	0.17
Attention Problems x Game of Dice Task	0.01	0.01	0.04	0.01	0.01	0.06
Marijuana Problems Scale x Game of Dice Task	-0.01	0.01	0.27	-0.01	0.01	0.15
Attention Problems, Marijuana Problems Scale, and Iowa Gambling Task						
Attention Problems	-0.003	0.03	0.92	-0.01	0.04	0.89
Marijuana Problems Scale	0.09	0.02	<0.01	0.10	0.02	<0.01
Iowa Gambling Task	-0.01	0.004	0.21	-0.01	0.004	0.22
Attention Problems x Marijuana Problems Scale	-0.01	0.01	0.07	-0.01	0.01	0.07
Attention Problems x Iowa Gambling Task	0.002	0.002	0.08	0.002	0.002	0.13
Marijuana Problems Scale x Iowa Gambling Task	-0.001	0.001	0.62	-0.0003	0.001	0.81
Rule-Breaking Behavior, Amount of Cannabis Use, and Cups Task						
Rule-Breaking Behavior	0.07	0.02	<0.01	0.07	0.03	<0.01
Amount of Cannabis Use	0.03	0.01	<0.01	0.03	0.01	<0.01
Cups Task	0.03	0.02	0.11	0.04	0.02	0.11
Rule-Breaking Behavior x Cannabis Use	-0.004	0.002	0.01	-0.004	0.002	0.02
Rule-Breaking Behavior x Cups Task	0.004	0.01	0.53	0.002	0.01	0.75
Cannabis Use x Cups Task	0.002	0.003	0.29	0.003	0.003	0.12
Rule-Breaking Behavior, Amount of Cannabis Use, and Game of Dice Task						
Rule-Breaking Behavior	0.08	0.02	<0.01	0.08	0.03	<0.01

Amount of Cannabis Use	0.04	0.01	<0.01	0.04	0.01	<0.01
Game of Dice Task	-0.01	0.02	0.44	-0.01	0.02	0.58
Rule-Breaking Behavior x Cannabis Use	-0.004	0.002	0.03	-0.002	0.002	0.13
Rule-Breaking Behavior x Game of Dice Task	-0.002	0.004	0.64	-0.001	0.004	0.73
Cannabis Use x Game of Dice Task	0.001	0.002	0.66	-0.0001	0.002	0.97
Rule-Breaking Behavior, Amount of Cannabis Use and Iowa Gambling Task						
Rule-Breaking Behavior	0.07	0.03	<0.01	0.08	0.03	<0.01
Amount of Cannabis Use	0.04	0.01	<0.01	0.03	0.01	<0.01
Iowa Gambling Task	-0.01	0.004	0.15	-0.01	0.004	0.13
Rule-Breaking Behavior x Cannabis Use	-0.003	0.002	0.03	-0.002	0.002	0.18
Rule-Breaking Behavior x Iowa Gambling Task	0.0001	0.001	0.95	0.0004	0.001	0.65
Cannabis Use x Iowa Gambling Task	0.0004	0.0004	0.17	-0.0002	0.0005	0.67
Rule-Breaking Behavior, Marijuana Problems Scale, and Cups Task						
Rule-Breaking Behavior	0.08	0.02	<0.01	0.09	0.02	<0.01
Marijuana Problems Scale	0.05	0.03	<0.01	0.03	0.04	0.40
Cups Task	0.04	0.02	0.10	0.04	0.03	0.08
Rule-Breaking Behavior x Marijuana Problems Scale	-0.01	0.01	0.03	-0.01	0.01	0.28
Rule-Breaking Behavior x Cups Task	0.0001	0.01	0.99	-0.002	0.01	0.77
Marijuana Problems Scale x Cups Task	0.01	0.01	0.13	0.02	0.01	0.08
Rule-Breaking Behavior, Marijuana Problems Scale, and Game of Dice						
Rule-Breaking Behavior	0.08	0.01	<0.01	0.08	0.02	<0.01
Marijuana Problems Scale	0.07	0.01	<0.01	0.10	0.03	<0.01
Game of Dice Task	-0.01	0.02	0.50	-0.01	0.02	0.38
Rule-Breaking Behavior x Marijuana Problems Scale	-0.01	0.01	0.12	-0.01	0.01	0.03
Rule-Breaking Behavior x Game of Dice Task	-0.00004	0.003	0.99	0.001	0.004	0.87
Marijuana Problems Scale x Game of Dice Task	-0.01	0.001	0.26	-0.01	0.01	0.06
Rule-Breaking Behavior, Marijuana Problems Scale, and Iowa Gambling Task						
Rule-Breaking Behavior	0.09	0.02	<0.01	0.08	0.02	<0.01
Marijuana Problems Scale	0.07	0.02	<0.01	0.08	0.03	<0.01
Iowa Gambling Task	-0.01	0.004	0.15	-0.01	0.004	0.15
Rule-Breaking Behavior x Marijuana Problems Scale	-0.01	0.01	0.06	-0.01	0.007	0.17
Rule-Breaking Behavior x Iowa Gambling Task	0.0002	0.001	0.81	0.0001	0.001	0.92
Marijuana Problems Scale x Iowa Gambling Task	-0.00002	0.001	0.99	0.0002	0.001	0.86
Aggressive Behavior, Amount of Cannabis Use, and Cups Task						
Aggressive Behavior	0.02	0.02	0.35	0.02	0.02	0.32
Amount of Cannabis Use	0.03	0.01	<0.01	0.02	0.01	<0.01
Cups Task	0.05	0.02	0.05	0.05	0.02	0.04

Aggressive Behavior x Cannabis Use	-0.0002	0.002	0.91	0.001	0.002	0.63
Aggressive Behavior x Cups Task	0.001	0.01	0.92	0.001	0.01	0.87
Cannabis Use x Cups Task	0.002	0.003	0.22	0.002	0.003	0.27
Aggressive Behavior, Amount of Cannabis Use, and Game of Dice Task						
Aggressive Behavior	0.03	0.02	0.15	0.02	0.02	0.35
Amount of Cannabis Use	0.04	0.01	<0.01	0.04	0.01	<0.01
Game of Dice Task	-0.01	0.02	0.56	-0.01	0.02	0.77
Aggressive Behavior x Cannabis Use	-0.001	0.002	0.62	0.001	0.002	0.38
Aggressive Behavior x Game of Dice Task	0.0003	0.003	0.90	0.0005	0.003	0.84
Cannabis Use x Game of Dice Task	0.001	0.002	0.49	0.0001	0.002	0.99
Aggressive Behavior, Amount of Cannabis Use and Iowa Gambling Task						
Aggressive Behavior	0.02	0.02	0.26	0.02	0.02	0.32
Amount of Cannabis Use	0.04	0.01	<0.01	0.04	0.01	<0.01
Iowa Gambling Task	-0.01	0.004	0.15	-0.01	0.004	0.13
Aggressive Behavior x Cannabis Use	0.0003	0.002	0.82	0.001	0.002	0.46
Aggressive Behavior x Iowa Gambling Task	0.001	0.001	0.36	0.001	0.001	0.21
Cannabis Use x Iowa Gambling Task	0.0004	0.001	0.18	-0.0002	0.0005	0.68
Aggressive Behavior, Marijuana Problems Scale, and Cups Task						
Aggressive Behavior	0.04	0.02	0.05	0.04	0.02	0.03
Marijuana Problems Scale	0.06	0.02	<0.01	0.06	0.03	0.08
Cups Task	0.05	0.02	0.04	0.05	0.03	0.06
Aggressive Behavior x Marijuana Problems Scale	-0.01	0.004	0.04	-0.01	0.01	0.16
Aggressive Behavior x Cups Task	-0.003	0.01	0.61	-0.003	0.01	0.60
Marijuana Problems Scale x Cups Task	0.01	0.01	0.09	0.01	0.01	0.15
Aggressive Behavior, Marijuana Problems Scale, and Game of Dice						
Aggressive Behavior	0.03	0.02	0.09	0.03	0.02	0.09
Marijuana Problems Scale	0.07	0.03	<0.01	0.11	0.03	<0.01
Game of Dice Task	-0.01	0.02	0.78	-0.01	0.02	0.77
Aggressive Behavior x Marijuana Problems Scale	-0.002	0.01	0.53	-0.01	0.01	0.12
Aggressive Behavior x Game of Dice Task	-0.0004	0.003	0.89	0.0001	0.003	0.96
Marijuana Problems Scale x Game of Dice Task	-0.01	-0.01	0.11	-0.01	0.01	0.04
Aggressive Behavior, Marijuana Problems Scale, and Iowa Gambling Task						
Aggressive Behavior	0.03	0.02	0.06	0.03	0.02	0.06
Marijuana Problems Scale	0.08	0.02	<0.01	0.10	0.03	<0.01
Iowa Gambling Task	-0.01	0.004	0.12	-0.01	0.004	0.17
Aggressive Behavior x Marijuana Problems Scale	-0.004	0.01	0.20	-0.01	0.01	0.09
Aggressive Behavior x Iowa Gambling Task	0.001	0.001	0.18	0.001	0.001	0.19

Marijuana Problems Scale x Iowa Gambling Task	-0.001	0.002	0.64	0.0004	0.001	0.79
Externalizing Symptoms (Parent Report), Amount of Cannabis Use and Cups Task						
Externalizing Symptoms	0.02	0.04	0.57	0.03	0.04	0.41
Amount of Cannabis Use	0.08	0.02	<0.01	0.07	0.02	<0.01
Cups Task	0.06	0.04	0.09	0.06	0.04	0.09
Externalizing Symptoms x Cannabis Use	-0.001	0.002	0.43	0.001	0.003	0.75
Externalizing Symptoms x Cups Task	0.003	0.01	0.71	0.0003	0.01	0.98
Cannabis Use x Cups Task	-0.01	0.004	0.02	-0.01	0.004	0.01
Externalizing Symptoms (Parent Report), Amount of Cannabis Use and Game of Dice Task						
Externalizing Symptoms	0.03	0.03	0.10	0.03	0.03	0.22
Amount of Cannabis Use	0.06	0.02	<0.01	0.06	0.02	<0.01
Game of Dice Task	0.03	0.03	0.26	0.03	0.03	0.25
Externalizing Symptoms x Cannabis Use	-0.001	0.003	0.28	0.001	0.004	0.70
Externalizing Symptoms x Game of Dice Task	-0.004	0.01	0.41	0.001	0.01	0.90
Cannabis Use x Game of Dice Task	-0.0004	0.003	0.86	-0.001	0.003	0.73
Externalizing Symptoms (Parent Report), Amount of Cannabis Use and Iowa Gambling Task						
Externalizing Symptoms	0.03	0.02	0.08	0.03	0.02	0.06
Amount of Cannabis Use	0.06	0.02	<0.01	0.06	0.02	<0.01
Iowa Gambling Task	-0.002	0.01	0.74	-0.003	0.01	0.63
Externalizing Symptoms x Cannabis Use	0.0001	0.002	0.93	-0.0004	0.003	0.83
Externalizing Symptoms x Iowa Gambling Task	0.003	0.002	0.04	-0.0004	0.001	0.53
Cannabis Use x Iowa Gambling Task	0.00002	0.001	0.98	0.002	0.002	0.09
Externalizing Symptoms (Parent Report), Marijuana Problems Scale and Cups Task						
Externalizing Symptoms	0.02	0.02	0.21	0.02	0.02	0.10
Marijuana Problems Scale	0.09	0.04	<0.01	0.07	0.05	0.12
Cups Task	0.10	0.04	0.01	0.10	0.04	0.01
Externalizing Symptoms x Marijuana Problems Scale	-0.002	-0.01	<0.01	0.001	0.01	0.93
Externalizing Symptoms x Cups Task	0.001	0.01	0.86	-0.001	0.01	0.87
Marijuana Problems Scale x Cups Task	-0.01	0.01	0.14	-0.01	0.01	0.41
Externalizing Symptoms (Parent Report), Marijuana Problems Scale and Game of Dice Task						
Externalizing Symptoms	0.03	0.02	0.08	0.03	0.02	0.08
Marijuana Problems Scale	0.08	0.03	<0.01	0.07	0.05	0.08
Game of Dice Task	0.02	0.03	0.57	0.02	0.03	0.49
Externalizing Symptoms x Marijuana Problems Scale	-0.01	0.01	0.20	-0.001	0.01	0.70
Externalizing Symptoms x Game of Dice Task	-0.003	0.01	0.61	-0.003	0.01	0.60
Marijuana Problems Scale x Game of Dice Task	-0.01	0.01	0.03	-0.01	0.01	0.08
Externalizing Symptoms (Parent Report), Marijuana Problems Scale and Iowa Gambling Task						

Externalizing Symptoms	0.04	0.02	0.04	0.04	0.02	0.02
Marijuana Problems Scale	0.08	0.04	<0.01	0.08	0.05	0.03
Iowa Gambling Task	-0.004	0.01	0.59	-0.002	0.01	0.75
Externalizing Symptoms x Marijuana Problems Scale	-0.004	0.01	0.24	-0.003	0.01	0.51
Externalizing Symptoms x Iowa Gambling Task	0.001	0.001	0.38	0.002	0.002	0.15
Marijuana Problems Scale x Iowa Gambling Task	0.001	0.003	0.68	-0.001	0.003	0.49

Note: Bolded results indicate significant variables.

Table 9. Summary of unstandardized regression coefficients (standardized regression coefficients are in parenthesis) for simple slope difference tests for all significant interaction effects for aim 1 (multiple linear regression)

Table 9. Summary of unstandardized regression coefficients (standardized regression coefficients are in parenthesis) for simple slope difference tests for all significant interaction effects for aim 1 (multiple linear regression)

Externalizing Symptoms, Marijuana Problems Scale and Game of Dice			
	Less Risk-Taking (GDT)	Average Risk-Taking (GDT)	Less Risk-Taking (GDT)
Marijuana Problems Scale	0.85 (0.59)**	0.58 (0.40)**	0.30 (0.21)*
Attention Problems, Marijuana Problems Scale and Cups Task			
	Low Attention Problems	Average Attention Problems	High Attention Problems
Marijuana Problems Scale	0.80 (0.55)**	0.53 (0.36)**	0.25 (0.17)
	Less Risk-Taking (CT)	Average Risk-Taking (CT)	More Risk-Taking (CT)
Marijuana Problems Scale	0.25 (0.17)	0.52 (0.36)**	0.80 (0.55)**
Attention Problems, Marijuana Problems Scale and Game of Dice Task			
	Low Attention Problems	Average Attention Problems	High Attention Problems
Marijuana Problems Scale	0.91 (0.62)**	0.66 (0.45)**	0.40 (0.28)**
	Less Risk-Taking (GDT)	Average Risk-Taking (GDT)	More Risk-Taking (GDT)
Attention Problems	-0.39 (-0.19)*	-0.10 (-0.05)	0.18 (0.09)
	Less Risk-Taking (GDT)	Average Risk-Taking (GDT)	More Risk-Taking (GDT)
Marijuana Problems Scale	0.91 (0.62)**	0.66 (0.45)**	0.41 (0.28)**
Attention Problems, Marijuana Problems Scale and Iowa Gambling Task			
	Low Attention Problems	Average Attention Problems	High Attention Problems
Marijuana Problems Scale	0.93 (0.64)**	0.65 (0.45)**	0.37 (0.26)**
Rule-Breaking Behavior, Amount of Lifetime Cannabis Use, and Cups Task			
	Less Risk-Taking (CT)	Average Risk-Taking (CT)	More Risk-Taking (CT)
Lifetime Amount of Cannabis Use	0.002 (0.17)	0.004 (0.33)**	0.006 (0.50)**
Aggressive Behavior, Marijuana Problems Scale, and Cups Task			
	Less Risk-Taking (GDT)	Average Risk-Taking (GDT)	More Risk-Taking (GDT)
Marijuana Problems Scale	0.87 (0.60)**	0.60 (0.42)**	0.34 (0.23)*
Externalizing Symptoms (Parent Report), Amount of lifetime Cannabis Use and Cups Task			
	Less Risk-Taking (CT)	Average Risk-Taking (CT)	More Risk-Taking (CT)
Lifetime Amount of Cannabis Use	0.02 (1.12)**	0.02 (0.80)**	0.01 (0.36)**

Note: * = p -value < 0.05, ** = p -value < 0.01

Table 10. Summary of unstandardized regression coefficients for simple slope difference tests for all significant interaction effects for aim 1 (poisson regression)

Externalizing Symptoms, Marijuana Problems Scale, and Game of Dice Task			
	Low Externalizing Symptoms	Average Externalizing Symptoms	High Externalizing Symptoms
Marijuana Problems Scale	0.09**	0.07**	0.03**
Attention Problems, Amount of Lifetime Cannabis Use and Game of Dice Task			
	Less Risk-Taking (GDT)	Average Risk-Taking (GDT)	More Risk-Taking (GDT)
Attention Problems	-0.08**	-0.01	0.07
Rule-Breaking Behavior, Amount of Lifetime Cannabis Use, and Cups Task			
	Low Rule-Breaking Behavior	Average Rule-Breaking Behavior	High Rule-Breaking Behavior
Lifetime Amount of Cannabis Use	0.05**	0.04**	0.02**
Externalizing Symptoms (Parent Report), Amount of lifetime Cannabis Use and Cups Task			
	Less Risk-Taking (CT)	Average Risk-Taking (CT)	More Risk-Taking (CT)
Lifetime Amount of Cannabis Use	0.11**	0.08**	0.05**

Note: * = p -value < 0.05, ** = p -value < 0.01

Table 11: Aim 2 results of multiple linear regression analyses

	Unstandardized Regression Coefficient	Standardized Regression Coefficient	SE	p- value	Unstandardized Regression Coefficient	Standardized Regression Coefficient	SE	p- value
Outliers Included in Analyses					Outliers Removed in Analyses			
Externalizing Symptoms, Amount of Cannabis Use and Cups Task								
Externalizing Symptoms	-0.003	-0.01	0.07	0.96	0.01	0.03	0.07	0.85
Amount of Cannabis Use	0.01	0.33	0.003	<0.01	0.005	0.14	0.005	0.34
Cups Task	-0.05	-0.04	0.15	0.76	-0.04	-0.03	0.15	0.81
Externalizing Symptoms, Amount of Cannabis Use and Game of Dice Task								
Externalizing Symptoms	-0.02	-0.03	0.07	0.81	-	-	-	-
Amount of Cannabis Use	0.01	0.30	0.003	0.01	-	-	-	-
Game of Dice Task	0.23	0.24	0.11	0.04	-	-	-	-
Externalizing Symptoms, Amount of Cannabis Use and Iowa Gambling Task								
Externalizing Symptoms	0.0001	0.0003	0.07	0.99	0.02	0.04	0.07	0.81
Amount of Cannabis Use	0.01	0.33	0.003	<0.01	0.01	0.14	0.005	0.35
Iowa Gambling Task	0.007	0.05	0.02	0.69	0.01	0.05	0.02	0.71
Externalizing Symptoms, Marijuana Problems Scale and Cups Task								
Externalizing Symptoms	0.03	0.05	0.07	0.70	-	-	-	-
Marijuana Problems Scale	0.21	0.18	0.16	0.17	-	-	-	-
Cups Task	-0.03	-0.03	0.16	0.84	-	-	-	-
Externalizing Symptoms, Marijuana Problems Scale and Game of Dice Task								
Externalizing Symptoms	0.02	0.03	0.07	0.81	-	-	-	-
Marijuana Problems Scale	0.15	0.13	0.15	0.33	-	-	-	-
Game of Dice Task	0.24	0.25	0.12	0.05	-	-	-	-
Externalizing Symptoms, Marijuana Problems Scale and Iowa Gambling Task								
Externalizing Symptoms	0.03	0.06	0.07	0.67	0.03	0.05	0.07	0.71
Marijuana Problems Scale	0.21	0.17	0.15	0.18	0.37	0.25	0.20	0.07
Iowa Gambling Task	0.01	0.04	0.02	0.78	0.005	0.03	0.02	0.80

Note: Bolded results indicate significant variables

Table 12: Aim 3 results of multiple linear regression analyses

	Unstandardized Regression Coefficient	Standardized Regression Coefficient	SE	p- value	Unstandardized Regression Coefficient	Standardized Regression Coefficient	SE	p- value
	Outliers Included in Analyses				Outliers Removed in Analyses			
Externalizing Symptoms and Cups Task								
Externalizing Symptoms	0.15	0.31	0.03	<0.01	-	-	-	-
Cups Task	0.13	0.13	0.07	0.06	-	-	-	-
Externalizing Symptoms x Cups Task	0.003	0.02	0.009	0.74	-	-	-	-
Externalizing Symptoms and Game of Dice Task								
Externalizing Symptoms	0.16	0.33	0.03	<0.01	-	-	-	-
Game of Dice Task	0.03	0.04	0.05	0.56	-	-	-	-
Externalizing Symptoms x Game of Dice Task	-0.005	-0.05	0.01	0.47	-	-	-	-
Externalizing Symptoms and Iowa Gambling Task								
Externalizing Symptoms	0.16	0.34	0.03	<0.01	-	-	-	-
Iowa Gambling Task	0.005	0.03	0.01	0.66	-	-	-	-
Externalizing Symptoms x Iowa Gambling Task	0.001	0.05	0.001	0.42	-	-	-	-
Attention Problems and Cups Task								
Attention Problems	0.16	0.12	0.10	0.10	-	-	-	-
Cups Task	0.13	0.13	0.07	0.07	-	-	-	-
Attention Problems x Cups Task	-0.02	-0.07	0.02	0.33	-	-	-	-
Attention Problems and Game of Dice Task								
Attention Problems	0.22	0.16	0.10	0.02	-	-	-	-
Game of Dice Task	0.03	0.05	0.05	0.52	-	-	-	-
Attention Problems x Game of Dice Task	0.002	0.01	0.02	0.91	-	-	-	-
Attention Problems and Iowa Gambling Task								
Attention Problems	0.23	0.17	0.10	0.02	-	-	-	-
Iowa Gambling Task	0.01	0.06	0.01	0.42	-	-	-	-
Attention Problems x Iowa Gambling Task	0.005	0.08	0.004	0.25	-	-	-	-
Rule-Breaking Behavior and Cups Task								
Rule-Breaking Behaviors	0.31	0.32	0.06	<0.01	-	-	-	-
Cups Task	0.12	0.13	0.07	0.07	-	-	-	-
Rule-Breaking Behaviors x Cups Task	0.01	0.04	0.02	0.55	-	-	-	-
Rule-Breaking Behavior and Game of Dice Task								
Rule-Breaking Behaviors	0.32	0.34	0.06	<0.01	-	-	-	-
Game of Dice Task	0.02	0.03	0.05	0.64	-	-	-	-

Rule-Breaking Behaviors x Game of Dice Task	-0.02	-0.12	0.01	0.07	-	-	-	-
Rule-Breaking Behavior and Iowa Gambling Task								
Rule-Breaking Behavior	0.33	0.35	0.06	<0.01	-	-	-	-
Iowa Gambling Task	0.002	0.01	0.01	0.88	-	-	-	-
Rule-Breaking Behavior x Iowa Gambling Task	0.002	0.06	0.003	0.36	-	-	-	-
Aggressive Behavior and Cups Task								
Aggressive Behavior	0.20	0.25	0.06	<0.01	-	-	-	-
Cups Task	0.14	0.15	0.07	0.03	-	-	-	-
Aggressive Behavior x Cups Task	0.005	0.02	0.02	0.76	-	-	-	-
Aggressive Behavior and Game of Dice								
Aggressive Behavior	0.22	0.27	0.06	<0.01	-	-	-	-
Game of Dice Task	0.03	0.05	0.05	0.49	-	-	-	-
Aggressive Behavior x Game of Dice Task	0.0001	0.001	0.01	0.99	-	-	-	-
Aggressive Behavior and Iowa Gambling Task								
Aggressive Behavior	0.23	0.28	0.06	<0.01	-	-	-	-
Iowa Gambling Task	0.01	0.04	0.01	0.57	-	-	-	-
Aggressive Behavior x Iowa Gambling Task	0.001	0.02	0.002	0.75	-	-	-	-

Note: Bolded results indicate significant variables.

Table 13: Aim 3 results of poisson regression analyses

	Unstandardized Regression Coefficient	SE	p-value	Unstandardized Regression Coefficient	SE	p-value
	Outliers Included in Analyses			Outliers Removed in Analyses		
Externalizing Symptoms and Cups Task						
Externalizing Symptoms	0.04	0.01	<0.01	-	-	-
Cups Task	0.05	0.02	0.01	-	-	-
Externalizing Symptoms x Cups Task	-0.001	0.002	0.50	-	-	-
Externalizing Symptoms and Game of Dice Task						
Externalizing Symptoms	0.04	0.01	<0.01	-	-	-
Game of Dice Task	0.02	0.02	0.35	-	-	-
Externalizing Symptoms x Game of Dice Task	-0.001	0.002	0.34	-	-	-
Externalizing Symptoms and Iowa Gambling Task						
Externalizing Symptoms	0.04	0.01	<0.01	-	-	-
Iowa Gambling Task	0.001	0.003	0.83	-	-	-
Externalizing Symptoms x Iowa Gambling Task	0.003	0.003	0.30	-	-	-
Attention Problems and Cups Task						
Attention Problems	0.06	0.03	0.03	-	-	-
Cups Task	0.05	0.02	<0.01	-	-	-
Attention Problems x Cups Task	-0.01	0.01	0.05	-	-	-
Attention Problems and Game of Dice Task						
Attention Problems	0.07	0.03	0.01	-	-	-
Game of Dice Task	0.01	0.01	0.43	-	-	-
Attention Problems x Game of Dice Task	-0.0001	0.01	0.99	-	-	-
Attention Problems and Iowa Gambling Task						
Attention Problems	0.07	0.03	<0.01	-	-	-
Iowa Gambling Task	0.002	0.003	0.47	-	-	-
Attention Problems x Iowa Gambling Task	0.001	0.001	0.23	-	-	-
Rule-Breaking Behavior and Cups Task						
Rule-Breaking Behaviors	0.10	0.02	<0.01	-	-	-
Cups Task	0.04	0.02	0.01	-	-	-
Rule-Breaking Behaviors x Cups Task	-0.002	0.004	0.61	-	-	-
Rule-Breaking Behavior and Game of Dice Task						

Rule-Breaking Behaviors	0.10	0.02	<0.01	-	-	-
Game of Dice Task	0.02	0.02	0.23	-	-	-
Rule-Breaking Behaviors x Game of Dice Task	-0.01	0.003	0.03	-	-	-
Rule-Breaking Behavior and Iowa Gambling Task						
Rule-Breaking Behavior	0.10	0.02	<0.01	-	-	-
Iowa Gambling Task	-0.001	0.003	0.71	-	-	-
Rule-Breaking Behavior x Iowa Gambling Task	0.001	0.001	0.14	-	-	-
Aggressive Behavior and Cups Task						
Aggressive Behavior	0.06	0.02	<0.01	-	-	-
Cups Task	0.05	0.02	<0.01	-	-	-
Aggressive Behavior x Cups Task	-0.002	0.003	0.56	-	-	-
Aggressive Behavior and Game of Dice						
Aggressive Behavior	0.06	0.02	<0.01	-	-	-
Game of Dice Task	0.01	0.01	0.39	-	-	-
Aggressive Behavior x Game of Dice Task	-0.001	0.003	0.73	-	-	-
Aggressive Behavior and Iowa Gambling Task						
Aggressive Behavior	0.06	0.02	<0.01	-	-	-
Iowa Gambling Task	0.002	0.003	0.54	-	-	-
Aggressive Behavior x Iowa Gambling Task	0.0001	0.0005	0.91	-	-	-

Note: Bolded results indicate significant variables.

Table 14. Summary of unstandardized regression coefficients for simple slope difference tests for all significant interaction effects for aim 3 (poisson regression)

Attention Problems and Cups Task			
	Less Risk-Taking (CT)	Average Risk-Taking (CT)	More Risk-Taking (CT)
Attention Problems	0.10**	0.06*	0.02
Rule-Breaking Behavior and Game of Dice Task			
	Less Risk-Taking (GDT)	Average Risk-Taking (GDT)	More Risk-Taking (GDT)
Rule-Breaking Behavior	0.14**	0.10**	0.06

Note: * = p -value < 0.05, ** = p -value < 0.01

Figure 1. Computer screen display of the Cups Task

Figure 2. Computer screen display of the Game of Dice Task

Figure 3. Computer screen display of the Iowa Gambling Task

Figure 4. Simple slopes of the effect of MPS-total score on RSBQ-total score at different levels of attention problems.

Note: RSBQ = risky sexual behavior questionnaire. Observed values are jittered.

Figure 5. Simple slopes of the effect of attention problems on RSBQ-total score at different levels of risk-taking on the GDT

Note: RSBQ = risky sexual behavior questionnaire and GDT = game of dice task. Observed values are jittered.

Figure 6. Simple slopes of the effect of lifetime amount of cannabis use (in grams) on RSBQ-total score at different levels of risk-taking on the CT.

Note: RSBQ = risky sexual behavior questionnaire and CT = cups task. Observed values are jittered.

Figure 7. Simple slopes of the effects of amount of lifetime cannabis use on RSBQ-total score at different levels of risk-taking on the CT

Note: RSBQ = risky sexual behavior questionnaire and CT = cups task. Observed values are jittered.

Figure 8. Simple slopes of the effects of MPS-total score on RSBQ-total score at different levels of risk-taking on the CT

Note: MPS = marijuana problems scale, RSBQ = risky sexual behavior questionnaire and CT = cups task. Observed values are jittered.

Figure 9. Simple slopes of the effects of MPS-total score on RSBQ-total score at different levels of risk-taking on the GDT

Note: MPS = marijuana problems scale, RSBQ = risky sexual behavior questionnaire and GDT = game of dice task. Observed values are jittered.

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SELECTED PUBLICATIONS

Waschbusch, D. A., Willoughby, M. T., Haas, S. M., Helseth, S. A., Crum, K. I., Altszuler, A. R., Ross, J. M., Coles, E. K., & Pelham Jr., W. E. (under review). Effects of behavioral treatment modified to fit the learning style of children with conduct problems and callous-unemotional (CU) traits.

Ross, J. M., Duperrouzel, J. C., Pacheco-Colon, I., & Gonzalez, R. (in press). *The Neuropsychology of Street Drugs*. In Baker, L. & Paul, R. (Eds.). *Encyclopedia on Health Psychology*. New Jersey: Wiley.

Duperrouzel, J. C., Laird, A. R., Sutherland, M.T., Ross, J. M., & Gonzalez, R. (2016, February). Functional neuroimaging consensus regarding executive function alterations among cannabis using adolescents and young adults. Poster presentation at the International Neuropsychological Society. Boston, MA.

Gonzalez, R., Ross, J. M., & Duperrouzel, J. C. (2016, February). Decision-making as a risk for development of cannabis dependence among teens: Preliminary observations. Paper presentation at the International Neuropsychological Society. Boston, MA.

Ross, J. M., Duperrouzel, J. C., Gonzalez, I. & Gonzalez R. (2016, February). Decision-making and cannabis use interact to predict risky sexual behavior among adolescents. Poster presentation at the International Neuropsychological Society. Boston, MA.

Ross, J. M., Duperrouzel, J.C., Vega, M., & Gonzalez, R. (2016). The neuropsychology of risky sexual behavior. *Journal of International Neuropsychological Society*, 22 (6), 586-594.

Ross, J. M., Graziano, P., Pacheco-Colon, I., Coxe, S., & Gonzalez, R. (2016). The role of decision-making in the relationship between cannabis use and body mass index among adolescent cannabis users. *Journal of International Neuropsychological Society*. Published Online: April 15, 2016.

Duperrouzel, J. C., Ross, J. M., & Gonzalez, R. (2015, June). Relationship between changes in cannabis use and anxiety among adolescents. Poster presentation at the College on Problems of Drug Dependence, Phoenix, AZ.

Levine, A., Gonzalez, R., Ross, J. M., & Martin, E. M. (2015). *Neurocognition in HIV and Substance Use Disorders*. In Gendelman, H.E., Grant, I., Everall, I.P., Gelbard, H.A., Fox, H.S., Lipton, S.A., and Swindells, S. (Eds.) *The Neurology of AIDS*, New York: Oxford University Press.

Ross, J. M., Coxe, S., Schuster, R. M., & Gonzalez, R. (2015). Risky sexual behavior in young adult cannabis users with conduct disorder symptoms: The role of decision-making. *Journal of Clinical and Experimental Neuropsychology*, 37 (3), 303-315. doi:10.1080/13803395.2015.1010489

Ross, J. M., Graziano, P., Duperrouzel, J. C., Gonzalez, I., & Gonzalez, R. (2015, June). Moderating effects of decision-making on cannabis use and body mass index among adolescents. Poster presentation at the College on Problems of Drug Dependence, Phoenix, AZ.

Ross, J. M., Coxe, S., Schuster, R. M., & Gonzalez, R. (2014, March). Decision-making, conduct disorder symptoms, and level of cannabis use interact to predict number of sexual partners. Poster presentation at the International Neuropsychological Society, Seattle, WA.

Sibley, M. H., Altszuler A. R., Ross, J. M., Sanchez, F., Pelham, W. E., & Gnagy, E. M. (2014). A group-based parent-teen collaborative intervention for high school students with ADHD. *Cognitive and Behavioral Practice*, 21 (1), 32-42.

Sibley, M. H., Pelham, W. E., Molina, B. S. G., Coxe, S., Kipp, H., Gnagy, E. M., Meinzer, M., Ross, J. M., & Lahey, B. B. (2014). The role of early childhood ADHD and subsequent CD in the initiation and escalation of adolescent cigarette, alcohol, and marijuana use. *Journal of Abnormal Psychology*, 123 (2), 362-374. doi: 10.1037/a0036585

Babinski, D., Sibley, M. H., Ross, J. M., & Pelham, W. E. (2013). The effects of single versus mixed gender treatment for adolescent girls with ADHD. *Journal of Clinical Child and Adolescent Psychology*, 42 (2), 243-250.

Sibley, M. H., Ross, J. M., Gnagy, E.M., Dixon, L., Conn, B., & Pelham, W. E. (2013). An intensive summer treatment program for ADHD reduces parent-adolescent conflict. *Journal of Psychopathology & Behavioral Assessment*, 35 (1), 10-19.

Sibley, M. H., Pelham, W. E., Mazur, A., Gnagy, E. M., Ross, J. M., & Biswas, A. (2012). The effect of video feedback on the social behavior of an adolescent with ADHD. *Journal of Attention Disorders*, 16 (7), 579-588.

Sibley, M. H., Pelham, W. E., Evans, S. W., Gnagy, E. M., Ross, J. M., & Greiner, A. R. (2011). Evaluation of a summer treatment program for adolescents with attention deficit/hyperactivity disorder. *Cognitive and Behavioral Practice*, 18 (4), 530-544.