PERSONALITY AND WORKING MEMORY THEORIES OF SUBSTANCE USE DISORDERS

A DISSERTATION

SUBMITTED TO THE FACULTY

OF

THE GRADUATE SCHOOL OF APPLIED AND PROFESSIONAL PSYCHOLOGY

OF

RUTGERS,

THE STATE UNIVERSITY OF NEW JERSEY

BY

ANNIE CLAIRE REN

IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE

OF

DOCTOR OF PSYCHOLOGY

NEW BRUNSWICK, NEW JERSEY MAY 2020

COMMITTEE MEMBERS:

Frederick Rotgers, Psy.D.

Shalonda Kelly, Ph.D.

ABSTRACT

Continued high relapse rates following SUDs treatment urges examination of aspects of SUDs which are currently undertreated. There are currently two theories on the development and maintenance of SUDs which offer valuable insight but are underutilized in informing treatment. One theory comes from personality science and views SUDs as hyperactivity of the behavioral activation system (BAS) combined with hypoactivity in the behavioral inhibition system (BIS). The second theory derives from the cognitive branch of psychology and states that low working memory capacity (WMC) is a primary contributor to the development of SUDs. The present paper demonstrates how these two theories intersect to form one unified theory for the conceptualization and treatment of SUDs. The present paper demonstrates that both high-BAS/low-BIS and WMC result in the same behavioral pattern which is observed in individuals with SUDs: impulsivity, the overvaluation of rewards, and the undervaluation of punishment. To improve treatment outcomes for SUDs, future developments in treatment need to target these behaviors.

ACKNOWLEDGMENTS

This work would not have been possible without the support from the faculty and my fellow students at Rutgers Graduate School of Applied and Professional Psychology. I am especially grateful to the chair of my dissertation committee, Dr. Frederick Rotgers, for the support and guidance he has given me throughout the years. I am grateful to Dr. Shalonda Kelly for all she has taught me as a professor and member of my dissertation committee. My gratitude also goes out to my academic adviser, Dr. Brian Chu, for all he has taught me about research and about being a psychologist.

I would like to acknowledge Dr. Brett Deacon, my former professor and research adviser during my three-year research assistantship at the University of Wyoming, for being one of the original inspirations for my passion for the field of psychology and for my deep respect for the scientific process. I would not be the person and therapist I am, without you. You taught me to conquer my fears and I aspire daily to help others do the same.

Many thanks to Dr. Zhaojie Zhang and Dr. Qun Ren, my parents and mentors for life. You have been inspiring role models and my biggest supporters in every step along the way. Thank you also to my sister Gracie, the comic relief in difficult parts of this journey. I would also like to acknowledge the colleagues and other indispensable members of my support crew, Dr. Nisha Kumar and Cristine Glendening, who believed in me when I did not believe in myself.

Thank you also to my colleagues and mentors at Kansas State University Counseling Services, University of Oklahoma Counseling Center, Rutgers Youth Anxiety and Depression Clinic, the Reeds Center, and Damon House, the latter of which is community that inspired this dissertation. It takes a village to raise a psychologist, and I have had the privilege of being a part of some of the best villages. Thank you.

Table of Contents

List of Tables

INTRODUCTION

Background

Substance use disorder (SUD) is defined as the inability to stop using a substance despite experiencing impairment in one or more domains, such as occupational impairment, legal trouble, or significant relationship distress. In any given year, one in every 12 Americans suffers from a substance use disorder (Hedden et al., 2015). In 2016 alone, around as many Americans died by drug overdose as during the entire Vietnam War (Hasin et al., 2016). Despite receiving treatment, relapse rates for SUDs remains high. For example, around 60% of patients treated for heroin SUD relapse within the first year of treatment (Gossop, Stewart, Browne, & Marsden, 2002).

Over the years, many factors have been proposed for why substance abuse occurs (Brown, 2002; Farley et al., 2004). These theories emerge from a vast array of domains including genetics (Jang, Livesley, & Vemon, 1996), family history, peer groups, trauma history (Farley et al., 2004), and more. Recent exploration of substance use has also taken into consideration specific psychological traits, namely the behavioral activation system (BAS), behavioral inhibition system (BIS), and working memory capacity (WMC). Research indicates that BAS/BIS and WMC influences SUDs, in that both psychological constructs impact decision-making to influence decisions to use substances. Increased levels of BAS predisposes individuals to seek rewards (Balconi, Finocchiaro, & Canavesio, 2015), while increased levels of BIS predisposes individuals to make choices that avoid negative consequences (Hamill, Pickett, Amsbaugh, & Aho, 2015). Similarly, the psychological construct of WMC influences decision making, where individuals who possess lower WMC more likely to abuse substances (Yan et al., 2014). Given that these two psychological constructs are related to decision-making and the

choice to use substances, interventions targeting both have been developed to address SUDs. An exploration of jointly addressing BAS/BIS and WMC has yet to be conducted.

Research Questions

RQ1. How can BAS/BIS and WMC theories be combined to improve the understanding of substance use disorder?

RQ2. What are the treatment implications for combining BAS/BIS and WMC theories?

Method

This study was a systematic review of the literature concerning two parallel theories of SUDs. Screening was conducted to ensure that only the most appropriate literature was included in the review. This screening limited the literature retained for the study to those that reported both SUDs and either WMC or BAS or BIS.

Definitions

Behavioral Activation System (BAS). Behavioral activation system refers to the degree to which a person's responses to reward stimuli.

Behavioral Inhibition System (BIS). Behavioral inhibition system refers to the degree to which a person is motivated to avoid the negative consequences of an action.

Working Memory Capacity (WMC). Working memory capacity refers to the short-term retention of information that people draw upon in decision making.

Substance Use Disorder (SUD). Substance use disorder refers to a person's inability to cease using various substances despite the fact that such use is causing impairments in at least one of several ways.

Drawing upon analysis of extant literature, there are a few assumptions that may be made. The first assumption regards the validity and reliability of the data. The result of the current study relies on the accuracy of previously published results.

A limitation to this approach was the comparative quality of the studies included for this review. Although attempts were made to ensure that study findings were significant, the quality of each independent study was variable. In a review of the literature, there was a reliance on the original author's own proclamations of design and results that may not be validated by the current researcher. A second limitation was that operational definitions are not always standardized across studies. For example, BAS/BIS may be measured by a variety of tools, which may not define BAS/BIS in precisely the same terms as other tools measuring the same variable.

Another issue with drawing from previous studies was the external validity of secondary research. Given that there was no sample drawn from which to test the findings regarding research and interventions, there is limited ability to extrapolate the findings to assert whether or not they actually applied to both research settings compared with clinical and community settings.

Significance of the Study

The research was significant first because it adds to the contributing literature on BAS/BIS, WMC, and SUDs. This study has the chance to impact future studies into reducing SUD by proposing a joint BIS/BAS-WMC intervention. In the long term, a newly proposed BAS/BIS-WMC joint intervention could be tested to determine whether it has an impact among populations that are at risk of SUD. A joint BAS/BIS-WMC intervention could then be applied

in practice outside the testing environment and used by professionals who are working with populations at risk of SUD in order to help reduce incidents of SUD.

LITERATURE REVIEW

Overview of SUDs and Behavior

In the treatment of SUDs, the usage of substances is viewed as the unilateral target behavior. Individuals with SUDs consistently exhibit a number of other problematic behavioral patterns (Braddock et al., 2011) which are not directly targeted in treatment. As an extreme example, individuals with SUDs drive without seatbelts more frequently than the nonclinical population (Braddock et al., 2011). This behavior is not targeted though this type of behavior is consistent with increased risk taking, impulsivity, and rule-breaking behavior. Addressing these underlying risky behaviors may help reduce SUDs but also address other risk-taking behaviors. Present theory posits that (1) these behaviors, including SUDs, are caused by high BAS, low BIS, and low WMC, that (2) this behavioral pattern is the unified framework to understanding both of these causal factors of SUDs and (3) the direct treatment of these behaviors is necessary to increasing treatment outcomes of SUDs.

When examining individuals with SUDs, distinct behavior patterns emerge. These behavior patterns include risk-taking, impulsivity, and rule-breaking (Grant & Chamberlain, 2014). Impulsivity is defined as making decisions which lead to short-term rewards in disregard of long-term harm. Risk-taking is the tendency to put oneself in situations where winning will result in a large reward, but is unlikely, while experiencing a loss (large or small) is the most likely scenario. The opposite of risk-taking is to place oneself in a situation where a reward is small but certain and a loss is unlikely to occur. Rule-breaking is a pattern of behavior of disregard for instructions from authorities. This particularly concerns the law. However, it can

also entail disregard to follow institutional behavior guidelines at work, in inpatient treatment units, and during childhood, at school and in the home. The characteristics of impulsivity, risk-taking, and rule-breaking sufficiently encompass many of the behaviors with which SUDs has been associated.

The link between behaviors and SUDs is sometimes unclear. Impulsivity, risk-taking, and rule-breaking are sometimes seen as a symptom of SUDs, through researchers question whether these inclinations cause SUDs or if they are a result of substance abuse (Grant & Chamberlain, 2014). One example of a behavior which has traditionally thought to be caused by SUDs, is stealing. Of all individuals arrested, around half test positive for illicit substances (Stevens, Trace, & Bewley-Taylor, 2005). It is commonly thought that drug use causes crime: individuals with SUDs engage in theft, burglaries, and robberies in order to buy more drugs. This is true for some (White, 2016). Yet even in the design of treatment programs, it is overlooked that for many individuals, stealing behavior predates substance use and addiction. A study found that in heroin users in particular, nondrug criminality (primarily stealing to generate income), predated substance use (Taylor & Albright, 1981). This lends evidence to the theory that certain behavioral patterns are not symptoms of SUDs, but symptoms of another issue which causes both stealing and SUDs.

Impulsivity is another behavior associated with SUDs. Delay discounting is a specific behavior which falls under the umbrella of impulsivity. Delay discounting is characterized by individuals who prefer an immediate reward versus a distal reward even when the distal reward is much larger than the immediate one. One study asked individuals with and without SUDs whether they would prefer to receive $30 today or $50 in a month, in addition to other similar tasks. Compared to non-users, substance users had a higher rate of choosing immediate rewards

even if it meant a smaller reward (Bickel & Marsch, 2001). For some individuals, chronic exposure to harmful substances causes changes to the brain, damaging the long-term decision-making processes (Bechara & Martin, 2004). Conversely, longitudinal studies have shown that after dividing non-users into impulsive vs. not impulsive groups, those with impulsivity were far more likely to develop a SUD later (Verdejo-Garcia, Lawrence, & Clark, 2008). The authors of the study likewise posited that (1) SUDs may cause impulsivity, (2) impulsivity may cause SUDs and (3) a third factor may cause both. The present paper seeks to elucidate the aforementioned third factor.

SUDs and risk-taking behaviors have long come hand-in-hand. Among teenagers, those who experiment with drugs are also likely to experiment with risky sexual behaviors even while sober (Feldstein & Miller, 2006). In adolescents, these two sets of behaviors (SUDs and sexual risk-taking) begin around the same time, offering no support that one causes the other. Another study examined risk-takers and control subjects and found that risk-takers were more likely to participate in illicit substance use and nondrug criminality (Lane & Cherek, 2000). The authors concluded that a sensitivity to reward, combined with insensitivity to punishment, was the cause of both substance use and other risk-taking behavior. This theory is one which is examined in depth in the current paper.

Current Treatment

Despite the known prevalence of SUD, and advancements in how these disorders are diagnosed, relatively few Americans receive adequate treatment, if they receive treatment at all (Lipari & Van Horn, 2017). Only 1.0% of the population over the age of 18 received treatment for SUDs despite SUDs being found in 8.4% of the adult population (Lipari & Van Horn, 2017).

These numbers suggested that adequate treatment of individuals with SUD continued to lag despite an evolution in how SUD was diagnosed (Lipari & Van Horn, 2017).

Moving forward, researchers suggest it is important to improve access to substance use treatment (Lipari & Van Horn, 2017). Previously, researchers indicated that the treatment of SUD was complicated for two major reasons (Lipari & Van Horn, 2017). First, individuals with SUD were not ready to give up either alcohol or drugs. A second reason was due to a lack of health care coverage, or an inability to pay for their treatment (Lipari & Van Horn, 2017). This study addressed the first of these by examining the behavioral aspects that underlying SUD in individuals.

Current therapeutic interventions include cognitive-behavioral therapy, contingency management, the community reinforcement approach, motivational enhancement therapy, the matrix model, and twelve-step facilitation therapy (OSG, 2016). Cognitive behavioral therapy is the most researched and evaluated form of behavioral therapy applied to those with SUD. Cognitive behavioral therapy has previously been identified as an effective means of addressing chronic disorders ranging from anger control to anxiety disorders, following meta-analysis of the existing literature (Hofmann, Asnaani, Vonk, Sawyer, & Fang, 2012).

Examination of the efficacy of cognitive behavioral therapy has often been performed in tandem with an examination of other psychological disorders, rather than performed as an analysis of substance use disorder alone (Hofmann et al., 2012). However, the existing literature indicates that these forms of therapy are effective in treating SUDs when present in tandem with post-traumatic stress disorder (PTSD). Results were less consistent for SUD than PTSD as SUD may be more difficult to treat (Najavits & Hien, 2013). Research by Lanza, Garcia, Lamelas, and Gonzalez-Menendez (2014) found that cognitive behavioral therapy was a more effective

treatment in reducing anxiety versus acceptance and commitment therapy, though acceptance and commitment therapy had superior outcomes in reducing drug use over time.

Theoretical Frameworks

Behavioral Activation System and Behavioral Inhibition System Theory.

Personality is the study of individual differences at the psychological level. Personality traits are often stable across the lifespan (Donnellan & Robins, 2009). Some traits have been linked to genetics more strongly than others (Jang, Livesley, & Vemon, 1996). Personality traits exist on a continuum, and at the extreme ends of the continuum: a person's personality may be so atypical as to limit their ability to live by their society's expectations. For example, when viewing empathy as a personality trait, those on the extreme low end of the spectrum are associated with psychopathy. Psychopathy is associated with criminality and other behaviors which impair societal functioning.

From the perspective of personality science, SUDs are the manifestation of being in the extreme ends of the continuum on two particular personality traits. These traits are known as the behavioral activation system (BAS) and the behavioral inhibition system (BIS). BAS is what motivates individuals to approach rewards, while BIS motivates people to avoid negative consequences. Scores on sensitivity to these systems are two separate continuums. Therefore, an individual may score high in both BAS and BIS, high in one but not the other, or low in both. The different behavioral patterns produced by various combinations of these different scores on these traits, are illustrated in Table 1.

A prime example of a behavior which leads to immediate, pleasurable sensations and long-term harm is substance use. Proximal, rather than distal consequences, are most powerful when influencing decisions. However, in situations where the negative consequences are distal

while rewards are immediate, individuals who have high-BAS with low-BIS (BAS+/BIS-) may experience more difficulty than the average person in taking long-term considerations into account in their decisions. Indeed, it has been established that the high-BAS/low-BIS profile is correlated with a variety of impulsive behaviors, such as binge eating (Nederkoorn, Braet, Van Eijs, Tanghe, & Jansen, 2006) and anger management issues (Smits & Kuppens, 2005). As shown in Table 1, the BAS+/BIS- profile shows the characteristics which were previously determined to be behavioral correlates of SUDs.

Table 1

BAS/BIS Matrix

	BAS+	BAS-
BIS+	• Sensitive to reward • Sensitive to punishment • Highly motivated	• Unsensitive to reward • Sensitive to punishment • Anxious • Risk-adverse • Wary of trying new things
BIS –	• Very sensitive to reward • Unsensitive to punishment • Impulsive • Risk-taking • Rule-breaking	• Unsensitive to reward • Unsensitive to punishment • Relaxed • Unambitious

Studies examining temporal precedence have found that BAS+/BIS- predates the development of SUD. Sher, Bartholow, and Wood (2000) assessed nearly 500 participants on a large variety of personality traits and their substance use. They waited six years and surveyed the same individuals again. They found one personality factor which predicted substance use significantly better than all other traits. If at the time of first measurement, an individual high BAS and low BIS, they were significantly more likely than other participants to have developed

a SUD six years later. Therefore, BAS+/BIS- is an underlying personality factor which leads to SUDs. This finding is supported by other studies. Grau and Ortet (1999) surveyed 149 women without SUDs on their alcohol consumption and personality. It was found that alcohol consumption was not related to anxiety or neuroticism but was highly correlated with traits associated with BAS+/BIS-, such as sensation-seeking and impulsivity. This shows that even prior to the clinical level of substance use, individuals with BAS+/BIS- are more susceptible to rewards associated with substances. It lends evidences to the suggestion that the specific behavioral pattern associated with BAS+/BIS-, specifically, sensation-seeking and impulsivity, predicts SUDs.

BAS+/BIS- was also found to be associated with the severity of substance use. Franken and Muris (2006) indicated that BAS was correlated with the amount of alcohol consumed in an average sitting, the number of drugs an individual had used, and the frequency of binge drinking. A mild, negative correlation was found between these behaviors and BIS, but the strongest predictor of the use of substances was higher scores in BAS. These findings suggest that high BAS is what directly impacts substance use behavior rather than BIS. Rather than BIS directly impacting substance use behavior, medium to high BIS may act as a buffer against the effects of high BAS. Their combination leads to not only substance use, but also more risk-taking when it comes to the specificity of substance-related behaviors.

Another such risky substance-related behavior is in experimenting and using different types of drugs. Lackner, Unterrainer, and Neubauer (2013) examined the difference in personality between individuals with polydrug-SUD versus alcohol-only SUD. Polydrug users were found to exhibit more sensation-seeking behaviors than the alcohol-SUD group. Therefore, those with high sensation-seeking, a product of BAS+/BIS-, were more likely to become

addicted to multiple types of drugs. As the number of drugs an individual is addicted to increases, the difficulty of treatment and propensity for overdose also increases (Earleywine & Newcomb, 1997). Therefore, BAS+/BIS- influences not only the development, but also the severity, of SUD.

The onset of SUDs was also influenced by BAS/BIS. In a longitudinal study by Tarter et al. (2013), youth were measured in BIS and substance use at ages 10-12 and followed up through age 19. BIS was a strong predictor for the development of SUDs. In fact, it exceeded drug use at age 10-12. Children with low BIS were 6.8 times as likely as high-BIS individuals to develop SUDs by adulthood. Substance use in childhood, in contrast, only made an individual 3.2 times more likely to have a SUD at age 19. This study is important in demonstrating the strength of the relationship between BAS/BIS with SUDs.

Similarly, Kim-Spoon et al. (1026) found that BAS+/BIS- was associated with early onset substance abuse. However, early onset of substance abuse did not occur when there was high BIS in conjunction with high BAS. This highlighted the interactional effect of BAS and BIS as separate traits.

Previously discussed as a behavioral pattern of SUDs was the preference for the immediate reward in the presence of a larger but distant reward. Madden et al. (1997) found that for those with SUDs, the timing of the reward also mattered. Compared with healthy controls, individuals with opioid SUD chose smaller immediate rewards over delayed rewards over larger, distant once. This effect is called delay discounting, a thinking bias where the value of a reward is discounted because of a delay. In this study, the trend also differed by the type of reward. The preference towards a smaller but immediate reward was more pronounced when the reward was heroin rather than money. Because of heroin's potential to trigger more dopamine responses in

the brain, it can be concluded that the more stimulating the reward, the greater the preference for immediacy over amount (Madden, 1997). This evidence strengthens the relationship between BAS/BIS and the behavioral pattern of SUDs.

Working Memory Theory

Working memory is the part of short-term memory that stores information which is currently being used. Those with higher working memory capacity (WMC) are able to hold larger amounts of information in the mind simultaneously to process them. They are better able to multitask, and also to focus despite the presence of noise or other external stimuli around them.

Lower WMC has been observed in individuals with SUDs versus those without SUDs (Yan et al., 2014). In this study, the 60 healthy controls showed significantly better working memory than the 60 participants with heroin SUD, even after the cessation of substance use. Furthermore, there was a negative correlation between WMC and the severity of the disorder, where those with less WMC had more severe addictions. Severity was measured by years of use, average use per day, and age of first use. This suggests a strong association between WMC and SUDs (Yan et al., 2014).

The relationship between WMC and impulsive decision-making, one of the behavioral markers of SUDs, has also been demonstrated (Hinson et al., 2003). Subjects were asked to choose rewards which were listed by time and delay, where the longer the subject was willing to wait for the reward, the larger the reward would be. Researchers randomized participants to different levels of being interrupted and asked to complete tasks which burdened WMC. They found that the higher the working memory load, the more short-sighted the decisions were made (Hinson et al., 2003). Importantly, this study manipulated the independent variable,

demonstrating causality and directionality of WMC's effect on impulsivity. The conclusion drawn was that those with chronically low WMC may be consistently at-risk for making impulsive decisions.

This hypothesis was confirmed in a separate study (Shamosh et al., 2008). In this study, 103 healthy subjects were tested for WMC and delayed discounting. WMC was first measured via three tasks, two of which were verbal and one of which was spatial. Delayed discounting was measured via giving participants seven different choices. Periods of delay ranged from one month, with a $2000 reward, to eight years with a $40,000 reward, with five choices in between the two with incremental periods of delay and monetary reward. Results were that individuals with generally low WMC showed a greater tendency to prefer immediate, smaller rewards. The lower the WMC, the greater the delay discounting.

Another study examined the relationship between WMC and risk-taking behavior in the context of a task that simulated gambling (Bechara & Martin, 2004). In the presence of experiencing loss in the gambling task, healthy controls promptly switched from a high-risk card deck to selecting a low-risk deck, but individuals in the SUDs group were slower to make the switch, if they switched at all. This demonstrated a tendency for risk-taking behavior in the SUDs group. The authors hypothesized that the reduction in working memory drove the risk-taking in participants with SUDs (Bechara & Martin, 2004).

In a similar study of a community sample of adolescents, those with lower WMC were found to be more likely to act without thinking (Romer et al., 2011). They were found to have higher rates of fist-fighting, gambling for money, using alcohol and cigarettes, and were more likely to have had disciplinary action taken against them at school and in the home. Therefore, strong ties exist not only between WMC and behaviors which involve a pattern of risk-taking,

impulsivity, and rule breaking. The WMC theory states that WMC is a strong risk factor leading to the development of SUDs. The present review demonstrates that WMC leads not only to SUDs, but a pattern of rule-breaking, impulsivity, and risk-taking.

Working memory was related to the progression of substance use at early stages, which predicted later substance use disorders among adolescents (Khurana, Romer, Betancourt, & Hurt, 2017). The researchers used longitudinal data drawn from 2005 through 2010 and included follow up data from 2012. Working memory of participants was assessed using computerized tasks, while the phenomenon of acting without thinking and delaying the discounting of drugs were gauged using self-reporting measures. Following an analysis of the data, the researchers found that those adolescents with weak working memory were the most likely to have low impulse control.

Researchers applied working memory theory and examined a working memory intervention and its ability to interfere with reconsolidation alcohol-related memories in a study of non-treatment seeking problem drinkers (Kaag et al., 2017). The study was conducted among heavy drinkers who had not yet sought treatment. It this study, the intervention involved applying a working memory training session that occurred either before or after a time when participants were asked to remember alcohol elated memory. In cases where the intervention was applied after memory retrieval, when working memory load was high, there was no impact on cravings. However, when the intervention was applied before the participant was asked to remember, there was a reduction in cravings (Kaag et al., 2017). Researchers concluded that the findings indicated applying a working memory intervention before remembering alcohol related memories could interfere with cravings and interrupt substance use disorders.

Low WMC was also found to be associated with poor outcomes in the treatment of alcohol abuse (Houck & Ewing, 2017). Researchers noted that previous attempts to intervene in addiction met with varying outcomes, and working memory was assumed to be one of factors influencing these outcomes. Researchers compared working memory along with three-month treatment outcomes following education efforts about alcohol and marijuana abuse. Researchers identified a relationship between lower working memory scores and poor treatment outcomes for alcohol abuse (Houck & Ewing, 2017).

Alcohol users' thoughts about alcohol has been shown to change in response to interventions designed to strengthen working memory (Snider et al., 2018). Researchers attempted to strengthen working memory in individuals with alcohol dependence and measure the success of the intervention by gauging whether they chose to gratify themselves in the short term or long term. The researchers drew data from 50 alcohol independent individuals and compared actual versus sham training sessions. The resulting data indicated that improving working memory helped to alleviate these bouts of episodic thinking and valuation of immediate reward (Snider et al., 2018). As such, improving working memory may help to delay these bouts that preceded the desire to drink.

Cognitive training has also impacted in methamphetamine SUD (Brooks et al., 2017b). This study found differences between users and non-users in baseline levels of self-control. Following the application of their intervention targeting WMC, users demonstrated improved levels of self-control, improved self-regulation, and lower levels of depression. (Brooks et al., 2017b). As such, the researchers hypothesized that working memory training may help to improve the impulsivity and self-regulation of those with SUDs.

Similarly, research conducted by Lechner, Day, Metrik, Leventhal, and Kahler (2016), indicated that alcohol consumption created working memory declines that in turn led to decreased ability to regulate alcohol consumption. The researchers noted that alcohol use reduced executive functions. This phenomenon was dose dependent, with increased consumption leading to further declines. The researchers were administered placebos and alcohol doses as well as had their working memory tested.

In summation, these studies have shown that low WMC was implicated to the development, severity, and treatment of SUDs. Similarly interventions to increase WMC led to improvements in impulsivity and self-control and have led to the improvement of symptoms related to SUDs.

THEORETICAL SYNTHESIS

Two theories of individual differences have been shown to contribute to the development and maintenance of SUDs and which could potentially be used as early identifying markers of risk for developing SUDs, especially when combined with other known risk factors. There are several notable similarities and areas of overlap between the two theories. Both involve mentally processing the promise of a reward. Within WMC theory is the idea that lowered WMC leads to delay discounting, or mentally decreasing the value of a reward due to its distance in time. Similarly, BAS/BIS theory suggests that individuals with BAS+/BIS- are very attuned to the promise of reward and tend to ignore the risk of punishment. Therefore, theorists from both camps would agree that how rewards are mentally processed, is a key component of understanding the psychological differences between substance users versus non-users.

From this perspective, the theories are a well-fitting combination. When considered in tandem, the implication is that individuals with BAS+/BIS- overvalue rewards and undervalue

punishment. WMC and delay discounting suggest that when the reward is proximate, it is worth more. Distal rewards are therefore worth less. This could be extrapolated to hypothesize that punishment, when distal, further decreases in value to the individual with SUDs. In combination, these offer a persuasive explanation for why the motivators which keep the average individual from pursuing overuse of substance is far less effective for certain individuals. The rewards associated with drug use – the immediate rush of dopamine and associated positive mood – is immediate. The rewards associated with sobriety – a happy marriage, healthy children, career advancement, etc. – are often distal. Therefore, the SUDs-prone brain has great difficulty in processing the latter group of rewards as being more meaningful than the immediate gains of substance use. Furthermore, punishments associated with substance use are also distal. Substances users are able to use for months or years before arriving at job loss, divorce, arrest, and imprisonment. BAS/BIS theory posits that substance users have difficulty processing the importance of potential punishment to begin with. WMC theory would suggest that because these punishments are distal, their likelihood of being overlooked in the decision-making process is even higher.

This glitch in decision-making is also important to evaluating the construction of public policies designed to reduce drug use and drug-related crime. The judicial system, due to constraints of practicality, is based on punishments rather than rewards. The average individual receives no government-awarded benefit for sobriety; however, individuals are imprisoned for the possession of controlled substances. Incarceration-diversion programs such as Drug Court are also almost always based on punishments rather than rewards. And where rewards exist, they are more distal than punishments. If an individual on special probation with Drug Court maintains sobriety every day, they will be awarded more privileges after six months (by ascending to the

next stage of probation). If they fail a drug test, they will be arrested within a day or two and spend 1-6 days in the county jail. The punishment is swift, but the reward is distal. Because punishment means little to individuals of this personality profile and distal rewards mean little to those of this cognitive profile, the BAS/BIS/WMC theory may explain the high relapse rate which these programs experience. The BAS/BIS and WMC both implicated the decision-making process and how individuals with SUDs may consider rewards and punishments differently than other individuals. The two theories dovetail nicely in this area.

A second similarity between the two theories is that their connection to the neurotransmitter dopamine. The BAS system is associated with the reward circuit in the brain. When the sensory cortex senses a reward in the system, it sends signals to the ventral tegmental area (VTA). The VTA increases dopamine function and supplies high levels of dopamine to the nuclear acumbens and the prefrontal cortex. The prefrontal cortex is the brain structure in which WMC is stationed. Zahrt, Taylor, Mathew, and Arnsten (1997) examined the effects of overstimulation of dopamine receptors on WMC. They injected dopamine receptor agonists into non-human study subjects prior to administering a task which uses WMC. They divided subjects into several groups, each with a different dosage of treatment. It was found that the higher the dose of the dopamine-enhancing chemical, the more impaired the WMC.

Dopamine therefore is implicated in both BAS/BIS theory and WMC theory. BAS/BIS posits a sensitivity to reward, suggesting that the reward circuit may be activated with more frequency and intensity in the brain of an individual with SUDs than the average person. Zahrt et al. (1997) showed that increased levels of dopamine are harmful to WMC. Dopamine as a link between the theories is later discussed. As of now, it is presented as an overlap between the theories.

A third similarity between the theories is that both are rooted in psychological traits which were traditionally considered immutable, but for which optimism lies on the horizon. Since both theories are very well supported by scientific literature, it can be suggested that the determiner of which theory is more deserving of funding and resources, is the theory which has the greatest potential to create change. That is to say, the theory which leads to changes in prevention programs, treatment methods, and judicial policy, is the one which is more useful. A theory which involves a mutable trait – one where individuals may improve – is a trait which makes a more meaningful target for change.

Traditionally, both were considered immutable. Personality, the umbrella which encompasses BAS and BIS, is thought to be stable after age seven (Deary, Whalley, Lemmon, Crawford, & Starr, 2000). Likewise, general intelligence, a cluster of mental abilities which includes working memory capacity, is thought to be immutable after the first grade (Schneider, Niklas, & Schmiedeler, 2014). However, hope is on the horizon in both these areas. As discussed previously, newer studies have shown treatment procedures which can increase WMC with lasting results. Similarly, behavioral activation-based therapies have gained evidence base in the treatment of depression. The next step is to adapt the treatment for application to individuals whose BAS-BIS gap is sufficiently large to cause impairment. These two theories, especially when combined, make an excellent area on which the future of addiction science should focus. The unified theory would involve the treatment of traits which were previously thought untreatable, yet which now have been shown to be fertile soil for the development of novel treatments.

Finally, both BAS/BIS and WMC can have a causal relationship towards behaviors which are risky, impulsive, and rule breaking. These behaviors are linked to difficulty in

occupational and social functioning. As previously demonstrated, these behaviors are not side effects of SUDs but rather central to our understanding of SUDs. Exploring the treatment of these behaviors as an adjunctive approach to treating SUDs may be the next step to improving treatment outcomes. Treatment techniques aimed towards these behaviors have already been tested and shown to be efficacious in other populations. A discussion of whether these treatments should be applied to the SUDs population will follow.

In summation, the BAS/BIS and WMC theories share important similarities. Firstly, they both involve processing rewards. This is particularly important when considering that current government-based tactics for combatting the rise of substance use involve distal punishment rather than immediate rewards. Secondly, both theories implicated dopamine as a biological substrate of these mental processes. Thirdly, both are rooted in traits which were previously thought untreatable, and therefore not worthy of substantial attention, but which are on the verge of becoming treatable constructs. This makes BAS/BIS/WMC theory an ideal candidate as the focus for future studies on the prevention and treatment of SUDs. Finally, they are both causal towards a behavioral pattern which could improve the understanding and treatment of SUDs.

Differences

The two theories also share notable differences. The primary differences between the two theories is that they hail from different subfields within the psychology. That they are being studied by two different groups of researchers is the primary reason for the lack of communication between theories behind each of these hypotheses. Conceptualizing the issue as two different facets will inevitability lead to different methodologies and conclusions to be drawn.

WMC is a cognitive ability. It is categorized with variables such as intelligence, memory, attention, visual-spatial reasoning, and other cognitive abilities. Cognitive traits are largely heritable. While there are treatments designed to attempt to increase natural ability, the majority of treatment for dysfunctions in these areas involve adapting the environment in order to increase social and occupational functioning. Those with memory deficits are taught to create a system for writing things down and organizing their notes. Those with auditory processing disorders buy televisions that offering captioning so they can read the script rather than rely on processing oral language. Schools offer individuals with ADHD extra time on exams.

BAS/BIS, in contrast, is a personality trait. It is measured and studied alongside characteristics such as sociability, honesty, agreeableness, and responsibility. Even though personality traits themselves may not be targeted for change, the behaviors which these traits lead to, are targets of change in the treatment of personality disorders. This is also the case in which there is not necessarily a disorder but a dearth or excess of one particular trait, which is a better characterization of the BAS/BIS profile. An example of behaviorally treating personality traits is that someone too high in the trait agreeableness, needs to be taught to stand up for themselves when their needs are at odds with others' requests. A person low in the trait agreeableness may need help learning not to engage in vehement arguments with bosses and customers when the urge arises. Treatment is therefore aimed at the helping the individual meet the demands of the environment rather than structuring the environment to fit the individual's needs.

A second difference is that cognitive abilities are typical stable across situations while the expression of personality traits is highly sensitive to the environment, a different which applies to WMC and BAS/BIS. Activities as different as carrying on conversations, adding up the cost of

a grocery list, and reading a road map, all use working memory. While issues such as stress or excess environmental noise may cause slight changes in performance in WMC, a person's ability is relatively stable. The BAS and BIS are not innate abilities which are present in every situation, but rather they are systems which are triggered by events in the environment. A store advertising "free product for the first five customers" triggers a BAS response, while a parking sign stating "violators will be towed" triggers the BIS system. How organizations such as schools, treatment centers, and the judicial system structure their attempt to motivate participants is important if an individual has a high-functioning BAS system versus little functioning of the BIS system. Whether a teacher states that "passing this test will earn you an extra recess" or "failing this test will result in a detention" makes little difference to an individual with a medium BAS and medium BIS. The former may improve the student's attitude towards school, however, either method is sufficient to motivate the average student to study. However, a BAS+/BIS- individual, one of these methods will lead to even better outcomes than average while the other will completely fail to motivate. Therefore, it is more pressing to consider the BAS/BIS theories when constructing Drug Court incentives, for structuring house rules in inpatient treatment centers, and for behavioral techniques when utilizing treatment protocols for individual and group therapies.

RQ1: Combining BIS/BAS and WMC Theories

There are important similarities and differences between the theories. The greatest similarity between the two is their tendency to cause a behavioral pattern of risk-taking, impulsivity, and rule breaking. The most notable difference is that one is a personality trait and the other is a cognitive ability. While personality science and cognitive psychology have been viewed in academia as being separate fields, in the case of their relationship to SUDs, the

distinction may be a construct which has thus far been a barrier to sharing knowledge and combining efforts to understanding SUDs. Due to their similarities, the most reasonable next step in theory and practical application, is to seek to combine the theories for maximal utility.

A unified framework has the potential to increase collaboration, thereby reducing redundancies and increasing efficient output among research studies. At the current juncture, many of the same cluster of factors related to SUDs such as trauma, dopamine, delay discounting, and more, are individually studied and examined in relation to WMC, and then individually studied in relation to BAS/BIS, by two groups of researchers. Given the amount of funding and manpower placed into conducting each single study, it would be far more cost effective to conduct unified studies which examine both BAS/BIS and WMC in relation to all other factors being studied, than to have separate but essentially identical studies examining these two separately. This leads to faster advances in the field, which equates to more people receiving more effective treatments sooner.

The development of more effective treatments is facilitated by the merging of the theories. Separate theories potentially result in separate treatments, which has been observed in existing treatment manuals for other disorders. Separate theories often result in multiple treatment manuals wherein chapters 1-10 are identical to other treatment manuals in order to cover the current best treatment, then each treatment manual has different chapters 11-12 to append the new technique which has been developed from a particular line of research. Neither BAS/BIS nor WMC is a framework for standalone treatment for SUDs deserving a treatment manual of its own. Both have the potential to become adjunctive modules which cover gaps in existing treatment protocols. Instead of asking patients and providers to produce the time and financial resources for two separate manuals or treatment programs, the unification of these

theories will result in a single treatment manual which covers all of following (1) the current best treatment but which takes BAS/BIS and WMC vulnerability into consideration throughout the treatment (2) modules for learning to cope with BAS/BIS vulnerability and (3) modules to increase WMC. The combination of these theories will result in the best treatment possible.

The literature reviewed suggest that the combination of BAS+/BIS- and WMC theories is that these factors cause a third variable which is explanatory for SUDs. The evidence strongly suggests that both BAS+/BIS- and low WMC lead to a behavioral pattern of risk-taking, impulsivity, and rule-breaking. Previous studies suggest that these behavior patterns and their causes (BAS, BIS, and WMC) are not side effects of SUDs but rather important associations and possible causal and maintenance factors for SUDs.

It has been shown that BAS+/BIS- causes delay discounting (Madden et al., 1997) as does low WMC (Hinson et al., 2003), meaning that immediate but smaller rewards are chosen over larger, distal rewards. They take greater gambles even when the odds are stacked against them (Bechara & Martin, 2004; Kim & Lee, 2011). Those with BAS+/BIS- but not SUDs tend to drink more (Franken & Muris, 2006; Grau & Ortet, 1999). BAS+/BIS- also predicts a likelihood of developing SUDs (Sher et al., 2000), developing it at a younger age (Tarter et al., 2013), and at a higher severity (Lackner et al., 2013). Likewise, WMC has observed to be lower in SUDs patients than the general population (Yan et al., 2014). Those with BAS+/BIS- and WMC engage a variety of risky behaviors apart from drugs, such as such as rejecting the use of seatbelts, (Braddock et al., 2011) driving over the speed limit (Kaye, 2014), engaging in fistfights (Romer et al., 2011). This demonstrates that BAS+/BIS- and WMC both lead to the behavioral pattern which is characteristic of the SUDs population: risk-taking, impulsivity, and rule-breaking.

All in all, the literature supports this combination theory above all others. Both factors have been linked to the same set of behaviors, in some cases causally (Hinson et al., 2003). The development of both of these factors has been shown to predate the development of SUDs (Sher et al., 2000; Khurana et al., 2013). It has previously been theorized that behaviors such as impulsivity mediate the causal relationship between WMC and SUDs (Khurana et al., 2013), and the literature surrounding BAS/BIS points in a similar direction. Further evidence from neuropsychology strengthens this position.

Neuropsychological Support for a Combined Theory

Neuropsychological ties between BAS+ and WMC offer further evidence that the two theories should be unified rather than remain separate. Specifically, both BAS+ and WMC and strongly linked to levels dopamine production and function. Dopamine is a naturally occurring brain chemical tied to pleasure and the reward circuit. Dopamine production is naturally triggered by activities such as exercise, achievements, music, food, and sex. Substances of abuse artificially flood the brain with higher than normal amounts of dopamine, leading to a period of pleasure which is more intense than naturally rewarding experiences. With frequent and chronic use, dopamine receptors in the brain become desensitized to accommodate for the flood of dopamine. This leads to using higher amounts of substances to achieve the same effect and decreased ability to gain pleasure from what should be naturally pleasurable activities. Dopamine is therefore at the core of the biology of SUDs.

Dopamine link to BAS. Behaviorally, dopamine deficiency translates to the reward-seeking behavior of individuals with high BAS. In one study, personality questionnaires and DNA blood tests to were administered to 119 healthy subjects (Noble et al., 1998). In particular, focus was placed on two facets of BAS: novelty seeking and reward dependence. Results were

that subjects with genes DRD2 allele B1 exhibited higher reward dependence than B2 and that subjects with gene DRD4 allele 7R exhibited higher novelty seeking than those with the other ten variations of DRD4. Therefore, possessing both B1 of DRD2 and 7R+ of DRD4 compared to one alone is an even stronger predictor of a higher combined BAS score. Therefore, genes creating lower endogenous levels of dopamine are likely responsible for high BAS (Noble et al. 1998).

Dopamine link to WMC. Lower endogenous dopamine has also been linked to lower WMC. To examine the relationship between dopamine and WMC, a variety of cognitive tasks were administered to 25 healthy, young adults (Cools, Gibbs, Miyakawa, Jagust, & D'Esposito, 2008). The measurement of WMC was particularly robust, including forward and backward digit span, Stroop Test, Wisconsin Card Sort Task, a reading test, a listening test, and a letter fluency task. Dopamine activity was measured using positron emission tomography (PET). There was a high correlation between WMC and dopamine levels in the brain, where individuals with lower endogenous levels of dopamine had lower WMC. This suggests that the increased dopamine activity leading to increased levels of BAS also leads to decreased WMC.

These results were replicated in another study of 23 healthy adults aged 55 and older (Landau et al., 2008). To measure levels of dopamine, data from both PET and functional magnetic resonance imaging (fMRI) were collected and used. Working memory was measured with the same listening test as the previous study plus a delayed recognition task. Similar to the previous study (Cools et al., 2008), it was found that dopamine levels in the brain were positively correlated with performance on WMC tasks. These results demonstrate a link between dopamine and WMC.

These two studies were selected from among many studies which show a direct relationship between dopamine and WMC. Studies in human subjects have largely been correlational in nature. A causal relationship has been demonstrated in numerous studies in rats, monkey, where levels of dopamine are able to be more directly manipulated and directly observed. Additionally, administering amphetamine-based medications has been shown to increase striatal levels of dopamine and increase cognitive performance in individuals with attention deficits including low WMC (Arnsten & Li, 2005; Previc, 2009)

Summary and Future Directions

The strength of the dopamine theory is that genetics and dopamine levels can be neatly and objectively measured compared with other factors, such as trauma and parental behavior. If SUDs, previously viewed from a BAS/BIS lens separately from a WMC lens, can be viewed through a singular theory wherein dopamine leads to BAS+/BIS- and low WMC, which then leads to a distinct behavioral pattern which is linked to SUDs. The question which the dopamine link still leaves unanswered, is where the biology of BIS plays into a neuropsychological view of this theory. This is a potential area to be addressed by future studies and theories. At present, the dopamine link between BAS and WMC is sufficiently strong to serve as evidence for the combination theory.

RQ2: Treatment Implications

Thus far, it has been established that there are two distinct theories for the development of SUDs. Various explanations for the overlap between the theories have been comprehensively examined. The strongest association between the theories is that there is a behavioral pattern which lies at the core of SUDs, and both BAS+/BIS- and low WMC contribute to creating this behavioral pattern. This new understanding is instrumental to the success of treatment.

The current standard of treatment does not conceptualize or directly address either WMC or BAS+/BIS- as targets of treatment. This is likely due to a lack of understanding of the large role which cognitive and personality factors play in SUDs, as highlighted by this article. Both areas are promising for potential innovations in novel treatment. Research is needed to develop and test a treatment manual which targets these processes in SUDs. Discussed below are the status of the literature concerning the treatment of WMC, BAS+/BIS-, and combination factors, respectively. Directions for the development of novel treatments are highlighted.

Increase WMC

Researchers previously indicated that lower WMC was related to a greater chance of SUD (Hinson et al., 2003). This was attributed to more than one factor, including poorer learning ability from past poor decisions or an inability to properly assess current information and judge potential outcomes (Kaag et al., 2017). Therefore, WMC theory indicates that improving WMC will lead to reduced SUD given that people will be better able to assess circumstances or learn from past experiences. Bickel, Yi, Landes, Hill and Baxter (2011) applied this theory by comparing a WMC intervention against placebo treatment, with the WMC intervention designed to improve WMC. The WMC training program resulted in improved delay discounting, which was characterized by the ability to delay immediate reward, thereby declining the value of the reward. In practice, this increased delay discounting would allow individual to devalue the use of substances. Consequently, interventions targeting WMC may lead to improved delay discounting, improving the ability for individuals to turn away from substance use. Researchers still warned that further research was required to identify optimal treatment methods.

The treatment of WMC has been the most studied and should be the first to be incorporated into the current treatment standard. Remembering that researchers indicated that

lower WMC was associated with a greater chance of SUD (Hinson et al., 2003), exercises should be introduced in order to improve WMC. Potential studies should begin by identifying participants with SUDs and measure their baseline WMC. Next, participants should either be randomly assigned two groups, or matched based on baseline WMC. The two groups will then be assigned to treatment-as-usual or WMC-enhanced programs. The enhanced treatment will involve SUDs treatment with a trained clinician with the WMC task administered in an additional 20-minute session by a research assistant or the primary therapist. Who administers the task is unimportant as long as consistency is maintained between participants of the same experimental condition. Alternatively, potential studies could recruit participants receiving SUDs treatment in a community setting with half of participants receiving WMC-enhancement sessions at a separate research facility. The present author hypothesizes that successful increase of WMC will be found to reduce a pattern of behaviors involving impulsivity, risk-taking, and rule-breaking, including substance use. An increase of WMC has previously been shown to result in improved delay discounting (Bickel et al., 2011), so it is anticipated that the WMC exercises will reduce SUD, which itself has previously been hypothesized to be a result of poorer delay discounting (Businelle, McVay, Kendzor, & Copeland, 2010).

Moderate BAS+/BIS- Behaviors

WMC is one factor shown to cause the behavioral phenomena of SUDs; the other is BAS+/BIS-. The current research on changing personality is not as sophisticated as research on changing cognitive ability. To date, few if any attempts have specifically been made to generate treatments specifically to target personality variables (Magidson, Roberts, Collado-Rodriguez, & Lejuez, 2014). Some studies have examined personality change as a positive side effect of standard treatments for other disorders. For example, both cognitive-behavioral therapy for

depression and the antidepressant medication Paxil have separately been shown to decrease scores in neuroticism (Tang et al., 2009). However, the search for a treatment technique which specifically targets personality traits that create vulnerability for problem behaviors, is understudied.

BAS/BIS research suggested that individuals may be more prone to rewards than others (Madden et al., 1997) or attempt behaviors that helped them avoid distress (Hamill et al., 2015). Either might contribute to SUDs since some individuals may be more responsive to the reward of a drug while others may use drugs to avoid distress. As such, reducing BAS or improving BIS may help to reduce SUDs. Piedmont (2001) examined SUDs within a BAS/BIS context by performing a six-week intensive outpatient (IOP) program, meaning five days per week and six hours per day. The program was focused on building adaptive behaviors pertaining to employment and reducing SUDs. It was found that across the duration of the program, participant conscientiousness scores significantly increased. On the measure used, a score of 45-55 normal for conscientiousness. At the time of enrollment, the group average conscientiousness was 41.3, which was below normal. The program raised the group average conscientiousness to 45.8, placing them in a normal range for the trait conscientiousness. The current review highlighted conscientiousness specifically, as the Big-5 trait with a negative correlation to BAS+/BIS- (Keiser & Ross, 2011) and therefore the best proxy for whether BAS/BIS may be amenable to change. As such, interventions may be introduced that address personality traits that improve BAS/BIS. However, researchers warned that this study was not intentionally designed to target personality change and that the effect was secondary, necessitating further study.

Reduce Impulsivity

One aspect of the behavioral phenomena of SUDs is impulsivity. Impulsivity has been the subject of a fair amount of research, and research has specifically targeted this quality. Researchers previously indicated that impulsivity was associated with risk taking and rule-breaking (Grant & Chamberlain, 2014). As such, reducing impulsivity may reduce risky behaviors, such as those leading to SUDs. Meta-analysis indicated that impulsivity could be reduced through approaches such as teaching strategies for reducing indulging impulses. These strategies included assessing all possible options before making a decision or waiting a certain period before responding. Teaching individuals these strategies may therefore be associated with reducing impulsivity, which itself was linked to SUDs.

Joint WMC-Impulsivity Interventions

Future studies should compare treatment-as-usual with enhanced versions of treatment which target WMC and/or impulsivity in order to evaluate the efficacy of treating cognitive and personality traits in SUDs. A clinical trial should compare the following four conditions: (1) standard treatment, (2) treatment + WMC training, (3) treatment + impulsivity training and (4) treatment + WMC training + impulsivity training. Comparing Condition 4 with Condition 1 will reveal how much, if any improvement, can be gained from targeting these variables in treatment. Comparing Conditions 2 and 3 will isolate the active ingredients to see whether one or both of the enhancement to treatment is the cause of the improvement. The present theory hypothesizes that Condition 4 will show the best treatment outcome and that Conditions 2 and 3 will show less improvement than Condition 4, but still be more efficacious than Condition 1. The theory also suggests that due to the large role WMC and BAS/BIS plays in SUDs, the difference in treatment outcome will be sufficiently substantial to warrant their addition to the current gold standard of

treatment. The present author hypothesizes that decreasing impulsivity via these methods will reduce the pattern of behaviors involving impulsivity, risk-taking, and rule-breaking, including substance use.

Schedule Stimulating Activities

Impulsivity and risk-taking are linked to sensation-seeking activities (Romer et al., 2011). Research therefore suggest that both sensation seeking activities should be addressed by interventions, since sensation-seeking activities may trigger the rush of adrenaline which can accompany impulsive and rule-breaking behaviors. Addressing sensation seeking as a treatment avenue is consistent with dopamine-deficiency theory, which states that individuals with SUDs must go to more extreme lengths than others to trigger the same release of dopamine and pleasure (Blum et al., 2000). Therefore, one potential method for curbing impulsive and rule-breaking behavior is to achieve the adrenaline rush through activities which could be labeled as dangerous, but which are more prosocial and therefore preferred over drugs and criminality.

To address dopamine deficiency caused by past drug use, current SUDs treatment incorporates pleasant event scheduling as a component of treatment. Pleasant event scheduling is the gradual and methodical incorporation of pleasurable activities such as music, exercise, and sober social activities into the patients' week, including addressing barriers to completing these activities. The importance of this is that when discontinuing drugs, patients' dopamine receptors have been overused, resulting in additional difficulty deriving pleasure from non-drug activities. At first, it is be difficult for patients to engage in activities from which they once derived pleasure. However, using therapy to motivate and keep patients accountable to engaging in these activities before they are pleasurable, is the best way to return dopamine receptors to the state where they re-learn to derive a sense of reward from healthy sources of pleasure. Pleasant event

scheduling originates from treatment from depression and according to the present theory of SUDs, has not been appropriately adapted to suit a SUDs-specific personality and baseline dopamine deficiency.

The importance of incorporating the present behavioral theory of SUDs into pleasant event scheduling, is that these hypotheses suggest that simply incorporating any pleasant activity into the weekly schedule, will not suffice for SUDs as it does for depression. The SUDs brain needs a much higher level of stimulation. The standard pleasant event scheduling chapter in SUDs treatment manual includes such suggested activities as “taking a bubble bath” and “gardening.” While a good start, for the SUDs brain, it will not be sufficient. This list needs to be expanded for SUDs to include a separate list specifically for activities which are highly stimulating and even risky. This list should include extreme sports which incorporate an element of danger and adrenaline. Items should include bicycle motocross (BMX), aggressive roller blading, martial arts, bungee jumping, skydiving, roller coasters, whitewater rafting, adventure trailing, and more. Emphasis needs to be placed that during the pleasant event scheduling module of treatment, SUDs patients must select a minimum number of scheduled events from this list. This newly posited approach addresses both BAS+/BIS- and the intersection of BAS/BIS and WMC, where dopamine deficiency precedes SUDs. Individuals with SUDs need activities which are more stimulating than the average person needs, in order to gain the same sense of pleasure. Pleasant event scheduling which addresses this unique need is the only way to attempt to replace the adrenaline rush of drug-seeking behaviors and therefore reduce such behaviors in the treatment of SUDs. The present author hypothesizes that combined with a regular course of treatment, scheduling highly stimulating activities into patients’ week will decrease urges to engage in substances and criminality.

Summary

WMC theory and BAS+/BIS- theory both suggest that individuals respond strongly to the same principle: the value of an immediate reward. Each theory suggests that the immediacy of the reward affects the value of the reward for a different reason. WMC theory indicates that the value of the reward, when distanced by time, declines. In contrast, BAS+/BIS- theory, suggests that the value of the reward is simply over-estimated. In practice, they both motivate the individual to pursue the reward. Consequently, the two theories suggest the same outcome occur, via two different pathways. Notably, there are two primary means by which SUDs may be addressed, according to a joint WMC and BAS+/BIS- approach.

The overvaluation of immediate rewards is one such factor which has implications for SUDs. In simplest terms, individuals tend to overvalue substances, and as a consequence, consume them rather than make the decision not to consume them. WMC theory indicates they do so because the saliency of a punishment for substance use is low and distant in time, compared to the immediate reward of using the substance. BAS+/BIS- theory suggests that rewards are always given more weight in the decision-making process, than punishments are given. In practice, both theories indicate that the individual overvalues the use of the substance in the immediate moment. Rewards associated with substance use, including positive moods and the rush of dopamine, are overvalued in comparison to the more distal regards of a healthy family and social functioning. As such, targeting overvaluation of reward found in both WMC and BAS+/BIS theories may help to reduce SUDs. In practice, devaluing substance-related rewards, in combination with increasing the saliency of punishments, may help to improve outcomes.

The two theories are similar in the biologically based issue of the neurotransmitter dopamine. Overactivity of dopamine increases overvaluation of reward, consistent with BAS+/BIS- theory, while also leading to impairment in WMC. In function, this means that dopamine reduces the cognitive ability for someone to properly assess value versus punishment and to overvalue immediate rewards. As such, addressing dopamine disfunction may help to address SUDs.

According to the literature, SUDs outcomes may show a joint response to SUDs. First, psychological interventions may help to address over-valuation caused by BAS+/BIS- and improve cognitive assessments of punishment/reward in accordance with WMC. Second, medical treatment may address dopamine disfunction, leading to improved cognitive assessment of punishment/reward and reduced valuation of immediate rewards. Table 2 outlines how each targets SUDs.

Table 2

Theories and Effects on SUDs

Theory	Treatment
BAS+/BIS-	Psychotherapy addresses valuation of rewards vs. punishment
	Medication addresses dopamine deficiency
WMC	Psychotherapy addresses overvaluation of immediate rewards and devaluation of distal punishment
	Medication addresses dopamine deficiency

Reward sensitivity is considered a personality trait under BAS+/BIS-, while the ability to judge rewards versus punishments is considered a cognitive ability under WMC. Though valuation of immediate reward is conceptualized differently under both theories, they result in

the same functional outcome. WMC includes the additional step of balancing this overvaluation of reward within the context of undervaluing distal punishment.

Overvaluation of immediate reward can be medically addressed within a BAS+/BIS-/WMC framework by targeting dopamine deficiency. From the standpoint of psychological treatment, improving the ability to appropriately assess punishment versus reward fits the WMC aspect of the framework, while overvaluation of immediate reward in fits both the BAS+/BIS- and WMC aspect of the framework. As such, the BAS+/BIS-/WMC combination theory suggests targeting overvaluation of immediate reward. The framework dovetails in that it suggests an intervention that addresses both the personality trait of reward sensitivity (consistent with BAS+/BIS-) and an intervention that addresses the cognitive ability to judge punishment versus reward (consistent with WMC).

There is a dearth of evidence which suggests whether BAS+/BIS- causes low WMC, whether the inverse is true, or whether the two combine to create a third variable that increases susceptibility to SUDs. Therefore, given the information available, the best option is to address dopamine deficiency and the overvaluation of reward. A psychological intervention could be used to improve the cognitive function of WMC, and a separate intervention used to reduce valuation of immediate reward. Adjacent qualities that motivate reward-seeking, such as impulsivity, could also be addressed using psychological interventions.

First, this synthesis reveals that addressing dopamine deficiency may address SUDs within a joint BAS+/BIS-/WMC framework. Second, this synthesis further reveals that devaluing immediate rewards is consistent with BAS+/BIS-/WMC theories, though separate interventions may be necessary to address personality variables (BAS+/BIS-) versus cognitive variables (WMC). Third, this synthesis indicates that treating SUDs under both theories dovetails when

addressing WMC, which necessitates the ability to properly value distal punishment. Finally, this synthesis indicates that there may be value to addressing adjacent traits, such as impulsivity, which may affect the ability to properly assess the value of a reward within the joint BAS+/BIS-/WMC framework. This synthesis combines BAS+/BIS- and WMC to create the emergence of treatment recommendations which simultaneously targets two individual factors which contribute to the development and maintenance of SUDs.

REFERENCES

Abbasi, M., Sadeghi, H., Pirani, Z., & Vatandoust, L. (2016). Behavioral activation and inhibition system's role in predicting addictive behaviors of patients with bipolar disorder of Roozbeh Psychiatric Hospital. *Iranian Journal of Nursing and Midwifery Research, 21*(6), 616-621. Doi:10.4103/1735-9066.197675

Arnsten, A. F., & Li, B. M. (2005) Neurobiology of executive functions: Catecholomine influences on prefrontal cortical functions. *Biological Psychiatry*, *57*(11), 1377-1384. Doi:10.1016/j.biopsych.2004.08.019

Balconi, M., Finocchiaro, R., & Canavesio, Y. (2015). Reward sensitivity (Behavioral Activation System), cognitive, and metacognitive control in gambling behavior: Evidences from behavioral, feedback-related negativity, and P300 effect. *The Journal of Neuropsychiatry and Clinical Neurosciences, 27*(3), 219-227. Doi:10.1176/appi.neuropsych.14070165

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121*(1), 65-94. Doi:10.1037/0033-2909.121.1.65

Bechara, A., & Martin, E. (2004). Impaired decision-making related to working memory deficits in individuals with substance addictions. *Neuropsychology (8)*1, 152-162. Doi:10.1037/0894-4105.18.1.152

Bickel, W. K., & Marsch, L. A. (2001). Toward a behavioral economic understanding of drug dependence: Delay discounting processes. *Addiction, 96*, 73-86. Doi:10.1046/j.1360-0443.2001.961736.x

Bickel, W. K., Yi, R., Landes, R. D., Hill, P. F., & Baxter, C. (2011). Remember the future: Working memory training decreases delay discounting among stimulant users. *Biological Psychiatry, 69*(3), 260-265. Doi:10.1016/j.biopsych.2010.08.017

Blum, K., Braverman, E. R., Holder, J. M., Lubar, J. F., Monastra, V. J., Miller, D., ... & Comings, D. E. (2000). The reward deficiency syndrome: A biogenetic model for the diagnosis and treatment of impulsive, addictive and compulsive behaviors. *Journal of Psychoactive Drugs*, *32*(sup1), 1-112. Doi:10.1080/02791072.2000.10736099

Boland, E. M., Stange, J. P., Labelle, D. R., Shapero, B. G., Weiss, R. B., Abramson, L. Y., & Alloy, L. B. (2015). Affective disruption from social rhythm and behavioral approach system (BAS) sensitivities. *Clinical Psychological Science, 4*(3), 418-432. Doi:10.1177/2167702615603368

Braddock, K. H., Dillard, J. P., Voigt, D. C., Stephenson, M. T., Sopory, P., & Anderson, J. W. (2011). Impulsivity partially mediates the relationship between BIS/BAS and risky health behaviors. *Journal of Personality*, *79*(4), 793-810. Doi:10.1111/j.1467-6494.2011.00699.x

Brooks, S. J., Funk, S. G., Young, S. Y., & Schioth, H. B. (2017a). The role of working memory for cognitive control in anorexia nervosa versus substance use disorder. *Frontiers in Psychology, 8*(1651), 1-28. Doi:10.3389/fpsyg.2017.01651

Brooks, S. J., Wiemerslage, L., Burch, K., Maiorana, S., Cocolas, E., Schiöth, H., … Stein, D. (2017b). The impact of cognitive training in substance use disorder: The effect of working memory training on impulse control in methamphetamine users. *Psychopharmacology, 234*(12), 1911-1921. Doi:10.1007/s00213-017-4597-6

Brown, R. T. (2002). Risk factors for substance abuse in adolescents. *Pediatric Clinics of North America*, *49*(2), 247-55.

Businelle, M. S., McVay, M. A., Kendzor, D., & Copeland, A. (2010). A comparison of delay discounting among smokers, substance abusers, and non-dependent controls. *Drug and Alcohol Dependence*, *112*(3), 247-250. Doi:10.1016/j.drugalcdep.2010.06.010

Carver, C. S., & White, T. L. (1994). Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS scales. *Journal of Personality and Social Psychology*, *67*(2), 319-333. Doi:10.1037%2F0022-3514.67.2.319

Cools, R., Gibbs, S., Miyakawa, A., Jagust, W., & D'Esposito, M. (2008). Working memory capacity predicts dopamine synthesis capacity in the human striatum. *Journal of Neuroscience, 28*, 1208-1212. Retrieved from http://www.jneurosci.org/content/28/5/1208.full

Daniel, M., Martin, A. D., & Carter, J. (1992) Opiate receptor blockade by naltrexone and mood state after acute physical activity. *British Journal of Sports Medicine, 26*, 111-115. Doi:10.1136/bjsm.26.2.111

Dasgupta, N., Bailey, E. J., Cicero, T., Inciardi, J., Parrino, M., Rosenblum, A., & Dart, R. C. (2010). Post-marketing surveillance of methadone and buprenorphine in the United States. *Pain Medicine*, *11*(7), 1078-1091. Doi:10.1111/j.1526-4637.2010.00877.x

Deary, I. J., Whalley, L. J., Lemmon, H., Crawford, J. R., & Starr, J. M. (2000). The stability of individual differences in mental ability from childhood to old age: Follow-up of the 1932 Scottish Mental Survey. *Intelligence*, *28*(1), 49-55. Doi:10.1016/S0160-2896(99)00031-8

Dimidjian, S., Hollon, S. D., Dobson, K. S., Schmaling, K. B., Kohlenberg, R. J., Addis, M. E., ... & Atkins, D. C. (2006). Randomized trial of behavioral activation, cognitive therapy, and antidepressant medication in the acute treatment of adults with major depression. *Journal of Consulting and Clinical Psychology*, *74*(4), 658-670. Doi:10.1037/0022-006X.74.4.658

Donnellan, M. B., & Robins, R. W. (2009). The development of personality across the lifespan. *The Cambridge Handbook of Personality Psychology*, 191-204. Retrieved from http://gtu.ge/Agro-Lib/PersonalityPsychology.pdf#page=247

Earleywine, M., & Newcomb, M. D. (1997). Concurrent versus simultaneous polydrug use: Prevalence, correlates, discriminant validity, and prospective effects on health outcomes. *Experimental and Clinical Psychopharmacology*, *5*(4), 353-364. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/9386962

Esch, T., & Stefano, G. B. (2004). The neurobiology of pleasure, reward processes, addiction and their health implications. *Neuroendocrinology Letters*, *25*(4), 235-251. Retrieved from http://www.wisebrain.org/media/Papers/Neurobioofpleasure_Stefano2004.pdf

Farley, M., Golding, J. M., Young, G., Mulligan, M., & Minkoff, J. R. (2004). Trauma history and relapse probability among patients seeking substance abuse treatment. *Journal of substance abuse treatment*, *27*(2), 161-167.

Feldstein, S. W., & Miller, W. R. (2006). Substance use and risk-taking among adolescents. *Journal of Mental Health, 15*(6), 633-643. Doi:10.1080/09638230600998896

Finn, P. R., Justus, A., Mazas, C., & Steinmetz, J. E. (1999). Working memory, executive processes and the effects of alcohol on Go/No-Go learning: Testing a model of behavioral regulation and impulsivity. *Psychopharmacology*, *146*(4), 465-472. Doi:10.1007/PL00005492

Franken, I. H., & Muris, P. (2006). BIS/BAS personality characteristics and college students' substance use. *Personality and Individual Differences*, *40*(7), 1497-1503. Doi:10.1016/j.paid.2005.12.005

Gossop, M., Stewart, D., Browne, N., & Marsden, J. (2002). Factors associated with abstinence, lapse or relapse to heroin use after residential treatment: Protective effect of coping responses. *Addiction*, *97*(10), 1259-1267. Doi:10.1046/j.1360-0443.2002.00227.x

Gottfried, J. A. (2011). *Neuroscience of sensation and reward*. Boca Raton, FL: CRC Press.

Grant, B. F., Saha, T. D., Ruan, W. J., Goldstein, R. B., Chou, S. P., Jung, J., ... & Hasin, D. S. (2016). Epidemiology of DSM-5 drug use disorder: Results from the National Epidemiologic Survey on Alcohol and Related Conditions–III. *Journal of American Medical Association, Psychiatry*, *73*(1), 39-47. Doi:10.1001/jamapsychiatry.2015.2132

Grant, J. E., & Chamberlain, S. R. (2014). Impulsive action and impulsive choice across substance and behavioral addictions: Cause or consequence? *Addictive Behaviors*, *39*(11), 1632-1639. Doi:10.1016/j.addbeh.2014.04.022

Grau, E., & Ortet, G. (1999). Personality traits and alcohol consumption in a sample of non-alcoholic women. *Personality and Individual Differences, 20*(6), 1057-1066. Doi:10.1016/S0191-8869(99)00047-1

Hamill, T. S., Pickett, S. M., Amsbaugh, H. M., & Aho, K. M. (2015). Mindfulness and acceptance in relation to Behavioral Inhibition System sensitivity and psychological distress. *Personality and Individual Differences, 72*, 24-29. Doi:10.1016/j.paid.2014.08.007

Hasin, D. S., O'Brien, C. P., Auriacombe, M., Borges, G., Bucholz, K., Budney, A., ... & Schuckit, M. (2013). DSM-5 criteria for substance use disorders: Recommendations and rationale. *American Journal of Psychiatry*, *170*(8), 834-851. Doi:10.1176/appi.ajp.2013.12060782

Hasin, D. S., Kerridge, B. T., Saha, T. D., Huang, B., Pickering, R., Smith, S. M., … Grant, B. F. (2016). Prevalence and correlates of DSM-5 cannabis use disorder, 2012–2013: Findings from the National Epidemiologic Survey on Alcohol and Related Conditions-III. *The American Journal of Psychiatry*, *173*, 588– 599.

Hedden, S. L., Kennet, J., Lipari, R., Medley, G., Tice, P., Copello, E. A. P., & Kroutil, L. A. (2015). Behavioral health trends in the United States: Results from the 2014 national survey on drug use and health. *Substance Abuse and Mental Health Services Administration, 1-64.* Retrieved from https://www.samhsa.gov/data/sites/default/files/NSDUH-FRR1-2014/NSDUH-FRR1-2014.pdf

Hinson, J. M., Jameson, T. L., & Whitney, P. (2003). Impulsive decision making and working memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*(2), 298-306. Doi:10.1037/0278-7393.29.2.298

Hofmann, S. G., Asnaani, A., Vonk, I. J., Sawyer, A. T., & Fang, A. (2012). The efficacy of cognitive behavioral therapy: A review of meta-analyses. *Cognitive Therapy and Research*, *36*(5), 427-440. Doi:10.1007/s10608-012-9476-1

Houck, J. M., & Ewing, S. W. (2017). Working memory capacity and addiction treatment outcomes in adolescents. *The American Journal of Drug and Alcohol Abuse, 44*(2), 185-192. Doi:10.1080/00952990.2017.1344680

Jackson, H., Mandell, K., Johnson, K., Chatterjee, D., & Vanness, D. J. (2015). Cost-effectiveness of injectable extended-release naltrexone compared with methadone maintenance and buprenorphine maintenance treatment for opioid dependence. *Substance Abuse*, *36*(2), 226-231. Doi:10.1080/08897077.2015.1010031

Jang, K. L., Livesley, W. J., & Vemon, P. A. (1996). Heritability of the big five personality dimensions and their facets: A twin study. *Journal of Personality*, *64*(3), 577-592. Doi:10.1111/j.1467-6494.1996.tb00522.x

Kaag, A. M., Goudriaan, A. E., Vries, T. J., Pattij, T., & Wiers, R. W. (2017). A high working memory load prior to memory retrieval reduces craving in non-treatment seeking problem drinkers. *Psychopharmacology, 235*(3), 695-708. Doi:10.1007/s00213-017-4785-4

Kaye, S. A. (2014). *Individual differences in the processing of punishment and reward cues: An application to road safety messages* (Doctoral dissertation). Queensland University of Technology.

Keiser, H. N., & Ross, S. R. (2011). Carver and Whites' BIS/FFFS/BAS scales and domains and facets of the Five Factor Model of personality. *Personality and Individual Differences*, *51*(1), 39-44. Doi:10.1016/j.paid.2011.03.007

Khurana, A., Romer, D., Betancourt, L. M., Brodsky, N. L., Giannetta, J. M., & Hurt, H. (2013). Working memory ability predicts trajectories of early alcohol use in adolescents: The mediational role of impulsivity. *Addiction*, *108*(3), 506-515. Doi:10.1111/add.12001

Khurana, A., Romer, D., Betancourt, L. M., & Hurt, H. (2017). Working memory ability and early drug use progression as predictors of adolescent substance use disorders. *Addiction, 112*(7), 1220-1228. Doi:10.1111/add.13792

Kim, B., & Kwon, S. (2017). The link between hypomania risk and creativity: The role of heightened behavioral activation system (BAS) sensitivity. *Journal of Affective Disorders, 215*, 9-14. Doi:10.1016/j.jad.2017.02.033

Kim, Y., Jeong, J., Cho, H., Jung, D., Kwak, M., Rho, M. J., . . . Choi, I. Y. (2016). Personality factors predicting smartphone addiction predisposition: Behavioral inhibition and activation systems, impulsivity, and self-control. *Plos One, 11*(8), 1-15. Doi:10.1371/journal.pone.0159788

Kim-Spoon, J., Deater-Deckard, K., Holmes, C., Lee, J., Chiu, P., & King-Casas, B. (2016). Behavioral and neural inhibitory control moderates the effects of reward sensitivity on adolescent substance use. *Neuropsychologia, 91*, 318-326. Doi:10.1016/j.neuropsychologia.2016.08.028

Kumari, S., Manalai, P., Leong, S., Wooditch, A., Malik, M., & Lawson, W. B. (2016). Factors associated with non-adherence to Buprenorphine-naloxone among opioid dependent African-Americans: A retrospective chart review. *The American Journal on Addictions*, *25*(2), 110-117. Doi:10.1111/ajad.12325

Lackner, N., Unterrainer, H. F., & Neubauer, A. C. (2013). Difference in big five personality traits between alcohol and polydrug abusers: Implications for treatment in the therapeutic community. *International Journal of Mental Health and Addiction, 11*(6), 682-692. Doi:10.1007/s11469-013-9445-2

Landau, S. M., Lal, R., O'neil, J. P., Baker, S., & Jagust, W. J. (2008). Striatal dopamine and working memory. *Cerebral Cortex*, *19*(2), 445-454. Doi:10.1093/cercor/bhn095

Lane, S. D., & Cherek, D. R. (2000). Analysis of risk-taking in adults with a history of risk-taking. *Drug and Alcohol Dependence, 60,* 179-187. Doi:10.1016/S0376-8716(99)00155-6

Lanza, P. V., Garcia, P. F., Lamelas, F. R., & Gonzalez-Menendez, A. (2014). Acceptance and commitment therapy versus cognitive behavioral therapy in the treatment of substance use disorder with incarcerated women. *Journal of Clinical Psychology*, *70*(7), 644-657. Doi:10.1002/jclp.22060

Lavonas, E. J., Severtson, S. G., Martinez, E. M., Bucher-Bartelson, B., Le Lait, M. C., Green, J. L., ... & Surratt, H. L. (2014). Abuse and diversion of buprenorphine sublingual tablets and film. *Journal of Substance Abuse Treatment*, *47*(1), 27-34. Doi:10.1016/j.jsat.2014.02.003

Lechner, W. V., Day, A. M., Metrik, J., Leventhal, A. M., & Kahler, C. W. (2016). Effects of alcohol-induced working memory decline on alcohol consumption and adverse consequences of use. *Psychopharmacology*, *233*(1), 83-88. Doi:10.1007/s00213-015-4090-z

Ling, W., Charuvastra, C., Collins, J. F., Batki, S., Brown, L. S., Kintaudi, P., ... & Renner, J. A. (1998). Buprenorphine maintenance treatment of opiate dependence: A multicenter, randomized clinical trial. *Addiction*, *93*(4), 475-486. Doi:10.1046/j.1360-0443.1998.9344753.x

Lipari, R. N., & Van Horn, S. L. (2017, August). Children living with parents who have a substance use disorder. *The CBHSQ Report,* 1-7. Retrieved from https://www.samhsa.gov/data/sites/default/files/report_3223/ShortReport-3223.pdf

Madden, G. J., Petry, N. M., Badger, G. J., & Bickel, W. K. (1997). Impulsive and self-control choices in opioid-dependent patients and non-drug-using control participants: Drug and monetary rewards. *Experimental Clinical Psychopharmacology, 5*, 256-262. Doi:10.1037/1064-1297.5.3.256

Magidson, J. F., Roberts, B. W., Collado-Rodriguez, A., & Lejuez, C. W. (2014). Theory-driven intervention for changing personality: Expectancy value theory, behavioral activation, and conscientiousness. *Developmental Psychology*, *50*(5), 1442. Doi:10.1037/a0030583

Miller, G. A. (1994). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 101*(2), 343-352. Doi:10.1037/0033-295x.101.2.343

Minozzi, S., Amato, L., Vecchi, S., Davoli, M., Kirchmayer, U., & Verster, A. (2011). Oral naltrexone maintenance treatment for opioid dependence. *Cochrane Database of Systematic Reviews*, (4). Doi:10.1002/14651858.CD001333.pub4

Najavits, L. M., & Hien, D. (2013). Helping vulnerable populations: A comprehensive review of the treatment outcome literature on substance use disorder and PTSD. *Journal of Clinical Psychology*, *69*(5), 433-479. Doi:10.1002/jclp.21980

National Institute on Drug Abuse. (2019). *Advancing addiction science: Opioid overdose crisis.* Retrieved from https://www.drugabuse.gov/drugs-abuse/opioids/opioid-overdose-crisis

Nederkoorn, C., Braet, C., Van Eijs, Y., Tanghe, A., & Jansen, A. (2006). Why obese children cannot resist food: The role of impulsivity. *Eating Behaviors*, *7*(4), 315-322. Doi:10.1016/j.eatbeh.2005.11.005

Noble, E. P., Ozkaragoz, T. Z., Ritchie, T. L., Zhang, X., Belin, T. R., & Sparkes, R. S. (1998). D2 and D4 dopamine receptor polymorphisms and personality. *American Journal of Medical Genetics*, *81*, 257-267. Retrieved from https://pdfs.semanticscholar.org/e783/612bbdf4fa06abce86ce69574aef3423004d.pdf

Piedmont, R. L. (2001). Cracking the plaster cast: Big Five personality change during intensive outpatient counseling. *Journal of Research in Personality*, *35*(4), 500-520. Doi:10.1006/jrpe.2001.2326

Powers, M. D., James, S., Benningfield, M. D., Margaret, M., & Clinton, M. S. W. (2016). SBIRT (screening brief intervention and referral to treatment): A primary care tool to assess for substance use disorder. *Tennessee Medicine E-Journal*, *2*(1), 1-5. Retrieved from https://ejournal.tnmed.org/cgi/viewcontent.cgi?article=1039&context=home

Previc, F. H. (2009). *The dopaminergic mind in human evolution and history*. New York: Cambridge University Press.

Romer, D., Betancourt, L. M., Brodsky, N. L., Giannetta, J. M., Yang, W., & Hurt, H. (2011). Does adolescent risk taking imply weak executive function?: A prospective study of relations between working memory performance, impulsivity, and risk taking in early adolescence. *Developmental Science*, *14*(5), 1119-1133. Doi:10.1111/j.1467-7687.2011.01061.x

Schneider, W., Niklas, F., & Schmiedeler, S. (2014). Intellectual development from early childhood to early adulthood: The impact of early IQ differences on stability and change over time. *Learning and Individual Differences*, *32*, 156-162. Doi:10.1016/j.lindif.2014.02.001

Shamosh, N. A., DeYoung, C. G., Green, A. E., Reis, D. L., Johnson, M. R., Conway, A. R., ... & Gray, J. R. (2008). Individual differences in delay discounting: Relation to

intelligence, working memory, and anterior prefrontal cortex. *Psychological Science*, *19*(9), 904-911. Doi:10.1111/j.1467-9280.2008.02175.x

Sher, K. J., Bartholow, B. D., & Wood, M. D. (2000). Personality and substance use disorders: A prospective study. *Journal of Consultation Clinical Psychology, 68*, 818-29. Doi:10.1037/0022-006X.68.5.818

Smits, D. J., & Kuppens, P. (2005). The relations between anger, coping with anger, and aggression, and the BIS/BAS system. *Personality and Individual Differences*, *39*(4), 783-793. Doi:10.1016/j.paid.2005.02.023

Snider, S. E., Deshpande, H. U., Lisinski, J. M., Koffarnus, M. N., Laconte, S. M., & Bickel, W. K. (2018). Working memory training improves Aacohol users' episodic future thinking: A rate-dependent analysis. *Biological Psychiatry: Cognitive Neuroscience and Neuroimaging, 3*(2), 160-167. Doi:10.1016/j.bpsc.2017.11.002

Soyka, M., Zingg, C., Koller, G., & Kuefner, H. (2008). Retention rate and substance use in methadone and buprenorphine maintenance therapy and predictors of outcome: Results from a randomized study. *International Journal of Neuropsychopharmacology*, *11*(5), 641-653. Doi:10.1017/S146114570700836X

Stevens, A., Trace, M., & Bewley-Taylor, D. (2005). Reducing drug-related crime: An overview of the global evidence. *The Beckley Foundation Drug Policy Programme, 1-16*. Retrieved from http://altgeorgia.ge/documents/publikaciebi%20ENG/BeckleyFoundation_Report_05.pdf

Tang, T. Z., DeRubeis, R. J., Hollon, S. D., Amsterdam, J., Shelton, R., & Schalet, B. (2009). Personality change during depression treatment: A placebo-controlled trial. *Archives of General Psychiatry*, *66*(12), 1322-1330. Doi:10.1001/archgenpsychiatry.2009.166

Tarter, R. E., Kirisci, L., Kirillova, G., Reynolds, M., Gavaler, J., Ridenour, T., ... & Vanyukov, M. (2013). Relation among HPA and HPG neuroendocrine systems, transmissible risk and neighborhood quality on development of substance use disorder: Results of a 10-year prospective study. *Drug and Alcohol Dependence*, *127*(1-3), 226-231. Doi:10.1016/j.drugalcdep.2012.07.008

Taylor, P. L., & Albright, W. J. (1981). Nondrug criminal behavior and heroin use. *International Journal of the Addictions*, *16*(4), 683-696. Doi:10.3109/10826088109038860

Thompson, J., Thomas, N., Singleton, A., Piggott, M., Lloyd, S., Perry, E. K., ... & Ferrier, I. N. (1997). D2 dopamine receptor gene (DRD2) Taq1 A polymorphism: Reduced dopamine D2 receptor binding in the human striatum associated with the A1 allele. *Pharmacogenetics*, *7*(6), 479-484. Retrieved from https://europepmc.org/abstract/med/9429233

Verdejo-Garcia, A., Lawrence, A. J., & Clark, L. (2008). Impulsivity as a vulnerability marker for substance-use disorders: Review of findings from high-risk research, problem gamblers and genetic association studies. *Neuroscience & Biobehavioral Reviews*, *32*(4), 777-810. Doi:10.1016/j.neubiorev.2007.11.003

Volkow, N. D., Wang, G. J., Fowler, J. S., Logan, J., Gatley, S. J., Hitzemann, R., ... & Pappas, N. (1997). Decreased striatal dopaminergic responsiveness in detoxified cocaine-dependent subjects. *Nature*, *386*(6627), 830-833. Retrieved from https://www.nature.com/articles/386830a0

Wardell, J. D., Quilty, L. C., & Hendershot, C. S. (2016). Impulsivity, working memory, and impaired control over alcohol: A latent variable analysis. *Psychology of Addictive Behaviors, 30*(5), 544-554. Doi:10.1037/adb0000186

Whelan, P. J., & Remski, K. (2012). Buprenorphine vs methadone treatment: A review of evidence in both developed and developing worlds. *Journal of Neurosciences in Rural Practice*, *3*(1), 45-50. Doi:10.4103/0976-3147.91934

White, H. R. (2016). Substance use and crime. *The Oxford Handbook of Substance Use and Substance Use Disorders*, *2*, 347-378. doi:10.1093/oxfordhb/9780199381708.013.004

Yan, W. S., Li, Y. H., Xiao, L., Zhu, N., Bechara, A., & Sui, N. (2014). Working memory and affective decision-making in addiction: A neurocognitive comparison between heroin addicts, pathological gamblers and healthy controls. *Drug and Alcohol Dependence*, *134*, 194-200. Doi:10.1016/j.drugalcdep.2013.09.027

Yeomans, M. R., & Gray, R. W. (2002). Opioid peptides and the control of human ingestive behaviour. *Neuroscience & Biobehavioral Reviews*, *26*(6), 713-728. Doi:10.1016/S0149-7634(02)00041-6

Young, L. B., Chan, P. S., Lu, X., Nallamothu, B. K., Sasson, C., & Cram, P. M. (2011). Impact of telemedicine intensive care unit coverage on patient outcomes: a systematic review and meta-analysis. *Archives of Internal Medicine*, *171*(6), 498-506. Doi:10.1001/archinternmed.2011.61

Zahrt, J., Taylor, J. R., Mathew, R. G., & Arnsten, A. F. (1997). Supranormal stimulation of D1 dopamine receptors in the rodent prefrontal cortex impairs spatial working memory performance. *Journal of Neuroscience*, *17*(21), 8528-8535. Doi:10.1523/JNEUROSCI.17-21-08528.1997