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Neuropsychological Predictors of Outcome in an Accountability Court Sample

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Abstract

Neuropsychological Predictors of Outcome in an Accountability Court Sample

By Gershom Theophilus Lazarus

This study investigated the use of neuropsychological predictors of outcome in an Accountability Court sample. Research has indicated evidence of neuropsychological impairment in chronic substance abusers. This relationship can have significant implications for treatment outcome. In this sample, treatment outcome was assessed in terms of graduation versus termination status and length of time spent in the program. In order to examine these predictor variables, a clinical interview and a neuropsychological battery were administered to each participant in the study. Findings suggest that increased length of time spent in the program and prior work history improved the odds of graduation while an increased number of arrests and performance on the Trail Making Test B improved the odds for termination. The sample was divided into three groups for analysis of the time spent in the program outcome; total, graduated, and terminated samples. Across all three groups performance on the MOCA Delayed Recall Multiple Choice (MDMCR) was positively correlated with time spent in the program. Across the total and terminated sample, performance on Trails A was negatively correlated with time spent in the program. In the total sample performance on Trails B (time) was also negatively correlated with time spent in the program. In the total and graduated group, number of arrests was negatively correlated with time in the program. In the total sample, anxiety scores were negatively correlated with time in the program and in the terminated group, duration of alcohol use was positively correlated with time in the program. The study will discuss the mechanisms of action of drugs of abuse, their role in recidivism rates among abusers and the public health impact of substance abuse for the community.

Neuropsychological Predictors of Outcome in an Accountability Court Sample

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Introduction

The widespread and ever-increasing use of psychoactive substances worldwide necessitates further research into the effects of these substances on neural functioning. The generic term "substance abuse" is used to include the use of street drugs, prescription drugs, alcohol and tobacco. Addiction can be classified as a brain disorder characterized by changes in cognitive function, especially in executive functioning (Fernandez-Serrano, Perez-Garcia, Rio-Valle, and Verdejo-Garcia, 2010; Goldstein and Volkow, 2002; Lubman, Yucel, and Pantelis, 2004). Thus, in order to effectively treat substance dependence and lower incidences of relapse, thus improving prognosis, it is necessary to understand the neuropsychological effects associated with drugs. Only in understanding the neuropsychological decrements associated with substance use can substance dependence be effectively treated.

Effects on Executive Functions

All substances of abuse, including cocaine, methamphetamine, MDMA, opiates, and alcohol, with the exception of cannabis, are associated with sustained deficits in executive functioning, especially inhibition (Holst and Schilt, 2011). Executive functions have been collectively defined as "higher –level cognitive functions involved in the control and regulation of lower-level cognitive processes and goal-directed, future-oriented behavior." These functions are often linked to the anatomical region referred to as the frontal lobes. Component factors sub serving executive functions have been identified as inhibition, switching, working memory, and sustained and selective attention (Alvarez and Emory, 2006). There are various neuropsychological measures used to assess areas of executive functioning with some of the most popular being the Wisconsin Card Sorting Test, Phonemic Verbal Fluency, Stroop Color Word Interference Test and Trail Making Test. A meta-analytic review of studies using the first

three assessments mentioned revealed the sensitivity, and not specificity, of these assessments to frontal lobe functioning. This may suggest that executive functioning is too broad a factor to be confined to a particular anatomical region. Furthermore, it is likely that there are multiple areas of neurocognitive functioning comprising executive functioning ranging from memory to attention and therefore assessment of individual factors will allow for more tailored interventions (Alvarez and Emory, 2006). Executive functioning deficits play a major role in the negative impact of substance abuse on treatment outcomes as intact executive functioning domains can protect against relapse (Holst and Schilt, 2011).

As most of the studies are done with polysubstance users it is difficult to link specific executive function deficits with a particular class of drug. Alcohol, cocaine and cannabis use have been associated with verbal fluency and decision making. Dose-dependent impairments on verbal working memory and analogical reasoning have been suggested in cannabis and cocaine use. Duration of use and shifting has been associated in cocaine and heroin use and the effect on inhibition has been linked to duration of cocaine use (Fernandez-Serrano et al., 2010). In a study by Leber, Parsons, and Nichols (1985), poor prognosis in a sample of alcoholics was related to diminished performance on neuropsychological tests, especially those that measure abstract reasoning and problem-solving. Neuropsychological deficits correlated with substance abuse negatively impacts participation in treatment, results in poorer clinical progression levels, and higher rates of relapse (Fernandez-Serrano et al., 2010; Leber et al., 1985; Fals-Stewart and Lucente 1994; Aharonovich, Brooks, Nunes, and Hasin, 2008; Aharonovich, Hasin, Brooks, Liu, Bisaga, and Nunes, 2006; Aharonovich, Nunes, and Hasin, 2003).

The studies conducted on chronic substance abuse lack uniformity when defining "chronic" or "long-term" use. Some studies even use "number of pills in a lifetime" as a

measure of severity of use. Generally, chronic or long-term use is considered to be over a year. Chronic substance abuse has been associated with impairments in neuropsychological functioning. Long-term substance abusers, regardless of substance choice, consistently demonstrate neuropsychological deficits across domains such as inhibitory control, working memory, attention and decision-making (Yücel, Lubman, Solowij, and Brewer, 2007). These domains can all be considered part of the broader domain often referred to as executive functioning. Impairments in these areas of cognitive functioning can prolong the period of abuse by increasing the likelihood of drug-seeking behavior and by interfering with the substance abuser's ability to assimilate and participate in treatment programs (Rogers and Robbins, 2001; McCrady and Smith, 1986). Studies have shown that the deficits associated with substance use result in poorer clinical progression levels (Fernandez-Serrano et al., 2010; Leber et al., 1985), lower levels of participation in treatment (Fernandez-Serrano et al., 2010; Fals-Stewart and Lucente, 1994), and higher rates of treatment drop-out and drug relapse (Fernandez-Serrano et al., 2010; Aharonovich et al., 2008; Aharonovich et al., 2006; Aharonovich et al., 2003). For example, working memory and cognitive flexibility impairments result in, or are associated with, lower treatment compliance and higher rates of relapse (Aharonovich et al., 2006; Holst and Schilt, 2011; Passetti, Clark, Mehta, Joyce, and King, 2008).

Individuals who use substances for recreational use can exhibit a different neuropsychological profile than substance-dependent individuals. For example, studies have shown mild and specific executive deficits in recreational users of cannabis and psychostimulants (Fernandez-Serrano et al., 2010; Leland and Paulus, 2005; Block and Ghoneim, 1993) whereas substance-dependent individuals demonstrate more generalized executive deficits that are also of greater magnitude (Fernandez-Serrano et al., 2010). Although drugs may differ

in their mechanism of action, resulting in subtle differences in impairment, there are some general cognitive deficits that are associated with chronic substance abuse across drug classes. This similarity in effect may occur owing to the fact that most of the neurotransmitters affected by the drugs of abuse exert their effects across the whole forebrain and other, wider cortical areas (Rogers and Robbins, 2011).

Cannabis

Heavy cannabis use is associated with small, but significant impairments in memory retrieval, verbal expression, and mathematical reasoning; however, there are also small improvements in concept formation (i.e. abstraction) (Rogers and Robbins, 2001; Block and Ghoneim, 1993). Another study demonstrated memory and attentional deficits in association with prolonged cannabis use (Rogers and Robbins, 2011; Fletcher et al., 1996). On the other hand, there is little evidence for protracted impairments in adult abstinent cannabis users (Holst and Schilt, 2011; Fisk and Montgomery, 2008). In addition, adolescents diagnosed with cannabis use disorder had neurocognitive profiles similar to control groups after an abstinence period of at least 30 days (Hooper, Woolley, and De Bellis, 2014). This finding poses some interesting questions in light of the research on the potential effects of psychoactive substances on the developing adolescent brain. This developmental period is often viewed as a crucial time when the brain is particularly vulnerable to stressors. However, the adolescent brain can also be viewed as being more "malleable" with the increased opportunity to repair itself through neuroplasticity that can be heightened during this period. G.S. Hall may have accurately captured this developmental period when he described it as a period of "heightened storm and stress" (Dahl, 2004).

Cocaine

Research on cocaine use has revealed a consistent and characteristic pattern of deficits associated with chronic cocaine abuse. Such deficits include impairments in visuo-motor performance, attention, and verbal memory (Rogers and Robbins, 2011; Beatty, Katzung, Moreland, and Nixon 1995; Berry et al., 1993; Roselli and Ardila, 1996) in addition to deficits in short-term and working memory and executive functions such as abstract reasoning skills (Holst and Schilt, 2011; 20). Neuropsychological impairments in verbal learning and memory (Verdejo-Garcia and Perez-Garcia, 2007; Fox, Jackson, and Sinha, 2009; DeOliveira, Barroso, and Silveira, 2009), attention (Woicik, Moeller, Alia-Klein et al., 2009; Verdejo-Garcia and Perez-Garcia, 2007; Pace-Schott, Morgan, and Malison et al., 2008), inhibition, cognitive flexibility (Woicik et al., 2009; De Oliveira et al., 2009; Colzato, Huizinga, and Hommel, 2009; Verdejo-Garcia et al., 2007), and decision-making abilities (Verdejo-Garcia and Perez-Garcia, 2007; Verdejo-Garcia et al., 2007) have been demonstrated in abstinent cocaine-dependent individuals (Holst and Schilt 2011). However, the participants in these studies (as in the current study population) are often polysubstance users, which complicates the categorization and attribution of deficits to a single drug. Furthermore, there are claims that residual deficits persist over months of abstinence (Rogers and Robbins, 2001; O'Malley, Adamse, Heaton, and Gawin, 1992; Strickland et al., 1993). The greater the intensity of cocaine use, and the earlier the onset, the more marked the deficits in neuropsychological measures associated with executive control, visuospatial abilities, psychomotor speed, and manual dexterity (Rogers and Robbins 2001; Bolla, Rothman, and Cadet, 1999; Strickland , Stein, Khalsa, and Andre, 1997) in abstinent cocaine-dependent individuals. Polysubstance dependent individuals, with cocaine as their preferred drug, exhibited more severe impairments than polysubstance dependent individuals

with heroin as their drug of choice. Specifically, these impairments were noted on measures of inhibition, measured by the Stroop test, and shifting, measured by the go/no go and category test. In both populations severity of drug use was negatively correlated with performance on updating measures (Verdejo-Garcia and Perez-Garcia, 2007).

Alcohol

Severe chronic alcohol abuse is associated with diminished performance on neuropsychological tasks measuring attention, short-term memory, visuospatial abilities, and executive functions such as problem solving, mental flexibility, judgment, working memory, response inhibition, and decision-making (Holst and Schilt, 2011; Moselhy, Georgiou, and Kahn, 2001). However, research indicates improvements in cognitive functioning after a period ranging from 1 week to several years of abstinence from alcohol use. This includes improved performance in areas of working memory, visuo-spatial functioning and attention after short-term abstinence. After one month of abstinence, there were improvements in working memory and verbal fluency performance though not in cognitive flexibility or planning (Holst and Schilt, 2011; Manning, Wanigaratne, Best, et al., 2008). Longer abstinence duration resulted in the complete recovery or at least substantial improvements in executive functions (Holst and Schilt, 2011; Fein, Torres, Price, and Di, 2006; Pitel, Witkowski, Vabret, et al., 2007; Pitel et al., 2009; Davies, Pandit, Feeney, et al., 2005). Pitel et al. (2009) demonstrated memory and executive functioning deficits in short-term abstinent alcohol-dependent subjects as compared to controls. However, after six months of abstinence, no differences between alcohol-dependent individuals and controls were to be found. Furthermore, Fein et al. (2006) found that there was little to no difference in performance on almost every domain except for in the spatial domain between abstinent alcoholics (abstinent for more than 6 years) and controls. Although there is evidence

that cognitive functions may improve after protracted abstinence (more than a year), there is also evidence that indicates neuropsychological deficits may be persistent (Davies et al., 2005).

Opiates

Long-term opiate users have demonstrated neuropsychological decrements in attention, concentration, visual and verbal recall and visual spatial skills (Holst and Schilt, 2011; Gruber, Silveri, and Yurgelun-Todd, 2007). Diminished cognitive functioning is associated with opiate use in various executive function domains such as inhibition, cognitive flexibility, and working memory (Holst and Schilt, 2011). Both abstinent opiate- dependent subjects on methadone maintenance and complete abstinent opiate-dependent subjects not on methadone maintenance (abstinent for >18 months) exhibit similar cognitive deficits in fluid intelligence, working memory, and design fluency compared to healthy normal controls (Prosser et al., 2008). The most consistent findings in abstinent opiate-dependent individuals (abstinent for 1-4 weeks) were abnormal executive functioning (such as lowered inhibition, verbal fluency, and decision-making skills) (Holst and Schilt, 2011; Verdejo-Garcia and Perez-Garcia, 2007; Brand, Roth-Bauer, Driessen, and Markowitsch, 2008; Verdejo-Garcia, Perales, and Perez-Garcia, 2007). These deficits persisted from 6 to 52 weeks (Holst and Schilt, 2011; Prosser et al., 2008; Davies, Liddiard, and McMillan, 2002). However, findings from a more recent study suggest that prospective memory is more sensitive to long-term opiate use than executive functioning (Terrett et al., 2014).

Methamphetamine

Short-term abstinent methamphetamine abusers (those who have been abstinent for 4 – 14 days) exhibit decrements in memory and learning, psychomotor speed, and informational processing (Holst and Schilt, 2011;Meredith, Jaffe, Ang-Lee, and Saxon, 2005). Chronic

methamphetamine users also demonstrate lower performance on immediate and delayed verbal memory tasks (Holst and Schilt, 2011; Hoffman et al., 2006; Iudicello, Woods, Vigil, et al., 2010; Chemer, Suarez, Casey et al., 2010), with decrements in immediate visual recall and delayed memory (Holst and Schilt, 2011; Iudicello et al., 2010; Chemer et al., 2010; Woods, Rippeth, Conover, et al., 2005). Chronic amphetamine and opiate abuse is marked by deficits on a range of neuropsychological tasks involving attentional control, planning, and spatial working memory (Rogers and Robbins, 2001; Ornstein et al., 2000). It should be noted, however, that there are subtle differences in the profile of deficits shown between amphetamine abusers and opiate abusers. One such differences is that amphetamine abusers are marked more by impairments in the control of attentional bias but have milder deficits in the use of strategy in spatial memory tasks. Furthermore, abstinent amphetamine users (those who have been abstinent for more than one year, with the mean duration of abstinence being 8 years) display diminished cognitive planning and poorer immediate/delayed pattern recognition compared to controls (Holst and Schilt, 2011; Jovanovski, Erb, and Zakzanis, 2005). However, the normalization of executive functioning in methamphetamine users who have been abstinent for more than one year has also been shown (Holst and Schilt, 2011; Salo et al., 2009).

Ecstasy (MDMA)

Ecstasy (MDMA) users exhibit impairments in tests of short-term memory and more complex attentional functioning (Rogers and Robbins, 2001; Krystal et al., 1992; Bolla et al., 1999; McCann, Mertl, Eligulahvilli, and Ricaurte, 1999; Gouzoulis-Mayfrank et al., 2000). There is evidence, however, that MDMA use results in impairments in verbal learning and memory ability and improvements in design fluency (Medina, Shear, and Corcoran, 2005). Furthermore, this study reports no significant relationship between MDMA consumption and

executive functioning or attentional abilities. Recent research indicates the possibility that certain impairments may require additional methods of assessment. Electroencephalography findings suggest evidence of abnormal executive functioning in ecstasy poly-substance drug users compared to non-ecstasy poly-substance drug users and non-substance abuse controls. In addition this study found no significant behavioral differences between the groups (Roberts, Fairclough, Fisk, Tames, and Montgomery, 2013).

Mechanisms of Action

The substances of abuse primarily act on the reward pathways. The ventral tegmental area (VTA), the nucleus accumbens, and the prefrontal cortex form part of one of these pathways.. The VTA is connected to both the nucleus accumbens and the prefrontal cortex via this pathway and it sends information to these structures via its neurons. The neurons of the VTA contain the neurotransmitter dopamine, which is released in the nucleus accumbens and in the prefrontal cortex. This pathway is activated by a rewarding stimulus.

Cannabis

Tetrahydrocannabinoid (THC), the main active ingredient in marijuana, binds to and activates specific receptors, known as cannabinoid receptors. There are many of these receptors in areas of the brain associated with memory, thought, concentration, time and depth perception, and coordinated movement. By activating these receptors, THC interferes with their normal functioning. THC initially binds to the CB1 receptors for anandamide that alter the activity of several intracellular enzymes, including cAMP, whose activity they reduce. A decrease in cAMP results in a decrease in protein kinase A. The reduced activity of this enzyme affects the potassium and calcium channels so as to reduce the amount of neurotransmitters released. Similarly to opiates, cannabis removes the inhibition on dopaminergic neurons that is normally

effected by GABAergic neurons. Chronic consumers of cannabis can suffer a loss of CB1 receptors in the brain's arteries that results in reduced blood flow, and therefore decreased glucose and oxygen flow to the brain.

Cocaine

Cocaine binds to sites in areas of the brain that are rich in dopamine synapses such as the VTA and the nucleus accumbens. Cocaine binds to the re-uptake pumps and prevents them from transporting dopamine back into the neuron terminal. This allows more dopamine to accumulate in the synaptic space thereby prolonging its action. This is the same ultimate effect that occurs with morphine, where morphine increased dopamine release from the terminal to produce more dopamine in the synaptic space.

Alcohol

Alcohol can produce its effects on the brain in several ways by altering their membranes, ion channels, enzymes, and receptors. In addition, alcohol also binds directly to the receptors for acetylcholine, serotonin, GABA, and the NMDA receptors for glutamate. This physiological effect is amplified when alcohol binds to the GABA receptor as it allows the ion channel to stay open longer and thus let more Cl- ions into the cell. The neuron's activity is therefore diminished resulting in the sedative effect of alcohol. This effect is compounded by the fact that alcohol also reduces glutamate's excitatory effect on NMDA receptors. However, chronic consumption of alcohol can result in the NMDA receptors developing a hypersensitivity to glutamate while desensitizing the GABAergic receptors. Therefore chronic use can result in the state of excitation characteristic of alcohol withdrawal. Alcohol can also increase the release of dopamine by inhibiting the activity of the enzyme monoamine oxidase that breaks dopamine down.

Opiates

Heroin is converted to morphine in the brain where it binds to opiate receptors in the ventral tegmental area (VTA), nucleus accumbens, thalamus, brainstem, and areas of the cerebral cortex and spinal cord. Opiates bind to opiate receptors that result in a decrease of GABA release. GABA normally inhibits the release of dopamine and therefore and inhibition of GABA release results in excessive dopamine release.

Amphetamines

Similar to cocaine, amphetamines increase the concentration of dopamine in the synaptic gap, however they achieve this via a different mechanism. Owing to their structural similarity to dopamine, amphetamines can bind to dopamine transporters and enter the terminal button of the presynaptic neuron. They can also enter the neural membrane directly via diffusion. Amphetamines can then expel dopamine into the synaptic gap by forcing the molecules out of the storage vesicles. Amphetamines can also work by reducing the reuptake of dopamine and, in high concentrations, inhibiting monoamine oxidase A (MAO-A) that breaks down dopamine. Amphetamines can also increase the "excitability" of dopaminergic neurons by removing the inhibiting effect of metabotropic glutamate receptors.

Ecstasy

Ecstasy (MDMA) is a synthetic drug that is structurally similar to amphetamines and LSD and can act as a stimulant and a hallucinogen. Similar to amphetamines and cocaine, ecstasy blocks the reuptake pumps for certain neurotransmitters, thus increasing their levels in the synaptic gap and prolonging their effect on the post-synaptic neurons' receptors. The distinguishing feature of ecstasy is its effects on serotonin transporters in addition to norepinephrine and dopamine. The resulting initial increase in serotonin can be experienced as

an increase in energy, euphoria, and the suppression of certain inhibitions in relating to other people. This initial reaction is followed a few hours later by a decrease in serotonin levels, amplified by the reduced activity of tryptophan hydroxylase, the enzyme responsible for synthesizing serotonin. This decrease can last much longer than the initial increase. In a similar fashion to other drugs, the initial "artificial" and excessive increase in neurotransmitter levels leads to a decrease below original levels. Similar to the other drugs mentioned, ecstasy increases the release of dopamine into the reward circuit. The increased serotonin produced by ecstasy leads indirectly to excitation of the dopaminergic neurons by the serotonergic neurons that connect to them. Essentially, the substances of abuse act on the reward pathways and cause these systems to shift out of their normal parameters by introducing excess stimuli, for example dopamine, in a short period of time.

Public Health Problem

In 2009 about 1 in 20 people worldwide ages 15 to 64 used an illegal drug. In North America alone, about 11% of the population between the ages of 15 to 64 used cannabis (marijuana). Between 14 million and 56 million people ages 15 to 64 worldwide used amphetamine-type stimulants, such as speed and crystal meth. Cocaine use was highest in North America in 2009, with about 14 million to 21 million users. Around the world opioid use, including heroin was estimated at between 12 million to 21 million users. There are between 11 million and 21 million people who inject drugs worldwide ("Global Study Finds Drug Abuse Highest in Richer Nations", 2012). The misuse and abuse of drugs is a relevant issue that grows increasingly urgent, impacting both the communities and personal lives of the drug users. As drug use proliferates across the world, substance abuse begins to have far-reaching consequences

that go beyond individual lives and small communities; it starts to impact society on a greater scale.

Focusing our attention towards the United States and, given the current economic situation, it is useful to view the effects of substance abuse in financial terms. The combined costs of the abuse of tobacco, alcohol, and illicit drugs are estimated to amount to over $600 billion annually. This includes costs related to crime, unemployment, decreased work productivity, and healthcare (Goldstein and Volkow, 2002). It is also important to keep in mind that these costs do not include the costs from the increasing numbers of those who abuse prescription medications. Furthermore, the effects of prolonged substance abuse on the social, physical, and psychological environment of children and any consequent implications for the following generation are not factored into the costs. Purely based on these preliminary economic data, and without considering the personal effects on the individual, it is evident that there is a desperate need to develop a theoretical model to aid in the understanding of the effects of substance abuse, from which successful assessment and intervention protocols can be based.

Current Focus

The current study is a pilot study with the aim of determining the value of neuropsychological assessments as predictors of outcome in a drug court population. Based on the existing literature this approach would seem to be a valid aim given the evidence of neuropsychological impairment present in chronic substance abusers. Preliminary data from an Accountability Court population will be presented. This particular population represents chronic substance users and the focus in this discussion will be on long-term substance use.

The first hypothesis stated that performance on executive functioning measures would predict graduation status. The second hypothesis stated that performance on executive functioning measures would predict time to graduate from the program.

Method

Subjects

Participants were recruited from the Accountability Drug Court in Fulton County Atlanta, GA, USA. Individuals convicted of drug offences in Atlanta, GA are given the option of incarceration or attending a drug rehabilitation program. The program spans 18 months and requires mandatory attendance of classroom sessions that include components such as GED preparation, employment readiness. Participants also receive cognitive rehabilitation services through Moral Recognition Therapy (MRT).

Measures

The interview and mental status examination was conducted first followed by administration of psychological and neuropsychological assessments. This is essentially a screening battery designed to fit within the program constraints of time and participant availability.

Interview and Mental Status Examination. A detailed account of past and present medical conditions, medication, psychiatric treatments, family, education, vocational, military, and social and drug history was collected. A behavioral/mental status examination was also done.

Montreal Cognitive Assessment (MOCA). The MOCA is a screening tool for mild cognitive dysfunction. The different cognitive domains assessed are: attention and concentration, executive functions, memory, language, visuo-constructional skills, conceptual thinking, calculations, and orientation. The maximum possible score is 30 and a score below 26 is indicative of mild cognitive impairment.

Kaufmann-Brief Intelligence Test II (K-BIT-II). The Kaufmann-Brief Intelligence Test II (K-BIT-II) is a brief intelligence test for individuals from 4 to 90 years of age. It is designed for traditional brief assessment purposes such as screening or conducting periodic cognitive reevaluations and allows the clinician to determine whether or not the patient requires more extensive follow-up testing. There are 3 subtests from which Composite, Performance and Verbal IQ scores are derived.

Wide Range Achievement Test-Revision 4 (WRAT-4). The Wide Range Achievement Test-Revision 4 (WRAT-4) was administered to estimate academic skills namely word reading, sentence comprehension, spelling, and math computation.

Rey-Osterrieth Complex Figure Test (RCFT) Copy Phase. The RCFT assesses aspects of visual spatial construction ability in all ages. The RCFT copy phase requires the participant to copy a complex geometric figure in as much time as is required. The RCFT copy phase is a measure of visual spatial construction ability. Visual spatial constructional ability is the ability to: combine elements into meaningful wholes, discriminate between objects, distinguish between left and right, to understand relationships among objects in space, adopt various perspectives and to represent and rotate objects mentally; comprehend and interpret symbolic representations of external space and work out the solution for non-verbal problems.

Finger Tapping Test & Hand Dynamometer. The Finger Tapping Test is a test of

manual dexterity and the Hand Dynamometer tests grip strength. The motor tasks are used as indicators of lesion lateralization as dexterity and strength varies widely between hands in patients with lateralized brain disorders. However, this variance is often seen in control subjects as well and therefore other non-motor tasks must be used when generating hypotheses about lateralization.

Trail Making Test (TMT) A & B. The TMT, although a relatively simple test to administer and score, is among the most sensitive neuropsychological instruments to the effects of brain damage. The cognitive alternation required by part B incorporates executive functioning, although other cognitive abilities, such as psychomotor speed and visual scanning, are also required in order to successfully complete the test. The two indicators of performance are, time to completion and number of errors.

Beck Depression Inventory II (BDI-II) & Beck Anxiety Inventory (BAI). The Beck Depression Inventory II (BDI-II) is a self-report measure assessing depressive symptoms experienced by an individual in the past two weeks while the Beck Anxiety Inventory (BAI) is a self-report measure assessing anxiety symptoms experienced by an individual in the past week.

Outcome Measures. There were two outcome variables measured, graduation status and length of time in the program, (i.e. length). Graduation status refers to whether the participant graduated from the program or whether they were terminated. Length of time in the program refers to the time the participant took to graduate or be terminated from the program.

Results

Summary of Predictor Variables for Graduation Status

Logistic regression analyses were conducted to determine possible predictor variables for graduation status. The logistic regression model revealed that increased time spent in the program significantly improved an individual's odds of graduating from the program compared to being terminated, (R^2=.148, p<.01) (Table 14). An independent samples T-test was conducted to determine if there is a statistically significant difference in the group means of time spent in the program between those who graduated compared to those who were terminated from the program. This result was statistically significant, t (54) = -3.138, p < .01, d= -0.84738 (Table 15).

The logistic regression model using work history as a predictor of graduation status was not statistically significant and there was no change in overall percentage prediction when comparing the two classification tables work history, (R^2=.149, p>.05) (Table 14). However, when using bootstrapping and increasing the sample size to 1000 samples, increased work history appears to also increase an individual's odds of graduating from the program compared to being terminated (p<.01) and therefore suggests the need for further exploration in this area. An independent samples t-test provides further evidence of this as there is a significant difference in the mean duration of work history when comparing those who were terminated from the program and those who graduated, t(30) = -3.239, p < .05, d=-0.934 (Table 15).

An increased number of arrests decreases an individual's odds of graduating from the program, (R^2=.081, p<.05) (Table 14). However, the t-test comparing the group means was not significant, t (18) = 1.704, p > .05, d=.274 (Table15).

The logistic regression model indicates that as the Trails B z score increases there is increased likelihood of an individual being terminated from the program, (R^2=.279, p<.05) (Table 14). However, the t-test comparing the group means was not significant, *t* (7) = 1.943, *p* > .05, d=.48 (Table 15).

Trails B time was also significant, as Trails B time decreased the odds of being terminated from the program also increase, (R^2=.332, p<.05) (Table 14). The t-test comparing the group means was also significant, *t* (17) = -2.623, *p* < .05, d= -1.34 (Table 15).

A multivariate analysis was conducted to determine if the MOCA subtests scores were significantly different when grouped according to graduation status. Figure 1 indicates the similarity of the scores between the two groups and the analysis was not statistically significant.

Prior work history, number of arrests, performance on Trails B and length of time in the program are variables that can be used to predict graduation status.

Summary of Predictor Variables for Length of Time in the Program

Total Sample. Correlation analyses were conducted on the total sample with the outcome variable length of time in the program as the primary focus. The following variables had significant positive correlations; MOCA Delayed Recall Multiple Choice Recall, Trails A time, and Trails B time (Table 8). The following variables were negatively correlated with length of time in the program; Number of arrests, Beck Anxiety Inventory, and Trails A z score (Table 8).

Regression analyses were then conducted to determine what portion of the variance in length of time outcome these predictors could account for; Number of arrests (19.7%), Beck Anxiety Inventory (20.1%), MOCA Delayed Recall Multiple Choice Recall (38.2%), Trails A z score (56.1%), Trails A time (50.8%), and Trails B time (26.2%) (Table 9).

Graduated Sample. Correlation analyses were conducted on the sample who graduated with the outcome variable length of time in the program as the primary focus. MOCA Delayed Recall Multiple Choice Recall was positively correlated while Trails A time and Number of arrests were negatively correlated with time in the program (Table 10). Regression analyses were then conducted to determine what portion of the variance in graduation length outcome these predictors could account for; Number of arrests (11.5%), MOCA Delayed Recall Multiple Choice Recall (52.5%) and Trails A time (36%) (Table 11).

Terminated Sample. Correlation analyses were conducted on the sample that was terminated from the program with the outcome variable length of time in the program as the primary focus. The following variables had significant positive correlations; Duration of Alcohol Use, MOCA Delayed Recall Multiple Choice Recall, and Trails A time while Trails A z score was negatively correlated (Table 12). Regression analyses were then conducted to determine what portion of the variance in length of time outcome these predictors could account for; Duration of Alcohol Use (63.7.5%), MOCA Delayed Recall Multiple Choice Recall (36.4%), Trails A z score (78.2%), and Trails A time (79.3%%) (Table 13).

Total Sample and Individual Groups. The motor tasks, namely Grip Strength or Finger Tapping were not significantly correlated to the outcome measures length of time in the program or graduation status.

Discussion

The main aims of the study were to investigate if any of the variables measured could function as predictor variables for the outcomes measured namely, graduation status and length of time spent in the program. Graduation status refers to whether an individual is terminated from the program or whether they graduate. Length of time spent in the program significantly

predicts graduation status. There was a large effect size when comparing the two groups (d=-0.85) suggesting that time spent in the program is an important factor. Given that the program has stringent requirements for graduation, for example, gaining employment and remaining abstinent, this finding suggests that the more effort the individual puts in, the greater chance they have of graduating. Increased time spent in the program would require attending more classes and therefore suggestive of increased effort.

The findings suggest that among the demographic variables, prior work history could be a useful predictor of graduation status. A longer period of work history can predict successful graduation from the program as compared to termination. This has important implications for the program given that one of the main target outcomes is vocational rehabilitation. This finding prompts the question of whether the current program is slightly biased towards those with prior work history in terms of the skills that are emphasized for graduation. Are those individuals with a longer work history more motivated to complete the program and gain employment, due to the fact that they have previously experienced the benefits of legal employment? Perhaps the argument could be made for those individuals with relatively little work history to be provided with additional assistance, for example, specific counseling and guidance on the benefits of legal employment. Based on the intake interviews, there are some individuals in the program who have survived largely by dealing drugs and therefore they may view this as the most feasible option to be financially secure in the future.

An increased number of arrests decrease an individual's odds of graduating from the program. Although individuals can, and do, get arrested while in the program, this figure largely reflects arrests prior to entering the program. Number of arrests is a "behavioral" factor that could be viewed as a "real world" indication of executive functioning. An increased number of

arrests can reflect impulsivity and diminished capacity to inhibit responses that favor long-term benefits over immediate rewards. It could be that a more sensitive measure on impulsivity and inhibition is required in the battery given that the Trails did not detect significant impairment in the terminated sample (mean Z score=-.3). Although adequate performance on the Trails does require the use of inhibition in terms of responding in a particular manner, perhaps an assessment like the Stroop would be a suitable addition to the battery. The predictors mentioned thus far, length of time in the program, prior work history and number of arrests may be sub-served by common factors. For example, certain personality traits can predispose an individual to remain in steady low paying legal employment rather than seek immediate and increased rewards from illegal ventures. Similar underlying traits can also keep these same individuals motivated to remain and complete in the program and stay abstinent. Identification of a personality profile that can "predict" graduation from the program is a crucial addition to the next phase of research. The positive correlation of Duration of Alcohol Use and length of time in the Terminated Sample may provide an indication of a source of "exacerbation" to the personality profile discussed above. Individuals who are biologically predisposed to impulsivity may have these tendencies strengthened by increased alcohol intake. However, the underlying traits may also account for the propensity to abuse alcohol. Therefore a developmental approach to this assessment is also necessary. Duration of alcohol use was also positively correlated with time on Trails A (r =.921, $p < .05$) and Trails B (r =.939, $p < .05$) in the terminated sample and with Trails A(r =.888, $p <$ .05) in the graduated sample. A positive correlation with time reflects a negative correlation with overall performance. Persistent deficits in spatial functioning in chronic alcohol abusers who were abstinent for more than 6 months have been demonstrated and this finding could be

reflected in the present sample. Deficits in spatial functioning can result in decreased performance on the Trails.

Among the neuropsychological variables the Trails B measures were significant in the model predicting graduation status. However, the "direction" of prediction may be surprising. An increase in Trails B time and a decrease in Z scores reflect a direction towards greater relative impairment. In this study, those who graduated had Trails B scores that reflected lower z scores and higher times than those who were terminated from the program. The z scores were not statistically different but the times were; the group who graduated had increased times on the Trails B compared to the group that were terminated, t (17) = 2.623, $p < .05$, d= 0.56. The Trails Z scores are traditionally used to denote impairment (Z< -1) as compared to "normal" functioning (Z> -1). A comparison of impaired Z scores from the terminated and graduated sample revealed no statistical difference. However, Z scores incorporate age and education and it's possible that the raw time scores are more sensitive than the Z scores. One explanation could lie in the reason for termination. It is possible among those in the terminated group that owing to their performance on the neuropsychological evaluation, scoring relatively higher on the Trails, improved their overall prognosis and recommendation for vocational rehabilitation. Once they received a job, these individuals failed to attend classes or drug screenings and were terminated from the program leaving those behind in the program who scored lower on the Trails. This is possibly reflected in the mean Z score of the Trails B from the graduated group that falls in the impaired range. This finding may be partly supported by the analysis of the MOCA subtests that revealed that the means of some subtests were higher among the "terminated" group than the "graduated" group (Figure 1); although this finding was not statistically significant. Given that there is no strict time limit imposed for graduation, any neuropsychological impairment may be

more likely to be reflected in the "length of time in the program" variable rather than the graduation status variable.

When the entire sample was analyzed, time on Trails A and B were positively correlated, and Trails A z score negatively correlated, with time spent in the program. A similar pattern was seen in the terminated group. However, in the graduated group Trails A time was negatively correlated with time in the program. One explanation could be that increased time in the program (the graduated group has been shown to spend a longer time in the program) allows for recovery of impaired cognitive functioning that is reflected in a decrease in Trails time. The results of the MOCA Delayed Recall Multiple Choice Recall (MDMCR) suggest some support for this hypothesis. The MDMCR provides an indication of recognition memory. A positive correlation with length of time in the program could be a reflection of improvement in this area of cognitive functioning over time. This positive correlation of MDMCR scores and length of time in the program was noted for the total, graduated, and terminated sample. Given that the improved performance noted for MDMCR was consistent across groups, while the Trails findings were more specific to the graduated group, it is may be reasonable to assume that while time spent in the program could account for the memory improvement (time can imply increased period of abstinence) there are other variables accounting for the improvement in Trails time in the graduated group. Perhaps these variables could be accounted for within the treatment plan of the current program.

A summary of the neuropsychological variables suggest that relative deficits in executive functioning (reflected by performance on the Trails) may be reflected by prolonged time spent in the program for the total and terminated sample. However, there seems to be improvement in

this area within the graduated group. In addition there seems to be recovery of recognition memory with longer periods of abstinence (increased length of time in the program).

Number of arrests was negatively correlated with time in the program for the total sample and for the sample who graduated. This ties in with its effect on graduation status; an increased number of arrests increased the likelihood of termination from the program. Given that termination is associated with a shorter duration of time in the program than graduation, this fits with the overall effect of an increased number of arrests. An improvement in anxiety scores was correlated with increased length of time in the program. This could be reflective of the individual's level of comfort with the program and an effect of the treatment provided. There was no significant difference in the anxiety scores for the terminated and graduated groups. The improvement in memory noted could also play a role in decreasing anxiety symptoms. Memory skills are vital in order for the participants to assimilate information from the classes and progress towards graduation. Improvements in any cognitive area that help achieve this goal will undoubtedly improve emotional functioning.

The variation in performance on the Trail Making Test suggests improvement and persistent deficits in certain areas of cognitive functioning over time. Trails A and B require recruitment of common cognitive areas such as visuospatial, attention, memory and motor speed. However, Trails B requires the additional involvement of areas of functioning such as inhibition, cognitive flexibility, set-shifting and conceptual tracking. Generally, when time taken to complete Trail A is relatively much less than time taken to compete Trails B, this can reflect impairment in the "additional" areas of functioning mentioned above. In this sample, across all three groups, the time taken to complete Trails A was significantly lower than the time taken to complete Trails B. The ratio of time taken to complete Trails B compared to Trails A was 2.02,

1.86, and 2.67 for the total, terminated and graduated group respectively. The improvement in Trails A performance and impairment in Trails B z scores noted above in the graduated sample, combined with these ratios suggest that areas common to Trails A and B, for example attention and memory improve with over time with abstinence, while other areas such as inhibition, cognitive flexibility, set-shifting and conceptual tracking may require more direct intervention.

The addition of other modalities of assessment may lend weight to the specificity of an executive functioning profile characteristic of chronic substance abuse as described above. The combination of behavioral indicators, arrest and work history, length of time in the program and performance on executive functioning measures suggest a cognitive profile consistent with pre-frontal impairment. The prefrontal cortex/orbitofrontal cortex (PFC/OFC) and anterior cingulate gyrus (ACG) are regions that are involved in higher-order cognitive and motivational functions (such as decision-making, judgment calls, and behavioral inhibition) and are most frequently implicated in drug addiction. These areas are activated during intoxication, craving and binging, but deactivated during withdrawal (Goldstein and Volkow, 2002). The PFC/OFC is primarily associated with executive functions and judgment, and, secondarily with behavioral inhibition, whereas the ACG is primarily associated with error processing, conflict monitoring, response selection, and avoidance learning. Just as damage, or decreased activity, in the PFC/OFC impairs judgment and decision-making, the same in the ACG produces changes in disinhibition, apathy, and aggressiveness (Bolla et al., 2004). On the other hand, the nucleus accumbens (NAc), amygdala, and hippocampus are associated with appetitive behavior, seeking and searching for reward, memory, and conditioned responses linked to craving, all of which are involved in the acute reinforcing effects of a drug (Goldstein and Volkow, 2002).

Functional MRI (fMRI) scans provide information on the level of activity in a certain region of the brain either at rest or in response to a task condition by examining at the levels of glucose metabolism. Scans specifically detect changes in the local magnetic field that result from changes in the oxygenation of hemoglobin in arterial blood vessels in specific brain regions (Chang and Chronicle, 2007). As neurons increase in activity, they increase their demand for oxygen, as fuel, and thus arterial blood vessels respond by delivering more oxygenated hemoglobin to the active brain region. Research indicates the value of using fMRI to detect subconscious processing that may imply functional impairments in areas such as emotional processing and executive functioning (specifically control of inhibition) in addicted individuals. These impairments may not appear as overt behaviors in the form of cravings, or in neuropsychological assessments as cognitive deficits (Wexler et al., 2001). Additionally, research has indicated that fMRI performed on methamphetamine addicts that were performing a psychological test predicted the relapse of the individuals within 1-3 years following treatment with 90% accuracy (Paulus, Tapert, and Schuckit, 2005).

Neuroimaging indicates “abnormalities” in the prefrontal cortex, amygdala, and hippocampus among youth with conduct disorder, a disorder commonly pre-dating substance abuse (Fairchild et al., 2011). If imaging can detect neurological abnormalities which are the underlying basis for conduct disorder, it may be possible for neuroimaging scans to detect abnormalities that may affect an individual’s predisposition to substance abuse, as previously discussed with the search for a personality profile, or any structural differences that may impact the success of treatment. Previous research indicates the prevalence of executive functioning impairment among substance abusers, due in part to a dysfunction in the prefrontal cortex

structures in addition to changes to the amygdala, hippocampus, and ACG (Schutter and van Honk, 2004).

Neuroimaging research has indicated evidence for "compensatory strategies" in a sample of chronic substance abusers. For example, when presented with a working memory task, long-term marijuana users recruited more brain areas than the control group. This can be an indication of a neurological response that allows the individual to function at a sufficient cognitive level in the face of long-term substance abuse; this can be viewed as an indication of cognitive reserve. However, chronic degenerative conditions, and chronic substance abuse, are a constant drain on cognitive reserves. Such neurological adaptation can be conceptualized as positive neuroplasticity and includes physiological adaptations such as the strengthening of dendritic connections, or the formation of new connections, and an increase in cognitive reserve. This adaptation can be enhanced by factors such as physical activity, sleep, education, cognitive training, and social interaction. Conversely, factors such as poor sleep and eating habits, lack of physical activity, substance abuse, depression and anxiety can inhibit positive neuroplasticity and promote negative neuroplasticity (the reverse physiological changes as positive neuroplasticity in the brain). An increased cognitive reserve has been associated with improved prognosis in neurodegenerative processes such as Alzheimer's disease, dementia and HIV. Measurements of cognitive reserve have accounted for a significant proportion of the global impairment scores in chronic substance abusers (Fein and Di Sclafani, 2004). Cognitive processes ranging from memory to attention and planning all promote positive neuroplasticity that provides the structural architecture for an increased cognitive reserve (Vance, Roberson, McGuinness, and Fazeli, 2010). Therefore, cognitive reserve can be thought of as a moderating factor of the effect of cognitive impairment from substance abuse.

The results of the analyses conducted suggest areas for intervention and improved assessment in order to maximize the effectiveness of the Accountability Court program to the target population. Prior work history and number of arrests should be assessed at the intake and those with a minimal length of work history (the current data does not suggest a specific length of prior work history) and increased number of arrests may be separated into a different tract. This tract should emphasize the value and benefits of legal employment. Perhaps these individuals can be paired with a previous graduate of the program who has current employment and can offer experiential advice.

Individuals, whose assessment results indicate cognitive impairment, can be assigned to a specific tract within the program that emphasizes certain activities designed to promote positive neuroplasticity and improve cognitive reserve. This tract can be designed to include physical activity, cognitive remediation, and increased social interactions, all of which have been shown to increase positive neuroplasticity (Vance et al., 2010). Furthermore, the cognitive rehabilitation should be targeted at the areas of executive mentioned, namely inhibition, concept formation, set shifting and conceptual tracking. The significant positive correlation between recognition memory and length to graduation may provide an indication as to more useful methods of presenting information to participants in order to improve spontaneous recall. Recognition memory, as measured, presents items in individual categories, for example, select the correct answer from a list of body parts rather than spontaneously recall a list including body parts, colors, flowers, etc. This can reflect a preference for recalling information presented in an "item-specific" manner as compared to relational or associative memory. Therefore, information presented in classes can be grouped according to specific content and questions presented in

multiple choice format on these specific topics. Once this information is learned then the class can progress to integration of the topics.

While the data suggests certain areas of executive functioning as intervention targets, the use of assessment techniques such as neuro-imaging may allow for more improved and tailored intervention strategies. Furthermore, one of the main goals of the program is vocational rehabilitation and therefore the ecological validity of the assessments given is extremely important. Do the cognitive domains tapped by the neuropsychological measures accurately relate to the cognitive requirements of "real world" situations, for example work and family stressors? Does "normal" performance on an executive functioning measure during assessment predict that the individual will be able to exercise these skills on a long-term basis in the face of multiple, concurrent stressors?

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Appendices

Tables

Table 1

Gender Demographics

Gender	Percent
Male	73.2
Female	26.8

Table 2

Education and Employment Demographics

	N	Minimum	Maximum	Mean	Std. Deviation
Education (years)	50	3	15	11	3.09
Longest continuous employment (years)	32	0	20	4.13	4.86
Number of arrests	51	0	29	5.63	6.18
Work History (years)	36	0	24	5.93	6.79

Table 3

Substance Abuse prevalence

Substance	Percent Using
Alcohol	42.59
Cocaine	61.82
Marijuana	58.18
Methamphetamine	5.45
Heroin	3.45

Table 4

Substance Abuse History

Years of Use	N	Minimum	Maximum	Mean	Std. Deviation
Alcohol	21	1.00	38.00	19.29	9.71
Cocaine	33	.75	39.00	18.51	8.45
Heroin	2	4	12.00	8	5.66
Marijuana	29	.50	39.00	17.12	11.64
Methamphetamine	3	3.00	16.00	9	6.56

Table 5

Neuropsychological Assessments

Test	% Impaired of Total Sample
MOCA Subtests	
Visuospatial/ Executive	64
Naming	12
Attention	54.2
Language	75
Abstraction	58.3
Delayed Recall	76
Delayed Recall Category	75
Delayed Recall Multiple Choice	50
Orientation	4
Total Score	61.8

Test	% Impaired of Total Sample
Trails Z score	
A	35.7
B	50

Test	% Impaired of Total Sample
Finger Tapping-DH	10.5
Finger Tapping NDH	15.8
Grip Strength-DH	50
Grip Strength-NDH	28.9

Note. *DH=dominant hand; NDH=non-dominant hand

Table 6

Psychological Assessments

Measure	Moderate-Severe Range (% of Total Sample)
BDI	12.5 %
BAI	13.64%

Table 7

Percent of Total Sample that Graduated or were Terminated from Program

	N	Percent
Terminated	19	33.93
Graduated	37	66.07
Total	56	100.0

Table 8

Total Sample Correlation Table with Pearson Correlation Coefficient (p-value)

	MOCA Delayed Recall (MC)	Trails A z score	Trails A Time	Trails B Time	BAI	Arrests(Number)
Time in Program	.618 ($p < .01$)	-.749 ($p < .01$)	.713 ($p < .01$)	.512 ($p < .05$)	-.449($p < .05$)	-.444($p < .01$)

Table 9

Total Sample Regression Table with R-Squared (p-value)

	MOCA Delayed Recall	Trails A z score	Trails A Time	Trails B Time	BAI	Number of Arrests
Time in Program	.382 (p<.01)	.561 (p<.01)	.508(p<.01)	.262 (p<.05)	.201 (p<.05)	.197 (p<.01)

Table 10

Graduated Sample Correlation Table with Pearson Correlation Coefficient (p-value)

	MOCA Delayed Recall	Trails A z score	Trails A Time	Trails B z score	Trails B Time	Number of Arrests
Time in Program	.725($p < .01$)	NS	-.600($p < .05$)	NS	NS	-.340($p < .05$)

Table 11

Graduated Sample Regression Table with R-Squared (p-value)

	MOCA Delayed Recall	Trails A z score	Trails A Time	Trails B z score	Trails B Time	Number of Arrests
Time in Program	.525(p<.01)	NS	.360(p<.05)	NS	NS	.115(p<.05)

Table 12

Terminated Sample Correlation Table with Pearson Correlation Coefficient (p-value)

	MOCA Delayed Recall (MC)	Trails A z score	Trails A Time	Trails B z score	Trails B Time	Alcohol Duration of Use
Time in Program	.604($p < .05$)	-.885($p < .01$)	.89($p < .01$)	NS	NS	.798($p < .05$)

Table 13

Terminated Sample Regression Table with R-Squared (p-value)

	MOCA Delayed Recall	Trails A z score	Trails A Time	Trails B z score	Trails B Time	Alcohol Duration of Use
Time in Program	.364(p<.05)	.782(p<.01)	.793(p<.01)	NS	NS	.637 (p<.05)

Table 14

Regression Table with Variables predicting Graduation Status with B (p-value)

	Work History	Number of Arrests	Trails B z score	Trails B Time	Time in the Program
Graduation Status	.218(p<.05)	-.103(p<.05)	-.496 (p<.05)	.048(p<.05)	.129 (p<.01)

Table 15

T-test Table with Variables predicting Graduation Status with T-statistic(p-value)

	Work History	Number of Arrests	Trails B z score	Trails B Time	Time in the Program
Graduation Status	.218(p<.05)	NS	NS	-.262(p<.05)	.-3.138 (p<.01)

Table 16

Summary of Neurocognitive effects of Different Classes of Substances

Drug	**Short-term Use** (not in introduction)	**Chronic use**	**Effects after abstinence**	**Population type**	**Age of participants**
Cannabis	- Attentional/executive function deficits (ex: decreased mental flexibility - Increased preservation and reduced learning) [62]	- Memory and attentional deficits [15] - Memory retrieval, verbal expression, and mathematical reasoning deficits [14]	-Verbal memory and inhibition deficits [61: 2 weeks]* - Little evidence for any long-lasting effects after abstinence [16: 5 weeks]	Polysubstance users	Adults, post-adolescence
Cocaine	- Small but significant cognitive dysfunction - Recreational users show stronger effects in attention while dependent users show stronger effects in working memory [63]	- Visuo-motor performance, attention, verbal memory, short-term/working memory, executive functioning deficits [17-20]	- Verbal learning and memory, attention, inhibition, cognitive flexibility, decision-making, psychomotor speed, manual dexterity impairments [21-27] - Conflicting claims on persistence of deficits over time periods of abstinence [28-29] - Executive control, visuospaital abilities, psychomotor speed, manual dexterity deficits [30-31]	Polysubstance users	Adults, post-adolescence
Alcohol	- excitation, reduced inhibition, slurred speech, increased reaction time, cognitive dysfunction (memory function deficits) [64]	- Attention, short-term memory, visuospatial abilities, executive function deficits [32]	- Dependent on length of abstinence: claims of improvements after 1 week – years of abstinence - General improved domains: working memory, visuospatial functioning, attention [10]	Polysubstance users	Adults
(Meth)amphetamine	- Improvements in visuospatial perception, attention, response speed, and inhibition [60]	- Immediate and delayed verbal memory tasks, immediate visual recall and delayed memory deficits [39-42] - Attentional control, planning, spatial working memory deficits [43]	- Memory and learning, psychomotor speed, and informational processing deficits [38: 4 -14 days] - Diminished cognitive planning, poorer immediate/delayed pattern recognition [44: >1 year] - Normalization of executive functioning [45: <1 year]	Polysubstance users	Adults
Opiate (i.e. heroin)	- attention, concentration, recall, visuospatial skill, psychomotor speed deficits [59]	- Planning and spatial working memory deficits [43] - Attention, concentration, visual & verbal recall, and visuo-spatial skill deficits [46] - Diminished executive functioning (ex: inhibition, cognitive flexibility) [10]	Abnormal executive functioning (lowered inhibition, verbal fluency, and decision-making skills) [22, 48, 49: 1-4 weeks]	Polysubstance users	Adults
Ecstasy (MDMA)	- Reduces verbal learning and memory ability in dose-dependent manner [58]	- Verbal learning and memory ability (i.e. variable reflecting learning, retention, recognition ability) impaired [58] - Better design fluency - MDMA impairments in short-term memory and more complex attentional functioning [2] - No relationship between MDMA consumption and executive functioning or attentional abilities [58]	- Verbal memory deficits, inconsistent reports of other executive functioning deficits [58] - Reversibility of deficits inconsistent [2]	Polysubstance users	Adults

*impairment found [reference: time of use/abstinence]

Figures

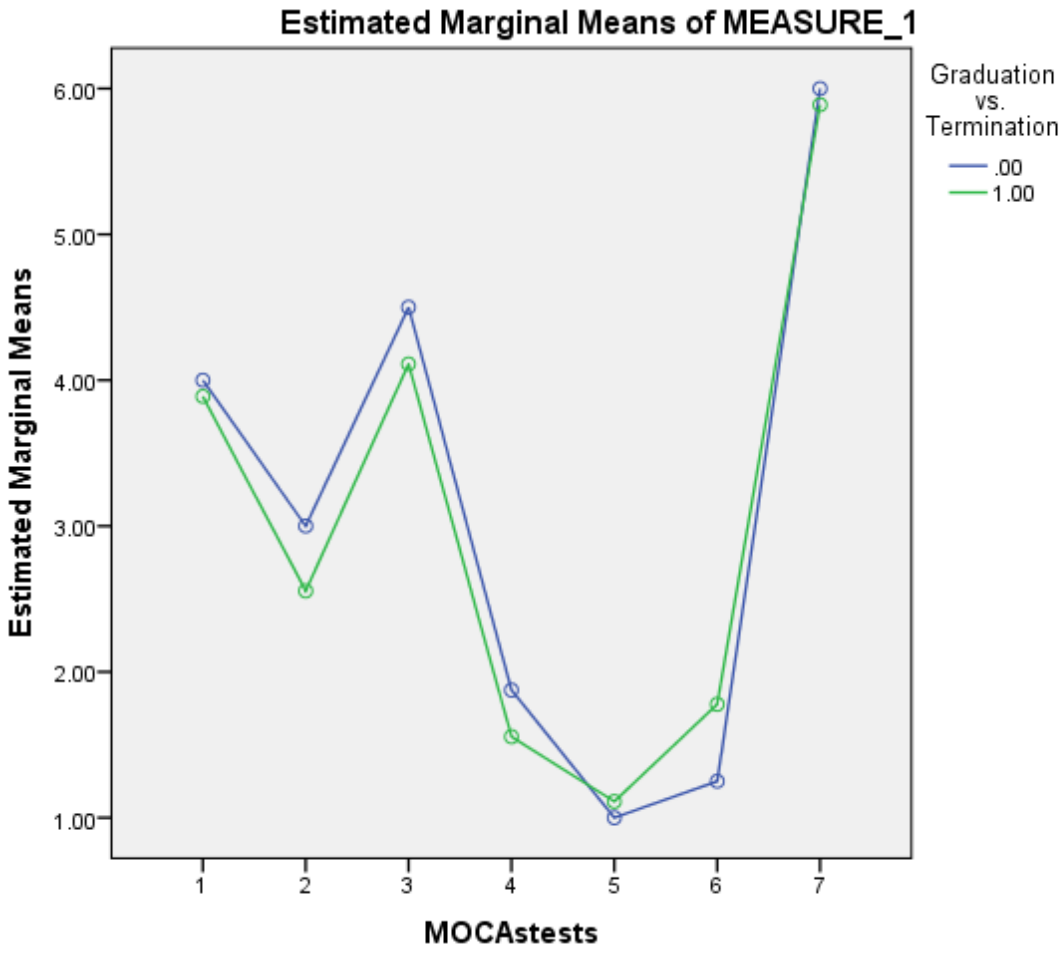

Figure 1. Comparison of MOCA subtest means between Terminated and Graduated Participants.