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An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
of the requirements of the degree of
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Abstract

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The issue of substance abuse in the United States continues to grow. Substance abuse has significant consequences for neuropsychological functioning. Specifically, chronic alcohol, marijuana, and cocaine use all impact the prefrontal cortex, which is implicated in executive functioning. Neuropsychological functioning speaks to the relationship between brain and behavior while executive functioning speaks specifically to higher-level processes such as decision-making, self-control, and planning. Drug courts (formally known as "accountability courts") have been gaining public and legal support as research has shown their efficacy in reducing crime and substance abuse. They are also reported to improve family relationships and increase employment rates. However, while research shows that neuropsychological functioning is implicated in outcomes of a drug court problem, current feedback from drug court administrators suggests that neuropsychological measures are not considered as a routine part of an evaluation. The main objective of this study aimed to establish a neuropsychological profile of individuals in the Fulton Country Accountability Court in Atlanta, Georgia. The second objective focused on predictor variables within neuropsychological variables in regards to drug court outcomes. The findings suggest that individuals in a drug court population show evidence of neuropsychological impairments compared to a normal control population. However, no significant neuropsychological predictor variables were found. Possible explanations as well as implications for future directions in neuropsychological assessments of individuals in a drug court population are discussed.

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Table of Contents

List of Figures

List of Tables

INTRODUCTION

The issue of substance abuse in the United States continues to grow with an 8.3% increase in the number of Americans using illicit drugs from 2002 to 2013 (National Institute of Drug Abuse, 2015). Drug courts (formally known as "accountability courts") have been gaining public and legal support due to their efficacy in reducing crime and substance abuse. These programs are also reported to improve family relationships and employment rates (Marlowe, 2010). More than half of the state prison and two-thirds of the local jail populations are diagnosed with substance abuse disorders (Center for Health and Justice at TASC & United States of America, 2013). Substance abuse is associated with significant impairments in psychological and behavioral functioning (Fernández-Serrano, Pérez-Garcia, & Verdejo-García, 2011), and substance abusers are therefore, likely to exhibit deficits in neuropsychological tests as well. Individuals enrolled in the Fulton County Accountability Court in Atlanta, Georgia, USA are defined as chronic substance abusers, with at least 10 years of alcohol, marijuana, and/or cocaine use. Therefore, it is important to model the neuropsychological impairments of these individuals based on psychometric measures and consider the possible relationship between performance on neuropsychological measures and outcomes in the drug court program.

In the following paper, I will first outline the neurobiology and social consequences of drugs of abuse followed by a review and discussion of the emergence and importance of drug courts. This discussion will be followed by a review of neuropsychological assessment and specifically executive functioning. Finally, I will attempt to relate neuropsychological functioning with indices of real-world functioning in the drug court population. The main hypothesis of this study is that the neuropsychological profile of individuals in the Fulton County Accountability Court in Atlanta, Georgia will show evidence of impairment in overall neuropsychological functioning, and especially in areas of executive functioning compared to a normal control population. The second hypothesis asserts that performance on neuropsychological measures among individuals enrolled in the Fulton County Accountability Court program will predict success or failure in the program.

Substance Abuse

The Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR[i]; see Appendix Endnote *i* for a list of abbreviations) diagnosis criteria of substance abuse[ii] are based on evidence of "impaired control, social impairment, risky use, and pharmacological criteria" ("Substance Use Disorders", 2015; see Appendix Endnote *ii*). The nonspecific term "substance" here refers to street drugs (illicit drugs used for its mood-altering, stimulant, or sedative effects), prescription drugs, alcohol, and tobacco. According to the National Institute on Drug Abuse (2015), illicit drug use in the United States has been increasing from 2002 to 2012. The increase is mostly due to recent rise in the use of marijuana, which is the most commonly used substance. Substance use usually begins before age 18 and more than 1 in 7 people (>16%) ages 12 and older have a substance problem (National Center on Addiction and Substance Abuse, 2014).

Neurobiology

In general, the development of substance abuse progresses from an initial stage in which a rewarding hedonic effect reinforces the use of substances, to a pathological stage in which there is heightened use, lack of inhibitory control in drug intake, and excessive drug seeking behaviors (Motzkin et al., 2014). Research suggests that addiction is linked to a failure of different components subserving executive functions involved in cognitive processes of "reward, pain, stress, emotion, habits, and decision-making" (George & Koob, 2010). For the purposes of this study, the effects of substances on the reward and control circuits will be the primary focus (**Figure 1**). Key components of these pathways are the ventral tegmental area (VTA), the NAc, and the frontal cortex, especially the PFC (**Figure 2**).

The VTA and NAc are implicated in the progression from the initial stage of reward reinforcement of drug use to the habitual and excessive drug seeking and drug taking behaviors (Everitt & Robbins, 2005). Research has found that relative to inmates without substance abuse disorders, those diagnosed with substance abuse disorders exhibit reduced connectivity between the NAc and brain regions involved in cognitive-behavioral control (dorsal anterior cingulate cortex, dorsolateral PFC, and frontal operculum) (Motzkin et al., 2014). The PFC (namely the dorsolateral PFC) has been linked to uncontrollable drug intake tendencies associated with the pathological progression of substance abuse (George & Koob, 2010).

Although substances all primarily directly or indirectly facilitate the release of dopamine (DA), a neurotransmitter produced in the VTA and NAc, they slightly differ in their mechanisms of action (Joffe et al., 2014). The mechanisms and effects of alcohol, marijuana, and cocaine are outlined below.

Alcohol (**Figure 3**)

Alcohol affects the brain in several ways by binding directly to the receptors for many neurotransmitters, including acetylcholine (ACh), serotonin (SE), gamma-Aminobutyric acid (GABA), and receptors for glutamate. It is proposed that alcohol leads to the disinhibition of GABA neurons, which in turn activates increased DA release from the VTA to the NAc (Spanagel, 2009). In addition, glutamatergic projections from PFC feed into both the VTA and NAc to induce DA release (Howland, Taepavarapruk, & Phillips, 2002; Omelchenko & Sesack, 2007). Evidence shows that the frontal lobes are especially vulnerable to changes in the brain caused by alcohol use (Oscar-Berman & Marinkovic, 2003). Chronic alcohol use results in significant impairments in many areas of executive functioning such as attention, short-term memory, visuospatial abilities, problem solving, mental flexibility, judgment, working memory, response inhibition, and decision-making (Holst & Schilt, 2011; Moselhy, Georgiou, & Kahn, 2001).

Marijuana (Cannabis) (**Figure 4**)

Tetrahydrocannabinoid (THC) is the main active ingredient in marijuana. THC binds to, and subsequently activates, specific receptors (cannabinoid receptors) that impact the release of GABA, glutamate, and DA neurotransmitters that are implicated in the reward pathways (Parsons & Hurd, 2015; Pertwee, 2008). An abundance of cannabinoid receptors in the PFC suggests that THC can alter neural transmission activity in this area. DA transmission in the PFC is increased by administration of cannabinoids. This leads to a reduction in GABA release, which then increases the excitatory glutamate transmission to the VTA (Egerton et al., 2006). In addition, marijuana intake causes alterations in cerebral blood flow and metabolism in the PFC (O'Leary et al., 2002). Research has shown deficits in memory (Bolla et al., 2002), attention (Rogers & Robbins, 2001), and decision-making and inhibitory control (Griffith-Lendering et al., 2012) with chronic marijuana use.

Cocaine (**Figure 5**)

Cocaine primarily acts on the reuptake of DA by binding to sites in areas of the brain that are rich in DA synapses, such as the VTA and the NAc (Nestler, 2005). An excessive amount of DA is associated with decreased dopamine receptors, which lead to the diminished sensitivity of the reward pathway (National Institute of Drug Abuse, 2010). In addition, chronic exposure of cocaine in rhesus monkeys has been hypothesized to regulate the expression of proteins related to functional abnormalities of dopamine signaling (McIntosh, Howell, & Hemby, 2013). Chronic cocaine abuse is associated with impairments in visuo-motor performance, attention, verbal memory, and abstract reasoning skills (Holst & Schilt, 2011; Rogers & Robbins, 2001). Research has shown more severe impairments in neuropsychological measures associated with executive control, visuospatial abilities, psychomotor speed, and manual dexterity in individuals with increased intensity and early onset of cocaine use (Bolla, Rothman & Cadet, 1999; Strickland et al., 1997; Rogers & Robbins, 2001).

Social consequences

As substance abuse continues to grow, there will inevitably be consequences for the society at large. Substance abuse is associated with and contributes to more than 70 other conditions requiring medical care as well, such as heart disease and stroke, pulmonary disease, pregnancy complications, and infectious diseases such as HIV and hepatitis. Increased substance use is also implicated in various mental health disorders such as depression, anxiety, post-traumatic stress disorder, bipolar disorder, schizophrenia, attention-deficit/hyperactivity disorder, conduct disorder, and eating disorder (Columbia, 2012). Substance abuse disorders and mental health problems also often co-occur in incarcerated individuals; around three-quarters of individuals in state prisons and local jails with mental health problems also have substance abuse disorders (Lincoln, 2015).

A big current issue in the United States is the gap between treatments that are needed and treatments that are actually provided. Although 8.6% of the population meet criteria for needing treatment for a substance related problem, only 0.9% of the population actually receive the necessary services. Similarly, 80%-85% of prisoners who meet criteria for substance abuse disorders and could benefit from treatment do not receive it (Chandler et al., 2009). To view this issue in financial terms, it is estimated that every year, federal, state, and local governments are spending close to $500 billion on addiction and substance abuse. However, according to the National Center on Addiction and Substance Abuse (2014) for every dollar that is spent, less than 2 cents goes to prevention and treatment. Research suggests that most of this spending is related to crime, unemployment, decreased work productivity, and healthcare (Goldstein & Volkow, 2002).

Although growing literature strongly suggests that drug treatment programs are effective, 57 percent of prisons and jails provide access to self-help programs whereas only 16 percent provide access to detoxification and treatment programs (McCarty & Chandler, 2009; Substance Abuse and Mental Health Services Administration, 2000; Travis, Western, & Redburn, 2014). Research shows that substance abuse and criminal behavior are closely related; some criminal behaviors result from a need to finance an individual's drug use (Håkansson & Berglund, 2012; Stewart et al., 2000). Structural and functional changes in the brain due to substance abuse can lead to deficits in self-regulation, which further perpetuates the cycle of addiction and abuse, and increases the likelihood for criminal behavior (Meijers, et al., 2015). Therefore, it is important to expand the understanding of the effects substance abuse has on neuropsychological functioning in a drug court population, from which successful intervention and prevention policies can arise.

Drug Courts

The "war on drugs" of the 1980s drastically increased incarceration rates, in which drug-related crimes accounted for over one-third of the overall increase in incarceration from 1985 to 1995 (Caulkins & Chandler, 2006). Increases in drug-related incarceration, the decrease in releases, and the re-incarceration for parole violation and recidivism contribute significantly to the overcrowding of prisons. In 2006, 40 out of 50 states were operating at 90 percent capacity or more (Justice Policy Institute, 2009). As a result, drug courts initially began as a part of a solution to the overcrowding of jails.

The first drug court was established in Florida in 1989. Since then, drug court programs have now taken on the role of treatment and rehabilitation for individuals with substance abuse disorders convicted of drug-related crime. As of 2012, there are 2,734 drug courts operating in every U.S. state and territory ("Drug Court History," n.d.). Drug Courts have five essential features:

> (a) the integration of alcohol and other drug treatment with judicial system case processing, (b) a non-adversarial courtroom approach, (c) random urine drug screens or other monitoring of abstinence, (d) judicial monitoring of a participant's progress via status hearings, and (e) a system of sanctions and rewards for program infractions and achievements.
> *Reproduced with permission from Wilson et al. (2006). Copyright 2006 Springer*

These judicially-supervised court curriculums have been shown to reduce more crime than any other program (Langan & Cunniff, 1992; Roman et al., 2003; US Government Accountability Office & United States of America, 2005), and the positive effects have been shown to last at least 3 to 14 years (Finigan et al., 2007; Gottfredson et al., 2005). In addition, meta-analyses of drug courts have found that the programs significantly reduce recidivism after the individuals graduate from the drug court program (Asos et al., 2006; Lattimer, 2006; Lowenkamp et al., 2005; Mitchell et al., 2012; Rempel, Green, & Kralstein, 2012; Shaffer, 2006; Wilson et al., 2006).

Requirements to graduate from the drug court program include successful attainment of a GED (if no high school diploma), sustained employment, financial stability, presence of a community sponsor, and community service hours (American University, 1998). In addition, one of the most important requirements to graduate from the drug court program is substance abstinence. In order for individuals to be abstinent from substance use, many must overcome their addictions. Research shows that addiction is a medical condition that can be classified as a brain disorder as its consequences are characterized by changes in cognitive, especially executive, functioning in the brain (Fernández-Serrano, Pérez-García, Río-Valle, & Verdejo-García, 2010; Goldstein and Volkow, 2002; Lubman, Yucel, & Pantelis, 2004).

Thus, it is important to consider cognitive changes in the brain when predicting outcomes for individuals in drug court programs. Current feedback from drug court administrators locally and in other geographic regions suggests that neuropsychological functioning measures are not considered as a routine part of an evaluation. Neuropsychological assessments can provide information such as deficits in certain areas of functioning that are linked to regions in the brain. This has implications for real-world functioning, as different regions of the brain are responsible for various areas of functioning in everyday life.

Neuropsychological assessments

Neuropsychological functioning is the broad term used to describe the relationship between brain functioning and behavior. The cognitive processes of the brain (i.e., mental functions) play a large role in neuropsychological functioning, especially through executive functions (Harvey, 2012). Neuropsychological assessments are designed to be sensitive to the effects of brain changes on an individual’s functioning and are concerned with identifying subsequent consequences of brain dysfunction in areas of cognitive, emotional, and behavioral functioning (Shum et al., 2015).

Substance abuse has neuropsychological consequences as it causes functional and structural changes in the brain, such as synaptic reorganization. This can lead to impairments in inhibition and planning (Joffe et al., 2014; Smith et al., 2014). Chronic use of alcohol, marijuana, and cocaine are all associated with deficits in attention and memory (see Appendix **Table 1** for outlined deficits in long- and short-term use as well as effects after abstinence, reproduced with permission from Lazarus, 2014). The PFC, which is implicated in the mechanisms of action for substances, plays a major role in inhibition control especially in its functions related to working memory and attentional control (Goldstein & Volkow, 2011). Research shows that individuals with substance abuse disorders do indeed have impairments in working memory and attentional control as demonstrated in their inability to ignore distractors on a task-switching test (Salo et al., 2005), as well as an attentional bias to drug-related cues (London et al., 2005).

Executive functions

Chronic substance abuse has been associated with impairments in neuropsychological functioning, and especially executive functions (Fernández-Serrano et al., 2011). Executive functions can be defined as higher-level cognitive functions that control and regulate lower-level cognitive processes as well as goal-directed, future-oriented behavior (Holst & Schilt, 2011). Components subserving executive functions include inhibition, switching, working memory, and sustained and selective attention (Alvarez & Emory, 2006). Executive functions are also defined as abilities of goal formation, planning, carrying out goal-directed plans, and effective performance, which are all necessary for socially appropriate and self-serving conduct (Jurado & Rosselli, 2007; Lezak, Howieson, & Loring, 2004).

Research suggests that performance on executive test measures reflect impairments in everyday life and are predictors of lack of insight (Burgess et al., 1998). Meta-analysis research shows that criminality is positively correlated with executive function deficits (Ogilvie et al., 2011). A recent systematic review shows that non-violent offenders are impaired in set-shifting, planning, working memory, inhibition, and problem-solving (Meijers et al., 2015). Research also suggests that executive functioning is significantly associated with employment status

(Kalechstein, Newton, & van Gorp, 2003). Employment is an important real-world functioning variable in the drug court program as employment is one of the requirements for graduation.

Neuropsychological impairments as a result of substance abuse are also associated with negative impacts on treatment participation, poorer clinical progression levels, and increased risk of relapse (Aharonovich et al., 2008; Aharonovich et al., 2006; Aharonovich, Nunes, & Hasin, 2003; Fals-Stewart & Lucente, 1994; Fernández-Serrano et al., 2010; Leber et al., 1985). Deficits in executive functioning play a major role in the treatment outcomes of substance abuse as impairment in domains of executive functioning is often implicated in a continuing pattern of substance abuse despite the negative outcomes (Bechara, 2005; Holst & Schilt, 2011).

The individuals in the drug court program involved in the current study have a history of chronic substance abuse, with at least 10 years of alcohol, marijuana, and/or cocaine use. Thus, this study aims to establish a psychometrically derived model of neuropsychological impairment in a drug court population. In addition, results of neuropsychological measures will be analyzed in order to determine possible variables with predictive value for success in the drug court program. The implications of this study include suggestions for further investigation of the relationship between neuropsychological functioning and drug court outcomes.

METHODS

Subjects

Fifty-six individuals enrolled in an Accountability Court (drug court) in Fulton County Atlanta, GA, USA were included in the study (42 male, 14 female) (**Figure 6)**. The age of the individuals ranged from 18 to 65 (M=41, SD=11.2). African-Americans made up the majority of the population (N=50) (**Figure 7**). The largest percentage of individuals in the population had less than 12 years of education (N=24) (**Figure 8**). Normal control population data was taken from previous research (Nasreddine et al., 2005; Ruffolo, Guilmette, & Willis, 2000).

Individuals convicted of drug-related crime in Atlanta, GA are given the option of incarceration or enrolling into the drug court program. The program is designed to be completed in a minimum of 18 months, and many individuals are enrolled for much longer (i.e., sample from the current study, M=29, SD=6.06). All individuals entering the program met criteria for an Axis I substance dependence diagnosis, which was confirmed through clinical interviews and examination of medical history. Cocaine was the most frequently used substance (N=40), followed by marijuana (N=32), then alcohol (N=28) (**Figure 9**). The frequencies do not add up to the total sample size (N=56), as most individuals were polysubstance users (N=41).

Measures

Interview and Mental Status Examination

Detailed account of past and present medical conditions, medication, psychiatric treatments, family, education, vocational, military, and social and substance use history was collected. A behavioral/mental status examination was completed as well.

Montreal Cognitive Assessment (MoCA)[iii] (see Appendix Endnote *iii*)

The MoCA is a brief screening tool for mild cognitive impairment and provides a swift indication of an individual's global cognitive state. The different domains are Visuospatial/Executive, Naming, Attention, Memory, Language, Abstraction, Delayed Recall, and Orientation. A score below 26 out of a maximum of 30 is indicative of mild cognitive impairment (MCI). MCI is typically referred to as cognitive dysfunction that does not significantly interfere with activities of daily living (ADL) and is often undetectable through standard mental status examinations. However, MCI is dangerous as it is indicative of cognitive decline beyond that of typical aging and many times a precursor to Alzheimer's disease (Peterson, 2011). The MoCA has been shown to have good construct related validity and has been proved to be an appropriate measure for cognitive screening (Freitas et al., 2012; Miller et al., 2014). Research has also shown the MoCA to be an efficient method of identifying individuals with substance abuse disorder who show neuropsychological impairments. This allows for increased certainty in targeting individuals who might need specialized interventions (Copersino et al., 2009). Subsequent research also shows that the MoCA has predictive value in clinically relevant behavior (i.e, perfect attendance of treatment programs) among individuals with substance abuse disorders (Copersino et al., 2012).

The MoCA covers a broad area of cognitive functioning including short-term memory, executive functions, visuospatial abilities, language, attention, concentration, working memory, and temporal and spatial orientation. The current study is focused on executive functioning measures, and because the MoCA total score is a measure of global cognitive functioning and goes beyond executive functioning, the following subtests with implications in executive functioning were considered: Modified trail making test, Clock drawing, Digit span, Letter A tapping, Serial 7 subtraction, Sentence repetition, Fluency, and Abstraction.

Brief justifications for each subtest are provided below (Julayanont et al., 2013):

1. Modified trail making test (TMT): the Modified TMT is a shortened version of the Trail Making Test-B (TMT-B). Mental flexibility to shift between numbers and letters is required for successful completion of TMT-B. Mental flexibility is an executive function that relies mainly on frontal lobe function.
2. Cube copy: To copy a cube, individuals must engage in spatial planning as well as visuomotor coordination which activates the frontal lobe.

3. Clock drawing: The executive functioning tasks required by the Clock drawing test include planning, conceptualization, symbolic representation, and inhibition.
4. Digit span: Digit span consists of the Digit Span Forward (DSF) and the Digit Span Backward (DSB). DSB especially requires executive functions, as it is a more demanding task of transforming digits into a reversed order before articulating. The DSB has also been shown to be associated with greater levels of activation in the prefrontal cortex, as it requires working memory.
5. Letter A tapping test: This test has good sensitivity to cognitive impairment in mild traumatic brain injury, which also impacts executive functioning. It requires sustained and focused attention as well as inhibition of a response to inappropriate stimuli.
6. Serial 7 subtractions: This task requires individuals to subtract 7 from 100 and continue subtracting 7 from the subsequent number. As with the digit span task, serial 7 subtractions also require working memory.
7. Sentence repetition: Repeating complex sentences requires attention and concentration, which are subserved by the working memory systems in the frontal lobes.
8. Fluency: Verbal fluency requires executive functioning from the frontal lobes including word generation, working memory, searching strategy and inhibition of irrelevant words.
9. Abstraction: Frontal executive function is implicated in this task, as semantic knowledge and conceptual thinking are required for successful completion.

Trail Making Test (TMT) A & B[iv] (see Appendix Endnote *iv*)

The TMT is thought to measure cognitive functioning in areas of processing speed, sequencing, mental flexibility, and visual-motor skills. TMT-A tests visual search/scanning and motor speed skills whereas TMT-B tests higher-level cognitive skills, for example mental flexibility and working memory (Bowie & Harvey, 2006; Sánchez-Cubillo et al., 2009). Longer TMT-A and TMT-B times indicate increased impairment. Research also shows that the TMT Difference score (B-A) as well as the TMT Ratio score (B/A) can provide a relatively pure indicator of executive control abilities as it minimizes the visuoperceptual and working memory demands (Sánchez-Cubillo et al., 2009; Horton & Roberts, 2001). Larger TMT Difference scores and TMT Ratio scores indicate increased impairment.

Kaufman-Brief Intelligence Test II (KBIT-II)

The K-BIT-II is a brief intelligence test 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 (Full), Verbal, and Performance IQ scores are derived (Kaufman & Kaufman, 2004)

Wide Range Achievement Test-Revision 4 (WRAT4)

The WRAT4 is administered to estimate academic skills namely word reading, sentence comprehension, spelling, and math computation (Wilkinson & Robertson, 2006).

Drug court outcome measures

Graduation status and the length of time an individual was enrolled in the program were used as outcome variables. Graduation status refers to whether an individual graduated from the program or was terminated. The length of time an individual was enrolled in the program is measured in months and it refers to the time it took for an individual to graduate or be terminated from the program.

Procedure

Data collection

A detailed account of past and present medical conditions, medication, psychiatric treatments, family, education, vocational, military, and social and drug history was collected prior to assessments. A complete mental status examination, the Beck Depression Inventory (BDI-II), as well as the assessments discussed above were administered. The combination of psychological and neuropsychological assessments was essentially a screening battery designed to fit within the program constraints of time and participant availability.

Statistics

Values for all applicable variables were explored and outliers for each variable were filtered out individually. Variables on a continuous scale were described using their number, mean, and standard deviation. These values were compared using independent samples t-tests to test for significance when necessary. Variables on a categorical scale were described using their number, frequencies, and percentiles. These values were compared to continuous values using multiple logistic regression models when necessary. All analyses were performed using SPSS software V23.0. Figures and tables were made using Microsoft Excel.

RESULTS[1] (see Appendix **Table 2** for Cohen's d effect size criteria)

Hypothesis 1: *The neuropsychological profile of individuals in the Fulton County Accountability Court in Atlanta, Georgia will show evidence of impairment in overall neuropsychological functioning, and especially in areas of executive functioning compared to a normal control population.*

1.1 Montreal Cognitive Assessment: subtest scores

Independent samples t-tests were conducted to compare the means of the MoCA subtests between the study population and a control population (Nasreddine et al., 2005; see Appendix

[1] Sample population refers to the population being studied in the current research

Table 3 for a comparison of demographics between the two populations). The following subtests were **significant**: 1) Cube copy; $t(76.4)= -3.21$, $p <.001$, d= 0.61; 2) Serial 7 subtraction; $t(48.4)= -3.09$, $p <.002$, d= 0.74; 3) Sentence repetition; $t(52.4)= -5.75$, $p <.001$, d= 1.32; and 4) Abstraction; $t(58.8)= -5.12$, $p <.001$, d= 1.48. The means between the sample group and the control group for the following were **not significant**: Modified trail making test, Clock drawing, Digit span, Letter A tapping, and Fluency were not significant ($p > .05$) (see **Table 4** below).

MoCA Subtest	Mean Sample	SD Sample	Mean Control[1]	SD Control[1]	t-value	Cohen's d
Total	24.7	3.7	27.4	2.2	-4.49**	0.97
Modified TMT	0.88	0.33	0.87	0.34	0.16	0.03
Cube copy	0.42	0.5	0.71	0.46	-3.21**	0.61
Clock	2.72	0.5	2.56	0.65	1.56	0.26
Digit span	1.7	0.56	1.82	0.44	-1.24	0.25
Letter A	0.91	0.29	0.97	0.18	-1.25	0.27
Serial 7	2.4	1	2.89	0.41	-3.09*	0.74
Sentence rep	1.16	0.72	1.83	0.37	-5.75**	1.32
Fluency	0.77	0.43	0.87	0.34	-1.34	0.27
Abstraction	1.22	0.37	1.83	0.43	-5.12**	1.48

***p <.001; *p <.002*

Table 4. Significant differences in mean MoCA subtest scores compared to a control population
[1]Mean Control and SD Control data taken from Nasreddine et al. (2005).

1.2: Montreal Cognitive Assessment: total score

Within the sample of the current study itself, 51.1% of the population fell below the suggested cutoff value of 26 and into the Mild Cognitive Impairment range. An independent samples t-test showed a significant difference between the means of MoCA total scores in the group scoring below 26 (M=21.7, SD=2.7) and the group scoring 26 or above (M=27.8, SD=1.4); $t(33.8)= -9.36$, $p < .001$, d= -3.22 (**Figure 10**). An independent samples t-test comparing the means of the MoCA total scores between the Fulton County Drug Court population (M=24.7, SD=3.7) and a Control population (M=27.4, SD=2.2) (Nasreddine et al., 2005) also showed a significant difference; $t(59.2)= -4.49$, $p < .001$, d= 0.97.

1.2: Trail Making Test: times, difference, ratio

An independent samples t-test comparing the means of the TMT B time between the Fulton County Drug Court population (M=73.5, SD=38.1) and a Control population (M=57.2, SD=17.2) (Ruffolo et al., 2000; see Appendix **Table 3** for a comparison of demographics between the two populations) showed a significant difference; $t(49.8)= 2.48$, $p < .02$, d= .57. An independent samples t-test also showed a significant difference between the TMT Difference of TMT-A and TMT-B means (i.e. mean TMT-B time - mean TMT-A time) in the sample population (M=49.3, SD= 6.24) versus a control population (M=30.6, SD=2.70) (Ruffolo et al., 2000); $t(47.2)= 17.3$, $p <.001$, d= 4.07. The TMT Ratio of TMT-A and TMT-B means (i.e. mean TMT-B time/mean TMT-A time) between sample group and the control group was also significantly different; $t(81.9)= 2.60$, $p < .02$, d= 0.56 (see **Table 5** below).

TMT	Mean Sample	SD Sample	Mean Control[1]	SD Control[1]	t-value	Cohen's d
A	24.2	8.32	26.6	7.9	-1.36	0.30
B	73.5	38.1	57.2	17.2	2.48*	0.57
Difference	49.3	6.24	30.6	2.7	17.3**	4.07
Ratio	2.64	0.84	2.15	0.91	2.60*	0.56

***p <.001;*p <.02*

Table 5. Significant differences in mean TMT scores compared to a control population

[1]Mean Control and SD Control data taken from Ruffolo et al. (2000).

Hypothesis 2: *Performance on neuropsychological measures among individuals enrolled in the Fulton County Accountability Court program will predict success or failure in the program.*

2.1: Outcome measure 1: Status (Graduation vs. Termination)

2.1.1: Montreal Cognitive Assessment (total, subtests)

Independent sample t-tests were first conducted to determine any significant differences in the mean values of variables in the Graduated group versus the Terminated group. There were no significant differences in the means of the MoCA Total and subtest scores between the Graduated versus the Terminated groups (p > .05) (**Figure 11, Figure 12**). Logistic regression analyses were then conducted to determine possible predictor variables for an individual's status (Graduated vs. Terminated). The logistic regression model revealed that the MoCA subtests as well as the MoCA Total score did not significantly predict an increased probability of an individual graduating from the program versus being terminated (p > .05).

2.1.2: Trail Making Test (time, difference, ratio)

Independent samples t-test analysis revealed that the mean TMT Difference in the Graduated group (M=66.4, SD=44.4) compared to the mean TMT Difference in the Terminated group (M=36.4, SD=24.1) was significantly higher; $t(26)$= -2.23, p <.05, d= 0.79. Independent samples t-test analysis also revealed that the mean TMT Ratio in the Graduated group (M=4.13, SD=2.63) compared to the mean TMT Difference in the Terminated group (M=2.55, SD=0.88) was also significantly higher; $t(15.9)$= -2.13, p <.05, d= 0.73 (see **Table 6** below). However, the p-values for these analyses were relatively close to the p < .05 level of significance (p=.035 and p= .049, respectively). In addition, subsequent logistic regression models revealed that neither TMT Difference nor TMT Ratio significantly predicted an individual's status in the drug court program (p= .136 and p= .369, respectively).

TMT	Mean Graduated	SD Graduated	Mean Terminated	SD Terminated	t-value	Cohen's d
Difference	66.4	44.4	36.4	24.1	-2.23*	0.79
Ratio	4.13	2.63	2.55	0.88	-2.13*	0.73

*$p < .05$

Table 6. Significant differences in mean TMT scores in Graduated versus Terminated group.

2.2: Outcome measure 2: Length (Months in program)

Correlation analyses were first conducted to determine any relationships between the neuropsychological measures and an individual's length of time spent in the program. Linear regression analyses were then conducted to determine possible predictor variables for the length of time (in months) an individual was enrolled in the drug court program. Correlation analyses revealed no significant correlations between the MoCA Total and subtest scores as well as the TMT measures ($p > .05$). The linear regression models revealed that the MoCA subtests, MoCA total, and TMT measures did not significantly predict the length of time an individual was enrolled in the drug court program ($p > .05$).

Supplemental analyses

Age

An independent samples t-test revealed a significant difference between the mean Age of individuals who graduated from the program (M=43.7, SD=10.5) versus individuals who were terminated (M=34.4, SD=10.0); $t(38)= -2.76$, $p < .01$, d= 0.90 (**Figure 13**). A subsequent logistic regression model was statistically significant, ($\boldsymbol{X}^2(1)= 7.16$, $p <.01$). The model explained 22.4% (Nagelkerke R^2) of the variance in Age. Individuals who graduated from the program were significantly older than individuals who were terminated.

Intelligence and Academic functioning measures

Average performance indicates a percentile rank (PR) falling within 25 to 75. Mean analysis showed that on measures of Intelligence, the means for the KBIT-II Full percentile (PR=26.9) and Performance percentile (PR=33.2) were in the Average range, while the Verbal percentile (PR=22.8) fell Below Average. On measures of Academic functioning, only the mean for WRAT4 Word reading percentile (PR=29.2) was in the Average range, while the WRAT4 Sentence percentile (PR= 3.9) and WRAT4 Math percentile (P =15.9) all fell in the Below Average range (**Figure 14**).

Frequency analysis showed that the largest percentage of the sample had less than 12 years of education (44.4%), while 12 years of education or a GED made up the next largest percentage (37.0%), with more than 12 years of education making up the smallest percentage of the sample (18.6%) (**Figure 7**).

DISCUSSION

This study was centered around developing a psychometrically derived model of neuropsychological impairments in a drug court population based off the existing literature that chronic substance abuse has serious consequences on neuropsychological functioning. Specifically, this study is focused on the population of individuals in the Fulton County Drug Court in Atlanta, Georgia, U.S.A. According to the Superior Court of Fulton County, their mission statement is:

> To provide a court supervised alternative sentencing program to those offenders who suffer substance abuse issues. Furthermore, the court will reduce recidivism, crime occurrence, reduce the cost to the community, and improve the quality of life for those participating. The court is committed to returning participants to the community as model citizens.
> *Source: "Drug and Mental Health Accountability Courts" (n.d.). Permission not required*

It is important to be able to predict the outcomes of a certain individual in the drug court program, for it can provide more insight as to which areas should be focused on in order to increase success in the drug courts. Evidence of neuropsychological impairments can provide suggested areas for intervention that can help improve an individual's chance for success in the drug court program.

Neuropsychological Measures

Much research has already been done linking increased substance abuse to impaired neuropsychological functioning. However, the uniqueness of a drug court population, in that the individuals are not only substance abusers but exhibit criminal behavior as well, provides a need to develop a psychometrically derived neuropsychological profile of this population. Research shows that criminal behavior is related to a range of deficits in executive functioning, including inhibition, cognitive flexibility, and the ability to predict future consequences, which in turn contribute to deficits in poor behavioral self-regulation, social skills, and judgment (Ross & Hoaken, 2011). Biosocial criminology is a paradigm that approaches the understanding of criminal behavior through the interaction of biological aspects of humans and the social and cultural environments they are in (Walsh & Beaver, 2009). The possible relationships between criminal behavior, neuropsychological functioning, and pre-morbid factors can be generally modeled using a triangular schema (see **Figure 15** below).

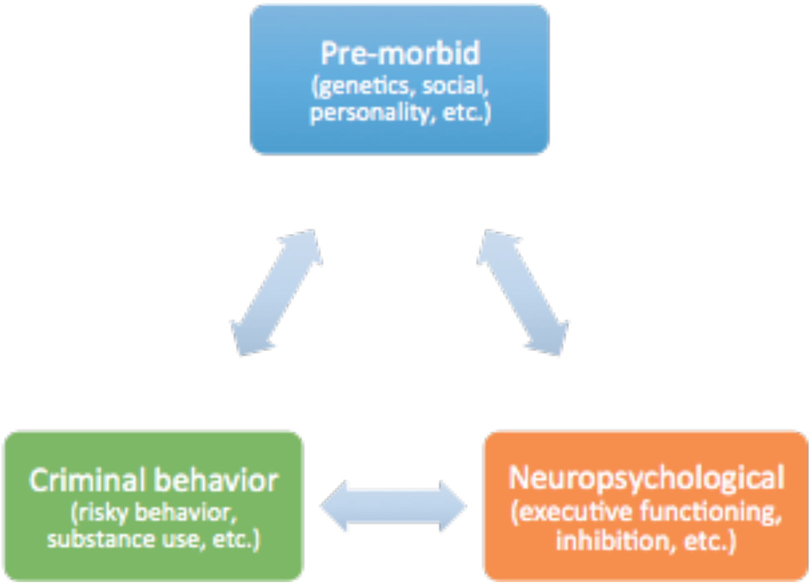

Figure 15. Triangular schema of relationship between criminal behavior, neuropsychological functioning, and pre-morbid factors.

A recent study on the neuropsychological consequences of chronic drug abuse argued that the identification of individuals with cognitive deficits is necessary for long-term treatment of substance abuse disorders (Cadet & Bisagno, 2015). Research also shows an inverse correlation between PFC activation and length of treatment retention (Brewer et al., 2008). Cade and Bisagno (2015) argue for the administration of thorough neuropsychological and neuroimaging assessments in order to identify a subset of drug abusers who exhibit impaired learning and memory functions. This impairment can have negative impacts on the ability to benefit from a general treatment plan, thus suggesting a need for alternative treatment options.

Hypothesis 1: *The neuropsychological profile of individuals in the Fulton County Accountability Court in Atlanta, Georgia will show evidence of impairment in overall neuropsychological functioning, and especially in areas of executive functioning compared to a normal control population.*

Hypothesis 1 was supported; the results indicate increased impairment in areas of executive functioning in a drug court population compared to a normal control population.

Montreal Cognitive Assessment (MoCA): interpretation and neural correlates

A study on the construct validity of the MoCA provided evidence of the multifactorial nature of the MoCA, suggesting that the MoCA measures more than just global cognitive ability (using the total score). This supports the idea that the subtests of the MoCA reflect different and specific aspects of cognitive functioning and thus provides an empirical rationale in investigating the subtests of the MoCA implicated in executive functioning (Freitas et al., 2012). Compared to the average subtest scores of a control population (Nasreddine et al., 2005), the sample population had significantly lower average scores on the following: Cube copy, Serial 7 subtraction, Sentence repetition, and Abstraction.

Successful completion of the Cube copy requires that an individual copy a cube accurately (i.e., facing the same direction, relatively parallel lines, no additional lines, etc.). Impairments in the Cube copy task suggest impairments in executive functions related to planning. The Cube copy incorporates various functions in different areas of the brain, including visual perception in the parieto-occipital lobe and planning in the frontal lobe (Julayanont et al., 2013).

The Serial 7 subtraction task requires calculation skills in order to be completed successfully. Calculation speaks to an essential part of everyday social living and functioning. Impairment on this task suggests impairments in working memory. Functional magnetic resonance imaging (fMRI) studies show that the bilateral premotor, the posterior parietal, and the prefrontal cortices show greater activation when engaging in this task (Julayanont et al., 2013).

Sentence repetition assesses language skills as well as attention and concentration supported by the working memory systems in the frontal lobes. Impairment on this task also suggests impairments in working memory. The left temporo-parietal-frontal circuit supports the necessary language skills implicated in sentence repetition (Julayanont et al., 2013).

Successful completion of the Abstraction tasks involves semantic knowledge and conceptual thinking. Impairment in this area suggests impairment in conceptual thinking. PET imaging shows greater activation of frontal and parieto-temporal regions of the brain during an abstraction task (Julayanont et al., 2013).

The MoCA subtests discussed above are implicated specifically in executive function measures of neuropsychological functioning. The MoCA total score is indicative of global cognitive functioning. Lezak et al. (2004) explains the distinction between executive functions and cognitive processes in the following way: " executive functions ask how or whether a person goes about doing something… questions about cognitive functions are generally phrased in terms of what or how much". Executive functions also have effects that spread to all cognitive processes, thus impairments in executive functioning can result in dysfunctional cognitive processes. On the other hand, if an individual experiences significant impairment in cognitive functions, they can still continue to be "independent, constructively self-serving, and productive" as long as the executive functions are intact (Lezak et al., 2004). Thus it can be argued that while cognitive functions are important, executive functions are vital for normative functioning.

More than half of the sample population fell in the MCI range based on the MoCA total score with a cutoff point at below 26 out of 30 possible points. The sample population also had a significantly lower average MoCA total score than a control population (Nasreddine et al., 2005).

These results indicate neuropsychological functioning impairments seen in the current population on the level of global cognitive functioning as well.

Trail Making Test (TMT): interpretation and neural correlates

The TMT is believed to measure certain cognitive domains such as processing speed, sequencing, mental flexibility, and visual-motor skills (Bowie & Harvey, 2006). TMT-B times as well as the TMT Difference scores and Ratio scores have been shown to be good indicators of executive functioning (Sánchez-Cubillo et al., 2009). The current population exhibited significantly higher TMT-B times, TMT Difference scores, and TMT Ratio scores compared to a control population (Ruffolo et al., 2000). This suggests impairment in a drug court population compared to a normal population on executive functioning skills such as mental flexibility, set-shifting, and working memory. Research suggests that the set-shifting component of TMT-B activates the left dorsolateral PFC and the supplementary motor area/cingulate sulcus, which are areas of the brain sensitive to cognitive flexibility (Moll et al., 2002).

Substance abuse: neural correlates

Accurate completion of the MoCA as well as the TMT all seem to involve activation of the frontal lobe of the brain, especially the PFC. The PFC plays a role in decision making and inhibitory control, thus deficits in this area can lead to disruptions in self-monitoring and decision-making processes. It is proposed that deficits in the PFC could lead to impairments in self-directed behavior and favor automatic sensory-driven behavior (Motzkin et al., 2014). The PFC is positioned to further process and to modify information that has already been processed at lower levels. Thus, the PFC is implicated in mediating executive functions, as executive functions require higher-level cognitive functioning involved in controlling lower-level processes (Royall et al., 2002).

Alcohol, marijuana, and cocaine use also affects the PFC through the reward pathways. Thus substance abuse leads to deficits in the PFC, which is also implicated in executive functions. Preliminary studies found that chronic administration of cocaine in rats leads to significant changes in synaptic connectivity in the PFC that can lead to changes in decision-making, judgment, and cognitive control (Robinson et al., 2001). Substance abuse is also associated in reductions in dorsolateral PFC activity, and studies have shown that deficits in the dorsolateral PFC impairs planning, hypothesis generation, and behavioral control (Chanraud et al., 2007; Royall et al., 2002).

Chronic alcohol use is associated with deficits in verbal fluency and decision-making, as well as working memory (Fernández-Serrano et al., 2010). A structural magnetic resonance study has shown significant reductions of grey matter in the bilateral dorsolateral PFC of alcoholics (Chanraud et al., 2007), and PET studies have shown reduced dorsolateral prefrontal activity (Dao-Castellana et al., 1998).

Chronic marijuana use is associated with deficits in memory, attention, decision-making, and psychomotor speed (Cadet & Bisagno, 2015). FMRI studies also show that chronic marijuana use in adults is associated with a decrease in PFC activation (Block et al., 2002; Hester et al., 2009; Wesley et al., 2011).

Chronic cocaine use is associated with impairments in decision-making, visual perception, psychomotor speed, and memory functions as well as increased impulsivity and poor verbal learning. Insight and judgment, foresight, and disinhibition, which are functions of the PFC, are also impaired in chronic cocaine users. FMRI studies show a decrease in PFC activation in both adult chronic and abstinent cocaine users (Barrós-Loscertales et al., 2011;

Camchong et al., 2011; Kübler et al., 2005; Moeller et al., 2010; Preller et al., 2014; Volkow et al., 2011).

'Chronic' use in the current study

One limitation of the use of the term 'chronic' is that many studies have different definitions as to what 'chronic use' entails. In the current study, all individuals were considered chronic substance users; Alcohol use, in years (M=13.2, SD=9.4); Marijuana use, in years (M=23, SD=10.8); Cocaine use, in years (M=17.2, SD=9.3). Most individuals were polysubstance users. Only 1 individual had been addicted to *just* alcohol (i.e. did not use any other drugs), only 6 individuals had been addicted to *just* marijuana, and another 6 were addicted to *just* cocaine. Some individuals had used a variety of drugs for a relatively short amount of time, but usually had a drug of choice they were addicted to.

Hypothesis 2: *Performance on neuropsychological measures among individuals enrolled in the Fulton County Accountability Court program will predict success or failure in the program.*

Hypothesis 2 was not supported; the results suggest that the current neuropsychological measures are not sufficient to predict outcomes of individuals in the drug court.

Trail Making Test (TMT): limited predictive value

Independent samples t-test analyses showed significantly different means of TMT scores in individuals who Graduated from the program versus those who were Terminated. However, subsequent logistic regression models did not significantly predict a relationship between the means of the two groups for both TMT Difference scores and TMT Ratio scores. A possible explanation is that the sample size is too small to find a significant relationship through logistic regression models (N=56, including the outliers). Another explanation is that the TMT could actually be a screening tool for cognitive impairment in individuals with substance abuse disorders. Robert and Horton (2001) evaluated the TMT as a screening tool for identifying cognitive impairments in a drug abuse treatment population and found that most individuals, regardless of the type of drug abused, performed within normal limits relative to commonly accepted cutoff scores on both TMT-A and TMT-B.

The "direction" of the finding from the current study is also surprising in that individuals in the Graduated group had larger TMT Difference and TMT Ratio scores than individuals in the Terminated group. As research suggests that smaller TMT Difference scores are a good indicator of increased executive control abilities, a larger difference in the TMT-B and TMT-A times in the Graduated group versus the Terminated group is surprising. Possible explanations come from a previous pilot study done within individuals in the same Fulton County Accountability Court (Lazarus, 2014). This pilot study found that increased TMT-B times (thus decreased performance) were significantly correlated with whether an individual Graduated or was Terminated from the drug court program. One explanation provided by this pilot study is that among those in the Terminated group, those performing better on the TMT-B (i.e., lower times) were more likely to become employed and thus subsequently failed to attend classes or drug screenings, resulting in termination.

An exit interview of graduates from drug court programs revealed that many individuals felt a big conflict between the number of meetings they had to attend and the program requirement of employment (Wolfer, 2006). This finding provides qualitative support for the explanation of better TMT-B performance in the Terminated group (as discussed by Lazarus, 2014). Shorter TMT-B times (thus increased performance) are indicative of increased executive functioning, thus increasing the odds of an individual becoming employed. Once employed, individuals might find it too difficult to continue attending all the meetings required by the drug court and do not go, resulting in their termination from the program. This explanation was partly supported by the finding in the pilot study that some means of the MoCA subtests were higher in the Terminated group compared to the Graduated group (though not statistically significant). This finding is also supported in the current study in which the Terminated group shows higher mean scores on the Modified TMT, Clock drawing, Serial 7 subtraction, Sentence repetition, and Letter fluency subtests of the MoCA (**Figure 12**).

Another possible explanation is that individuals in the Graduated group took longer on the TMT-B, not because they were impaired, but because they were being more cautious as to not make a mistake. However, this possibility is ruled out when the differences in the mean amount of errors each group made on the TMT-B are explored. Mean analysis found that individuals in the Graduated group actually exhibited a greater number of errors (M=1.45, SD=1.27) compared to individuals in the Terminated group (M=0.71, SD=0.99) (although independent samples t-test analysis was not statistically significant $p > .05$). This finding warrants further exploration into the idea proposed by Robert and Horton (2001) that the TMT could be used as a screening tool for cognitive impairments in a population of substance abusers.

Outcome measures: limitations and need for follow-up measures

A major possibility as to the non-predictive value of neuropsychological measures on drug court outcomes may be that the two outcome measures studied, status (Graduation vs. Terminated) and length of time in the program, are not adequate and/or appropriate correlates to reflect the relationship between neuropsychological functioning and real-world functioning. While there are many studies that examine recidivism and relapse rates for individuals who successfully graduate from drug court programs, it seems that there are no studies that focus on recidivism and relapse rates for individuals who did not successfully graduate. While an individual might graduate from the drug court program, it does not eliminate the possibility that those individuals may relapse to using drugs and are just not getting caught (Wolfer, 2006). This poses a problem in looking for biased outcomes in individuals who graduated from the program.

Another important factor when assessing individuals' outcomes from a drug court program is the structured environment a drug court provides. Graduates, in hindsight, admit that the structured programs forced them to make changes and were beneficial to their long-term abstinence (Wolfer, 2006). Research shows that individuals returning to a more disadvantaged neighborhood recidivate at a greater rate (Kubrin & Stewart, 2006). This means that even if an individual graduates from the program, returning to a disadvantaged neighborhood or to a place with minimal structure increases the likelihood of recidivism.

Supplementary analyses: implications for real-world functioning variables

In the current study, age was positively correlated with whether an individual graduates from the program or not. Research suggests that as offenders age, they are less likely to relapse and recidivate than younger offenders (Logan et al., 2000). Younger offenders are also more likely to "drop out" or fail drug court programs (Saum, Scarpitti, & Robbins, 2001). As research suggests that age is an important factor in drug court outcomes, the relationship between age and drug court outcomes should continue to be explored.

Examination of intelligence and achievement measures in the current study found that individuals perform in the below to low average range compared to a normal population. More than 80% of the population has less than or equal to 12 years of education. The current literature on the relationship between education and drug court outcomes are inconsistent, thus is it also important to further explore these related areas (Wolfer, 2006).

Another study found that additional charges prior to drug court intake (i.e., number of arrests in the current study) were significantly related to termination from the program (Hickert, Boyle, & Tollefson, 2009). The number of terminated individuals in the mentioned study was 155 compared to 15 terminated individuals in the current study. As this study is ongoing, it is important to continue examining these real-world functioning variables as research done with larger sample sizes suggests that variables such as age, race/ethnicity, education, and work history do predict outcomes in drug court programs (Butzin, Saum, & Scarpitti, 2009; Kalechstein et al., 2003).

Future Directions

Social/demographic factors

The current population in the study was composed of mostly males (75%, **Figure 6**) and African-Americans (90.9%, **Figure 7**). Although research on the relationship between gender and outcomes in drug court programs are inconclusive, it is important to consider the differences between males and females in drug courts as some studies have found that multiple problems and barriers are more evident in drug-using female offenders compared to male offenders (Butzin et al., 2002).

Studies have also found that nonwhite participants were less successful in drug court programs than white participants (Brewster, 2001; Schiff & Terry, 1997; Sechrest & Shichor, 2001). Although both gender and ethnicity were not significantly correlated with drug court outcomes in the current study, these research findings suggest a need for further exploration. It is also important to consider that sociodemographic factors are often highly correlated (Butzin et al., 2002).

Social variables, such as stereotypes, can also play a role in drug court outcomes. Studies show that although African-Americans and non-Hispanic whites have the same likelihood of using or selling drugs, African-Americans are more likely to be arrested for drug-related crimes (Beckett et al., 2005; Kakade et al., 2012). In addition, a very recent study conducted this year found that contrary to stereotypes, African-Americans had the lowest prevalence of drug-use disorders (Welty et al., 2016). These findings suggest that it is important to consider these variables when investigating drug court outcomes in a certain population.

Personality

Research has shown that the Big Five personality traits (i.e., extraversion, agreeableness, openness, conscientiousness and neuroticism) are correlated differentially with the use of marijuana, pain medication, sedative/hypnotics, and/or stimulants (Gonzalez, 2013). Sher and Bartholow (2000) found that impulsive sensation-seeking or behavioral disinhibition traits were the best predictors of a substance abuse disorder diagnosis. Impulsivity traits were also related to executive functioning deficits (Dolan, Bechara, & Nathan, 2008).

Genetics

In the current study, the variables considered in individuals in drug courts are mostly environmental factors. However, genetics also play a large role in predisposing certain individuals to substance dependence and addiction (Hiroi & Agatsuma, 2005). Genetic variation in individuals is also a fundamental element of complex personality and physiological traits, including impulsivity, risk taking, and stress responsivity (Kreek et al., 2005). This ongoing study is in the preliminary stages of collecting saliva samples to measure cortisol levels in individuals enrolled in the Fulton County Accountability Court.

Limitations and Strengths

The current study's small sample size is one of the limitations of this study. As this study is ongoing, the neuropsychological profile of individuals in the Fulton County Accountability Court will continue to be analyzed and updated. Another big limitation is the lack of a control group. The normative data used from previous research (i.e., Nasreddine et al., 2005; Ruffolo et al., 2000) exhibit variance in the demographic variables of the control population. This has implications for the current study as demographic variables can play a role in scores on the MoCA (Freitas et al., 2012) and TMT (Hester et al., 2005).

In the future, it would be beneficial to collect data on a control population with similar demographics to compare with the drug court population. As this is an ongoing study, the results from the current study can serve as important pilot data in assessing the different variables related to individuals in a drug court program, and thus have implications for future development of plans and policies within drug court programs in treating substance abuse and criminal behavior.

Conclusions

The first objective of this study was to establish a psychometrically derived neuropsychological profile of individuals in the Fulton County Accountability Court in Atlanta, GA. Results show that individuals in the drug court are significantly impaired on several tests of neuropsychological functioning, particularly executive functioning. The second objective was to identify possible neuropsychological measures with predictive value in regards to drug court outcomes. Although no significant predictor variables were found, the preliminary results warrant further exploration, as the current sample size is small and the study is ongoing. It is important to consider neuropsychological impairment in individuals in a drug court population, as these individuals might need specialized interventions. Results from neuropsychological measures can indicate suggested areas for intervention specific to an individual's needs. It is also important that future research consider other variables implicated in substance abuse and criminal behavior such as personality, sociocultural variables, and genetics.

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APPENDIX

Figure 1. Brain areas implicated in the reward pathways, as well as their roles in a non-addicted and addicted brain. For the purposes of this study, primarily focused on the VTA, NAc, and PFC. *Reproduced with permission from Lee et al. (2012). Copyright 2012 John Wiley and Sons*

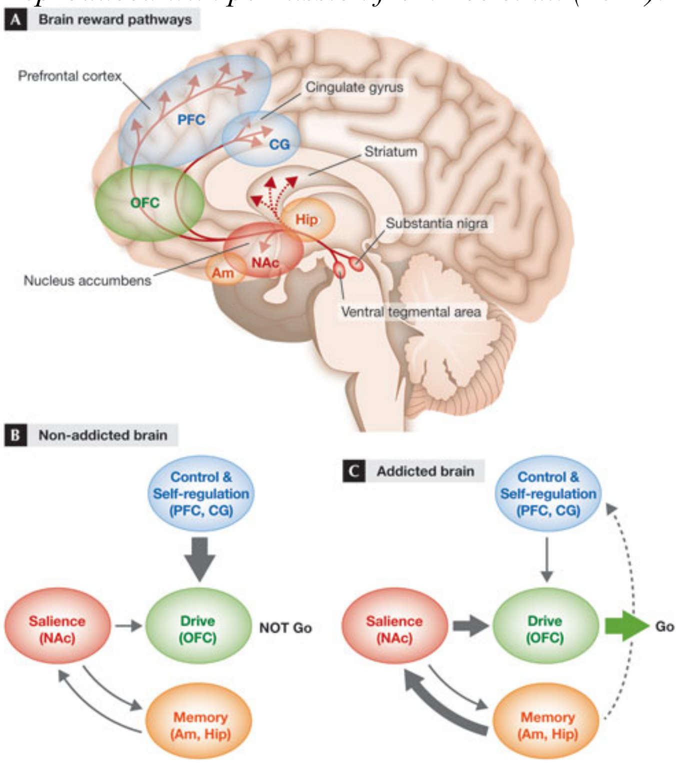

Figure 2. Brain areas implicated in substance abuse. For the purposes of this study, primarily focused on the VTA, NAc, and PFC. *Reproduced with permission from Koob and Volkow (2010). Copyright 2009 Nature Publishing Group*

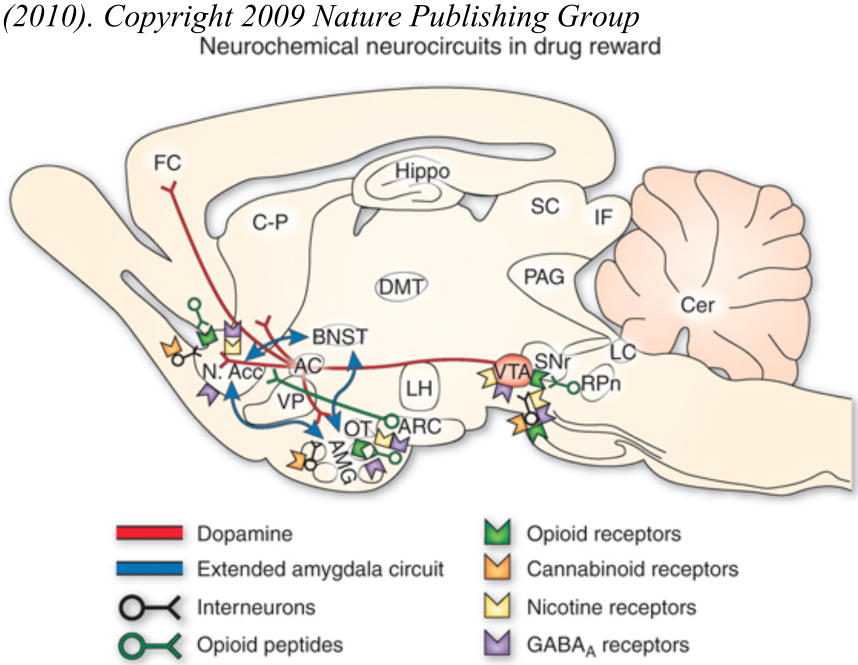

Figure 3. Effect of alcohol on neurotransmission. *Source: Spanagel (2009). Permission not required*

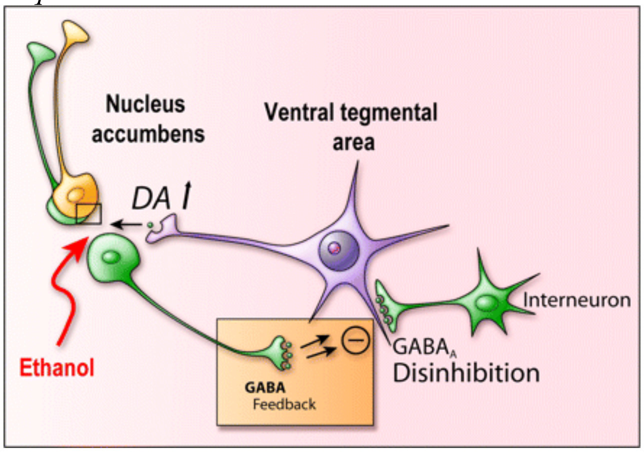

Figure 4. Effect of cannabis on neurotransmission. *Reproduced with permission from Egerton et al. (2006). Copyright 2006 Elsevier*

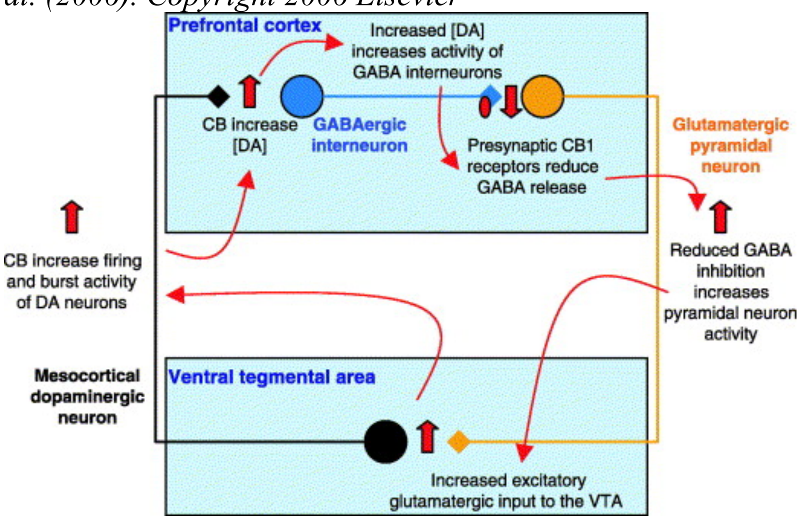

Figure 5. Effect of cocaine on neurotransmission. *Source: National Institute of Drug Abuse (2014). Permission not required*

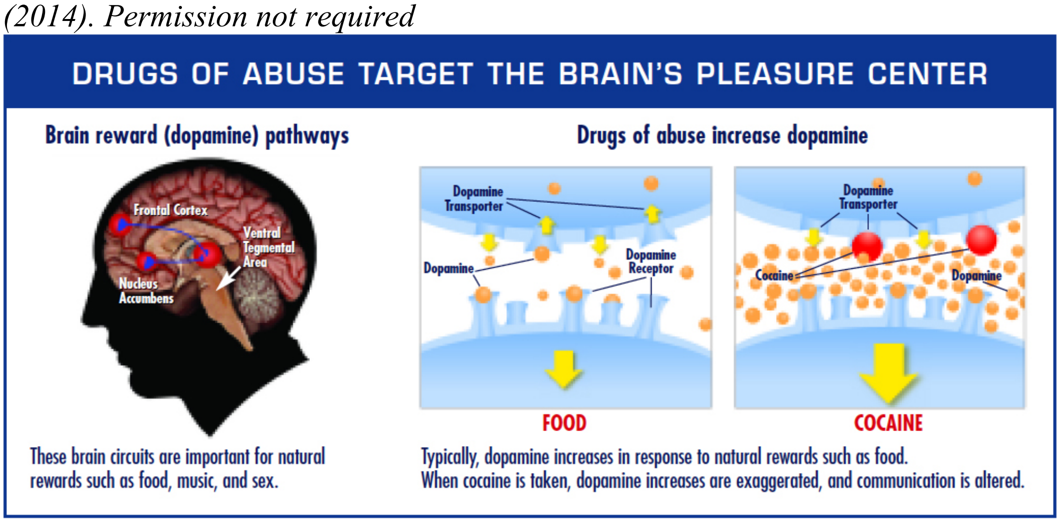

Figure 6. Gender of sample population.

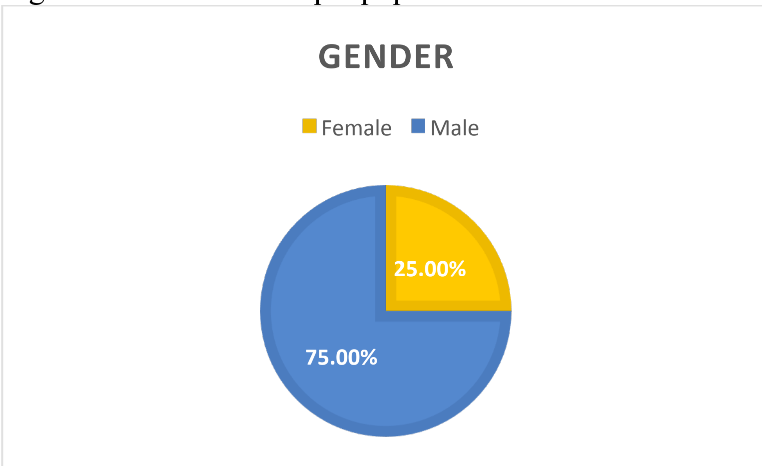

Figure 7. Ethnicity of sample population.

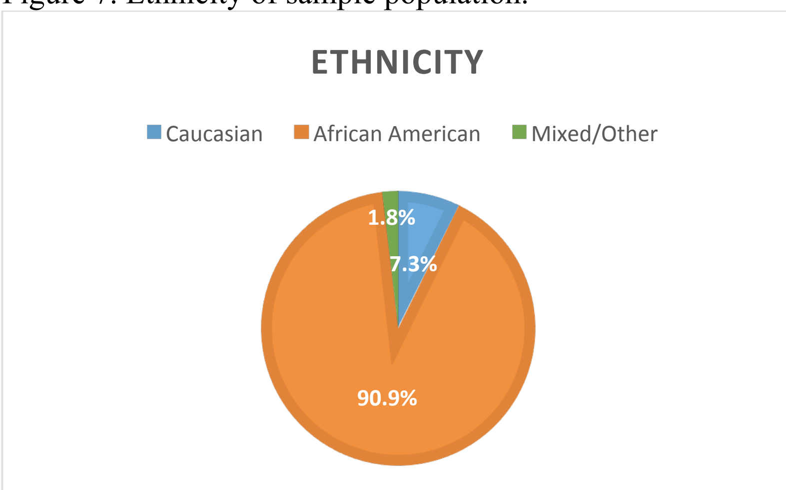

Figure 8. Education (years) of sample population.

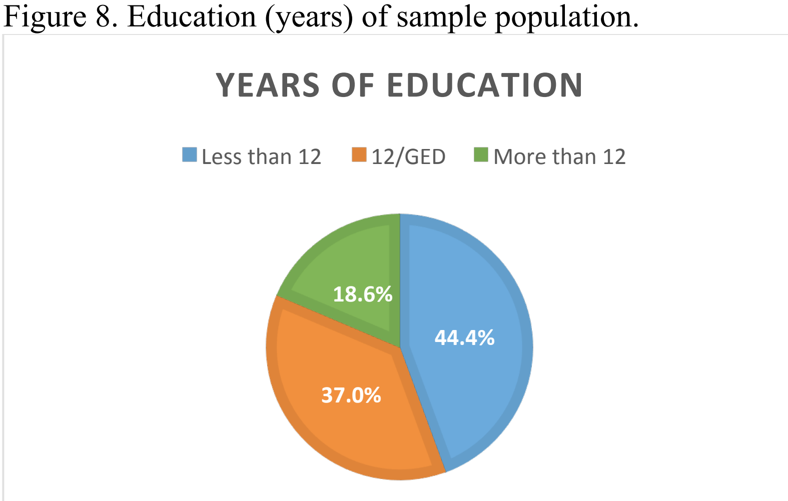

Figure 9. Substance abuse (number of users) in sample population.

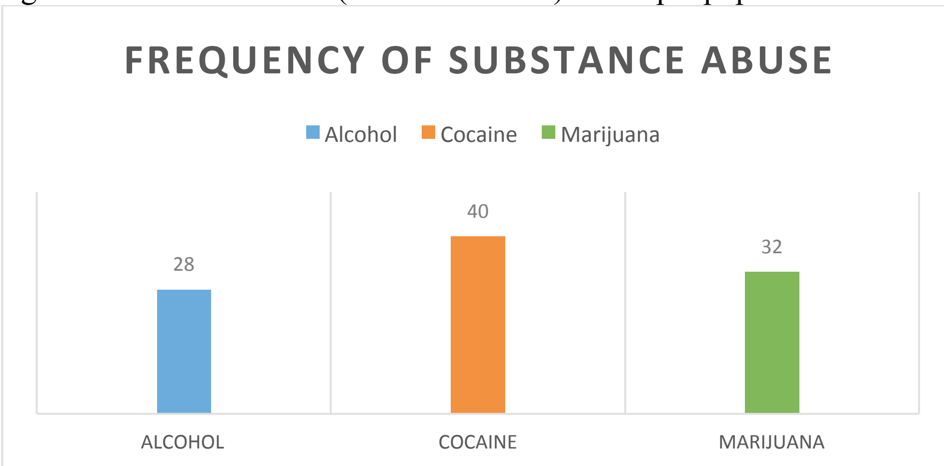

Figure 10. Mean MoCA Total scores in MCI (<26) group versus no MCI group.

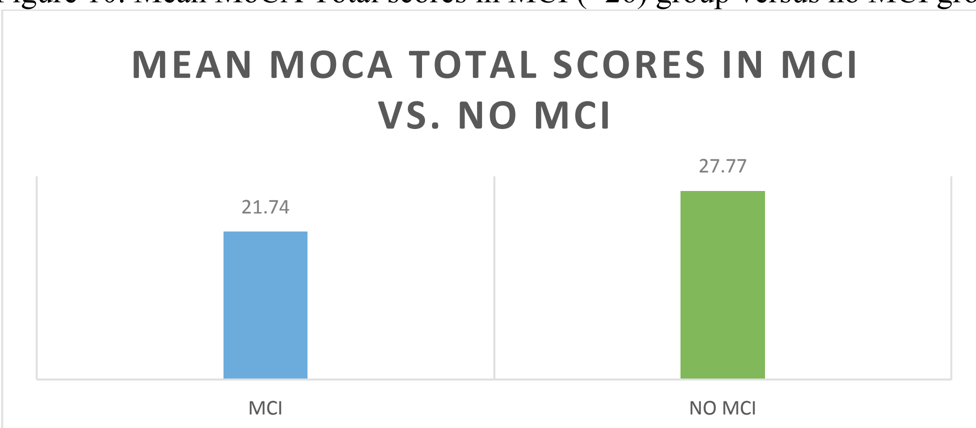

Figure 11. Mean MoCA Total scores in Graduated group versus Terminated group.

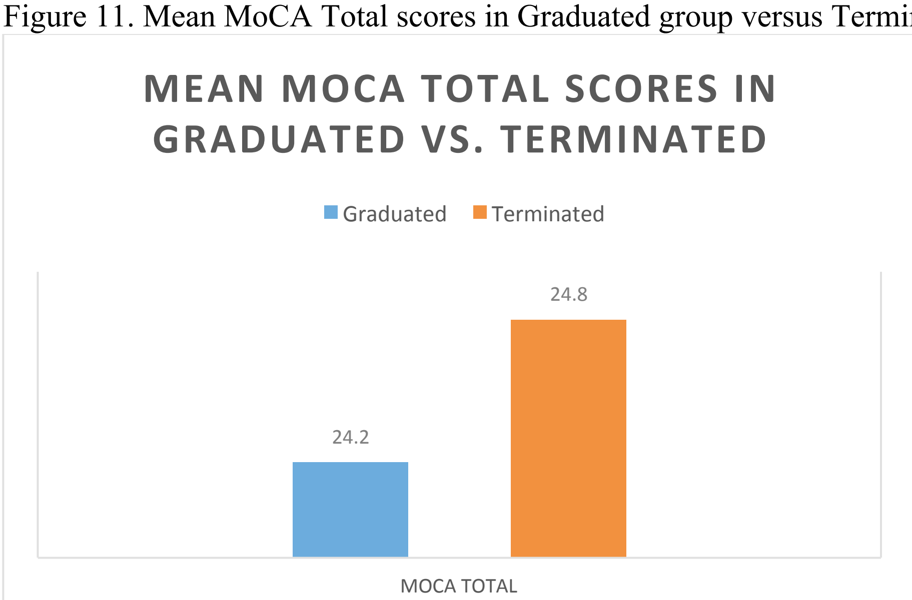

Figure 12. Mean MoCA subtest scores in Graduated group versus Terminated group.

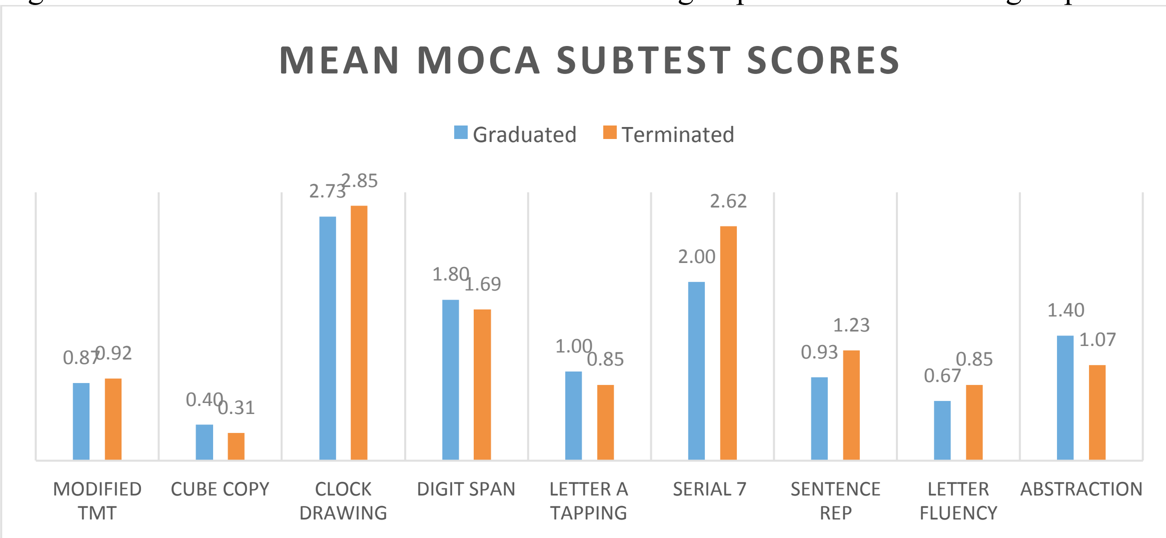

Figure 13. Mean age in Graduated versus Terminated group.

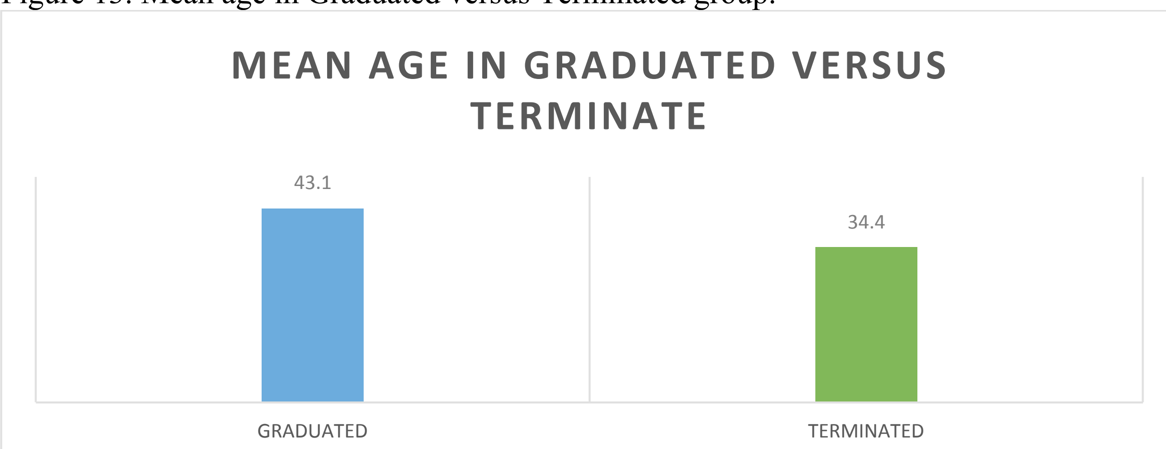

Figure 14. Intelligence (KBIT-II subscales) and Achievement (WRAT4 subscales) functioning (Average = 25 to 75).

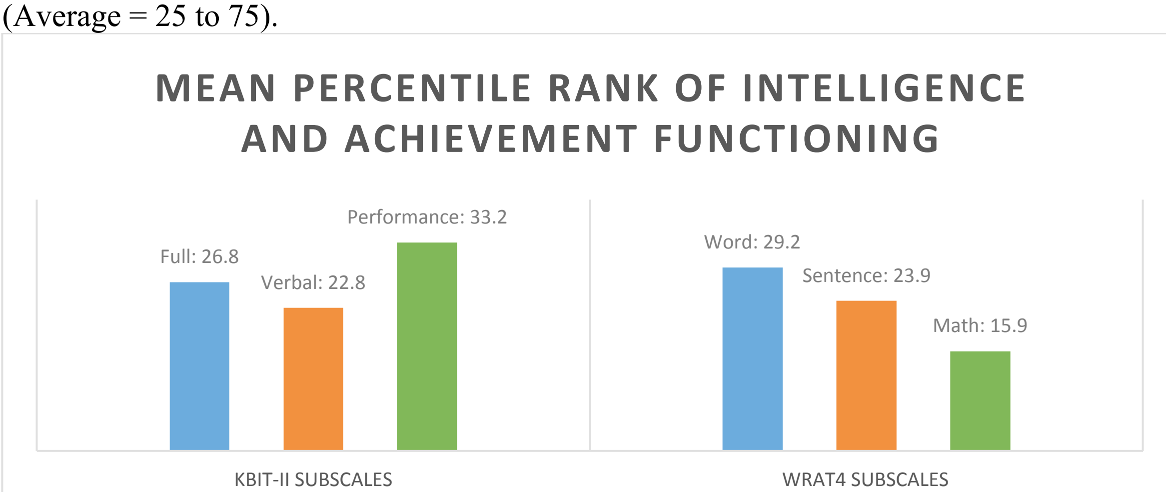

Table 1. Summary of neurocognitive effects on different classes of substance use and abstinence (Lazarus, 2014).

Substance	Short-term Use	Chronic use	Effects after abstinence	Population Type	Age of participants
Marijuana (Cannabis)	-Attention/ executive function deficits (e.g., decreased mental flexibility) - Increased preservation and reduced learning	- Memory and attention deficits - Memory retrieval, verbal expression, and mathematical reasoning deficits	-Verbal memory and inhibition deficits [2 weeks] - Little evidence for any long-lasting effects after abstinence [5 weeks]	Poly-substance 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	- Visuo-motor performance, attention, verbal memory, short-term/working memory, executive functioning deficits	- Verbal learning and memory, attention, inhibition, cognitive flexibility, decision-making, psychomotor speed, manual dexterity impairments - Conflicting claims on persistence of deficits over time periods of abstinence - Executive control, visuospaital abilities, psychomotor speed, manual dexterity deficits	Poly-substance users	Adults, post-adolescence
Alcohol	- Excitation, reduced inhibition, slurred speech, increased reaction time, cognitive dysfunction (memory function deficits)	- Attention, short-term memory, visuospatial abilities, executive function deficits	- Dependent on length of abstinence: claims of improvements after 1 week – years of abstinence - General improved domains: working memory, visuospatial functioning, attention	Poly-substance users	Adults

Table 2. Cohen's d effect size criteria.

	d	*r*	***r equivalent to d****
Small	0.20	0.10	0.10
Medium	0.50	0.30	0.24
Large	0.80	0.50	0.37

Table 3. Comparison of demographic variables between the sample population and normal control populations.

Demographics	Sample Population	MoCA Normal Population[1]	TMT Normal Population[2]
N	56	90	49
Sex (% male)	75.0%	40.0%	N/A
Education	11.5	13.3	14.3
Age	41.1	72.8	29.1

[1] Nasreddine et al., 2005; [2] Ruffolo et al., 2000

Endnotes

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[i] Abbreviations:

ACh: Acetylcholine
DA: Dopamine
DSM-IV-TR: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision
fMRI: Functional magnetic resonance imaging
GABA: Gamma-aminobutyric acid
KBIT-II: Kaufman-Brief Intelligence Test II
MCI: Mild cognitive impairment
MoCA: Montrea Cognitive Assessment
NAc: Nucleus accumbens
PFC: Prefrontal cortex
SE: serotonin
THC: tetrahydrocannabinol
TMT: Trail making test
VTA: Ventral tegmental area
WRAT4: Wide Range Achievement Test-Revision 4

[ii] DSM IV-TR Diagnostic criteria for Substance Abuse
These criteria are obsolete.

A. A maladaptive pattern of substance use leading to clinically significant impairment or distress, as manifested by one (or more) of the following, occurring within a 12-month period:

(1) recurrent substance use resulting in a failure to fulfill major role obligations at work, school, or home (e.g., repeated absences or poor work performance related to substance use; substance-related absences, suspensions, or expulsions from school; neglect of children or household)
(2) recurrent substance use in situations in which it is physically hazardous (e.g., driving an automobile or operating a machine when impaired by substance use)
(3) recurrent substance-related legal problems (e.g., arrests for substance-related disorderly conduct)
(4) continued substance use despite having persistent or recurrent social or interpersonal problems caused or exacerbated by the effects of the substance (e.g., arguments with spouse about consequences of Intoxication, physical fights)

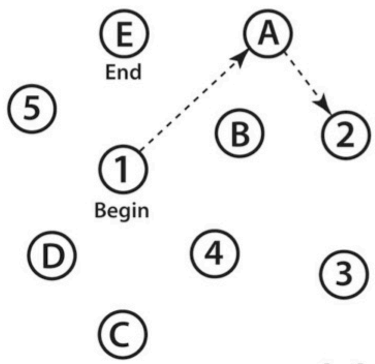
B. The symptoms have never met the criteria for Substance Dependence for this class of substance.

[iii] Montreal Cognitive Assessment

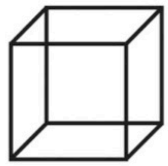
MONTREAL COGNITIVE ASSESSMENT (MOCA)
Version 7.1 Original Version

NAME :
Education :
Sex :
Date of birth :
DATE :

	POINTS
VISUOSPATIAL / EXECUTIVE	



[ ]



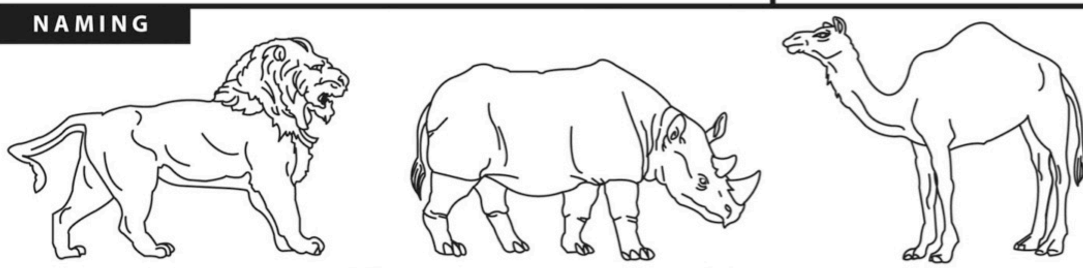
Copy cube

[ ]

Draw CLOCK (Ten past eleven)
(3 points)

[ ] Contour [ ] Numbers [ ] Hands — ___/5

NAMING



[ ] [ ] [ ] — ___/3

MEMORY Read list of words, subject must repeat them. Do 2 trials, even if 1st trial is successful. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION Read list of digits (1 digit/ sec.).
Subject has to repeat them in the forward order [ ] 2 1 8 5 4
Subject has to repeat them in the backward order [ ] 7 4 2 — ___/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B — ___/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt** — ___/3

LANGUAGE Repeat : I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ] — ___/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] _____ (N ≥ 11 words) — ___/1

ABSTRACTION Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler — ___/2

DELAYED RECALL	FACE	VELVET	CHURCH	DAISY	RED	Points for UNCUED recall only	___/5
Has to recall words **WITH NO CUE**	[ ]	[ ]	[ ]	[ ]	[ ]		
Optional Category cue							
Multiple choice cue							

ORIENTATION [ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City — ___/6

 www.mocatest.org Normal ≥ 26 / 30

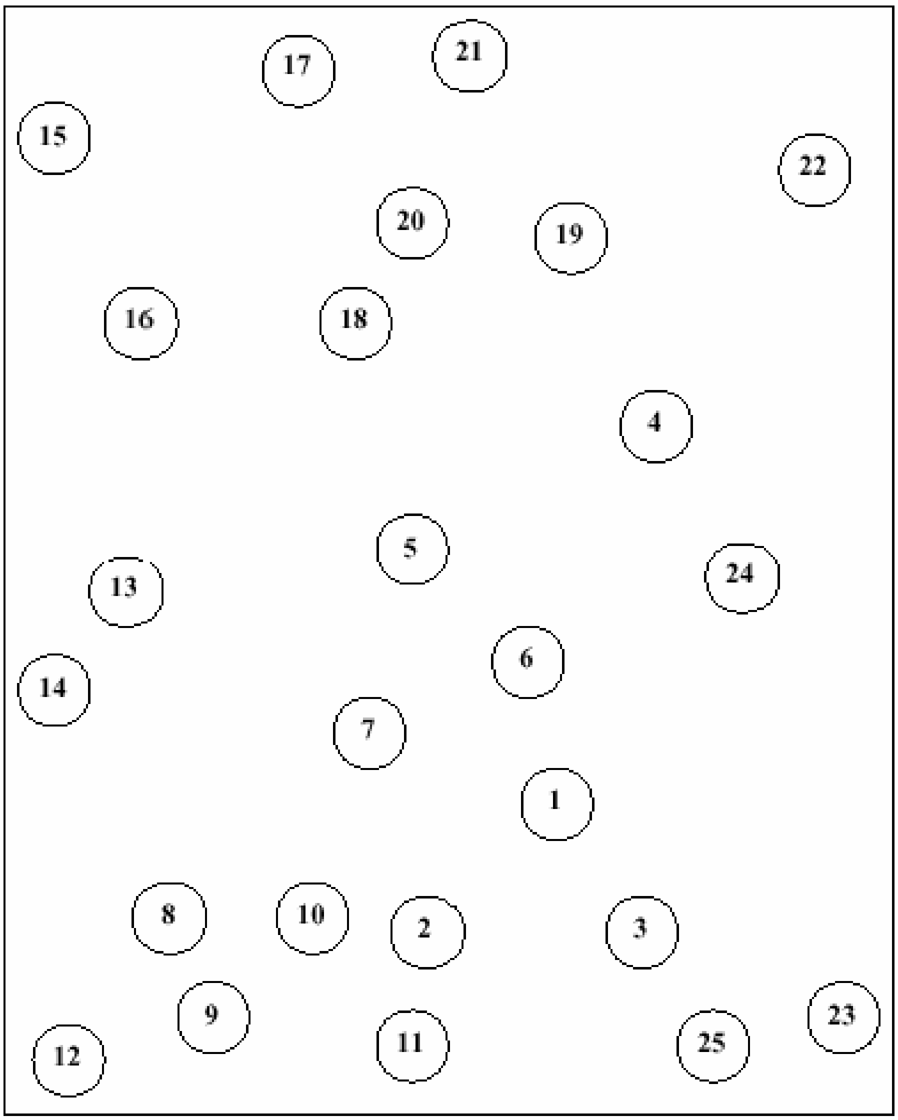
TOTAL ___/30
Add 1 point if ≤ 12 yr edu

Administered by: ______________________________

[iv] Trail Making Test (TMT)

Trail Making Test Part A

Patient's Name: ______________________________ Date: ____________________



Trail Making Test Part B

Patient's Name: ______________________________ Date: ____________________