ABSTRACT

The Differential Roles of Objective Neuropsychological Testing and Self Report Measures in Assessing Neurocognitive Impairment in Relation to Addiction Severity Among Alcohol Abusing Individuals

Lauren C. Hertzberg, Psy.D.

Mentor: Sara L. Dolan, Ph.D.

Background: Individuals with varying levels of alcohol use severity may present with unique neuropsychological deficits. While some of these deficits are apparent, others may not be noticeable until challenged to utilize them in specialty settings such as residential treatment. These deficits span areas such as behavioral inhibition, cognitive flexibility, working memory, and attentional control. While self report measures of executive function are widely used, studies have indicated subjective perceptions of one's impairment are impacted by a variety of factors, including lack of insight and depressed mood. Objective, performance based measures tend to produce more accurate markers of actual executive function but are less likely used in alcohol treatment settings. This preliminary study was conducted based on pilot study results indicating a combination of objective performance based measures and subjective self report data may best associate with alcohol addiction severity.

Methods: Archival de-identified medical record data were attained from medical records from a neuropsychological assessment private practice (N = 98) and were included in multiple regression analyses. This study employed a within subjects design comparing performance across objective (WCST, TMT, IVA, WMI) and subjective (BRIEF) measures of executive function with a dependent measure of alcohol addiction severity (AUDIT).

Results: When controlling for mood disruption and age of drinking onset, both objective and self report measures were significantly associated with alcohol addiction severity. Specifically, the combination of objective measures of perseveration as well as self report measures of behavioral inhibition deficits in behavioral inhibition and task completion were significantly associated with alcohol addiction severity. Also, age of drinking onset was significantly associated with alcohol addiction severity.

Conclusion: Results from this preliminary analysis illustrate that both performance based and self report measures are vital to identifying subsyndromal executive deficits that may impede an alcohol abusing individual's progress in treatment. This line of research extends previous literature findings in TBI, epilepsy and dementia to the realm of alcohol abuse in an effort to merge theory with practice. Practical findings suggest the most effective assessment tools to identify cognitively impaired individuals with alcohol use disorders to direct them to the most appropriate alcohol treatment setting.

The Differential Roles of Objective Neuropsychological Testing and Self Report Measures in Assessing Neurocognitive Impairment in Relation to Addiction Severity Among Alcohol Abusing Individuals

by

Lauren C. Hertzberg, B.A., M.A., M.Ed., M.S.C.P.

A Dissertation

Approved by the Department of Psychology and Neuroscience

____
Charles A. Weaver III, Ph.D., Chairperson

Submitted to the Graduate Faculty of
Baylor University in Partial Fulfillment of the
Requirements for the Degree
of

Doctor of Psychology

Approved by the Dissertation Committee

____
Sara L. Dolan, Ph.D., Chairperson

____
Thomas A. Fergus, Ph.D.

____
Gary R. Elkins, Ph.D.

____
Shawn J. Latendresse, Ph.D.

____
Brian D. Konecky, Ph.D.

____
James W. Ellor, Ph.D.

Accepted by the Graduate School

August 2017

____
J. Larry Lyon, Ph.D., Dean

Page bearing signatures is kept on file in the Graduate School.

TABLE OF CONTENTS

LIST OF TABLES vi

ACKNOWLEDGMENTS viii

CHAPTER ONE 1
Introduction 1

CHAPTER TWO 3
Literature Review 3
Executive Function and Alcohol Use 8
Neuropsychological Functions and Abstinence-Related Skill Deficits 10
Pilot Study 13
Specific Aims 18

CHAPTER THREE 21
Methods 21
Participants 21
Measures 23
Design and Data Analysis 29

CHAPTER FOUR 33
Results 33

CHAPTER FIVE 50
Discussion 50

REFERENCES 60

LIST OF TABLES

Table 1. Pilot study descriptive statistics for each cognition and addiction severity measure 15

Table 2. Pilot study objective measure correlation matrix 16

Table 3. Pilot study subjective report correlation matrix....................16

Table 4. Pilot study subjective report measures by objective measure correlation matrix 17

Table 5. Participant demographics....................23

Table 6. Descriptive statistics for objective measures of executive function 33

Table 7. BRIEF descriptive statistics....................34

Table 8. MMPI-2 descriptive statistics for RC scales....................34

Table 9. Objective measure correlation matrix....................37

Table 10. Subjective report correlation matrix 37

Table 11. Correlation matrix with objective-subjective method pairs....................38

Table 12. Objective measure correlation matrix with covariates and AUDIT 40

Table 13. Subjective measure correlation matrix with covariates and AUDIT....................41

Table 14. Objective measures regression analyses predicting alcohol consumption severity....................42

Table 15. Subjective measure regression analyses predicting alcohol consumption severity....................43

Table 16. Objective measure and subjective test combined regression analyses predicting alcohol consumption severity 45

Table 17. Significant objective measure and subjective test combined regression analyses predicting alcohol consumption severity....................46

Table 18. Objective and subjective composite variable regression analyses predicting alcohol consumption severity 47

Table 19. Domain composite regression analyses predicting alcohol consumption severity 48

ACKNOWLEDGMENTS

My dissertation completion marks both the end of an arduous yet rewarding journey as well as the beginning of a career as a doctor in loving service to the world.

A tremendous and resounding thank you to my mentor, Dr. Sara Dolan, for inviting me into her lab, mentoring and guiding me throughout this journey, and believing in me as a clinician and person. Your commitment to my growth and excellence is unrivalled.

A rich thank you to my dissertation committee members Dr. Thomas Fergus and Dr. Shawn Latendresse for your guidance and faith from start to finish, and a special thank you to Dr. Gary Elkins, Dr. Brian Konecky, and Dr. Jim Ellor for stepping in during the final portion of my dissertation journey in order to make my defense possible. Thank you also to Dr. J.D. Smith and Dr. Lea Steele for helping my dissertation process off to a strong start.

I am forever in gratitude for the love, support and humor from my husband Christian and my best friend Aleeza Di Pietra. Also, thank you to all the friends, teammates, and colleagues that have lent an eye, ear, and heart. Thank you for your graciousness and for being an integral part of truly seeing and knowing who I am.

Finally, to my loving grandparents who raised, inspired, and loved me until the end, and then showed me what everlasting love looks like, I love you and honor your memory with all I am.

CHAPTER ONE

Introduction

Of the 18.0 million Americans who suffer from alcohol use disorders, only 1.4 million actually received formal treatment (Substance Abuse and Mental Health Services Administration, 2014). Of these few who seek treatment, outcomes (i.e., sobriety) are not as high as what researchers and clinicians would hope to see in light of the depth and breadth of interventions available. Despite innovations in alcohol treatment (e.g. Hubbard et al., 1997; Merkx et al., 2014), large scale studies (e.g Project MATCH, the COMBINE study, National Epidemiologic Survey on Alcohol and Related Conditions) continue to show treatment success rates around 20% to 33% (Project MATCH, 1997; Anton et al., 2006; Willenbring, 2010). Recent studies are beginning to focus on understanding the effect of neurocognitive functioning on treatment success (Bates et al., 2006; Zahr, Kaufman, & Harper, 2011).

Approximately 33 to 75% of individuals with alcohol use disorders entering treatment display neurocognitive deficits, mostly in the mild to moderate range (Bernardin et al., 2014; Meek, Clark, & Solana, 1989; Morgenstern & Bates, 1999). Mild to moderate range deficits tend to be subsyndromal and relatively undetectable in everyday activities. In alcohol treatment, however, even mild deficits in executive function, learning, memory, and visuospatial skills can negatively impact one's ability to learn and apply abstinence based skills (Bernardin et al., 2014; Ritz et al., 2015). Individuals with higher pretreatment cognitive functioning, including executive functioning, less severe alcohol dependence, and fewer psychiatric disorders have better outcomes in alcohol treatment (Project MATCH, 1997; Dawson et al., 2006; Bates & Convit, 1999). When treatment providers understand the client's pretreatment neurocognitive functioning, treatments and expectations for outcomes can be tailored before the client begins treatment.

Many psychological assessment instruments exist to assess perceptions of both neurocognitive function and addiction severity, but the relationship between the two is unclear. It would be particularly valuable to assess and distinguish between different measures of neuropsychological function and their relation to perceived addiction severity. Improved treatment recommendations, as neuropsychological function may be an indicator of the level of insight into addictive behaviors that a patient may have. The best way to test the validity of scales measuring these constructs is to examine correlations with well validated criterion variables since these variables enjoy empirical support. In addition, identifying significant relationships may help clinicians identify which measures of neuropsychological function relate more closely to alcohol addiction severity and therefore better selection of these measures when performing pre-treatment assessments.

CHAPTER TWO

Literature Review

Emerging evidence of the role of neurocognitive dysfunction's impact on alcohol treatment planning and how to use information about a patient's cognitive recovery in treatment has mostly been correlational to date (e.g., Bates et al., 2013; Naim-Feil et al., 2014; Parks et al., 2010). Some studies have examined the utility of neurocognitive screening tools such as the Repeatable Battery for Assessment of Neuropsychological Status (RBANS; Randolph et al., 1998) and the Montreal Cognitive Assessment (MOCA; Nasreddine et al., 2005) in identifying cognitive impairments with substance abusing patients, but these instruments tend to lack the specificity and sensitivity for alcohol related cognitive impairments (Walvoort, Wester & Egger, 2012).

The mechanisms and interdependence of neurocognitive skills vital to abstinence can be best understood through the dual process model, which explains the role of the impulsive and reflective cognitive systems in understanding drinking behavior mechanisms. The impulsive system involves memory, inhibitory, and behavioral processes, and the reflective system involves enacting controlled cognitive processes, executive functions, regulating the impulsive system to promote adaptive behavior (Bernardin et al., 2014). Disruption in any one domain, even on a mild to moderate level, can result in difficulty abstaining from alcohol. Bernardin and colleagues (2014) advocate for close consideration of the alcohol abusing individual's cognitive impairments upon admission since management of these deficits have far reaching implications for both treatment and future abstinence.

Understanding the specific executive function deficits that are most influential as well as most insidious in patients with alcohol use disorders seeking treatment will help clinicians be flexible in *how* treatment material is delivered, as well as *which* treatment modalities are employed (Bates et al., 2013; Feil et al., 2010). Pre-treatment assessment of neurocognitive executive functioning is therefore critical in designing and implementing intervention strategies that are most likely to result in abstinence (Bates, Barry, & Bowden, 2002; Walvoort, Wester, & Egger, 2012).

Executive function refers to a wide range of neurocognitive tasks involving cognitive and behavioral processes which are commonly assessed through objective, performance based measures (Chan et al., 2008). Many widely used neuropsychological assessment measures such as the Trail Making Tests of the Halstead-Reitan Battery and the Wisconsin Card Sorting Task have been validated for use across a broad domain of populations, including alcohol and substance use (Salgado et al., 2008; Houston et al., 2014; Parks et al., 2010).

Objective performance based measures are typically administered by a trained professional and aim to provide data independent of confounding factors such as mood or biases in self-perception (Harvey, 2012). Recent literature has seen an advent of a non-clinician required administration of a brief objective neuropsychological assessment focused on assessing alcohol related neuropsychological impairments. A study by Ritz and colleagues (2015) provided preliminary evidence for the utility of a brief performance based screening tool (BEARNI) for alcohol related neuropsychological impairments with inpatients undergoing alcohol detoxification treatment and validated measures against well validated neuropsychological instruments. This study focused on measurement of domains of verbal episodic memory, working memory, executive function, and visuospatial abilities are measured by the BEARNI and validated against measures of learning (California Verbal Learning Test (CVLT)), memory (Wechsler Working Memory Index (WMI)), processing speed (Trail Making Test A), fluency tasks and the Stroop (Ritz et al., 2015). However, there are many other executive function abilities that are not specifically covered by the BEARNI, such as abstract reasoning and set shifting, skills that have been shown as vital for acquiring and maintaining skills for abstinence (Bernardin et al., 2014; Houston et al., 2014).

Given that performance based measures can be expensive, time consuming, and only administered by a trained professional, subjective self report measures may be more efficient and easy to administer. Self-report measures enjoy flexibility and ease of administration, which make them ideal for use across a variety of clinically based settings to screen and monitor progress in treatment (Nowinski et al., 2010). Self report measures are typically questionnaire style and typically require less professional expertise and test materials, but they may also be susceptible to inaccuracies in self perception (Vazire & Mehl, 2008).

While generally accurate if used under specific circumstances (Sobell & Sobell, 2003), subjective self-report measures have their drawbacks, especially with individuals possessing cognitive impairments (Vazire & Mehl, 2008) who may not have an accurate perception of their cognitive abilities. First, self-report measures are significantly affected by mood state. A literature review conducted by Sobell and Sobell (2003) revealed that alcohol abusers tend to describe themselves generally in a more negative fashion compared to collateral sources and underestimate their alcohol consumption. Alcohol users tend to give less accurate self-reports if they have a long drinking history and are answering questions requiring subjective judgment (Sobell & Sobell, 2003). In addition to subjective judgment deficits and other deficits observed on objective neuropsychological measures, patients with executive function deficits have been shown to lack self-awareness and perform differently on subjective measures of executive functioning (Mograbi et al., 2015; Marino, et al., 2009; Spikman & van der Naalt, 2010). Specifically, these studies illustrate that objective measures of executive function tend to be more illustrative of executive function deficits and measure them with more specificity and sensitivity than subjective measures of executive function.

Self-report measures of substance use and related problems are more routinely administered in treatment settings but may be limited in accuracy and scope with cognitively impaired individuals (Marino et al., 2009). Compounded with actual skill learning, executive function deficits may alter the alcohol abuser's perception of their actual abilities (Fadardi & Cox, 2006). Studies have found that self reports of executive function are subject to perception based errors which may produce less accurate results about an individual's actual, objective functioning due to method variance (Marino et al., 2009; Mograbi et al., 2015; Spikman & Vandernalt, 2010). One possible explanation for these findings is that certain self-report measures of executive functioning assess subjective experience of one's deficits rather than state-based behavioral procedures which tend to capture more objective data (Stanford et al., 2009). In short, objective measures and subjective reports of executive function may provide vastly different information and be altered and impacted by a variety of sources in the substance abusing population.

Self report measures of executive functioning have also played a significant clinical role in the realm of neuropsychology and added a new dimension to multimodal assessment of executive function deficits (Isquith et al., 2008). While elevations on such measures may be indicative of impaired executive functioning, studies have also illustrated confounds such as mood and physical functioning affecting perceptions of one's executive functioning (Toplak et al., 2013; Marino et al., 2009). The Behavior Rating Inventory of Executive Function - Adult (BRIEF; Roth et al., 2005) is one of the most commonly used subjective rating scale of executive function (Toplak et al., 2013). The BRIEF-A is a broad band self report measure of executive function that provides a global assessment across domains of inhibitory self control, flexibility and emergent metacognition. Higher scores reflect greater level of perceived impairment (Roth et al., 2005). Various versions of the BRIEF have been validated for use with a wide variety of populations, including child TBI (Donders et al., 2010), child development (Huizinga & Smidts, 2011), ADHD (Roth et al., 2013) and distinguishing autism from ADHD profiles (Lawson et al., 2014), and risk factors for alcohol based aggression (Giancola et al., 2012).

The executive function problems being targeted in these assessments are the exact executive functions that are typically seen as impaired in persons with alcohol use disorders. It is important to emphasize that self-report measures like the BRIEF measure perceptions, not actual executive function. One study examining the performance of the BRIEF with amnesiac and depressed patients showed that individuals with mild cognitive impairments as well as healthy non-depressed older adults reported clinically meaningful executive problems, specifically with episodic memory, above and beyond what outside informants report (Rabin et al., 2006). While the BRIEF may be sensitive to subtle executive function changes, results from this study failed to show strong correlations between objective neuropsychological test results and subjective self-reported deficits in executive function (Rabin et al., 2006).

Executive Functioning and Alcohol Use

Executive function in the realm of alcohol use has been defined as the processes thought to monitor, direct, and organize or regulate behavior so individuals can achieve desired goals while minimizing adverse consequences (Blume & Marlatt, 2009; Houston et al., 2014). These functions include verbal reasoning, sustaining attention, cognitive flexibility, adaptability to feedback and novel situations, associative learning, working memory, problem-solving, and planning (Giancola, 1995; Chan et al., 2008; Blume & Marlatt, 2009; Naim-Feil et al., 2014). Impairment in any executive function domain can gravely impact one's ability to work, attend school, function independently, or develop and maintain social relationships (Chan et al., 2008).

Neurological literature further describes executive functions as a series of abilities to achieve a goal, many of which can be tested through neuropsychological assessment (Konrad et al., 2012). Within the domain of alcohol research, specific instruments have enjoyed robust literature support in generalizing neuropsychological test findings to specific real life functioning deficits in alcohol abusing populations (Courtney & Polich, 2009; Konrad et al., 2012). A patient with deficient performance on tests that measure set-shifting, mental flexibility, or response inhibition may exhibit the same kind of deficits in real-life. Individuals with alcohol use disorders present with unique constellations of neuropsychological deficits, including behavioral inhibition, cognitive flexibility, learning and memory, and attentional control (Rubio et al., 2008; Ratti et al., 2002; Naim-Feil et al., 2014; Bates et al., 2006; Dolan et al., 2008).

Studies have shown intact executive function processes as necessary components for changing maladaptive alcohol abuse patterns (Blume & Marlatt, 2009). Executive function deficits correlate with poorer adoption of skills needed to remain abstinent (Courtney & Polich, 2009; Schacht et al., 2011; Bernardin et al., 2014).

Assessing alcohol abusing patients prior to treatment may help preemptively identify potentially problematic executive function deficits. First, assessment may serve to identify where a client may either fail to acquire strategies taught during treatment (Sanchez-Craig & Walker, 1982; Smith & McCrady, 1991). In addition, understanding even the mildest of executive function deficits may predict where strategies taught in treatment may be less effective in preventing relapse (Morgenstern & Bates, 1999). One study (Parks et al., 2010) found that while simple neurocognitive tasks may not be significantly compromised in alcohol abusing individuals with mild deficits, more complex task performance and neurocognitive functions necessary for acquiring new skills in treatment, such as executive functions, are negatively impacted. Another investigation found that patients with neurocognitive deficits in treatment may display cognitive rigidity and problems adapting cognitively to new paradigms taught in treatment (Guardia et al., 2007).

Each executive function domain deficit has its own unique consequences on treatment prognosis and relapse prevention. Deficits in abstract thinking may negatively impact a patient's ability to generalize relapse prevention skills outside of treatment. Additionally, impairment in cognitive flexibility may reduce the patient's ability to produce adaptive behavioral alternatives to substance use (Bates et al., 2013). Response inhibition problems may make it more likely that patients react impulsively with pre-potent responses (i.e. substance use) to environmental stimuli such as stress or high-risk situations (Bates et al., 2006). Working memory deficits may impair a patient's ability to hold more than one concept in mind simultaneously; this may impair a patient's ability to recall coping skills that were learned in treatment while thinking of the positive consequences of substance abuse (Pitel et al., 2007).

Neuropsychological Functions and Abstinence-Related Skill Deficits

Patients' performances on a number of neuropsychological tests have been found to correlate with or moderate/mediate whether or not the patient can maintain abstinence post-treatment. Learning- and memory-related tests as well as tests of executive functions appear to have the strongest relationship with treatment outcome (Morgenstern & Bates, 1999; Voelbel, Bates, & Labouvie, 2000). Deficits in executive function domains of abstraction, cognitive flexibility, working memory, and psychomotor processing speed have been shown to interfere with treatment goals of abstinence via less treatment compliance and lower self-efficacy (Bates et al., 2006).

A wide array of empirically validated neuropsychological instruments has been included in studies that have evaluated cognitive correlates of substance use disorders, but certain tests have enjoyed robust support and validation for use with alcohol abusing populations. Within the domains of learning and memory, instruments such as the Working Memory Index (WMI) on the Wechsler Adult Intelligence Scale – 4th Edition

(WAIS-IV; Wechsler et al., 2008) have shown increased learning and memory deficits in treatment-seeking populations (e.g. Parks et al., 2010). Practical impacts of learning and memory deficits include the inability to remember specific relapse prevention strategies, deficits in encoding and recollection of treatment strategies during situations conducive to relapse (Bernardin et al., 2014).

Abstract reasoning has been defined as the ability to both identify and form concepts which require the individual to consider and manipulate information about events, objects, and concepts not readily accessible in the immediate environment (Solomon et al., 2011). The Wisconsin Card Sorting Task (WCST; Heaton et al., 1993) is one such task that has been used to measure abstract reasoning with alcohol treatment populations (e.g. Du et al., 2002) with practical applications such as decision making about one's alcohol consumption, creating and adopting mental maps conducive to maintaining abstinence, and employing multistep response strategies to relapse provoking situations (Oscar-Berman & Marinkovic, 2007; Walvoort et al., 2012)

Cognitive flexibility has been defined as the ability to shift directions of thought and action to perceive, process and response to situations flexibly and adaptively (Eslinger & Grattan, 1993). Studies have often used the Trail Making Tests of the Halstead-Reitan Battery (TMT) to measure cognitive flexibility with alcohol treatment populations with special attention paid to Trail Making Test B (e.g. Cordovil De Sousa Uva et al., 2010; Parks et al., 2010). Specifically, treatment populations demonstrated slower TMT completion times (Cordovil De Sousa Uva et al., 2010) and decreased ability to categorize or set shift (Ersche & Sahakian, 2007). Practical implementation may include adapting skills from a structured treatment setting to a relatively unstructured real life situation, shifting one's attention away from alcohol and related cravings in relapse provoking situations, and engaging in complex planning to avoid situations involving alcohol use (Cordovil De Sousa Uva et al., 2010).

Behavioral inhibition has been defined as the process required to stop an intended or planned action and is associated with suppression of emotional, cognitive, and behavioral responses (Ersche & Sahakian, 2007). Inhibition of responses and behaviors require enacting sustained attention, which is defined as a state of being ready to respond to unpredictable, possibly random, and rarely occurring stimuli over various periods of time (Sarter et al., 2001). Response and behavioral inhibition tests with alcohol treatment populations have taken the form of continuous performance tests as an objective means to identify activation and inhibition deficits (Frazier, Demaree, & Youngstrom, 2004). Studies have shown alcohol abusing populations to have increased simple response times on such tasks (Cairney et al., 2007) as well as increased responding to distracters (Salgado et al., 2009) on measures such as the Continuous Performance Test (CPT-II; Conners, 2000) and the Integrated Visual and Auditory CPT (IVA; Sandford & Turner, 2004). Slower response times and inhibition deficits translate practically into alcohol users' inability to abstain from alcohol consumption and respond to triggers and cues in a timely fashion to prevent relapse (Rubio et al., 2008).

Behaviorally anchored instruments assessing alcohol use severity include The Alcohol Use Disorder Identification Test (AUDIT; Saunders et al., 1993), which is a 10-item Likert scale questionnaire that screens for hazardous or harmful alcohol consumption. Initially developed by the World Health Organization (WHO), the AUDIT is a behaviorally anchored instrument to assess the patient's perception of their alcohol cravings and patient perceptions of the extent to which their alcohol use has caused general life problems. Results can help treatment providers make predictions about treatment outcom since the test correctly classifies 95% of people as having (or not having) an alcohol use disorder (Babor et al., 2001). The AUDIT is particularly suitable for use in primary care settings and has been used with a variety of populations and cultural groups. In addition, its behavioral anchors are conducive to more objectively based reporting since behaviors are quantifiable (Rubio et al., 1998a).

Pilot Study

In order to evaluate the feasibility of a study with the intended outpatient neuropsychological private practice assessment population, a clinical neuropsychological private practice, and doing a secondary chart review with archival data, a pilot study was conducted with archival assessment protocol data obtained between years 2013 to 2014. Objective measures of executive function included in this analysis were: the Wisconsin Card Sorting Task (WCST – Total Score; Heaton et al., 1993), Trail Making Tests of the Halstead Reitan Battery (TMT A and B; Reitan & Wolfson, 1993), Integrated Visual and Auditory Continuous Performance Test (IVA + Plus – Auditory Prudence and Visual Prudence scores; Sandford & Turner, 2004), and the Wechsler Adult Intelligence Scale - 4th Edition Working Memory Index (WAIS-IV WMI; Wechsler et al., 2008). The subjective measure of executive function included was the Behavior Rating Inventory of Executive Function – Adult (BRIEF-A; Roth et al., 2005). Given that no standardized alcohol use severity measure was administered to each patient, the Minnesota Multiphasic Personality Inventory-2 Addiction Admission Scale (MMPI-2 AAS; Butcher, 2001) was included as a proxy measure of alcohol use severity since each patient had completed the MMPI-2 as part of their neuropsychological assessment battery.

A total of 21 protocols were initially retrieved, and 15 patients were included in this pilot study. Patient protocols were omitted if one of the instruments included in analysis was missing from the battery. Participants ranged in age from 18 to 44 years with a mean age of 24.53 (SD = 8.37). Participants were primarily female (N = 10, 66.7%) and White/Caucasian (N = 11, 73.3%) with 20.0% African American/Black (N = 3), and 6.7% Asian/Asian American (N = 1).

For each objective measure of cognition, standard scores (M = 100, SD = 15) were provided for all outputs except the Trail Making Tests. The Trail Making Test scores were converted from raw scores (measured in seconds) to standard scores by subtracting the obtained score from the mean score, dividing by the standard deviation, multiplying by 15 and adding 100. For each subjective test of cognition, T-scores were provided for all outputs (M = 50, SD = 10).

Table 1 depicts descriptive statistics for each objective measure of cognition, subjective test of cognition, and subjective test of addiction severity. The mean scores for each objective measure aside from the IVA Auditory and Visual Prudence scores all were within the Average range of functioning according to the administration manual for each test. In contrast, almost all subjective tests, as measured by the BRIEF, were considered clinically significant and elevated (except for Emotional Control and Self Monitor). The MMPI-2 AAS mean score, a standard score, is also considered clinically elevated.

Table 1

Pilot study descriptive statistics for cognition and addiction severity measures

Instrument/Scale	M (SD)
Objective Measures of Cognition	
1-WCST Total Score	109.00 (12.32)
2-Trail Making Test A	104.14 (18.60)
3-Trail Making Test B	90.93 (21.58)
4-IVA Auditory Prudence	87.69 (37.98)*
5-IVA Visual Prudence	81.69 (27.93)*
6-WAIS-IV WMI	97.73 (10.10)
Subjective Tests of Cognition	
7-BRIEF Inhibit	67.00 (10.71)*
8-BRIEF Shift	66.07 (10.12)*
9-BRIEF Emotional Control	61.60 (12.15)
10-BRIEF Self Monitor	60.50 (13.34)
11-BRIEF Initiate	72.00 (8.01)*
12-BRIEF Working Memory	76.67 (10.52)*
13-BRIEF Plan/Organize	72.53 (11.22)*
14-BRIEF Task	74.64 (11.38)*
15-BRIEF Organization of Materials	67.00 (14.20)*
Subjective Test of Addiction Severity	
16-MMPI-2 AAS	76.93(35.62)*

M = mean; SD = standard deviation
* Denotes clinically significant elevation according to each respective test's manual

Correlation matrices were conducted in line with Campbell and Fiske's multitrait-multimethod model (1959). Specifically, the matrix serves to distinguish heterotrait momomethod (either objective or subjective) and heterotrait heteromethod (combining objective and subjective). Within objective measures, three significant correlations were found. Trails A and B were correlated (*r* = .57, p = .03) as well as the IVA Auditory and Visual Prudence measures (*r* = .70, p = .01) with one another, as expected. Across objective measures, the IVA Visual Prudence and WAIS Working Memory Index (WMI) were correlated (*r* = .77, p = .02). Objective measure results are found in Table 2.

Table 2

Pilot study objective measure correlation matrix

Objective Measures	1	2	3	4	5	6
1. WCST Total	--					
2. Trail Making Test A	-.26	--				
3. Trail Making Test B	.29	.57*	--			
4. IVA Auditory Prudence	.47	-.04	-.27	--		
5. IVA Visual Prudence	.46	-.03	-.07	.70**	--	
6. WAIS-IV WMI	.38	.10	-.29	-.02	.77*	--

* p < .05, ** p < .01

Within subjective measures, many of the BRIEF scales were significantly intercorrelated (see Table 3).

Table 3

Pilot study subjective report correlation matrix

Subjective Reports	1	2	3	4	5	6	7	8	9
1. Inhibit	--								
2. Shift	.19	--							
3. Emotional Control	.47	.60*	--						
4. Self Monitor	.62*	.48	.73**	--					
5. Initiate	-.20	.48	.02	-.02	--				
6. Working Memory	.37	.52*	.36	.10	.67*	--			
7. Plan/Organize	.50	.36	.27	.42	.93**	.64*	--		
8. Task	-.02	.47	.18	.17	.80**	.47	.79*	--	
9. Organization of Materials	.53*	.56*	.27	.31	.30	.64*	.45	.28	--

* p < .05, ** p < .01

In the matrix examining correlations across objective and subjective measures of executive function, only the TMT-B score was significantly, and negatively, correlated with the BRIEF Inhibit scale (r = -.60, p = .02). There were also trends suggesting relationships between IVA Auditory Prudence and various subjective domains (i.e. Shift, Initiate, Task, and Organization of Materials; r = .44 – .53; p = .10 – .14) as well as

Organization of Materials, and Working Memory Index with Self Monitor (r = -.62, p = .06). Results are listed in Table 4.

Table 4

Pilot study subjective report measure by objective measure correlation matrix

BRIEF Scales	WCST	TMTA	TMTB	IVA Aud Pru	IVA Vis Pru	WMI
1. Inhibit	-.33	-.30	-.60*	-.26	-.16	-.29
2. Shift	.03	-.09	-.12	.47	.13	-.09
3. Emotional Control	.14	.20	-.12	.25	-.07	-.35
4. Self Monitor	.01	-.16	-.28	-.07	-.11	-.62
5. Initiate	.15	.14	.39	.53	.39	-.10
6. Working Memory	-.10	.14	.08	.26	.01	-.18
7. Plan/Organize	-.11	-.09	-.05	.21	.13	-.24
8. Task	-.08	.06	.04	.49	.22	-.15
9. Organization of Materials	-.19	-.22	-.42	.44	.41	-.18

* p < .05, ** p < .01

In relation to addiction severity, IVA Auditory Prudence (r = -.61, p = .03), BRIEF Initiate scale (r = -.61, p = .05), and BRIEF Task scale (r = -.59, p = .03) were significantly correlated with MMPI-2 Alcohol Addiction Severity (AAS) scale.

Taken together, preliminary results of this pilot study suggest promise for further examination with a larger sample size and the use of a commonly-administered self-report measure of alcohol addiction severity. Specifically, results suggest that using multiple methods to assess executive function in alcohol abusing individuals may be best practice in pre-screening for deficits prior to treatment. It is important to understand the disconnect between subjective and objective measures since studies have shown distinct differences in the information each measure specifically provides (Marino et al., 2009; Stanford et al., 2009), and few studies have evaluated the relative contribution of subjective perceptions and objective contributions to executive function in alcohol abuse.

Specific Aims

Aim 1: This study explored the interrelationships between objective tests and subjective measures of executive function with alcohol abusing individuals.

It was hypothesized that overall objective measures of executive function will more strongly intercorrelate with each other than with any subjective measure scales or subscales, and subjective measure scales of executive function domains will more strongly intercorrelate with each other than with any of the objective measures of executive function. Campbell and Fiske (1959) posit that monomethod analyses should provide evidence of convergent validity, whereas heteromethod analyses should provide evidence of discriminant validity.

Exploratory Hypotheses

Aim 2: This study explored the relationship between objective measures and subjective measures of executive function with alcohol addiction severity as the outcome and mood as a covariate.

It was hypothesized that objective measures would be more related to alcohol addiction severity than subjective self reports. Studies have shown objective measures of executive function perform differentially in epilepsy studies with subjective measures correlating more significantly with mood dysfunction than objective cognitive deficits (Marino et al., 2009; Esbjornsson et al., 2013), with objective measures more accurately measuring cognitive deficits compared to subjective reported deficits (Harvey, 2012). This hypothesis is an effort to examine the unique variance and incremental validity each measure explains.

Aim 3: This study explored the relationships between objective and subjective measures of executive function within distinct domains of neurocognitive functioning and with alcohol addiction severity as the outcome measure and mood, age of drinking onset as covariates.

While memory, learning, and flexible thinking are important skills for an individual with an alcohol use disorder to enact relapse prevention and treatment based abstinence strategies, it is not clear whether there are stronger relationships within domains (e.g., self-reported working memory correlates more strongly with objectively-measured working memory) or within methods (e.g., self-reported executive functioning scales correlate more strongly with one another than with objective measures of the same domains). The literature suggests that the differential performance of subjective perception versus objective measures of executive functions is highly relevant for pre-treatment assessment and identifying appropriate treatments based on executive function capacity.

If one method of executive function reporting, objective performance based versus subjective self-report, is more strongly related to addiction severity, findings may directly impact pre-treatment decisions which significantly impact treatment outcomes. If one assessment method provides better information about executive function than the other, then assessors should only do the more informative test instead of engage in time consuming pursuits and overlapping data from other testing instruments. Findings from this study may inform the most effective line of treatment, which may positively impact treatment outcomes if the person is in a treatment program that fits their cognitive capacity.

Overall, the present study examined the differences and contributions that both objective and subjective perception measures of neurocognitive dysfunction have with regard to addiction severity in populations with alcohol use disorders. Ultimately, this study seeks to more effectively understand the relationship between executive function and alcohol addiction severity and provide a starting point to construct a pre-treatment multimodal neuropsychological assessment battery to identify executive function deficits requiring different treatment modalities.

CHAPTER THREE

Methods

Participants

Participants in this study were patients from an outpatient neuropsychological assessment private practice. This study was a medical chart review study; data from routine clinical neuropsychological assessments were gathered from the medical charts after data had been deidentified. Specifically, data were collected from patients referred from the community by psychiatrists, primary care physicians, psychotherapists, previous patients, and the practice's website to the clinic for a comprehensive neuropsychological assessment. Participants were administered a standardized assessment battery as part of their clinical assessment, including cognitive, neuropsychological, and personality based testing. Licensed clinical psychologists or doctoral students under licensed psychologist supervision administered each instrument to each client. Standardized procedures for administration and scoring were followed for each client.

Because this is a retrospective review of deidentified medical records, the requirement for informed consent was waived (Baylor University IRB Reference #: 728301). Inclusion criteria included clinical neuropsychology patients referred for an assessment between the ages of 18 and 60 and having a score of 8 or above on the AUDIT as the qualifier for alcohol abuse problems. Since the goal of this study is to identify executive function deficits in alcohol abusing individuals, individuals who did not self report problems with alcohol were systematically excluded. Exclusion criteria included: prior and/or current diagnosis of any type of organic brain disease such as stroke, dementia, or moderate to severe traumatic brain injury (TBI); being under age 18 or over age 60 at the time of testing, no self reported problems with alcohol use, and presence of acute and active psychosis. Because of the elevated risk for malingering and its effect on accuracy on test scores, any involvement in litigation and completing the assessment for court related purposes, and/or elevated scores on measures of malingering were exclusionary. From each protocol, only specific measures included for analysis in this study were collected, included in the dataset, and analyzed, and these measures were chosen based on research and clinical support and utility.

TBI, dementia, and epilepsy studies suggest that mood impacts objective measures and subjective reports of neurocognitive dysfunction differently (Esbjornsson et al., 2013; Spikman et al., 2010; Struchen et al., 2008). For example, Marino and colleagues (2009) found that epilepsy patients tended to demonstrate moderate effects between subjective perception of cognitive function and mood with little to no relationship between objective measures and mood. These findings suggest that mood, specifically depression, may be an important covariate for this study.

Out of 367 files reviewed, 98 met inclusion and exclusion criteria for this study. Of the 98 participants, most were White (82.7%), slightly over half were female (53.1%), and two-thirds were aged 25 and under (68.4%). The mean age of this study's participants was 25.97 years old (SD = 11.59), and the mean age of drinking onset was 13.96 years (SD = 1.36). Age of drinking onset was assessed by asking each participant how old he or she was when they had their first drink containing alcohol. Participants were referred by a psychiatrist (36.7%) or psychotherapist (29.6%), and in the medical practice from which these records were gathered, referral questions included assessment of memory problems, attentional problems, and other cognitive problems. In other words, assessment of addiction was not a referral question for this sample. See Table 5 for this study's demographics.

Table 5

Participant Demographics

Demographics, No. (%)	Number (%)
Age, mean (SD)	25.97 (11.59)
Men	46 (46.9)
Women	52 (53.1)
Race/ethnicity	
White	81 (82.7)
Latino/a	5 (5.1)
Black	7 (7.1)
Asian	5 (5.1)
Age of drinking onset, mean (SD)	13.96 (1.36)
Referral Source	
Psychiatrist	36 (36.7)
Psychotherapist	29 (29.6)
Primary care physician	18 (18.4)
Unknown source	8 (8.2)
Word of mouth	5 (5.1)
Website	2 (2.0)

Measures

Objective Measures of Executive Function

To pursue examination of aspects of executive functioning reflective of deficits seen in alcohol treatment populations, widely used measures of abstract thinking, cognitive flexibility, response inhibition, learning and memory, and psychomotor speed were selected.

Abstract thinking. The Wisconsin Card Sorting Test (WCST) is a test of executive and psychomotor functioning measuring reasoning and concept formation (Heaton et al., 1993). A commonly used measure in neuropsychological and TBI assessment settings (McCrea & Powell, 2012), the WCST involves patients sorting cards based on three separate stimulus demands. Successful completion of the WCST requires the individual to perceive alternative sorting strategies and to flexibly shift strategies in response to unprompted changes in the intended target strategy. Perseverative errors occur if the patient continues sorting to a previously correct strategy and not the current strategy. This measure was included in this study to examine abstract thinking. The reliability of the WCST for this study was exceptional (Cronbach alpha = .96) and similar to other study findings examining executive function in alcohol abusing patients (Loeber et al., 2009). This study used the following scales as dependent measures: Total Score, Perseverative Responses, Perseverative Errors, Nonperseverative Responses, Nonperseverative Errors, and Number of Categories Completed. Standard scores from this sample ranged from severely impaired (<55) to Very Superior (145) with means within the normal range (102-106; SD = 14-18).

Response inhibition. The Integrated Visual and Auditory Continuous Performance Test (IVA + Plus) is an assessment instrument which assesses attention, response activation, and behavioral inhibition (Sandford & Turner, 2004). A computer-based continuous performance test, the IVA assesses the patient's ability to both activate responses to a desired prompt (i.e. the number "1") and inhibit responses to distracter prompts (i.e. the number "2"). Failure to respond correctly is considered an omission error whereas responding incorrectly is considered a commission error. The IVA was selected to isolate pure effects of simple response inhibition based on its stimulus simplicity (i.e. two numbers instead of multiple letters) as well as its good reliability and validity (Sandford, Fine & Goldman, 1995; Seckler et al., 1995). Results from the pilot study suggest that measures of auditory and visual prudence may be the most appropriate measures of response inhibition for this study. Prudence is a measure of the ability to stop, think, and not automatically react to a foil (distracter). If a person has a low Prudence score, he or she can be described as having problems with response inhibition and impulse control, and may also be demonstrating carelessness in responding and over-reactivity (Sandford & Turner, 2004). The reliability of the IVA for this study was exceptional (Cronbach alpha = .94), which is a significant increase from IVA normative studies. This study included measures of auditory and visual vigilance, and auditory and visual prudence. The mean score for Auditory Prudence was within the normal range (M= 91.6, SD = 27.0), but mean scores for Visual Prudence (M = 87.2, SD = 25.0), Auditory Vigilance (M = 77.8, SD 34.9), and Visual Vigilance (M = 77.8, SD 37.0) fell in ranges indicative of significant deficits according to the IVA manual (Sandford and Turner, 2004). Standard scores ranged from extremely impaired (0) to Superior (121).

Complex working memory. The Wechsler Adult Intelligence Scale – Fourth Edition Working Memory Index (WAIS-IV WMI; Wechsler et al., 2008) is a measure of working memory abilities, which involve attention, concentration, mental control and reasoning. Subtests of the WMI include Digit Span which contains three measures of rote learning, memory, attention, auditory processing, mental manipulation, and working memory; and Arithmetic which measures mental manipulation, concentration, attention, short and long term memory, and numerical reasoning. The WMI has been validated for use in neuropsychological assessment batteries and uses standard scores (McCrea & Powell, 2012). The reliability of the WMI for this study was good (Cronbach alpha = .86). The sample mean (M = 100.6, SD = 13.7) was within normal limits, and scores ranged from Impaired (68) to Very Superior (150).

Psychomotor speed. The Trail Making Tests of the Halstead Reitan Battery (TMT; Reitan & Wolfson, 1993) is a two part task (labeled Trails A and Trails B) designed to assess visual-motor processing, selective attention, and cognitive flexibility (Reitan & Wolfson, 1993; Roberts & Horton, 2002). It is a multifaceted task requiring both speed, accuracy, and flexibility for successful execution and highly sensitive to brain damage and executive dysfunction (Bates et al., 2006). Trails A is a speed based test which consists of 25 consecutive numbered circles that the client connects in succession by drawing continuous lines in the series. TMT-A has been widely accepted in the literature as one of the most sensitive measures of cognitive impairment and is widely used to screen individuals with alcohol and drug abuse problems (Roberts & Horton, 2002). The mean Standard score (M = 99.7, SD = 16.2) was within normal limits, and scores ranged from extremely impaired (49) to Very Superior (137).

Cognitive flexibility. The Trail Making Tests of the Halstead Reitan Battery Part B is a more complex task requiring the client to engage in a task with both a series of numbers (1-13) and letters (A-L) and mentally set shift to connect the numbers and letters alternately (i.e. 1-A-2-B…). Errors and corrections count toward increasing performance time (Reitan & Wolfson, 1993). TMT-B is also a highly sensitive instrument to cognitive impairment and has been widely studied with alcohol abusing populations

(Roberts & Horton, 2002). Raw scores obtained from each protocol (measured in seconds) were converted to standard scores for ease of comparison with other objective measure standard scores. Raw scores were subtracted from the mean score (in seconds), and this score was then divided by the standard deviation. Next, this number was multiplied by 15 and then added to 100 to produce a standard score. The mean standard score (M = 94.4, SD = 17.5) was also within normal limits with scores ranging from extremely impaired (42) to Superior (124) range. Cronbach's alpha for TMTA and TMTB is .713, which is considered acceptable.

Self-Reported Executive Function

To pursue examination of self-report aspect of executive functioning reflective of deficits seen in alcohol treatment populations, a general self-report measure encompassing measures parallel to the objective measures portion, such as abstract thinking, cognitive flexibility, response inhibition, learning and memory, and psychomotor speed.

Behavior Rating Inventory of Executive Function – Adult version (BRIEF-A). The BRIEF-A (Roth et al., 2005) is a self-report measure used to assess perceptions of behaviors in specific executive functioning domains. The BRIEF-A domains and clinical scales are non-overlapping and aligned with theoretical and empirically derived domains of executive function. The BRIEF consists of two indexes: Behavioral Regulation (BRI) and Metacognition (MI). The BRI is comprised of four scales (Inhibit, Shift, Emotional Control, and Self-Monitor) and the MI contains five scales (Initiate, Working Memory, Plan/Organize, Task Monitor, and Organization of Materials). Higher scores are indicative of greater perceived executive function difficulties. The Cronbach alpha reliability values of the BRIEF indices for this study ranged from .73 (Inhibit scale) to .94 (Emotional Control scale), which mirror similar results from the normative BRIEF sample (Roth et al., 2005).

Addiction Severity

To identify alcohol addiction severity while mitigating the potentially confounding effects of self-reported behavior, a behaviorally-based measure of alcohol use severity was selected for this study.

AUDIT. Alcohol addiction severity and treatment outcome was assessed using the AUDIT, a 10-item screening instrument for hazardous and harmful alcohol consumption (Saunders et al., 1993). An instrument designed to identify people who would benefit from reducing or ceasing drinking, the AUDIT covers the domains of alcohol consumption, drinking behavior, and alcohol-related problems (Babor et al., 2001). Scores above the threshold of 8 or greater typically indicate likely problematic and harmful use. The AUDIT has been validated for use across numerous subpopulations. The reliability of the AUDIT for this study was good (Cronbach alpha = .79), which is similar to the normative sample (Saunders et al., 2003), among alcohol abusing patients (Babor et al., 2001), and in recent neuropsychological validation studies (Lundin et al., 2015). The mean score was 11.71 (SD = 5.23) with scores ranging from 8 to 33.

Mood

In accordance with prior studies illustrating the impact of mood on subjective measures of EF, three measures of mood as covariates were selected for this study.

MMPI-2 RC scales. In the current study, mood was controlled for using the following MMPI-2 Restructured Clinical (RC) Scales: RCdem scale (demoralization – overall life distress), RC2 scale (Depression), and RC7 scale (Psychasthenia). The MMPI-2 RC scales were selected since they include most of the variance for each clinical scale and also have a global measure of general mood distress (RCdem). The reliability for the RC scales included in this study's analysis was good (Cronbach's alpha = .77) and similar to RC scale validations studies (Sellbom et al., 2008) and studies examining alcohol abusing patients (Walvoort et al., 2012). The sample mean for the RCdem scale was T = 62.26 (SD = 12.03) with a range of scores from 37 to 89. For the RC2 and RC7 scales, the sample mean scores were not significantly elevated (RC2 M = 63.67, SD = 16.38; RC7 M = 62.51, SD = 13.75) but manifested T-score ranges from 33 to 109. Covariate mood measures (along with age of drinking onset covariate) were entered simultaneously into the regression model in the first block to control for the amount of variance explained by covariates. Independent executive function measures (objective and subjective) were inputted subsequently into later blocks in the regression model to identify unique variance explained by these measures.

Design and Data Analysis

Aim 1: This study explored the interrelationships between objective tests and subjective measures of executive function among alcohol abusing individuals.

H1 hypothesized that all objective measures of executive function will more strongly intercorrelate with each other than with any subjective measure scales or subscales, and the subjective measure scales of executive function domains will more strongly intercorrelate with each other than with any of the objective measures of executive function.

This initial hypothesis was tested through performing a multitrait-multimethod analysis of convergent and discriminant validity for monomethod and heteromethod scales. Specifically, correlations were calculated for monomethod and heteromethod domains, and then a canonical correlation was calculated to investigate the overall correlation between two sets of variables, objective and subjective. Canonical correlation specifically allows for comparison of results across method (objective-subjective) within specific domains of executive function. In this study, the sets of variables include objective executive function performance and subjective perception of executive function performance.

Aim 2: This study explored the incremental variance explained by objective and subjective measures of executive function with alcohol addiction severity as the outcome and mood and age of alcohol use onset as covariates.

H2 was tested initially through examining correlations between executive function measures and correlates as well as alcohol addiction severity. Next, multiple linear regression was used to identify which measures are more closely related to alcohol addiction severity while covarying mood and age of alcohol use onset. Initially, mood and age of drinking onset were entered into the model hierarchically using block entry. In the second block entry step, the executive function measures were entered. The first regression only included objective measures in the second step, the second regression was limited to subjective report measures in step two, and the third regression included both objective and subjective measures in the second step of the model. F-tests initially were analyzed to determine significance, and t-tests and beta weights were subsequently analyzed for strength and direction of prediction. Beta weight sizes were compared to assess the best measure of executive function associated with alcohol addiction severity. The R^2 showed the percent of variance explained by each domain of variables as well as each variable.

Aim 3: This study explored the relationships between objective and subjective measures of executive function within distinct domains of neurocognitive functioning and with alcohol addiction severity as the outcome measure and mood and age of alcohol use onset as covariates.

Prior to these analyses, theoretical models, empirical research findings were conducted to identify the most appropriate composite factors. Six composite factors were identified in the principal component analysis which explained almost 75% of the model variance. The objective factors were reduced based on theoretical and empirical findings to three composites: Executive Cognitive Function which includes all five WCST variables measured, Working Memory which includes the WMI, and Attentional Control which includes the four IVA variables plus TMTA and TMTB.

According to the BRIEF manual, scales grouped into two factors of behavioral regulation and metacognition (Roth et al., 2005), but studies have shown a third factor, emotional control, to emerge with ADHD and TBI populations (Harvey, 2012; Roth et al., 2013). Based on these studies, the Emotional Control and Shift scales were omitted from Aim 3's analysis. After close review of the BRIEF manual (Roth et al., 2005) and the aforementioned research studies, three composites were created: Executive Cognitive Function which includes Plan/Organize, Task Monitor, and Organization of Materials scales, Working Memory which includes Working Memory scale, and Attentional Control which includes Inhibit, Self Monitor, and Initiate scales.

Next, composite variables were calculated for domains of Executive Cognitive Function, Attention, and Working Memory in each of objective measure and subjective perception domains. Composite variables were created by taking the average of the standard scores for each domain. For the BRIEF scales, the T-scores were first transformed into standard scores and then averaged. For the second analysis, objective and subjective measures were collapsed into the three domains of Executive Function, Attention and Working Memory. These composite scores were created by adding each domain's objective and subjective composite scores.

To assess H3, two regression analyses were performed. As with H2, hierarchical regression was performed, and covariates were entered into the first block with composite variables entered into the second block. Linear regression was used for both across and within domain analyses to explore this aim across domains of executive function. Specifically, F-tests initially were analyzed to determine significance, and t-tests and beta weights were subsequently analyzed for strength and direction of these relationships.

The current study employed a within-subjects design to maximize power. Data were analyzed using Statistical Package for the Social Sciences (SPSS), Version 22.0 (IBM Corp., 2011). Initially, descriptive statistics of mean and SD were calculated. The p-level for significance of tests was set at $p < 0.05$.

CHAPTER FOUR

Results

Descriptive statistics were calculated to understand the nature of the outpatient population with alcohol abuse issues seeking an assessment for possible neuropsychological impairments. Descriptive statistics were calculated for each measure included in this study.

Objective performance based measure descriptive statistics are included in Table 6. Each scale is converted to a standard score with a mean of 100 and standard deviation of 15. Within this assessment method, only the IVA Visual Prudence, IVA Auditory Vigilance, and IVA Visual Vigilance mean scores were considered below average, and only the two IVA measures of Vigilance were below one standard deviation.

Table 6

Descriptive statistics for objective measures of executive function

Instrument/Scale	M (SD)
Working Memory Index (WMI)	100.60 (13.71)
Trail Making Test A	99.69 (16.21)
Trail Making Test B	94.39 (17.48)
WCST Total Score	103.97 (15.60)
WCST Perseverative Responses	106.15 (18.04)
WCST Perseverative Errors	105.92 (17.26)
WCST Nonperseverative Errors	102.83 (14.12)
WCST Conceptual Level	103.65 (16.20)
IVA Auditory Prudence	91.59 (27.03)
IVA Visual Prudence	87.24 (25.01)*
IVA Auditory Vigilance	77.79 (34.87)*
IVA Visual Vigilance	77.81 (37.02)*

M = mean; SD = standard deviation

* Denotes clinically significant elevation according to each respective test's manual

Demographic data for the subjective self-report BRIEF illustrate similar findings. Only the Working Memory, Task, MI and GEC mean scores fell in the significantly elevated range (see Table 7).

Table 7

BRIEF Descriptive Statistics

Scale	M (SD)	Range
Inhibit	61.58 (13.00)	37 - 88
Shift	60.16 (13.32)	4 - 91
Emotional Control	56.49 (11.67)	38 - 85
Self-Monitor	56.62 (11.99)	37 - 84
BRI composite	60.02 (11.00)	38 - 85
Initiate	64.84 (11.40)	40 - 96
Working Memory	70.36 (13.88)*	39 - 99
Plan Organize	64.63 (11.40)	40 - 96
Task	66.93 (13.46)*	40 - 99
Organization of Materials	60.38 (13.33)	36 - 89
MI composite	67.80 (12.44)*	38 - 102
GEC composite	65.17 (11.82)*	39 – 96

M = mean; SD = standard deviation
* Denotes clinically significant elevation according to normative data published in respective test's manual

Demographics were calculated for mood covariates as measured by the MMPI-2 (T-score mean = 50, sd = 10). None of the mood measures were significantly above the mean. Scores ranged from 33 to 109, with the largest spread occurring on the RC2 scale (Low Positive Emotions). Table 8 denotes the MMPI-2 RC scale demographics.

Table 8

MMPI-2 Descriptive Statistics for RC scales

Scale	M (SD)	Range
RCd – Demoralization	62.26 (12.03)	37 – 89
RC2 – Low Positive Emotions	63.67 (16.37)	33 – 109
RC7 – Dysfunctional Negative Emotions	62.51 (13.75)	34 – 92

M = mean; SD = standard deviation

For the AUDIT, a score of 8 is the minimum score allowed for inclusion in this study, which denotes significant problems with alcohol use. Since this study's primary purpose is to assess cognitive deficits with alcohol abusing individuals, only participants with significant alcohol use were included, thus raising the mean score for the AUDIT. The mean score for the AUDIT in this study was 11.71 (SD = 5.23) with a range of 8 to 33.

This study's first hypothesis stated that all objective measures of executive function will more strongly intercorrelate with each other than with any subjective measure scales or subscales, and the subjective measure scales of executive function domains will more strongly intercorrelate with each other than with any of the objective measures of executive function. To test this hypothesis, multiple correlations were calculated. First, correlations among objective measures (Table 9) and subjective measures (Table 10) were performed separately. Next, a multitrait-multimethod correlation matrix was run to test convergent and divergent validity (Table 11). Significant correlations were examined.

Within the objective measures domain, performance based working memory (WMI) was significantly correlated with both objective cognitive flexibility (TMTB; $r = .39$, $p < .001$) and all five Wisconsin Card Sorting Test measures of abstract thinking ($p < .01$). A continuous performance based measure of Visual Vigilance correlated significantly with measures of cognitive flexibility (TMTB; $r = .30$, $p = .002$), four out of five abstract thinking measures (WCST, $p < .05$; the fifth abstract thinking measure approached significance at $p = .055$). Most of the significant correlation results indicate medium to large effects within objective measures of executive function.

Interestingly, both auditory response inhibition scales (Prudence, Vigilance) correlated significantly with both Auditory and Visual scales of Prudence and Vigilance, but the Visual component to each scale did not significantly correlate to the Auditory component of the other scale (i.e. Visual Vigilance did not significantly correlate with Auditory Prudence, and Visual Prudence did not significantly correlate with Auditory Vigilance).

Within the domain of subjective self report measures of executive function, each BRIEF scale and composite scale was found to be significantly correlated with each of the other scales measured and included in this study at the $p < .001$ level. These results suggest medium to large effects among individual self report scales of executive function.

To understand the relationship between each set of executive function measures (objective and subjective) and establish discriminant validity, an examination of correlations across methods was conducted. First, correlations were examined between each objective performance and subjective perception pairing. Bonferroni corrections were performed to eliminate Type I error. Objective performance on measures of abstract reasoning (WCST) was significantly correlated with the following subjective perception scales: Inhibit, Shift, Self Monitor, Initiate, Plan/Organize, Task Completion, and Organization of Materials. Subjective perception of working memory deficits (Working Memory scale) was significantly associated with objective performance on the Working Memory Index, WCST, and the Visual Prudence continuous performance test

Table 9

Objective measure correlation matrix

Objective Measures	1	2	3	4	5	6	7	8	9	10	11
1. WMI	-										
2. TMTA	.09	-									
3. TMTB	.39**	.56**	-								
4. WCST Total	.36**	.13	.13	-							
5. WCST Perseverative Responses	.28**	.04	.11	.84**	-						
6. WCST Perseverative Errors	.29**	.07	.12	.86**	.98**	-					
7. WCST Nonperseverative Errors	.39**	.15	.16	.94**	.69**	.71**	-				
8. WCST Conceptual Level	.36**	.13	.12	.97**	.80**	.82**	.92**	-			
9. IVA Auditory Prudence	.06	.01	.16	.10	.13	.11	.12	.11	-		
10. IVA Visual Prudence	-.03	-.06	-.01	.04	.02	-.01	.05	.06	.64**	-	
11. IVA Auditory Vigilance	.06	-.04	.11	.12	.12	.15	.14	.14	.30*	.08	-
12. IVA Visual Vigilance	.17	.06	.30**	.22*	.19	.21*	.22*	.25*	.46**	.21*	.51**

* p < .05, ** p < .01

Table 10

Subjective report correlation matrix

Subjective Reports	1	2	3	4	5	6	7	8	9
1. Inhibit	-								
2. Shift	.29**	-							
3. Emotional Control	.38**	.46**	-						
4. Self Monitor	.60**	.34**	.37**	-					
5. Initiate	.41**	.45**	.42**	.38**	-				
6. Working Memory	.51**	.51**	.45**	.36**	.64**	-			
7. Plan/Organize	.48**	.56**	.47**	.46**	.72**	.75**	-		
8. Task	.42**	.42**	.22*	.38**	.60**	.57**	.63**	-	
9. Organization of Materials	.43**	.37**	.40**	.36**	.41**	.60**	.68**	.47**	-

* p < .05, ** p < .01

Table 11

Correlation matrix with objective-subjective method pairs

Executive Function Measures	Inhibit	Shift	Emotional Control	Self Monitor	Initiate	Working Memory	Plan/ Org	Task	Org of Materials
WMI	-.07	-.13	-.01	-.14	-.15	-.27**	-.11	-.28**	-.09
TMTA	-.10	-.19	-.09	-.10	-.15	.03	-.05	.02	-.05
TMTB	.02	-.10	.08	-.02	-.01	.12	.10	.01	-.02
WCST Total	-.30**	-.20**	-.16	-.21*	-.31**	-.31**	-.20*	-.24*	-.20*
WCST Persev Responses	-.23*	-.11	-.10	-.17	-.27**	-.28**	-.20	-.16	-.19
WCST Persev Errors	-.24*	-.11	-.10	-.19	-.27**	-.27**	-.20	-.16	-.17
WCST Nonpersev Errors	-.28**	-.21*	-.15	-.16	-.32**	-.29**	-.19	-.29**	-.20*
WCST Conceptual Level	-.30**	-.18	-.11	-.19	-.28**	-.32**	-.17	-.22*	-.18
IVA Auditory Prudence	-.12	-.01	-.11	-.08	-.06	-.16	-.10	-.03	-.10
IVA Visual Prudence	-.23*	-.10	-.13	-.17	-.08	-.24*	-.19	-.14	-.08
IVA Auditory Vigilance	-.31**	-.03	.02	-.02	-.11	-.20	-.12	-.15	-.08
IVA Visual Vigilance	-.17	-.03	.02	-.15	-.08	-.16	-.05	-.09	-.15

* p < .05, ** p < .01

scale. In addition, the subjective Inhibit scale was significantly correlated with objective measures of abstract reasoning (WCST), and Visual Prudence and Auditory Vigilance continuous performance measure scales. Overall, there is high convergent validity across objective and subjective measures of executive function, which is contrary to what was hypothesized.

A better way to measure discriminant validity between objective and subjective measures is through canonical correlation, which measures the linear relationship within each domain of measurement. Specifically, canonical correlation assesses the linear relationship between two sets or domains of variables. For this study, the sets are objective performance based measures and subjective self report tests of executive function with alcohol abusing individuals. Omnibus tests of significance showed the Wilks' lambda value as not significant ($\Lambda = 0.23$; $F = 1.18$; $p = .12$). In addition, no canonical roots were statistically significant. These results indicate that there is no significant linear relationship between the two sets of variables, and can conclude that the two sets of variables, objective performance and subjective perception, are independent.

Aim 2 sought to investigate the incremental variance explained by objective and subjective measures of executive function with alcohol addiction severity as the outcome and mood and age of alcohol use onset as covariates. Procedurally, Aim 2 was examined through separate multiple regression analyses to test convergent and divergent validity to explore the incremental variance explained by objective and subjective measures of executive function with alcohol addiction severity as the outcome and mood and age of alcohol use onset as covariates.

First, correlation matrices were run to assess executive function measure correlations with both mood and age of drinking onset covariates as well as with the alcohol addiction severity outcome measure. Results from correlations performed with objective measures of executive function showed that age of drinking onset was correlated with measures of working memory and abstract reasoning. The depression and anxiety mood covariates were only correlated with the IVA Visual Prudence scale. Neither the MMPI RCdem measure of overall life distress nor the AUDIT were significantly correlated with any objective measure of executive function. Results can be found in Table 12.

Table 12

Objective measure correlation matrix with covariates and AUDIT

Objective Measures	Age of Drinking Onset	MMPI RCdem	MMPI RC2	MMPI RC7	AUDIT
1. WMI	.21*	-.025	.023	.009	-.16
2. TMTA	.077	.071	.14	-.015	.013
3. TMTB	-.039	.18	.085	-.026	-.11
4. WCST Total	.21*	-.084	.044	-.009	-.057
5. WCST Perseverative Responses	.22*	-.011	.094	.015	-.073
6. WCST Perseverative Errors	.24*	-.012	.096	.016	-.11
7. WCST Nonperseverative Errors	.21*	-.068	.058	.015	-.047
8. WCST Conceptual Level	.22*	-.062	.036	.032	-.024
9. IVA Auditory Prudence	.011	.048	-.12	-.16	-.004
10. IVA Visual Prudence	-.033	-.16	-.22*	-.25*	-.008
11. IVA Auditory Vigilance	-.070	.000	.12	.055	-.041
12. IVA Visual Vigilance	-.033	.077	.093	-.054	-.022

* p < .05, ** p < .01

Results from correlations performed between subjective measures of executive function and both covariates and outcome measures showed a variety of significant correlations. The MMPI RCdem scale correlated with all BRIEF scales except Inhibit and Organization of Materials, and the RC2 and RC7 scales also correlated highly with most BRIEF scales. The AUDIT was only significantly correlated with the BRIEF Inhibit scale, and age of drinking onset was not significantly correlated with any subjective measure of executive function. Results are detailed in Table 13.

Table 13

Subjective measure correlation matrix with covariates and AUDIT as outcome

BRIEF Scales – Subjective Measures	Age of Drinking Onset	MMPI RCdem	MMPI RC2	MMPI RC7	AUDIT
Inhibit	-.14	.18	.004	.020	.27**
Shift	.002	.40**	.18	.45**	-.055
Emotional Control	.016	.33**	.36**	.31**	.024
Self Monitor	-.17	.22*	.035	.19	.16
Initiate	.022	.43**	.32**	.31**	.003
Working Memory	.082	.40**	.25*	.28**	-.034
Plan/Organize	-.010	.32**	.19	.25*	.022
Task	.12	.25*	-.027	.11	-.14
Organization of Materials	-.014	.16	.024	.19	.035

* $p < .05$, ** $p < .01$

Next, a regression containing only objective measures of executive function plus covariates was done to isolate the relationship with alcohol addiction severity. In this first model, the mood and age of drinking onset covariates explained about 23% of variance ($R^2\ \Delta = .23$, $p < .001$) with age of drinking onset as the only significant covariate. The addition of objective measures of executive function explained an additional 9.8% of model variance ($R^2\ \Delta = .098$, $p = .45$) which was not significant. Age of drinking onset persisted as the only significant predictor of alcohol addiction severity ($\beta = -.51$, $p <.001$). The overall model was significant ($R^2 = .33$, $F(16,81) = 2.44$, $p = .005$), but the addition of objective measures did not significantly impact the model (significant F change = .45449). A summary of this analysis is included in Table 14.

Table 14

Objective Measures Regression Analyses Predicting Alcohol Consumption Severity

Regression	ΔR^2	*F*	df_1	df_2	sig.	β	*t*	*p*	LLCI	ULCI	sp*r*
Step 1	.23	6.74	4	93	<.001						
RCdem						.01	.08	.93	-.10	.11	<.001
RC2						.07	.61	.54	-.05	.10	.003
RC7						-.04	-.37	.72	-.10	.07	.001
Age Onset						-.48	-5.17	<.001	-2.53	-1.13	.22
Step 2	.098	2.44	12	81	.005						
RCdem						.08	.52	.59	-.09	.16	.002
RC2						.06	.51	.61	-.06	.10	.002
RC7						-.10	-.83	.41	-.13	.05	.006
Age Onset						-.50	-5.00	<.001	-2.70	-1.16	.21
WMI						.01	.05	.96	-.08	.09	<.001
TMTA						.18	1.49	.14	-.02	.14	.019
TMTB						-.25	-1.86	.07	-.16	.01	.029
WCST Total						-.27	-.42	.68	-.53	.34	.001
WCST PerResp						.97	1.73	.09	-.04	.60	.025
WCST PerErr						-1.08	-1.66	.10	-.72	.07	.023
WCST NonpErr						-.05	-.13	.90	-.28	.25	<.001
WCST ConRes						.51	1.30	.20	-.09	.42	.014
IVA Aud Pru						.02	.15	.88	-.05	.06	<.001
IVA Vis Pru						-.04	-.32	.75	-.06	.05	<.001
IVA Aud Vig						-.04	-.37	.71	-.04	.03	.001
IVA Vis Vig						.01	.09	.93	-.03	.04	<.001

* $p < .05$, ** $p < .01$

Note. Table 14 illustrates the effects of mood, age of drinking onset and objective measures of executive function on alcohol addiction severity. *F* = F change, sig. = significant F change, df_1 = degrees of freedom between, df_2 = degrees of freedom within, β = standardized beta, LLCI = lower limit confidence interval, ULCI = upper limit confidence interval, sp*r* = semi-partial R^2.

The second regression contained only subjective measures as independent variables. In this second model, the mood and age of drinking onset covariates explained about 23% of variance ($R^2\ \Delta = .23$, $p < .001$) with age of drinking onset again as the only significant covariate. The addition of subjective measures of executive function explained an additional 9.8% of model variance (R^2 Δ = .098, p = .23), which was not statistically significant. Age of drinking onset (β = -1.47, p <.001), as well as the Inhibit scale (β = -.15, p = .007) were the only significant predictors of alcohol addiction

Table 15

Subjective Test Regression Analyses Predicting Alcohol Consumption Severity

	ΔR^2	*F*	df_1	df_2	sig.	β	*t*	*p*	LLCI	ULCI	sp*r*
Step 1	.23	6.74**	4	93	<.001						
RCdem						.005	.084	.93	-.10	.11	<.001
RC2						.023	.61	.54	-.051	.097	.003
RC7						-.016	-.37	.72	-.10	.070	.001
Age Onset						-1.83	-5.17**	<.001	-2.53	-1.13	.223
Step 2	.098	3.08**	13	84	.001						
RCdem						.016	.27	.79	-.10	.13	<.001
RC2						.016	.39	.70	-.065	.097	.001
RC7						.013	.29	.78	-.079	.11	<.001
Age Onset						-1.47	-3.98**	.000	-2.20	-.74	.13
Inhibit						.15	2.79**	.007	.042	.25	.063
Shift						-.031	-.64	.52	-.13	.066	.003
Emotional Control						-.031	-.57	.57	-.14	.075	.003
Self Monitor						-.010	-.18	.86	-.12	.096	<.001
Initiate						.013	.18	.85	-.123	.15	<.001
Working Memory						-.043	-.74	.46	-.16	.073	.005
Plan/Organize						.037	.49	.62	-.11	.19	.002
Task						-.088	-1.68	.096	-.19	.016	.023
Organization-Materials						.010	.19	.85	-.09	.11	<.001

* p < .05, ** p < .01

Note. Table 15 illustrates the effects of mood, age of drinking onset and subjective tests of executive function on alcohol addiction severity. *F* = F change, sig. = significant F change, df_1 = degrees of freedom between, df_2 = degrees of freedom within, β = standardized beta, LLCI = lower limit confidence interval, ULCI = upper limit confidence interval, sp*r* = semi-partial R^2.

severity. The overall model was significant (R^2 = .32, F (13,84) = 3.08, *p* = .001). A summary of this analysis is included in Table 15.

In the regression analysis which included both objective and subjective measures, mood and age of onset covariates again explained about 23% of the model variance ($R^2 \Delta$ = .23, p <.001), and both objective and subjective perception measures of executive function explained another 23% ($R^2 \Delta$ = .23, p = .13), though not significant. Age of drinking onset, WCST Perseverative Responses, WCST Perseverative Errors, BRIEF Inhibit, and BRIEF Task all demonstrated significant beta weights in the combined model including covariates plus both objective and subjective measures of executive function. Although not statistically significant, the TMTA appeared to explain some of the model variance and may be a useful variable to include and examine in future analyses. The overall model was significant (R^2 = .46, F (25,72) = 2.40, *p* = .002). Results suggest that mood disruption may not be a significant covariate to consider for this sample, but age of drinking onset definitely is significant and important to consider in comparing objective and subjective measures associations with alcohol addiction severity. In addition, a combination of objective and subjective measures together appear to glean more significant additions to the model than when examined separately. A summary of these analyses are in Table 16.

When alcohol addiction severity was predicted using age of drinking onset and mood as covariates, there were medium positive associations between alcohol addiction severity and number of perseverative responses given on an abstract thinking task (WCST Perseverative Responses β = 1.15, *p* = .040) as well as number of perseverative errors made (WCST Perseverative Errors β = -1.36, *p* = .037). Subjective perception

Table 16

Objective Measure and Subjective Test Combined Regression Analyses Predicting Alcohol Consumption Severity

	ΔR^2	*F*	df_1	df_2	sig.	β	*t*	*p*	LLCI	ULCI	spr
Step 1	.23	6.74**	4	93	<.001						
RCdem						.011	.084	.93	-.10	.114	<.001
RC2						.071	.61	.54	-.051	.097	.003
RC7						-.041	-.37	.72	-.10	.070	.001
Age Onset						-.48	-5.17**	<.001	-2.53	-1.13	.22
Step 2	.23	2.40**	25	72	.002						
RCdem						.10	.74	.47	.049	.086	.004
RC2						-.004	-.026	.98	.031	-.003	<.001
RC7						-.014	-.11	.92	.030	-.013	<.001
Age Onset						-.37	-3.30**	.002	-.47	-.36	.082
WMI						-.10	-.79	.43	-.16	-.092	.005
TMTA						.24	1.92	.058	.013	.22	.028
TMTB						-.25	-1.70	.093	-.11	-.20	.022
WCSTTotal						.12	.18	.86	-.057	.021	<.001
WCST PerResp						1.15	2.09*	.040	-.073	.24	.033
WCST PerErr						-1.36	-2.12*	.037	-.11	-.24	.034
WCST NonprEr						-.34	-.92	.63	-.047	-.11	.006
WCST ConRes						.53	1.34	.19	-.024	.16	.013
IVA AudPru						-.004	-.031	.98	-.004	-.004	<.001
IVA VisPru						.015	.11	.91	-.008	.013	<.001
IVA AudVig						.91	.74	.46	-.041	.087	.004
IVA VisVig						.018	.15	.88	-.022	.017	<.001
Inhibit						.47	3.25**	.002	.27	.36	.080
Shift						-.043	-.33	.74	-.055	-.039	.001
Emo Control						-.084	-.69	.49	.024	-.081	.004
Self Monitor						-.065	-.51	.61	.16	-.060	.002
Initiate						.074	.45	.65	.003	.053	.002
Working Mem						-.027	-.15	.88	-.034	-.018	<.001
Plan/Organize						.059	.29	.77	.022	.035	.001
Task						-.34	-2.35*	.02	-.14	-.27	.042
Org-Materials						.034	.24	.81	.035	.029	<.001

* p < .05, ** p < .01

Note. Table 16 illustrates the effects of mood, age of drinking onset and both objective and subjective tests of executive function on alcohol addiction severity. *F* = F change, sig. = significant F change, df_1 = degrees of freedom between, df_2 = degrees of freedom within, β = standardized beta, LLCI = lower limit confidence interval, ULCI = upper limit confidence interval, sp*r* = semi-partial R^2.

measures of Inhibit and Task both showed small associations with alcohol addiction severity (BRIEF Inhibit β = .47, *p* = .002; BRIEF Task β = -.34, *p* = .022).

Based on these results, we conducted a regression analysis to identify the unique variance explained by each significant measure from H2 after covarying age of drinking onset since it emerged as a significant covariate, while mood variables did not. The overall model included age of drinking onset as a covariate, objective measures of TMTA, WCST Perseverative Responses, and WCST Perseverative Errors, and subjective measures of Inhibit and Task. The overall model was statistically significant ($F(6,91) = 7.90$, $p < .001$). In the first block, age of drinking onset as a covariate explained 22% of

Table 17

Significant Objective Measure and Subjective Test Combined Regression Analyses Predicting Alcohol Consumption Severity

	ΔR^2	*F*	df_1	df_2	sig.	β	*t*	*p*	LLCI	ULCI	sp*r*
Step 1	.22	27.10	1	96	<.001						
Age Onset						-.47	-5.21**	<.001	-2.49	-1.12	.22
Step 2	.13	7.90	6	91	<.001						
Age Onset						-.40	-4.38**	<.001	-2.20	-.83	.14
TMTA						.10	1.17	.24	-.02	.09	.01
WCST Persev Resp						1.01	2.11*	.04	.02	.57	.03
WCST Persev Errors						-.98	-2.03*	.05	-.59	-.01	.03
Inhibit						.33	3.35**	.001	.05	.21	.08
Task						-.23	-2.38*	.02	-.16	-.02	.04

* p < .05, ** p < .01

Note. Table 17 illustrates the effects of significant scales that emerged from previous regression analyses on alcohol addiction severity. *F* = F change, sig. = significant F change, df_1 = degrees of freedom between, df_2 = degrees of freedom within, β = standardized beta, LLCI = lower limit confidence interval, ULCI = upper limit confidence interval, sp*r* = semi-partial R^2.

the model variance ($R^2 \Delta = .22$). The addiction of objective measures of processing speed (TMTA) and perseverative responses (WCST Perseverative Responses) combined with subjective measures of Inhibit and Task in the second block explained 13% of the model variance of variance in the model ($R^2 \Delta = .13$). A summary of these results can be found in Table 17.

Finally, Aim 3 sought to explore the relationships between objective and

Table 18

Objective and Subjective Composite Variable Regression Analyses Predicting Alcohol Consumption Severity

	ΔR^2	*F*	df_1	df_2	sig.	β	*t*	*p*	LLCI	ULCI	sp*r*
Step 1	.23	6.74	4	93	<.001						
RCdem						.01	.08	.93	-.10	.11	<.001
RC2						.07	.61	.54	-.05	.10	.01
RC7						-.04	-.37	.72	-.10	.07	.001
Age Onset						-.48	-5.17	<.001	-2.53	-1.13	.22
Step 2	.06	3.38	10	87	.001						
RCdem						-.01	-.04	.97	-.12	.11	<.001
RC2						.06	.47	.64	-.06	.09	.002
RC7						-.04	-.32	.75	-.10	.07	.001
Age Onset						-.43	-4.30**	<.001	-2.43	-.89	.15
ECF obj						.12	1.01	.27	-.03	.11	.01
WM obj						-.11	-1.06	.29	-.12	.04	.01
Attn obj						-.04	-.36	.72	-.07	.05	.001
ECF subj						-.17	-1.13	.26	-.15	.04	.01
WM subj						-.05	-.35	.73	-.09	.07	.001
Attn subj						.31	2.24*	.03	.01	.21	.04

* p < .05, ** p < .01

Note. Table 18 illustrates the effects of domain composite method separate scales and covariates (mood, age of drinking onset) on alcohol addiction severity. *F* = F change, sig. = significant F change, df_1 = degrees of freedom between, df_2 = degrees of freedom within, β = standardized beta, LLCI = lower limit confidence interval, ULCI = upper limit confidence interval, sp*r* = semi-partial R^2.

subjective measures of executive function within distinct domains of neurocognitive functioning and with alcohol addiction severity as the outcome measure and mood and age of alcohol use onset as covariates. To assess Aim 3, as with Aim 2, linear regression was used to explore this aim across domains of executive function and between executive function methods. Shift and Emotional Control were not included in the composite variables because prior factor analysis research with ADHD, TBI and healthy adults demonstrate that these scales load on an Emotional Control based factor rather than a behavioral regulation or metacognition (Donders & Strong, 2015; Roth et al., 2013). In

Table 19

Domain Composite Regression Analyses Predicting Alcohol Consumption Severity

	ΔR^2	F	df_1	df_2	sig.	β	t	p	LLCI	ULCI	sp$r$
Step 1	.23	6.74	4	93	<.001						
RCdem						.011	.084	.93	-.10	.11	<.001
RC2						.071	.61	.54	-.051	.097	.003
RC7						-.041	-.37	.72	-.10	.070	.001
Age Onset						-.48	-5.17	<.001	-2.53	-1.13	.22
Step 2	.055	3.38	10	87	.001						
RCdem						.006	.041	.97	-.12	.12	<.001
RC2						.076	.64	.52	-.051	.099	.003
RC7						-.027	-.23	.82	-.099	.079	<.001
Age Onset						-.46	-4.58**	<.001	-2.52	-1.00	.18
ECF						.034	.32	.75	-.048	.066	.001
WM						-.080	-.70	.48	-.074	.035	.004
Attn						.059	-.56	.58	-.041	.073	.003

* p < .05, ** p < .01

Note. Table 19 illustrates the effects of domain composite method separate scales and covariates (mood, age of drinking onset) on alcohol addiction severity. F = F change, sig. = significant F change, df_1 = degrees of freedom between, df_2 = degrees of freedom within, β = standardized beta, LLCI = lower limit confidence interval, ULCI = upper limit confidence interval, sp$r$ = semi-partial R^2.

the first regression comparing objective and subjective domains of Executive Cognitive Functioning (ECF), Attentional Control (AC), and Working Memory (WM), only the subjective Attentional Control composite and Age of Drinking Onset covariate were both significant. A summary of these results can be found in Table 18.

In the second regression examining the domains combining measurement types, the model was significant ($p = .001$), but the only significant variable in the model was the Age of Drinking Onset ($t = -4.58$, $p < .001$). None of the domain composite variables had statistically significant beta weights, but this may be due to lack of sensitivity of the composite variable. Age of drinking onset continues to be statistically significant. A summary of the results can be found in Table 19.

CHAPTER FIVE

Discussion

This study sought to provide evidence for executive function measures most appropriate for use with alcohol abusing individuals possessing subsyndromal cognitive deficits to guide treatment referrals. Specifically, understanding the specific nature of these subsyndromal deficits can help treatment providers craft a comprehensive treatment plan to include cognitively appropriate intervention strategies. Understanding the differential value of objective performance based measures and subjective self reported perceptions of executive function may help clinicians construct an effective multimethod assessment battery to assess the patient's capacity for success in treatment. In addition, understanding the utility and limits of each test based on its type (i.e. objective measure versus subjective self report) will help assessors administer the most appropriate instruments in the shortest amount of time, which will help treatment providers trust the fidelity of their test results and make more appropriate pre-treatment decisions for the patient with an alcohol use disorder.

The first hypothesis postulated that objective tests and subjective reports of executive function would not significantly overlap due to the different type of measurement used (performance based test versus a self report questionnaire) and different domains targeted (objective performance tests provide results of actual ability, whereas subjective reports provide results of one's perceptions about his/her abilities). Results from correlational and canonical correlational data indicate that despite some overlap between objective and subjective test types, the domains of performance based and self report are distinct entities, for the most part.

Results supporting this study's first hypothesis are somewhat similar to prior literature findings illustrating distinct differences between objective and subjective tests (Marino et al., 2009; Vazire & Mehl, 2008); however, significant overlap between some objective and subjective measures is mildly discrepant with prior literature. More importantly, the BRIEF, the primary measure of subjective self report data, has been validated against both objective and subjective measures of executive function (Roth et al., 2005). This may explain this study's overlap of subjective and objective measures. In addition, the sample used for this study is a community sample not being referred for alcohol treatment with few significant executive function deficits. Discrepancies in performance between objective measures and subjective tests tend to be seen in individuals with mild to moderate TBI (Schiehser et al., 2001) and significant emotional disruption (Chamelian & Feinstein, 2006; Marino et al., 2009), These findings suggest that different types of measurement tools may add valuable information to the assessment process, and both may be valuable and important clinically.

Aim 2 sought to identify the incremental validity provided by individual objective and subjective measures of executive function in predicting alcohol addiction severity while controlling for mood and age of drinking onset. Results showed that the age of drinking onset covariate provided the most significant and robust incremental validity for addiction severity. For this population, age of drinking onset was shown to be an important covariate in explaining model variance and may be the most closely associated variable to addiction severity. This finding aligns well with numerous longitudinal studies showing correlations between early onset drinking and future heavy alcohol use (Moss, Chen, & Yi, 2014; Rossow & Kuntsche, 2013) as well as with prior studies examining relapse prevention, treatment efficacy, and alcohol addiction severity (e.g. Hingson, Heeren & Winter, 2006; NIAAA, 2009).

When considering unique variance explained by neuropsychological measures, the picture is less clear. The model including both objective and subjective measures in the second regression block is significant, which shows that neuropsychological testing results are important to consider. Given the varied correlations between neuropsychological measures with all covariates and the AUDIT, the contribution of each individual neuropsychological variable, both objective and subjective, is less clear.

Subjective reports of inhibition (BRIEF Inhibit scale) added significant incremental validity to the model in Aim 2 and is the only neuropsychological measure significantly correlated with alcohol addiction severity. These findings align well with the TBI (Donders et al., 2010) and alcohol use literature (Frazier et al., 2004) and may be more easily recognizable subjectively since this domain typically involves metacognitive processes (Roth et al., 2013) as well as social feedback and consequences (Salgado et al., 2008; Zeigler et al., 2005).

Objective measures of perseverative thinking and the thinking errors caused by perseveration were also both uniquely associated with alcohol addiction severity in this study. These findings align well with the unique alcohol related executive function deficits seen in prior studies (e.g. Du et al., 2002; Oscar-Berman & Marinkovic, 2007; Walvoort et al., 2012) and not included in other measures of brief executive function performance based measures for use with alcohol abusing individuals (Ritz et al., 2015).

Studies on perseveration in alcohol use have found this executive function deficit to be particularly difficult to ameliorate and deficient even in mild alcohol using populations (Martin-Fardon & Weiss, 2016), especially when cognitive impairment and expectancies are coupled (Pabst et al., 2014). Taken together, these findings indicate that objective and subjective domains of executive function offer unique contributions and should be used in tandem toward understanding the complete picture of the patient's cognitive impairments prior to beginning alcohol treatment.

Aim 3's goal was to assess the concurrent validity of domains of functioning on alcohol addiction severity. Executive functioning domains were significant predictors of addiction severity. Results also indicate unique contributions from subjective perception based measures of executive function. Specifically, this population's experience of deficits related to behavioral inhibition and task completion are significantly associated with alcohol addiction severity. As seen in prior studies, these two executive function domains are critical for the patient with alcohol use disorder to adopt relapse prevention strategies and be able to enact abstinence based behaviors (Houston et al., 2014). Given the subsyndromal nature of this population's cognitive deficits, significant results on subjective measures are promising since this demonstrates that the individual with an alcohol use disorder has some awareness of his declining functioning.

This study showed the BRIEF's efficacy and utility in providing useful information about the subsyndromal executive function deficits and subsequent capacities and limitations in alcohol treatment. The BRIEF has been demonstrated across numerous studies to be both sensitive and specific to executive function deficits across various populations (e.g. Huizinga & Smidts, 2011; Roth et al., 2013). Results of this study demonstrate that alcohol using individuals with subsyndromal executive function deficits do indeed have awareness of their behavioral inhibition and task completion deficits, which holds promise for their abilities to engage effectively in treatment. Awareness that these deficits exist and can directly inhibit the individual with alcohol use disorder's ability to abstain from drinking can be a starting point of conversation with the alcohol abusing individual in treatment. Treatment can specifically focus on behaviorally based interventions of behavioral inhibition and ways the patient with alcohol use disorder can complete tasks in a way that is congruent with their abilities and not limited by the executive function deficits. When analyzing the comparative utility of different types of executive function measurement, results suggest that using subjective perception based measures may provide good information about one's attention based skills.

This study also identified perseverative thinking, and its errors, as an important executive function deficit to assess in relation to alcohol addiction severity. Individuals who perseverate on alcohol related cues, stimuli, and thoughts tend to be more severely addicted to alcohol since it is more difficult for them to channel their thoughts away from alcohol (i.e. Bates et al., 2002; Spada et al., 2015). Individuals who tend to perseverate might benefit from interventions designed to stop and redirect thought processes (e.g. coping cards, self-statements, grounding). Redirecting perseverative and persisting thoughts about alcohol may be a simple yet extremely effective intervention for this population. Instead of walking through a complicated role play mimicking a situation involving alcohol, the interventions may wish to focus on a metacognitive model to help identify perseverative thinking patterns that lead the individual with alcohol use disorder to alcohol enticing situations in the first place (i.e. Bates et al., 2002; Spada et al., 2015).

In practice, this model may entail in vivo exposures to alcohol related stimuli in the real world while writing down specific relapse prevention techniques associated with each specific stimuli (i.e. “avoid specific coffee shop next to the bar the alcohol abusing patient used to frequent to drink”) to provide concrete means to redirect perseverative thoughts.

Addiction severity is an important outcome to examine in the context of executive function, and the AUDIT provides an analog measure and correlate of treatment outcome. The AUDIT has shown robust evidence in identifying alcohol dependence, risky drinking, and alcohol use disorder in both clinical alcohol treatment populations (Babor et al., 2001) as well as in the general population (Lundin et al., 2015). This makes the AUDIT an appropriate measure of alcohol addiction severity. The AUDIT also provides a behaviorally based, simple measure that is negatively correlated with treatment outcome (Allen et al., 1997). A well validated alcohol addiction severity measure that is simple and short to administer (as well as relatively easy for a layperson to interpret) is critical in applications with cognitively impaired alcohol abusing individuals. The more severe an individual’s executive dysfunction, the worse his or her addiction to alcohol would be because of the unique cognitive processes involved in executive dysfunction. Prior studies have shown strong correlations between poorer executive function and higher alcohol addiction severity (i.e. Bernardin et al., 2014; Meek, Clark, & Solana, 1989; Morgenstern & Bates, 1999). Establishing an efficient way to measure alcohol addiction severity with the AUDIT provides more avenues by which to study the relationship between executive function and alcohol addiction severity.

In this study, performance based measures of working memory and processing speed were not significantly associated with alcohol addiction severity and did not perform commensurately as in prior studies (i.e. Morgenstern & Bates, 1999; Voelbel et al., 2000). Learning and memory have widely been found to have a strong relationship with alcohol treatment outcome, yet this study did not find a significant association between working memory and alcohol addiction severity. Interestingly, a study by Houston and colleagues (2014) examining various domains of executive function did not show working memory as significantly deficient with heavy drinking population. Part of this finding may be due to the relatively limited sample size for the Houston study. Future studies with larger sample sizes may afford greater opportunities for factor analyses which can further clarify complex working memory's contribution to understanding subsyndromal executive function deficits. In addition, larger sample sizes will help clarify the unique information objective performance based measures and subjective perception based measures of executive function explain with alcohol abusing individuals possessing subsyndromal cognitive deficits.

In this study, mood disruption was significantly correlated with many subjective measures of executive function, but mood disruption was not shown to be a significant factor associated with alcohol addiction severity in this population. These results appear conflicting and may in part be the result of limited sample size and sampling from a community based population primarily seeking neuropsychological care. In this study, self reported mood disruption did not significantly impact performance on objective measures nor perception based responses of executive function deficits, but other studies have found mood as a significant factor or covariate impacting one's subjective perceptions (Marino et al., 2009; Roth et al., 2005; Vazire & Mehl, 2008). This phenomenon may be explained by the fact that this sample's overall mood related psychopathology may not be severe enough to warrant additional intervention based concerns beyond outpatient care and specific concerns about their executive function coming to a neuropsychology specialty clinic. Therefore, the generalizability of mood related findings is limited and warrant further investigation.

A particular strength of this study is that it is drawn from a community based sample of alcohol abusing individuals. This study is exploratory and theoretical in nature and was designed as a preliminary examination of potential neuropsychological assessment instruments with utility in identifying alcohol abusing individuals who may not be successful in traditional treatment due to subsyndromal cognitive deficits.

One limitation of this study is that the sample size was too small to be able to conduct factor analyses, which would have helped further inform Aim 1's goal of showing objective and subjective domains as distinct. Data collection did not involve active recruitment, and dissertation timing constraints were prohibitive of obtaining sample sizes above 100. Future studies may want to actively recruit individuals who engage in problematic drinking to help bolster this study's findings and continue identifying and confirming assessment instruments that identify executive function deficits in this particular population.

A second limitation of this study is that no control group was used, so it was not possible to deduce that this study's findings are significantly different from the general population. A close approximation, an analog of the normative sample from each measure, was used in order to facilitate this exploratory study and provide direction for future research. Still, future studies may benefit from the use of a control group of non-problematic drinkers to further assess differences in cognitive functioning and subsyndromal executive function deficits found in some alcohol abusing individuals.

The Wisconsin Card Sorting Test as an objective measure of abstract reasoning has enjoyed robust literature support, and results of this study suggest that the WCST has the capacity to be a powerful and useful tool in identifying patients with both alcohol use disorder and subsyndromal executive function deficits who may struggle in traditional treatment settings. Further studies may wish to explore the totality of perseverative thinking's contributions to the subsyndromal cognitively impaired alcohol abusing patient while continuing to validate the WCST for use with this subset of individuals with alcohol use disorders.

Future research should focus on confirming the utility of objective and subjective measures of executive function identified in this study as well as conducting validation studies with the spectrum of alcohol abusing individuals (subsyndromal to severely cognitively impaired) to identify if certain instruments hold utility with more or less severely impaired individuals. Specifically, since this study's sample is not the intended population for which this battery would be employed, future longitudinal research with treatment seeking individuals would help bridge theory with practice. In conclusion, future research should focus on identifying those problematic cognitive deficits that may prove detrimental to the individual with alcohol use disorder's success in treatment so they can be diverted to more appropriate programs or aligned with supports that best help them achieve abstinence.

In conclusion, this study is a theoretical merging of clinical practice with knowledge about the relationship between executive function and alcohol addiction severity. This study is a first step in establishing a neuropsychological assessment battery for pre-treatment alcohol using individuals and is also a piece in developing the theory between executive function deficits and alcohol use disorders.

REFERENCES

Allen, J.P., Litten, R.Z., Fertig, J.B., & Babor, T. (1997). A review of the research on the Alcohol Use Disorders Identification Test (AUDIT). *Alcoholism: Clinical and Experimental Research, 21*(4), 613-619.

Anton, R. F., O'Malley, S. S., Ciraulo, D. A., Cisler, R. A., Couper, D., Donovan, D. M., ... & Longabaugh, R. (2006). Combined pharmacotherapies and behavioral interventions for alcohol dependence: the COMBINE study: a randomized controlled trial. *Jama*, *295*(17), 2003-2017.

Babor, T.F., Higgins-Biddle, J.C., Saunders, J.B., & Montiero, M.G.(2001). The Alcohol Use Disorders Identification Test: guidelines for use in primary care. *World Health Organization.* 2001: 2nd Edition.

Bates, M.E., Buckman, J.F., Voelbel, G.T., Eddie, D., Freeman, J., Quednow, B.B., & ... Bickel, W.K. (2013). The mean and the individual: integrating variable-centered and person-centered analyses of cognitive recovery in patients with substance use disorders. *Frontiers In Psychiatry*, *4*1-12. doi:10.3389/fpsyt.2013.00177

Bates, M.E., Pawlak, A.P., Tonigan, J., & Buckman, J.F. (2006). Cognitive impairment influences drinking outcome by altering therapeutic mechanisms of change. *Psychology Of Addictive Behaviors*, *20*(3), 241-253.

Bates, M.E., Bowden, S.C., & Barry, D. (2002). Neurocognitive impairment associated with alcohol use disorders: Implications for treatment. *Experimental And Clinical Psychopharmacology*, *10*(3), 193-212.

Bates, M.E., & Convit, A. (1999). Neuropsychology and neuroimaging of alcohol and illicit drug abuse. In A. Calev (Ed.) , *Assessment of neuropsychological functions in psychiatric disorders* (pp. 373-445). Washington, DC US: American Psychiatric Association.

Bernardin, F., Maheut-Bosser, A., & Paille, F. (2014). Cognitive impairments in alcohol-dependent subjects. *Frontiers In Psychiatry*, *5.*

Blume, A.W., & Marlatt, G.A. (2009). The Role of Executive Cognitive Functions in Changing Substance Use: What We Know and What We Need to Know. *Annals Of Behavioral Medicine, 37*(2), 117-125. doi:10.1007/s12160-009-9093-8

Butcher, J.N. (2001). *Minnesota Multiphasic Personality Inventory-2: Manual for administration and scoring*. Minneapolis, MN: University of Minnesota Press.

Cahn-Weiner, D.A., Malloy, P.F., Boyle, P.A., Marran, M., & Salloway, S. (2000). Prediction of functional status from neuropsychological tests in community-dwelling elderly individuals. *The Clinical Neuropsychologist, 14*, 187-195.

Cairney, S., Clough, A., Jaragba, M., & Maruff, P. (2007). Cognitive impairment in Aboriginal people with heavy episodic patterns of alcohol use. *Addiction*, *102*(6), 909-915.

Campbell, D.T., & Fiske, D.W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin*, *56*(2), 81-105.

Chamelian, L., & Feinstein, A. (2006). The effect of major depression on subjective and objective cognitive deficits in mild to moderate traumatic brain injury. *The Journal of neuropsychiatry and clinical neurosciences*.

Chan, R.K., Shum, D., Toulopoulou, T., & Chen, E.H. (2008). Assessment of executive functions: Review of instruments and identification of critical issues. *Archives Of Clinical Neuropsychology*, *23*(2), 201-216. doi:10.1016/j.acn.2007.08.010

Conners, C.K., & MHS Staff (2000). *Conners' Continuous Performance Test (CPT II) computer programs for Windows technical guide and software manual.* North Tonawanda, NY: Multi-Health Systems.

Cordovil De Sousa Uva, M., Luminet, O., Cortesi, M., Constant, E., Derely, M., & De Timary, P. (2010). Distinct effects of protracted withdrawal on affect, craving, selective attention and executive functions among alcohol-dependent patients. *Alcohol And Alcoholism*, *45*(3), 241-246.

Courtney, K.E., & Polich, J. (2009). Binge drinking in young adults: Data, definitions, and determinants. *Psychological Bulletin*, *135*(1), 142-156.

Dawson, D.A., Grant, B.F., Stinson, F.S., Chou, P.S., Huang, B., & Ruan, W.J. (2006). Recovery from DSM-IV alcohol dependence: United States, 2001-2002. *Alcohol Research & Health*, *29*(2), 131-142.

Dolan, S.L., Bechara, A., & Nathan, P.E. (2008). Executive dysfunction as a risk marker for substance abuse: The role of impulsive personality traits. *Behavioral Sciences & The Law*, *26*(6), 799-822. doi:10.1002/bsl.845

Donders, J., DenBraber, D., & Vos, L. (2010). Construct and criterion validity of the Behaviour Rating Inventory of Executive Function (BRIEF) in children referred for neuropsychological assessment after paediatric traumatic brain injury. *Journal Of Neuropsychology*, *4*(2), 197-209. doi:10.1348/174866409X478970

Du, W., Guo, S., & Jiang, Z. (2002). Cognitive impairment of alcoholic dependents measured by the Wisconsin Card Sorting Test. *Chinese Mental Health Journal*, *16*(5), 296-298.

Ersche, K.D., & Sahakian, B.J. (2007). The neuropsychology of amphetamine and opiate dependence: Implications for treatment. *Neuropsychology Review*, *17*(3), 317-336.

Esbjornsson, E., Skoglund, T., & Sunnerhagen, K.S. (2013). Fatigue, psychosocial adaptation, and quality of life one year after traumatic brain injury and suspected traumatic axonal injury; Evaluations of patients and relatives: A pilot study. *Journal of Rehabilitative Medicine*, *45*, 771-777.

Eslinger, P.J., & Grattan, L.M. (1993). Frontal lobe and frontal-striatal substrates for different forms of human cognitive flexibility. *Neuropsychologia*, *31*(1), 17-28. doi:10.1016/0028-3932(93)90077-D

Fadardi, J., & Cox, W. (2006). Alcohol attentional bias: Drinking salience or cognitive impairment?. *Psychopharmacology*, *185*(2), 169-178.

Feil, J., Sheppard, D., Fitzgerald, P. B., Yücel, M., Lubman, D. I., & Bradshaw, J. L. (2010). Addiction, compulsive drug seeking, and the role of frontostriatal mechanisms in regulating inhibitory control. *Neuroscience And Biobehavioral Reviews*, *35*(2), 248-275.

Frazier T. W., Demaree, H. A., & Youngstrom, E. A. (2004). Meta analysis of intellectual and neuropsychological test performance in Attention Deficit/Hyperactivity Disorder. Neuropsychology, 18(3), 543-555.

Giancola, P. (1995). Evidence for dorsolateral and orbital prefrontal cortical involvement in the expression of aggressive behavior. *Aggressive Behavior*, *21*, 431-450.

Giancola, P. R., Godlaski, A. J., & Roth, R. M. (2012). Identifying component-processes of executive functioning that serve as risk factors for the alcohol-aggression relation. *Psychology Of Addictive Behaviors*, *26*(2), 201-211. doi:10.1037/a0025207

Guardia, J., Trujols, J., Burguete, T., Luquero, E., & Cardús, M. (2007). Impaired Response Inhibition Scale for Alcoholism (IRISA): Development and psychometric properties of a new scale for abstinence-oriented treatment of alcoholism. *Alcoholism: Clinical And Experimental Research*, *31*(2), 269-275. doi:10.1111/j.1530-0277.2006.00314.x

Harvey, P. D. (2012). Clinical applications of neuropsychological assessment. *Dialogues in Clinical Neuroscience*, *14*(1), 91–99.

Heaton, R. K., Chelune, G.J., Talley, J.L., et al. (1993). *Wisconsin Card Sorting Test Manual*. Odessa, FL, Psychological Assessment Resources.

Hingson, R.W., Heeren, T., & Winter, M.R. (2006). Age at drinking onset and alcohol dependence: age at onset, duration, and severity. *Archives of Pediatrics and Adolescent Medicine, 160*(7), 739-746.

Houston, R. J., Derrick, J. L., Leonard, K. E., Testa, M., Quigley, B. M., & Kubiak, A. (2014). Effects of heavy drinking on executive cognitive functioning in a community sample. *Addictive Behaviors*, *39*(1), 345-349. doi:10.1016/j.addbeh.2013.09.032

Hubbard, R.L., Craddock, S.G., Flynn, P.M., Anderson, J., & Etheridge, R.M. (1997). Overview of 1-year follow-up outcomes in the Drug Abuse Treatment Outcome Study (DATOS). *Psychology of Addictive Behaviors, 11*, 261-278.

Huizinga, M., & Smidts, D. P. (2011). Age-related changes in executive function: A normative study with the Dutch version of the Behavior Rating Inventory of Executive Function (BRIEF). *Child Neuropsychology*, *17*(1), 51-66. doi:10.1080/09297049.2010.509715

IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.

Isquith, P.K., Gioia, G.A., & Roth, R.M. (2008). Executive function: Concepts, assessment and intervention. Presented at the Executive Functioning Workshop, Salt Lake City, UT.

Konrad, A., Vucurevic, G., Lorscheider, M., Bernow, N., Thümmel, M., Chai, C., & ... Fehr, C. (2012). Broad disruption of brain white matter microstructure and relationship with neuropsychological performance in male patients with severe alcohol dependence. *Alcohol And Alcoholism*, *47*(2), 118-126. doi:10.1093/alcalc/agr157

Lawson, R. A., Papadakis, A. A., Higginson, C. I., Barnett, J. E., Wills, M. C., Strang, J. F.,Wallace, G. L., & Kenworthy, L. (2014). Everyday executive function impairments predict comorbid psychopathology in autism spectrum and attention deficit hyperactivity disorders. *Neuropsychology*. Advance online publication. http://dx.doi.org/10.1037/neu0000145

Loeber, S., Duka, T., Welzel, H., Nakovics, H., Heinz, A., Flor, H., & Mann, K. (2009). Impairment of cognitive abilities and decision making after chronic use of alcohol: The impact of multiple detoxifications. *Alcohol*, *44*(4), 372-381.

Lundin, A., Hallgren, M., Balliu, N., & Forsell, Y. (2015). The use of Alcohol Use Disorders Identification Test (AUDIT) in detecting alcohol use disorder and risk drinking in the general population: Validation of AUDIT using Schedules for Clinical Assessment in Neuropsychiatry. *Alcoholism: Clinical and Experimental Research, 39* (1), 158-165.

Marino, S. E., Meador, K. J., Loring, D. W., Okun, M. S., Fernandez, H. H., Fessler, A. J., & ... Werz, M. A. (2009). Subjective perception of cognition is related to mood and not performance. *Epilepsy & Behavior*, *14*(3), 459-464. doi:10.1016/j.yebeh.2008.12.007

Martin-Fardon, R., & Weiss, F. (2016). Perseveration of craving: effects of stimuli conditioned to drugs of abuse versus conventional reinforcers differing in demand. *Addiction biology*.

McCrea, M., & Powell, M. R. (2012). The concussion clinic: A practical, evidence-based model for assessment and management of sport-related concussion. *Journal Of Clinical Sport Psychology*, *6*(3), 275-292.

Meek, P.S., Clark, H.W., & Solana, V.L. (1989). Neurocognitive impairment: The unrecognized component of dual diagnosis in substance abuse treatment. *Journal of Psychoactive Drugs, 21*, 153-161.

Merkx, M.M., Schippers, G. M., Koeter, M. J., De Wildt, W. M., Vedel, E., Goudriaan, A.E., & Van Den Brink, W. (2014). Treatment outcome of alcohol use disorder outpatients with or without medically assisted detoxification. *Journal Of Studies On Alcohol & Drugs*, *75*(6), 993-998.

Mograbi, D. C., Ferri, C. P., Stewart, R., Sosa, A. L., Brown, R. G., Laks, J., & Morris, R. G. (2015). Neuropsychological and behavioral disturbance correlates of unawareness of memory impairment in dementia: A population-based study. *Journal Of Geriatric Psychiatry And Neurology*, *28*(1), 3-11. doi:10.1177/0891988714541868

Morgenstern, J. & Bates, M.E. (1999). Effects of executive function impairment on change processes and substance use outcomes in 12-step treatment. *Journal of Studies on Alcoholism, 60*, 846-855.

Moss, H. B., Chen, C. M., & Yi, H. Y. (2014). Early adolescent patterns of alcohol, cigarettes, and marijuana polysubstance use and young adult substance use outcomes in a nationally representative sample. *Drug and alcohol dependence*, *136*, 51-62.

Naim-Feil, J., Fitzgerald, P. B., Bradshaw, J. L., Lubman, D. I., & Sheppard, D. (2014). Neurocognitive deficits, craving, and abstinence among alcohol-dependent individuals following detoxification. *Archives Of Clinical Neuropsychology*, *29*(1), 26-37.

Nasreddine, Z.S., Phillips, N.A., Bedirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J.L., & Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society, 53*(4), 695-699.

NIAAA (2009). A Developmental Perspective on Underage Alcohol Use. (2009). Retrieved March 11, 2016, from http://pubs.niaaa.nih.gov/publications/AA78/AA78.htm

Nowinski, C. J., Victorson, D., Cavazos, J. E., Gershon, R., & Cella, D. (2010). Neuro-QOL and the NIH Toolbox: implications for epilepsy. *Therapy*, *7*(5), 533–540.

Oscar-Berman, M., & Marinković, K. (2007). Alcohol: Effects on neurobehavioral functions and the brain. *Neuropsychology Review*, *17*(3), 239-257. doi:10.1007/s11065-007-9038-6

Pabst, A., Kraus, L., Piontek, D., Mueller, S., & Demmel, R. (2014). Direct and indirect effects of alcohol expectancies on alcohol-related problems. *Psychology of Addictive Behaviors*, *28*(1), 20-30.

Parks, M. H., Greenberg, D. S., Nickel, M. K., Dietrich, M. S., Rogers, B. P., & Martin, P. R. (2010). Recruitment of additional brain regions to accomplish simple motor tasks in chronic alcohol-dependent patients. *Alcoholism: Clinical And Experimental Research*, *34*(6), 1098-1109.

Pitel, A.L., Beaunieux, H., Witkowski, T., Vabret, F., Guillery-Girard, B., & Quinette. P. (2007). Genuine episodic memory deficits and executive dysfunctions in alcoholic subjects early in abstinence. *Alcohol Clin Exp Res* (2007) 31:1169–78. doi:10.1111/j.1530-0277.2007.00418.x

Project Match Research Group. (1997). Matching alcoholism treatments to client heterogeneity: Project MATCH Posttreatment drinking outcomes. *Journal of Studies on Alcohol*, *58*, 7-29.

Rabin, L.A., Roth, R.M., Isquith, P.K., Wishart, H.A., Nutter-Upham, K.E., Pare, N., Flashman, L.A., & Saykin, A.J. (2006). Self- and informant reports of executive function on the BRIEF-A in MCI and older adults with cognitive complaints. *Archives of Clinical Neuropsychology*, *21*, 721-732.

Randolph, C., Tierney, M.C., Mohr, E., & Chase, T.N. (1998). The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS): Preliminary clinical validity. *Journal of Clinical and Experimental Neuropsychology*, *38*(7), 310-319.

Ratti, M. T., Bo, P., Giardini, A., & Soragna, U. (2002). Chronic alcoholism and the frontal lobe: Which executive functions are impaired? *Acta Neurologica Scandinavia, 105*, 276-281.

Reitan, R.M., and Wolfson, D. (1993). *The Halstead-Reitan Neuropsychological Test Battery: Theory and Clinical Interpretation (2nd ed),* Neuropsychology Press, Tucson, AZ.

Ritz, L., Lannuzel, C., Boudehent, C., Vabret, F., Bordas, N., Segobin, S., Eustache, F., Pitel, A.L., & Beaunieux, H. (2015). Validation of a brief screening tool for alcohol-related neuropsychological impairments. *Alcoholism: Clinical and Experimental Research, 39*(11), 2249-2260.

Roberts, C., & Horton, A. J. (2002). Derived Trail Making test indices in a sample of alcohol abusers: Demographic effects. *International Journal Of Neuroscience, 112*(3), 337-346. doi:10.1080/00207450212031

Rossow, I., & Kuntsche, E. (2013). Early Onset of Drinking and Risk of Heavy Drinking in Young Adulthood—A 13-Year Prospective Study. *Alcoholism: Clinical and Experimental Research*, *37*(s1), E297-E304.

Roth, R.M., Isquith, P.K., & Gioia, G.A. (2005). BRIEF-A: Behavior Rating Inventory of Executive Function - Adult Version. Lutz, FL: Psychological Assessment Resources.

Roth, R. M., Lance, C. E., Isquith, P. K., Fischer, A. S., & Giancola, P. R. (2013). Confirmatory factor analysis of the Behavior Rating Inventory of Executive Function-Adult Version in healthy adults and application to attention-deficit/hyperactivity disorder. *Archives Of Clinical Neuropsychology*, *28*(5), 425-434. doi:10.1093/arclin/act031

Rubio, G., Bermejo, J., Caballero, C., Santo-Domingo, J. (1998a) Validacion del test de identificacion de trastornos por uso de alcohol (AUDIT) en atencion primaria. *Revista Clinica Espanola, 198,* 11–14.

Rubio, G., Jiménez, M., Rodríguez-Jiménez, R., Martínez, I., Ávila, C., Ferre, F., & ... Palomo, T. (2008). The role of behavioral impulsivity in the development of alcohol dependence: A 4-year follow-up study. *Alcoholism: Clinical And Experimental Research*, *32*(9), 1681-1687.

Salgado, J., Malloy-Diniz, L., Campos, V., Abrantes, S., Fuentes, D., Bechara, A., & Correa, H. (2009). Neuropsychological assessment of impulsive behavior in abstinent alcohol-dependent subjects. *Revista Brasileira De Psiquiatria, 31*(1), 4-9. doi:10.1590/S1516-44462009000100003

Sanchez-Craig, M. & Walker, K. (1982). Teaching coping skills to alcoholics in a coeducational halfway house. assessment programme. *British Journal of Addiction, 15,* 35-50.

Sandford, J. A., & Turner, A. (2004). Manual for the Integrated Visual and Auditory Continuous Performance Test. Richmond, VA: Brain Train

Sarter, M., Givens, B., & Bruno, J. P. (2001). The cognitive neuroscience of sustained attention: Where top–down meets bottom–up. *Brain Research Reviews*, *35*(2), 146-160. doi:10.1016/S0165-0173(01)00044-3

Saunders, J.B., Aasland, O.G., Babor,T.F., de la Fuente, J.R. and Grant,M. (1993). Development of the Alcohol Use Disorders Identification Test (AUDIT): WHO collaborative project on early detection of persons with harmful alcohol consumption. *Addiction, 88,*791-804.

Schacht, J. P., Randall, P. K., Waid, L. R., Baros, A. M., Latham, P. K., Wright, T. M., & ... Anton, R. F. (2011). Neurocognitive performance, alcohol withdrawal, and effects of a combination of flumazenil and gabapentin in alcohol dependence. *Alcoholism: Clinical And Experimental Research*, *35*(11), 2030-2038.

Scheiser, D.M., Delis, D.C., Filoteo, J.V., Delano-Wood, L., Han, S.D., Jak, A.J., Drake, A.I., & Bondi, M.W. (2011). Are self-reported symptoms of executive dysfunction associated with objective executive function performance following mild to moderate traumatic brain injury? *Journal of Clinical and Experimental Neuropsychology, 33*(6), 704-714. doi**:** 10.1080/13803395.2011.553587

Seckler, P., Burns, W., Montgomery, D., & Sandford, J. A. (1995). A reliability study of IVA: Integrated Visual and Auditory Continuous Performance Test. Presented at the Annual Convention of Children and Adults with ADHD (CHADD) Washington, DC.

Sellbom, M., Ben-Porath, Y. S., & Bagby, R. M. (2008). Personality and psychopathology: Mapping the MMPI-2 Restructured Clinical (RC) Scales onto the Five Factor Model of Personality. *Journal Of Personality Disorders*, *22*(3), 291-312. doi:10.1521/pedi.2008.22.3.291

Smith, D.E. & McCrady, B.S. (1991). Cognitive impairment among alcoholics: Impact on drink refusal skill acquisition and treatment outcome. *Addictive Behaviors, 16,* 265-274.

Sobell, L. C., & Sobell, M. B. (2003). Alcohol consumption measures. In J. P. Allen & M. Columbus (Ed.), *Assessing alcohol problems: A guide for clinicians and researchers.* (pp. 55-73). Rockville, MD: National Institute on Alcohol Abuse and Alcoholism. http://pubs.niaaa.nih.gov/publications/AssessingAlcohol/index.pdf

Solomon, M., Buaminger, N., & Rogers, S. J. (2011). Abstract reasoning and friendship in high functioning preadolescents with autism spectrum disorders. *Journal Of Autism And Developmental Disorders*, *41*(1), 32-43. doi:10.1007/s10803-010-1017-8

Spada, M. M., Caselli, G., Nikčević, A. V., & Wells, A. (2015). Metacognition in addictive behaviors. *Addictive behaviors*, *44*, 9-15.

Spikman, J. M., & van der Naalt, J. (2010). Indices of impaired self-awareness in traumatic brain injury patients with focal frontal lesions and executive deficits: Implications for outcome measurement. *Journal Of Neurotrauma*, *27*(7), 1195-1202. doi:10.1089/neu.2010.1277

Stanford, M. S., Mathias, C. W., Dougherty, D. M., Lake, S. L., Anderson, N. E., & Patton, J. H. (2009). Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personality And Individual Differences*, *47*(5), 385-395. doi:10.1016/j.paid.2009.04.008

Struchen, M.A., Clark, A.N., Sander, A.M., Mills, M.R., Evans, G., & Kurtz, D. (2008). Relation of executive functioning and social communication measures to functional outcomes following traumatic brain injury. *NeuroRehabilitation, 23,* 185-198.

Substance Abuse and Mental Health Services Administration (2014). *Results from the 2013 National Survey on Drug Use and Health: Summary of National Findings*, NSDUH Series H-48, HHS Publication No. (SMA) 14-4863. Rockville, MD: Substance Abuse and Mental Health Services Administration.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Do performance-based measures and ratings of executive function assess the same construct?. *Journal Of Child Psychology And Psychiatry*, *54*(2), 131-143. doi:10.1111/jcpp.12001

Vazire, S., & Mehl, M.R. (2008). Knowing me, knowing you: The accuracy and unique predictive validity of self-ratings and other-ratings of daily behavior. *Journal of Personality and Social Psychology*, *95*(5), 1202-1216.

Voelbel, G.T., Bates, M.E., & Labouvie, E.W. (2000). Effects of executive cognitive impairment on addictions treatment outcome. *Archives of Clinical Neuropsychology, 15*, 670-671.

Walvoort, S. W., Wester, A. J., & Egger, J. M. (2012). Neurocognitive parameters should be incorporated in the Minnesota Multiphasic Personality Inventory-2 assessment of patients with alcohol use disorders. *Drug And Alcohol Review*, *31*(4), 550-557.

Wechsler, D., Psychological Corporation, & Pearson Education, Inc. (2008). *WAIS-IV: Wechsler adult intelligence scale.* San Antonio, TX: Pearson.

Willenbring, M.L. (2010). The past and future of research on treatment for alcohol dependence. *Alcohol Research and Health, 33,* 57-63.

Zahr, N.M., Kaufman, K.L., & Harper, C.G. (2011). Clinical and pathological features of alcohol-related brain damage. Nature Reviews Neurology, 7, 284-294. doi:10.1038/nrneurol.2011.42

Zeigler, D.W., Wang, C.C., Yoast, R.A., Dickinson, B.D., McCaffree, M.A., Robinowitz, C.B., & Sterling, M.L. (2005). The neurocognitive effects of alcohol on adolescents and college students. *Preventive Medicine*, *40*, 23-32.