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Airline Pilots in Recovery From Alcoholism: A Quantitative Study of Cognitive Change

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Abstract

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Dissertation Submitted in Partial Fulfillment

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Abstract

In order to perform their duties, airline pilots must have no clinical diagnosis of mental illness or any substance use disorder. However, provisions have been in place since the 1970s that provide for a return to work for airline pilots with alcohol problems. To date, over 5,000 airline pilots have undergone rehabilitation for Alcohol Use Disorder (AUD) and successfully returned to work. An important gap in the literature remains with regard to what extent improvements in cognitive performance may be experienced by airline pilots who complete treatment and to what extent age influences the amount of change. This study examined the archival data of 95 male Caucasian pilots who were assessed for cognitive performance shortly after entry to 30-day inpatient treatment and approximately 5 months later during the return to work evaluation. A nonexperimental within subjects design compared pre- and post-treatment scores on the Wechsler Adult Intelligence Scale-IV (WAIS-IV) full scale and 4 index scores as well as differences for age groups (25 to 44, 45 to 54, and 55 to 64). Repeated measures ANOVA revealed that there were significant gains on all WAIS-IV measures pre–post treatment for AUD. MANOVA results indicated no differences between age groups. These findings support current Federal Aviation Administration program practices with regard to returning airline pilots to work following rehabilitation and a sufficient period of abstinence. The potential of this study to promote the agenda of social change may be substantive for raising awareness of the cognitive deficits associated with AUD and how these may impact the safety of flight operations.

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Dedication

I would like to dedicate this dissertation to the late Dr. Thomas Trocchio whose passion for teaching and leading Walden University students was unparalleled. I will always be incredibly grateful for his insight, support, and the humorous cajoling that kept this study on track.

Heather Hamilton

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Chapter 1: Introduction to the Study

Human factors studies in transportation have always been concerned with the analysis of human error in order to develop pragmatic solutions to human-machine interface and engineering problems (Dekker, 2005). As a result, modern aircraft have evolved to unprecedented levels of automation and system redundancy such that the human interface can be considered a design flaw in the system (Elliot, 2013). While there are any number of physiological reasons why pilots may be the weak link when compared with several hundred thousand pounds of composites and aluminum, some limitations may be self-imposed. Some of these limitations include flying when sick, being fatigued due to poor pretrip planning, or having the discomfort of hangover symptoms prior to reporting for duty (Hankes, 2013; Schweizer & Vogel-Sprott, 2008).

Over the past 4 decades, there have been numerous investigations of fatal accidents and near-misses caused by pilot error that are attributed to physiological (fatigue) or cognitive (faulty decision-making processes) factors (Hamilton, 2004). These investigations have often resulted in regulatory changes, improvements in aircraft design, and enhanced pilot training programs (Hamilton 2004). During this same period, attention has also been given to medical and psychiatric issues (Walker, 2014). Psychiatric conditions such as a diagnosis of alcohol use disorder (AUD) or major depressive disorder result in the suspension of piloting privileges for those affected.

With the complexity of modern aircraft, crowded skies, and environmental stressors, piloting comprehensively engages and taxes all neurocognitive domains

(Porges, 2013). Pilots must be able to sustain periods of high mental workload to maintain situational awareness and make timely decisions that support safe flight operations. There is no rationale to support the notion that physiological changes and cognitive deficits due to alcohol abuse discriminate among professions (Hankes, 2013). Rather, they are linked to factors such as gender, ethnicity, age, health, and genetic predisposition as well as the duration, frequency, and the amount of use (Galanter, 2008). While the profession as a whole has historically low rates for substance abuse treatment (Hudson, 2013), Porges (2013) argued that alcoholism is prevalent at rates similar to the general population.

It has been established that alcohol abuse can result in cortical and subcortical changes that negatively affect cognitive and psychomotor performance and accelerate mental aging (Fals-Stewart & Lucente, 1994; Holden et al., 1988; Schrimsher & Parker, 2008). Furthermore, significant deficits (greater than one standard deviation) in working memory and processing speed have surfaced in studies of individuals with AUD. Cognitive and neuropsychological deficits have the potential to impair piloting performance, and by extension, affect crew performance (Porges, 2013). Accordingly, it is critical to identify, prevent, and when possible, remediate cognitive deficits within this population (Hankes, 2013). Research in other populations is mixed with respect to how much persons with AUD can recover cognitive functioning after treatment and abstinence (Stvro, Pelletier, & Potvin, 2012).

The purpose of this study was to investigate whether airline pilots diagnosed with AUD improve in cognitive functioning as measured by the Wechsler Adult Intelligence Scales-IV (WAIS-IV) Full Scale and Index scores 5 months after entering a specialized alcoholism treatment program. In this research, I used data from airline pilots who complied with treatment protocols established by the Human Intervention Motivation Study (HIMS) Program. The HIMS program is a joint effort between the Federal Aviation Administration (FAA), AirLine Pilots Union (ALPA), and participating airlines. HIMS is the only program that provides for the rehabilitation and return to work for airline pilots diagnosed with AUD.

In this study, I found significant cognitive changes for airline pilots who received treatment for AUD and discuss the implications of deficits and improvements in the context of crew performance and flight safety. It is anticipated that findings from this research study will be disseminated via a presentation at the annual 3-day HIMS program training seminar held in Denver, Colorado. This training is attended by all HIMS participating airlines, peer-support pilots, aviation psychologists, senior aeromedical physicians, and psychiatrists who provide specialized services to pilots in recovery.

The potential of this study to promote the agenda of social change may be substantive for advocating the benefits of treatment and recovery. Pilots as a whole tend to be proud of what they do and what they have achieved, and can be quite competitive, proud, and compulsive (Prewett, 2014). It is hoped that pilots questioning their alcohol use might be motivated to seek help earlier if (in addition to other psychosocial factors) they believe that they can prevent or rehabilitate deficits in cognitive functioning. Other researchers using the Wechsler Adult Intelligence Scales have found that specific capabilities can improve with abstinence (Schrimsher & Parker, 2008), and these are discussed further in Chapter 2. In this chapter, I briefly review human as well as other factors in the aviation industry related to health, alcohol abuse, airline pilots, definitions, and recovery from alcoholism.

Background

For more than a century, beginning with the introduction of automobiles, research has been conducted to respond to concerns about alcohol impairment and the effect on motor skills (Schweizer & Vogel-Sprott, 2008). A number of these studies have suggested that there is a significant skill impairment experienced by those who operate vehicles under the influence. These studies and distressing statistics have provided ample justification for federal and state statutes that govern the operation of vehicles and other modes of transportation under the influence of drugs and alcohol. Less studied and likely as problematic to safety-sensitive occupations may be the more enduring skill deficits and cognitive inefficiencies brought on by sustained, chronic alcohol use (Stvro et al., 2012).

Current statistics for the general U.S. population suggest more than 30% of U.S. adults will meet the criteria for an AUD at some point during their lives (NIAAA, 2013). Approximately 80,000 Americans die from alcohol-related causes each year (Center for Disease Control, 2012). For most people, alcohol consumption and the associated consequences do not increase with age. However, for those who consistently abuse alcohol, there may be a gradual increase in tolerance before significant social, professional, or physical problems arise (Hankes, 2013). Some individuals manage to stop drinking on their own, but most need some form of treatment (Anton, 2010).

Identifying individuals with AUD can be difficult when there are no obvious external signs such as absenteeism, arrests, domestic complaints, or physical changes (Storbeck, 2013). In routine medical evaluations, high blood pressure, elevated cholesterol, or nutritional deficiencies are just as likely to be attributed to occupational or familial stressors and poor dietary habits (Walker, 2013). When questioned by healthcare providers, denial of the frequency, amount, or duration of use is not uncommon for those on the path to alcohol dependency (Porges, 2013). In 1999, it was reported that only 20% of those afflicted will be diagnosed with AUD, and of those, only 20% will receive treatment (Kanser et al., 1999).

Alcoholism is a progressive disease that if untreated may lead to premature death (Hankes, 2013). The course of the disease can be unpredictable and is influenced by individual factors such as diet, health, and heredity as well as environmental, social, and cultural factors. Similarly, the extent of physical and cognitive impairment also varies with age, duration, and frequency of use. There is an extensive body of research regarding the physical symptoms of alcoholism and damage resulting from alcohol abuse. These include but are not limited to liver damage, cardiomyopathy, and gastrointestinal bleeding as well as endocrine and reproductive issues (Knight & Longmore, 1994).

Cognitive changes occur as well and range from mild impairment to severely debilitating alcohol-related dementias.

As portrayed in the 2012 movie *Flight* (Zemeckis, 2012) as well as the story *Grounded* (Alcoholics Anonymous, 1995), alcohol and drug dependence can and does occur in the airline pilot community (Alcoholics Anonymous, 1995; Zemeckis, 2012). The stories of pilots who violate FAA regulations governing alcohol are typically less dramatic than portrayed in the movie. Nonetheless, these incidents almost always make national news. Likely the lore of aviation and a history of bold and courageous men and women has led to an overly romantic notion of pilots as individuals who are fearless, capable, and always in control (Kay, Thurston, & Front, 2013). To this day, the public expects nothing less than the best from aviators. Heads turn as pilots stride through congested terminals, dashing and commanding figures clad in dark uniforms emblazoned with gold. Uniforms that may be concealing from immediate scrutiny the individual who may be psychologically vulnerable or otherwise impaired.

By 2008, there were 107,000 pilots flying in commercial operations in the United States, and approximately 76,000 were flying for regional and major airlines (Department of Labor, 2008). It is estimated that between 5 to 7% of pilots would meet the threshold for alcohol abuse or dependence; however, far fewer pilots are identified and treated (HIMS, 2012). Thousands of random pre- and post-flight urine screens are collected each year. On average, only 12 pilots are found to have a blood-alcohol concentration (BAC) above the FAA threshold for intoxication (Hudson, 2013). Typically, 120 airline pilots are treated for alcohol dependence under the HIMS protocol in the United States every year, and most return to work within 6 months of initial treatment (HIMS, 2013). Even though the HIMS program is a joint protocol, the FAA aeromedical branch retains the final decision as to whether a pilot may return to work.

The FAA has regulatory oversight for the certification of pilots with two distinct areas of responsibility. Federal Aviation Regulations (FARs) Title 14 Code of Federal Regulations (CFR) part 61 provides for the issuance of pilot certificates such as airline transport pilot (ATP) and specific aircraft type ratings (Boeing - 777). The second area is medical certification. The FARs part 67 and the *Guide for Aviation Medical Examiners* (FAA, 2013a) describe the U.S. medical certification standards.

An airline captain must hold a first-class medical certificate. These are renewed every 6 months for pilots over the age of 40 or annually for those under age 40 (Title 14 CFR 67; FAA, 2013a). Medical certificates are issued by select licensed physicians who undertake specialized training and receive the designation Aviation Medical Examiner (AME, FAA, 2013a). A second tier of examiner, Senior AME, designates a higher level of issuance (FAA, 2011, Order 8520, 2G). These physicians work with airmen who have had their medical certificates revoked or suspended due to major illnesses, surgeries, or psychiatric issues (FAA, 2011, Order 8520, 2G).

The success rates are quite high for those who participate in the HIMS program. The three-year success rate is approximately 95% with an estimated lifetime abstinence rate of 88% to 90% (Franzos, 2012, Hankes, 2013). The majority of pilots who enter into the minimum mandated 28-day residential treatment programs do so as a result of a company intervention after a DUI or other incident (Porges, 2013). To date, limited data has been published on the HIMS program.

Information is also sparse regarding the average age of pilots entering treatment, level of education, and position held (captain vs. first officer). While some of these demographic factors might be of interest, age as well as cognitive performance have been the historically important factors in pilot hiring and retention (Olson, McCauley, & Kennedy, 2013). The mandatory retirement age for pilots from 1959 to 2007 was age 60 due to health and age-related concerns (such as cognitive deficits due to the onset of dementia). Amid much controversy, this was raised to age 65 in 2008, however, “the competence of aging aviators continues to be an emotionally charged issue” (Georgemiller, 2013, p. 276).

Age within the population of this study is of particular interest. Some researchers have reported that alcoholism may lead to premature cognitive aging (average advance of 7 years) resulting in detriments to performance (Holden et al., 1988). Ryan (1982) found that alcoholics performed well below their normal counterparts on tasks that require visuoperceptive skills, abstract reasoning, learning, and memory. Later, studying IQ across the lifespan, Ryan (2000) found that processing speed scores on WAIS-III tests declined more rapidly with age than tests of verbal abilities. Exploring the more recent WAIS-IV normative data across age groups, Ryan (2009) found that age differences in scores of perceptual reasoning and speed of information processing begin to decline noticeably beginning with ages 65 to 69. It logically follows that if those with AUD suffer from premature cognitive aging (Holden et al., 1982; Ryan, 2009), then cognitive declines in processing speed and perceptual reasoning may be accelerated for the more senior pilots in this study. Given the complexity and cognitive demands of the aviation environment, this suggests an ongoing need to investigate the relationship between AUD and age-related changes within the airline pilot population.

Statement of the Problem

The FAA (2013a) stated in the FARs, under Title 14 CFR 67.107 (a) (1). 67.207 (a) (1) n 67.307 (a) (1) that to qualify for a medical certificate an applicant must have "no established medical history or clinical diagnosis of ...substance dependence" (Title 14 CFR 67.13). Because of that regulation, prior to 1976 it was very difficult for pilots who reported their alcoholism to regain certification after being grounded (Russel & Davis, 1985). The HIMS program was implemented in the mid-1970s to help pilots with alcohol or drug problems return to the cockpit following rehabilitation and a period of intense monitoring.

Routine screening of cognitive abilities is not standard practice, and thus neurological impairment in drinkers is often missed (Green et al., 2010). An important gap in the literature addressed by this study is that there are significant cognitive changes for airline pilots in recovery from AUD. The examination of age was considered important to this study because it is highly likely that the older group of participants (56-64) in this study are senior captains with their respective airlines. Age has been found to be a significant factor in cognitive rehabilitation, with individuals under 40 realizing greater gains following a period of abstinence (Goldman, 1983).

As described in the literature review in the following chapter, the research on cognitive changes in recovery from alcoholism reveals numerous limitations. With few exceptions, most studies concerned with cognitive assessment and alcohol abuse have focused on a single phase of the alcoholic continuum. They range from observations of intoxication at admission to hospitals (Turner, Kivlahan, Rimmele, & Bombardier, 2006), studies that correlate levels of intoxication against specific measures (Alfonso-Loeches & Guerri, 2011), posttreatment cognitive assessments (Steinmetz & Federspiel, 2012), brain damage from imaging studies (Rosenbloom, Sullivan, & Pfefferbaum, 2003), and postmortem examinations (Tomberg, 2010). Over the years, simulated studies have documented that alcohol consumption impairs performance during flight (Petros et al., 2003; Yesavage, Dolhert, & Taylor, 1994). At best, these types of studies reaffirm the need for a mandatory period of abstinence prior to flight. Other limitations are introduced as the criteria, terms, tools and methodologies used to describe and evaluate cognitive functioning have evolved over the past century (Cox, Schmidt, Slack, & Foster, 2013). Alcohol affects many different structural areas of the brain and inconsistency across studies makes it difficult to correlate significant findings.

This study adds to the literature regarding inpatient treatment, cognitive change, and abstinence from alcohol. No researcher has explored specific cognitive changes due to AUD that could impair task dependent skills and legitimately affect the safety of flight operations. Further, there have been no studies of changes in cognitive functioning postalcoholism treatment in populations with enhanced cognitive and problem-solving skills. Therefore, it is important to determine if changes occur over time as a consequence of participation in a rehabilitation program like the HIMS. In this study, I also answer the call for further research using the most recent version (WAIS-IV) of the Wechsler Adult Intelligence Scales (Sattler & Ryan, 2009).

Significance of the Study

Pilots are currently required by FAA regulations to abstain from drinking alcohol a minimum of 8 hours prior flight, and some airlines have operating policies extending that window to 12 hours. It is well known that the effects of a hangover occur with decreasing concentrations of BAC. The effects reach a maximum when BAC reaches 0, with a duration up to 24 hours after the last drink (Gallanter, 2008). Flight simulator studies of postintoxication effects of alcohol support the premise that even after an intervening night's sleep with a BAC of 0%, there are performance deficits for participants whose BAC was above .10% prior to the cut-off (Petros et al., 2003). What has not been studied in the pilot population is how alcohol-related impairments in executive functions critical to crew resource management (CRM) may change as a consequence of treatment and abstinence. Some of these functions include maintaining vigilance, situational awareness, and timely/accurate decision-making. Deficits in cognitive functions related to cockpit duties have the potential to affect CRM skills and ultimately the safety of flight operations. From a social impact perspective, research of this nature can evaluate the effects of abstinence, educate pilots regarding the consequences of alcohol abuse, and provide validation or guidance for current HIMS program treatment protocols.

When compared with overall relapse rates following inpatient treatment for alcohol (40-95%; National Institute of Mental Health, 2009), the HIMS program has astounding statistics with regards to abstinence. The majority of participants remain sober at the 2-year mark and beyond (85-90%; HIMS, 2013). Aside from abstinence rates, no other studies specifically validate the program or document any cognitive or psychological changes that may be taking place in the period of recovery.

Studying cognitive change over a 5-month period of abstinence provides insight into the cognitive functioning of participants. As an approved treatment provider for the HIMS program, I have the opportunity to disseminate any findings from this research directly to participating airlines, the FAA aeromedical branch, and HIMS trained providers. Studies have demonstrated that cognitive remediation is possible with abstinence from alcohol (Gasnler et al., 2000; Harper, 2007; Kiefer & Mann, 2005; Spencer & Boren, 1995; Rosenbloom et al., 2003; Tomberg, 2010). It is hoped that the significant results from this study may provide additional incentive for pilots abusing alcohol to seek help earlier in the alcoholic continuum and for those already in recovery to remain abstinent.

Purpose of the Study

The purpose of this nonexperimental within subjects study was to examine the extent to which cognitive function changes from baseline to 5 months after treatment for airline pilots who received treatment for AUD. In addition, age was examined as a second independent variable. Research in alcoholism treatment literature has associated a higher risk of cognitive deficits in older persons with AUD (Holden, Mclaughlin, Reilly, & Overall, 1988; Williams, Ray, & Overall, 1973), and aviation studies have noted concerns about extending the age limits for piloting because of potential declines in cognitive capacities (Georgemiller, 2013; Noda & Yesavage, 2007; Taylor, Kennedy, & Tsang, 1997).

The independent variables in this study are time (baseline and 6 months posttreatment) and age (25 to 44, 45 to 54, and 55 to 64). The dependent variables are cognitive change as measured by WAIS-IV Full Scale IQ scores and four index scores (Verbal Comprehension Index [VCI], Perceptual Reasoning Index [PRI], Working Memory Index [WMI], and Processing Speed Index [PSI]).

Testing is not required at entry to treatment under the HIMS protocol, so to date, no research has been published that has examined cognitive change from pre-to post-inpatient treatment for this professional group. However, there are specific cognitive aptitudes and skills that are critical to the job of a professional airline pilot and that contribute to flight safety (Hamilton, 2004; Porges, 2013). For example, the ability to quickly and accurately recall information (working memory) results in error prevention and improved CRM (Hoffman, Hoffman, & Kay, 1999). While some historical data exist with regard to pilots' performance on earlier versions of the WAIS (Kay, 2002), there is very little that discusses specific subtests as they relate to actual cockpit duties.

The WAIS-IV is one the most widely used standardized instruments (Canivez & Nelson, 2010), and the numerical variables are reported in accordance with the WAIS-IV manual. It is important to mention, however, that factor analyses of normal populations such as standardization samples may not be applicable for interpreting the performance of atypical individuals suffering from cognitive deficits (Blaha & Mandes, 1993; Walbron, Blaha, & Whrry, 1973). Pilots typically perform considerably better on psychometric testing than the general population (Kay 2013; Thompson, 2004). The only way to determine whether an aviator has experienced a decline in cognitive skills is to compare his or her performance with a sample of his or her peers (Thompson, 2004). Presently, there are no published WAIS-IV norms or performance expectations for airline pilots returning to work after rehabilitation. For this reason, a repeated measures study focused on abstinent airline pilots should help understand cognitive functioning as it relates to alcohol abuse in this population.

Research Questions and Hypotheses

In this study, I examine archival data for airline pilots who were given the WAIS-IV at entry to treatment for AUD and again approximately 6 months later.

Research Question 1

Does cognitive functioning, as measured by the index scales of the WAIS-IV (VCI, similarities, vocabulary, and information; PRI, block design, matrix reasoning, and visual puzzles; WMI, digit span and arithmetic; PSI, coding and symbol search) change over 6 months for airline pilots who participate in the HIMS program for recovery from AUD?

$H_0$1: There is no difference in cognitive functioning, as measured by the WAIS-IV VCI, PRI, WMI, and PSI for airline pilots from pre- to post-treatment for AUD.

H_a1: There is a significant difference in cognitive functioning, as measured by the WAIS-IV VCI, PRI, WMI, and PSI for airline pilots from pre- to post-treatment for AUD.

Research Question 2

Are there differences in the change in cognitive functioning, as measured by the WAIS-IV VCI (similarities, vocabulary, and information), PRI block design, matrix reasoning, and visual puzzles), WMI (digit span and arithmetic), and PSI; (coding and symbol search) indexes between airline pilots of different age groups who participate in the HIMS program for recovery from AUD?

$H_0$2: There is no age group difference in cognitive functioning, as measured by the WIAS-IV VCI, PRI, WMI, and PRI for airline pilots from pre- to post-treatment for AUD.

H_a2: There is a significant age group difference in cognitive functioning, as measured by the WAIS-IV VCI, PRI, WMI, and PRI for airline pilots from pre- to post-treatment for AUD.

Research Question 3

Does cognitive functioning, as measured by the WAIS-IV Full Scale IQ change over 6 months for airline pilots who participate in the HIMS program for recovery from AUD?

H_03: There is no difference in cognitive functioning, as measured by the WAIS- IV Full Scale IQ score for airline pilots from pre- to post-treatment for AUD.

H_a3: There is a significant difference in cognitive functioning, as measured by the WAIS-IV Full Scale IQ for airline pilots from pre- to post-treatment for AUD.

Research Question 4

Are there differences in the change in cognitive functioning, as measured by the WAIS-IV Full Scale IQ between airline pilots of different age groups who participate in the HIMS program for recovery from AUD?

H_04: There is no age group difference in cognitive functioning, as measured by the WAIS-IV Full Scale IQ score for airline pilots from pre- to post-treatment for AUD.

H$_a$4: There is a significant age group difference in cognitive functioning, as measured by the WAIS-IV Full Scale IQ score for airline pilots from pre- to post-treatment for AUD.

Nature of the Study

Most research data concerning pilots is a product of military studies, college-level aviation programs, human factor accident analysis, and preemployment screening (Caretta & Ree, 2003). In the United States, after pilots are hired by a major airline, it is very unlikely they will ever be subjected to any further psychological or cognitive assessment (Porges, 2013). These types of assessments are only performed as a result of traumatic brain injury, medical conditions, unexplained training difficulties, or as a result of participation in the HIMS program (Prewett, 2014). While some researchers have focused on specific professions in recovery such as railroad employees and physicians, there is very little research documenting cognitive change in recovery from AUDs.

Methodological requirements for recovery studies are complex, and there are a number of problems such as unreported relapse, motivation, or attrition that can complicate or compromise data collection and interpretation (Goldman, 1983). Studies of alcohol treatment programs do demonstrate that cognitively impaired patients do not respond as well to treatment as do their cognitively intact counterparts (Fals-Stewart & Lucente, 1994), and this raises another issue. The administration of standardized psychological tests is time-consuming, expensive, and in most states, scores must be interpreted by a licensed psychologist. As a result, very few treatment facilities conduct a comprehensive, standardized psychological battery at intake; even fewer follow-up with retesting (Bedi, 2014, Copersino et al., 2009). Therefore, many patients (and treatment providers) may be unaware of the extent of cognitive deficits related to the abuse of alcohol (Prewett, 2013). With respect to research, this lack of intake data makes it difficult to find within-subjects, repeated measures data conducted on a heterogeneous population that receives the same intervention that is governed by the same protocols and personnel.

In order to study cognitive change, at least two assessments over a specified period are essential (Fields, 2009). At present, the HIMS program only requires that pilots undergo a psychological and psychiatric assessment prior to returning to work (HIMS, 2014). While the assessment illustrates a single point in time, there is no way to ascertain whether the pilot has experienced cognitive change as a result of abstinence. The HIMS protocol is very specific with respect to treatment and aftercare requirements. However, airline management and the company pilots' union retain total discretion as to the facility where impaired pilots go for inpatient treatment. For this study, comparison of cognitive change across different inpatient treatment programs was not considered practical. Treatment programs vary widely in their curriculum, orientation, mode of treatment, and intensity of programming. Instead, an archival study was chosen (likely the only design available) due to the difficulty in obtaining consistent data for airline pilots in recovery.

In this study, I relied on the only known dataset for U.S. airline pilots in recovery that meets the basic requirements for repeated measures design (Ellis, 1999; Elliot, 2013; Porges, 2014). As stated earlier, in the first hypothesis, the independent variable is time (baseline and approximately 6 months posttreatment) with cognitive change (measured by the WAIS-IV Index scores), the dependent variable. This analysis will indicate if there are any significant differences across the four index scores. The second analysis examines time and cognitive change across the four index scores but adds the independent variable of age groups. For the third hypothesis, time is the independent variable, and cognitive change (measured by the WAIS-IV Full Scale IQ) score is the dependent variable. Hypothesis 4 addresses two independent variables, time and age groups, with the dependent variable cognitive change (measured by the WAIS-IV Full Scale IQ scores).

Theoretical Framework

The HIMS program is an occupation-specific program, so from a theoretical perspective, career development theories lend themselves to the study of airline pilots in recovery. These theories suggest that it is important to understand how cognitive aptitudes as well as personality traits lend themselves to the process of becoming a pilot for a regional or major U.S. airline. One has to ask if there specific skill sets, knowledge and attitudes (KSA’s) that pilots have in common. To answer these questions, the writings of Parsons (1909), Holland, (1959), Bandura (1982), and Super (1990) are reviewed in Chapter 2. Their research and developmental approaches affirmatively support the theory that cognitive ability and personality types are a major influence in career choice development. Also from a theoretical perspective, there is a discussion of how cognitive ability is an essential attribute for CRM and safety of flight.

Operational Definition of Terms

Aftercare : As defined by the FAA Office of Aviation Medicine describes the specific structured outpatient treatment that occurs after the initial intensive phase. This structured outpatient treatment usually includes periodic meetings with a psychiatrist and weekly group therapy sessions (HIMS, 2013).

Airline transport pilot: The certificate that is required for an individual to act as pilot-in-command for a scheduled airline (Title 14 CFR 61).

Alcoholism: According to the FAA, this is a “condition in which a person’s intake of alcohol is great enough to damage his/her physical health or personal or social functioning, or when alcohol has become a prerequisite to normal functioning” (14 CFR, Part 67).

Attention: A state of focused awareness on a subset of the available perceptual information (APA, 2013). Attention is not a unitary phenomenon; it can be subdivided using a commonly described taxonomy that includes selective, sustained, and divided components as well as information processing speed and supervisory or executive aspects (McCullagh, & Feinstein, 2011).

AUD: Includes both alcoholism and harmful drinking that has not reached the level of dependence (NIAAA, 2013). (Refer to the DSM-V for further diagnostic criteria.)

Aviation medical examiner: A physician designated by the FAA and given the authority to perform airman physical examinations for the issuance of second- and third-class medical and student pilot certificates. (NOTE: Senior examiners perform first-class airman examinations; FAA, 2013a).

Aviation psychologist: A person who is concerned with pilot performance and reducing flight crew error. Psychology applied to aviation is an integrative field involving knowledge of just about all areas in psychology, including perception, attention, and cognition. Other areas of focus include memory and decision-making skills, pilot selection, cockpit designs, human-computer interaction, human factors design, program management and human performance research (Reynolds, 2013).

Cognitive deficit: Defined here as a decrease in functional problem-solving skills as measured by a standardized assessment tool (Rath, Hradil, Litke, & Diller, 2011).

Crew resource management (CRM): Skills known as "the human factors in flight" that include broad areas such as situational awareness, decision-making, communication, team building/leadership, and workload management. It is a multidisciplinary concept that draws from behavioral and social sciences, engineering, physiology, and psychology to optimize human performance and reduce human error (Helmreich & Foushee, 1993; National Research Council, 1989).

Crystallized intelligence: The facet of intelligence involving the knowledge a person has already acquired and the ability to access that knowledge, measured by vocabulary, arithmetic, and general information tests (APA, 2013).

Executive function: Associated with the prefrontal cortex and defined as the set of cognitive processes necessary to complete goal-oriented, complex tasks (Ahmed & Miller, 2013; Lezak, Howieson, & Loring, 2004; Zelazo & Frye, 1998).

First class medical certificate: Under Title 14 of the Code of Federal Regulations (14 CFR) Part 1, and the Guide for Aviation Medical Examiners (FAA, 2013a), the FAA defined a medical certificate as "acceptable evidence of physical fitness on a form prescribed by the Administrator." The primary goal of the airman medical certification program is to protect not only those who would exercise the privileges of a pilot certificate but also air travelers and the general public (14 CFRPart67; FAA, 2013a).

Human intervention motivation study: An occupational substance abuse treatment program, specific to commercial pilots. The program governs the identification, treatment, and return to work process for affected aviators. It is an industry-wide effort in which managers, pilots, healthcare professionals, and the FAA work together to preserve careers and enhance air safety (HIMS, 2013).

Intelligence and IQ: An expression of an individual's ability at a given point in time relative to age norms that are amenable to modifications through environmental interventions (Anastasi, 1968). It is a reflection of prior educational achievement and is often an effective predictor of performance in higher education as well as occupations (Anastasi, 1968).

Long-term memory (LTM): Memory processes associated with the preservation of information for retrieval at any later time (APA, 2013).

Monitoring: A term used to describe the abstinence testing conducted by the HIMS Independent Medical Sponsor (IMS) or the company (HIMS, 2013).

Senior aviation medical examiner: An AME delegated with the additional authority to accept applications and perform physical examinations necessary to determine qualifications for the issuance of first-class FAA Airman Medical Certificates (Title 14 CFR 67).

Short-term memory (STM): Memory processes associated with preservation of recent experiences and with retrieval of information from LTM; STM is of limited capacity and stores information for only a short length of time without rehearsal (APA, 2013).

Situational awareness: A pilot's awareness of operational conditions and contingencies that include factors such as monitoring, vigilance, planning, and distraction avoidance (Helmreich & Foushee, 1993).

Substance use disorder: A cluster of cognitive, behavioral, and physiological symptoms indicating that the individual continues using the substance despite significant substance-related problems (APA, 2013b).

Working memory: A memory resource that is used to accomplish tasks such as reasoning and language comprehension and consists of the phonological loop, visuospatial sketchpad, and central executive (APA, 2013).

Assumptions, Limitations, Scope, and Delimitations

Assumptions

The first assumption of this study is that the participants were highly motivated to perform to the best of their abilities during the first and second administrations of the WAIS-IV. This assumption is thought to be valid for this study due to the tendency for pilots to attempt to portray themselves in an overly favorable light on other assessment instruments (Butcher, 1994; Ganellen, 1994). Another assumption is that the WAIS-IV will be able to detect cognitive abilities and impairments on core subtests as a result of abstinence. Although it might be possible for a study participant to continue drinking, it is highly unlikely due to the motivation to resume their career, intense aftercare monitoring, and the frequency of random urine and drug screens. Other assumptions made were that factors such route of entry into the airlines (civilian vs. military), education, income level, and geographical information are not of significant interest to this study. The use of archival data for this study ensures that none of the participants or testing personnel were aware of this study and hypotheses at the time of testing. Due to the nature of archival data, another benefit is that only complete records meeting the criteria for this study were used, eliminating any issues associated with missing or incomplete data.

Another assumption of this study is that the participants received equal care and similar testing environments. A unique aspect of this study is the standardization of treatment and assessment protocols. All participants attended the same inpatient rehabilitation program. They were followed from intake through return-to-work by the same psychological practice. All testing with the WAIS-IV was conducted in the same office, by the same psychometrist. All original test response booklets, interpretation, and summary sheets were reviewed by the same psychologist and secured continuously at the office where testing was administered. For this study, the de-identified summary sheets contain both sets of full WAIS-IV index and subtest scores.

Limitations

This study has several limitations. The limitations regarding external validity include the following:

1. The study data consist of archival records of the 95 pilots who completed the WAIS at two points in time. Since it is a convenience sample (i.e., not a random sample selected from the population of pilots who attended this program), external validity (the ability to generalize to the target population of airline pilots who received treatment) is limited and the results are interpreted cautiously. In this study, I examined a population where participants were selected solely on the basis of attending treatment at the same treatment and aftercare facilities as well as completing the WAIS-IV at the two intervals. As a result, generalizing results to other facilities or programs is limited.

2. Another limitation to the generalization of findings is that occupational alcoholism programs may have a higher success rate than nonwork-related programs. Study results are not be compared with dissimilar types of recovery programs.
3. This study was based on a population of all male Caucasian airline pilots and as such results are unlikely to be an accurate representation for female pilots or those of different ethnicities.
4. The model presented in this study only uses as a potential moderator. Pilot history with regard to the duration, frequency and amount of alcohol used will vary greatly across this population, and thus the model of this study is likely to be underspecified.

There are several limitations with respect to internal validity:

1. There is a risk of selection bias (Mitchell & Jolley, 2004), as there was no random assignment to treatment. Only those pilots who were motivated to return to work and stop drinking were included.
2. Two problems inherent to within-subjects design research are fatigue and practice or “carry-over” effect (Mitchell & Jolley, 2004). Fatigue was not considered a factor given the lengthy time interval between assessments. Practice effect could systematically bias the results between the first and final testing sessions. In this study, the 5-month interval between tests is dictated

by return-to-work requirements specified by the FAA makes it highly unlikely that the posttreatment results would be compromised.

3. To increase internal validity, correlations of study data with measures that have been used to establish validity of the properties of the WAIS-IV would have been desirable (Mitchell & Jolley, 2004).
4. The FAA's definition of alcoholism differs from the DSM-V and has a lower threshold for diagnosis as well as entry to inpatient treatment. Pilots with alcohol problems may identified earlier and be less impaired than other populations admitted to treatment under American Society of Addiction Medicine (ASAM, Mee-Lee et al., 2001) treatment level protocols.
5. As this is an archival study, I did not have control of the data collection events or intervention. While this completely eliminates researcher bias (Mitchell & Jolley, 2004), this also eliminates my ability to observe and verify the data collection process. However, the WAIS-IV data used for this study were collected in strict accordance with the administration protocols established in the WAIS-IV Manual. Over the entire course of this study, the assessments were administered in a quiet, windowless testing office by a trained psychometrist with 20 years experience with Wechsler instruments. All data were reviewed for accuracy and interpreted by a highly experienced HIMS psychologist who maintains the original test data and data summary sheets. While the data for this study were de-identified at the summary sheet

prior to data entry, a random code enabled me to request a review of a dataset file if required.

With regard to construct validity, studies of factor analysis indicate the WAIS-IV is a good measure of general intelligence (Sattler & Ryan, 2009) with exemplary norms (Canivez & Watkins, 2010). Higher order factor analyses (ages 16-90) indicate that the 10 WAIS-IV core subtests used in this study are properly associated with their theoretically proposed factor (Canivez & Watkins, 2010). Correlations among the WAIS Index scores (dependent variables) are moderate, which is desirable for the MANOVA analysis. Recent studies across all age groups (Nelson, Canivez, & Watkins, 2013) consistently support the four-factor structure validity of the WAIS-IV model as reported in the WAIS-IV Technical and Interpretative Manual (Wechsler, 2008b).

Scope and Delimitations

The scope and design of this study were to address cognitive change in a select group of airline pilots in recovery from alcoholism. A standardized cognitive measure, the WAIS-IV, was used to assess all the study participants at two points in time; entry to treatment and during the psychiatric and psychological (P&P) return to work evaluations.

Specific delimitations were background variables that were not be considered in this study. These included whether the participant was employed by a major or regional airline, education level, or how long individuals reported drinking heavily. Other variables not taken into consideration were whether individuals were experiencing distressful consequences of alcoholism such as the possibilities of incarceration, divorce, or termination. These variables may have some impact on premorbid and posttreatment cognitive functioning, overall mental and physical health, and quality of aftercare support.

Lastly, for several decades, the military was a major source for airlines looking to hire qualified pilots (Cox et al., 2013). During times of industry expansion, military aviators who were eligible for discharge flooded airlines with applications with the hopes of a landing a stable civilian career. The airlines had the luxury of drawing from a pool of homogenous, highly motivated, extremely intelligent, and college educated candidates (Kay et al., 2013). It might be argued that this type of selection has resulted in a truly unique cohort when viewed from the cognitive perspective. Higher education has been found to correlate with higher levels of executive functioning, and this may be of protective significance against the development of frontal function disorders (Nowakowska, Jablokowska, & Borkowska, 2008).

Summary

It has been established that extended alcohol abuse will produce impairments in cognitive functioning. This study of airline pilots in recovery from AUD furthers the understanding of changes with regard to cognitive functioning and abstinence. As suggested in theories of career development, cognitive capabilities as well as personality play an important role in career choice. For airline pilots, the complexity of the flight operating environment and unusually frequent technical evaluations requires that these cognitive abilities be maintained (Porges, 2013). While a few researchers have looked at specific changes with a period of abstinence, this is the first study of AUD that compares within-group pre- and post-treatment scores for airline pilots with the WAIS-IV. This study has the potential to promote the agenda of social change by increasing awareness of the effect of AUD on cognitive skills known to maintain safe flight operations. In support of the HIMS program, results from this study will be made available to program participants. Most treatment providers who attend the HIMS training work with individuals in other safety-sensitive occupations where a diagnosis of AUD can result in professional sanctions. Studies like this one can continue to promote discussions focused on assessment, intervention, and abstinence for other professional groups.

In Chapter 2, I review the current literature on the effects of alcohol abuse on the brain as well as historical findings from AUD research using earlier editions of the Wechsler Adult Intelligence test. The relevance of the WAIS-IV subtests to the cockpit environment is described within the context of skills, CRM, and flight safety. Within the scope of HIMS program, there is a discussion of the role of the airlines, ALPA, and the FAA in returning pilots to work. Finally, a review of research concerning the cognitive and personality profiles of airline pilots provides readers with insight into the characteristics of those who have followed this career path. In Chapter 3, I present an overview of the research design, participants, instrumentation, data collection, and analyses. Chapter 4 will address the results of the analyses. Chapter 5 will demonstrate the findings and present recommendations for future research with this population and other high-stress, safety-sensitive occupations.

Chapter 2: Literature Review

In this study, I investigated the changes in cognitive functioning for airline pilots who returned to work following participation in the HIMS program for AUD. A gap in the literature was identified. No researcher has explored specific cognitive deficits due to AUD that could impair task dependent piloting skills and affect the safety of flight operations. Routine screening of cognitive abilities is not standard practice after employment as an airline pilot and is not required at entry to treatment under the HIMS protocol. Some historical data exist with regard to pilots' performance on earlier versions of the Wechsler. However, no researchers have fully examined which subtests, and associated skill sets, may be impacted by alcohol abuse and affect the performance of cockpit duties. A handful of studies have demonstrated that cognitive remediation is possible with abstinence from alcohol; however, very little research has been conducted in the past 20 years.

This literature review opens with a review of AUDs and a comprehensive overview of the effect of alcohol on the brain and cognitive processes. Aviation psychology and theories relevant to career choice follow. Specifically discussed are the abilities, aptitudes, and skills required by individuals to perform the duties of an airline pilot. A review of historical studies employing the WAIS is presented with a discussion of significant cognitive deficits as a result of alcohol abuse. At the subtest level, the core WAIS tests are then related to the human factors, skills, and situations relevant to safely carrying out the duties of an airline pilot. I conclude the review with an overview of treatment and aftercare protocols for airline pilots in recovery as well as the roles of the FAA, HIMS program, and aviation medical examiner.

Literature Search Strategy

The research for this literature review was conducted primarily through the PubMed, Thoreau, and EBSCO (psychology) databases as well as the Google search engine. Key terms included *airline pilots and alcohol, aviation and alcohol abuse, cognitive deficits and alcohol, alcohol and the brain,* and *addiction*. The search spanned from 1920 through 2014 and also included the FAA, HIMS program, and Airline Pilots Association websites. Other sources included conference proceedings from the annual 2012 and 2013 HIMS conference, magazine articles as well as select aviation and aeromedical psychology textbooks.

Alcohol Use Disorder

Alcohol Use Disorder

Alcohol use disorder is defined by a cluster of behavioral and physical symptoms, which can include withdrawal, tolerance, and craving (DSM-V, APA, 2013). With the publication of the DSM-V, the familiar but separate DSM-IV categories of alcohol abuse and alcohol dependence have been combined under AUD, requiring the clinician to specify severity based on the presence of symptoms. Diagnosis of mild substance use disorder requires two to three symptoms, moderate four to five symptoms, and severe is indicated by the presence of six or more symptoms (APA, 2013). The diagnostic features of AUD highlight cravings, tolerance, and withdrawal as well as major areas of life functioning likely to be impaired. These include driving and operating machinery, school and work, interpersonal relationships and communication, and health. Other diagnostic criteria include behaviors such as taking alcohol in larger amounts than was intended, unsuccessful attempts to cut down, and a great deal of time spent procuring or recovering from the effects of alcohol (DSM-V, 2013).

How the FAA Views Alcohol Use

The FAA's definition of alcohol abuse differs from the DSM-V diagnostic criteria. The FAA defines alcoholism as a "condition in which a person's intake of alcohol is great enough to damage his/her physical health or personal or social functioning, or when alcohol has become a prerequisite to normal functioning" (Russel & Davis, 1985). The FAA acknowledged that alcohol use is prevalent in society but warns that problems arise in the performance of safety-related activities when individuals are under the influence. In reviewing the statistics for general aviation fatalities, an average of 12% of pilots were under the influence of alcohol (FAA, 2004). Simulator studies of pilots under the influence of alcohol have revealed that regardless of flying experience, pilots showed impairment in their ability to fly an Instrument Landing System approach, to fly Instrument Flight Rules, and to perform routine tasks (Salazar & Antunano, n.d.). Almost as dangerous as flying under the influence may be flying with a hangover (Hankes, 2013; Porges, 2013). From a safety perspective, the FAA has conservatively suggested that pilots stop drinking 24 hours ahead of flying (Salazar & Antunano, n.d).

Scope of Alcohol Use Disorders

For at least 5,000 thousand years, there has been the recognition that alcohol use can result in profound health, social, and safety-related problems. Records from ancient Egypt document the "presence of people who provided care in their homes for people who were mad from wine or beer" (White, 1998, p. 21). Alcohol use increases the risk for accidents, violence and suicide (DMS-V). In the United States, data indicate a lifetime prevalence of 14.7% for AUDs, with one in five intensive care admissions related to alcohol. Approximately 100,000 individuals die each year from alcohol-related disease or injury (Galanter, 2008). Economic costs for health-care related to alcohol are thought to exceed 185 billion a year (Galanter, 2008) without accounting for losses attributed to absenteeism, reduced productivity, and on-the-job accidents (APA, 2013). Most individuals will develop the condition of AUD before age 40 years, with approximately 10% having a later onset (APA, 2013; Schuckit & Smith 2011). In older individuals, physical changes may result in increased brain susceptibility to neurotoxic damage from alcohol (DSM-V, 2013).

The Effect of Alcohol on Brain Function

One of the major target organs of alcohol action is the brain, and it is well established that cognitive inefficiencies result from alcohol abuse (Alfonso-Loeches & Guerri, 2011). From a physiological perspective, addiction to alcohol is considered a brain disease, whereby drug actions on brain circuitry result in changes in the control of behavior (Tomberg, 2010b). There is no specialized alcohol addiction area of the brain. It is thought that the brain is affected progressively top-down from outer cerebral areas inwards to the more dense subcortical limbic structure (Tarter & VanTheil, 1985; Tomberg, 2010). Despite numerous studies, it is still unclear how alcohol produces functional changes in the brain (Alfonso-Loeches, & Guerri 2011; Bühler & Mann, 2011). Alcohol is known to act on a wide range of excitory and inhibitory nervous systems (Tomberg, 2010); however, three circuits in particular are key to understanding the cycle of addiction (Galanter, 2008):

1. A drug reinforcement circuit (reward and stress) is composed of the extended amygdala, including the central nucleus of the amygdala, the bed nucleus of the stria terminalis, and the transition zone in the shell of the nucleus accumbens.
2. A drug and cue-induced reinstatement (craving) neurocircuit is composed of the prefrontal (anterior cingulate, prelimbic, orbitofrontal) cortex, and basolateral amygdala, with a primary role hypothesized for the basolateral amygdala in cue-induced craving.
3. A drug-seeking circuit (compulsive) circuit is composed of the nucleus accumbens, ventral pallidum, thalamus, and orbitofrontal cortex (Galanter 2008).

Alcohol and Brain Chemistry

Alcohol is oxidized in the brain into acetaldehyde by alcohol dehydrogenase and then transformed into acetate by acetaldehyde dehydrogenase (ALDH). Current researchers have suggested that ethanol acts as a prodrug and the metabolite acetaldehyde becomes the active drug (Karahanian et al., 2011). There is no hemato-encephallic barrier for alcohol, so a short time after intake, alcohol concentration in the brain closely matches that in the blood (Houa, Tomberg, & Noel, 2010). This explains the diversity of symptoms following alcohol intake; some feel euphoric and less inhibited socially, others may become aggressive or simply sleepy (Tomberg, 2010). Blood alcohol levels increase when the rate of intake exceeds the capacities of metabolic disposal. Alcohol is mostly eliminated from the body by the liver, and for an adult male, the rate is approximately 15 to 20 mg/dl per hour (Tomberg, 2010). Inequalities between individuals' capacity to drink is likely due to the ALDH activity, which is known to vary across ethnic groups (Heilig & Spanagel, 2015; Luczak et al., 2014).

The molecular actions of alcohol on the brain cause metabolic changes such as lower glucose metabolism (Buhler & Mann, 2011) while increased oxidative stress causes alterations or disruptions in the balance of neurotransmitter receptors such as glutamate and γ aminobutyric acid (GABA; Alfonso-Loeches & Guerri, 2011). The reward and reinforcement profile of alcohol is likely due to the modulation of the GABA agonist and antagonist receptors. While there is controversy on where these receptors may be active, one possibility is that they synapse onto dopaminergic neurons in the ventral tegmental areas (VTA). This reward area of the brain in turn projects to the nucleus accumbens and prefrontal cortex (Tomberg, 2010; Xiao, Zhou, Li, & Ye, 2007) most likely through an increase in the firing rate of dopaminergic neurons in the VTA

(Bunney, Appel, & Brodie, 2001). This increased activity and the interaction of dopaminergic inputs on N-methyl-D-aspartate (NDMA) receptors may promote the plasticity that is thought to be important to ethanol reinforcement (Gonzales 2004; Harris, 1999).

During alcohol intake, there is excessive stimulation of the NDMA receptors; however, when intake stops, there is a resulting high influx of calcium that has cytotoxic effects (Verbaten, 2009). Structures such as the frontal lobes and hippocampus are most sensitive to damage from alcohol consumption because of their large numbers of glutaminergic and subcortical cells (Verbaten, 2009). Important features of the hippocampal region are memory and learning, while executive functions such as attention, planning, and problem-solving are features of the prefrontal cortex (Tomberg, 2010). It is possible that alterations to the hypothalamo-pituitary adrenal function axis may contribute significantly to the development of alcoholism. After heavy consumption, Rose, Shaw, Pendergast, and Little (2010) found elevated levels of glucocoticoids (cortisol) that are thought to be in part responsible for neuronal damage and cognitive deficits seen in withdrawal.

Consistently, brain imaging using conventional magnetic resonance imaging has revealed that those with alcoholism have a reduced brain weight compared to controls (Rosenbloom et al., 2003). Postmortem studies have found a 10 to 15% percent reduction caused by damage and/or necrosis of white and grey matter (Verbatem, 2009) and a correlation between the degree of brain atrophy and the rate and amount of alcohol consumed over a lifetime (Harper, 2007). A reduction and degradation of white matter fibers that carry information between brain cells largely accounts for the reduction in brain weight and volume and varies by region (Harper, 2007; Rosenbloom et al., 2003). Some white matter volume reversal is documented with abstinence (Rosenbloom et al., 2003) and likely involves changes in both myelination and axonal integrity (Harper, 2007). With prolonged abstinence, changes in protein synthesis may let preserved nerve-cell bodies and lost or malfunctioning axons to be reestablished and restored to functioning. This in turn would allow for the slow reversal of frontal brain abnormalities (Gasnler et al., 2000; Kiefer & Mann, 2005).

Anatomical changes as a result of alcohol use have been measured in all lobes including the prefrontal cortex, hippocampus (learning and memory; Nowakowska, Jablowska, & Borkowska, 2008) and cerebellum (Parks et al., 2010). Alcohol dependence has also been directly attributed to cerebral atrophy in the parietal and temporal lobes as well as structural changes to the insular cortex (Chattopadhyay et al., 2011). It has been proposed that cortical atrophy in the latter area may be directly linked to the emergence of psychopathology as well as deficits in attention and the recall of information (Chattopadhyay et al., 2011).

Cognitive Changes in Heavy Drinkers

It is well documented that brain damage occurs for alcohol-dependent individuals and that structural changes may occur for those with intact psychosocial functioning as early as 10 years prior to the appearance of neurological disorders (Chanraud, 2007).

Consistently, alcohol dependence has been associated with neuropsychological impairments with deficits in executive functioning such as planning and problem-solving (Chanraud, 2007) disturbances of working memory (Nowakowska et al., 2008), information processing, learning, and selective attention (Schweizer & Vogel-Sprott, 2008). Researchers have also found impairments in abstract reasoning, processing speed, and fine-motor skills (Schrimsher & Parker, 2008) as well as nonverbal intelligence and visuospatial processing (Goldstein, 1987). These deficits are likely due to changes in the prefrontal cortex (Tomberg, 2010) and the hippocampus.

Recently it has been discovered that individuals with AUD have decreased dopamine transmission in the dorsolateral prefrontal cortex, medial prefrontal cortex, orbital frontal cortex, temporal cortex, and medial temporal lobe (Tomberg, 2010). These areas are associated with problems with disinhibition, impulsivity, STM, attention, learning, planning, problem-solving, and poor motivation (Kraus & Maki, 1997; Tomberg, 2010). One assumption that can be made about brain functioning is that several parts of the brain may be harnessed simultaneously to serve complex demands. Following injury, the brain can modify the functioning of the system to "workaround" affected structures (Bradshaw & Mattingly, 1995) but the efficacy of cognitive operations may be impaired (Nowakowska et al., 2008).

Several studies have addressed the cognitive effects of alcohol and reported disturbances in brain functioning. In an fMRI study of patients with chronic alcoholism, Parks et al. (2010) discovered during a self-paced tapping stimulus exercise that brain activation patterns in patients with alcoholism were significantly different from the control group. In a more effortful than automatic fashion, the participants with alcoholism employed the parietal lobe rather than fronto-cerebellar network, suggesting the presence of distinct neural pathway impairment (Parks et al., 2010). A separate study designed to detect differences in impulse control (*n* = 167) found that heavy alcohol use altered functioning in the anterior insula (provides feedback of negative events and bodily sensations) and that severe users took longer to make decisions (Claus, Kiehl, & Hutchison, 2011). Spencer and Boren (1995) found that heavy drinkers under the age of 40 recovered from cognitive deficits more quickly than those with alcoholism over 40. For those over age 40, it took longer to recover, and even after 3 months of abstinence, there were residual deficits in visuospatial processing.

Contrary to studies that suggest cognitive dysfunctions may resolve with abstinence, a 2008 study of individuals with alcoholism reported that core deficits in the prefrontal cortex were enduring in nature (Nowakowska, Jablokowska, & Borkowska, 2008). Using the Wisconsin Card Sorting Test (WCST) 88 patients who met the criteria for alcohol dependence were tested immediately after alcoholic trance. Results were then compared with 37 persons who had maintained at least one year of abstinence, and a control group of 30 normal persons. Abstinence was not correlated with improvement of cognitive functions. Those with a longer period of addiction obtained the worst results on perseverance errors and only higher education was found to be correlate with higher levels of executive functioning (Nowakowska, Jablokowska, & Borkowska, 2008).

Airline Pilots and Alcohol Use

Drug and Alcohol Testing in the Aviation Industry

In 1990, in response to several high profile alcohol incidents within the transportation industry, Congress enacted legislation the Omnibus Transportation Employee Testing Act (OTETA) of 1991 (H.R. 3361 – 102nd Congress). This act required mandatory alcohol testing for transportation employees with safety-sensitive functions. Major airlines (Part 121 certificate holders), commuter air carriers and air taxis (Part 135 certificate holders) were also required to implement alcohol and drug misuse prevention programs (Gohua, et al., 2010).

By DOT definition, an alcohol violation is defined as an alcohol concentration level of 00.04 g/dl (equivalent to 0.04 g of alcohol per 210 liters of breath), shy lung or refusal to submit to testing (Brady, Baker, DiMaggio, McCarthy, Rebok, & Li, G., 2009). Reporting for duty or remaining on duty while having a BAC of .04, a ban of Title 14, CFR Part 91.17, may lead to emergency revocation of a pilot's airman, medical and any other FAA issued certificates under Title 14, CFR Part 61.16 (Kalfus, 2003). Title 14, CFR Part 91.7 prohibits any person from acting or attempting to act as a crewmember of a civil aircraft under any of the following conditions:

1. Within 8 hours after the consumption of any alcoholic beverage
2. While under the influence of alcohol
3. While using any drug that affects the person's faculties in any way contrary to safety

4. While having a 0.04 percent weight or more alcohol in the blood (Title 14, CFR Part 91.7).

Besides violating company and federal regulations, an infraction may also result in the prosecution of criminal charges resulting in imprisonment and substantial fines (Kalfus, 2003). Pilots are also required to report any arrest or conviction for operating vehicles under the influence within 60 days of the action (Offenses Involving Alcohol or Drugs, 2010). The FAA crosschecks the National Driver's Registry and failure to comply with notification is grounds for revocation of all certificates and a minimum suspension of one year (Refusal to Submit to an Alcohol Test or to Furnish Test Results, 2010)

Random drug and alcohol testing in the aviation industry reveals a very low prevalence of workplace violations for aviation employees (Brady et al., 2009). Pilots however are subject to greater scrutiny than ever before and allegations of alcohol use may come from security screeners, passengers, fellow flight crew members and even air marshals (Kalfus, 2003). Kalfus & Riccitello (2013) caution pilots who may be challenged in a "non-joking" manner to contact their company, not report for duty and understand that a refusal to test may be grounds for FAA certificate action.

Airline Pilots and Alcohol Use Disorder

In a discussion of alcohol use and civil aviation, Holdener (1993) challenged passengers' beliefs that pilots never fly under the influence of alcohol by pointing out that alcoholism affects lawyers, physicians and clergymen. So why would there not be pilots who have alcoholism as well? Obviously there are, and as Hankes (2009) shared, "wings and stripes confer no immunity". What is more difficult to predict or analyze is the frequency in which pilots fly hung over while having a BAC of .0. It is well known that hangover effects occur after alcohol levels in the body reach zero. Cognitive performance with regard to alcohol-increased error is most impaired on the descending side (declining BACs) of the alcohol curve (Schweizer & Vogel-Sprott, 2008). Nausea, headaches, dizziness, dehydration and other biological reactions to alcohol such as elevated homocysteine levels impair performance of both technical and cognitive tasks (Wilhelm, et al., 2006).

The majority of pilots who consume alcohol will not abuse or develop dependence on alcohol (Porges, 2013). However for those who do there are signs and symptoms that use may be reaching abusive levels. For pilots, these may include DUI charges, missed appointments, over use of sick leave or last-minute sick-outs from trips (Storbeck, 2012). Other signs may include irregular pilot proficiency in recurrent simulator proficiency checks, line checks, isolation on layovers, or observations of volatile personality/erratic behavior (Hankes, 2012). It is not unusual for pilots who have the desire to drink and enough company seniority to bid desirable international trip lines. These trips typically have longer layovers, allow for periods of binge-type drinking and recovery with far less likelihood of drug or alcohol screening prior to flight (Porges, 2013).

Storbeck (2012) suggested that peers use intuition and common sense in identifying pilots who may be abusing alcohol. Very few pilots are identified by failures on random drug screens. Most information regarding a pilot's behaviors related to alcohol abuse or dependence comes from co-workers who may notice physical symptoms, a defensive or abrasive personality, or extensive rationalizations for unusual behavior (Mason & Tasci, 2012). Other sources for identifying alcohol problems include disclosures made on flight physicals, FAA driving record screens, on-duty DOT tests, security screener reports, hotel incident reports, instructor and check airmen reports, family members, and self-referrals (Storbeck, 2013).

Alcohol Use Disorder, Airline Pilots and Aging

For decades, age 60 meant retirement from flying as an airline captain or first officer. In the mid-nineties, coincident with the increasing age of the airline pilot population, ALPA and other industry groups suggested that there were convincing reasons to review the mandatory retirement rule (Georgemiller, 2013). Studies indicate that age affects cognitive functions such as perceptual processing, memory, psychomotor coordination, time-sharing and decision-making (Tsang, 1997). For pilots, these deficits might surface in slower reaction times to display information, increased difficulty encoding and repeating ATC clearances, and less precise aircraft handling (Taylor, Kennedy, Noda & Yesavage, 2007). Research however has contradicted this logic. A 5-year review of mishap rates for naval pilots found younger pilots were more prone to perceptual error (Eyraud & Borowsky, 1985; Tsang 1997).

Hardy, Staz, Delia, and Uchimaya (2007) found that while there are minor age-related differences in information processing, attention and executive ability, there are no differences in other domains related to verbal and visual–spatial recall. Their regression results showed no appreciable acceleration or change in rate of cognitive difference with pilot age. Instead, the study suggests that "flight experience may hone skills that can compensate for natural age-related declines" (Hardy, Staz, Delia, Uchimaya, 2007). Tsang (1997) suggests that complex performance developed through extensive training may be more resistant to negative age effect. Flight simulator research conducted by Schriver, Morrow, Wickens, & Talleur (2008), measuring differences in expertise and attentional strategies related to decision-making, found that with equivalent cognitive abilities, more experienced pilots made better decisions in terms of speed, and accuracy. These benefits tended to be greater for more difficult tasks that involved integrated cognitive processes (Schriver, Morrow, Wickens, & Talleur, 2008). For the present study, the age groups being studied (Group 1, 35-0-0 through 44-11-30, Group 2, 45-0-0 through 54-11-30, and Group 3, 55-0-0 through 64-11-30) reflect the exact age groups for which the WAIS-IV quantitative tables were developed (Sattler & Ryan, 2009). A final factor concerning age is that the pilot group as a whole is cognitively superior (Kay 2013) and may be less susceptible to the effects of aging (Tsang, 1997).

The HIMS Program

In the 1970's, a medical research project called HIMS (Human Intervention Motivation Study) was spearheaded by ALPA and funded by the National Institute for Alcohol Abuse and Alcoholism (NIAAA) (HIMS, 2013). This study focused on the prevalence of alcoholism in the professional pilot community and resulted in the creation of a cooperative joint program. The program makes provisions for the treatment of afflicted individuals and the return to cockpit duties. As stated in the HIMS literature, “the purpose of the program is to effectively treat the disease of chemical dependency in pilot populations and ensure the pilot remains abstinent in order to save lives and careers while enhancing flight safety” (HIMS, 2013).

There are several parties to an air carrier HIMS program airline management, including pilot peer volunteers, healthcare professionals, and FAA medical specialists. Each airline may modify their program slightly to reflect corporate culture and specific employment practices and policies. Due to early influences, particularly the disease model of addiction, the HIMS program relies on treatment principles while taking into account the unique nature of the airline transportation system (Hankes, 2013). Most pilots come into HIMS through a peer and manager led intervention. These typically result in a referral for a diagnostic evaluation, and if indicated, treatment begins immediately. Not all pilots referred to evaluation meet the diagnostic threshold for inpatient treatment. Following successful treatment and comprehensive continuing care, the pilot is eligible to seek FAA medical recertification (Elliot, 2013).

The assumptions that characterize the HIMS program as it was developed remain at the core of the program today:

1. Alcoholism is a primary treatable disease.
2. The FAA and the American Medical Association will define alcoholism.

3. Occupational alcoholism programs will have a higher success rate than nonwork-related programs.
4. The intensity of job motivation characteristic of airline pilots will yield a greater recovery rate.
5. Abstinence is essential to successful rehabilitation.
6. Alcoholism readily fits the disease-prevention model.
7. Education can be a factor in changing behavior.
8. Airline pilot professionalism and the ALPA Code of Ethics promote periodic review of performance.
9. Knowledgeable and trained individuals are required to staff the program.
10. An open, honest approach toward recovery is basic to quality sobriety and is consistent with pertinent FARs.
11. An alcoholic pilot deserves individual professional attention.
12. Unsuccessful repeated efforts at treatment for alcoholism warrant cessation of flying on medical grounds.
13. Education of the pilot group members is crucial to the success of the program (HIMS, 2013).

In 1985, the FAA studied 587 records from airline pilots who participated in the HIMS program who were issued special issuance (SI) medical certificates after treatment for alcoholism. Some of their initial findings were that 79% of those pilots did not have a relapse and 85% were successfully rehabilitated, some after one or two relapses (Russel

& Davis, 1985). More recent studies indicate that the initial treatment recovery rate remains at or above 80% (Hudson, 2013).

The Rehabilitation of Impaired Airline Pilots

The rehabilitation treatment protocol for impaired pilots is a minimum of four weeks of inpatient treatment and most often the facility is determined by the company rather than the pilot. Typically during treatment the pilot will meet with his union HIMS committee representative and members from management to discuss recovery issues and benefits that may be available during the period of unemployment (Storbeck & Tutor, 2013). In some cases, this is the opportunity for a pilot to provide full disclosure of any additional issues that may impact his future availability to line flying. Some carriers require their pilots to sign recovery contracts or "last-chance agreements" where pilots agree that their continued employment is dependent on meeting HIMS and company specific criteria (Storbeck, 2013).

The FAA Office of Aviation Medicine uses the term aftercare to mean "the specific structured outpatient treatment that occurs after the initial intensive phase" (HIMS, 2013). Following treatment, the FAA specifies that at minimum pilots must attend at a weekly aftercare group as well as periodic meetings with a psychiatrist (Porges, 2013). After the pilot returns to duty, group therapy and monitoring may continue for two to three years. In the event of a relapse, these requirements may be extended until the pilot retires (Bryman, 2012).

There has been some resistance to the group model due to the difficulty of making weekly meetings when pilots return to the line; however it is expected that pilots will attend at least 50% of these meetings (Hankes, 2013b). Other criticisms have included a lack of groups that have a specific focus on regulatory and licensure issues (HIMS, 2013). Some airlines have monthly group meetings at their domiciles that may include the chief pilot, human resources, and union representatives (Prewett, 2013). Although these meetings may be helpful from a peer support function, the FAA indicated that these do not meet the level of the desired aftercare group therapy model (Russel & Davis, 1985).

In some cities, such as Atlanta, the airlines contract with counselors and psychologists to provide these weekly aftercare meetings (Prewett, 2013). Continuing care may also include monthly face-to-face meetings with peer monitors. Monitors are airline pilots in recovery who have attended the 3-day HIMS training program. They are held in positive regard by program participants and can be a significant resource for the newly-sober pilot (Bryman, 2012).

Over the years, telephone contact alone has proven ineffective at identifying behaviors that may lead to relapse (Tyler, 2012). At some airlines peer monitoring is required while, at others, participation may be voluntary. Most unions work in concert with the company to provide effective aftercare programs. If in place, aftercare agreements are negotiated between the airline and its pilots' union. As a result, provisions, benefits, and stipulations vary greatly across the industry (HIMS, 2013).

Although it is not mandated by the FAA, the HIMS literature strongly suggested that on the completion of inpatient treatment pilots should attend 90 AA meetings in 90 days, get a temporary sponsor (in addition to the peer monitor) and attend Birds of a Feather (BOAF, 2013) meetings (Hankes, 2013b). BOAF is a worldwide organization based on the principles of Alcoholics Anonymous. BOAF was founded in 1976 for pilots and cockpit crewmembers that are active or inactive in private, commercial or military aviation. "Nests" exist in major aviation hub cities in the US and Canada as well as other countries (Korea) and meetings are held on a weekly or monthly basis (http://www.boaf.org/).

Alcoholics Anonymous (AA) and other organizations such as Narcotics Anonymous (NA), and Cocaine Anonymous (CA) are considered to be the cornerstone for a pilot's durable recovery. Due to strict anonymity it is difficult to know the extent of participation even when it is mandated by the company or legal system. Similarly, although some companies may want to know the frequency with which a pilot has communication or meets with his sponsor the nature of this communication is privileged (Prewett, 2013). Some treatment centers offer annual 2-3 day return visits, and while these may be voluntary pilots report that these can strengthen a recovery program (HIMS, 2013).

Thirty days following treatment is the earliest that the pilot can submit to psychiatric and psychological evaluation (P & P) required to begin the reinstatement of the airmen's medical certificate. Both a HIMS trained psychologist and a psychiatrist conduct the P & P to ensure that the recovering pilot does not have any psychiatric or cognitive problems that need to be addressed before the pilot can return to flight status. Most airlines, medical examiners, and providers will suggest that pilots complete the 90 meetings in 90 days before beginning the P&P process around the 5th month following treatment. Testing and assessment is very aggressive and takes place over a 2-day period. The current battery of required tests includes:

1. CogScreen-Aeromedical Edition (CogScreen-AE)
2. The complete Wechsler Adult Intelligence Scales (Processing Speed and Working Memory Indexes must be scored)
3. Trail Making Test, Parts A and B (Reitan Trails A & B should be used since aviation norms are available for the original Reitan Trails A & B, but not for similar tests [e.g., Color Trails; Trails from Kaplan-Delis Executive Function, etc.])
4. Category Test or Wisconsin Card Sorting Test, and
5. Stroop Color-Word Test
6. Paced Auditory Serial Addition Test (PASAT)
7. A continuous performance test (i.e., Test of Variables of Attention [TOVA], or Conners' Continuous Performance Test [CPT-II], or Integrated Visual and Auditory Continuous Performance Test [IVA+])
8. Test of verbal memory (WMS-IV subtests, Rey Auditory Verbal Learning Test, or California Verbal Learning Test-II)

9. Test of visual memory (WMS-IV subtests, Brief Visuospatial Memory Test-Revised, or Rey Complex Figure Test)
10. Tests of Language including Boston Naming Test and Verbal Fluency (COWAT and a semantic fluency task)
11. Psychomotor testing including Finger Tapping and Grooved Pegboard or Purdue Pegboard
12. Personality testing, to include the Minnesota Multiphasic Personality Inventory (MMPI-2)

After the P&P is completed the reports are sent to the pilot's aviation medical examiner (AME). The HIMS AME then acts as the Independent Medical Sponsor (IMS) to coordinate the FAA re-certification process (HIMS, 2014). As a relapse prevention measure, as long as the pilot hold a special issuance medical certificate, the initial IMS provides oversight of the pilot's continuing care. As long as the pilot is required to follow the HIMS protocol, the IMS reviews monthly reports from trained flight managers, the pilot peer monitor, and aftercare providers (Bryman, 2012).

Sometimes aftercare recommendations from the P&P may include counseling if the pilot's prior using (or a relapse) had a significant impact other areas of life (HIMS Faculty, 2013). Changes may be profound such as the losses brought forth by divorce, incarceration, unemployment, and bankruptcy. The FAA is not involved in voluntary therapy, and sessions cannot be used in-lieu of group aftercare meetings (HIMS, 2013).

Monitoring and Return to Work

There may be several components to a pilot's monitoring program following treatment. Primarily for the pilots in the HIMS program this includes the abstinence testing conducted by the HIMS Independent Medical Sponsor (IMS) or the company and monitoring the pilot's progress in recovery. Once there is a strong record of recovery as evidenced by quarterly reports the FAA may either release the pilot from the special issuance program or reduce aftercare requirements. To assist in this decision process, the FAA requires that the group therapist provide a description of the therapy process. The report includes a discussion of the critical issues affecting the pilot's sobriety and report of any adverse change in the pilot's behavior (HIMS, 2013). In order to retain a medical certificate pilots in the HIMS program must remain abstinent (Bryman, 2012). A very effective component of monitoring are the random testing programs in place at all air carriers. The sophistication and longer look-back period of FAA approved tests (including hair-sample) discourage relapse and will most likely identify pilots who do (Kalfus & Riccitello, 2013).

Assessing Changes in Cognitive Functioning

Psychometric testing is designed selectively to assess certain aspects of an individual's emotional, behavioral, or cognitive functioning. These aspects are interrelated in that disruption in one area may affect other areas of functioning. For example, an individual who is below average in intellectual functioning may also express avoidant traits (Prewett & Hamilton, 2013). In this case it may be difficult to ascertain whether the personality style is an adaptive response to conceal cognitive impairment, or if anxiety in a social learning environment affected cognitive development. For reasons such as these, it is important to select instruments that have a history of validity and reliability to ensure that the instrument measures what it is supposed to and that findings are factual.

Construct validity insures that the psychological attribute to be measured is actually being assessed (Mitchell & Jolley, 2004). Predictive validity is important in the choice of tests. Low scores in a specific area of functioning such as attention should correlate with difficulty in task completion (Groth-Marnatt, 2008). Incremental validity must be considered in the battery style test environment. Does the test provide additional information that is not captured by other measures? Finally, test-retest reliability must be such that there is stability of the characteristic being measured when the test is repeated (Groth-Marnatt, 2008). Changes on a given scale should accurately reflect the change on that dimension. This is particularly true when an individual will be assigned to a diagnostic category such a below average, average or superior (Mitchell & Jolley, 2004). From an assessment perspective, there are key areas that are important to intellectual functioning. These include information processing and storage, retrieval, attention, learning, and problem-solving (Trivedi, 2006). The Wechsler tests have been designed to assess many of these dimensions and are the most widely used assessments for testing intelligence and memory (McCrea & Robinson, 2011).

Using the WAIS - IV to Assess Cognitive Status

The WAIS–IV (Wechsler, 2008a) is the latest version of the Wechsler-Bellevue Intelligence Scale Form I (Wechsler, 1939) and is composed of ten core subtests that yield the Verbal Comprehension (VCI; similarities, vocabulary, and information), Perceptual Reasoning (PRI; block design, matrix reasoning, and visual puzzles), Working Memory (WMI; digit span and arithmetic), and Processing Speed (PSI; coding and symbol search) indexes (Groth-Marnatt, 2009). The 4 index scores yield a full scale IQ score (FSIQ). The WAIS-IV uses standard scores (M=100, SD = 15) for the VCI, PRI, WMI, PSI, and FSIQ (Sattler & Ryan, 2009). Scaled scores (M = 10 SD = 3) are used for the 15 subtests (Sattler & Ryan, 2009). In addition to the ten core subtests the WAIS-IV contains five supplemental tests, however these are not used in this study. The WAIS–IV was standardized on 2,200 individuals who were divided into 13 age groups between 16 and 90 years and stratified according to five educational levels, five ethnicities, and four geographic areas of residence (Kreiner, Ryan & Tree, 2009; Sattler & Ryan, 2009). The WAIS-IV has excellent reliability with internal consistency reliability coefficients, and these are discussed in greater detail in Chapter 3.

Cognitive Evaluation of Alcohol Dependent Populations

As early as 1941 the Wechsler-Bellevue test was used to study participants (n = 29) hospitalized with alcoholism. Wechsler reported that there were obvious indications of CNS dysfunction and deficits in new learning, abstract reasoning and perceptual organization (Goldman, 1983). In 1972, a follow-on study of hospitalized patients (*n* =158) with alcoholism was conducted using the full WAIS. Using Wechsler's original normative values the study found accelerated mental aging and evidence of organicity in test profiles (Williams, Ray, & Overall, 1973). The study also found that there was a somewhat greater organic involvement after age 35. A similar study conducted with the WAIS in 1988 reaffirmed that patients with alcoholism show significantly advanced mental aging with respect to normal cognitive abilities (Holden, Mclaughlin, Reilly, & Overall, 1988).

Based on earlier findings (ten studies) that those with alcoholism are unimpaired on Information McLachlan and Levinson (1974) designed a study using Information and Block Design WAIS subtests at two points (intake and one year later) to detect the presence of brain damage in a population with alcoholism. They found that participants who remained abstinent significantly improved on Block Design and problem-solving abilities when compared with participants who returned to drinking (McLachlan & Levinson, 1974).

To assess the extent of brain dysfunction Smith and Smith (1977) administered the WAIS to three groups; patients classified as having cirrhosis, non-cirrhotic patients with alcoholism, and a control group. The mean scores for the summary IQ scores (Verbal, Performance and Full Scale) are significant for the group with cirrhosis, and comparison score decrements range between 9 and 14 points across the indexes. Performance IQ showed the greatest deterioration while there was little difference found on Vocabulary or Information scores (Smith & Smith, 1977). Spencer and Boren (1990) also reported that verbal intelligence is considered to be more resistant to alcohol-related damage, but that impairment in this domain may surface in the ability to develop new linguistic skills.

Studies of performance on Block Design, Symbol Digit substitution, and Object Assembly frequently reveal impaired functioning (Goldman, 1983; Parsons & Farr, 1981). Symbol Digit substitution has been a consistently sensitive test of alcoholic dysfunction with deficits appearing in visuoperceptive analysis and the ability to learn new associations (Kapur & Butters, 1977). Goldman (1983) suggested that those with alcoholism have an unsystematic filing system and lack appropriate strategies to encode information that must be retrieved later. When speed is a factor, this lack of strategy may impair the ability to process new complex information efficiently. A 1993 comparison of the WAIS-R and WAIS with alcohol abusers (n = 94) found that while performance on Digit Span and Vocabulary were relatively intact, there was impairment on Block Design, Digit Symbol, and Object Assembly (O'Mahoney & Doherty, 1993).

In their study of adults (n = 58) admitted to a 24-day substance abuse treatment program, Schrimsher & Parker (2008) found significant improvement on the WAIS-III Similarities subtest for patients who completed treatment. The most outstanding findings were failures related to the constructional ability and copy capacity [recognition as identical or nonidentical designs] (Schrimsher & Parker, 2008). A recent study by Broderson et al., (2014) in Argentina of patients (n = 43) with liver disease employed the WAIS in conjunction with other instruments. The study found very poor performance in the visual motor and spatial areas and attributed these deficits to serious deterioration in the speed of mental processes involved with the perception and discrimination of objects. The authors concluded that poor results on the Similarities subtest support previous research that highlights deficits in comprehension, associative capacity and conceptual judgment (Broderson et al., 2014). Finally, a four year study (1983 – 1989) designed to explore factors in treatment retention administered 11 subtests of the WAIS to 495 participants. It was found that low scores on Digit Symbol, and Block Design were significant predictors of shorter length of stays in a therapeutic community (Fals-Stewart & Schafer 1992).

In summary, data suggests the neuropsychological profile associated with alcohol abuse reflects an IQ in the normal range with minimal impact on verbal skills (Green et al., 2010). Significant impairment may be found on tests of executive skills, memory, learning new information, as well as visuospatial analysis and perceptual motor integration (Green et al., 2010). A few studies suggested that cognitive skills improve following inpatient care (McLachlan & Levinson, 1974; Schrimsher & Partker, 2008).

WAIS-IV Subtests and the Relationship to Cockpit Skills

According to Sattler and Ryan (2009) Block Design measures nonverbal reasoning and assesses the following cognitive factors: visual processing, visualization, visual spatial construction ability, visual-perceptual reasoning, visual-perceptual organization, visual-motor coordination, spatial perception, abstract conceptualizing ability, analysis and synthesis, speed of mental and visual-motor processing, planning ability, concentration, fine-motor coordination, and visual-perceptual discrimination. There are a number of cockpit situations and aircraft maneuvers that rely upon these skills. These include arrival or departure planning, terrain and traffic avoidance, entering and exiting holding patterns, accepting and executing air traffic control (ATC) changes, as well as coping with emergencies such as engine failure or last-minute diversions to an alternate airport (Olson, 2014). Executing most flight changes typically involves control input and a heightened sensitivity to time. Block Design is an excellent measure of an individual's rate of motor activity and the ability to work accurately and efficiently under time pressure (Sattler & Ryan, 2009).

Similarities require that the individual state how two objects are alike and then combine common elements together into a meaningful concept (Sattler & Ryan, 2009). This subtest measures verbal concept formation as well as memory and requires an individual to stay focused on the task demands (Sattler & Ryan, 2009). Cognitive factors that are assessed include: crystallized knowledge, language development, lexical knowledge, verbal comprehension, abstract thinking ability, reasoning capability, capacity for associative thinking, ability to separate essential from nonessential details, long-term memory, vocabulary and receptive and expressive language (Sattler & Ryan, 2009).

One of the best illustrations of the application of these skills can be found in the incredible workarounds implemented by the United Airlines crew that saved Flight 232 from total fatality. During a routine flight, the United DC-10 suffered the catastrophic failure of the number 3 tail-mounted engine which destroyed the hydraulic control systems and rendered the aircraft unstable. Through a process of systematic elimination, a focus on essential tasks, the creative use of differential power, and exquisite crew coordination, they were able to land the aircraft (Ginnet, 1993). Prior to the crash of flight 232 United Airlines had begun CRM training and following the crew success in this accident the FAA mandated CRM training for all carriers (Kanki & Palmer, 1993).

Digit Span is a core working memory subtest that measures short-term memory and auditory processing (Sattler & Ryan, 2009). Cognitive factors that are assessed include working memory, rote memory, memory span, intermediate auditory memory, immediate auditory memory, attention, concentration, and numerical ability (Sattler & Ryan, 2009). There are obvious applications of Digit Span to cockpit communication, coordination, and working with ATC. The safety of flight and ground operations depend on the pilots' ability to encode information and within seconds, accurately repeat critical clearance instructions verbatim to the controlling authority. Digit Span Backward and Digit Span Sequence also involve the added ability to plan and the ability to transform stimulus before responding (Sattler & Ryan, 2009). These abilities can be likened to receiving an ATC clearance and simultaneously visualizing and evaluating the implications of the instructions while responding. Sattler and Ryan (2009) suggest that Digit Span Forward appears to measure immediate short-term memory where the other two appear to be more complex measures of working memory (Sattler & Ryan, 2009).

To underscore the importance of accurate ATC communications, the deadliest aviation accident in history remains the 1977 runway collision of two Boeing 747 aircraft at the Tenerife airport. There were unusual factors that day that do have to be acknowledged. An explosion at another airport resulted in numerous aircraft diversions to Tenerife. Ramp congestion eventually limited movement on taxiways. This forced departing aircraft to taxi on the active runway and make a 180-degree turn at the end to line up for departure. This “back-taxi” procedure caused frustrating delays made worse by the arrival of heavy fog that significantly reduced ground visibility. The KLM 747 was eventually cleared to taxi and the Pan Am 747 was instructed to follow but get off of the runway on another taxi-way. After back-taxi and finally being in position for takeoff, the first officer in the KLM 747 mistakenly interpreted ATC route instructions as a clearance for takeoff. Because the first officer did not use standard phraseology in repeating instructions back to ATC, the error was not caught before the captain initiated the takeoff roll. Fixated on takeoff, the KLM crew did not acknowledge, query, or respond to subsequent communications from ATC or the PanAm 747 until it was too late to prevent a collision.

Matrix Reasoning is a Perceptual Reasoning subtest that measures nonverbal fluid reasoning ability without a speed component (Sattler & Ryan, 2009). Some of the cognitive factors that are assessed include: visual processing, induction, visualization, visual-perceptual organization, reasoning ability, attention to detail, concentration, spatial ability, and visual-perceptual discrimination (Sattler & Ryan, 2009). From a modern glass cockpit perspective, the ability to maintain visual awareness is key to recognizing and discriminating useful information from clutter (Wickens, 2003). This skill is particularly in demand when multiple layers of information such as weather radar returns and navigation information are overlaid on a single screen or heads-up display (Olson, 2014). Besides visual acuity, Sattler and Ryan (2009) also relate performance on Matrix Reasoning to motivation and persistence, and the ability to work to a goal (Sattler & Ryan, 2009).

Vocabulary is a core Verbal Comprehension subtest that measures knowledge of words and is an excellent measure of an individual's ability to learn and accumulate information (Sattler & Ryan, 2009). According to Sattler and Ryan (2009) it assesses cognitive factors that include crystallized knowledge, language development, lexical knowledge, verbal comprehension, vocabulary, fund of information, richness of ideas, long-term memory, verbal fluency, conceptual thinking, and receptive and expressive language (Sattler & Ryan, 2009). The vocabulary of aviation is somewhat rigid and checklist oriented. Communication skills and knowledge however are highly relevant to maintaining a safe and coordinated cockpit environment as well as maintaining crew rapport (Kanki & Palmer, 1993). These skills also help to combat fatigue, stress, and the apathy or boredom that can set in during long international flights (Olson, 2014). An important factor of Vocabulary is that it provides an excellent estimate of intellectual ability that is extremely stable over time and resistant to both neurological deficits and psychological disturbances (Sattler & Ryan, 2009). When scores on the Verbal

Comprehension Index are significantly higher than other index scores, this may provide insight to pre AUD levels of intellectual functioning (O'Mahoney & Doherty, 1995; Prewett, 2013).

Arithmetic is a core Working Memory subtest that measures numerical reasoning (Sattler & Ryan, 2009). The subtest assesses cognitive factors that include quantitative knowledge, short-term memory, fluid reasoning ability, mathematical achievement, working memory, quantitative reasoning, long-term memory, mental computation, application of basic arithmetical processes, concentration, attention, mental alertness, and auditory sequential processing (Sattler & Ryan, 2009). Fortunately for most airline pilots the days of manual slide rules, compasses, and calculators are history. With advanced flight management computers, the ability to understand and perform computations adds a layer of protection to automated flight planning. Basic calculations for fuel management, aircraft weight and balance, and flight time, speed, and distance computations are similar to the questions and logic in the arithmetic subtest.

Symbol Search is a core Processing Speed subtest that measures speed of visual-perceptual scanning and discrimination (Sattler & Ryan, 2009). It assesses several cognitive factors including processing speed, perceptual speed, rate of test taking, psychomotor speed, attention, concentration, visual short-term memory and fine-motor coordination (Sattler & Ryan, 2009). Symbol search taps some of the same skills used to maintain situational awareness. These skills include the pilot's cross check of cockpit instruments and indicators and scanning the outside environment for cues such as an airport beacon, weather, or converging traffic (Olson, 2014). Crosscheck, a disciplined visual scanning technique, has long been recognized as one of the significant behavioral elements key to maintaining situational awareness and flight safety. Crosscheck is a skill that prevents fixation - cited as the human factor cause of Eastern Airlines flight 401 crash into the Florida Everglades. On approach, the crew became so fixated on a burnt out indicator bulb that they failed to notice the disconnect of the aircraft's autopilot resulting in the aircraft's slow descent into terrain (Kayton, 1993). Similarly crew failure to crosscheck any instrumentation resulted in a total loss of situational awareness causing the flight crew of Northwest flight 188 to overshoot its destination by 77 miles (FAA, 2009). In that flight, the crew reportedly were so engrossed with a new scheduling program on their laptops that ATC contact was lost for over 40 minutes.

Visual Puzzles, a core Perceptual Reasoning subtest measures spatial-visual-perceptual reasoning (Sattler & Ryan, 2009) The subtest assesses cognitive factors that include nonverbal reasoning, nonverbal fluid reasoning ability, mental transformation, analysis and synthesis, speed of visual-perceptual processing, spatial ability, visual-perceptual discrimination, attention, and concentration (Sattler & Ryan, 2009). Visual puzzles can be likened to the approach phase of flight that requires the selection of the best approach and runway for a given set of conditions. This subtest is highly related to decision-making abilities as well as those skills associated with flying a successful approach and landing within desired parameters. These skills are particularly relevant to commuter operations when touchdown in the landing zone may not be desirable, but there is still the requirement to fly a stabilized approach. Most operations under 10,000 feet and certainly those that involve hand-flying demand high levels of attention and the ability to concentrate (Olson, 2014).

Information is a core Verbal Comprehension subtest that measures long-term memory for factual information (Sattler & Ryan, 2009). It assesses cognitive factors that include crystallized knowledge, general verbal information, verbal comprehension, range of factual knowledge, alertness to environment, and receptive and expressive language (Sattler & Ryan, 2009). Information is certainly reflective of an aviator's educational background, drive, and intellectual curiosity. This type of long-term drive and curiosity enhances CRM to the extent that the individual remains motivated to maintain professional expertise and mastery of the knowledge and skills required to perform successfully over the span of their career.

Coding is a core Processing Speed subtest that measures the ability to learn an unfamiliar task involving speed of mental operation and psychomotor speed (Sattler & Ryan, 2009). It assesses cognitive factors that include processing speed, rate of test taking, visual motor coordination or dexterity, scanning ability, visual short-term memory, visual recall, attention, concentration, visual perceptual symbol associative skills, visual processing, fine motor coordination, numerical recognition, and visual-perceptual discrimination (Sattler & Ryan, 2009). One of the flight activities that involves speed of mental operations, attention, visual scanning, and fine-motor skills is the situation where the pilot has to execute a missed approach unexpectedly at low altitude. Rapid recognition of aircraft position, reconfiguration requirements, and compliance with ATC instructions require the ability to work under pressure, respond quickly to changing circumstances, and maintain a high level of focused attention (Olson, 2014). The ability to learn new tasks are important when pilots change airlines, aircraft, cockpit position, or shift from domestic to international operations. LOFT simulator training scenarios are a superb practical application of the skills tapped by the Coding subtest.

Cognitive Attributes and Crew Resource Management Skills

No discussion of pilot performance and cognitive abilities would be meaningful without a discussion of crew resource management skills (CRM). CRM is broadly defined by the FAA as

> the utilization of all available human, informational, and equipment resources toward the effective performance of a safe and efficient flight. CRM is an active process by crewmembers to identify significant threats to an operation, communicate them to the pilot in command, and to develop, communicate, and carry out a plan to avoid, or mitigate each threat. (FAA, 2003)

In 2004, the FAA stated that “investigations into the causes of air carrier accidents have shown that human error is a contributing factor in 75 to 80 percent of all air carrier incidents and accidents” (FAA, 2004). CRM skills provide a primary line of defense against the threats that abound in the aviation system and against human error, and its consequences (Helmreich & Foushee, 1993). In the aviation context, human error has been defined as “crew action or inaction that leads to deviation from crew or organization intentions or expectations” (Helmreich, Klinect & Wilhelm, 1999).

There are five types of errors relevant to flight safety that include intentional errors, procedural errors, proficiency errors, communication errors, and operational decision errors (Helmreich, Klinect & Wilhelm, 1999). Intentional errors include deviations from explicit guidance or standard operating procedures such as attempting to land from an unstabilized approach (Dismukes & Loukopoulos, 2004). Procedural errors include mistakes such as overlooking a checklist item or remembering an altimeter setting incorrectly (Durso & Alexander, 2010). The probability of these types of errors occurring escalate with increases in fatigue, stress, workload and time pressure (Sherman, 2003; Vidulich, 2003). Proficiency errors can happen when crews are required to execute rarely used non-normal procedures or when training fails to adequately address unusual procedures (Bent & Chen, 2010). Communication errors (like those described in the Tenerife accident) occur when information is missing, misinterpreted, presented incorrectly, omitted, or ignored (Kanki & Palmer, 2003). Lastly operational decision errors often occur in situations when workload is high and switching attention among concurrent tasks hampers the crews’ ability to choose and execute the correct response in a matter of seconds (Dismukes & Loukopoulos, 2004).

Most problems that occur in the cockpit tend to cluster on poor CRM skills in the face of error management. The primary CRM skills are: situational awareness (SA), decision-making (DM), communication (COM), workload management (WM) and crew coordination (CC) (FAA, 2004). CRM skills rely entirely upon cognitive abilities that at a minimum include detection, accurate interpretation, retrieval and efficient processing of information, working memory, problem-solving, as well as verbal acuity and accuracy. WM and CC are highly interdependent and rely on the core skills of SA, DM, and COM. For the purpose of discussing cognitive implications within the context of this research, the primary focus is on the core skills.

Situational awareness is comprised of elements that include actively monitoring of aircraft systems and flight status, staying ahead of operational contingencies, using inquiry/advocacy to maintain awareness, recognition of errors, and the sharing of relevant information with other crew members (FAA, 2004). Orasanu (1992) writes that not only must crews go beyond noticing the presence of cues, they must appreciate their significance. DiCatherwood et al., (2014) share that the loss of SA in challenging environments can result in serious consequences. From a cognitive perspective their EEG study of brain activity and the loss of SA suggests that "perception is a top-down function that involves the high-order frontal, cingulate, and parietal regions associated with cognition under uncertain conditions" (DiCatherwood et al., 2014). SA relies on information recognition and perception within the context of knowledge and expertise. Working and long-term memory are necessarily tasked to support goal-oriented decisions (Vidulich, Wickens, & Flach, 2010).

Pilots frequently make decisions, and most of these are routine or procedural in nature (Degani & Weiner, 1993). It is important to recognize that automation does not reduce the need for SA. Instead automation transforms the nature of the pilot's job from system operator to that of system monitor or supervising controller whose primary function is to make high-level or risky decisions (Dekker, 2006). Some specific problems with SA can be attributed to faulty spatial perception, diverted attention, shifts in bias, an inability to acquire information in a timely manner, or the failure to detect missing information (Dekker, 2006; Hunt & Rouse, 1981). Events where attentional failures have prevented pilots from noticing critical information or events are plentiful (Vidulich, Wickens, & Flach, 2010). An example of a crew's failure to process information is found in the final accident report of Air France flight 447 that crashed in the Atlantic Ocean en route from Rio de Janeiro to Paris in 2009. At cruise altitude, ice crystals blocked the plane's pitot tubes (part of the system used to determine air speed) which caused the autopilot to disconnect. Misreading the situation, the pilots reacted by over-controlling the aircraft and flew it into a sustained stall, signaled by a warning message and strong buffeting. The final accident report states that "despite these persistent symptoms, the crew never understood they were in a stall situation and therefore never undertook any recovery maneuvers" (Bureau d'Enquêtes et d'Analyses, 2012). The report also concluded that there was "total loss of cognitive control over the situation" (Bureau d'Enquêtes et d'Analyses, 2012). Three minutes and thirty seconds later with both engines running, a vertical descent speed over 10,000 feet per minute, the

Airbus crashed in the Atlantic Ocean killing all onboard. WAIS-IV subtests that closely relate to skills required to maintain SA are Symbol Search, Coding, and Matrix Reasoning.

Decision-making relies largely on SA but adds the components of seeking additional information, weighing, selecting and evaluating alternatives, and taking action with a regard for compliance with standard operating procedures (FAA, 2004). The most difficult types of decisions are those that demand creative problem-solving where procedures do not exist to meet the situation such as those encountered by the crew of United Airlines flight 232 (Orasanu, 1992). Naturalistic decision-making, heuristics, and biases, are some of the theories that have been discussed within the context of pilot decision-making (Orasanu & Fisher, 1997). Some of the key concepts relevant to cognitive assessment and decision-making include the recognition-primed decision which draws on knowledge, expertise, working memory, mental shortcuts, decision biases, and the tendency toward confirmation bias. Recent studies have found that with modern cockpits, pilots become further susceptible to automation bias. Mosier (2007) suggests that under time-pressure situations, pilots may be relying on automated information as a heuristic replacement for vigilant information seeking and processing. As a result, they may fail to seek additional and critical information (Curtis, Jentsch, & Wise, 2010). The WAIS-IV subtests that most closely relate to DM are Information, Arithmetic, Visual Puzzles and Block Design.

Communication has a number of components which range from conducting operational briefings, stating decisions clearly, listening to and encouraging others to provide input, and keeping the feedback loop open to overcome operational issues (FAA, 2004). Other factors include accurately encoding, recording, and repeating instructions. One of the significant aspects of interpersonal communication discussed by Kanki and Palmer (1993) is that it can "integrate crewmembers to create a single, effective team with a positive orientation toward sharing tasks and information relevant to completion of those tasks". Communication is key to the pre-flight interpretation of aircraft maintenance issues that may impact the type of operations, and result in delays, cancelations, or diversions (Munro, Kanki & Jordan, 2008). Furthermore, effective communication is key to maintaining multi-departmental awareness of security threats or risks that have the potential to significantly impact personnel, passengers and airport operations (Hamilton, 2004). The WAIS-IV subtests that most closely relate to COM are Vocabulary, Digit Span, and Similarities.

It is not a stretch to suggest that impaired cognitive abilities result in poorer CRM skills. For example, Hoffman, Hoffman & Kay (1995) discovered in their study of cognitive factors and CRM that the faster pilots make comparisons and are systematic and flexible in applying rules, the better they are at CRM. Also significant to CRM outcomes was that the more accurate pilots were and the less time they spent reacting, (skills reflective of processing speed) the better the outcome (Hoffman, Hoffman & Kay, 1995). Are there differences in the change in cognitive functioning, as measured by

Verbal Comprehension (VCI; similarities, vocabulary, and information), Perceptual Reasoning (PRI; block design, matrix reasoning, and visual puzzles), Working Memory (WMI; digit span and arithmetic), and Processing Speed (PSI; coding and symbol search) indexes between airline pilots of different age groups who participate in the HIMS program for recovery from AUD? What is important to take away from this section is that some of the cognitive aptitudes measured by the WAIS-IV are critical to situational awareness and decision-making capabilities. Is it possible that airline pilots with AUD experience deficits in visuospatial processing or problem-solving reflected by low scores on relevant WAIS-IV subtests?

Aviation Psychology and Career Theory

For research focused on a specific profession, career development theories lend themselves to the study of airline pilots in recovery. Research has suggested that there are certain cognitive aptitudes, personality attributes, and traits that lend themselves to the process of becoming an airline pilot (Fitzgibbons, Davis and Schutte, 2004). As a group, pilots typically enjoy superior intelligence (Kay, 2013) and share similar views, interests, and attitudes (Fitzgibbons, Davis and Schutte, 2004). For these reasons, it is suggested that superior cognitive ability and certain personality traits are key elements to being successful as a pilot (Porges, 2013).

Holland (1959) took the position that members of an occupational group have similar personalities and will respond to situations similarly. He suggested that the choice of occupation is an expression of personality and that both career stability and achievement rest on the congruence between personality and job environment (Capuzzi & Stauffer, 2006). Using the Holland typology, the three attributes identified for the profession of commercial airline pilots are Realistic, Investigative and Enterprising (RIE; Gottfredson & Holland, 1989). Realistic is found in traditional male careers and presents an adventurous, active and practical individual who is stable and enjoys working with machines. Investigative describes the individual who is analytical, inquisitive (more interested in ideas than people) intellectual, challenging, and critical. Lastly, enterprising individuals are persuasive leaders who are ambitious and energetic with a tendency to dominate others. While not all pilots will be represented by the RIE profile, these attributes do surface in other types of assessments (Butcher, 1994). Prewett suggests that health professionals may encounter resistance when working with airline pilots that endorse both the RIE profile and alcohol dependence (Prewett, 2013). These may arise from a pilot's strong sense of autonomy and high self-confidence, and an innate distrust/questioning of authority, that can reinforce denial as a defensive strategy (Earley, 2013).

Bandura's (1982) theory of self-efficacy is another context from which to understand why an individual might choose a specific career. His theory is that people gravitate toward occupations requiring capabilities they think they either have or can develop (Capuzzi & Stauffer, 2006). The process of becoming an airline pilot for a major airline can be lengthy, expensive and challenging. Many airlines require a four-year college degree, the airline transport pilot rating (ATP), and experience in certain types of aircraft in specific conditions. The aviation industry has always been highly cyclical in hiring and this can present significant economic challenges for aspiring pilots (Kay, Thurston & Front, 2013). In the past, there have been long periods where due to recession or events such as 9-11, furloughs of several years were common, and hiring was nil. Along those lines, Bandura (1982) emphasized that perseverance toward personal goals plays a central role in career outcome (Bandura, 1982; Capuzzi & Stauffer, 2006). Achievement of goals is directly related to the determination to engage in all the activities required to achieve a desired outcome. In the case of becoming an airline pilot, goals serve to help guide and organize behavior over long periods of time.

Most airline pilots report that they wanted to fly from a very young age (Porges, 2013, Olson 2014). Most can even recall the event or day that the passion for aviation took hold (Storbeck, 2013). This certainly resonates with Super’s (1990) developmental theory of self-concept over a lifespan (Super, 1990; Capuzzi & Stauffer, 2006). Super’s exploration phase (around age 14) coincides for many aspiring pilots with their first flight. It is not uncommon for these individuals to fly their first solo flight as soon as they reach the required age of 16. A number of hopeful pilots enroll in specific aviation programs (such as those offered by the Armed Forces, Embry-Riddle Aeronautical University, the University of North Dakota, and the University of Iowa). This serves to further crystallize and narrow their vocational preference. Once established at the airline of their choice, pilots enter Super’s maintenance phase (44-65) where advancement is mostly dictated by seniority until retirement (Kay, Thurston & Front, 2013). Numerous bankruptcies, acquisitions and mergers affected pilots who once thought they were set for life (consider Trans World Airlines, Eastern Airlines, Pan-American, Air Tran, etc.). These pilots often find themselves unemployed or displaced to lesser positions within a new airline (Kay, Thurston & Front, 2013). For the pilot who has few other occupational opportunities, transitions in employment can be very stressful with significant geographical, and economic ramifications (Olson, 2014).

No discussion of occupational choice would be complete without acknowledging Parson's trait and factor theory (Parson, 1909; Capuzzi & Stauffer, 2006). Matching traits and aptitudes to occupation has been historically significant in the screening and selection of military and civilian pilots. Pilot selection within the Armed Forces was and remains highly competitive. The focus is largely on cognitive abilities and traits that have a proven track record for supporting mission success (Saitzyk, Alfonzo, Greydanus, Reaume, & Parsa, 2013). An illustration of this selection is found in a study of USAF pilot candidates (*n* = 5617) designed to establish aviator-specific intelligence norms. The mean full-scale IQ (FSIQ) was reported to be 120, with a verbal intelligence quotient (VIQ) of 119, and a performance intelligence quotient (PIQ) of 118 (Thompson, Orme, & Zazaeckis, 2004). In another study of aviator intelligence norms with commercial pilots (*n* = 456) Kay (2002) found the average FSIQ on the WAIS–R was 118.5 (Kay, 2002). The average VIQ was 116, and the average (PIQ) was 117. As mentioned earlier, the FAA takes great concern when there is evidence of cognitive impairment such as that brought on by traumatic brain injury, human immunodeficiency virus (HIV), dementia, psychiatric disorders, and substance abuse (Kay, 2013). Any significant decrements in cognitive ability when compared with aviator norms are of great concern (Hankes, 2013).

Aviation Psychology

Humorously, the Wright brothers described the pilot of an airplane as a skilled active controller of an unstable vehicle (Tsang & Vidulich, 2003). Aviation psychology has evolved over time from the selection of aviators and the interface between human and machine to an integration of aviation medicine and clinical psychology (Olson, McCauley, & Kennedy, 2013). As an applied science, it has its origins in World War II and the unprecedented development of complex, fast aircraft with sophisticated weaponry (Cox, Schmidt, Slack & Foster, 2013). Rapid expansion produced an urgent need to train large numbers of pilots. This in turn created demand for innovative training programs, optimal selection of personnel, as well as studies focused on prolonging the lives of highly skilled operators (Tsang & Vidulich, 2003).

Several key psychology concepts relevant to this study are situational awareness, mental workload, and decision-making. Mental workload in this case is the cost of accomplishing task requirements for the human element in a human-machine interface (Vidulich, 2003). A variable that modulates attention and information processing resource to meet task demands (Kantowitz, 2000). Vidulich (2003) writes that situational awareness is more concerned with the quality of the information apprehended by the pilot relying on factors such as perception, working memory, and long-term memory. The pilot's ability to manage his or her attention, prioritize tasks, and switch between tasks as necessary is key to safe operations (Dismukes, 2010). Most improvements in cockpit instrumentation and warning systems are an unfortunate result of human factor accidents; however, they have been designed with the goals of increasing situational awareness and reducing pilot workload (Curtis, Jentsch, & Wise, 2010).

Decision-making naturally follows situational awareness and is characterized as the act of choosing between alternatives under conditions of uncertainty (O'Hare, 2003). Interestingly, O'Hare (2003) found that working memory, rather than performance on FAA textbook knowledge, was one of the best predictors of optimal decision-making. Flexibility, attention switching, and timeliness (speed) are also key components to the decision-making process (Tsang. 2003). Some have argued that cognitive aging is a factor in the performance of some of these skills; however, research has suggested that expertise can mitigate certain age–related declines (Yesavage, 1999). The WAIS-IV is an excellent measure of many of these domains and is required for FAA return-to-work evaluations (Kay, 2013).

The Cognitive Profile of an Airline Pilot

Aviators represent a unique population, and there are very few normative samples available to psychologists (Kay, 2013). The majority of research has been focused on screening pilots for training. Kay & Horst (1992) warn that the skills required to train successfully as a pilot may be different from skills used by experienced pilots when flying (Kay & Horst, 1992). As a professional group studies indicate that pilots share a superior level of intelligence (greater than one standard deviation above the mean). For this reason, standard normative samples do not accurately reflect the airline pilot population (Kay, Thurston & Front, 2013). When evaluating a pilot for fitness to return to work after a head injury or other illness this lack of data can be problematic (Thompson, 2004).

In order to evaluate how an individual performs relative to their peers, there is a requirement for normative data. Individuals typically perform in a consistent manner in the expression of cognitive functions. If an individual has cognitive impairment, then it would be expected that test results would be lower than those of their peers (Prewett, 2013). Taking published base rates into account, a significantly lower score on a subtest or scale should flag further evaluation of the individual (Hankes, 2013). Kay (2013) suggests the criterion that scores that fall at or below the 15th percentile fall outside the normal expected range for healthy pilots and those below the 5th percentile indicate impaired performance.

In response to a deficit of aviator specific assessment tools, the CogScreen®-Aeromedical Edition was developed and normed for use with aviators (Kay, 2013). Designed for the Federal Aviation Administration (FAA) the Cogscreen AE test is sensitive to the likelihood of brain injury; however, compared with tests such as the WAIS-IV, this test is rarely used outside the aviation community). Historical pilot norms may be less representative of the current level of education and intelligence of commercial pilots. Those with the financial resources are more likely to choose professions where they will earn an income more reflective of their abilities (Kay, Thurston, & Front, 2013).

The Personality Profile of an Airline Pilot

Insight regarding the psychological profile of airline pilots has historically come from two sources: "(a) assessment of cognitive and perceptual motor abilities; and (b) assessment of personality and emotional factors" (Butcher, 1994). Until the 1990's the typical pilot profile was based on military aviators. Some selection studies date back as far as World War I and designed to increase the likelihood of mission successes as well as training and equipment costs (Beaulieu, 1991).

A landmark 1985 study of 350 males enrolled in the U.S. Air Forces' undergraduate pilot training program (December 1984 to September 1985) was among the first to use the MCMI. The study reported scores that revealed "predominant histrionic and narcissistic patterns of personality" (Deitz & Johnson, 1991). Follow-up studies conducted with airline pilots surface similar personality findings and suggests that for a period of time, there may have been a common pilot personality (Fitzgibbons, Schutte & Davis, 2000).

In recent years, major airlines as well as industry researchers have evaluated cognitive, personality, and performance attributes across different settings. These include line observations at both major and regional carriers, simulator scenarios focused on line-oriented flight training (LOFT), and the pre-screening phase of employment and students enrolled in college-level civilian aviation programs. Pre-employment screening at air carriers serves several purposes. First it can identify candidates whose knowledge and skills are superior to their peers and materialize in both short and long-term cost savings (Kay, Thurston & Front, 2013). Screening can also identify those candidates whose personality traits and communication styles may be undesirable in a highly disciplined and structured team environment (Carretta & Rae, 2003).

A few studies using formal assessment instruments identify similar traits across different measures. A National Aeronautics and Space Administration (NASA) study using the NEO Personality Inventory – Revised (NEO-PI-R, Costa & McRae, 1992) found that as a group pilots tend to report being emotionally stable (65% were found to be very low on Neuroticism) (Fitzgibbons, Schutte & Davis, 2000). There was a small trend towards Extraversion (42%), a normal distribution for both Openness and Agreeableness and an overwhelmingly high trend toward Conscientiousness (Fitzgibbons, Schutte & Davis, 2000). In exploring the atypical facets, the authors found that 61% of the pilots reported low levels of both anxiety and depression, very low levels of perceived vulnerability, and high levels of assertiveness. Other general findings were that pilots tended to be dutiful, straightforward, trusting and active individuals (Fitzgibbons, Schutte & Davis, 2000). A finding relevant to research with pilots affected by alcoholism is that on the measure of impulsiveness, 57% of the pilots were low whereas 17% were high. In this domain impulsiveness refers to an inability to control cravings and urges as related to drugs and food. In Ganellen's (1994) study of pilots with alcoholism, these impulsive urges surfaced there as dependency responses on the Rorschach.

In the United States, psychological testing is not a requirement to earn an FAA certificate or pilot license. That said, for many years the Minnesota Multiphasic Personality Inventory (MMPI) and MMPI-2 have been widely used in the aviation industry to assess the mental health of pilot applicants and aid in the selection process. Butcher (1994) studied 437 qualified male pilots who were applying for positions with major airlines and describes the group as highly skilled and emotionally stable. The study found that pilots often attempt to present themselves in an overly favorable light (high K scores) and deny/minimize any weaknesses or problems. As a group pilots endorsed very few symptoms of psychopathology and significantly endorsed positive features such as ego-strength, responsibility, and dominance (Butcher 1994). Rose (2004) discovered that pilots score high on the "optimistic-coping" end of the scales, have an unusual ability to handle criticism, and are patient with a dislike of being rushed. A European study of pilot personality and successful job performance surfaced other positive characteristics that included social ability and well-balanced self-assertiveness (Hörmann & Maschke, 1996).

The Pilot "Personality" and Alcohol Use Disorder

Like other professionals influenced by genetic vulnerability (diabetes, alcoholism, and bipolar disorder), life changes, and unpleasant environments, pilots are similarly vulnerable to conditions that affect emotional well-being (Butcher, 2002). Once employed personality screenings are rare and only conducted when behaviors exceed a threshold to result in detectable performance decrements (Prewett, 2013).The most frequent mental health problem among flight crew members is alcoholism, and it is likely considerably greater than numbers show (Butcher, 2002, Porges, 2013). One of the points made by Bangs (2004) is that “abuse creates a circular dilemma. It is difficult to know if the pilot is abusing alcohol because of underlying problems, or if problems were caused by the alcohol abuse” (Bangs, 2004).

Ganellen (1994) studied 16 commercial pilots who met the diagnostic criteria for alcohol or substance abuse approximately 2 – 3 months after they completed inpatient treatment. Both the MMPI and Rorschach were administered to test whether a defensive style of responding on the MMPI would be reflected in fewer than average or constricted protocols on the Rorschach. There were contradictory findings. On the Rorschach, the sample participants gave an average number of responses and level of effort. However, it was clear that the Rorschach identified levels of emotional distress not endorsed on the MMPI, in particular those associated with interpersonal relationships and self-perception (Ganellen, 2004). In keeping with other studies, the Rorschach responses indicated that these individuals had tendencies to be self-centered (narcissistic), highly self-critical, stubborn, resentful, and independent, with a basic lack of trust in others (Ganellen, 1994).

This lack of trust in others also surfaces in a study that examined the psychological effects of constant evaluation on airline pilots. With some exceptions such as those carriers with Advanced (or Continuing) Qualification Programs (AQP, CQP) airline captains are tested for proficiency every six months throughout their commercial careers (Proficiency Check Requirements, 2003). These oral, line and simulator evaluations are stressful as poor performance could result in a failure to upgrade, demotion or termination. Pilots in a study conducted by Lempereuer & Lauri. (2006), reported that the fear, frustration and resentment in reaction to this constant monitoring resulted in diminished trust in their organization, management, and fellow crewmembers. With regard to stressors, pilots reported that even when they are experiencing stress-related psychological problems they do not feel any obligation to disclose these during their routine medical evaluations (Lempereuer & Lauri. 2006).

By nature of the profession, pilots are trained to doubt, question and double-check the accuracy, reliability and reality of what is in front of them (Olson, 2014). Over time, this may translate into a rejection of all forms of authority and the belief that they are the only person that can protect themselves (Earley, 2013). This self-reliance and mistrust of others makes it even more challenging for pilots who know they need help to become willing to ask for it (Earley, 2013; Prewett, 2013). It is not surprising that most pilots enter treatment for alcohol or drug abuse as a result of DUI arrests or peer observation and intervention (Porges, 2013).

As a group, pilots have traditionally been reluctant to report peers who may be struggling with alcohol or other mental health issues (Hankes, 2013b). Bangs (2004) suggests that pilots are afraid that they may be negative fallout from their employer, peers or the individual in question. However as ALPA has stood behind pilots who enter the HIMS program, the program has earned the trust within the aviation community (Hankes, 2013b). Fewer flight crew members and ground personnel are willing to look the other way and risk jeopardizing flight safety or their careers (Hudson, 2013). The benefit of early intervention with pilots who may be struggling with alcohol is the potential for heading off further problems. During assessment, even if they do not have a legal situation such as a DUI, pilots may recognize the need for inpatient treatment to quit drinking. Even a pilot referred for an evaluation that does not meet diagnostic criteria for treatment, may be motivated to re-examine drinking patterns and behaviors.

Summary

This chapter has reviewed addiction as well as the effects of alcohol on the brain. Also reviewed are studies using earlier versions or specific subtests from the WAIS documenting cognitive impairment related to alcohol abuse. Impairments are found in two domains; working memory and processing speed but only a handful of studies focus on within-subject assessments. Assessment and aviation psychology were discussed as a prelude to discussions of the cognitive and personality profiles of airline pilots. Rounding out the review other topics include the prevalence and treatment of pilots with alcoholism as well the roles of the FAA and the HIMS program. Of particular relevance, the relationship between the WAIS-IV subtests and CRM were discussed at length to provide readers with insight to the critical nature of certain aptitudes and skills in maintaining flight safety. This thorough search of the literature has not identified a substantive body of literature studying cognitive changes in airline pilots after participating in alcoholism treatment, and hopes that this study may begin to address gaps in this body of literature.

Chapter 3: Research Method

The purpose of this study was to identify the extent to which recovery from AUD changes the cognitive functioning of airline pilots, and if pilot age moderates the amount of change. The information obtained from this study provides a better understanding of the relationship between AUD and cognitive functioning and of the role of aging in cognitive functioning in a population whose career depends on greater than average cognitive skills. Researchers have suggested that alcohol abuse affects cognitive functioning (Alfonso-Loeches & Guerri, 2011) and that these functions may improve with sobriety (Rosenbloom et al., 2003). Prior researchers have also suggested that age may play a role in recovery from cognitive impairments (Spencer & Boren, 1990).

Pilots are known to be intelligent and cognitively capable of handling complex situations (Kay, 2013; Porges, 2013). However, a review of the literature did not produce a scientific examination of changes in cognitive functioning for airline pilots in recovery from AUD. Therefore, in this study, I compared scores on the WAIS-IV index scores for pilots as they entered inpatient treatment with scores collected approximately 6 months later. I also examined age as a grouping variable to determine if (a) cognitive functioning changes over time and (b) if there is a significant difference in the change across age groups. In this chapter, I present an overview of the study’s research design and rationale and discuss the participants, instrumentation, sample size, data collection, and analysis as well as ethical considerations.

Research Design and Rationale

This study was conducted using a quantitative, within-subjects design. There were two independent variables, time (baseline and 6 months posttreatment) and age. Cognitive functioning, as measured by the four index scores and full score from the WAIS-IV, were the dependent variables. Archival data from a convenience sample was examined, comparing WAIS-IV index scores taken prior to entering treatment with index scores obtained 6 months after treatment. A within-subjects design was chosen as the accessible data are quantitative and consistently administered at two points in time on a fairly homogenous sample.

One of the benefits of quantitative approaches to research studies is that they are designed to validate or explore existing or new theories of why phenomena may be occurring (Creswell, 1994). When the sample is random in nature, the results may generate significant findings that can be generalized to a population or lead to quantitative predictions (Mitchell & Jolley, 2004). In this case, however, the data were not collected using a random sampling process. Rather, I employed a convenience, archival sample, which limits external validity.

The data collection process for quantitative studies is usually easier, particularly in research like this where the data were archival. These numerical data allowed for multivariate analyses that could determine if there were factors (in this case, age and abstinence) that could significantly describe differences between groups (Creswell, 1994).

A convenience sample from archived data was the only option for this repeated measures research. With the protected nature of pilots’ records in the HIMS program, it would be impossible to acquire a complete list of all pilots who have participated in the program. Also, there is only one facility that maintains repeated measures dataset for U.S. airline pilots in recovery from alcohol abuse (Elliot, 2013b, Prewett, 2013).

As mentioned earlier, this study’s design has limited external validity (Black, 1999). There is no way to estimate the representativeness of this sample to other airline pilots in recovery or estimate the standard error of the sample (Nachmias & Nachmias, 1996). The benefits of archival data are that the data collection process is very unobtrusive, there is lower risk of missing data, and there is no opportunity for researcher bias to influence actual WAIS-IV assessment results.

The data included WAIS-IV records of 96 airline pilots 35-0-0 through 64-11-30 years old. These pilots had a diagnosis of AUD and entered inpatient treatment between January, 2009 and December, 2014. Before the first administration of the WAIS-IV, these pilots were interviewed by a psychologist who determined that these individuals were competent to complete a battery of assessments. These individuals were specifically asked if they had memory problems, sleep disturbances, any history of head trauma, or learning disorders that might affect their performance (Prewett, 2014). Although numerous assessments were given, for the purposes of this research, only information from the WAIS-IV is presented. The psychologist who was responsible for the initial diagnosis of study participants had over 20 years experience with the treatment of addiction. The master's level licensed psychometrist who administered the WAIS-IV and other standardized assessments was very experienced and only responsible for the administration and scoring of the instruments. This researcher likely served in the role of aftercare group counselor for some of the participants included in this study; however, she did not know the identity of nor administered testing or individual counseling to any of the participants. The WAIS-IV was administered in strict accordance with the test protocols and there were no substitutes for the 10 primary subtests.

Methodology

Population

This target population consisted of male airline pilots who had been treated for AUD within the last 5 years. The accessible population consisted of pilots who received 4 weeks of inpatient treatment for alcoholism at the same facility located in a southeastern state within the United States. Although alcoholism does affect female pilots and those of other ethnicities, none went through treatment at this facility during the period of this study.

Sampling and Sampling Procedures

The convenience sample for this study consists of the archival data for 95 Caucasian male airline pilots treated for AUD between January 2009 and December, 2014. For purposes of clarification, all pilots included in this study met the criteria for alcoholism as defined by the FAA. That definition or threshold for diagnosis is distinct from that described in the DSM-V in that the FAA does not take into consideration whether a pilot abuses or is dependent on alcohol. The FAA has held to the definition that alcoholism is a "condition in which a person's intake of alcohol is great enough to damage his/her physical health or personal or social functioning, or when alcohol has become a prerequisite to normal functioning" (Russel & Davis, 1985). To be consistent, any pilot who was diagnosed with addiction to drugs was excluded from this study.

Additional exclusion criteria for this study were pilots who did not meet the FAA diagnosis for alcoholism and pilots who did not fly for major or regional air carriers. This research is limited from an ethnic or cultural perspective in that it was a convenience sample of Caucasian males who attended the same facility. Female pilots and those with other ethnic backgrounds do have problems with alcohol. However, they simply did not go through treatment at this particular facility during the period of this study. This convenience sample is one of a kind. Presently, there is only one known treatment facility and affiliated aftercare provider that captures both admission and return-to-work data for U.S. airline pilots in recovery (Elliot, 2013b; Prewett, 2013).

Finally, statistical power may play a role in limiting the significance of some of the statistical comparisons conducted because of the modest sample size in the present study (N = 105). A priori F-test MANOVA computation conducted using GPower (Faul, Erdfelder, Lang, & Buchner, 2007) with a moderate effect size (.15) alpha set at .05, six groups, four measurements, and correlation among repeated measures set at 0 suggests a minimum total sample size of 150. Due to the limited archival data available, the sample size for this study was less than desired.

Instrumentation

The latest version of the WAIS–IV was used to measure the dependent variable (Wechsler, 1939, 2008a). Previous editions include the WAIS (Wechsler, 1955), WAIS–R (Wechsler, 1981), and WAIS–III (Wechsler, 1997). The WAIS-IV is composed of 10 core subtests that yield the VCI (similarities, vocabulary, and information), PRI (block design, matrix reasoning, and visual puzzles), WMI (digit span and arithmetic), and PSI (coding and symbol search) indexes (Groth-Marnatt, 2009). The 10 subtests yield a FSIQ. The WAIS-IV uses standard scores (M = 100, SD = 15) for the VCI, PRI, WMI, PSI, GAI, CPI, and FSIQ (Sattler & Ryan, 2009). Scaled scores (M = 10, SD = 3) are used for the 15 subtests (Sattler & Ryan, 2009). In addition to the 10 core subtests, the WAIS-IV contains five supplemental tests; however, these were not used in this study.

In this study, I focused on data from the WAIS-IV Full Scale IQ score and index scores (VCI, PRI, WMI, PSI). If data analysis suggested significant differences at the subtest level, such as Block Design or Digit Span, these scores may be discussed further within the context of previous research findings (Goldman, 1983; McLachlan & Levinson, 1974; O'Mahoney & Doherty, 1993; Parsons & Farr, 1981).

The WAIS–IV was standardized on 2,200 individuals who were divided into 13 age groups between 16 and 90 years and stratified according to five educational levels, five ethnicities, and four geographic areas of residence (Kreiner et al., 2009; Sattler &

Ryan, 2009). There were 200 participants in each age group between 16 to 69 years and 100 individuals in the four age groups between 70 and 90 years. The sample closely matched the population of the United States during the October 2005 U.S. census (Kreiner et al., 2009; Sattler & Ryan, 2009).

The WAIS-IV has excellent reliability with internal consistency reliability coefficients for the 13 age groups ranging from .94 to .98 for Verbal Comprehension, from .92 to .96 for Perceptual Reasoning, from .92 to .95 for Working Memory, from .87 to .92 for Processing Speed, and from .97 to 98 for the Full Scale (Sattler & Ryan, 2009, p. 37). Internal consistency reliabilities for the subtests are lower than for the scales simply because there are fewer items on the subtests and range from .84 for Picture Completion to .94 for Vocabulary (Sattler & Ryan, 2009, p. 37). The average standard errors of measurement in standard score points are 2.85 for Verbal Comprehension, 3.48 for Perceptual Reasoning, 3.67 for Working Memory, 4.78 for Processing Speed, and 2.16 for the Full Scale (Sattler & Ryan, 2009, p. 39). The test-retest stability coefficients for the WAIS-IV (*M* interval = 22 days) were .95 for Verbal Comprehension, .85 for Perceptual Reasoning, .87 for Working Memory, .89 for Processing Speed, and from .94 to .96 for Full Scale. Mean increases from the first to second testing were 2.5 points for Verbal Comprehension, 3.9 points for Perceptual Reasoning, 3.1 points for Working Memory, 4.4 points for Processing Speed, and 4.3 points for the Full Scale (Sattler & Ryan, 2009, p. 39).

Sattler and Ryan (2009) concluded that prior exposure to items on the PRI and PSI (*M* Interval 22 days) result in better performance more than items on the VCI and WMI. Given a significantly longer period between test and retest, (*M* interval ≥ 90 days) in the present study, any direct comparisons with the published test-retest data must be made with caution. Factor analysis from both the technical manual and Sattler and Ryan indicated that the WAIS-IV is a good measure of general intelligence (Sattler & Ryan, 2009). While the WAIS-IV has numerous strengths, Sattler and Ryan pointed out that there are some limitations such as no conversion tables for computing index and FSIQ when supplemental subtests are used. Other limitations include a reduced number of subtests available for those aged 70 through 90, limited range of scores for individuals who are extremely low functioning, and limited criterion validity studies (Sattler & Ryan, 2009) These limitations are not considered to be problematic to the present study. While the Full Scale IQ scores are reported for each of the analyses, in this study, I focused on the WAIS-IV Index scores (VCI, PRI, WMI, and PSI) to explore within-group differences. The principal axis factor analytic results performed by Sattler and Ryan (2009) provide empirical support that the four individual Index scales in the WAIS-IV are separately functioning entities (Sattler & Ryan, 2009).

Age

The participants selected for this study were between the ages of 35 and 64 -11-0 at the time of the initial assessment. The age grouping selected for this study, (Group 1, 35-0-0 through 44-11-30, Group 2, 45-0-0 through 54-11-30, and Group 3, 55-0-0 through 64-11-30) are the exact age groups for which the WAIS-IV quantitative tables were developed (Sattler & Ryan, 2009). According to Prewett (2013) and Porges (2014), it is rare that airline pilots under the age of 35 or over the age of 65 enter into treatment for alcoholism under the HIMS program.

Intervention

All participants in this study received a diagnosis of alcoholism in accordance with the FAA definition for the condition. Additionally, all participants were in the HIMS program and attended the same 30-day inpatient treatment facility. The program consisted individual and group therapy, a supportive community living environment, random alcohol and drug testing, meetings with company representatives as well as required AA and BOAF meetings. Following inpatient treatment, intense random drug and alcohol testing continued throughout the length of the study. In order to be eligible to return to work, participants had to meet HIMS requirements as described in Chapter 2, such as attending 90 AA meetings in 90 days as well as weekly group aftercare meetings. Unless circumstances dictate otherwise, pilots return to work within the 6 months following treatment.

Archival Data Collection Procedures

In this study, I employed archival data. As such, I had no direct contact with participants during their treatment and return-to-work recovery period. I relied upon de-identified data from archival neuropsychological assessment records, and this is documented in the permission letter submitted to the Internal Review Board (IRB) of Walden University

(See Appendix A; IRB approval # 01-23-15-01-3763). Prior to the collection of data, approval was obtained from the IRB of Walden University and from the psychologist who maintains the data. The data collection process was limited to a single de-identified sheet already maintained in the treatment record of each participant. The data provided to me contained the basic information such as birth date, treatment date, dates of the two WAIS-IV administrations, and the subtest, index and full scale IQ scores for each administration. A screening of the data sheets ensured that only complete WAIS-IV results were selected for this study.

Ethical Protection of Participants

The only agreement required to gain access to the data was the one with Dr. David Prewett, the treating psychologist for all participants. To protect participants the author travelled to Atlanta and worked in the office where the files are maintained. All names were removed from the data summary sheets and the records were de-identified except for the random numbers assigned to the individual during the record review. These records were entered directly into SPSS Version 21. The original hard copy records remain in storage at the facility where the assessments were conducted. A key code was created that links the random numbers to SPSS entry in the event that any records need to be reviewed at a later date. This list is stored by the author on a separate password protected personal computer maintained separately from the computer used to create the dataset. The data set will be retained for five years and then discarded.

Research Questions and Hypotheses

Research Question 1

Does cognitive functioning, as measured by the index scales of the WAIS-IV VCI; (similarities, vocabulary, and information), PRI; (block design, matrix reasoning, and visual puzzles), WMI; (digit span and arithmetic), PSI; (coding and symbol search) change over six months for airline pilots who participate in the HIMS program for recovery from AUD?

Hypotheses 1

H_o^1 There is no difference in cognitive functioning, as measured by the WAIS-IV Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed Indexes for airline pilots from pre to postreatment for AUD.

H_1^1 There is a significant difference in cognitive functioning, as measured by the WAIS-IV Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed Indexes for airline pilots from pre to postreatment for AUD.

Research Question 2

Are there differences in the change in cognitive functioning, as measured by the WAIS-IV Verbal Comprehension (VCI; similarities, vocabulary, and information), Perceptual Reasoning (PRI; block design, matrix reasoning, and visual puzzles), Working Memory (WMI; digit span and arithmetic), and Processing Speed (PSI; coding and symbol search) indexes between airline pilots of different age groups who participate in the HIMS program for recovery from AUD?

Hypotheses 2

H_o^2 There is no age group difference in cognitive functioning, as measured by the WIAS-IV Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed Indexes for airline pilots from pre to postreatment for AUD.

H_1^2 There is a significant age group difference in cognitive functioning, as measured by the WAIS-IV Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed Indexes for airline pilots from pre to postreatment for AUD.

Research Question 3

Does cognitive functioning, as measured by the WAIS-IV Full Scale IQ change over six months for airline pilots who participate in the HIMS program for recovery from AUD?

Hypotheses 3

H_o^3 There is no difference in cognitive functioning, as measured by the WAIS- IV Full Scale IQ score for airline pilots from pre to postreatment for AUD.

H_1^3 There is a significant difference in cognitive functioning, as measured by the WAIS-IV Full Scale IQ for airline pilots from pre to postreatment for AUD.

Research Question 4

Are there differences in the change in cognitive functioning, as measured by the WAIS-IV Full Scale IQ between airline pilots of different age groups who participate in the HIMS program for recovery from AUD?

Hypotheses 4

$H_o{}^4$ There is no age group difference in cognitive functioning, as measured by the WAIS-IV Full Scale IQ score for airline pilots from pre to postreatment for AUD.

$H_1{}^4$ There is a significant age group difference in cognitive functioning, as measured by the WAIS-IV Full Scale IQ score for airline pilots from pre to postreatment for AUD.

Data Analysis

Analyses were conducted in SPSS Version 21. Prior to conducting statistical analyses basic descriptive statistics were analyzed including age, WAIS-IV scores, and test dates to ensure the accuracy of the collected data. Plots were be conducted to screen the dataset for any outliers. Age groupings (35-0-0 through 44-11-30, 45-0-0 through 54-11-30, and 55-0-0 through 64-11-30) used in this study reflect the age groups used for age norms in the current WAIS-IV administration and scoring manual.

Two factorial approaches were used to examine the research questions: ANOVA and MANOVA. Repeated measures ANOVA was used to examine changes over time (baseline to six months) for analyses of the WAIS-IV Full-Scale IQ and Index scores. For the analyses that included the between groups factor, age, repeated measures MANOVA was used, because it is designed to simultaneously evaluate multiple dependent variables providing an overall statistical test of significant change over time (e.g., Wilks-Lambda; Pillai's); as well as testing for significant change over time for each scale (F test). In both cases, analyses were conducted to report on how well the data meet the assumptions of each statistical test; e.g., normality of the dependent variables, homogeneity of variance (Levene's test and Box's M), and in the case of MANOVA, non-collinearity of the subscales).

Threats to Validity

This study has several limitations. The limitations regarding external validity include:

1. The archival data represent a convenience sample. Since the data was not collected using a random sampling procedure, the meaning of the results with respect to the target population must be discussed with caution.
2. This study examines a population where participants were selected solely on the basis of attending treatment at the same treatment and aftercare facilities as well as completing the WAIS-IV at the two-time points. As a result, generalizing results to other facilities or programs is not appropriate.
3. Another limitation to the generalization of findings is that occupational alcoholism programs may have a higher success rate than nonwork-related

programs (Hankes, 2013), and as such, study results should not be compared with dissimilar types of recovery programs.

4. This study was based on a population of all male Caucasian airline pilots and as such results may not be an accurate representation for female pilots or those of different ethnicities.
5. Patient history with regard to the duration, frequency and amount of alcohol used is likely to vary greatly across any inpatient population. Therefore, the results and model of change over time is not fully specified.

There are several limitations with respect to internal validity:

1. There is a risk of selection bias (Mitchell & Jolley, 2004), as there was no random assignment to treatment. Only those pilots who were motivated to return to work and stop drinking were included.
2. This study of archival data does not provide for a control group. (Ellis, 1999). The lack of a control group means that any detected change over time cannot be attributable to the treatment program per se. Further, examining change over only two points in time prohibits the researcher from making statements about program efficacy, as alcoholism research has demonstrated the risk of relapse is high six months post-intervention (Hankes, 2013, Hudson, 2012).Two problems inherent to within-subjects design research are fatigue and practice or “carry-over” effect (Mitchell & Jolley, 2004). Fatigue was not considered a factor given the lengthy time interval between assessments.

Practice effect could systematically bias the results between the first and final testing sessions. In this study, the six-month interval between tests is dictated by return-to-work requirements specified by the FAA and outside the control of this researcher. It is unlikely that one exposure to this kind of test six months ago would substantively improve scores.

3. As this is an archival study, the researcher does not have control of the data collection events or intervention. While researcher bias is excluded, this also eliminates the researcher's ability to observe and verify the data collection process. However, the WAIS-IV data used for this study was collected in strict accordance with the administration protocols established in the WAIS-IV. Manual. Over the entire course of this study, the assessments were administered in a quiet, windowless testing office by a trained psychometrist with 20 years' experience with Wechsler instruments. All data was reviewed for accuracy, and interpreted by a highly experienced HIMS psychologist who maintains the original test data and data summary sheets. While the data for this study is de-identified at the summary sheet prior to data entry, a random code enables the researcher to request a review of a data sheet if required.

A delimitation unique to this study is that the FAA sets forth a definition of alcoholism that differs from the DSM-V and has a lower threshold for diagnosis, as well as entry to inpatient treatment. Pilots with alcohol problems may identified earlier, and be less impaired than other populations admitted to treatment under American Society of Addiction Medicine (ASAM, Mee-Lee, Shulman, Fishman, et al, 2001) treatment levels.

Summary

It has been established that changes in cognitive functioning can occur for individuals who abuse or become dependent on alcohol; and, research with previous versions of the WAIS in populations with AUD have shown deficits in certain skill areas as measured (Goldman, 1983). Further, there has been some research to suggest that cognitive functioning may improve in persons with AUD who go through treatment and abstain. However, this has not been specifically examined in pilots, who represent a unique population of cognitively advanced individuals performing in an occupation that depends high cognitive functioning, integrative problem-solving, and team leadership.

This research proposes to compare scores on two administrations of the WAIS-IV, to investigate changes in cognitive functioning experienced by airline pilots who have completed treatment and returned to work under the protocols of the HIMS program. This research design uses archival data for airline pilots ranging in age from 35-0-0 through 64-11-30. All participants had a diagnosis of AUD as defined by the FAA. The WAIS-IV was administered to all participants at initial entry to treatment and approximately five months later during the return-to-work evaluation. Chapter 4 discusses the findings of this study.

Chapter 4: Results

Understanding how abstinence from alcohol may affect cognitive functioning meaningfully contributes to the literature and raises awareness of the implications of AUD for airline pilots. In the present study, I measured mean differences in WAIS-IV (2008) dependent variables for repeated administrations. Two independent variables were considered: time (abstinence) and age groups. The first research question addressed what extent cognitive functioning as measured by the WAIS-IV index scores may change as a result of a period of sobriety. The second question explored whether age influences the magnitude of intellectual change in recovery from AUD measured by the WAIS-IV index scores. The third question examined changes in Full Scale IQ as a result of a period of sobriety, while the fourth research question posed whether age influences significant cognitive change as measured by FSIQ. In this chapter, I present the basic demographic information, a review of the four hypotheses, statistical results, and a summary of findings.

Participant Demographics

The data for this study were collected from an archival convenience sample of 95 airline pilots diagnosed with AUD. These participants all attended inpatient treatment for AUD at a facility in the Southeast United States between January 2009 and December 2014. The collected demographics included gender, race, age, and dates of test administrations. All of the participants were White males. The age of participants ranged from 35 through 63 years of age (M = 49, SD = 7). Although AUD does affect females and persons of other ethnic backgrounds, during the period of this study, none received treatment through the practice where the data were collected for this study. Industry wide, it is estimated that White males comprise 86% of the workforce; 4.1% of ATPs are women, 2.7% are Black or African-American, 2.5% are Asian, and 5% are Hispanic or Latino (Zirulnik, 2014). This sample represents approximately 18% of U.S. airline pilots who attended inpatient treatment for AUD between 2009 and 2014.

Data Screening

Prior to any analysis, all summary data sheets were screened for missing or inappropriate values, outliers, and violations of assumptions. In the first review of the data sheets (n =105), seven sheets were missing variables, and these were omitted prior to data entry. I examined the z-scores for each of the dependent variables of interest. Three univariate outliers were found to be greater than plus or minus 3.00 and were omitted from subsequent analysis. The final sample consisted of 95 pilots. Examination of the skewness and kurtosis for the dependent variables revealed no significant values.

Results

Research Question 1

The first research question asked whether there are changes in cognitive functioning as measured by the WAIS-IV Index scales for airline pilots who participate in the HIMS program for recovery from AUD. For this hypothesis, the independent variable is the time of abstinence between the testing conducted at entry to treatment (T1) and subsequently during the return to work evaluation (T2). To test this hypothesis, repeated measures ANOVA was performed for the four repeated index scores. Table 1 contains the mean and standard deviation index scores for the first and second test administrations.

Table 1

Summary of Mean WAIS-IV Index Scores for T1, T2, (n = 95)

	N	*M*	*SD*	*SE*
Verbal Comprehension T1	95	109.51	8.38	0.86
Verbal Comprehension T2	95	118.18	8.58	0.88
Working Memory T1	95	111.13	11.94	1.22
Working Memory T2	95	122.48	11.94	1.23
Perceptual Reasoning T1	95	110.27	10.94	1.12
Perceptual Reasoning T2	95	122.18	10.434	1.06
Processing Speed T1	95	104.73	10.87	1.12
Processing Speed T2	95	113.63	9.09	0.93

Using Pillai's trace to test the hypothesis of differences over time, the results indicated a significant effect for abstinence on the repeated Index scores $V = .845$, $F(4. 91) = 124.29$, $p < .001$, partial $\eta 2 = .85$. The index scores were examined independently, and there were significant gains on each of the four measures. The repeated measures ANOVA of Verbal Comprehension scores indicated that participants experienced significant gains *F*(1.94) = 107.21, *p* < .001), *η2* = .53. This is also true for Perceptual Reasoning *F*(1.94) = 155.15, *p* < .001), partial *η2* = .62, Working Memory *F*(1.94) = 100.35, *p* < .0005), partial *η2* =.52, and Processing Speed scores *F*(1.94) = 97.41, *p* < .0005), partial *η2* =.51.

Table 2 contains the summary for the four index scores from the two WAIS-IV administrations. The data are presented in the format of test 2 minus test 1 (T2-T1), and include the mean, standard error, 95% confidence interval, *F* statistic, significance, and Pearson *r* value.

Table 2

Summary of Repeated Measures ANOVA

Index	*M*	*SE*	95% CI Range	*F*	Sig	*Partial η2* r
VCI T2 - VCI T1	8.66	0.86	7.02 - 10.325	107.21	.000	0.53
PRI T2 - PRI T1	11.91	0.96	10.07 – 13.80	155.14	.000	0.62
WMI T2 WMI T1	11.34	1.13	9.10 – 13.61	100.35	.000	0.52
PSI T2 - PSI T1	8.91	0.90	7,11 - 10.70	97.41	.000	0.51

Research Question 2

The second research question explored whether there are any cognitive differences by age group as a result of abstinence measured by the repeated WAIS-IV

Index scores. MANOVA was conducted with age group and abstinence as the independent variables and the WAIS Index scores as the dependent variables. No outliers were found after an examination of plots. Table 3 contains the mean and standard deviation index scores for the WAIS –IV index scores by age group.

Table 3

Summary of Mean Age Group Scores on WAIS-IV Index Scores (n = 95)

Index	Age group	*M* 1	*SD* 1	*M* 2	*SD* 2	*M* diff
VCI	1	109.07	7.49	118.23	10.71	*9.16*
	2	109.10	10.03	117.16	6.95	*8.06*
	3	110.30	7.63	119.06	8.38	*8.76*
PRI	1	106.80	8.11	119.63	9.92	*12.83*
	2	110.45	11.06	122.93	10.36	*12.48*
	3	113.18	12.35	123.74	10.56	*10.56*
WMI	1	106.47	10.35	120.10	8.90	*13.63*
	2	111.52	13.00	120.10	13.73	*8.58*
	3	114.88	11.07	126.76	11.65	*11.88*
PSI	1	103.17	12.79	113.19	9.07	*10.02*
	2	106.84	10.33	114.58	10.10	*7.74*
	3	104.18	9.46	113.17	8.30	*8.99*

Note. $F(16) = 1.231$, Partial $\eta^2 = .104$, $p = .249$.

To ensure that the assumptions of MANOVA were met, the data were tested. The Box's *M* value of 101.98 was associated with a *p* value of .083, which was interpreted as nonsignificant. Thus, the covariance matrices between the groups were assumed to be equal for the purposes of the MANOVA. Levene's test confirmed equality of variances for all the dependent variables $p > .05$. Kolmogorov-Smirnov tests indicated multivariate normality for the dependent variables. I expected that participants would vary by age group according to differences on the WAIS-IV index scores. However, results indicated that no significant difference existed between age groups and the repeated dependent measures, Wilks' $\lambda = .80$ F (16,170) = 1.24, $p = .249$; partial $\eta 2 = .104$. These results do not support Hypothesis 2. Therefore, the null hypothesis is retained.

Research Question 3

The third research question explored whether there are changes in cognitive functioning for Full Scale IQ as a result of abstinence. For this hypothesis, the independent variable was the time of abstinence between the testing conducted at entry to treatment (T1) and subsequently during the return to work evaluation (T2). To test the third hypothesis, repeated measures ANOVA was performed for the repeated Full Scale IQ scores. Using Pillai's trace, there was a significant affect found for abstinence on the repeated Full Scale IQ scores $V = .825$, $F(1.94) = 443.22$, $p < .001$), partial $\eta 2 = .83$. Therefore, the null hypothesis was rejected. Table 4 contains the summary for the Full Scale IQ scores from the two WAIS-IV administrations.

Table 4

Summary of Mean WAIS-IV Full Scale IQ Scores (n = 95)

	N	Mean	*SD*	*SE*
FSIQ T1	95	111.31	8.22	0.84
FSIQ T2	95	124.13	9.04	0.93

Research Question 4

The fourth research question explored whether there are cognitive changes as measured by the WAIS-IV Full Scale IQ for abstinence by age group. To test the fourth hypothesis, MANOVA was conducted with age group and abstinence as the independent variables and the WAIS Full Scale IQ score as the dependent variable. To ensure that the assumptions of MANOVA were met, the data were tested. The Box's *M* value of 5.78 was associated with a *p* value of .469, which was interpreted as nonsignificant. Thus, the covariance matrices between the groups were assumed to be equal for the purposes of the MANOVA. The assumption of homogeneity of variance is met as the *F* values for Levene's test of FSIQ1 and FSIQ2 are 1.796 and 1.348 with Sig. (*p*) values of .172 and .265 respectively. Kolmogorov-Smirnov tests indicated multivariate normality for the dependent variables. Table 5 contains the mean and standard deviations by age group for the Full Scale IQ scores.

Table 5

Mean Age Group Scores on WAIS-IV Full Scale IQ Scores (n = 95)

Index	Age group	*M*1	*SD*1	*M*2	*SD*2	*M*diff
FSIQ	1	108.37	6.25	122.77	8.28	14.40
	2	111.81	8.87	123.45	10.18	12.64
	3	113.44	8.22	125.94	8.28	12.50

Note. $F(4) = 2.18$, Partial $\eta^2 = .04$, $p = .073$.

I expected that participants would vary by age group according to differences on the WAIS-IV Full Scale IQ score. However, results indicated that no significant difference existed between age groups and the repeated dependent measures, Using Pillai's trace, for the repeated Full Scale IQ scores, age did not have a significant effect on cognitive change V = .09, $F(4,184) = 2.17$, $p = >.05$, partial $\eta 2 = 0.046$. Hence, the null hypothesis was retained.

Summary

In this chapter, I presented the data collection method, descriptive statistics, data analysis, and results for each hypothesis. Statistical analysis favored rejecting the Null Hypothesis 1 and Null Hypothesis 3. The null hypothesis for Hypotheses 2 and 4 were retained. Hypothesis 1 indicated that there was a significant difference in the overall

distribution for both pre- and post-treatment scores for the four index scores.
The results were significant for the WAIS-IV Index score and suggests that with an average of 140 days of abstinence, there are significant cognitive gains in recovery from alcohol use disorder. Hypothesis 2 examined these same data to explore whether there are differences on the WAIS-IV Index scores by age group. The data indicated a nonsignificant relationship between age group, abstinence, and cognitive changes, and the null hypothesis was retained. Hypothesis 3 indicated that there was a significant difference in the overall distribution for both pre- and post-treatment scores for Full Scale IQ. The results were significant for the WAIS-IV Full Scale IQ scores, indicating that after 140 days of abstinence, there are significant cognitive gains in recovery from alcohol use disorder. Hypothesis 4 examined whether there are differences for Full Scale IQ scores by age group. The data indicated a nonsignificant relationship between age group, abstinence, and cognitive change, and the null hypothesis was retained. There were differences with respect to the magnitude of change in the overall index scores, and these are discussed further in Chapter 5.

In Chapter 5, I discuss and summarize the results of this study and explore the findings from this study within the context of recovery from AUD, cockpit skills, CRM skills, and potential implications for flight safety.

Chapter 5: Discussion, Conclusions, and Recommendations

It is estimated that the lifetime prevalence for developing alcohol abuse and alcohol dependence in the United States are estimated at 17.8 and 12.5%, respectively (Hasin et al., 2007). While numerous treatment programs and self-help groups exist for the general population, treatment for airline pilots diagnosed with AUD is governed by the HIMS program. As discussed in previous chapters, the HIMS program has very specific treatment and aftercare requirements that enable these pilots to return to work following a monitored period of abstinence. For decades, alcohol use has been a significant concern in aviation operations; however, on an annual basis, relatively few airline pilots are diagnosed and treated under the HIMS protocol. This quantitative study using the WAIS-IV was designed to answer whether airline pilots experience significant cognitive change as a result of abstinence and if age is a factor for cognitive change. Chapter 4 showed an analysis of a repeated measures study of unique WAIS-IV data for airline pilots in recovery from AUD. Previous research has found that AUD has implications for cognitive impairment; however, there are fewer studies that have addressed the extent to which abstinence may improve cognitive functioning.

The WAIS-IV measures cognitive abilities that are powerfully related to the flight and CRM skills that support the safety of flight operations. A review of studies based on earlier versions of the Wechsler intelligence tests have illustrated that specific cognitive skills may be affected for those with AUD. Smith and Smith (1977) found significant deterioration for Performance IQ (Perceptual and Processing Speed Indexes), while other researchers have found impaired functioning in Block Design and Symbol Digit Substitution (McLachlan & Levinson, 1974). In the present study, I sought to further explore these findings by looking for relationships between abstinence and performance on the WAIS-IV FSIQ and four index scores (VCI, PRI, WMI, and PSI).

Interpretation of the Findings

An archival convenience sample of airline pilots treated for AUD was used to examine whether AUD affects cognitive performance as measured by the WAIS-IV. For each test administration, scores were entered into SPSS version 21 for the 10 subtests, four index scores, and Full Scale IQ. Participants were also categorized into three age groups that exactly reflect those used for the WAIS-IV norms (Group 1, 35-0-0 through 44-11-30, n = 30; Group 2, 45-0-0 through 54-11-30, n = 31; and Group 3, 55-0-0 through 64-11-30, n = 34; Sattler & Ryan, 2009).

Four main analyses were then conducted to compare the pre- and post-treatment scores across the entire sample and also by age group. The data showed significant differences in all index scores and the Full Scale IQ scores. Subsequent analysis compared abstinence and pilot’s age for the repeated WAIS-IV Index and Full Scale scores and found no significant differences.

Research Discussion

The first question to be addressed in the present study was to document to what extent cognitive functioning may change as a result of a period of sobriety. The second question to be addressed was whether age influences the magnitude of intellectual change in recovery from AUD. Cognitive functioning, was measured by the index scales of the WAIS-IV (VCI, PRI, WMI and PSI over a 5-month period for airline pilots who participated in the HIMS program for recovery from AUD. With abstinence, there were significant and positive changes on the Full Scale and index scores; however, no significant differences were found between the different age groups.

The VCI measures verbal concept formation as well as LTM, verbal comprehension, abstract, associative, and conceptual thinking, reasoning, alertness to the environment, and receptive and expressive language (Sattler & Ryan, 2009). Researchers have suggested that skills measured on this index may be more resistant to impairment from alcohol use disorder; however, results of the repeated measures ANOVA indicate significant and unexpected gains on this index and subtests. The results suggest that AUD may impair a pilot's ability to recall key concepts from LTM, evaluate a situation, communicate clearly, and ultimately maintain effective crew coordination.

The PRI measures nonverbal fluid reasoning ability, visual perceptual speed and processing, visualization, spatial-visual reasoning, mental transformation, discrimination, attention, and concentration (Sattler & Ryan, 2009). The results of the repeated measures ANOVA indicate significant gains on this index. Deficits in visual acuity and processing due to AUD could impair a pilot's ability to recognize and discriminate useful information from nonessential, stay focused, and make optimal selections in less than desired conditions.

The WMI measures immediate, short, and LTM, auditory processing, attention, mental computation, numerical ability, and fluid reasoning (Sattler & Ryan, 2009). The results of the repeated measures ANOVA show significant gains on this index. Deficits in memory, numerical, and fluid reasoning due to AUD could impair a pilot's abilities to accurately encode instructions or clearances, visualize and evaluate changes, and execute changes while simultaneously communicating with ATC.

The PSI measures speed of visual perceptual scanning and discrimination, psychomotor speed, visual STM, fine motor coordination as well as the ability to learn a new task (Sattler & Ryan, 2009). Studies have indicated that processing speed is impacted by AUD (Broderson et al., 2014; Smith & Smith, 1977), and results from the repeated measures ANOVA indicate significant gains on this index. Deficits in processing speed could impair a pilot's speed of mental operations, visual scanning, and crosscheck as well as fine motor skills and awareness of the flight operating environment. In comparing scores for four index scores that comprise FSIQ, the lowest scores and smallest incremental change were found on this index. This finding would support prior findings and suggest that even for individuals with superior intelligence, deficits in this domain may be more profound and enduring in recovery from AUD.

The third research question explored whether cognitive functioning, measured by the FSIQ scores of the WAIS-IV, changes over a 5-month period for airline pilots who participate in the HIMS program for recovery from AUD. In this analysis, the results were significant and reflected the significant gains on all the index scores. The fourth hypothesis explored cognitive changes on Full Scale IQ by age group and there was no significant finding. This was surprising given the preponderance of literature that suggested that age correlates with deficits on WAIS tests related performance (Overall, Hoffman, & Levin, 1978) and that recovery of cognitive deficits for those with AUD has been shown to be significantly greater for individuals under age 40 (Spencer & Boren, 1995). One possible explanation might be seen in the initial WAIS FSIQ scores for the three age groups. On average, the oldest group of pilots has the highest scores at entry to treatment. It is possible that in prior decades when the applicant pool was larger, selective hiring artificially influenced the current pilot age group norms. It has been reported by Kay (2013) that new-hire pilot IQ scores have on average decreased and that previous norms may need to be revised.

In aviation, the significance of deficits on all the WAIS-IV index scales and associated subtests should be put in the context of CRM skills. The CRM context furthers understanding of how cognitive deficits have the potential to impact the safety of flight operations. Most problems that occur in the cockpit have little to do with technical skills, rather they tend to cluster on poor CRM skills (FAA, 2004). CRM skills rest entirely upon cognitive abilities related to detection and interpretation, working memory, the retrieval and processing of information, problem-solving as well as verbal acuity and accuracy.

As discussed, the primary CRM skills are SA, DM, COM, WM, and CC. SA is a critical skill in the context of error and accident prevention. Although most flights are routine in nature, an extensive Line Operations Safety Audit observed that crews made an average of 2.8 mistakes per flight (Helmreich et al., 2002). SA does tax a number of domains. However, the cognitive processes most closely related to SA are perceptual in nature (Endsley, 1995). Several of the WAIS-IV subtests (Symbol Search, Coding, and Matrix Reasoning) measure speed of visual-perceptual processing, discrimination, and attention (Sattler & Ryan, 2009). The data are significant for these subtest scores and would suggest that deficits in attention and perceptual reasoning due to AUD has the potential to negatively impact SA.

Decision making logically follows SA but adds the components of seeking additional information, weighing alternatives, and taking action in a timely manner. One study of cognitive processes found that the more accurate and efficient pilots are; the better they score on CRM (Hoffman & Kay, 1998). These skills are closely related to those measured by information, arithmetic, block design, and visual puzzles. Processing speed factors into the ability to execute informed, timely decisions and includes speed of mental operation, visual perceptual scanning, psychomotor speed, and perceptual speed (Sattler & Ryan, 2009). Cockpit skills associated with DM include the ability to accurately encode instructions, visualize, plan, evaluate changes, and maintain concentration. The cognitive processes related to DM include the ability to recognize and discriminate useful information and put that information into the context of knowledge and expertise in order to make optimal selections in less than desired conditions. The data are significant for these subtest scores and suggest that timely as well as accurate decision making could be impacted by AUD.

Communication and workload management depend on factors such as recognition, precise communication, the ability to prioritize, short-term auditory memory, and the ability to recall procedures or pertinent information from LTM. Both COM and WM require skills related to those measured by the subtests of vocabulary, similarities, and digit span. In the cockpit environment, pilots must be able to describe the flight anomaly or emergency. They must be able to solicit feedback from the other crewmember(s) alert company dispatch and inform ATC of required diversions to flight path (altitude and/or heading). Accurate communication helps to ensure safe separation from other aircraft during descent and alerts the landing airport of circumstances that may require fire rescue, law enforcement, or medical support. COM relies on short-term auditory memory, verbal comprehension, accurate processing, concept formation as well as accurate and expressive language. The data are significant for the verbal index score and suggest that comprehension and accurate communication could be impacted by AUD. Gains were not anticipated on this index given the results of earlier studies discussed in Chapter 3. One might hypothesize that increases in reasoning ability might influence performance on the similarities subtest as this is the only verbal subtest that requires reasoning. However it is just as likely that following the initial test, pilots may have remembered which questions were answered incorrectly on the information or vocabulary tests and learned this information prior to the second test.

Workload management rests on the pilot's awareness of the cockpit operating environment, task demand, LTM, and the discipline to follow recommended operating procedures whenever possible. For pilots to coordinate effectively with other crewmembers and support facilities, they must be able to prioritize and organize and choose which tasks to perform and which to defer (Durso & Alexander, 2010). These skills are strongly associated with capabilities such as reasoning, associative, and abstract thought process; however, they depend on SA, DM, and COM as previously discussed. These skills are required when flight crews must respond to changes in flight operations, the flight environment, and emergencies. Deficits in any of the CRM skills due to AUD could affect both workload management and crew coordination.

Implications for Social Change

The potential of this study to promote the agenda of social change may be substantive for advocating the benefits of treatment for AUD and recovery. Through this study, I had the goal of exploring cognitive change for airline pilots in recovery from AUD. The findings are significant and could result in positive social change by providing empirical data to pilots and HIMS providers that illustrate the cognitive benefits of abstinence. It is hoped that pilots questioning their alcohol use might be motivated to seek help earlier if (in addition to other psychosocial factors) they believe that they can prevent or rehabilitate deficits in cognitive functioning. Another important and positive aspect of this study is that it raises solid arguments that support the position that cognitive impairment has an effect on CRM skills. The implications of cognitive deficits and specific CRM skills discussed in this study have not been addressed in the HIMS training program to date. By providing this information to HIMS leadership, it is hoped that pilots will benefit by enhanced training on how AUD can affect cognitive functioning and ultimately the safety of cockpit operations.

It is anticipated that findings from this research study will be disseminated several ways. On final approval, this dissertation will be provided to the HIMS chairman as well as the FAA physician who oversees the HIMS program. It is anticipated that this research will be presented at the annual 3-day HIMS program training seminar held in Denver, Colorado. This training is attended by all HIMS participating airlines, peer-support pilots, aviation psychologists, senior aeromedical physicians, and psychiatrists who provide specialized services to pilots in recovery.

Some of the limitations of this study discussed in previous chapters are due to the relatively small sample size and that there was only data for Caucasian male pilots. This could not be avoided. Another consideration was that work-related alcohol programs may have higher rates of success due to strict protocols and motivation for compliance. The discussion on pilot personality would support this limitation as there are common traits of pride, autonomy, compulsiveness, and competitiveness that may not apply to other recovery populations. The HIMS protocol is the only way a pilot with AUD will return to cockpit duties and motivation to comply is certainly high. The uniqueness of pilot skills, knowledge, and specification do not translate well to other nontransport career opportunities. Another limitation is that the FAA has a lower criteria for alcohol related behaviors that result in an individual being sent to treatment for AUD. This study supports the retention of that criteria in that even at entry to treatment, the majority of pilots in this study were still functioning at the high end of average functioning (T1FSIQ = 111).

Recommendations for Further Research

Having discussed the cognitive and personality characteristics of airline pilots, one has to ask whether there are traits common to these individuals that contribute significantly to the scores achieved on the WAIS-IV with abstinence. Admittedly the HIMS program does have strict protocols that require compliance to regain and retain employment. But is the success rate attributed to the desire to be abstinent, or are there other personality factors that motivate pilots to comply, such as pride, discipline, and competitiveness? Conversely, are there common traits within this population that trigger the desire to drink that over time may lead to the abuse or dependence on alcohol?

In the cockpit environment there are clear, written expectations as to roles, responsibilities, behavior, and expectations. Emergencies aside, for the most part the professional environment is controlled, predictable, and demands precision. Studies have found that as a group, pilots tend to have a blend of narcissistic and compulsive traits that are well suited to the demands of this environment (Butcher, 2004; Holland, 1960; Prewett, 2013). It has been established however that life events beyond the control of the pilot, such as relationship or family difficulties, may give rise to unpleasant interpersonal stress and result in an increase in alcohol consumption (Ross & Ross, 1995). In their study, Ross and Ross (1995) also found that pilots report drinking because they believe this will help them relax. Additional research in this area may suggest that CRM training should include a discussion of typical airline personality traits, and how these traits may increase stress outside the professional environment.

A comparison of index scores in this study suggests that processing speed lags behind other index scores both pre and post-treatment for pilots with AUD. Although direct comparisons cannot be made between the WAIS-IV and WAIS-R, normative data (n = 455) published by Kay (2002) suggests that at that time there were no significant differences for pilots between verbal (116.2) and performance (117.04) index scores. Consistency is expected across a range of cognitive skills and this is also supported in a study designed to establish aviator norms for US Air Force pilots (Thompson, 2004). The study employed the Multidimensional Aptitude Battery that is patterned after the WAIS-R but designed to be administered in a group setting. For male Caucasian pilots there was little difference between verbal (119.8) and performance (118.7) index scores (Thompson, 2004). Administration of the WAIS-IV or the CogScreen AE early in treatment may provide encouragement for pilots to engage in cognitive rehabilitation activities well before the return to work evaluation. An intervention designed to rehabilitate processing speed skills might result in improved performance on this index following treatment for AUD.

The cockpit environment provides high levels of stimulation that is well suited to the cognitive abilities and personality traits of pilots. Pilots pride themselves on vigilance, observation, and performing to high standards under pressure. Research could explore whether the affinity for stimulation affects other areas of life. Do pilots get so accustomed to the fast pace and high demands, that they are challenged by periods of low stimulation? If pilots are less tolerant of boredom do they unconsciously seek mood-altering situations that may lead to an increase in alcohol consumption or other risk-taking behaviors?

In numerous FAA and NTSB incident and accident reports, pilot fatigue is cited as a contributing factor. A recent study of international long-haul flying discovered that the amount of sleep obtained in the 24 hours before a trip was significant and a key predictor of the ability to sustain attention at the end of flights (Petrilli, Roach, Dawson, & Lamond, 2005). After 24 hours of sustained wakefulness, cognitive performance decreases to the level equivalent of an alcohol concentration of .10" (Dawson, & Reid, 1997). It is known that at all dosages, alcohol causes a reduction in sleep onset latency, an increase in sleep disruption in the second half of sleep, and REM interference (Ebrahim, Shapiro, Williams, & Fenwick, 2013). Does fragmented sleep due to alcohol use have a greater affect for long-haul pilots already challenged by longer periods of cognitive workload and sustained attention? Studies have suggested that the FAA 8-hour rule is insufficient (Yesavage, Dolhert, & Taylor, 1994, Lesavage & Leirer, 1986). New research may support a longer period of abstinence prior to flight based on the type of flight operations.

Finally, are there patterns that may indicate problematic drinking behavior? The Ross & Ross (1995) study reported that pilots drank because they wanted to be part of the group on layovers. Two decades later, it is still common practice for pilots to socialize and have a drink with fellow crewmembers on longer layovers. The practice raises an interesting question as to whether pilots tend to drink most heavily away from home or during periods of time off. For an individual who fits the diagnostic criteria for alcohol use disorder, there may eventually be no difference, but the questions prompt another issue. Are there patterns of bidding certain trips or rotations that support problematic drinking behaviors or may contribute to a relapse for HIMS participants?

Answers to questions like these could provide valuable insight that adds depth to the annual HIMS training. Answers could also result in training modules that help pilots understand their cognitive and personality strengths and recognize areas of vulnerability with the hope of preventing alcohol use disorder within this population. In the U.S., airline pilots are presently operating at the highest levels of safety achieved in nearly a century of commercial flight. The safety gains are the result of significant efforts over the past three decades to analyze the human factors, and engineering errors associated with accidents. There have been tremendous innovations in cockpit technology and simulation, procedural changes, and training that integrate ergonomics and CRM elements with the goal of reducing human error (Hamilton, 2004). That said, there is a general consensus in the industry that the airlines are no longer attracting individuals with the same cognitive abilities (Kay, 2013). If significant cognitive deficits develop as a result of AUD and the average intelligence of pilots is dropping what can be done now that will continue to ensure the safety of passengers into the future? Should there be standards for airline pilot cognitive functioning? Pilots are routinely measured on proficiency in the simulator throughout their careers but is that enough? There is no research that would suggest that airline pilots are any less susceptible than other populations to cognitive decline or mental illness. With the recent and deliberate act of pilot suicide (German Wings crash, March, 2015) it is suggested that the industry consider what might be done on a consistent basis to assess and evaluate the cognitive and mental health of airline pilots after they are hired.

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Appendix A: Data Use Agreement

DATA USE AGREEMENT

This Data Use Agreement ("Agreement"), effective as of 2/1/2015 ("Effective Date"), is entered into by and between Heather Hamilton ("Data Recipient") and Dr. David Prewett ("Data Provider"). The purpose of this Agreement is to provide Data Recipient with access to a Limited Data Set ("LDS") for use in research **in accord with laws and regulations of the governing bodies associated with the Data Provider, Data Recipient, and Data Recipient's educational program.** In the case of a discrepancy among laws, the agreement shall follow whichever law is more strict.

1. Definitions. Due to the study's affiliation with Laureate, a USA-based company, unless otherwise specified in this Agreement, all capitalized terms used in this Agreement not otherwise defined have the meaning established for purposes of the USA "HIPAA Regulations" and/or "FERPA Regulations" codified in the United States Code of Federal Regulations, as amended from time to time.

2. Preparation of the LDS. Data Provider shall prepare and furnish to Data Recipient a LDS in accord with any applicable laws and regulations of the governing bodies associated with the Data Provider, Data Recipient, and Data Recipient's educational program.

3. Data Fields in the LDS. **No direct identifiers such as names may be included in the Limited Data Set (LDS).** In preparing the LDS, Data Provider shall include the **data fields specified as follows**, which are the minimum necessary to accomplish the research: Gender, Age, Dates of WAIS-IV test administrations, The WAIS-IV Full Scale IQ, Index, and Subtest scores for each administration.

4. Responsibilities of Data Recipient. Data Recipient agrees to:

   a. Use or disclose the LDS only as permitted by this Agreement or as required by law;

   b. Use appropriate safeguards to prevent use or disclosure of the LDS other than as permitted by this Agreement or required by law;

   c. Report to Data Provider any use or disclosure of the LDS of which it becomes aware that is not permitted by this Agreement or required by law;

   d. Require any of its subcontractors or agents that receive or have access to the LDS to agree to the same restrictions and conditions on the use and/or disclosure of the LDS that apply to Data Recipient under this Agreement; and

   e. Not use the information in the LDS to identify or contact the individuals who are data subjects.

d. Counterparts. This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

e. Headings. The headings and other captions in this Agreement are for convenience and reference only and shall not be used in interpreting, construing or enforcing any of the provisions of this Agreement.

IN WITNESS WHEREOF, each of the undersigned has caused this Agreement to be duly executed in its name and on its behalf.

DATA PROVIDER	**DATA RECIPIENT**
Signed: ____________	Signed: ____________
Print Name: David Prewett, Psy.D.	Print Name: Heather Hamilt
Print Title: Clinical/Aviation Psychologist	Print Title: Licensed Mental Counselor WA

5. Permitted Uses and Disclosures of the LDS. Data Recipient may use and/or disclose the LDS **for its Research activities only.**

6. Term and Termination.

   a. Term. The term of this Agreement shall commence as of the Effective Date and shall continue for so long as Data Recipient retains the LDS, unless sooner terminated as set forth in this Agreement.

   b. Termination by Data Recipient. Data Recipient may terminate this agreement at any time by notifying the Data Provider and returning or destroying the LDS.

   c. Termination by Data Provider. Data Provider may terminate this agreement at any time by providing thirty (30) days prior written notice to Data Recipient.

   d. For Breach. Data Provider shall provide written notice to Data Recipient within ten (10) days of any determination that Data Recipient has breached a material term of this Agreement. Data Provider shall afford Data Recipient an opportunity to cure said alleged material breach upon mutually agreeable terms. Failure to agree on mutually agreeable terms for cure within thirty (30) days shall be grounds for the immediate termination of this Agreement by Data Provider.

   e. Effect of Termination. Sections 1, 4, 5, 6(e) and 7 of this Agreement shall survive any termination of this Agreement under subsections c or d.

7. Miscellaneous.

   a. Change in Law. The parties agree to negotiate in good faith to amend this Agreement to comport with changes in federal law that materially alter either or both parties' obligations under this Agreement. Provided however, that if the parties are unable to agree to mutually acceptable amendment(s) by the compliance date of the change in applicable law or regulations, either Party may terminate this Agreement as provided in section 6.

   b. Construction of Terms. The terms of this Agreement shall be construed to give effect to applicable federal interpretative guidance regarding the HIPAA Regulations.

   c. No Third Party Beneficiaries. Nothing in this Agreement shall confer upon any person other than the parties and their respective successors or assigns, any rights, remedies, obligations, or liabilities whatsoever.