AFRL-SA-BR-TR-2010-0006

MULTIPLE APTITUTE BATTERY-II NORMATIVE INTELLIGENCE TEST DATA THAT DISTINGUISH U.S. AIR FORCE AC-130 GUNSHIP SENSOR OPERATORS

Wayne Chappelle, Psy.D., ABPP
Kent McDonald, Lt Col, USAF, MC, FS
William Thompson, MA
Katharine McMillan, Ph.D.
Mark Marley, MA

June 2010

Air Force Research Laboratory
711th Human Performance Wing
School of Aerospace Medicine
Aerospace Medicine Consultation Div.
2507 Kennedy Circle
Brooks City-Base, TX 78235-5116

NOTICES

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The mention of trade names or commercial products in this publication is for illustration purposes and does not constitute endorsement or recommendation for use by the United States Air Force.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

Government agencies and their contractors registered with Defense Technical Information Center (DTIC) should direct requests for copies to: Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Ft. Belvoir, VA 22060-6218.

//signed//
WAYNE CHAPPELLE, Psy.D., ABPP
Dept. of Neuropsychiatry

//signed//
TIMOTHY W. SOWIN, Colonel, USAF, MC, SFS
Chief, Aerospace Medicine Consultation Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
06/01/2010	Final	N/A

4. TITLE AND SUBTITLE
Multiple Aptitude Battery-II Normative Intelligence Test Data that Distinguish U.S. Air Force AC-130 Gunship Sensor Operators

5a. CONTRACT NUMBER
N/A

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
Wayne Chappelle, Psy.D., ABPP,
Kent McDonald, LtCol, USAF, MC, FS
William Thompson, M.A.*
Katharine McMillan, Ph.D.*
Mark Marley, M.A.*

5d. PROJECT NUMBER
N/A

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Material Command, Air Force Research Laboratory, 711 Human Performance Wing, USAF School of Aerospace Medicine, Aerospace Medicine Consultation Division, 2507 Kennedy Circle, Brooks City-Base, TX 78235-5116
*Eagle Applied Sciences, Inc., 200 Concord Plaza, Suite 430, San Antonio, TX 78216

8. PERFORMING ORGANIZATION REPORT NUMBER
AFRL-SA-BR-TR-2010-0006

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
Distribution Statement A: Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
U.S. Air Force (USAF) AC-130 Gunship sensor operators (SOs) represent a unique group of enlisted aircrew in a challenging and high-risk profession. Aside from motivation and key personality traits, cognitive ability is considered to have a pivotal role in succeeding as a gunship SO (Chappelle, et al., 2009). This study evaluated intelligence test scores from volunteers in the current inventory of Gunship SOs. The purpose of such intelligence testing was to develop normative tables on the general intellectual functioning of SOs who successfully pass training, and to identify cognitive aptitudes that distinguish Gunship SOs from peers in the civilian, non-aircrew, general population, and airmen who fail SO training. The results of the study shed light on distinct objective differences in cognitive aptitudes that distinguish Gunship SOs from peers in the general population. Specific recommendations for the development of assessment and selection procedures and an aeromedical case vignette are provided to illustrate application of findings.

15. SUBJECT TERMS
USAF AC-130 Gunship; sensor operators; assessment and selection; cognitive functioning

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Wayne Chappelle
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL	32	19b. TELEPONE NUMBER *(Include area code)*

THIS PAGE IS INTENTIONALLY BLANK

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Acknowledgements

This study was conducted in part, via financial support and grant from the Defense Health Program (DHP). The authors of this study would like to thank the contributions of military operational psychology consultants to Air Force Special Operations Command, Carroll Greene, Col, USAF (Ret), and Stephanie Allison, Maj, USAF. They were instrumental in the logistical-administrative operations of this study.

THIS PAGE IS INTENTIONALLY BLANK

Multiple Aptitude Battery-II Normative Intelligence Test Data that Distinguish U.S. Air Force AC-130 Gunship Sensor Operators

INTRODUCTION

AC-130 Gunship sensor operators (SOs) represent a unique group of enlisted airmen in a challenging, high-risk profession. They have a central role in reconnaissance, surveillance, and precision strike aerial operations. In addition, they are integral to the safe, effective, and efficient identification, targeting, and battle damage assessment of enemy combatants and assets. As can be surmised, AC-130 Gunship SO duties can be viewed as an extraordinary activity requiring special traits, talents, and skills of those who pursue such a profession. In addition to high levels of courage, self-discipline, and self-confidence, interviews with subject matter experts (SMEs) indicate a high level of intelligence, cognitive aptitude, and visual performance based abilities are critical to performance (Chappelle, Patterson, Sowin, & Randall, 2009). General intelligence (e.g., general cognitive ability) and specific cognitive aptitudes have been demonstrated to predict attrition, acquisition of job skills, as well as quality of job performance in a broad body of research for both USAF and civilian occupations (e.g., Reel Earles, & Teachout, 1994; Schmidt & Hunter, 2004). While normative data regarding general intelligence and cognitive aptitudes exist for various occupations for use in assessment and selection of incumbents and training candidates, such norms are not established for AC-130 Gunship SOs. As a result, there is no clear understanding of the general level of cognitive functioning and variability among such a unique group of airmen.

Information about general intelligence and corresponding cognitive aptitudes is a critical factor for USAF medical and mental health providers who are tasked with evaluating the suitability of an AC-130 Gunship SO incumbent or training candidate who may (or may not) possess the cognitive disposition to participate in such a challenging and high risk occupation. Furthermore, normative data regarding the cognitive disposition of such a unique and high risk special operations occupational group may help to: predict occupational performance among incumbents and training candidates, assist in the assessment and selection of training candidates most likely to succeed and adapt to the changes of the position, as well as improve the aeromedical evaluation process of trainees and (or incumbent's) in need of an aeromedical waiver to fly to attend training or return to duty. The need, therefore, for a clear understanding of normative data regarding general intelligence for AC-130 Gunship SOs is apparent.

To fill the gap in the current literature, this study obtained intelligence testing on the current inventory of USAF AC-130 Gunship SOs in an effort to: (a) obtain normative intelligence data on AC-130 SO incumbents to assess how such a specialized group of enlisted aircrew differ from the civilian, non-aircrew general population; (b) develop a distribution of intelligence tests scores for AC-130 Gunship SO incumbents for use in aeromedical evaluations; and (c) assess how the cognitive aptitudes (i.e., visual learning/memory, visual spatial analysis, visual attention to detail, and visual constructive abilities) of incumbents specifically differ from enlisted airmen who fail training. Assessing for critical differences in the cognitive aptitude of those who fail training may help improve the current assessment and selection process of training candidates for SO duties.

High Demand & Critically Manned

The role of the AC-130 Gunship aircrew is to provide critical support to a wide range of USAF special operations in combat zones within theaters of conflict that include: transportation of special duty operators, surveillance and reconnaissance, close air support, and the deployment of weapons in precision strike operations. A key role of the aircraft's mission involves the destruction of enemy combatants and assets. As a result, the AC-130 Gunship operations are essential to the support of various combat related missions supporting ground troops and combat related operations. Since the onset of conflict in Afghanistan and Iraq over the last decade, the demand for combat operations has increased substantially.

The aircrew of the AC-130 gunship is composed of several different commissioned officers (i.e., a pilot, co-pilot, navigator, fire control officer, and electronic warfare officer), and enlisted personnel (i.e., a flight engineer, loadmaster, SO, infrared detection sensor operator, and aerial gunners). Although each officer and enlisted crew position is instrumental to successful mission performance, there is growing attention and focus on the SO's role because of the requirements of this position for identifying, targeting, and destroying enemy combatants and resources through "real time" full motion video imagery analysis and electronic weaponry. Without such a crew position, the reconnaissance and precision strike capabilities of AC-130 Gunship are significantly limited. As a result, command and medical leadership often conclude the duty position of a SO is the most important enlisted aircrew position on the AC-130 Gunship and is best suited for military personnel with a high level of cognitive aptitude (e.g., Chappelle, Patterson, Randall, & Sowin, 2009).

As mentioned above, AC-130 Gunship operations have increased substantially over the past decade, creating a large burden on aircrew to fulfill the demand. This is particularly concerning for the enlisted position of sensor operators. The USAF has approximately 120 operational sensor operators at any one time. The career field is very small in respect to other enlisted aircrew positions. As a result, there is a pressing need to retain (and return to duty) AC-130 Gunship SO incumbents to ensure operational units can meet mission readiness demands. The high demand for such a position often puts pressure on line and medical leadership to return to duty as soon as appropriate, any SO incumbent that has been disqualified for medical reasons (physical or psychological) and who must receive an aeromedical waiver prior to return to their duties.

In addition to retaining and returning to duty AC-130 Gunship SO incumbents, there is also a pressing need to identify enlisted personnel with the appropriate psychological disposition and attributes to succeed in training prior to their enlistment in the USAF. That is, identifying the "right airman for the position." The 19th SOS leadership and instructors reported the strenuous demands associated with SO duties are similar to other high-risk, high demand operational positions that require a core set of psychological attributes, such as a high level of cognitive ability, to be successful during and after training (Chappelle at al., 2009). At the present time, according to conversations with 19th SOS leadership, there is a 30-40% failure rate in training gunship SOs. One of the main reasons for failure, reported by training instructors, includes problems with cognitive ability.

Based on conversations with Air Force Special Operations Command (AFSOC) personnel, it costs approximately one million dollars a year to train each AC-130 Gunship SO; making even a single trainee failure a significant operational and financial loss. In addition to the fiscal cost, the failure of a trainee restricts mission capability and readiness. This, in turn, places additional burdens on incumbents to continue the high operational tempo and deployment schedule of their current combat related missions without any additional manpower relief. A single training failure can add an additional 120 deployment days per year to the current SO incumbent deployment schedule. According to leadership and incumbents, this additional pressure can generate difficulties associated with motivation, performance, and occupational "burnout." In addition, a trainee who has failed the program is faced with potential embarrassment and uncertainty over his or her future career and disposition in the USAF. The task of finding another assignment can be a rather cumbersome

experience. The length of time to find an alternative training assignment for an individual that has failed their assignment can vary considerably, often taking several weeks to several months.

Intelligence/Cognitive Aptitude and Job Performance

The effects and critical impact of intelligence on occupational performance has been well established in the empirical literature. General intelligence has been found to be a better predictor of occupational outcomes than other predictors (e.g., personality traits) in a number of studies and meta-analyses. Furthermore, based upon the nature of SO duties (Nagy et al., 2006) and input from SMEs (Chappelle et al., 2009), a person can logically conclude that a high level of cognitive aptitude is required to successfully complete training and adapt to the rigorous operational demands. Meta-analyses regarding the body of research investigating the impact of cognitive aptitude on job performance are particularly valuable as they statistically analyze studies according to a set of appropriate criteria. Key meta-analyses have been performed which bear direct implications for this study.

A meta-analysis by Hunter and Hunter (1984) demonstrated the importance of general cognitive ability and intelligence on job performance at all levels and in all types of work. They found general cognitive ability to have a significant impact on job performance for different levels of job complexity. Furthermore, the role of intelligence in job performance and training for all job complexity levels, except the most basic, was moderate to high.

Some of the most carefully studied relationships between general intellectual ability and occupational outcomes have been conducted in the military. Studies by Ree and Earles (1990; 1991; 1992), as well as Ree, Earles, and Teachout (1994) investigated the relative degree to which training success and job performance was predictable from specific aptitudes and general intellectual ability for a wide variety of occupational specialties in the USAF. This is particularly important given that training success in the USAF is often a prerequisite to a specialty assignment, and achievement in training has proved to be an excellent predictor of actual job performance. The results of their studies revealed that a significant portion of occupational training success is largely a function of general cognitive ability.

A meta-analysis conducted by Herrnstein and Murray (1994) revealed the significant and positive influence that general intelligence has on important outcomes such as job performance and occupational status, as well as health problems, marital difficulties, and behavioral problems. The authors presented a wide array of data highlighting the distinctions between persons of different intellectual abilities, while controlling for potential biasing effects (e.g., socioeconomic status and race). As a result, problems related to health, marriage, and behavior may impede the cognitive performance of AC-130 Gunship SOs from participating in their operational duties until such problems are resolved.

A meta-analysis was conducted by Schmidt and Hunter (1998) regarding the validity and utility of selection methods in personnel psychology over the previous 85 years. Out of the numerous selection procedures (e.g., job experience), measures of general intelligence and cognitive ability had significantly higher levels of predictive validity for job performance. Among the variables that were examined were work samples, job experience, structured and unstructured interviews, integrity tests, biographical data, peer ratings, reference checks, and years of education. The authors concluded that measures of general intelligence and cognitive aptitude should be used as the primary means for hiring personnel and other measures (e.g., biographical data, work history, personality testing) be used as supplemental information for decision making.

Another more recent meta-analysis of the literature by Schmidt and Hunter (2004) revealed that general intellectual ability predicted both occupational level and performance within a person's chosen profession (military or civilian). Similar to their earlier meta-analysis of civilian personnel selection, intelligence scores serve as better success predictors than numerous other abilities or traits. The conclusion of their analysis of empirical data indicates further support that general intelligence may serve as a primary source of predictive data.

Aeromedical Importance of Normative Test Data

Although there may be controversy over the aspects and specific cognitive abilities that constitute the *right stuff*, there is little argument about deficits that represent the *wrong stuff*. A person with low general cognitive ability and borderline functioning in visual-spatial, visual learning, or visual-constructive abilities should likely not engage in Gunship SO duties. Such difficulties in cognitive functioning can conceivably elevate the risk for an aviation mishap where the threat to human life, national security, foreign relations, military operations, and loss of a multimillion dollar aircraft is already high. While an SO Gunship applicant's general cognitive ability is easily estimated from his or her responses to the Air Force Qualifying Test (AFQT) an enlisted applicant must complete prior to entry into the USAF, there is no clear data regarding the distribution of such test scores for successful AC-130 Gunship SO incumbents or those who fail training. Furthermore, the AFQT does not directly assess the visual-spatial aptitudes deemed critical to performance reported by SMEs in the study by Chappelle et al. (2009).

USAF civilian and active duty psychologists are regularly called upon to assess the cognitive disposition of aircrew in high-risk jobs, and assist flight surgeons in making recommendations about whether an aircrew member is aeromedically fit to continue in his or her flying duties. USAF aeromedical policy requires intellectual assessments for a number of neuropsychological and psychiatric conditions (Air Force Instruction 48-123, volume 3, 2006). An aeromedical evaluation of a person's cognitive functioning is required when there is a history of cognitive difficulties (e.g., memory, attention, reasoning, information processing) stemming from a head injury, medical illness (e.g., bacterial meningitis), developmental disorder (e.g., attention deficit and hyperactivity, learning disorder) or emotional problems (e.g., depression, anxiety). In general, intelligence testing is a common part of an aeromedical evaluation when there is concern regarding an SO's general cognitive ability or specific aptitudes related to medical or psychological illness/injury.

However, AC-130 Gunship SO incumbents (or training candidates) seeking waivers may be unfairly penalized if they are clinically compared with *aviator expectations* based upon pilot data that may exceed the normative data for SOs. SOs, for example, who perform in the average range 6 months after a mild head injury may be suspected of having residual cognitive deficits based on comparison to aviator expectations when in fact they may have returned to baseline. Such an incorrect interpretation would improperly slow the aviator's return to flight status and normal duties which may subsequently impact mission readiness and capabilities of the unit. Conversely, it is unclear if normative data based upon the civilian, non-aircrew general population is appropriate for evaluating AC-130 Gunship SOs. Use of general population norms may also mask actual cognitive deficits that place SOs and other aircrew at risk if they participate in training or rigorous combat related flying operations. Taken together, the above issues highlight the need for the clinical and aeromedical importance of establishing normative data on the general intellectual and cognitive functioning of today's USAF AC-130 gunship SOs.

Conceptualizing and Measuring Intelligence

An accurate conceptualization of general intelligence is fraught with difficulty and controversy largely because intelligence is an abstract construct. Intelligence is assumed to produce abilities that cannot be easily observed or directly measured but can be inferred from intelligence testing (Weinberg, 1989). In general, the concept of intelligence may be viewed as a label for a group of processes that are inferred from observable responses to specific stimuli. As such, intelligence is similar to the term *force* in physics: force is known by its effects and its presence must be inferred.

Over the course of the last century, the conceptualization of intelligence has evolved as attention to new aspects, processes and mechanisms, as well as a deeper understanding of related issues, have emerged. Theories have evolved from conceptualizing intelligence as a single underlying factor (Spearman, 1904; 1927) to multiple factor theories (Thurston, 1938; Gardner, 1993), to hierarchical models which describe specific abilities arranged according to increasing specificity and developmental complexity (Guilford, 1988; Horn, 1985; Vernon, 1961). Theories have also evolved from strictly biological approaches (Halstead, 1961; Horn & Cattell, 1966; Hebb, 1972, Piaget, 1950) to highly complex information processing approaches (Sternberg, 1985). Despite the notion of several competing theories, most definitions of intelligence imply, include or elaborate on the following five areas: abstract thinking, learning from experience, solving problems through insight, adapting to new situations and information, and focusing and sustaining abilities to achieve a desired goal (Groth-Marnat, 1999, p. 133).

One of the most prominent theories of intelligence that has emerged is by Wechsler (1958). He considered intelligence to be a global concept that involved an individual ability to act purposefully, think rationally, and deal effectively with the environment. He considered intelligence not only as global entity but also as an aggregate to specific abilities. He explained that intelligence is global because it characterizes the individual's behavior as a whole. It is also specific because it is composed of elements that are qualitatively different. He also proposed that intelligence should be measured by both verbal and visual-performance based tasks, which measure ability in different ways and which could be aggregated to form a general, global construct. Although factor analytic studies account for significant percentage of the overall variance of intelligence, he also believed in another group of attributes (such as basic motivations, and personality traits such as persistence) not tapped directly by existing measures of intellectual ability.

Wechsler's theory of intelligence is central to the development of the mostly widely used intelligence test in the United States, the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1997). The WAIS intelligence test measures specific verbal- and visual-performance based cognitive aptitudes using different modes (e.g., written questions and figure arrangement) that allow for those measures to be aggregated as a global or full-scale intelligence score. Thus, the WAIS intelligence test generates a full scale intelligence quotient which is a composite of verbal (VIQ) and performance (PIQ) intelligence quotients, which are the two major dimensions that comprise general intelligence. The WAIS intelligence test is widely used as it has been demonstrated to serve as the most common test of intelligence in use by practitioners (Rabin, Barr, & Burton, 2005).

From the perspective of the authors of this study, an intelligence test as comprehensive and useful as the WAIS would be beneficial in assessing AC-130 Gunship SOs. Normative data based upon such an intelligence test could help to establish cognitive benchmarks for aeromedical assessment and selection evaluations. The requirements for assessing cognitive ability and developing normative data include the identification of an instrument that has high reliability and validity, as well as ease and cost of administration, and that can be administered in both group and individual settings. One instrument that suits these

requirements for the purposes of this study the Multidimensional Aptitude Battery-II (MAB-II; Jackson, 2003) which is based upon the structure and content of the WAIS and Wechsler's theory of intelligence.

Cognitive Aptitude of AC-130 Gunship SOs (Incumbents vs. Training Failures)

Chappelle, Patterson, Sowin, and Randall (2009), launched an investigation into the psychological attributes of AC-130 Gunship SOs. They conducted a qualitative investigation in an effort to develop a theoretically organized list of psychological attributes deemed critical to performance. Their study gathered information in the form of interviews from subject matter experts (SME) such as training instructors, squadron commanders, pilots. SMEs were asked to describe an array of qualities they perceived as essential for SO training candidates and incumbents to possess in order to successfully complete major job tasks and adapt to the rigorous occupational demands. Based on a qualitative analysis of SME data, they identified a core set of psychological attributes deemed critical to SO training and performance in combat-operational missions. Of the many different attributes reported, SMEs repeatedly emphasized that AC-130 Gunship SO training candidates and incumbents require higher than average general cognitive functioning and visual-spatial performance abilities (e.g., visual learning, memory, construction, reasoning, spatial analysis). They reported specific domains of intelligence that required notable strengths were in the areas of visual-spatial, visual-constructive, and visual discrimination abilities, as well as speed of information processing. SO candidates who failed and incumbents who continued to have performance related problems appeared to struggle with vigilance, situational awareness, and task saturation. It was reported by SMEs those who had such difficulties did not likely have the cognitive aptitude required for the position.

Despite the qualitative analysis and findings by Chappelle et al (2009), objective data is needed to validate the reports by SMEs regarding the high level of intelligence and cognitive aptitudes among successful AC-130 Gunship SO training candidates and incumbents. This is particularly important given that all SO trainees are selected based upon general cognitive aptitude. Any enlisted airman interested in becoming an AC-130 Gunship SO must score within the high average range on the Air Force Qualifying Test (AFQT) in areas that assess general cognitive ability. Given that SOs are pre-screened according to their cognitive ability, it is unclear how training failures differ according to such ability or aptitude. Therefore, another purpose of this study is to target intelligence as a specific area of research that merits a thorough investigation based upon the earlier study by Chappelle, et al. (2009).

Purpose of the Study

As mentioned previously, to fill the gap in the current literature, to fill the gap in the current literature, this study obtained intelligence testing on the current inventory of USAF AC-130 Gunship SOs in an effort to: (a) obtain normative intelligence data on AC-130 SO incumbents to assess how such a specialized group of enlisted aircrew differ from the civilian, non-aircrew general population; (b) develop a distribution of intelligence tests scores for AC-130 Gunship SO incumbents for use in aeromedical evaluations; and (c) assess how the cognitive aptitudes (i.e., visual learning/memory, visual spatial analysis, visual attention to detail, and visual constructive abilities) of incumbents specifically differ from enlisted airmen who fail training. Assessing for critical differences in the cognitive aptitude of those who fail training may help improve the current assessment and selection process of training candidates for SO duties.

METHOD

Subjects

Incumbents

A total of 59 (46% of the total USAF AC-130 Gunship SO population) AC-130 Gunship SOs who passed training from the 1st Special Operations Group at Hurlburt Field, FL volunteered to participate in cognitive testing for this study. There were 55 males and 4 females with an average of 31.57(SD = 7.18) years of age. A total of 22 (37%) were single, 32 (54%) were married, and 5 (9%) were divorced. There were a total of 50 (85%) Caucasians, 3 (5%) African Americans, 4 (7%) Hispanics, 1 (2%) Asian, and 1 (2%) who did not report his or her racial background. There were a total of 12 (20%) between the rank of Airmen thru Senior Airmen (E1 – E4), 30 (51%) between the rank of Staff Sergeant and Technical Sergeant (E5 – E6), and 17 (29%) between the rank of Master Sergeant and Chief, Master Sergeant (E7 – E8). Furthermore, estimated intelligence test scores from the AFQT-FSIQ for all 128 AC-130 Gunship SOs in the USAF were obtained for comparison.

Trainees Who Failed

A total of 20 enlisted airmen who failed AC-130 Gunship SO training (approximately 80% of those who failed in the past 2 ½ years) assigned to the 19th Special Operations Group at Hurlburt Field, FL volunteered to participate in cognitive testing for this study. There were 18 males and 2 females with an average age of 25.75 years of age (SD = 5.20). A total of 5 (25%) reported being single, and 5 (25%) reported being divorced. However, obtaining an adequate assessment of marital status was difficult given that 10 (50%) did not report whether they were married or single. There were a total of 11 (55%) Caucasians, and 1 (5%) African-American. However, obtaining an accurate assessment of racial status was also difficult to obtain given that 8 (40%) did not report their racial status. There were a total of 7 (35%) between the range of Airmen thru Senior Airmen (E1- E4), 11 (55%) between the rank of Staff Sergeant and Technical Sergeant (E5 – E6), and 2 (10%) between the rank of Master Sergeant and Chief, Master Sergeant (E7 – E8).

The voluntary and fully informed consent of subjects used in this research was obtained as required by 32 CFR 219 and AFI 40-402. The purpose and methodology of the study was reviewed and granted exemption from the Wright Patterson Air Force Base (WPAFB) Institutional Review Board (IRB) and assigned protocol number F-WR-2009-0027-E.

Measures

The Multidimensional Aptitude Battery- Second Edition (MAB-II; Jackson, 2003) is a broad-based test of intellectual ability. It is patterned after the Wechsler Adult Intelligence Scale (WAIS-III; Wechsler, 1997), which is the most widely used individually administered test of intelligence. The MAB-II was chosen because it is easily administered in group settings in a cost-efficient fashion. The MAB-II has 10 subtests that are each 7 minutes long and all items have five multiple-choice responses. The MAB-II requires only 70 minutes to complete and can be administered in group settings. Administration of this test produces verbal (VIQ),

performance (PIQ) and full scale (FSIQ) intelligent quotient scores. The test is separated in to Verbal abilities (i.e., information, comprehension, arithmetic, similarities, and vocabulary) and Visual-Performance abilities (digit symbol coding, picture completion, spatial analyses, picture arrangement, and object assembly). MAB-II normative subtest scores for the general population have a mean score of 50 and a standard deviation of 10. Indice scores (i.e., VIQ, PIQ, and FSIQ) for the general population have a mean of 100 and a standard deviation of 15. The MAB-II manual has well documented internal consistency, validity and, test-retest reliability coefficients. See table 1 for a description of the general intellectual abilities each subtest measures.

TABLE 1. Brief description of cognitive aptitudes measured by the MAB-II.

	Subtest	Aptitude Measured
Verbal Subtests		
	Information (INF)	General fund of knowledge on diverse topics; long- term memory
	Comprehension (COM)	Social reasoning, judgment, and comprehension
	Arithmetic (ARI)	General and numerical reasoning, and problem solving
	Similarities (SIM)	General conceptual and abstract reasoning and problem-solving; flexibility and adjustment to novelty
	Vocabulary (VOC)	Verbal reasoning, classification, and openness to new verbal information; ability to retrieve verbal concepts
Performance Subtests		
	Digit Symbol (DS)	Adaptation to new set of demands; visual learning and coding, figural memory, and speed of information processing
	Picture Completion (PC)	Visual attention to detail; knowledge of common objects; perceptual and analytical skills
	Spatial Analysis (SP)	Ability to visualize and mentally rotate abstract two dimensional images of objects in different positions; figural-domain reasoning
	Picture Arrangement (PA)	Visual reasoning; ability to identify a meaningful sequence; perceptual reasoning
	Object Assembly (OA)	Visualization and visuo-construction skills; perceptual analytical skills need to identify a meaningful object from left-to-right sequence

Another effective means for identifying the general cognitive functioning of AC-130 SO incumbents and training candidates is to obtain the full scale general intellectual (FSIQ) ability estimates through the use of the Armed Serviced Vocational Aptitude Battery (ASVAB) that USAF applicants must take prior to enlistment. The ASVAB is the military entrance examination used to identify applicants who meet each U.S. military service department's cognitive aptitude standards and to assist in job placement. This test produces several scores, including the Armed Forces Qualification Test (AFQT) score. The estimated FSIQ from the AFQT portion of the ASVAB is the pre-accession testing score that most closely measures a person's general intellectual functioning. The AFQT score is made up of the ASVAB subtests that measure mathematical, reasoning, computation, vocabulary, and reading comprehension abilities. The AFQT scores is known to correlate between .71 and .92 with general measures of intelligence. The formula for estimating FSIQ MAB-II scores was developed by Orme, Brehm, and Ree (2001) is used by the USAF Personnel Center (AFPC). The AFQT and estimated MAB-II FSIQ scores of all 128 USAF AC-130 SOs was obtained from AFPC.

Procedure

The research team contacted leadership within the 1st Special Operations Group regarding the purpose of the study and the need for cognitive testing to improve aeromedical understanding of the general intellectual abilities of the current inventory of personnel in such a sensitive and high-risk position. Leadership was also instructed of the intent to identify cognitive differences that distinguish those who successfully pass training to provide recommendations to AFPC that would potentially improve assessment and selection procedures to identify suitable training candidates.

Military leadership identified AC-130 SO incumbents and training failures available for cognitive testing with the MAB-II. A list of volunteers for testing was solicited by researchers through e-mail, phone, and in-person solicitations. Participants were informed of the purpose of the study and that non-participation would not be viewed negatively or have a negative effect on their occupational disposition. They were informed test results were confidential and would not be included in their military medical or personnel records. They were also instructed that leadership within their chain-of-command would not have access to individual scores and their test results would remain locked within the Neuropsychiatry Branch within the USAF School of Aerospace Medicine. They were instructed on how they could obtain access to their test score or study results, if needed, at a later date.

Volunteer participants were assigned to groups of 8 to 10 and tested in a classroom within the 19th Special Operations Squadron training facility. The conditions of the classroom were closely monitored to ensure an appropriate testing environment free from noise distractions with controlled temperature conditions. Testing was administered by an operational military psychologist. Participants were given paper-pencil version of the MAB-II. Participants were given 7 minutes to complete each subtest and provided a set of standardized instructions for taking each subtest as specified in the MAB-II manual.

Normative Data Analyses

Following administration of testing, the means and standard deviations, as well as minimum and maximum standard scores for the Indices (i.e., VIQ, PIQ, and FSIQ) of the MAB-II and the AFQT estimated full scale IQ (FSIQ) were calculated. See Table 2. See Figure 1 for a box plot analyses of the standard scores for MAB-II Indices and AFQT estimated FSIQ for incumbents and training failures. See Figures 2 and 3 for a box plot analyses of the T scores for the verbal and visual-performance subtests of the MAB-II for AC-130 SO incumbents and training failures.

A series of paired samples Pearson correlation coefficients were conducted to assess the relationship between the AFQT estimated FSIQ and the Indices scores (VIQ and FSIQ) of the MAB-II. The correlation coefficients allow for an analyses of how incumbents' recent Indices scores on the MAB-II compare with baseline testing taken with the AFQT several months to years earlier just prior to enlistment in the USAF and basic military training. See note at the bottom of Table 2 for results.

A distribution table of AC-130 Gunship SO standardized T-scores for the subtests of the MAB-II was constructed to assess how the distribution differed from the standard distribution of the general population. See Table 3. This table is essential for having an adequate understanding regarding the distribution of cognitive aptitude and intelligence quotient scores within the AC-130 Gunship SO incumbents. Such a distribution of scores is important for interpretation of test values when determining whether scores from a trainee or SO incumbent falls within or outside normal limits of those who have adequately passed training.

Between Groups Comparison

A series of two tailed t-tests were conducted comparing the mean standard scores for the Indices (VIQ, PIQ, and FSIQ) and mean T-scores of the MAB-II subtests for AC-130 Gunship SO incumbents with those of the general population normative sample, and those who failed training. See Table 4.

A statistical significance level of .01 was established a priori when conducting t-tests. Furthermore, a two-tailed t-test was not considered clinically significant unless the comparison was: (a) statistically significant, (b) had a power equal to or great than .80, and (c) had an effect size equal to or greater than .50 (as defined by Cohen, 1988). Since the individual t-test comparisons stand alone and were not being analyzed relative to other subtest scores, there was no need to adjust the p-values for multiple t-tests. The apriori criteria for operational significance was established to ensure identified differences that were statistically significant were large enough to be meaningful.

RESULTS

TABLE 2. Standard scores for the MAB-II Indices, as well as AFQT estimated FSIQ for AC-130 SO incumbents.

	Passed				Failed			
Indices	**Min**	**Mean**	**SD**	**Max**	**Min**	**Mean**	**SD**	**Max**
Verbal Intelligence Quotient (VIQ)	90	109.3	7.3	123	97	110.3	8.7	126
Performance Intelligence Quotient (PIQ)	91	114.4	10.2	134	100	115.3	10.4	134
Full Scale Intelligence Quotient (FSIQ)	95	112.5	77	126	103	113.6	7.7	132
AFQT Estimated FSIQ	98.5	113.8	7	125.5	100.5	117.9	8.2	124.5

Note: In analyzing the scores of AC-130 Gunship Incumbents, the Pearson correlation coefficients between the estimated FSIQ from the AFQT were statistically significant for the MAB-II VIQ ($r = .40$, $p<.00$), and FSIQ ($r=.32$, $p<.00$). Although the correlation with the MAB-II PIQ ($r = .27$, $p<.05$) was statically significant, it was relatively small. In analyzing the scores for the

TABLE 3. Distribution table of T-scores for the MAB-II subtests for AC-130 SO incumbents (N=59).

		Percentiles											
Subtests	**Min**	**5th**	**10th**	**15th**	**25th**	**40th**	**50th**	**60th**	**75th**	**85th**	**90th**	**95th**	**Max**
Information	42	45	47	50	51	56	61	62	65	67	68	69	74
Comprehension	38	42	47	50	51	53	55	57	59	61	61	64	64
Arithmetic	42	43	46	48	52	52	55	57	61	63	64	67	77
Similarities	40	49	51	51	53	55	56	57	58	61	63	64	67
Vocabulary	42	43	45	46	48	52	54	54	56	60	62	63	64
Digit Symbol	36	40	47	50	52	53	55	58	59	61	66	71	78
Picture Completion	35	44	47	50	54	56	59	61	63	67	69	73	78
Spatial	22	35	44	48	50	55	56	58	62	64	66	73	74
Picture Arrangement	34	41	47	51	51	57	58	61	64	64	64	68	71
Object Assembly	46	48	51	53	55	59	61	63	66	68	69	70	73

Note: The distribution table of T-scores enables comparison of how AC-130 SO T scores for each subtest as a group differ when compared with the standard distribution of general population, civilian, non-aircrew T-scores. The distribution of T-scores also corrects for differences dues to age.

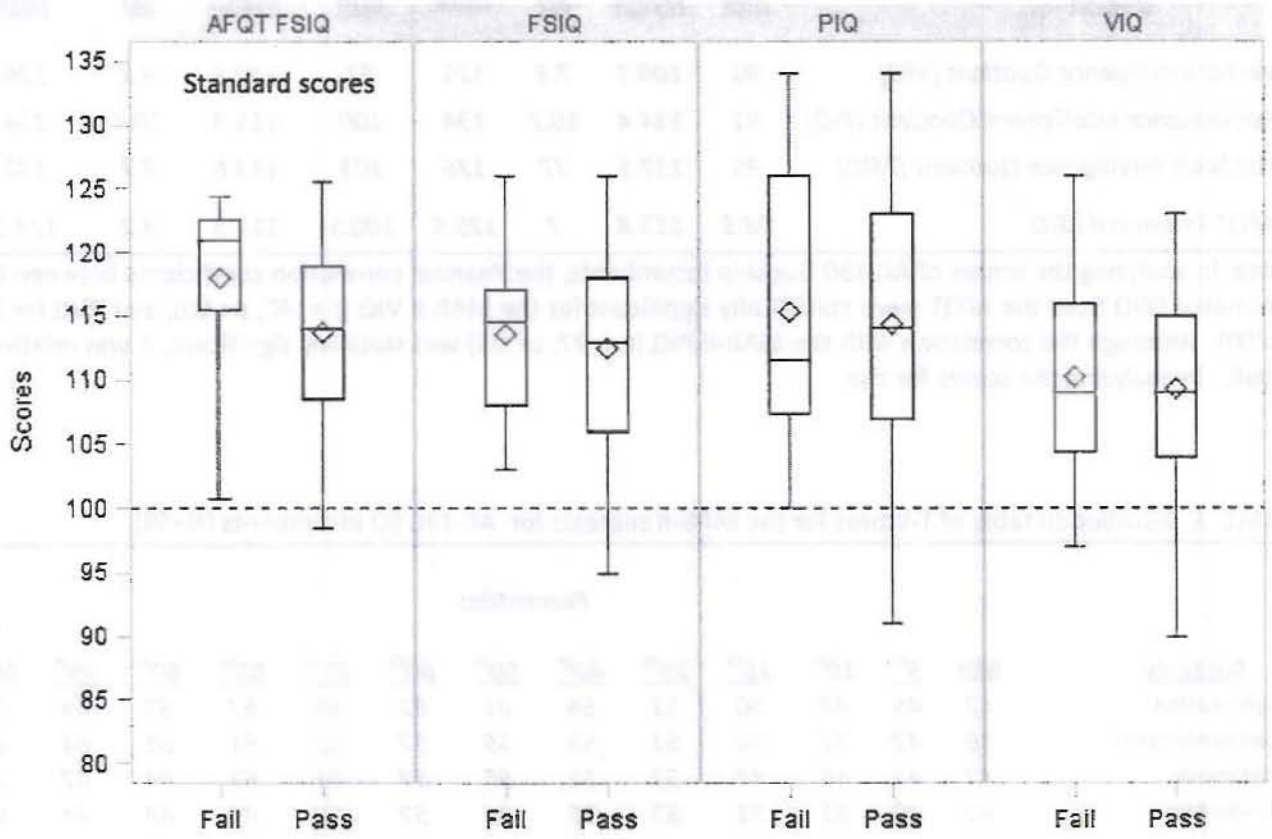

Figure 1. Box plot analyses of Standard Scores for the MAB-II Intelligence Quotient (IQ) Scores, as well as AFQT estimated Full Scale Intelligence Quotient (AFQT FSIQ) for AC-130 SO incumbents (n = 59) and training failures (n = 20). Note: ◇ = mean, — = median, □ = + or – 1 standard deviation.

The Box Plot depicts the range and average scores. The diamond shape is the mean. The horizontal line within each box is the median. The area within each box represents 1 standard deviation above and below the mean. The average standard VIQ, PIQ, and FSIQ scores in the general population have a mean of 100 and a standard deviation of 15. AFQT estimated FSIQ scores have a mean of 100 and a standard deviation of 15. The results of the study reveal the range of general intelligence quotients for AC-130 Gunship SO incumbents and those who failed training is more restricted and in the high average range when compared with peers of similar age in the general population.

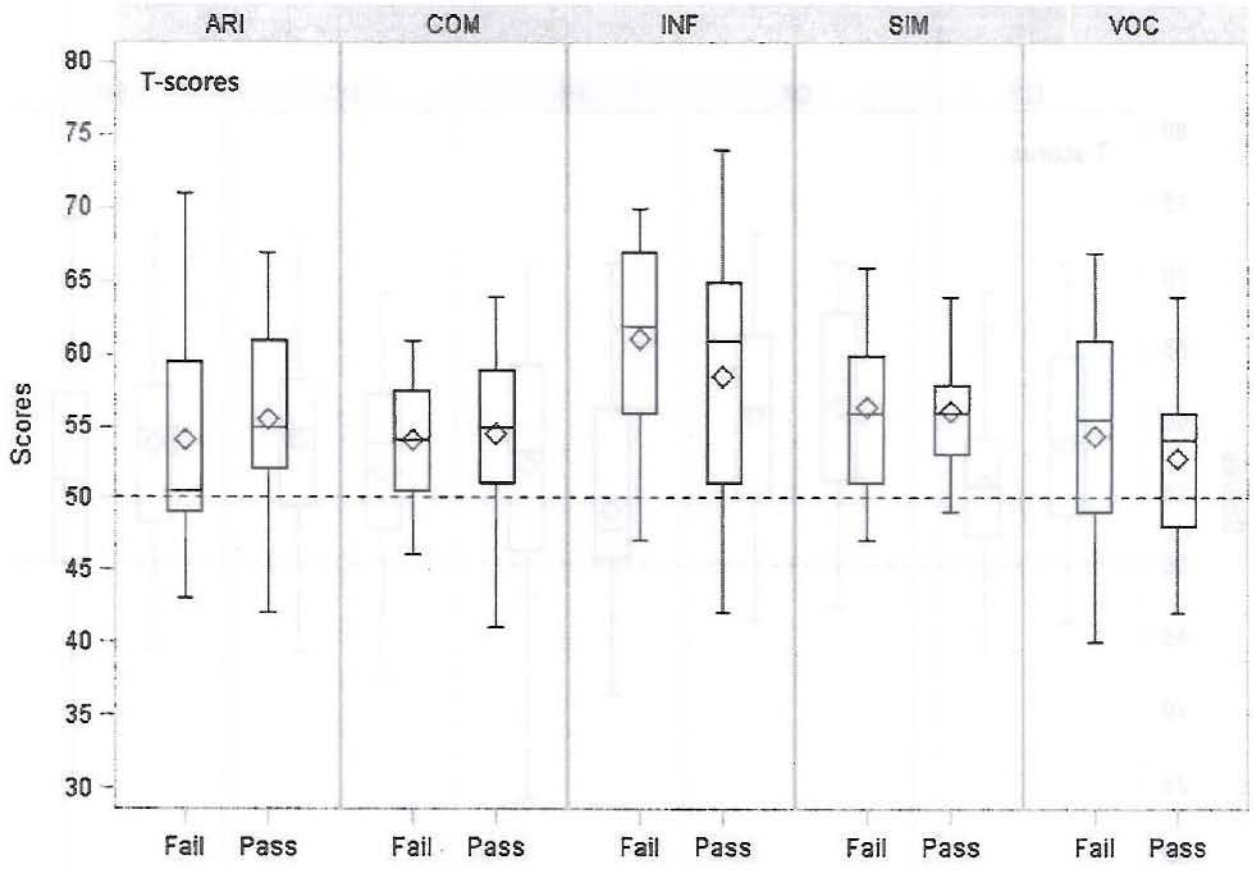

Figure 2. Box plot analyses of MAB-II verbal aptitude subtest T-scores for AC-130 SO incumbents (n= 59) and those who failed training (n = 20). Note: ◇ = mean, — = median, ▭ = + or – 1 standard deviation.

The Box Plot depicts the range and average scores. The diamond shape is the mean. The horizontal line within each box is the median. The area within each box represents 1 standard deviation above and below the mean. The average standard MAB-II verbal aptitude subtest scores in the general population have a mean of 50 and a standard deviation of 10. The results of the study reveal the verbal aptitude for AC-130 Gunship SO incumbents and those who failed training is, for the most part, in the high average to superior range when compared with peers of similar age in the general population.

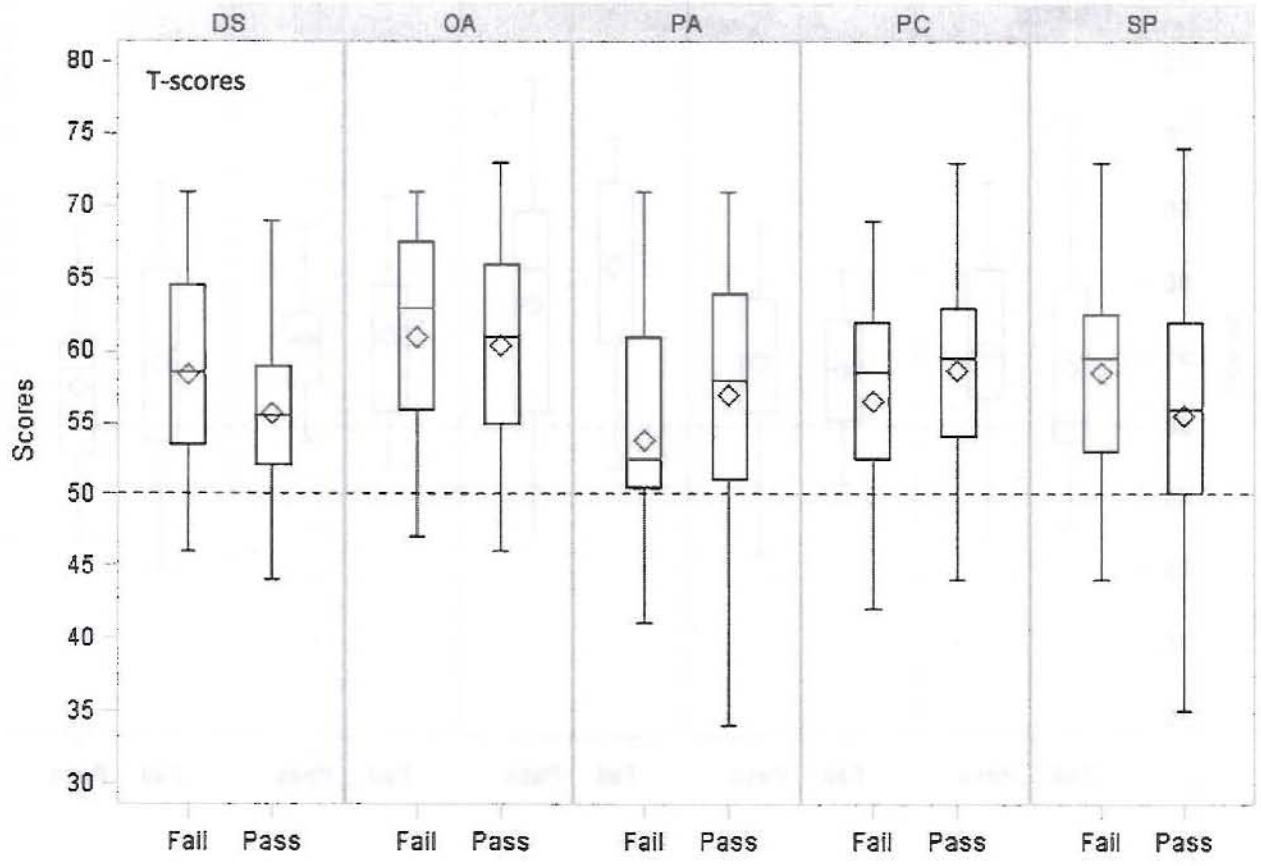

Figure 3. Box plot analyses of MAB-II visual-performance aptitude subtest T-scores for AC-130 SO incumbents (n= 59) and those who failed training (n = 20). Note: ◇ = mean, — = median, ▭ = + or – 1 standard deviation.

The Box Plot depicts the range and average scores. The diamond shape is the mean. The horizontal line within each box is the median. The area within each box represents 1 standard deviation above and below the mean. The average standard MAB-II visual-performance subtest scores in the general population have a mean of 50 and a standard deviation of 10. The results of the study reveal the visual-performance aptitude for AC-130 Gunship SO incumbents and those who failed training is, for the most part, in the high average to superior range when compared with peers of similar age in the general population.

TABLE 4. MAB-II score comparisons for AC-130 Gunship SOs who passed training with those of the general population normative sample, and those who failed training.

DOMAIN/FACET SCORES	DESCRIPTIVES								ANALYSES OF MEANS					
	Passed			Failed			Civilian Sample		Passed vs. Civilian sample			Passed vs. Failed		
	N	M	Std	N	M	Std	M	Std	t-test	p-value	Cohen's	t-test	p-value	Cohen's
Verbal Subtests														
Information	60	58.3	8.1	20	61.2	7.0	50	10	7.94	0.00	1.10	-1.39	0.17	-0.38
Comprehension	60	54.5	5.6	20	54.1	4.7	50	10	6.24	0.00	0.87	0.35	0.73	0.08
Arithmetic	60	55.7	7.1	20	54.1	8.5	50	10	6.29	0.00	0.73	0.85	0.40	0.20
Similarities	60	56.1	4.9	20	56.3	5.6	50	10	9.54	0.00	1.16	-0.19	0.85	-0.04
Vocabulary	60	52.8	5.9	20	54.4	7.5	50	10	3.64	0.00	0.41	-0.99	0.33	-0.24
Performance Subtests														
Digit Symbol	60	55.7	7.7	20	58.4	7.4	50	10	5.72	0.00	0.75	-1.35	0.18	-0.36
Picture Completion	60	58.9	8.2	20	56.6	9.4	50	10	8.40	0.00	1.01	1.07	0.29	0.26
Spatial Analysis	60	55.8	10.3	20	58.6	7.9	50	10	4.38	0.00	0.63	-1.07	0.29	-0.31
Picture Arrangement	60	56.9	7.7	20	53.9	9.3	50	10	6.87	0.00	0.81	1.43	0.16	0.35
Object Assembly	60	60.6	6.6	20	61.0	7.4	50	10	12.35	0.00	1.51	-0.23	0.82	-0.06
Verbal Intelligence (VIQ)	60	109.2	7.3	20	110.3	8.5	100	15	65.05	0.00	1.18	-5.07	0.61	-0.13
Performance Intelligence (PIQ)	60	114.8	10.2	20	115.3	10.2	100	15	50.34	0.00	1.45	-2.69	0.79	-0.06
Full Scale Intelligence (FSIQ)	60	112.6	7.7	20	113.6	7.5	100	15	64.84	0.00	1.68	-4.85	0.63	-0.12

Note: Intelligence Quotients (Verbal, Performance and Full Scale IQs) have mean of 100 and a standard deviation of 15 in the general population, while scaled subtest scores are T scores that have a mean of 50 and a standard deviation of 10 in the general population.

DISCUSSION

AC-130 SO Incumbent Normative Data

The first objective of this study was to obtain normative intelligence data on AC-130 SO incumbents to assess *how such a specialized group of enlisted aircrew differs from the civilian, non-aircrew general population.*

The results of the study reveal the general intellectual functioning of AC-130 Gunship SOs that successfully pass training is in the high average range (MAB-II standard scores for VIQ = 109.2, 73rd %ile; PIQ = 114.8, 84th %ile, and FSIQ = 112.6, 81st %ile) and significantly higher than the general population. More specifically, large differences were found between the mean scores for the general population and AC-130 Gunship SOs on subtests that assessed: visual-construction and perceptual analytical skills need to identify meaningful objects from left-to-right sequence (i.e., mean T- score for Object Assembly subtest = 61, 86th %ile); general fund of knowledge and long-term memory (i.e., mean T- score for Information subtest = 58, 79th%ile); as well as visual attention to detail, knowledge of common objects, and visual-perceptual and analytical skills (i.e., mean T- score for Picture Completion subtest = 59, 79th %ile). Moderate differences were found between the mean scores for the general population and AC-130 SOs on subtests that assessed: visual-perceptual reasoning, and social intelligence (i.e., mean T- score for Picture Arrangement subtest = 57, 73rd %ile); general reasoning and problem solving (i.e., mean T- score for Similarities subtest = 56, 70th %ile); numerical reasoning and problem solving (i.e., mean T- score for Arithmetic subtest = 56, 70th %ile); visual learning and coding, figural memory, and speed of information processing (i.e., mean T-score for Digit Symbol subtest = 56, 68th %ile); ability to evaluate social behavior and social reasoning (i.e., mean T-score for Comprehension subtest = 55, 68th %ile); ability to visualize and mentally rotate abstract two dimensional images of objects in different positions, figure-domain reasoning (i.e., mean T-score for Spatial subtest = 56, 70th %ile). Overall, AC-130 Gunship SO performances on these subtests are significantly higher than the general population and within the high average range of functioning. It is also evident from of the distribution of scores in figures 1 and 2, as well as Tables 2 and 3 that the cognitive performance within the group of gunship SOs does not vary nearly as much as those in the general population, reflecting a much more cognitively homogenous group.

The results of these findings support the report of SMEs in an earlier qualitative study by Chappelle, et al. (2009) that AC-130 Gunship SOs general cognitive functioning is higher than the general population and that they have strengths in visual-performance based abilities. As mentioned previously, visual performance based abilities were considered "critical" by SMEs to passing training and managing operational duties during flight. This finding is particularly important to the aeromedical evaluation of AC-130 Gunship SO incumbents (or training candidates) who have been medically disqualified due to a history of an illness affecting their psychological disposition and who are seeking an aeromedical waiver to return to fly as soon as possible.

Aeromedical Application of Normative Data

The second objective of the study was to develop normative data and distribution of intelligence tests scores of AC-130 Gunship SO incumbents for use in aeromedical evaluations.

Critical to the accurate interpretation of intelligence testing scores for AC-130 Gunship SO incumbents involves the use of normative data specific to such a specialized enlisted aircrew. Through the use of normative data it is possible to view the strengths and direction of an individual's specific cognitive aptitudes as compared with peers. Pattern analysis of subtests scores, on the other hand, involves examining the

person's scores to develop an overall profile of a person's cognitive aptitudes are suited to various settings and situations. For example, if an AC-130 Gunship SO training candidate's scores on cognitive testing reveal (when compared with SO incumbents) someone who has significant weaknesses in visual-spatial aptitudes, then there would be reason to suspect the person's cognitive capability may be incompatible with the demanding nature of SO duties during training and operational missions. Another example is when an incumbent has been disqualified from flying due to a history of illness (e.g., bacterial meningitis). If the incumbents test scores reflect the absence of cognitive difficulties and the presence of a high level of general intellectual, as well as visual-performance based functioning (and is within normal limits when compared with other AC-130 Gunship SOs), then there may be reason to conclude the person could return to his or her flying duties.

Although general population norms can be helpful in distinguishing how a SO's intellectual functioning compares with an age matched cohort, it does not allow for determining how a person compares with incumbents. For example, a recovering SO may show a general pattern of above average scores vis-à-vis the general population, but these scores may be below AC-130 Gunship SO norms, as well as below the SO's previous level of functioning. (For a case example, see below). Therefore, it is important to utilize Table 3 in this study when clinically evaluating and interpreting the scores of an SO incumbent or candidate. The percentile tables allow a psychologist to determine how a specific score compares with the distribution of scores for SO incumbents as a group. In general, scores that fall above the 90th or below the 10th percentile can be viewed as outliers and significantly different from most others.

The utility of this data is illustrated by the case of a 30 year old, male, AC-130 Gunship SO with a history of a mild head injury. His history of such an injury disqualifies him from SO duties according to USAF aeromedical policy (AFI 48-123 volume 3, 2006). In this case, following the required period of observation prior to returning to fly (1 month), he needed an evaluation to determine if his history of a mild head injury was fully resolved and if he met the aeromedical waiver criteria for returning to his operational duties. He was referred to the installation's active-duty psychologist for an evaluation. The psychologist who evaluated the SO included general intellectual testing (i.e., MAB-II) as part of his comprehensive psychological evaluation. It was particularly important for the psychologist to determine if his cognitive disposition was compatible with managing the rigorous nature of his duties as an AC-130 Gunship SO.

Based upon his responses to items on the MAB-II, the psychologist reported his scores (when compared with males in the civilian, non-aircrew normative sample) to be within normal limits and compatible with others in the civilian, non-aircrew, general population. For example, when compared with others in the general population, the scores of his FSIQ (95 = 37th %ile), PIQ (93 = 32nd %ile), and visual-performance based subtests of Object Assembly (44 = 27th %ile), Spatial Analysis (46, 34th %ile), Picture Completion (45 = 30th %ile), and Digit Symbol (43 = 25th %ile) were within normal limits. However, utilizing the distribution of test scores from Tables 3, it would have been incorrect to conclude his scores were within normal limits for AC-130 Gunship SOs. When compared with occupationally specific normative data, such scores were at or below the 10th percentile. His scores revealed his general intellectual functioning and visual-performance based aptitudes (considered critical to SO duties) were outside normal limits and within the low functioning range. As mentioned previously, high average level of visual-performance based aptitudes are considered critical by SMEs for Gunship SO training and performance.

Equally as important to comparing his scores with other AC-130 Gunship SO normative data is comparing his current scores to his pre-accession baseline testing obtained shortly before entry into the USAF. It was discovered his AFQT estimated FSIQ score (124 = 95th %ile) was in the superior range when compared with the general population, and at the higher end of the average range when compared with AC-130 Gunship SOs- suggesting his cognitive disposition had not fully returned to baseline.

After reviewing additional information and an exhaustive evaluation, the psychologist concluded the SO's current cognitive aptitude had not returned to baseline, was substantially lower than SO incumbents, and thereby not compatible with the challenging and dangerous conditions associated with operations of the AC-130 Gunship. As a result, his cognitive disposition did not appear to meet the aeromedical waiver criteria for flying, and it was believed his mild injury was more reflective of a moderate injury, and he could benefit from additional time to heal prior to his resumption of his flying duties.

The occupationally specific normative data included in Table 3 helped the psychologist to accurately interpret his test scores in comparison to AC-130 Gunship SOs as a group, and to render a difficult and very important decision about his readiness to return to fly, where the safety risks and potential losses from an aviation mishap are high. It is clear that occupationally specific normative data is needed to effectively evaluate AC-130 Gunship SO candidates and incumbents when rendering aeromedical decisions about their cognitive and intellectual disposition.

There are significant group differences between the AC-130 Gunship SO normative scores and those utilized in the MAB-II civilian, non-aircrew general population normative sample. As a result, psychologists should be sensitive to such differences and utilize the occupationally specific normative data that more accurately represents the group with which a person is being compared. Otherwise, as in the case illustrated above, a person may mistakenly conclude that an SO incumbent's (or training candidate's) scores are within normal limits when, in fact, the scores are not when compared with norms for AC-130 Gunship SO incumbents. Appropriate normative data is central to the clinical interpretation of psychological test scores that are often a part of the aeromedical evaluation process for selecting applicants and for considering an incumbent's readiness for returning to his or her duties after being disqualified for psychological reasons.

Incumbents vs. Candidates who Failed Training

The third objective of the study was to assess how the intellectual abilities (i.e., visual learning/memory, visual spatial analysis, visual attention to detail, and visual constructive abilities) of incumbents differ from enlisted airmen who failed training.

It is notable there were no significant differences in the cognitive aptitude (as measured via the MAB-II) between those who passed and those who failed training. The MAB-II is a highly sensitive intelligence test that measures aptitudes considered critical to performance as reported by interviews with SMEs (Chappelle, et al., 2009). As mentioned previously, it was reported by SMEs that those who failed training appeared to have difficulties with task saturation, task management and prioritization, channelized attention, and situational awareness during simulator and live flight training. They reported slower and inaccurate responses by those who failed. As a result, it was believed by many SMEs that those who failed had lower levels of cognitive aptitude in areas critical to performance. However, the results of this study do not support such a perception by SMEs.

Furthermore, the results of the study did not support the findings in the general industrial organizational literature regarding the predictive properties of general intellectual functioning (i.e., Schmidt & Hunter, 2004). As mentioned previously, general cognitive functioning is a powerful predictor of performance among both military and civilian occupations. However, as mentioned above, there were no cognitive differences between incumbents and those who failed training. A likely explanation for this finding is the notion that all AC-130 SO training candidates are selected based upon their cognitive aptitude scores on the Air Force Qualifying Test (AFQT). Similar to the results of the MAB-II, the AFQT estimated FSIQ score for AC-130 Gunship SOs training candidates was significantly higher (estimated FSIQ standard score = 112.6, 82%) than the general population. This indicates that baseline testing is effectively used to identify enlisted airmen

with a level of intellectual functioning compatible with AC-130 Gunship SO incumbents. The results of this study suggest the current use of the AFQT is a helpful, expeditious, and cost-efficient measure for selecting AC-130 Gunship SO training candidates with the appropriate cognitive aptitude. The use of pre-existing AFQT data that correlates well with the VIQ and FSIQ of the MAB-II. The use of the AFQT is also particularly helpful for having to screen a large number of applicants each year and within a time critical period.

It is important to note the results of this study suggest that although a high level of cognitive aptitude is required, it is insufficient for passing training. There are other variables that likely account for problems with performance during training (e.g., task saturation, channelized attention, situational awareness, etc.). For instance, SMEs also reported several personality traits and characteristics required to successfully pass training (Chappelle, et al., 2009). It is possible the psychological attributes that distinguish incumbents for those at high risk of failure (e.g., due to observed problems in task saturation, channelized attention) is more related to psychological variables such as emotional stamina, conscientiousness, perseverance, and motivation. Such personality triats have been deemed critical to performance among USAF special duty aircrew (Pican et al, 2006) as well as AC-130 Gunship SO SMEs (Chappelle, et al., 2009). However, an additional study is needed to investigate whether or not such personality traits truly account for differences between incumbents and those who fail training.

Given that the number of selectees screened each year is relatively small (approximately 30 to 40 candidates each year for 10 openings), the use of a comprehensive intelligence test such as the MAB-II (when compared with the AFQT) allows for a more focused evaluation of visual performance aptitudes, and greater granularity in determining how SO candidates within the selection pool vary on such aptitudes. It is especially important to select the candidate with the appropriate level of cognitive aptitude given: (a) the economic costs ($1 million per year, per candidate) are high, (b) the non-standard, unconventional duty demands of the position are psychologically demanding, and (c) gunship operations are carried out in an environment where the threat to human safety, issues of national security, foreign relations, and mission failure can be substantial.

Limitations to the Study

Although this study used close to half (49%) of the entire population of AC-130 SO incumbents with a reliable and valid measure of intellectual functioning, there are limitations. First, it is unknown whether there are existing cohort differences related to age and/or time of training, and if such effects would impact comparisons of this study to previous studies. For example, it is unclear if there are important general intellectual differences between those who entered into AC-130 Gunship SO training 10 to 15 years ago versus those who more recently completed training. Second, generalizing the results of this study to other SOs in other airframes (i.e., JSTARS and AWACS) is likely not appropriate. The selection process, type of military flying, and aviation related missions differ. Another variable that may have impacted study results is the voluntary nature of participants. It is possible that only those who knew they would perform well volunteered to participate in cognitive testing, thus skewing the group results of incumbents and/or those who failed training. And lastly, aeromedical evaluations that involve selection and assessment of AC-130 Gunship SO training candidates and incumbents being considered for SO duties or returning to fly should include collateral sources of information from others. Other sources of information (e.g., conversations with spouse, military commanders, supervisors), and clinical interviews are needed to fully understand the reliability and validity of specific cognitive test scores as they relate to gunship SO training and performance.

Recommendations

The authors of this study concluded above that the normative intelligence data for AC-130 Gunship SO training candidates and incumbents has important operational and clinical applications. It is contended that normative data (when added to other tools for evaluation) has the potential to improve aeromedical evaluation of incumbents in a way that fully assess their readiness to fly, reduce attrition and improve retention among incumbents and training candidates. Given these implications for use of the data, this information may provide significant savings in terms of dollars, expenditure of effort and time, and preservation of manpower within a highly specialized occupational group of special operations airmen. The dissemination and implementation of baseline cognitive/intelligence is highly recommended. Military and civilian psychologists, when armed with information on cognitive/intelligence abilities of AC-130 Gunship SOs can make more effective and enhanced aeromedical decisions when interpreting test scores of training candidates and incumbents.

It is also advised to continue studies on personality and character traits to further improve normative data and extend the scope of reliable criteria for such a specialized group of airmen. Logical extensions would include investigations such as longitudinal studies that examined long term outcomes of AC-130 Gunship SOs who were returned to flying status after suffering head injury or depression. Studies should include examining the current selection methods and comparing the success/failure outcomes on personality traits reported as critical to success by SMEs. Another recommendation is investigating via logistical regression the combination of cognitive aptitude, emotional-interpersonal traits, and motivational factors that clearly distinguish AC-130 Gunship SOs who excel in the position from those who fail. In conclusion, the initial SME qualitative study by Chappelle et al. (2009) along with this study serve as solid first steps for producing reliable criteria for aeromedical assessment and selection evaluations.

Conclusion

A valid intellectual and cognitive assessment is a crucial part of the evaluation process of military personnel in unique and high risk positions, such as AC-130 Gunship SOs. Aside from motivation for military flying, general intellectual functioning and specific cognitive aptitudes are reported by SMEs to play a key role in effectively adapting and succeeding as an SO. The results of this study have helped to provide partial validation of cognitive attributes of AC-130 Gunship SOs reported by SMEs as critical to performance. The results of the study also provide normative intelligence test data and distribution of subtest and Indice scores for the MAB-II to improve the clinical acumen of military and civilian psychologists' interpretation of test scores. Having an accurate assessment of the general intellectual characteristics of personnel in such a high risk occupation is of substantial interest to medical and mental health professionals who are tasked with evaluating AC-130 SO candidates and incumbents. Normative cognitive data is essential to making precise aeromedical decisions about whether military personnel have the cognitive disposition to pursue (or continue in) such a unique and high-risk occupation.

REFERENCES

Chappelle, W., Patterson, J., Sowin, T. & Randall, B. (2009). Critical psychological attributes of U.S. Air Force AC-130 gunship sensor operators according to subject matter experts. United States Air Force Technical Report: #AFRL-SA-BR-TR-2009-0015. USAF School of Aerospace Medicine, Brooks City Base, TX.

Gardner, H. (1993). *Multiple intelligences: The theory in practice*. New York: Basic Books.

Groth-Marnat, G. (1999). *Handbook of Psychological Assessment-Third Edition*. New York, NY: John Wilsey & Sons Inc.

Guilford, J.P. (1988). Some changes in the structure-of-intellect model. *Educational and Psychological Measurement, 48*, 1-4.

Halstead, W.C. (1961). Biological intelligence. In J.J. Jenkins & D.G. Paterson (Eds.), *Studies in individual differences* (pp.661-668). New York: Appleton-Century-Crofts.

Hebb, D.O. (1972). *Textbook of psychology* (3rd ed.). Philadelphia: W.B. Saunders.

Hernstein, R. J. & Murray, C. (1994). *The bell curve: intelligence and class structure in American Life*. New York: The Free Press.

Horn, J.L. (1985). Remodeling old models of intelligence. In B. Wolman (Ed.), *Handbook of intelligence* (pp. 267-300). New York: Wiley.

Horn, J.L. & Cattell, R.B. (1966). Refinement and test of the theory of fluid and crystallized intelligence. *Journal of Educational Psychology, 57*, 253-270.

Hunter, J.E., & Hunter, R.F. (1984). Validity and utility of alternative predictors of job performance. *Psychological Bulletin, 96*, 72-98.

Jackson, D (2003). *Multidimensional Aptitude Battery- Second Edition* (MAB-II). Sigma Assessment Systems, Inc. Port Huron, MI.

Piaget, J. (1950). *The psychology of intelligence*. New York: Harcourt, Brace & World.

Rabin, L.A., Barr, W. B., & Burton, L.A. (2005). Assessment of practices of clinical neuropsychologists in the United States and Canada. A survey of INS, NAN, and APA Division 40 members. Archives of Clinical Neuropsychology, 20(33-65.

Ree, M.J., & Earles, J.A. (1990). Differential validity of an aptitude test. USAF Technical Report. Brooks Air Force Base, Texas: Air Force Systems Command.

Ree, M.J., & Earles, J.A. (1991). Predicting training success: Not much more than g. *Personnel Psychology, 44, 321-332.*

Ree, M.J. & Earles, J.A. (1992). Intelligence is the best predictor of job performance. *Current Directions in Psychological Science, 1*, 86-89.

Ree, M.J., Earles, & Teachout, M. (1994). Predicting job performance: Not much more than g. *Journal of Applied Psychology, 79*, 518-524.

Orme, D., Brehm, W., & Ree, M. (2001). Armed Forces Qualification Test as a measure of pre-morbid intelligence. *Military Psychology, 13*, 187-197.

Schmidt, F. L. & Hunter, J. (2004). General mental ability in the world of work: Occupational attainment and job performance. *Journal of Personality and Social Psychology, 86*(1), 162-173.

Schmidt, F.L. & Hunter, J.E. (1998). The validity and utility of selection methods in personnel psychology: Practical and theoretical implications of 85 years of research findings. *Psychological Bulletin, 124(2), 262-274.*

Spearman, C. S. (1904). General intelligence objectively determined and measured. *American Journal of Psychology, 15*, 201-209.

Spearman, C.S. (1927). *The abilities of man: Their nature and measurement*. New York: Macmillan.

Sternberg, R.J. (1985). *Beyond I.Q.: A triarchic theory of human intelligence*. New York: Cambridge University Press.

Thurstone, L.L. (1938). Primary mental abilities. *Psychometric Monographs, 1*.

Vernon, P.E. (1961). *The structure of human abilities* (2nd ed.). London: Methuen.

Wechsler, D. (1958). *The measurement and appraisal of adult intelligence* (4th ed.). Baltimore: Williams, & Wilkins.

Wechsler, D (1997). *Wechsler Adult Intelligence Scales-Third Edition* (WAIS-III). The Psychological Corporation: San Antonio, TX.

Weinberg, R.A. (1989). Intelligence and IQ: Landmark issues and great debates. *American Psychologist, 44*, 98-104.