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PSYCHOLOGICAL PILOT SELECTION IN THE U.S. AIR FORCE, THE LUFTWAFFE, AND THE GERMAN AEROSPACE RESEARCH ESTABLISHMENT

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This technical report has been reviewed and is approved for publication.

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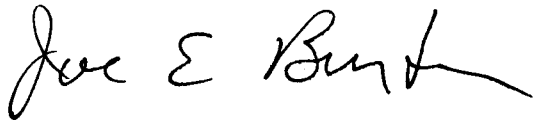

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13. ABSTRACT *(Maximum 200 words)*
As financial resources for the U.S. Air Force (USAF) and the German Luftwaffe (LW) dwindle, reducing attrition from military aviation training becomes vital. Finding the optimal mixture of applicant personality, stamina, and psychomotor skills for aviation is a goal as complicated as it is elusive. This paper compares the USAF, LW and German Aerospace Research Establishment (DLR) pilot selection programs. The LW and DLR utilize a sequential psychological selection system including apparatus tests, psychological interviews and behavioral observations, while in the USAF psychological selection does not play an important role. Instead, medical standards, flight screening, and training attrition are used as USAF selection criteria. However, a new USAF program, Neuropsychiatrically Enhanced Flight Screening (N-EFS) will examine the personality characteristics of pilot applicants for further study. The USAF and LW could learn from the strengths and weaknesses of their respective selection programs. The opportunity for cooperative research is even greater, considering that the USAF and LW pilot students share common jet pilot training.

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INTRODUCTION

Attrition from military aviation training is costly in monetary and in human terms. The need for improving methods of selecting and classifying pilot training applicants becomes even more important in times of diminishing financial resources for the U.S. Air Force (USAF) and the German Luftwaffe (LW). Finding the optimal mixture of applicant personality, stamina, and psychomotor skills for aviation is a goal as complicated as it is elusive. Compared to the past, military pilots of the 21st century have to master complex computerized aircraft, highly accurate weapon systems, and supersonic speeds. These new technologies increase physical and psychological stress factors for the pilot, as decision time drops from minutes to seconds. A minor error can cause fatal consequences not only for the pilot, but also for the crew, passengers, and any other individuals on the ground. The painful loss of life to "friendly fire" in Desert Storm and in the misidentified U.S. helicopters over Iraq in 1993 highlight some of the challenges facing future aviation warfighters. Perhaps an effective selection of pilot students could have a life-preserving value even beyond preventing needless and expensive training fatalities (Hilton and Dolgin, 1991).

Since World War I, military psychologists have sought to develop valid tests to select candidates who will complete undergraduate pilot training (UPT) and perform well in their careers. Test development for pilot selection has mainly been based in three areas: (a) psychomotor skill/quickness, (b) intelligence/aptitude, and (c) personality/character (Hilton and Dolgin, 1991). Although the emphasis in each of these areas varied for different countries over time, these components have remained part of most USAF and LW pilot selection batteries.

In the USAF and LW, psychological pilot selection has relied upon measurements of psychomotor skills and intelligence/aptitude rather than personality/character. Two factors have influenced this choice of testing. First, the prediction of UPT completion appears highly related to the student's manual control abilities, which are fairly easy to measure. Second, accurate assessment of an applicant's personality characteristics is more difficult and depends significantly on subjective factors, which causes concerns about the reliability of the data. Yet, both countries are aware that personality is as an important factor in the prediction of a student's success. The successful aviator not only <u>can</u> (sufficient cognitive and psychomotor skills) complete training, but <u>will</u> (sufficient stress coping and motivation) pursue a military aviator career. These questions seem best answered by analyzing individual differences in the personality of the students.

Dolgin and Gibb (1989) found identifying characteristics that promised an improved likelihood of later success in aviation (e.g., persistence, motivation, coolness under pressure and novel problem solving). Nevertheless, there are still many unanswered questions about military aviator psychology. Can one identify personal/psychological differences between the successful fighter, transport, and rescue pilot? If personality differences exist between these pilots that suggest optimal cockpit "fit," then more focused training, improved selection criteria, and enhanced mission performance (Flynn, Sipes, Grosenbach and Ellsworth, 1994) could result.

The purpose of this paper is to describe the currently used pilot selection systems in the USAF and LW and compare a new personality assessment battery used in the USAF to the investigation of personality characteristics in the LW pilot selection. Cross-cultural aspects and application are discussed later. In addition to military pilot selection, the selection process of airline pilot applicants by the German Aerospace Research Establishment (DLR) which uses a multidimensional personality questionnaire will be presented.

PSYCHOLOGICAL PILOT SELECTION IN THE USAF

For almost 80 years, various screening criteria have been used to determine which individuals could enter UPT. Since World War I, the US military has used both apparatus tests (e.g., rotary pursuit, stick and rudder, compensatory tracking) and a variety of paper-and-pencil tests (e.g., general intelligence, mechanical comprehension, perception, vocabulary, reading comprehension) (Carretta, 1989) in selection. Although these psychomotor tests demonstrated a validated utility in predicting UPT success, the USAF terminated their use in 1955 primarily for administrative reasons, including the decentralization of the testing procedures and locations (Carretta, 1992). Since then, pilot applicants have been selected at an annual or semiannual board, based on results of the Air Force Officer Qualifying Test (AFOQT), as well as medical fitness, academic performance, background and biographical data, and previous flying experience.

In the 1980s, the USAF Air Training Command asked (a) whether the latest computerized-testing technologies could be used to reliably measure perceptual and motor skills and (b) whether these measurements could improve pilot selection procedures. A multiyear research project utilizing a computerized test system called the Basic Attributes Test (BAT) was started (Bordelon and Kantor, 1986). Both test batteries, the AFOQT and the BAT are currently used as measures in the attempt to predict UPT performance and training success. It is expected that individuals with better psychomotor skills and quicker reaction times will be more likely to complete UPT. However, the BAT is not yet a decisive selection device and its predictive validity is still being tested (Carretta, 1992).

If there is information available on who <u>can</u> (aptitude) perform well in pilot training, the search for predictive data on who <u>will</u> (motivation) finish UPT and become mission-qualified pilots remains elusive (King, 1994; Siem, 1992; Street, Helton, Nontasak, 1993; Youngling, Levine, Mocharnuk, Weston, 1977). Further, predicting success in UPT does not necessarily predict a pilot's mission readiness in a particular weapon system. Helmreich, Sawin and Carsrud (1986) point out the existence of the "honeymoon effect" in psychological studies of applicants, where the only the criterion of success is completion of training. This means that student pilots, attempting to look their best, can maintain high performance levels during short periods. However, the value of UPT is the addition of a mission qualified aviator in a USAF weapon system. The USAF is currently pursuing a longitudinal study, Neuropsychiatrically Enhanced Flight Screening (N-EFS), to search for identifiable and measurable information about personal and psychological qualities that define successful military pilots. This study builds on previous attempts to define desirable personal qualities that differentiate top performer pilots from their fellow aviators (Flynn et al., 1994). The following sections will give a closer description of the

AFOQT and BAT batteries. Then, the Neuropsychiatrically Enhanced Flight Screening (N-EFS) and the included tests will be presented.

AFOQT and BAT Test Systems

The AFOQT is a paper-and-pencil test battery used to select civilian applicants for officer precommissioning training programs. It's goal is to classify commissioned officers into aircrew job specialties like pilot vs. navigator training (Carretta, 1989). The instrument consists of 16 subtests which measure five composite scores including Verbal, Quantitative, Spatial, Aircrew Interests/Aptitude, and perceptual speed skills. Fourteen of the subtests are used for the Pilot and Navigator-Technical composite scores applied in pilot candidate selection. Using these subtests scores, prediction of successful UPT performance is being researched.

The BAT battery of 15 subtests determine individual differences in the applicant in: psychomotor coordination, information processing, perceptual speed, personality, and attitudes. Despite the primary goal to measure psychomotor skills, six subtests were included to begin to assess personality and attitude characteristics: the Dot Estimation Task, Risk-Taking, Embedded Figure Test, Self-Crediting Word Knowledge, Activities Interest Inventory, and Automated Aircrew Personality Profiler (Dolgin and Gibb, 1989).

NEUROPSYCHIATRICALLY ENHANCED FLIGHT SCREENING (N-EFS)

Neuropsychiatrically Enhanced Flight Screening (N-EFS) is a program that will gather neuropsychological test data on intelligence, personality, and judgment in pilot applicants for comparison to occupational success. While this comparison may help identify factors that predict future mission success, a second goal of the project is to obtain baseline measures of individual aviator cognitive functioning for use in future medical evaluations (King and Flynn, in press).

Personality and attitude factors are typically underutilized in prediction of primary flight training success, focusing on sensory-motor skills instead. Yet human factors, such as motivation and personality traits, are increasingly recognized as important in cockpit success, especially when considering new crew stressors such as mixed-gender squadrons. Carrier launch and landing, inflight refueling, and air combat maneuvers demand a mixture of human performance capabilities. Psychological stress factors, such as risk taking and "fear of failure" contribute to the pilot's "emotional workload," which may contribute to aviation mishaps (Alkov, 1986). Therefore, aspects of human error leading to flight failure is of particular interest in military aviation safety, where pilot distractibility or inaction can be fatal. Perhaps permanent personality characteristics (traits) of the operator will be recognized as contributing to pilot failure (Gerbert and Kemmler, 1986).

The N-EFS research study will examine whether personality characteristics affect a pilot's later performance and achievement. For this investigation, the test battery consists of the Revised NEO Personality Inventory (NEO-PI-R), the Multidimensional Aptitude Battery (MAB), the Personal Characteristics Inventory (PCI), and the CogScreen (which is an assessment tool for

cognitive functioning). The current N-EFS study and the test battery will be described in the following sections.

Subjects

In the N-EFS program, pilot candidates at Hondo, Texas and the US Air Force Academy (USAFA) in Colorado Springs, Colorado are tested before entering the USAF flight screening program. Their commissioning source is either USAF Reserve Officer Training Corps (AFROTC), USAFA, or USAF Officer Training School (AFOTS). Male and female students are screened, and their ages are in the early to mid 20s. AFROTC and USAFA cadets are between their junior and senior year in college; AFOTS-commissioned officers have at minimum a college education. The training aircraft is the fully acrobatic T-3A, "Firefly.
"

Procedure

At the beginning of initial flight screening, student pilots are required to take the CogScreen and MAB as part of a medical baseline procedure, supervised by a licensed psychologist and an experienced mental health technician. Then, all students are invited to voluntarily complete the NEO-PI-R and PCI for research purposes. The testing takes about six hours, rest breaks and lunch included.

Instrumentation

Revised NEO Personality Inventory (NEO-PI-R)

The NEO-PI-R is an instrument that measures 5 domain scales and 30 facet scales to assess normal traits of adult personality (Costa and McCrae, 1992). There are two versions of the NEO-PI-R, one self-report version, Form S; and one for observer ratings, Form R. In this study, the Form S is used, which consists of 240 items answered on a 5-point scale. Form S is self-administered and appropriate for men and women of all ages. Personality measurements on the NEO-PI-R may be useful in assessing an individual's suitability or fitness for special tasks, especially for military training and pilot selection. NASA considers the NEO-PI-R a valuable tool in astronaut selection (King and Flynn, in press). Table 1 shows the domains and subdivided facet scales measured by the NEO-PI-R, as they are described in the manual (Costa and McCrae, 1992).

Multidimensional Aptitude Battery (MAB)

The MAB is a wide-range assessment tool for adolescents and adults measuring general aptitude or intelligence, and consists of five verbal and five performance subtest scores (Jackson, 1984). In addition to the ten subscale scores, the MAB yields a Verbal IQ, a Performance IQ, and a Full Scale IQ. In Table 2, the ten subscales of the MAB are presented. The MAB may be used for a variety of purposes, such as educational and career counseling settings, business and industry worker evaluations, medical clinics and mental health facilities, and as a basic research

tool (Jackson, 1984). The administration of the MAB can be to individuals alone or in groups. In the current study, the MAB was administered in groups.

Personal Characteristics Inventory (PCI)

The PCI (Chidester, Helmreich, Gregorich, and Geis, 1991) measures an aviator's judgment and potential for effective crew resource management. It assesses "crew coordination qualities" in aviators through answers to 254 questions with a Likert scale response pattern. Responses are categorized into eight groups from the "right stuff" to the "wrong stuff" in crew coordination (Gregorich, Helmreich, Wilhelm, 1989). Table 3 shows the subscales of the PCI as they are presented by King and Flynn (in press).

CogScreen

This is a computerized screening test measuring cognitive functioning. It was developed for the medical recertification of civilian airmen in coordination with the Federal Aviation Administration (FAA). The battery consists of eleven tests, measuring a wide range of perceptual/cognitive processes that are thought to be required in aviation tasks. Table 4 shows the test components of the CogScreen (from the unpublished CogScreen User's Manual, Richard L. Horst, Gary G. Kay). Research is currently underway with civilian aviators to determine correlation between CogScreen test scores and cockpit performance (Horst and Kay, 1991).

PSYCHOLOGICAL PILOT ASSESSMENT IN THE LUFTWAFFE

In order to attain a proper selection of future military aviator personnel, a sequential psychological selection system for pilot applicants was developed for the German Forces. Every individual who wants to become an aviator in the German Air Force or Luftwaffe (LW) has to complete a several-stage psychological selection procedure, which lasts about one to two years. Most parts of the pilot selection are administered by Division VI of the Luftwaffe Institute of Aerospace Medicine (FMI) in Fürstenfeldbruck, Germany. The division consists of four special branches: Selection Branch, Screening Branch, and Diagnostics and Experimental Psychology Branch. The team of psychologists and their assistants work primarily to select pilots and air traffic control personnel. However, they also provide psychological training and rehabilitation for aircrew affected by flight accidents or incidents, fear of flying, or motion sickness. Additionally, the psychologists hold classes for flight surgeons and instructor pilots, and conduct scientific research related to military aviation concerns. The psychological selection process is organized into three sequential selection steps: Preselection, Main Selection, and Flight Screening. Every applicant must successfully complete all steps in order to be admitted to pilot training (Hoffelt and Gress, 1993).

Preselection

Any male that wishes to become a pilot in the LW may apply for training. Applicants who want to fly a jet, must first become an officer (helicopter and transport applicants do not absolutely have to be officers). The average applicant to the aviation service is about 19 years

old. Some months prior to achieving the German university entrance level (Abitur), he will take the Officer's Qualification Test (OQT) where objective testing, interviews, and a physical stamina test are conducted. A pilot applicant who passes the OQT must also take an intelligence and a concentration test (Hoffelt and Gress, 1993): the IT-70 intelligence test by Amthauer and the KBT concentration test by Kirsch. Depending on the achieved results in these tests, the candidates are classified into one of three performance groups. Generally only the performers of group I and II are accepted for the next psychological selection step, called main selection. However, in case of insufficient applicant numbers, the less proficient performers of group III are also accepted for further testing (Hoffelt and Gress, 1993). In fact, since 1993, because of a decreasing amount of applications, every applicant who passes the preselection has participated further in the selection process.

Main Selection

The main selection process is a one-day examination conducted in the Selection Branch of FMI Division VI. Approximately 800-1000 applicants are tested there annually, or an average of six applicants a day. At this selection step, about 30% of the candidates are rejected (Hoffelt, 1994, unpublished data). All applicants must pass the same aviator test battery, regardless of their future flying status: jet, propeller, helicopter or weapon systems officer (WSO).

Three computer-based psychomotor tests, a biographical inventory, and a diagnostic interview are administered in the main selection cycle. The psychomotor tests are the Instrument Coordination Analyzer (ICA), the Sensomotoric Test (SMT), and the Decision Reaction Timer (ERT). These measure psychomotor coordination, selective attention, information processing, reasoning, multiple task performance, reaction time, reaction accuracy, stress tolerance, and decisiveness (Hoffelt and Gress, 1993). In the diagnostic interview, the psychologist focuses on the applicant's stress reactions during the tests, coping strategies, achievement, and flying motivation, as well as personality characteristics and traits which could influence future success in military aviation.

All psychologists are involved in the final selection decision of an applicant. They meet in a board to allow each individual's test results to be presented and discussed. Only successful applicants from psychological main selection are scheduled for the flight physical medical examination on the following day. If approved through preselection, main selection and medical examination, the jet aviation candidate will then proceed to Officers Training School and then to flight screening.

Flight Screening

Applicants who successfully pass the psychological and medical selection must then successfully complete primary military training and the Officer's Training School (OTS), before beginning the flight screening program. Flight screening usually begins approximately 18 to 24 months after the psychological main selection. First, the candidates are tested on a complex simulator-type test device, the FPS-80. The candidates have to fly several "missions" on the FPS-80 while their behavior and performance are observed and rated by a psychologist. Next, a

70-hour academic course at the flight training school in Goodyear, Arizona, teaches candidates about navigation, meteorology, aerodynamics, aircraft instruments, and airmanship (Hoffelt and Gress, 1993)

If required performance standards on the FPS-80 and in the academic course are met, the final step in the screening process is 18 hours of flight time in the F-33 Beechcraft, "Bonanza," which culminates in a solo flight. Depending on the amount of points achieved in the flying screening, it is decided whether the candidate will start jet pilot training in EURO-NATO Joint Jet-Pilot Training (ENJJPT) at Sheppard AFB, Texas (King and Lochridge, 1991), or Weapon Systems Officer (WSO) training at Randolph AFB, Texas.

INSTRUMENTATION

The tests utilized in the different steps of the pilot selection in the LW will be further described in the following sections:

Preselection

Intelligenz-Struktur-Test 70 (IT-70)

The IT-70 is an intelligence test for adolescents and adults which every pilot applicant must take during the preselection phase. It is a special military version of the Intelligenz-Struktur-Test 70 (IST-70) by Amthauer (1970). The IST-70 consists of nine subscales and 180 items chiefly measuring verbal, arithmetic, spatial orientation, and memory skills (Weise, 1975), and can be administered individually or in groups. The nine subscales in Table 5 have been translated from the German subscales described by Weise (1975). The IT-70 that is used in pilot selection contains only the five subscales measuring arithmetics, spatial orientation, and memory.

Konzentrations-Belastungs-Test (KBT)

The Concentration-Stress-Test (KBT) by Kirsch is also applied in the preselection of all pilot applicants. It is a symbol-digit-encoding test measuring perceptual speed, concentration, memory, attention, and achievement under time pressure (Kirsch, 1973). The test consists of a key showing 19 similar symbols that are assigned single digits that is used to complete ten working-columns (each consisting of 18 symbols like the one in the key). The applicant has to correctly match the digits to the symbols of each column, finally adding the numbers together. Started at the bottom of each column, the time to complete each column is limited to one minute. The test achievement is represented by the number of correct digit sums. Some examples of the key and the working columns are shown in Table 6.

Main Selection

Instrument-Coordination-Analyzer (ICA)

The ICA is an apparatus test measuring control precision and control effort (Hoffelt and Gress, 1993). On a computer screen, several flight instruments (altimeter, speedometer,

compass) and a program clock are presented. The applicant is asked to fly certain "flight maneuvers," e.g., a 360-degree left or right turn while maintaining an altitude of 2000 feet. Management of the altitude and speed is performed with the control and throttle stick. Additionally, horizontal and/or vertical gusts are introduced to make the test more complicated.

A second task of simple addition and subtraction problems may be added through a headset to the candidate. However, the problems are only introduced if the subject's performance meets a required level. The subject is continuously informed about the dissonance of his actual and required performance level (Hoffelt and Gress, 1993). The ICA-test takes about 70 minutes and results in scores on control precision and effort, concentration ability, and psychomotor coordination. During the entire test, a psychologist observes and notes the behavior and reactions of the applicant. A new multidimensional simulation-test system for pilot selection has been tested (ICA 90) since 1991, for future replacement of the older ICA battery.

Sensomotoric Test (SMT)

The second test of the main selection step is the SMT, a 35 minute computerized test quite similar to the ICA that mainly measures psychomotor skills. On a display, the applicant has to stabilize a moving cross within a circle by means of the control stick. In addition to the primary task, a continually changing speed indication must be stabilized with a throttle, while a yaw indicator must be held on a fixed mark by using rudder pedals. The computer registers the time on target, the deviations from required values and the control efforts (Hoffelt and Gress, 1993). A test-assistant registers the behavior of the applicant.

Decision-Reaction Timer (ERT)

The ERT is the third test of the main selection step and measures the individual reaction times to different optical stimuli (Hoffelt and Gress, 1993). During several trials, subjects have to compare an exposed optical stimulus on a display with eight other, almost similar stimuli. The correct stimulus match has to be identified from the eight possibilities as quickly as possible, and the correct button is pressed. The reaction time is measured as well as the number of correct, false, late, and omitted reactions.

Biographical Questionnaire and Interview

In addition to these tests, the applicant has to fill out a semistructured biographical inventory covering topics about family and educational background, hobbies, and flying motivation. After the entire main selection testing procedure, an interview is conducted by a psychologist. The objective of the interview is to obtain personality information in addition to personality questionnaires, where the applicant's social desirability tendencies may limit responses. During the interview, data on test-related thoughts and feelings, like achievement motivation, appraisal of own test performance, stress reactions and coping strategies during the testing, and flying motivation of the applicant are also sought.

Flight Screening

The Flight Psychological Selection System (FPS-80)

The FPS-80 is a simulator-like test device used in the flight screening program. The system consists of two independent working cockpits with three color-graphic-displays. The subjects have to "fly" several missions while the computer continuously monitors and registers the flight parameters (Hansen, 1987). From a nearby room, the psychologist can observe the student's behavior and can rate the performance in several skill areas after the student has finished. Some of the skills measured with the FPS-80 are: time sharing, flexibility of attention, speed perception, reaction time, learning speed, precision of control, psychomotor coordination, stress resistance, self-control, and the capacity to adapt to a complex man-machine-system. Although the FPS-80 looks like a flight simulator, it is not a trainer but a diagnostic instrument based on psychological testing theory and methods

.

USAF AND LW PILOT SELECTION IN COMPARISON

The pilot selection procedures in the USAF and LW show a vast difference in emphasis on psychological selection. In the LW, the psychological pilot selection consists of a sequential-stage process including preselection, main selection, and aspects of flight screening. These psychological selection steps precede even the medical selection, and LW applicants who do not pass these first steps are washed out. In the USAF, neither psychological assessment nor the BAT is a selection criterion. Instead, the primary selection criteria to decide who can participate in flight screening are the medical examination followed by the USAF aviator selection board (A. Hernandez, personal communication, Sept 1, 1994). The USAF aviator selection board relies on a mixture of other selection measures after medical standards are met: e.g., scores on the AFOQT, military bearing, and scholastic achievement at the university level.

Other differences beyond psychological selection and one similarity should also be noted. How pilot aspirants apply to become pilots is different in both countries. While in the USAF the testing locations are decentralized, every applicant to the LW has to take the same tests at one location, the FMI. Naturally, to achieve a more centralized system, as in the LW, is not as easy in the larger United States. However, N-EFS will be administered at only two locations, which is more similar to the LW testing program. Most of the LW applicants come directly from the German equivalent of U.S. high school and are exclusively males. In the USAF, candidates (male and female) arrive from different sources: the USAFA, AFROTC and AFOTS; and have completed three to four years of college. One similarity is the multitude of cultural differences and the various educational systems that add further complexity for developing universal psychological standards in both countries, especially now that Germany is unified.

Attrition Rates in Selection and Training

A comparison of the attrition rates in selection and training of both countries is difficult because their system differences. However, Figures 1, 2, and 3 may be helpful in this review. Figure 1 presents the LW annual average attrition rates from 1987-1990 (Hoffelt, 1994,

unpublished data) within each of the different selection steps, including the ENJJPT and the WSO training. Most applicants are screened out in the preselection, main selection, and medical selection procedures. Very few (about 7%) of the candidates don't pass the officer's training school, which occurs before flight screening. The attrition rate for flight screening (where there is further psychological screening and F-33 training) are less than the pre- and main selections; the rate drops further at ENJJPT, and is least at WSO training.

Figure 2 shows the percent attrition of USAF pilot candidates in 1994 (L. D. Marvin, personal communication, Sept 1, 1994), and the 5% average annual medical attrition from 1990-1992 (A. Hernandez, personal communication, Sept 1, 1994). The one month USAF flight screening program with the T-41, or with the new T-3A, shows a similar rate to medical attrition, about 7%. In 1994, 8.4% of the USAF students in ENJJPT failed in the training phase with the subsonic T-37 jet trainer, and another 4% failed in supersonic T-38 jet training.

Figure 3 compares the LW and USAF attrition rates. It is difficult to compare pre- and main selection attrition between the LW and USAF. The road to USAF UPT is arduous. USAF aviator applicants also have the opportunity to compare their personal data on abilities in university academics, military participation, and AFOQT scores to known successful applicants' scores. Data on how many applicants are washed out in this process are not kept by the USAF. In addition, USAF aviator hopefuls also participate in medical "pre-screening" by making a preliminary visit to their local physician to see if they pass well-documented USAF aviation physical standards. If they do not, then they know that entry into USAF aviation training will not be possible.

These factors probably account for the unusual difference between the 30% LW medical attrition compared to the 5% USAF medical failure rate. Fewer US applicants fail the medical and flight screening programs, and the ENJJPT attrition is higher for the LW compared to the US. USAF student average annual failure in ENJJPT has been fairly constant at about 12% in recent years. This is less than the 17% attrition of all other international Air Forces' candidates participating in ENJJPT (L. D. Marvin, personal communication, Sept 1, 1994). However, USAF pilot students performed better at ENJJPT, when compared to the 1994 attrition rate for all USAF UPT bases, which was 16.5% overall (and very similar to the 17% noted above). Attrition from WSO training is similar in both Air Forces, but the LW loses fewer students from this training.

Cross-Cultural Problems and Opportunities

A large number of the LW pilot applicants are known to wash out in the screening process before ENJJPT. The authors speculate that this may also be true in the USAF, although data on applicant attrition prior to the medical examination and selection board are not kept. Given this limit of accurate "early" data, it appears the USAF loses most aviation candidates in the flight screening and UPT phases. Despite this, USAF attrition in ENJJPT is less than that of the LW, or the average for all international Air Forces. The high attrition in ENJJPT for the LW pilot students may have several reasons.

Although many of the presumed "wrong stuff" applicants are washed out in the LW psychological and medical selection stages, fewer applicants could cause less qualified students to be accepted for training. However, other factors probably have more impact. LW pilot students have flown only 18-hours in the F-33 during flight screening, compared to 24 hours flight time in the USAF T-41 or T-3A program. In addition, the LW pilot students face cultural difficulties in American training: e.g., dealing with barriers in language fluency in speech and thought, adapting to differences in the educational system, coping with separation from major social supports (such as family and friends), and living in an unaccustomed environment

Jet pilot training is difficult enough without these added cultural stressors. Both air forces could benefit from improved selection systems that reduce the number of paid trainee slots that do not produce a qualified military aviator. In 1993, the LW ENJJPT attrition came primarily from flying deficiencies (78%) and medical reasons (10%), with only 11% from self-elimination (Gress, 1994). The psychological selection in the LW plays an important role in selecting-out the "wrong stuff," and goes beyond producing quantitative data of the applicants psychomotor abilities. Qualitative statements about the personality are made by means of the interviews, biographical data and behavioral observations during the testing. One wonders how severe attrition might be without the thorough LW psychological screening program, and what benefits the USAF could gain from applying aspects of their selection program.

Hoffelt and Gress (1993) note a recent study that showed correlation between various personality dimensions and the performance at ENJJPT: successful trainees are significantly more self-assured, more natural, less inhibited, more assertive, more stress resistant, and more cooperative than those who fail. The eliminated trainees are characterized significantly more often as being more sensitive, more dependent on social acceptance, and generally more aggressive. The statements of instructor pilots reflect these findings: the successful flying student has a stable achievement motivation, a certain "go-lucky attitude," an effective stress coping technique, and the ability to cooperate and set priorities.

The current N-EFS program might benefit from adding interviews and behavioral observations as utilized by the LW. The LW psychological selection might gain from adopting the N-EFS approach of performing its tests closer to flight screening, rather than almost two years before ENJJPT. During these years, the applicant's maturational processes may be influencing the predictive validity of the selection tools. The LW might add the NEO-PI-R and the PCI into their selection process, as applicants are not now given a personality inventory, only a biographical questionnaire. The MAB intelligence test, however, is very similar to the IT-70 used in the LW: both tests include subscales measuring verbal, arithmetics, and spatial orientation. The CogScreen test battery, which measures cognitive processes of attention, memory, response speed and mental arithmetics, has similarities to the KBT and the three apparatus tests (ICA, SMT, ERT and FPS-80) used in the LW. Joint USAF and LW research efforts could benefit both countries and could be easily established between the Neuropsychiatry Branch of the USAF Aerospace Medicine Directorate, Brooks AFB, TX; and the LW counterpart, the FMI.

PILOT SELECTION IN THE GERMAN AEROSPACE RESEARCH ESTABLISHMENT DLR

For more than 35 years, the Department of Aviation and Space Psychology of the German Aerospace Research Establishment (DLR) has been selecting airline pilot applicants for ab-initio pilot training (which means that no flying experience is required by the trainees at the beginning), mainly for Lufthansa German Airlines. Although the selection systems were originally developed for pilots, these are now applied to other occupations like selection of air traffic controllers or science astronauts (Goeters, Hörmann and Maschke, 1989).

Personality assessment has always been a part of the selection procedures, even though the DLR has chosen applicants for ab-initio pilot training based chiefly on psychomotor skills. In the past, projective tests and hand-writing analysis were used. Today, the DLR utilizes standardized personality questionnaires, psychological interviews, and behavioral observations for pilot selection (Hörmann and Maschke, 1993). Most of these tests were developed by the DLR itself. The need to obtain information about distinctive personality characteristics in airline pilots led to the development of a multidimensional personality questionnaire known as the Temperament Structure Scales (TSS). The development of the TSS began in the 1960s, and the different scales were based on an analysis of identified stresses in aviation (Goeters, Timmermann and Maschke, 1993). The next section presents a summary of the process of the ab-initio pilot selection and training. Then, the Temperament Structure Scales will be presented.

The AB-Initio Program

Most student pilots of the German Lufthansa airlines are trained from a status of no flight experience at all to a commercial pilot level at the pilot schools in Bremen, Germany, and in Phoenix, Arizona. Every pilot applicant must have completed the German university entrance level (Abitur) and must not be older than 27 years (Goeters et al., 1989). Male and female trainees are accepted if they complete the selection program successfully. After two years of pilot training, the student holds all relevant airline pilot licenses including the Airline Transport Pilot License. Then, after a transition phase of five months including the type rating and a line check, the young pilot is able to fly as first officer on airplanes of Lufthansa's entry fleet: Boeing 737 (Goeters et al., 1989).

The selection process contains two steps where flying skills and managerial skills are tested with a multi-modal evaluation including biographical data, performance and personality tests. The first step lasts two days, where all applicants have to perform group-administered performance and personality tests measuring: Technical Knowledge and Comprehension, Mathematics, Concentration Ability, Perception Speed, Memory (Auditory/Visual), Spatial Orientation, and Temperament Characteristics (Maschke and Hörmann, 1989). This phase normally reduces the number of applicants by 70-75%. The successful applicants continue with the second step, which lasts three days and consists of three parts: psychomotor coordination and multiple task capacity tests (first day) , an interview in front of the selection board (second day), and medical examination (third day). After the second phase, the number of acceptable

applicants is only about 10% of the original group. The basic structure of the assessed traits in the psychological selection of pilot training applicants are listed in Table 7 (Goeters et al., 1989):

The Temperament Structure Scales (TSS)

The TSS is a multidimensional personality questionnaire consisting of 234 items. Goeters et al., (1993) report 10 personality dimensions measured by the scales: work-related traits (Motivation, Rigidity, Mobility, and Vitality), social behavior traits (Extraversion, Dominance, and Aggressiveness) and stress resistance/emotionality factors (Emotional Stability, Spoiltness, and Empathy). Please note Table 8. While most of these dimensions are well described personality factors, the Vitality and Mobility scales are especially important for pilot selection criterion. The Vitality scale was designed to take into account the physical demands in aviation, e.g., long flights, jet lag, and preservation of physical fitness. The Mobility scale determines the risk-taking behavior of pilots in dangerous situations (e.g., unfamiliar conditions or emergency situations).

There are two versions of the TSS for two age levels: one for applicants in the early 20s, the other one for older professional pilots who already have flying experience. The TSS is available in German, English, and Spanish. These personality scales assess interpersonal behavior, emotions and feelings, as well as work and achievement attitudes. The dimensions are measured on a nine-point stanine scale with distinctive positive and negative scores. Middle values are normally considered as the optimum (Hörmann and Maschke, 1993). The TSS subscales and an additional scale measuring Social Desirability (Openness), are described in Table 8, as Goeters et al., (1993) present them.

A study to evaluate the validity of the TSS scales as predictors of successful career development in licensed airline pilots was started in 1989. During the selection, 274 (270 male and four female) licensed airline pilots applying for employment at a European charter airline were examined with the TSS. The career development of all 274 applicants was followed for three years after hiring (Hörmann and Maschke, 1993). Results of the study have shown consistent empirical evidence for correlation between several dimensions measured by the TSS (Extraversion, Dominance, Emotional Instability, Aggressiveness) and defined job success criteria of airline pilots, described by Hörmann and Maschke (1993). An advantage of the TSS is that it was developed on an airline pilot population to which it is applied now as a selection instrument (Hörmann and Maschke, 1993). Therefore, the TSS can be regarded as a useful instrument for assessing personality characteristics of future successful airline pilots.

SUMMARY

The comparison of USAF and LW pilot selection programs has shown a variety of differences, especially in the emphasis placed on psychological selection of pilot applicants. While the LW utilizes a sequential psychological selection system that includes apparatus tests, psychological interviews, and behavioral observations to select the "right stuff", psychological selection in the USAF does not currently play an important role. Although indicators point to a high percentage of attrition prior to the USAF aviation selection board, there is a lack of central

data to confirm this. Instead, available data supports the concept that the USAF emphasizes medical selection, flight screening, and UPT as pilot selection criteria. However, the N-EFS study is a new step in the search for identifiable and measurable information about cognitive and psychological qualities of successful USAF pilots. The USAF N-EFS program looks more closely at personality measurement, with the NEO-PI-R and PCI, than is currently performed in the LW selection batteries.

Beyond the question of individual ability (psychomotor skills and intelligence) to perform in pilot training, is the question of whether the pilot will become mission-ready and will remain motivated when facing the demanding tasks in military aviation. A better scientific understanding of pilot personality could improve the selection of aviators assigned to the different military tasks of flying a fighter, transport, or reconnaissance airplane. One personality type might fit better in a single-seat aircraft, while another could contribute to an excellent crew cohesiveness and task performance in a multicrew airframe. The PCI may be a helpful tool in this research effort, but the USAF might also gain answers from research with the TSS (and there are already multilingual versions available.)

The average attrition in ENJJPT of LW and other international pilot students combined is 17%, which is higher than USAF ENJJPT students (12%); but similar to the overall USAF UPT attrition rate of 16.5%. Several reasons may contribute to a higher LW attrition rate, including: fewer highly qualified applicants, less flight time during flight screening, or perhaps the application of psychological screening too early in the selection process. Perhaps the LW could benefit from the N-EFS approach of using psychological screening closer to the flight training period--rather than nearly 2 years before. In military aviation, flying can be very demanding for the pilot, not only physically but also psychologically. Collaboration between USAF and LW selection scientists could help both countries find answers to the difficult question of what cognitive and personality traits best serve the military aviator.

The purpose of this paper was to compare the pilot selection systems of the USAF, the LW and the DLR. The LW places special emphasis on psychological selection of aviation candidates, and there is a growing interest for this methodology in the USAF pilot selection program. Additionally, the DLR selection process of German airline pilots using the TSS personality inventory was presented as a further example of personality measurement in pilot applicants. The USAF and LW should learn from each other's aviator selection programs' strengths and weaknesses in their search for the "right stuff" that makes a successful military aviator. Collaborative research ventures might reap scientific and occupational benefits at reduced costs for both countries, by splitting investigative efforts while following students through the already established common jet training at ENJJPT. In the near future, successful military operations will depend upon a small group of highly skilled aviators flying fewer, but more complex weapon systems. "Now" is the time to select aviators who can optimally manage the physiological and psychological demands of the 21st century military cockpit.

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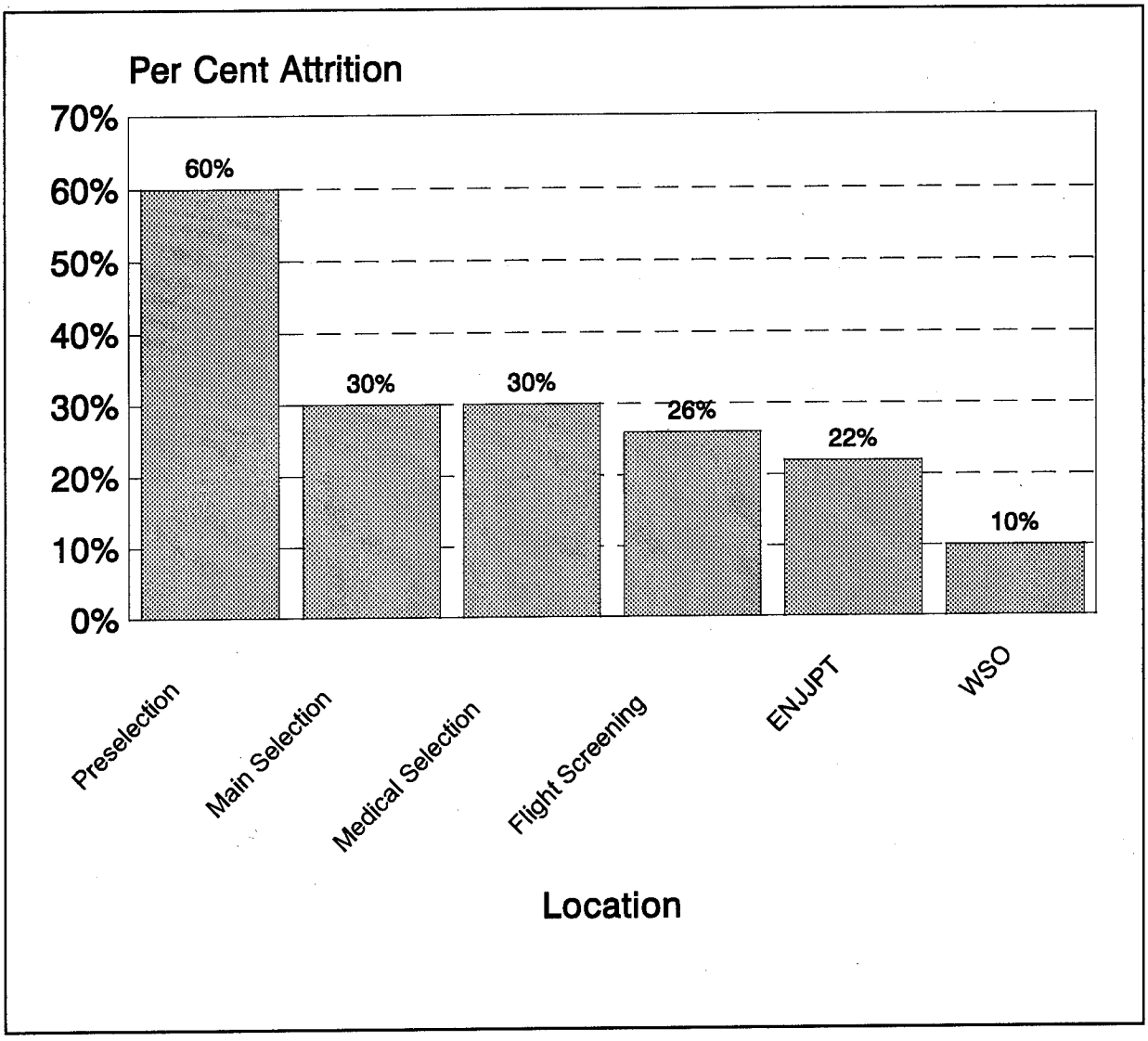

Figure 1. LW average percent attrition in Selections, Medical, and Training (1987-1990).

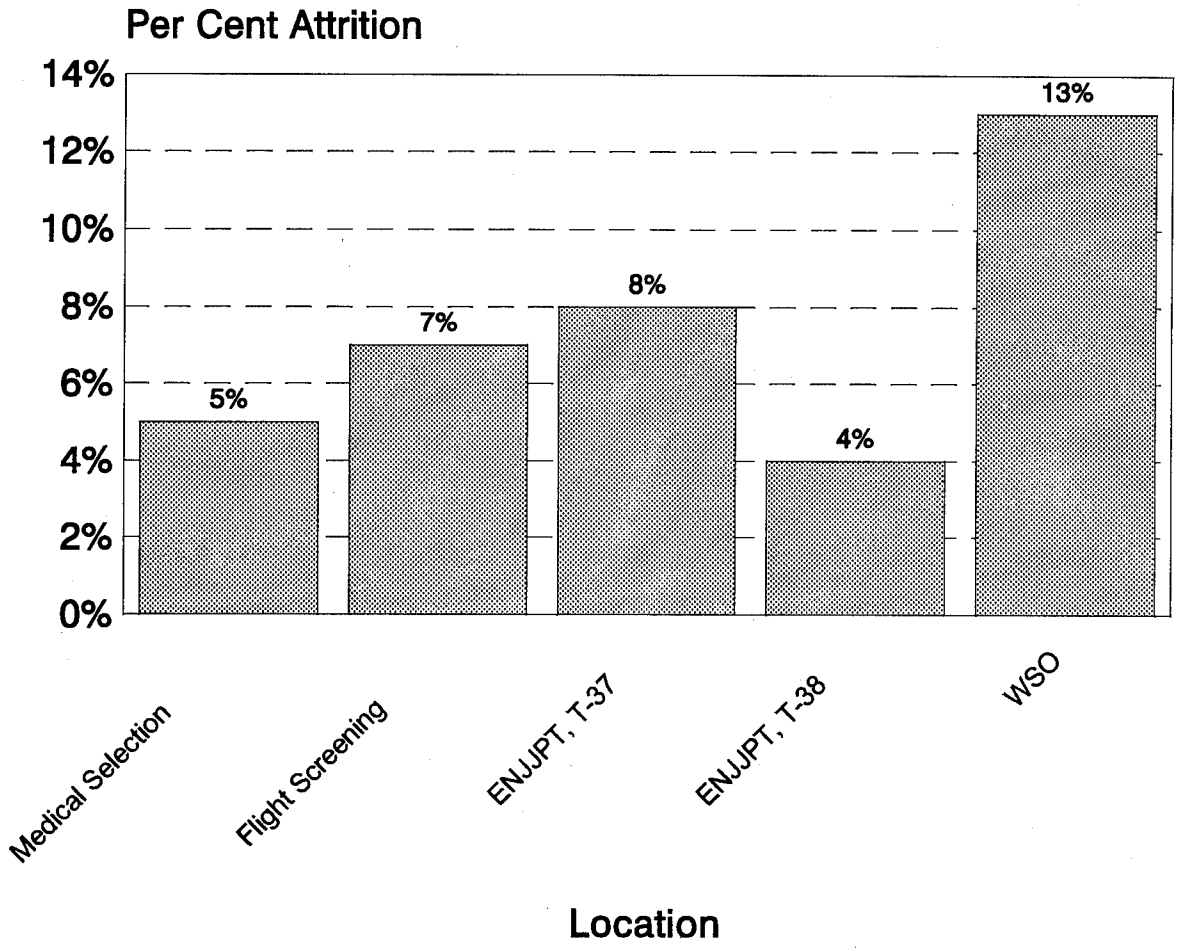

Figure 2. USAF percent attrition in Medical (1990-1992), Flight Screening and Training (1994).

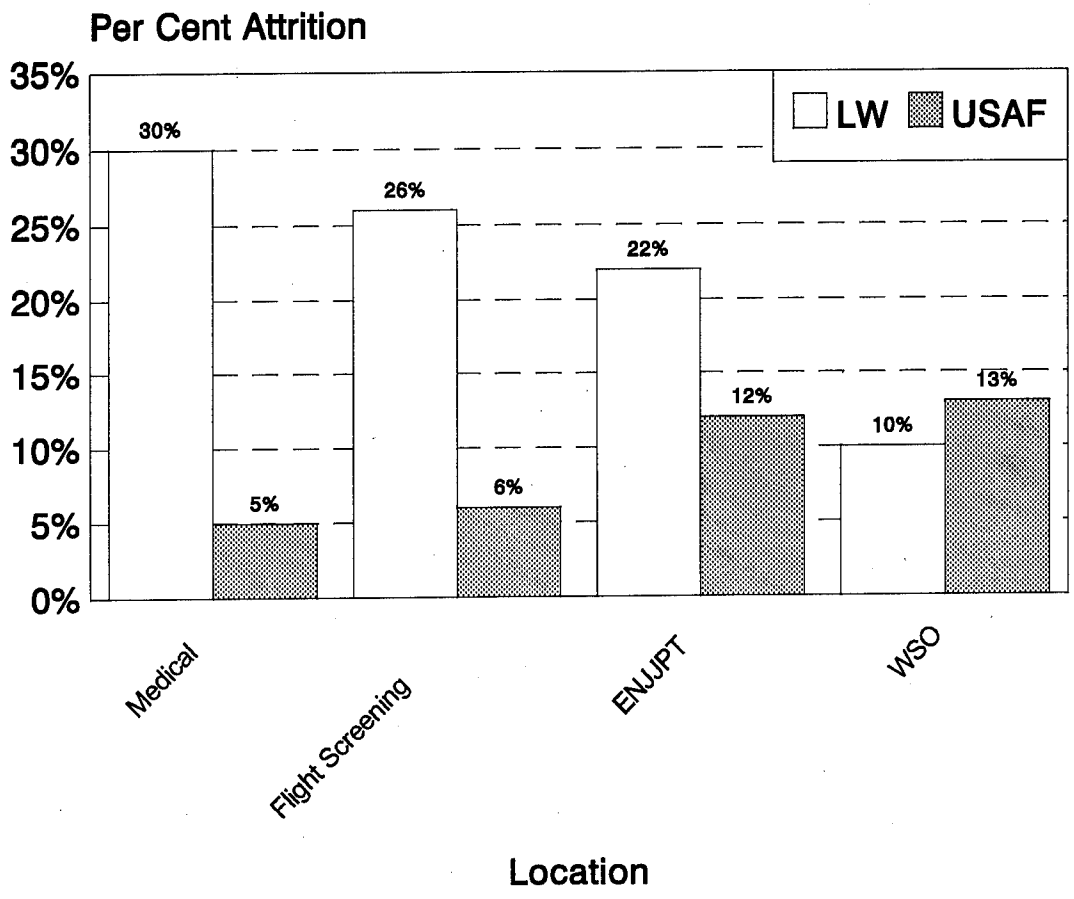

Figure 3. LW and USAF annual attrition from Selections and Training.

Table 1.

Revised NEO Personality Inventory (NEO PI-R)

Domain	Facet
Neuroticism (N)	Anxiety (N1) Angry Hostility (N2) Depression (N3) Self-Consciousness (N4) Impulsiveness (N5) Vulnerability (N6)
Extraversion (E)	Warmth (E1) Gregariousness (E2) Assertiveness (E3) Activity (E4) Excitement-Seeking (E5) Positive Emotions (E6)
Openness (O)	Fantasy (O1) Aesthetics (O2) Feelings (O3) Actions (O4) Ideas (O5) Values (O6)
Agreeableness (A)	Trust (A1) Straightforwardness (A2) Altruism (A3) Compliance (A4) Modesty (A5) Tender-Mindedness (A6)
Conscientiousness (C)	Competence (C1) Order (C2) Dutifulness (C3) Achievement Striving (C4) Self-Discipline (C5) Deliberation (C6)

Table 2.

Multidimensional Aptitude Battery (MAB)

Verbal IQ	Information Comprehension Arithmetic Similarities Vocabulary
Performance IQ	Digit Symbol Picture Completion Spatial Picture Arrangement Object Assembly
Full Scale IQ	Comprised of all subtests

Table 3.

Personal Characteristics Inventory (PCI)

Instrumentality (Goal Orientation)	Mastery
	Work
	Competitiveness
	Instrumentality (I+)
	Negative Instrumentality (I-)
Expressivity (Interpersonal Orientation)	Expressivity (E+)
	Verbal Aggressiveness (Eva-)

(The following scales can also be gleaned: Negative Communion [Ec-], Achievement, and Impatience including Achievement Striving [AS] and Impatience/Irritability [I/I].)

Table 4.

CogScreen

Name of Test	What it Measures
Backward Digit Span	Attention, working memory, verbo-sequential processing
Math Problems	Working memory, long-term memory, mental arithmetic, logical reasoning
Visual Sequence Comparison	Attention, working memory, and verbo-sequential processing
Symbol Digit Coding	Attention, visual scanning, working memory, verbo-sequential processing
Symbol Digit Coding - Immediate Recall	Immediate recall
Matching to Sample	Visuo-spatial memory, response speed
Manikin Figures	Visuo-spatial orientation, ability to rotate mental images, long-term memory
Divided Attention Test	Speed and accuracy of responding. In dual task mode: Divided attention, working memory, visual-spatial processing, verbo-sequential processing
Auditory Sequence Comparison	Attention, working memory, verbo-sequential processing
Pathfinder	Verbo-sequential processing, working memory, attention, ability to systematically apply rules
Symbol Digit Coding - Delayed Recall	Memory and recall
Shifting Attention Test	Concept formation, conceptual flexibility, deductive reasoning, response interference

(Extracted from the unpublished CogScreen User's Manual, authored by Richard L. Horst and Gary G. Kay, Georgetown University School of Medicine, Washington, DC, December 4, 1991.)

Table 5.

Intelligenz-Struktur-Test 70 (IT-70)

Verbal	Sentence Completion Word Choice Analogies Similarities
Arithmetic	Word Problems Series Completion
Spatial	Figure Recognition Cube Rotation
Memory	Word Recall

Table 6.

Konzentrations-Belastungs-Test (KBT)
(Concentration-Stress-Test)

Key Example: (incomplete)

+(	:(	)*	-)
2	1	7	3

Column Example:

+(	)+	-(	"(
:(	)"	+)	)"
*)	:)	):	*(
")	-(	(-	+)

Table 7.

Basic Requirements Studied in DLR Selection

Performance

Basic Knowledge:
- English
- Technical Knowledge and Comprehension
- Mathematics

Operational Aptitudes:
- Reasoning
- Memory (Auditory/Visual)
- Perception and Attention (Auditory/Visual)
- Spatial Orientation
- Psychomotor Coordination
- Multiple Task Capacity

Personality

Achievement-Oriented Traits:
- Motivation
- Rigidity
- Mobility
- Vitality

Interpersonal Behavior:
- Extraversion
- Empathy
- Aggressiveness
- Dominance

Stress Resistance:
- Emotional Stability

Table 8.

Temperamental Structure Scales (TSS)

TSS Subscale	What it Measures
Achievement Motivation(AC)	Ambition, competition, industriousness
Emotional Instability(IN)	Mood stability, anxiety proneness, optimism
Rigidity(RI)	Conscientiousness, organized, punctiliousness
Extraversion-Introversion(EI)	Social comfort, gregariousness
Aggressiveness(AG)	Conflict orientation, impulsiveness
Vitality(VI)	Orientation toward physical challenges
Dominance(DO)	Leadership comfort, decisiveness
Empathy(EM)	Detachment, helpfulness
Spoiltness(SP)	Frugality, pretentiousness
Mobility(MO)	Risk behavior, adventurous
Openness(OP)	Sociability, others vs self orientation

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